NUREG/CR-5908
BNL-NUREG-52333
Vol. 2

Advanced Human-System Interface Design Review Guideline

Evaluation Procedures and Guidelines for Human Factors Engineering Reviews

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Carlow International Incorporated

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U.S. Nuclear Regulatory Commission

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Manuscript Completed: June 1994
Date Published: July 1994

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Prepared for
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Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
NRC FIN L1317

ABSTRACT

Advanced control rooms will use advanced human-system interface (HSI) technologies that may have significant implications for plant safety in that they will affect the operator's overall role in the system, the method of information presentation, and the ways in which operators interact with the system. The U.S. Nuclear Regulatory Commission (NRC) reviews the HSI aspects of control rooms to ensure that they are designed to good human factors engineering principles and that operator performance and reliability are appropriately supported to protect public health and safety. The principal guidance available to the NRC, however, was developed more than ten years ago, well before these technological changes. Accordingly, the human factors guidance needs to be updated to serve as the basis for NRC review of these advanced designs. The purpose of this project was to develop a general approach to advanced HSI review and the human factors guidelines to support NRC safety reviews of advanced systems. This two-volume report provides the results of the project. Volume 1 describes the development of the Advanced HSI Design Review Guideline (DRG) including (1) its theoretical and technical foundation, (2) a general model for the review of advanced HSIs, (3) guideline development in both hard-copy and computer-based versions, and (4) the tests and evaluations performed to develop and validate the DRG. Volume 1 also includes a discussion of the gaps in available guidance and a methodology for addressing them. Volume 2 provides the guidelines to be used for advanced HSI review and the procedures for their use.

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EXECUTIVE SUMMARY

Background

Advanced control room (ACR) concepts are being developed in the commercial nuclear industry as part of future reactor designs and as improvements to current control rooms. The ACRs will use advanced human-system interface (HSI) technologies that may have significant implications for plant safety in that they will affect the operator's general role (function) in the system, the method of information presentation, the ways in which the operator interacts with the system, and the requirements on the operator to understand and supervise an increasingly complex system. The U.S. Nuclear Regulatory Commission (NRC) reviews the HSI aspects of control rooms to verify that they are designed to good human factors engineering (HFE) principles and that operator performance and reliability are appropriately supported to ensure public health and safety. The principal review guidance available to the NRC (NUREG-0700), however, was issued in 1981, well before many of these technological changes. Accordingly, the human factors guidance needs to be updated to serve as the basis for NRC review of these advanced designs. The objective of the project described in this report was to develop an approach for the evaluation of advanced HSIs called the Human Factors Engineering Program Review Model (HFE PRM) and an Advanced Human-System Interface Design Review Guideline (DRG).

This summary addresses the development and evaluation of the HFE PRM and the DRG.

HFE Program Review Model

In order to develop an approach for the evaluation of HSIs, it was necessary to consider: (1) standardization of nuclear power plant (NPP) designs, (2) the trends in advanced NPP HSIs, (3) the human factors issues associated with advanced technology, and (4) the state-of-the-art of human factors guidelines for advanced HSIs. Considering these issues, it was concluded that safety reviews of the HFE aspects of advanced reactor designs should: (1) be performed throughout the design of the plant; (2) extend beyond checklist-based evaluations to include a variety of assessment techniques; and (3) accommodate a broad range of CR "types" and a diversity of approaches to advanced HSI technology.

These factors have led to the development of the HFE PRM. It is largely based on applied general systems theory and represents a top-down approach to the review of HSIs. This approach starts with plant goals/functions and leads to the detailed design and validation. The HFE PRM is composed of eight elements and is divided into four review phases: HFE program planning, design analysis, interface design, and verification & validation. The review process allows the tracking of the design from initial conception through final design implementation. Within the context of the HFE PRM, the role of DRG is to provide the review guidance for evaluation of advanced HSIs to assure their conformance to accepted human factors engineering principles, standards, and guidelines.

DRG Development Methodology

Following a review of research and industry experience related to the integration of personnel into advanced systems, a set of "High-Level Design Review Principles" was developed. These principles identify the important design goals for maximizing primary task performance (i.e., the operator's process monitoring, decision-making, and control tasks); minimizing secondary task effects (i.e., the distracting effects of tasks such as configuring a workstation) which are unrelated to the primary task; and minimizing human error and making systems more tolerant to human errors when they occur. Then more

detailed review guidance was developed for specific HSI implementations (e.g., graphic displays, touch screens, and expert systems).

The effort to develop detailed guidelines began with an identification of human factors guidance documents for advanced HSIs. Through a review of the human factors literature and contact with organizations that sponsor such research, over 50 guideline efforts were identified. The next step was to select those documents that would serve as the "primary sources" for the initial set of guidelines to be incorporated in the DRG. A high priority was given to establishing the validity of the guidelines; i.e., assuring that they were based upon empirical research and/or accepted human engineering practice. Validity was defined in terms of two aspects of document development. "Internal" validity was evaluated by the degree to which the individual guidelines within a document were based upon research and an audit trail to the research maintained. "External" validity was evaluated as a function of the degree to which the guidelines were subjected to independent peer review. The peer review process was considered a good method of screening guidelines for conformance to accepted human engineering practices. Documents which had strong validity were considered primary source documents to serve as a basis for the DRG.

The guidelines from the primary sources were edited to combine similar guidelines and to transform the material into a standardized format. Where compound guidelines were encountered (several guidelines in a single statement) an effort was made to break them into logical units and represent the units as separate guidelines. Conflict resolution between guidelines was handled on a case-by-case basis.

The guidelines were sorted into seven major sections described below. Some sections are currently empty pending the completion of other NRC projects that are developing new guidelines in those areas. Each of these sections contains a set of general guidelines and more detailed guidelines addressing specific HSI applications.

The seven sections are:

- **Information Display** - This section deals primarily with the formatting of visual displays, both text-based and graphics-based. Following a section of general guidelines, guidance is provided in top-down fashion beginning with display formats (such as mimic displays and trend graphs), display format elements (such as labels, icons, symbols, color, text, coding, etc.), data quality and update rate, and display devices (such as video display terminals and large board displays).

- **User-System Interaction** - This section addresses the modes of interaction between the operator and the HSI. Topics include dialog format, navigation, display controls, entering information, system messages, prompts, and system response time. This section also contains guidelines concerning methods for ensuring the integrity of data accessed through the user interface. Guidance covers 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.

- **Process Control and Input Devices** - This section addresses information entry, operator dialogue, display control, information manipulation, and system response time. Considerations of display-control integration are also included here.

- **Alarms** - This section is a place holder for the results of another NRC research project to develop review guidance in the area of advanced alarm systems.

- **Analysis and Decision Aids** - This section addresses the use of knowledge-based systems.

- **Inter-Personnel Communication** - This section contains guidelines for activities related to speech and computer-mediated communication between plant personnel, e.g., preparing, addressing, transmitting and receiving messages.

- **Workplace Design** - This section addresses the organization of displays and controls within individual workstations, control room configuration, and environment.

In addition to a hard-copy document, the DRG has been developed as an interactive, computer-based review aid. The interactive document will simplify guideline access and review, editing, compilation of individual guidelines for a specific review, and incorporation of new guidelines as they become available. Availability of the DRG on a portable computer will also facilitate on-site reviews.

The guidelines are stored in a database composed of several primary fields: guideline number, title, guideline statement, additional information, and source (link to primary source document). Other "reviewer-support" fields are also provided, e.g., a note pad for reviewers to append comments related to specific guidelines. The interactive review aid provides for many document functions such as instant table of contents (ToC) access, context index, glossary, and placemarkers. Reviewers can automatically go to desired sections by clicking on the ToC or index entry. DRG evaluation summary and reporting functions are also available.

DRG Test and Evaluation

The DRG has been evaluated with respect to its scope and technical content (i.e., adequacy for the review of advanced HSI technology), and usability (i.e., DRG presentation, interactive document functionality, and user interfaces). The test and evaluation (T&E) program consisted of three methodologies: Development Test, User Test, and Peer-Review Workshop. The Development Test provided a preliminary evaluation of the DRG and an opportunity to correct interface problems before subsequent testing. The User Test was a field test of the DRG in advanced control room environments by experienced human factors reviewers. The third evaluation was a Peer-Review Workshop. The workshop provided a different type of evaluation than the two testing tasks and addressed the broader aspects of the DRG, such as the validity and technical basis for the DRG.

The general results supported the DRG's validity. The primary source documents were considered an appropriate technical basis upon which to develop the DRG. However, several further developments were recommended including a reduction in the total number of guidelines, the specification of a review process or procedure to facilitate DRG usage by a review team, and development of additional guidelines for several topics that were not adequately addressed (such as computer-based alarm processing systems).

With respect to the interactive version of the DRG, most interface characteristics thought to be indicative of usability (such as visual clarity, consistency, explicitness, ease of use, ease of learning, low memory load, etc.) were rated highly. Some difficulties were encountered, mainly concerning input devices, reporting and help functions.

Based upon the results of the T&E program, modifications were made to address the identified considerations.

Final Version of the DRG

Based upon the results of the T&E program, modifications were made to the technical content of the guidelines. These included reducing the number of guidelines and "layering" the guidelines into (1) general principles, (2) general guidelines in each of the major sections, and (3) more detailed guidelines addressing specific HSI implementations, techniques, and formats. The DRG was also revised to eliminate redundancy and standardize terminology to ensure consistency throughout the document. Procedures were developed for use of the DRG to evaluate (1) a plant-specific HSI guideline or design specification document and (2) an actual ACR design.

Many modifications have been made to the interactive document. These include the development of a review planning aid to support the identification and selection of guidelines for a specific review and improvements in the review functions to mitigate the troublesome characteristics of the interface identified in the evaluations. In addition, a maintenance function was developed to enable easy export of the guidelines to a text file for editing and import of the revised guideline.

Conclusion

A general framework for the review of advanced HSI technology and design review guidelines was developed to support NRC staff reviews of advanced HSI technology. The methodological approach established for the development of advanced HSI design review guidance will support the further refinement of the DRG to ensure that the document is maintained up-to-date and with valid human factors review guidance.

The report consists of two volumes. Volume 1 provides the technical basis for the guideline development. Volume 2 provides the HFE guidelines and the procedures for their use.

PREFACE

This report was prepared for the Human Factors Branch of the Nuclear Regulatory Commission's Office of Nuclear Regulatory Research. The U.S. Nuclear Regulatory Commission (NRC) Project Manager for this effort is Jerry Wachtel. This document is submitted as part of the work performed for the "Advanced Control Room Design Review Guideline" project (FIN L-1317).

The objective of the project was to develop an Advanced Human-System Design Review Guideline (DRG). The results are reported in a two-volume NUREG/CR. The contents of each are briefly described below.

Volume 1: General Evaluation Model, Technical Development, and Guideline Description
Volume 1 provides an overview of the project. Section 1 outlines the tasks performed as part of the DRG development. Section 2 describes the general issues, regulatory considerations, and theoretical factors that provided the context for both general model and guideline development. Section 3 describes the development of a general model for the review of advanced NPP human factors. The model is called the Human Factors Engineering Program Review Model (HFE PRM). Section 4 describes the methodology used to develop the design review guidelines for advanced HSIs that are available in the DRG. This section also briefly describes the organizational structure of the guidelines, an overview of guideline content, and procedures for DRG usage. Section 5 describes the development of the interactive, computer-based version of the DRG and briefly explains its present functions and user interfaces. Section 6 describes the tests and evaluations performed as part of DRG development and validation. Section 7 describes review needs and a methodology for the development of additional guidance.

Volume 2: Evaluation Procedure and Guidelines for Human Factors Engineering Reviews
Volume 2 contains the detailed guidelines and procedures for their use. It is divided into two technical parts. Part 1 provides a brief background to the use of the DRG within the context of the overall HFE PRM, the intended use and limitations of the DRG, and a description of the DRG's contents. Also included in Part 1 are procedures for using the Guideline for the review of (1) a design-specific guideline or detailed design specification, and (2) an HFE verification of an implemented HSI design. Part 2 contains the guidelines used to conduct reviews of advanced HSIs. In addition to a set of high-level design review principles, the guidelines are divided into seven sections: (1) Information display, (2) User-system interaction, (3) Process control and input devices, (4) Alarm systems, (5) Analysis and decision aids, (7) Inter-personnel communication, and (7) Workplace design. Volume 2 also contains a detailed glossary and index to support DRG use.

ACKNOWLEDGMENTS

The authors wish to give special thanks to the NRC technical monitor for the program, Jerry Wachtel, for his careful review, constructive comments, and supportive guidance during all phases of this project. We also thank the NRC reviewers who provided excellent comments and suggestions on draft versions of this report. In addition, we are very grateful to the many participants and their organizations in the test and evaluation programs associated with the technical aspects of the project. Their efforts contributed greatly to the development of the final product.

We also extend our gratitude to our colleagues at Brookhaven National Laboratory who provided insights, assistance, and constructive reviews of all work associated with the project: Robert Hall, James Higgins, Sonja Haber, and William Stubler. Special thanks are given to Kathleen Nasta for her tremendous assistance in preparing the manuscript.

ACRONYMS

DRG	Design Review Guideline
FSAR	Final Safety Analysis Report
FSER	Final Safety Evaluation Report
HF	Human Factors
HFE	Human Factors Engineering
HSI	Human System Interface
ITAAC	Inspections, Tests, Analyses, and Acceptance Criteria
MUX	Multiplex
NPP	Nuclear Power Plant
NRC	U.S. Nuclear Regulatory Commission
P&ID	Piping and Instrumentation Diagram
VDU	Video Display Unit

PART 1:

REVIEW PROCEDURES FOR DRG UTILIZATION

1. BACKGROUND

Advanced control rooms will use advanced human-system interface (HSI) technologies that may have significant implications for plant safety in that they will affect the operator's overall role in the system, the method of information presentation, and the ways in which operators interact with the system. The U.S. Nuclear Regulatory Commission (NRC) reviews the HSI aspects of control rooms to ensure that they are designed to good human factors engineering (HFE) principles and that operator performance and reliability are appropriately supported to protect public health and safety. The principal guidance available to the NRC, however, was developed in 1981, well before these technological changes. Accordingly, the human factors guidance needs to be updated to serve as the basis for NRC review of these advanced designs. The main purpose of this project was to develop an Advanced HSI Design Review Guideline (DRG), including review procedures and acceptance criteria, based upon accepted HFE principles, standards, and guidelines to support staff reviews of advanced HSIs.

The DRG is contained in two-volumes. Volume 1 describes the development of the DRG including (1) its theoretical and technical foundation, (2) a general model for the review of advanced HSIs, (3) guideline development in both hard-copy and computer-based versions, and (4) the tests and evaluations performed to develop and validate the DRG. Volume 1 also includes a discussion of the gaps in available guidance and a methodology for addressing them.

This document is Volume 2. The purpose of Volume 2 is to provide the detailed guidelines and procedures for their use. The volume is divided into two technical parts. Part 1 provides the intended use and limitations of the DRG, and a description of the DRG's contents. Also included in Part 1 are procedures for using the DRG for the review of (1) a design-specific guideline or detailed design specification, and (2) an HFE verification of an implemented HSI design. Part 2 contains the guidelines used to conduct reviews of advanced HSIs. In addition to a set of high-level design review principles, the guidelines are divided into seven sections: (1) Information display, (2) User-system interaction, (3) Process control and input devices, (4) Alarm systems, (5) Analysis and decision aids, (7) Inter-personnel communication, and (7) Workplace design. A detailed glossary and index to support DRG use are also provided.

2. INTENDED USAGE AND LIMITATIONS OF THE GUIDELINE

As indicated in the previous section, the purpose of the guidelines presented in this document is to support NRC HSI design reviews to help assure safe operation of the plant by verifying that the controls, displays, and data processing support provided by the HSI are appropriate to the crew tasks and designed according to accepted HFE guidelines, standards, and principles. The guidelines can also be used to review a designer's HFE guidelines or design specification document.

There are many important reasons for conducting safety reviews using HFE guidelines as presented here:

1. Such reviews help assure that the design accommodates general human physiological and cognitive capabilities.

2. HFE guidelines generally represent knowledge concerning HSI characteristics that support operating crew tasks, derived from a large array of systems developed over many years. HFE guidelines capture years of lessons learned from system design and research.

3. HFE guideline reviews highlight design characteristics that may detract from human performance. When the review addresses a designer's preliminary design specification or prototype, these characteristics can be addressed in a timely fashion well before the design becomes fixed and difficult to change.

4. HFE guideline reviews provide an evaluation which may be applicable to all uses of an HSI, as contrasted with integrated system validation which will generally be more limited due to the time and effort required to conduct crew-in-the-loop tests.

5. HFE guideline reviews can benefit from a comparison to HSIs in other systems standardized to the same set of design principles.

While an HFE guideline review provides valuable information to support safety determinations, it has its limitations as well. It is essential that the reviewer recognize both the strengths and weaknesses of HFE guideline reviews. Some of these limitations are discussed below:

1. An HFE guideline review is a necessary, but not sufficient basis to determine if the crew can monitor and operate the HSI to adequately perform system functions.

2. HFE guidelines are not sensitive to the time required to perform a task, as are dynamic performance tests.

3. Since the establishment of a validated set of guidelines requires professional consensus from research and industry experience, HFE guidelines will always be somewhat incomplete in scope and coverage of advanced technology (where research and lessons learned from practical applications do not yet fully address all technology applications).

4. HFE guidelines are generally insensitive to interactive effects of multiple guidelines and their tradeoffs, e.g., between requirements for consistency and flexibility.

As a result of these limitations it is important to recognize two issues when conducting HFE guideline evaluations. First, design-specific discrepancies from generic review guidelines are not necessarily inappropriate. The significance of discrepancies from individual guidelines has to be considered within the context of the individual review. Second, other methods of evaluation (such as integrated system validation) should be considered in conjunction with guideline reviews to provide a complete foundation upon which to base safety evaluations. This approach to safety reviews is consistent with the multi-method approach to evaluation presented in Volume 1 of this document.

3. TECHNICAL SCOPE AND GUIDELINE CONTENTS

The scope of the document is primarily the regulatory review of advanced HSI, i.e., the crew's interface with:

- Information/data, e.g., with the displays of system status and parameter trends;
- Software, e.g., with the plant control systems, data management systems, and interface controls such as menus, windows, and software support for user "navigation" through display hierarchies; and
- Computer hardware devices, e.g., video display units (VDUs), mice, and touch screens.

Guidelines for "conventional" technology HSIs, as covered in NUREG-0700, are not duplicated in this document. The guidance provided in this document and in NUREG-0700 are being integrated to produce NUREG-0700, Revision 1. The guidelines pertain to the HFE aspects of HSI design and do not address instrumentation and control, software, and related issues.

With respect to the specific topic areas addressed by the DRG, it was deemed inappropriate to restrict the types of technology and interaction modes that would be included in the DRG and, therefore, only in obvious cases were guidelines screened out as inapplicable to a nuclear power plant (NPP) application. As discussed in Volume 1, there is great diversity in the available HSI designs and dialogue modes in advanced systems. There is also diversity in the types of tasks operators may be called upon to perform and in the ways those tasks may be performed in advanced reactor designs. Thus, the DRG contains a broader diversity of guidelines than might be expected in a NPP review guideline. For example, guidelines for text processing are available, although it may seem unlikely that text processing tasks would be a significant operator activity in advanced plants. These guidelines were included in the DRG to provide a basis for review of a particular application utilizing this type of operator activity (such as operator interface with knowledge-based systems or computer-based interaction with maintenance crews). *Guidelines which are inappropriate to a particular design review need not be used by the reviewer.*

The organizational structure of the DRG (see Table 1) contains a few selected sections, which do not currently contain guidelines. These were included for three reasons:

1. To provide "place holders" for ongoing NRC research projects which are currently developing guidelines that will eventually be integrated with the DRG.
2. To provide a reference in a location where a reviewer may logically expect the information, but where the relevant guidelines are contained elsewhere. Thus, the section provides a cross-reference to another section. For example, under Section 1.5 - Display Devices, a reviewer might expect to find guidelines for the review of audio display devices. However, these guidelines are in Section 6.2 - Speech-Based Communication. Thus, Section 1.5.4 - Audio Display Devices cross references Section 6.2.

Table 1. DRG Organizational Structure

1.0 INFORMATION DISPLAY
- 1.1 General Display Guidelines
- 1.2 Display Formats
  - 1.2.1 Continuous Text Displays
  - 1.2.2 Tables and Lists
  - 1.2.3 Data Forms and Fields
  - 1.2.4 Bar Charts and Histograms
  - 1.2.5 Graphs
  - 1.2.6 Pie Charts
  - 1.2.7 Flowcharts
  - 1.2.8 Mimics and Diagrams
  - 1.2.9 Maps
  - 1.2.10 Graphic Instrument Panels
  - 1.2.11 Speech Displays
- 1.3 Display Elements
  - 1.3.1 Alphanumeric Characters
  - 1.3.2 Abbreviations and Acronyms
  - 1.3.3 Labels
  - 1.3.4 Icons and Symbols
  - 1.3.5 Numeric Data
  - 1.3.6 Scales, Axes, and Grids
  - 1.3.7 Borders, Lines, and Arrows
  - 1.3.8 Color
  - 1.3.9 Size, Shape, and Pattern Coding
  - 1.3.10 Highlighting by Brightness and Flashing
  - 1.3.11 Auditory Coding
- 1.4 Data Quality and Update Rate
- 1.5 Display Devices
  - 1.5.1 Video Display Units
  - 1.5.2 Large Screen Displays
  - 1.5.3 Printers and Plotters
  - 1.5.4 Audio Display Devices

2.0 USER-SYSTEM INTERACTION
- 2.1 General User Interaction Guidelines
- 2.2 User Input Formats
  - 2.2.1 Command Language
  - 2.2.2 Menu Selection
  - 2.2.3 Function Keys
  - 2.2.4 Macros/Programmable Function Keys
  - 2.2.5 Forms
  - 2.2.6 Direct Manipulation
  - 2.2.7 Natural Language
  - 2.2.8 Query Language
  - 2.2.9 Question and Answer
  - 2.2.10 Speech
- 2.3 Cursors
  - 2.3.1 Appearance
  - 2.3.2 Controls
  - 2.3.3 Movement
  - 2.3.4 Multiple Cursors
  - 2.3.5 Pointing Cursors
  - 2.3.6 Text Entry Cursors
- 2.4 System Response
  - 2.4.1 General
  - 2.4.2 Prompts
  - 2.4.3 Feedback
  - 2.4.4 Cautions and Warnings
  - 2.4.5 Error Messages
  - 2.4.6 User Guidance/Help
  - 2.4.7 System Response Time
- 2.5 Managing Displays
  - 2.5.1 Display Selection & Navigation
  - 2.5.2 Display Control
  - 2.5.3 Display Update/Freeze
  - 2.5.4 Display Suppression
  - 2.5.5 Scrolling and Paging
  - 2.5.6 Windows
- 2.6 Managing Information
  - 2.6.1 Editing Documents
  - 2.6.2 Saving Files
  - 2.6.3 Temporary Editing Buffer
  - 2.6.4 Excerpt File
- 2.7 Prevention/Detection/Correction of Errors
  - 2.7.1 Validating User Input
  - 2.7.2 Correcting Information/Command Entries
  - 2.7.3 Confirming Entries
  - 2.7.4 Protecting Data
- 2.8 System Security
  - 2.8.1 User Identification
  - 2.8.2 Information Access

3.0 PROCESS CONTROL & INPUT DEVICES
- 3.1 General Control Guidelines
- 3.2 Input Devices
  - 3.2.1 Alphanumeric Keyboards
  - 3.2.2 Function Keys
  - 3.2.3 Trackballs, Joysticks, and Mice
  - 3.2.4 Touch Screens, Light Pens, and Graphics Tablets
  - 3.2.5 Speech Input Devices

4.0 ALARM SYSTEMS

5.0 ANALYSIS AND DECISION AIDS
- 5.1 Knowledge-Based Systems

6.0 INTER-PERSONNEL COMMUNICATION
- 6.1 General Communication Guidelines
- 6.2 Speech-Based Communication
- 6.3 Computer-Based Communication
  - 6.3.1 General
  - 6.3.2 Preparing Messages
  - 6.3.3 Sending Messages
  - 6.3.4 Receiving Messages

7.0 WORKPLACE DESIGN
- 7.1 Workstation Configuration
- 7.2 Control Room Configuration
- 7.3 Environment

3. To provide internal completeness within a section. For example, input formats, e.g., command and direct manipulation dialog modes, are addressed in Section 2.1. While speech is a potential mode of user input to the system, no guidelines were available. Section 2.2.7 - Natural Language was, therefore, added for completeness.

Descriptions of the general contents of the individual sections of the DRG are provided in Section 3.1 below. In Section 3.2, a description of the format for the individual guidelines is provided.

3.1 Description of Guideline Sections

3.1.1 Section 0 - High-Level HSI Design Evaluation Principles

The principles in this section represent the generic HSI characteristics necessary to support crew performance. The principles are not specific review *guidelines*, but are intended to be used to support the interpretation of the significance of individual guideline discrepancies and to support the identification of significant HSI issues (as is discussed in Part 1: Section 6 of this document). The principles provide the link between general human information processing characteristics and HSI design features (see Volume 1 for a complete explanation of the derivation of the design evaluation principles). The 18 principles are divided into four categories (see Table 2):

- *General Principles* - These principles ensure the HSI design supports personnel safety and is compatible with general cognitive and physiological capabilities.

- *Primary Task Design* - These principles support the operator's primary task of process monitoring, decision-making, and control to maintain safe plant operation.

- *Secondary Task Control* - These principles minimize secondary tasks, i.e., tasks the operator must perform when interfacing with the system but which are not directed to the primary task. Examples of secondary tasks include activities associated with managing the interface such as navigation through displays, manipulating windows, and accessing data. Performance of secondary tasks detract from the crews' performance of primary tasks, so their effects must be controlled.

- *Task Support* - These principles support for the operator's use of the HSI, such as providing (1) HSI flexibility so tasks can be accomplished in more than one way, (2) user guidance, and (3) error mitigation.

3.1.2 Section 1 - Information Display

This section deals primarily with the review of visual displays, both text- and graphics-based. Guidance is provided in top-down fashion beginning with general display guidelines (Section 1.1) and then proceeding to finer levels of display details. Section 1.2, Display Formats, addresses review guidelines for common display forms such as continuous text, mimics/piping and instrumentation diagrams (P&IDs), trend graphs, and flowcharts. If novel formats are encountered in a review, they can be evaluated using the general display guidelines and the guidelines in Section 1.3, Display Elements. Any display format can be decomposed into a set of "basic elements" such as alphanumeric characters, icons, symbols, color, highlighting, abbreviations, labels, coding, highlighting, and the presentation of numeric data. Review guidelines for these basic elements are covered in Section 1.3, Display Elements.

Guidelines for the review of data quality and display update rate are contained in Section 1.4. Section 1.5, Display Devices, addresses the hardware aspects of displays. Review guidelines for display devices, such as video display units, large panel displays, and hardcopy display devices (printers and plotters) are provided. Section 1.5.4, Audio Display Devices, is included for cross-reference purposes to Section 6.2, Speech-Based Communication, which contains guidelines for these devices.

Table 2. High-Level Design Review Principles

CATEGORY	PRINCIPLE
General	Personnel Safety Cognitive Compatibility Physiological Compatibility Simplicity of Design Consistency
Primary Task Design	Situation Awareness Task Compatibility User Model Compatibility Organization of HSI Elements Logical/Explicit Structure Timeliness Controls/Displays Compatibility Feedback
Secondary Task Control	Cognitive Workload Response Workload
Task Support	Flexibility User Guidance and Support Error Tolerance and Control

3.1.3 Section 2 - User-System Interaction

Section 2 is the largest and most diverse section of the DRG composed of eight subsections which address the various approaches to user interaction with the HSI. Section 2.1 provides general review guidelines for user-system interaction with an emphasis on user inputs to the HSI. Section 2.2 provides review guidelines for user input and dialog formats such as menus, direct manipulation, and command language. These guidelines address the issuance of sequence control commands to the system. Sequence control refers to operator inputs that initiate or interrupt transactions (i.e., functions of the system). The specific means by which such command inputs are made is the transaction dialogue. A poorly-designed operator dialogue will inhibit operators from moving efficiently from one task to the next and may prevent operators from interacting effectively with the system by imposing unnecessary constraints on the selection or sequencing of actions. The types of input formats addressed are:

Command Language - A command language dialogue requires the operator to specify the functions to be performed without prompting; the operator is assumed to be aware of the available options, the proper command syntax, etc.. A command language dialogue is

appropriate when a great deal of flexibility is required regarding the sequencing and content of operator inputs, and the operator is very familiar with the system.

Menus - A menu dialogue presents the operator with a number of options from which the desired action is chosen (e.g., by positioning the cursor, entering a keystroke code, etc.). This style of dialogue is appropriate when the number of options is limited and speed and accuracy are critical.

Function Keys - Function keys are dedicated to a single option or action and are, therefore, best used to select from among a small number of frequently-used options that are available at any point in the operator/system interaction (i.e., functions that are available only in certain modes of system operation are typically not assigned to function keys).

Macros/Programmable Function Keys - Macros are user-defined strings (or chains) of commands which are executed upon a single user command. Often macros are assigned to programmable function keys which execute the command string upon a single key press.

Form - A form-filling dialogue requires the operator to enter data in predefined fields presented on the display. This style of interaction is, therefore, appropriate to situations in which the categories of data to be input can be specified, but flexibility is required with respect to the data to be input. It is an appropriate method for entry of information into a computer system when that information already exists in hardcopy forms.

Direct Manipulation - A direct manipulation or graphic interface typically displays pictographic icons to represent control actions and options; actions and options not easily represented in pictographic form are presented in menus. Icons or menu items are "selected" by positioning a cursor, usually by means of a pointing device (i.e., a mouse or trackball).

Natural Language - A natural language interface allows instructions or requests to be entered through the keyboard using "everyday" vocabulary with few requirements as to syntax.

Query Language - Query language is a specialized type of command language used to retrieve information from a system.

Question and Answer - In a question and answer dialogue, the system poses questions for the operator to answer. This style of interaction is appropriate when the types of information to be input are specified, and the order in which the data are to be input is predefined.

Speech - A speech interface allows users to input information and commands through voice rather than through some manual input as in natural language, query and question/answer dialog formats. The system utilizes a speech-recognition system to parse and understand the speech input from the operator.

Section 2.3, Cursors, provides review guidelines for this aspect of the HSI. When interacting with a computer-based system, the appearance and behavior of the on-screen cursor (or more generally the "follower" - the on-screen image which tracks the user's input) can significantly affect performance.

Section 2.4, System Response, contains review guidelines address prompts (including routine messages), operator guidance (feedback and on-line help), and decision aids (i.e., expert systems). Well-designed prompts indicate not only that input is expected, but also the proper format and means of performing the entry. Useful error messages clearly convey the nature of the problem and facilitate its correction. The overall goal of prompting and user guidance is to ensure that operators, at any point in the interaction, are aware of what type of action is appropriate, what their options are, how they should proceed, and how they can request help. Also covered in this section are response time guidelines. These guidelines address the necessity of the system to respond promptly to operator input.

Section 2.5, Managing Displays, contains guidelines on a variety of display interactions and modes (e.g., selection, freezing, updating, paging, scrolling) and windows. The objective of the design of display control functions is to allow the operator to access the specific information required for the task at hand while maintaining awareness of the ongoing process and the display/control context.

Section 2.6, Managing Information, addresses the manipulation of data in the system including the processing of text.

Section 2.7, Protection/Detection/Correction of Errors, contains guidelines pertaining to methods for ensuring the integrity of data used by the system. Guidance covers 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. Measures taken to protect data will usually involve trade-offs between security and ease-of-use. The inconvenience introduced by the necessity to verify potentially destructive actions, for example, should be appropriate to the costs of such actions.

Section 2.8, System Security, contains guidelines for the review of safeguards to prevent unauthorized users from gaining access to system information, data, and controls.

3.1.4 Section 3 - Process Controls and Input Devices

This section provides review guidelines for general control guidelines in Section 3.1 and for input devices in Section 3.2. Section 3.2 is focused on computer-input devices: keyboard devices (including special and variable function keys); direct manipulation controllers (including trackballs, joysticks, and mice); and "pointing devices" (including touch screens, light pens, and graphics tablets). The final section addresses speech input devices and provides a cross reference to Section 6.2, Speech-Based Communication, containing guidelines for these devices.

3.1.5 Section 4 - Alarm Systems

At present no guidelines have been included in this section. This section is a "place holder" for the results of a NRC research project to develop review guidance in the area of alarm systems.

3.1.6 Section 5 - Analysis and Decision Aids

This section addresses the aids provided to the operator for situation analysis and decision making. Guidelines for knowledge-based aids are provided. These address some of the functional requirements of such systems, such as explanation and simulation facilities, and the desirable characteristics of their user interfaces.

3.1.7 Section 6 - Inter-Personnel Communication

Section 6.1, General Communication Guidelines, contains guidelines for communications activities among plant personnel. Detailed guidelines are provided for speech- based (Section 6.2) and computer-mediated (Section 6.3) communication among the plant personnel such as preparing, addressing, sending, and receiving messages. Speech-based communication guidelines address the characteristics of speech input and output devices. Computer-mediated communication guidelines are concerned with minimizing the demands placed on the operators of the system while providing them with flexibility in communications.

3.1.8 Section 7 - Workplace Design

Like Section 4, Alarm Systems, Section 7 is a "place holder" pending further development. At present, limited review guidance is presented in Sections 7.1, Workstation Configuration, and 7.3, Environment. Section 7.1 addresses workstation configuration, i.e., the integration of individual control and display devices into a console. The guidelines address VDU viewing distance, viewing angle, and glare. Section 7.2, Control Room Configuration, is currently empty, but will address the integration of individual workstations, supervisors consoles, and large screen displays into an integrated control room. Section 7.3, Environment, is also limited and at present addresses only illumination in the area of workstations.

3.1.9 Technical Areas Not Fully Addressed by the DRG

In addition to the DRG sections identified as "place holders" above, there are several additional areas for which HFE review guidance is currently limited. Pending further development, reviews of these topics can utilize the DRG but may have to be supplemented with additional evaluation methods such as the utilization of alternative guidance documents, results of testing and trade-off analysis, and dynamic performance evaluation. For example, the DRG does not specifically address computer-based procedures. However, the computer-based implementation of procedures may be evaluated by using the guidelines for general displays, text-based displays, and flowcharts (if appropriate). These guidelines may be supplemented with other NRC and industry guidance on procedures. A partial list of such areas is provided below (a discussion of each can be found in Volume 1 of this report):

- alarm systems,
- situation awareness displays and group displays,
- graphical data presentation and novel display technologies (e.g., 3-D displays),
- interfaces to automated control systems,
- intelligent operator aids,
- computer-based procedures,
- interface management and navigational strategies,
- visual display hardware characteristics,
- unique characteristics of flat panel displays,
- workstation configuration for VDU-based operations, and
- large-screen display integration with workstations.

If a reviewer considers it appropriate to supplement the review guidance provided here, a database of additional guidance documents that may be consulted is available (O'Hara and Brown (1991)). The database may be searched for key words to identify potentially applicable sources of information. These

sources of information, in addition to the guidelines contained in this document, should provide a solid basis for the review of most HFE aspects of advanced HSI.

3.2 Format of Individual Guidelines

The guidelines were developed into the standardized format shown below.

1.1.-1 Display Screen Partitioning for HSI Functions

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

ADDITIONAL INFORMATION: Consistent display formats will help establish and preserve user orientation. Reserved screen areas, for example, might be used for a display title, data output by the computer, display control options, instructions, error messages, and user input and command entry. Display formats should be consistent with accepted usage and existing user habits.[E,B,D]

The four components of the standard guideline format are described below:

- *Guideline Number* - Within section/subsections individual guidelines are numbered consecutively from 1 to n. Each guideline has a unique number which reflects its section/subsection location followed by a dash and then its unique number. For example, in guideline 1.1-1 Display Screen Partitioning for HSI Functions, the "1.1" reflects its location in Section 1.1 - General Display Principles and the "-1" indicates that it is the first guideline in the section.

- *Guideline Title* - Each guideline has a brief unique title.

- *Guideline Statement* - Each guideline contains a concise statement of the criterion/characteristic the HSI should embody. An effort was made to restrict each guideline statement to a single concept rather than allowing compound guidelines, thus reducing the ambiguity that may exist if an interface was acceptable with respect to one aspect of a guideline, but discrepant with another aspect of the guideline.

- *Additional Information* - For many guidelines additional information is provided which may address clarifications, examples, exceptions, details regarding measurement, figures, or tables. This information is intended to support the reviewer's interpretation or application of the guideline.

- *Source* - The primary source document(s) from which the guideline was developed is shown in superscript. To conserve space, the source documents are indicated using letter codes. Table 3 provides the letter code reference for each.

Table 3. Source Documents

LETTER CODE	AUTHOR	DOC. NUMBER	YEAR	TITLE
A	U.S. DoD	DoD-HDBK-761A	1990	Human Engineering Guideline for Management Information Systems
B	Gilmore et al.	ISBN 0-12-283965-X	1989	User-Computer Interface in Process Control
C	U.S. DoD	MIL-STD-1472D	1989	Human Engineering Design Criteria for Military Systems, Equipment, & Facilities
D	NASA	USE-HCIG-1000	1988	Space Station Freedom Human-Computer Interface Guide
E	U.S. DoD	ESD-TR-86-278	1986	Guidelines for Designing User Interface Software
F	HFS	ANSI/HFS-100-1988	1988	American National Standard for Human Factors Engineering of Visual Display Terminal Workstations
G	U.S. NRC	NUREG-0800	1984	Standard Review Plan

Note: DoD = United States Department of Defense; NASA = National Aeronautics and Space Administration; HFS = Human Factors Society (now called the Human Factors and Ergonomics Society); U.S. NRC = United States Nuclear Regulatory Commission.

4. PROCEDURE FOR DESIGN-SPECIFIC GUIDELINE DOCUMENT REVIEW

As indicated above, the DRG may be used to review an applicant's document providing an HSI guideline, style guide, or detailed design specification. The objectives of an NRC review of such a applicant document are to evaluate the document with respect to its scope, technical basis/validity, level of detail, guideline integration, and procedure for implementation. This review should be conducted by an experienced human factors professional. Interpretation and communication of the findings are addressed in Section 6.

4.1 Scope

The NRC reviewer should determine whether all aspects of the HSI important to safe operation and maintenance of the plant by plant personnel are addressed in the applicant's document. Generally the applicant's document should include guidance for the topic areas presently addressed in the DRG, NUREG-0700, Chapter 18 of NUREG-0800, and other topics identified by the NRC reviewer as important to safety.

4.2 Technical Basis and Validity

The content of design-specific guidelines and specifications should be derived from (1) the application of generic HFE guidance to the specific application, and (2) the development of the applicant's own guidelines based upon design related analyses and experience.

Selection of generic guidelines source documents for a vendor's design-specific guidelines should be based on consideration of "validity" principles. Validity may be evaluated in terms of two aspects of potential source document development which loosely correspond to the empirical research support and conformance with accepted human engineering practice. First, "internal" validity is evaluated by the degree to which the individual guidelines within a source document were based on research and whether an audit trail exists linking each guideline back to its basis. The latter makes it possible to go back to the original source documents to evaluate the appropriateness of an individual guideline's technical basis. Second, "external" validity is evaluated as a function of the degree to which the source documents were subjected to peer review. A document which had undergone extensive peer review is considered to have high external validity. Consideration of internal and external validity is used for reviewing guidelines for conformance to accepted human engineering practices. In general, documents which have both good internal and external validity were considered the best sources for design-specific guidance documents.

The design guideline/specification may contain guidance that is not derived from generic HFE guidelines and it may contain guidelines which are discrepant from NRC review guidance. In these cases, justification should be provided to support the acceptability of these guidelines and their deviations. A documented rationale should be provided for these guidelines, such as:

- an analysis of recent literature,
- an analysis of current practices,
- tradeoff studies and analyses, and
- the results of design engineering experiments and evaluations.

4.3 Level of Detail

Generic HFE guidelines cannot be used in the abstract. They can be applied to a specific design only when a thorough knowledge of the design-specific tasks which the crew is to perform is available. Thus the tailoring (translating/interpreting) of individual guidelines to the specific design through function and task analysis data should be reflected in the applicant's document and should be available for review. The applicant's document should be detailed enough to permit use of the document by design personnel and subcontractors to achieve a clear, consistent, and verifiable design that meets applicant's guideline/specification.

4.4 Guideline Integration

The review should examine the integration of the individual guidelines with each other. Since the applicant's document reflects a selected subset of available generic guidelines, the guidelines in the selected subset should be consistent with each other in terms of the overall design goals. For example, a designer may want to use P&ID formats to display component status on a VDU. The same design may permit operators to control components by touching the on-screen component icon. The guidance for on-screen icon size will have to reflect the touch-screen use of the display and specify icon sizes to be larger than would be necessary if touch-screen control was not used. Thus, the HSI design guidance should reflect the integration of indication and control in a single display.

4.5 Procedure for Implementation

The applicant's guideline specification document should provide an indication of how it is to be used in the overall design process.

5. PROCEDURE FOR HFE VERIFICATION REVIEW

The DRG may be used to conduct a HFE Verification review. The objective of the review is to help assure safe operation of the plant by verifying that all controls, displays, and data processing support provided by the HSI are appropriate to the crew tasks and designed according to accepted HFE guidelines, standards, and principles. Further, if HFE issues were identified during the earlier reviews, resolution of those issues may also be verified as part of the HFE Verification.

The use of the DRG that is proposed below requires a multi-step process similar to that described in NUREG-0700. The activities performed at each step may differ depending on the unique requirements of each individual review (e.g., availability of supporting documentation). A major consideration is whether the review is directed toward a new HSI design developed as part of advanced reactor design certification/licensing or whether the review is directed toward a upgrade to an existing plant. The eight steps recommended for a full review are listed below and each is described in the remainder of this section:

1. Assemble NRC Review Team
2. Assemble Supporting Information
3. Identify Human Functions and Tasks
4. Sample Human Tasks to Guide the HFE Review
5. Characterize Tasks Used in the Evaluation
6. Characterize the HSI
7. Select the Guidelines to be Used in the Evaluation
8. Conduct Evaluation

Interpretation and communication of the findings of the review are addressed in Section 6.

5.1 Assemble NRC Review Team

As identified in NUREG-0700 (p. 2-1), an NRC Review Team should be assembled. The team should include individuals with human factors expertise and operations experience, and should have access to related areas of expertise including:

- Nuclear and Plant Systems Engineering,
- I&C, and
- Software Design.

Additional skills may also be required based upon the unique requirements of a specific review.

5.2 Assemble Supporting Information

The specific information necessary and available to support the HFE verification review will differ depending on the requirements of the review, e.g., the information requirements differ for a modification or upgrade to an existing plant when compared to an entirely new plant design. The generic information requirements are identified below along with the types of information that may be utilized. This step is ongoing throughout the review based upon the NRC Review Team's information needs for performing the subsequent steps. Information needs should be carefully defined at each of the following

steps in order to minimize the information processing burden of both the NRC Review Team and the designer/applicant.

1. Description of Plant System(s) the HSI is designed to monitor and control

   - Applicable Final Safety Analysis Report (FSAR) descriptions, certified design descriptions, and inspections, tests, analyses, and acceptance criteria (ITAAC),
   - System design description,
   - Piping and instrumentation drawings, and
   - Control logic diagrams.

2. Human Role in the System

   - System requirements analysis,
   - Function analysis and description,
   - Task analyses, and
   - Minimum task set.

3. Description of the HSI

   - HSI guideline or design specification,
   - Control room description (floor plan, environmental characteristics and control, etc.),
   - Workstation and panel layout drawings and photographs,
   - Communications equipment,
   - Description of data management system structure (roadmap of screen structure, display hierarchies, databases, supporting applications access),
   - Screen displays,
   - Display screen layout and consistency conventions,
   - Control and input device inventory and functionality inventory, and
   - Dictionary of acronyms, abbreviations, symbols, icons, and coding.

4. Concept of Operations

   - Operator training materials related to the system and its interfaces with other systems,
   - Procedures related to systems and their interfaces with other systems, and
   - "User's Manual" and related user operation support documentation describing how users interact with the system (e.g., select data and displays, system messages, dialogue types, user input and control methods).

5. Analyses and Evaluations

   - Final Safety Evaluation Report (FSER),
   - HSI design decision audit documentation,
   - Results of applicant's evaluations pertaining to HFE evaluations, technology assessments, trade-off studies, etc., pertaining to the HSI design,
   - Results of the applicant's HFE verification analysis,

- Results of probabilistic risk assessment and human reliability analysis, including fault/event tree, failure mode and effects analyses, importance analyses, and sensitivity analyses of human actions,
- Event reports related to the system or related/similar systems,
- Issue tracking system issue status, and
- 10 CFR 50.59 safety analyses.

For HSI reviews conducted under advanced reactor certification/licensing reviews, much of the information identified above will be available in the applicant's reports to the NRC and in staff reviews for other HFE PRM element submittals.

5.3 Identify Human Functions and Tasks

HFE review guidelines cannot be used in the abstract. The most important aspect of design evaluation is knowing what functions are assigned to plant personnel and the tasks they must perform. These tasks must be understood in terms of their information, decision-making, and control requirements. Using system requirements analysis, function allocation analyses, and task analyses provided by the applicant, the NRC Review Team should identify the human functions in the overall system for normal and emergency conditions and the tasks performed by plant personnel to support those functions. The human tasks to be defined should include general monitoring and control functions, for example:

- Base load vs. load follow,
- Operator interfaces to global, system, and component monitoring and control as well as the fault management functions, for example:
  - fault detection,
  - diagnosis,
  - evaluation,
  - mitigation control,
  - use of procedures, and
  - communications with plant personnel and NRC.

5.4 Sample Human Tasks to Guide the HFE Review

Advanced control rooms and advanced HSIs may include hundreds or thousands of individual displays. The NRC Review Team is faced with the same "keyhole" effect as the operators; i.e., observation of displays and controls can be limited by the viewing area provided through workstation VDUs. It is impractical and unnecessary to review all displays and controls. Therefore, the NRC Review Team may employ a sampling strategy to guide the selection of HSIs for review. The sampling strategy discussed below is driven by human functions and tasks. It is intended to include, as needed, a wide range of human interactions with the plant to evaluate the HSIs that support the crew's roles as safety monitors, potential transient initiators, plant response monitors, and in-the-loop controllers during events. Considerations regarding sample size are discussed at the end of this section.

As indicated above, a multidimensional sampling space should be utilized from which HSI elements should be identified to assure a comprehensive consideration of the safety significance of HSIs. The sampling space for HFE verification reviews can be defined by the following dimensions:

- Normal, abnormal, and emergency conditions,
- Human functions,
- Task structures,
- Crew interactions,
- Risk dominant human interactions based on PRA/HRA analyses,
- Human Factors (HF) issue resolutions, and
- Issues identified in review preparation.

1. HFE verification evaluations should include a sample of HSIs reflecting a *range of normal, abnormal, and emergency conditions* in which humans are involved:

   - HSIs involved in normal plant evolutions (e.g., start-up, full power, and shutdown operations),
   - HSIs involved when instrument failures occur (e.g., logic and control units, fault tolerant controllers, local "field units" for multiplex (MUX) system, MUX controller),
   - HSIs involved when equipment and processing failures occur (e.g., loss of VDUs, loss of data processing, loss of large overview display),
   - HSIs involved in transient management (e.g., turbine trip, loss of offsite power, station blackout and loss of all feedwater),
   - HSIs involved in accident management from Control Room (e.g., main steam line break, positive reactivity addition, control rod insertion at power, control rod ejection, anticipated transient without scram, and various-sized loss of coolant accidents),
   - HSIs involved in accident management from the Technical Support Center, and
   - HSIs involved in emergency management (e.g., from the Emergency Operations Facility).

2. HFE verification evaluations should include a sample of HSIs reflecting *major human functions* in the system, e.g.:

   - Status monitoring and situation awareness of critical safety functions,
   - Surveillance testing and maintenance (e.g., equipment blocking, tagging, and bypass),
   - Alarm monitoring, analysis, and response,
   - Fault detection, analysis, diagnosis, mitigation,
   - Monitoring of automated safety functions, and
   - Override of automated systems and their direct control.

3. HFE verification evaluations should include a sample of HSIs reflecting a *range of task structure*, e.g.:

   - Procedure supported:
     - normal,
     - abnormal,
     - emergency,
     - alarm response, and
     - test.
   - Knowledge-based activities.

4. HFE verification evaluations should include a sample of HSIs reflecting major human-human interactions, e.g.:

   - Between main control room operators,
   - Main control room operators and auxiliary operators,
   - Main control room operators and support centers,
   - Shift turnover and walkdowns, and
   - Management, NRC, and other outside organizations.

5. HFE verification evaluations should include a sample of HSIs reflecting risk-significant human interactions (human actions, systems, and sequences contributing highly to risk, as defined by the PRA):

   - Dominant human actions (via sensitivity analyses),
   - Dominant accident sequences, and
   - Dominant systems (via "importance measures").

6. HFE verification evaluations should include a sample of HSIs involved in resolutions to HF Issues that may have been identified in earlier reviews.

7. HFE verification may also include issues identified by the NRC Review Team during preparation for the review.

The issue of how much of the HSI should be subject to review (i.e., the sample size) is a difficult one. Generally, the NRC Review Team should review a large enough sample to identify all significant safety issues. Thus, the sample should be stratified to be representative of the larger population of HSI elements (accounting for the significant dimensions identified above). In addition to limits in sampling imposed by available resources, the extent of the sampling may be limited by other factors as well. A more limited sampling may be used if:

- The HSI to be reviewed has been through the HFE PRM and an HSI guideline/specification review has already been performed, and/or

- The applicant has already performed an HFE verification following a procedure similar to the one outlined in this section and the results of the verification are available for audit.

If, however, no prior NRC reviews have been performed, a more extensive sampling may be required for HFE verification.

The size and extent of sampling will be governed by the results of the review as well. For example, following the procedure outlined below, the NRC Review Team may define a sample of 30 displays for review. Several findings made in the course of the review may indicate that a larger sample is warranted. Such findings may include:

- The identification of numerous discrepancies,

- The identification of a pattern of discrepancies associated with a particular type of display (in this case the team may wish to increase the number of those types of displays to be reviewed), and

- The observation of inconsistency (or variation) across displays which makes the achievement of a representative sample difficult; i.e., in order to achieve a representative sample, given equal population size, the sample size will have to be greater in a heterogeneous population when compared with a homogeneous population.

By contrast, if the team reviews a large number of displays and finds a high degree of consistency and very few discrepancies, then the team can have a high degree of confidence that the sample is representative of the total display population and further sampling may not be necessary.

5.5 Characterize Tasks Used in the Evaluation

For those human tasks for which the review will be performed (defined as a result of step 5.4), the NRC Review Team can utilize the applicant's human task requirements analyses to characterize the operator's tasks to be addressed by the review. The specific information needed will vary depending on the requirements of the review. Since the tasks may include local control station actions as well as actions in the main CR, the task requirement specifications defined below are broad. The types of task requirements information that may be identified include:

- Information and Decision-Making Requirements

  - Description of the monitoring and decision requirements,
  - Evaluations to be performed,
  - Decisions that are probable based on the evaluation of available information (opportunities for cognitive errors should be identified and carefully analyzed), and
  - Information requirements to support monitoring and decision activities, including cues for task initiation such as alarms.

- Response Requirements

  - Action to be taken,
  - Overlap of task requirements (serial vs. parallel task elements),
  - Frequency,
  - Speed/time line requirements,
  - Tolerance/accuracy,
  - Operational limits of personnel performance,
  - Operational limits of machine and software, and
  - Body movements required by action taken.

- Feedback Requirements

  - Feedback required to monitor and evaluate the adequacy of actions taken.

- Workload

  - Cognitive,
  - Physical, and
  - Estimation of difficulty level.

- Task Support Requirements

  - Procedures,
  - Special/protective clothing,
  - Job aids or reference materials required,
  - Tools and equipment required, and
  - Computer processing support aids.

- Workplace Factors

  - Layout of controls and displays,
  - Workspace envelope required by action taken,
  - Workspace conditions,
  - Location and condition of the work, and
  - Environment (lighting, temperature, and noise).

- Staffing and Communication Requirements

  - Number of personnel, their technical specialty, and specific skills,
  - Communications required, including type, and
  - Personnel interaction when more than one person is involved.

- Hazard Identification

  - Identification of potential hazards involved.

5.6 Characterize the HSI

Using information provided by the applicant, the NRC Review Team can characterize the HSIs associated with the human tasks analyzed in step 5.5 in terms of implementation and functionality. The HSI may be characterized in terms of the specific implementation of HSI technology, e.g.:

- Displays - structure of information/formats/coding/elements,
- Modes of Interaction,
- Controls and devices,
- Alarms,
- Aids (use of procedures and knowledge-based aids),
- Communications, and
- Workplace considerations (workstation integration, control room layout, environment, local control stations).

While task analyses define required HSI functionality, the NRC Review Team should also identify:

- Unwanted/unnecessary/unintended functionality (functions which are available, but do not support crew tasks),
- Potential safety issues (e.g., operator set-point adjustment), and
- Potential security concerns (e.g., software modification).

Therefore, to aid in the identification of such issues, the NRC Review Team should request an inventory of HSI functionality from the designer/applicant.

5.7 Select the Guidelines to be Used in the Evaluation

Not all of the guidelines will be applicable to each evaluation. The subset of guidelines appropriate to the specific design should be identified by the Review Team. As is indicated in Volume 1, the guideline can be divided into three layers. The first two layers are applicable to most reviews. These are the General Design Principles and the General guidelines under each major section. Next the NRC Review Team may select the guidelines that are specific to the design of the HSI under review. This is accomplished by using the intersection of the HSI characterization developed in 5.6 above and the task review selection developed in Sections 5.4 and 5.5 above. This information will indicate which aspects of the HSI should be reviewed and the technology-specific implementations to be reviewed.

For example, suppose the HSI characterization indicates that the design utilizes bar charts, graphs, and mimic display formats. DRG, Guideline Section 1.2, provides review guidelines for display format reviews. The reviewer might select the following subsection of 1.2 to be used in the evaluation:

- 1.2.4, Bar Charts and Histograms
- 1.2.5, Graphs
- 1.2.8, Mimics and Diagrams

The other subsections from Section 1.2 can be omitted from the review.

For a specific review, only a subset of DRG guidelines will be used. The broad scope of the DRG enables the review of a wide diversity of HSI designs.

Several aspects of the interface may not be addressed by the current version of the DRG (such as computer-based alarms). In that case the NRC Review Team may (1) seek supplemental guidance from alternative sources such as the HFE standards and guidance database identified in Section 3.1.9); and/or (2) identify the guidance utilized by the designer/applicant in designing the system and evaluate that guidance using the methodology presented in Section 4. If no guidance exists to review, then that aspect of the HSI should be evaluated by other methodologies, such as operator interview and dynamic performance evaluation.

5.8 Conduct Evaluation

The review can be conceptualized in three parts:

1. *Global Features Review* - A global features review addresses general HSI features that relate to the configurational and environmental aspects of the HSI, such as control room layout, general workstation configuration, and environment. These aspects of the review, e.g., CR lighting, will tend to be evaluated only once.

2. *Standardized Features Review* - A standardized features review addresses the HSI features which are governed by the applicant's design standards and conventions (as defined by the applicant's standards and guidelines documents) used across individual controls and displays (e.g., display screen organization, format conventions, and coding conventions). They should, therefore, be fairly consistent across the interface and be more predicable than design features which are not addressed by the standards and guidelines. Thus, for example, if display labeling is controlled by an applicant's standard convention (and which is acceptable to the NRC), display labels can be spot checked and the NRC Design Review Team need not spend a great deal of resources reviewing this aspect of the HSI.

3. *Detailed Features Review* - A detailed features review addresses individual displays and controls in their task-support context. The majority of this effort will be directed towards the task-appropriateness of HSI features and aspects of the HSI which are not governed/controlled by the applicant's standards and guidelines. These aspects of the HSI can be expected to be more variable than the standardized design features (discussed above). For each HSI element, the NRC Review Team should use the guidelines as the basis of the evaluation only after the following have been identified:

    - The task(s) for which the HSI is being used by the crew

    - The role of the HSI in support of the task; e.g., identifying the task information that is intended to be provided to the operating crew by a particular display.

Depending on the availability of documentation and supporting information, the NRC Review Team may have access to several potential data sources while conducting the review:

- Design documentation linking task analysis to interface design
- NRC Review Team observations
- Interviews with plant staff
- HSI walk-downs using procedures

All available information should be used to support the HSI review and to identify inconsistencies between different sources of information (since these inconsistencies may be indicative of broader issues).

With respect to each guideline used in the review, the NRC Review Team may indicate whether the aspect of the HSI under review is:

- "Acceptable,"
- "Discrepant" from the guideline (therefore, potentially unacceptable), or
- "Not Applicable."

The evaluation of discrepancies is addressed in Section 6 below.

Special considerations should be given to the following issues for the evaluation of a modification/upgrade to an existing HSI:

- Satisfying "crew-identified" functionality in addition to that specified by system designers (i.e., when a digital system is introduced to replace an existing system, it is important

to make sure that all functional uses of the old system have been addressed, even though it may not have been part of the initial (or original) intended use of the system by the applicant. The design of the replacement system should consider the actual usage of the old system by its users.)

- Integration with the rest of the HSIs,
- Integration with procedures and training, and
- Impact on operator tasks and workload.

5.9 Interpretation of Findings

When interpreting the findings, one should consider that the review consists of a sampling of selected features of the HSI. Thus, rather than focusing on discrepancies from individual guideline, discrepancies should be treated as potential indicators of broader problems. For example, the identification of an inappropriate format for an individual display should be considered a potential indication that other display formats may be incorrectly used or that the observed format is inappropriately used elsewhere. As another example, the observation of many discrepancies associated with one particular aspect of the HSI design, such as the remote shutdown panel, may indicate that there are further problems with that aspect of the design, such as the inconsistent use of design procedures and standards. In some cases, the evaluation of discrepancies may warrant further review in the identified areas of concern.

Discrepancies should be evaluated for their potential safety significance based on their possible effects on:

- Achievement of significant system functions (as identified in Section 5.3 above).
- Achievement of significant user task requirements (as identified in Section 5.5 above).
- Compliance with the High-Level Design Review Principles (as presented in Part 2 - Section 0 of this volume).
- Mitigation of general human performance issues associated with advanced systems, such as information overload, navigation workload, "keyhole" effects (as discussed in Volume 1 of this report and related literature).
- Contribution of the HSI to operating experience issues resolution.

In addition to specifically linking issues to the importance dimensions identified above, discrepancies may also be considered important if individual aspects of the HSI (such as an important display) are associated with numerous discrepancies and, in the judgement of the NRC Review Team, the accumulation of the otherwise insignificant discrepancies may pose a safety concern.

As indicated in Section 2, HFE guideline reviews have limitations. Thus, discrepancies may be acceptable within the context of the fully-integrated design. The NRC Review Team may consider an applicant's documented analysis-based rationale as providing evidence of a discrepancy's acceptability. The technical basis for such a determination may include an analysis of recent literature or current practices, tradeoff studies, or results of design engineering evaluations and data. As a result of an evaluation, some discrepancies may be eliminated from further consideration; others may be judged important, that is, potentially safety significant and unjustified by the applicant's analysis-based rationale.

The unjustified discrepancies should be addressed through design modification. An HSI design modification plan should be developed by the applicant and reviewed for acceptability by the NRC. The NRC may review the implementation of the design modification to verify that the discrepancy is acceptably resolved.

6. REFERENCES

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PART 2:

GUIDELINES FOR HUMAN FACTORS ENGINEERING REVIEW

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0 GENERAL HSI DESIGN REVIEW PRINCIPLES

0.1 General Principles

0.1-1 Personnel Safety

The design should minimize the potential for injury and exposure to harmful materials.

0.1-2 Cognitive Compatibility

The operator's role should have a level of workload that is not so high as to negatively affect performance, but sufficient to maintain vigilance and familiarity by carrying out purposeful and meaningful activities.

0.1-3 Physiological Compatibility

The design of the interface should reflect consideration of human physiological characteristics including visual/auditory perception, biomechanics (reach and motion), characteristics of motor control, and anthropometry.

0.1-4 Simplicity of Design

The HSI should represent the simplest design consistent with functional and task requirements.

0.1-5 Consistency

There should be a high degree of consistency between the HSI, the procedures, and the training systems. At the HSI, the way the system functions and appears to the operating crew always should be consistent and reflect a high degree of standardization and be fully consistent with procedures and training.

0 GENERAL HSI DESIGN REVIEW PRINCIPLES
0.2 Primary Task Design Principles

0.2-1 Situation Awareness
The information presented to the users by the HSI should be correct, rapidly recognized and easily understood (e.g., "direct perception" or "status at a glance" displays) and support higher-level goals of user awareness of the status of the system.

0.2-2 Task Compatibility
The system should meet the requirements of users to perform their tasks (including operation, safe shutdown, inspection, maintenance, and repair). Data should be presented in forms and formats appropriate to the task (including the need to access confirmatory data or raw data in the case of higher-level displays) and control options should encompass the range of potential actions; there should be no unnecessary information or control options.

0.2-3 User Model Compatibility
All aspects of the system should be consistent with the users' mental models (understanding and expectations about how the system behaves developed through training, use of procedures, and experience) and consistent with established conventions (i.e., expressed in customary, commonplace, useful and functional terms, rather than abstract, unusual or arbitrary forms, or in forms requiring interpretation).

0.2-4 Organization of HSI Elements
The organization of all aspects of the HSI (from the elements in individual displays, to individual workstations, to the entire control room) should be based on user requirements and reflect the general principles of organization by importance, frequency, and order of use. Critical safety- function information should be available to the entire operating crew in dedicated locations to ensure its recognition, and to minimize data search and response.

0.2-5 Logical/Explicit Structure
All aspects of the system (formats, terminology, sequencing, grouping, and operator decision support aids) should reflect an obvious logic based on task requirements or some other non-arbitrary rationale. The relationship of each display, control, and data processing aid to the overall task/function should be clear. The structure of the interface and its associated navigation aids should make it easy for users to recognize where they are in the data space and should enable users to get rapid access to data not currently visible (e.g., on other display pages). The way the system works and is structured should be clear to the user.

0.2-6 Timeliness
The system design should take into account users' cognitive processing capabilities as well as process-related time constraints to ensure that user tasks can be performed within the time required. Information flow rates and control performance requirements that are too fast or too slow may diminish performance.

0.2-7 Controls/Displays Compatibility
The data entry and control requirements should be compatible with the displays.

0.2-8 Feedback

The system should provide useful information on system status, permissible operations, errors and error recovery, dangerous operations, and validity of data.

0.3-1 Cognitive Workload

The information presented by the system should be rapidly recognized and understood; therefore, the system should minimize the cognitive capacities that the user must allocate to making mental calculations or transformations and use of recall memory (recalling lengthy lists of codes, complex command strings, information from one display to another, or lengthy action sequences). Raw data should be processed and presented in directly usable form (although raw data should be accessible to the user for confirmation).

0.3-2 Response Workload

The system should require the minimum number of necessary actions required to accomplish an action; e.g., single vs. command keying, menu selection vs. multiple command entry, single input mode (keyboard, mouse) vs. mixed mode. In addition, the system should not require the entry of redundant data, nor the re-entry of information already in the system, or information the system can generate from already resident data.

0.4-1 Flexibility

The system should give the user multiple means to carry out actions (and verify automatic actions) and permit display/control to be formatted in a configuration most convenient for the task. Flexibility should be limited to situations where it offers advantages in task performance (such as to accommodate different levels of experience of the users); it should not be provided for its own sake because there is a trade-off with consistency and the imposition of interface management workload (which detracts from monitoring and operations tasks).

0.4-2 User Guidance and Support

The system should provide an effective "help" function. Informative, easy-to-use, and relevant guidance should be provided on-line and off-line to help the user understand and operate the system.

0.4-3 Error Tolerance and Control

A fail safe design should be provided wherever failure can cause damage to equipment, injury to personnel or inadvertent operation of critical equipment. Therefore, the system should generally be designed such that a user error will not have serious consequences. If an error is made, its negative effects should be controlled and minimized. The system should offer simple, comprehensible notification of the error, and provide simple, effective methods for recovery.

1 INFORMATION DISPLAY

1.1 General Display Guidelines

1.1-1 Display Screen Partitioning for HSI Functions

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

ADDITIONAL INFORMATION: Consistent display screen organization will help establish and preserve user orientation. Reserved screen areas, for example, might be used for a display title, data output by the computer, display control options, instructions, error messages, and user input and command entry. Display formats should be consistent with accepted usage and existing user habits.[E,B,D]

1.1-2 Display Conventions

Consistent interface design conventions for all display features (such as labels) should be evident.

ADDITIONAL INFORMATION: Consistent structure for data and labels should be used within and across displays. Even minor inconsistencies can distract a user and delay comprehension as the user wonders momentarily whether some apparent difference represents a real difference. Both the items on display and the displays themselves should be standardized. Although standardization is desirable, it should not take precedence over the grouping principles of frequency, sequence, locations, and importance.[A,B,E]

1.1-3 Distinctive HSI Functional Organization and Display Elements

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).

ADDITIONAL INFORMATION: Different display areas can be separated by spacing (where space permits). Outlining can also be used to separate different areas so that displayed data, control options, instructions, etc., are distinct from each other.[D,E]

1.1-4 Display Title

Every display should begin with a title or header at the top, briefly describing the contents or purpose of the display.

ADDITIONAL INFORMATION: There should be at least one blank line between the title and the body of the display.[A,C,D,E]

1.1-5 Display Identification

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

ADDITIONAL INFORMATION: The page identification could be its title, or an alphanumeric code or an abbreviation which is prominently displayed in a consistent location. It should be short enough (3-7 characters) and/or meaningful enough to be learned and remembered easily. At least one blank line between the title and the body of the display should be provided.[A,E C]

1.1-6 Hierarchy of Titles

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.

ADDITIONAL INFORMATION: Character size variation and indentation are two common methods of expressing a hierarchy. Bolding, underlining and letter case are also frequently used, but conventions for their use are not been well established.[D]

1 INFORMATION DISPLAY
1.1 General Display Guidelines

1.1-7 Display Simplicity
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.
ADDITIONAL INFORMATION: Displayed information should be tailored to user needs, providing only necessary and immediately usable data for any transaction; displays should not be overloaded with extraneous information. Information not needed for the current task should not be displayed. In general, the fewest lines or objects in a graphical display should be used.[B,E,D]

1.1-8 Availability of Task-Related Information
All information required by the user during a transaction should be available on the current display.
ADDITIONAL INFORMATION: A user should not have to remember data from one screen to the next.

1.1-9 Uncluttered Displays
Displays should be as uncluttered as possible.
ADDITIONAL INFORMATION: Display packing density should not exceed 50 percent. Density should be minimized for displays of critical information. The unused area should be distributed to separate logical groups, rather than having all unused area on one side. 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).[B,A,C,E]

1.1-10 Task-Related Partitioning of Displays
When displays are partitioned into multiple pages, function/task related data items should be displayed together on one page.
ADDITIONAL INFORMATION: Relations among data sets should appear in an integrated display rather than partitioned into separate windows.[A,C,E]

1.1-11 Numbering Pages of Multipage Displays
Users working with a multipage displays should be provided with a page location reference within the display sequence.
ADDITIONAL INFORMATION: Each page of a multipage display sequence should be numbered. Typically, the phrase "page x of y" is commonly used for this purpose. A recommended format is to identify pages by a note immediately to the right of the display title. Leading zeros should not be used in the display of page numbers.[C,E]

1.1-12 Display Frame Location Cues
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.
ADDITIONAL INFORMATION: 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. For example, in a corner of the frame, the computer might show a rectangle representing the overall display, in which a smaller rectangle is placed to indicate the position and extent of the currently visible portion of that display.[A,E]

1 INFORMATION DISPLAY

1.1 General Display Guidelines

1.1-13 Grouping of Information in a Display

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

ADDITIONAL INFORMATION: Table 1.1 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.[B,C,D,E]

1.1-14 Demarcation of Groups

Information groups should be visually distinct, e.g., separated by blanks, lines, color coding, or other means.[A,D,C,E]

1.1-15 Appropriate Display Format

The display presentation format, e.g. table, graph, or flowchart, should be consistent with tasks that the user will be performing with the displayed information.

ADDITIONAL INFORMATION: Table 1.2 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 alternative formats that reflect changes in task requirements.[A,C,D,E]

1.1-16 Display Information in Directly Usable Form

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

ADDITIONAL INFORMATION: Users should not have to convert displayed data into another form to make it useful to the ongoing task. A user should not have to transpose, compute, interpolate, or translate displayed data into other units, or refer to documentation to determine the meaning of displayed data.[A,C,D,E]

1.1-17 Display Information Consistent with User Conventions

Information should be displayed consistently according to standards and conventions familiar to users.

ADDITIONAL INFORMATION: The wording of displayed data, labels, etc. should incorporate familiar terms and the task-oriented jargon of the users, and avoid the unfamiliar jargon of designers and programmers.[A,C,E]

1.1-18 Display Information Consistent with Control Requirements

Displays should be consistent in word choice, format, and basic style with requirements for data and control entry.

ADDITIONAL INFORMATION: When entry formats are consistent with display formats, users are less likely to make errors.[C,D,E]

1.1-19 Display Flexibility

Users should be able to control the amount, format, and complexity of displayed data to meet task requirements.[A,E]

Table 1.1. Information Grouping Principles

Grouping Method By:	Conditions for Appropriate Use
Task	Information necessary to support a user's task should be grouped together.
Sequence of Use	Where displayed information are 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.

Table 1.2. Display Formats for Representative User Tasks

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 coordinant system

Table 1.2. Display Formats for Representative User Tasks (Continued)

NOTES:

Continuous Text Displays

Text may be used to present information in narrative form. However, presentation of lengthy instructions or descriptions is not a preferred method if other formats are available. Text displays are very demanding of the cognitive resources of the user and may be processed more slowly than other formats.

Lists

A series of related items (words, phrases, instructions, etc.) should be displayed in a list rather than as continuous text. A list format will facilitate rapid, accurate scanning.

Speech Displays

Speech displays for user guidance messages may be used in environments with low ambient noise, when a user's attention may not be directed toward a visual display or when a visual display is unpractical. Speech displays should be used as a means of supplementing visual display, or as an alternative means of data output in applications where visual displays are not feasible. Speech displays may be impractical in situations where high ambient noise prevents accurate listening. As compared with visual displays, speech displays offer a potential advantage in attracting a user's attention. On the other hand, speech displays suffer from a number of comparative disadvantages. Speech displays generally do not offer as great a range of coding options. Because speech displays are essentially sequential they do not permit easy scanning to discern critical data items.

Flowcharts

A flowchart should be provided to aid problem solving when a solution can be reached by answering a series of questions, and when no tradeoffs will be required. Flowcharts should be used for schematic representation of sequence information to display data that are logically related in terms of sequential processes. A flowchart can add structure to complex problem solving by illustrating a set of discrete decision points. With a flowchart, a user is given specific steps to follow in solving a problem, helping to ensure that all relevant factors are considered. For simple problems, however, a tabular or text format may be read more quickly than a flowchart. Flowcharts are not useful when a user must make tradeoffs. For example, if a user must evaluate alternative outcomes, then using a flowchart would be cumbersome and time consuming, and a tabular format may be more efficient. For example, in process control, a flowchart might aid problem diagnosis when a user must determine the cause of abnormal conditions and take appropriate action.

Tables

When information handling requires detailed comparison of ordered sets of data, a tabular format for data display should be provided.

Data Forms

Forms should be used to display related sets of data items in separately labeled fields. Forms can aid review of related data items by displaying explanatory labels to caption each data field.

Table 1.2. Display Formats for Representative User Tasks (Continued)

Maps

Maps should be provided to display spatial relationships within a geographic area. Here the term "map" refers to the display of relatively stable geographic data which may also have additional geographic-related information included, such as a display of plume tracks.

Mimics and Diagrams

Mimics and diagrams are simplified graphical depictions of a system and its components. They should be used to show system component and functional relations. Mimics and diagrams are used to support representations such as process flow paths (e.g., P&IDs) and electronic circuitry. Diagrams are considered a special form of picture. Mimics and diagrams should be kept as simple as possible, omitting unnecessary data.

Line Graphs

Line graphs, consisting of smooth curves, straight lines, or straight line segments, should be used for displaying relations between two continuous variables. Unlike printed graphs, computer-generated curves can show dynamic data change. Line graphs are generally superior to other graphic methods for speed and accuracy in interpreting data trends. For example, for tasks with limited time to estimate trends and high requirements for accuracy, a line graph should be used rather than a bar chart or histogram. If the shape of a function is important in making decisions, a line graph should be chosen rather than a table. If data interpolation is necessary, line graphs should be used in preference to tables. However, a curve implies a continuous function. Where that could be misleading, a better choice might be a bar graph (see below) composed of discrete display elements from one data point to the next. Trends are a special case of line graphs and are used to display the status of a variable over time. Data sources which may be more appropriately displayed as trends include time critical information or relatively imprecise information.

Graphs: Scatterplots

Scatterplots should be used to show the spatial distribution of data points within a coordinate system. Scatterplots, as the name implies, are sometimes used to show a dispersal intended to indicate non-correlation of variables. But scatterplots may not be convincing for that purpose, because users will often perceive patterns in scattered data points where none actually exist. Curves can be superimposed on scatterplots (data plotted as points in a two- dimensional graph) to indicate computed data trends, correlations, or other derived statistical measures, thus combining two types of graphic display.

Bar Charts and Histograms

Bar charts should be used when comparing a single measure across a set of several discrete entities or for a variable sampled at discrete intervals.

Pie Charts

A pie chart should be used only to show the relative distribution of data among categories. Pie charts are appropriate for displaying data that represent proportional parts of a whole. Pie charts should not be used when the viewer is to extract quantitative information; a bar chart will permit more accurate interpretation for such applications. Multiple pie charts will not permit accurate comparison of different totals, although different-sized pies can be used to indicate gross differences. Stacked bar graphs will prove more effective when it is necessary to show proportions of different totals.

1 INFORMATION DISPLAY

1.1 General Display Guidelines

1.1-20 Range of Conditions Displayed

The display system should correctly display information about the plant's safety status including severe accident symptoms.[G]

1.1-21 Rapid Recognition of Safety Status Change

User comprehension of a change in the safety status from critical safety function displays should be achieved in a matter of seconds.[G]

1.1-22 Dedicated Display of Critical Safety Function Parameters

Dedicated displays should be available to provide continuous indication of at least the minimum set of parameters necessary to assess the safety status of the plant.[G]

1.1-23 Critical Safety Function Display Visibility

Critical safety function displays should be readable from the workstations of users needing access to these displays.

ADDITIONAL INFORMATION: User categories include shift supervisor, reactor operator, and shift technical advisor.[G]

1.1-24 Normal Value Reference Index

Displays should contain reference(s) to the values of normal operating condition(s).

ADDITIONAL INFORMATION: With references showing normal parameter operating values, the users are more likely to notice deviations from normal conditions. In such cases, the index might be displayed as a horizontal or vertical line, or perhaps as a reference curve of some kind. For example, a horizontal line representing normal operating conditions should be superimposed on the display.[A,D,E]

1.1-25 Critical Value Reference Index

A reference index should be included in a display when the user must compare displayed information with some critical value. Limit marks should be used for each critical plant parameter displayed.

ADDITIONAL INFORMATION: Indexing may be complicated in some situations, such as when a series of bar charts do not have a common measure. In such a case, it might help to use an index scheme such that bar lengths will fall in the same zone under normal conditions, so that deviations in bar length will be readily noticed by users who must monitor changing data. For example, a horizontal line might be an adequate reference index for a vertical bar graph.[A,C,E,G]

1.1-26 Critical Parameter Monitoring Support

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: Users may not be able to perceive the values of changed parameters if the update rate is very fast. For slowly changing data, fixation on a display for an extended period of time (1-10 minutes) may result in delayed reaction time to an updated stimulus.[D]

1.1-27 Choice of Setpoints

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

1.1-28 Coding Display Items Requiring Rapid Discrimination

Coding should be provided when a user must distinguish rapidly among different categories of displayed data.

ADDITIONAL INFORMATION: Differential use of color, for example, as a background to grouped items can greatly aid users utilization of information.[A,E]

1.1-29 Meaningful Codes

Meaningful or familiar codes should be used, rather than arbitrary codes.[C,E]

1.1-30 Consistent Coding Across Displays

Consistent meanings should be assigned to codes, from one display to another.

ADDITIONAL INFORMATION: When coding is not consistent, the user's task of display interpretation may be made more difficult than if no auxiliary coding were used at all.[A,E]

1.1-31 Readability of Coded Information

Coding should not interfere with the readability of displayed information.[A,D,C]

1.1-32 Coding and Transmission Time

Coding should not increase transmission time.[C]

1.1-33 Distinctive Coding of Critical Information

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.

ADDITIONAL INFORMATION: 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 which 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. But 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.)[A,D,C,E]

1.1-34 Highlighting Text Displays

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.

ADDITIONAL INFORMATION: Use of capitalization as a coding technique should be limited since it reduces readability. A single word might be capitalized for emphasis, but capitalizing an extended passage should not be used for coding.[E]

1.1-35 Graphic Display Enhancement With Text

When a graphic display contains some outstanding or discrepant feature that merits attention by a user, supplementary text should be displayed to emphasize that feature.

ADDITIONAL INFORMATION: For example, a flow diagram for process control might include a current advisory message, POSSIBLE PRESSURE VALVE FAILURE, as well as appropriate graphic indications of the problem.[E]

1.1-36 Graphic Display Enhancement With Numeric Values

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

ADDITIONAL INFORMATION: For example, adjacent numeric annotation might be added to the ends of displayed bars on a bar graph; numeric data might be displayed to mark the points of a plotted curve.[C,E]

1.1-37 Display Enhancement With Time Data

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

1.1-38 Alert to Higher Level Displays

While viewing secondary displays, a perceptual (audible or visual) cue should be provided by the system to alert the user to return to the primary display format if significant information in that display requires user attention.[G]

1.1-39 Freezing Rapidly Changing Information

When task requirements dictate that current information changes be continuously viewed and the display is changing so rapidly that the information is difficult to read, the user should have the capability of simultaneously viewing the information in a supplemental "snapshot" display (display frozen to enhance readability) along with the continuous display.

ADDITIONAL INFORMATION: For example, if a numeric data display is changing rapidly and the user finds it difficult to read, it should be possible to display a frozen, unchanging value representing the data at the point of the request. The original display should continue to be presented.[D]

1.1-40 Freeze Feedback

If a display has a freeze capability, the display should have an obvious reminder that it is in the freeze mode.

ADDITIONAL INFORMATION: It is desirable to provide this information to the operator in an attention grabbing mode, such as with a flashing message.[C]

1.1-41 Indication of Display System Failure

A display feature should be provided to indicate to the user that the system is operating properly (or that a system failure has occurred).

ADDITIONAL INFORMATION: Display of calendar date and time is an example of such a display.[G]

1.1-42 On-Line Dictionary of Display Element Definitions

The user should have access to a dictionary that contains definitions for all display element conventions through the display or an on-line Help System.

ADDITIONAL INFORMATION: Definitions should be available for all symbols, icons, coding techniques, etc. A legend on the display may be provided for display conventions.[D,E]

1 INFORMATION DISPLAY

1.1 General Display Guidelines

1.1-43 Display Background Color

A single nondistracting background color should be used that has a hue/contrast which allows the data (foreground) to be easily visible and which does not distort or interfere with the coding aspects of the display.

ADDITIONAL INFORMATION: Background color can influence the way a user perceives a color symbol (e.g., shape, lines). When a color is surrounded by another color, the surrounding color can change the appearance of the enclosed color. For example, green on a yellow background will appear more blue than the same shade of green on a blue background. Different colored backgrounds may be used as a coding method to meaningfully group information, provided that colors are chosen to maintain good contrast and legibility.[A]

1.1-44 Readability Conditions

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

ADDITIONAL INFORMATION: Some pictorial patterns may be effective only when the viewing distance and lighting conditions are optimum.[B]

1.1-45 Labeling Scrollable and Multipage Displays

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

ADDITIONAL INFORMATION: Display formats such as tables, lists, forms, and graphs may be scrollable. When this capability is available, all labeling information should be preserved.[A,E]

1.1-46 Data Overlays

Displayed information which temporarily overlays and obscures other display data should not erase the overlayed data.[E]

1.1-47 Physical Overlays

Overlays should not distract or interfere with the observation or interpretation of displayed information.

ADDITIONAL INFORMATION: Mechanical overlays on VDUs should be avoided.[G]

1.1-48 Hardcopy of VDU Displays

Users should be able to obtain a hardcopy of any VDU display.

ADDITIONAL INFORMATION: On-line displays can offer some advantages over printed graphics, in terms of animation and highlighting. When a display is to be printed, however, it is important that limitations of the print medium can be taken realistically into account. If a printed replica of the screen does not appear satisfactory, it should be reformatted to maintain readability and clarity.[A,E]

1.2.1-1 Standard Text Format

A standard text display format should be used from one display to another.[A,E]

1.2.1-2 Consistency Between VDU-Based Text and Printed Text

VDU displays of textual data, messages, or instructions, should generally follow design conventions for printed text.

ADDITIONAL INFORMATION: Adoption of familiar design conventions for text display will permit users to rely on prior reading skills.[A,E]

1.2.1-3 Sentences Begin with Main Topic

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

1.2.1-4 Clarity of Wording

Text displays should employ simplicity and clarity of wording.[A,E]

1.2.1-5 Distinct Wording

Distinct words rather than contractions or combined forms should be used, especially in phrases involving negation.

ADDITIONAL INFORMATION: For example, "will not" should be used rather than "won't."[A,E]

1.2.1-6 Concise Wording

The text should be worded concisely to aid comprehension.

ADDITIONAL INFORMATION: Wording should be concise but not cryptic. Omitting articles ("the", "a"), prepositions ("of", "by") and relative pronouns ("that", "which", "who") may save some space, but may also reduce understandability.[E]

1.2.1-7 Abbreviations Defined in Text

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

ADDITIONAL INFORMATION: An on-line dictionary of abbreviations for convenient reference should be available to users.[E]

1.2.1-8 Affirmative Sentences

Affirmative statements rather than negative statements should be used.

ADDITIONAL INFORMATION: The user should be told what to do rather than what to avoid. For example, "Start the pump before opening the valve" is preferred over "Do not open the valve before starting the pump." [A,E]

1.2.1-9 Active Voice

Sentences should be composed in the active rather than passive voice.

ADDITIONAL INFORMATION: Sentences in the active voice will generally be easier to understand. For example, "Clear the screen by pressing RESET" is preferred over "The screen is cleared by pressing RESET."[A,E]

1.2.1-10 Temporal Sequence

When a sentence describes a sequence of events, it should be phrased with a corresponding word order.

ADDITIONAL INFORMATION: Temporal order is clearer. Reverse order may confuse a user. For example, "Start pump before opening the valve" is preferred over "Before opening the valve, start the pump."[E]

1.2.1-11 Minimum Number of Displayed Lines

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

ADDITIONAL INFORMATION: Four lines of text is the minimum that should be displayed when the reading material is simple in content. If the content is more complex, or if a reader will need to refer frequently to previous material, then more lines of text should be displayed.[A,D,E]

1.2.1-12 Line Length

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

ADDITIONAL INFORMATION: When space for text display is limited, a few long lines of text rather than many short lines of text should be displayed. Line lengths of less than 50 characters result in slower reading times, but line lengths from 50 to 80 characters do not produce differences in reading time.[E]

1.2.1-13 Minimal Hyphenation

In display of textual material, words should be kept intact, with minimal breaking by hyphenation between lines.

ADDITIONAL INFORMATION: Text is more readable if each word is entirely on one line, even if that makes the right margin more ragged.[A,E]

1.2.1-14 Conventional Punctuation

Conventional punctuation should be used in textual display.

ADDITIONAL INFORMATION: Sentences, for example, should end with a period.[A,E]

1.2.1-15 Inter-Word Spacing

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.

ADDITIONAL INFORMATION: Reading is easier with constant spacing, which outweighs the advantage of an even right margin achieved at the cost of uneven (nonproportional) spacing. Uneven spacing is a greater problem with narrow column formats than with wide columns. Uneven spacing handicaps poor readers more than good readers. Right justification with nonproportional spacing (fill justified) slows reading time. Right justification should only be employed if it can be achieved by variable spacing, maintaining constant proportional differences in spacing between and within words, and consistent spacing between words in a line.[F,A,D,E]

1.2.1-16 Inter-Line Spacing

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

ADDITIONAL INFORMATION: The specified spacing is in addition to the space used for uppercase accent marks or for lower case descenders of characters.[F]

1.2.1-17 Inter-Paragraph Spacing

Displayed paragraphs of text should be separated by at least one blank line.[A,E]

1.2.1-18 Combining Text with Other Data

When text is combined with graphics or other data in a single display, thus limiting the space available for text, the text should be formatted in a few wide lines rather than in narrow columns of many short lines.[E]

1.2.1-19 Placing Figures Near Their Citations

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.

ADDITIONAL INFORMATION: Users may not bother to find and look at a figure if it is displayed separately from its citation in the text. As an exception, if a figure is cited at several points in the text, then it might be desirable to allow optional display of the figure at user request, perhaps as a temporary window overlay at each point of citation. Also, if a figure is cited at several points in printed text, and particularly if that text may be accessed at different places by its readers, then it might be desirable to group figures consistently at a particular location, such as at the end of each section.[A,E]

1.2.1-20 Underlining for Emphasis

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.[E]

1.2.1-21 Font Coding

Within a text file or table, the use of a different font style should be preferred over the use of a different size for highlighting information.

ADDITIONAL INFORMATION: It is often not possible to introduce into displayed text differences in type size large enough to be readily discernable.[D]

1.2.1-22 Attention Symbols in Alphanumeric Displays

Special symbols, such as asterisks, arrows, etc., should be used to draw attention to selected items in alphanumeric displays.[A,E]

1.2.1-23 Markers Close to Words Marked

When a special symbol is used to mark a word, the symbol should be separated from the beginning of the word by a space.

ADDITIONAL INFORMATION: A symbol immediately adjacent to the beginning of a word will impair legibility.[E]

1.2.1-24 Hardcopy for Lengthy Text Displays

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

ADDITIONAL INFORMATION: Reading lengthy text on an electronic display may be 20-30 percent slower than reading it from a printed copy.[A,E]

1.2.2-1 Logical Organization

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

ADDITIONAL INFORMATION: If the data in the rows has order, the order should be increasing from left to right. If the data in the columns has order, the order should be increasing from top to bottom of the display. Items in lists should be arranged in a recognizable order, such as chronological, alphabetical, sequential, functional, or importance. Where no other principle applies, lists should be ordered alphabetically. It is the user's logic which should prevail rather than the designer's logic, where those are different.[A,C,E]

1.2.2-2 Table Layout by Row and Column

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

ADDITIONAL INFORMATION: The left-most column should contain the labels for the row variables, and the top row should contain the labels for the column variables. When tables are used for reference, the reference item should be displayed in the left column, and the material most relevant for user response should be displayed in the next adjacent column.[A,C,D,E]

1.2.2-3 Row and Column Labels

Each row and column should be uniquely and informatively labeled and should be visually distinct from data entries.[A,D,E]

1.2.2-4 Labeling Units of Measurement

Labels should include the unit of measure for the data in the table; units of measurement should be part of row or column labels.[A,C,D,E]

1.2.2-5 Consistent Spacing Within Tables

Consistent column and row spacing should be maintained within a table, and from one table to another. Similarly, spacing between rows should be consistent within a table and between related tables.

ADDITIONAL INFORMATION: As an exception, when columns are grouped under superheadings, extra space between superheadings may help, in order to emphasize that the columns under any single superheading are related.[A,C,D,E]

1.2.2-6 Minimum Column Spacing

The spacing between columns should be greater than any internal spaces that might be displayed within a tabulated data item.

ADDITIONAL INFORMATION: The columns in a table should be separated by enough blank spaces, dots, or by some other distinctive feature, to ensure separation of entries within a row.[A,C,D,E]

1.2.2-7 Row Separation

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

ADDITIONAL INFORMATION: For many applications it will suffice to insert a blank line after every five rows.[A,C,D,E]

1.2.2-8 Consistent Character Appearance

The font and size of alphanumeric characters should be consistent within a table and between related tables.

ADDITIONAL INFORMATION: An exception to this guideline is when a word or set of characters is highlighted by varying the typeface, for example, through the use of italics or a "bold" font.[D]

1.2.2-9 Justification of Alphabetic Data

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

ADDITIONAL INFORMATION: As an exception, indentation can be used to indicate subordinate elements in hierarchic lists. Also, a short list (of just four or five items) could be displayed horizontally on a single line, in the interest of compact display format, if that is done consistently.[A,D,E]

1.2.2-10 Justification of Numeric Data

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.[A,D,E]

1.2.2-11 Arabic Numerals for Numbered List Items

When listed items are numbered, Arabic rather than Roman numerals should be used.

ADDITIONAL INFORMATION: Arabic numbers are more familiar to most users, and require less interpretation than Roman numerals do. The advantage of Arabic numbers becomes greater when large numbers are used.[A,C,E]

1.2.2-12 Numbered Items Start with "1"

Item numbers should begin with one rather than zero.[A,E]

1.2.2-13 Continuous Numbering in Multipage Lists

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.

ADDITIONAL INFORMATION: For example, items continued on the next page should be numbered relative to the last item on the previous page.[C,E]

1.2.2-14 Repeated Elements in Hierarchic Numbering

For hierarchic lists with compound numbers, the complete numbers should be displayed; i.e., repeated elements should not be omitted.

ADDITIONAL INFORMATION: Implicit numbering may be acceptable for tasks involving perception of list structure. Complete numbering is better, however, for tasks requiring search and identification of individual items in the list.[A,E]

1.2.2-15 Single-Column List Format

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

ADDITIONAL INFORMATION: A list should be displayed as a single column. As an exception, listing in multiple columns may be considered where shortage of display space dictates a compact format.[A,C,E]

1.2.2-16 Marking Multiline Items in a List

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.

ADDITIONAL INFORMATION: A continued portion should not appear to be a separate item. Items might be separated by a blank space, or continuing lines within an item might be indented, or each item might be numbered or marked by a special symbol such as an arrow or bullet.[A,C,E]

1.2.2-17 Vertical List Extension Beyond One Page

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

1.2.2-18 Hierarchic Structure for Long Lists

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.[C,E]

1.2.2-19 Vertical Ordering in Multiple Columns

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.[A,C,E]

1.2.2-20 Annotating Display of Continued Data

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.

ADDITIONAL INFORMATION: For example, incomplete lists might be marked "continued on next page," "continued," or "more." Concluding lists might display a note such as "end of list" or "end." As an exception, short lists whose conclusion is evident from the display format need not be annotated in this way.[E]

1.2.3-1 Comparing Data Fields

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

1.2.3-2 Consistent Format Across Displays

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

ADDITIONAL INFORMATION: For example, time records might be consistently punctuated with colons, as HH:MM:SS or HH:MM. The convention chosen should be familiar to the prospective users.[A,E]

1.2.3-3 Consistency of VDU and Hardcopy Formats

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

ADDITIONAL INFORMATION: Users should be able to transfer their previous training and experience with the hardcopy format to the computer display.[D]

1.2.3-4 Form Compatible for Data Entry and Display

When forms are used for data entry as well as for data display, the format for data display should be compatible with whatever format is used for data entry.[A,C,E]

1.2.3-5 Visually Distinct Labels and Data Entry Areas

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

ADDITIONAL INFORMATION: Special characters (such as underlining) or graphics (such as "boxing") should be used to delineate data fields. A broken underscore, for example, could be used to indicate the number of characters available for an entry.[A,E]

1.2.3-6 Separation of Field Label and Data Entry Area

The label and the data entry area should be separated by at least one character space.[B,D]

1.2.3-7 Data Field Separation

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

ADDITIONAL INFORMATION: Where space constraints exist, vertical lines may be substituted for spaces for separation of columns of fields.[B]

1.2.3-8 Justification: Data Field Labels of Equal Length

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.[B]

1.2.3-9 Justification: Data Fields Labels of Unequal Length

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.[B]

1.2.3-10 Protected Labels

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

ADDITIONAL INFORMATION: When a user must change a displayed form, including changes to field labels, then that user must be able to override label protection.[E]

1.2.3-11 Highlight Active Data Entry Field

The current field to be entered should be highlighted.

ADDITIONAL INFORMATION: Irrelevant objects slow perceptual processing by competing for resources. Use of highlighting makes the current data field discriminable from irrelevant data.[D]

1.2.3-12 Data Entry Cues

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

ADDITIONAL INFORMATION: For example, "DATE (MM/DD/YY): __/__/__/."[D]

1.2.3-13 Label Punctuation as Entry Cue

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

ADDITIONAL INFORMATION: A symbol should be reserved exclusively for prompting user entries.[E]

1.2.3-14 Data Form Entry Error

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

ADDITIONAL INFORMATION: A beep, for example, can be used to signal an error.[D]

1.2.3-15 Distinguishing Blanks from Nulls

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

ADDITIONAL INFORMATION: Some special symbol might be adopted to denote null entry. If field delimiters are displayed to guide data entry, then it will often be sufficient simply to leave those delimiters unchanged when no entry has been made.[A,E]

1.2.3-16 Labeling Groups of Data Fields

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

1.2.3-17 Data Field Group Separation

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

1.2.3-18 Headings and Label Indentation

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.

ADDITIONAL INFORMATION: Scanning an inquiry screen will be aided if logical groupings of fields are identified by headings (see Figure 1.1). This permits scanning of headings until the correct one is located, at which point the visual search steps down one level to the items within the grouping itself. The above guideline is intended to provide easily scanned headings.[B]

1.2.3-19 Heading Proximity to Subordinate Labels

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.

ADDITIONAL INFORMATION: Scanning an inquiry screen will be aided if logical groupings of fields are identified by headings (see Figure 1.2). This permits scanning of headings until the correct one is located, at which point the visual search steps down one level to the items within the grouping itself. The above guideline is intended to provide easily scanned headings.[8]

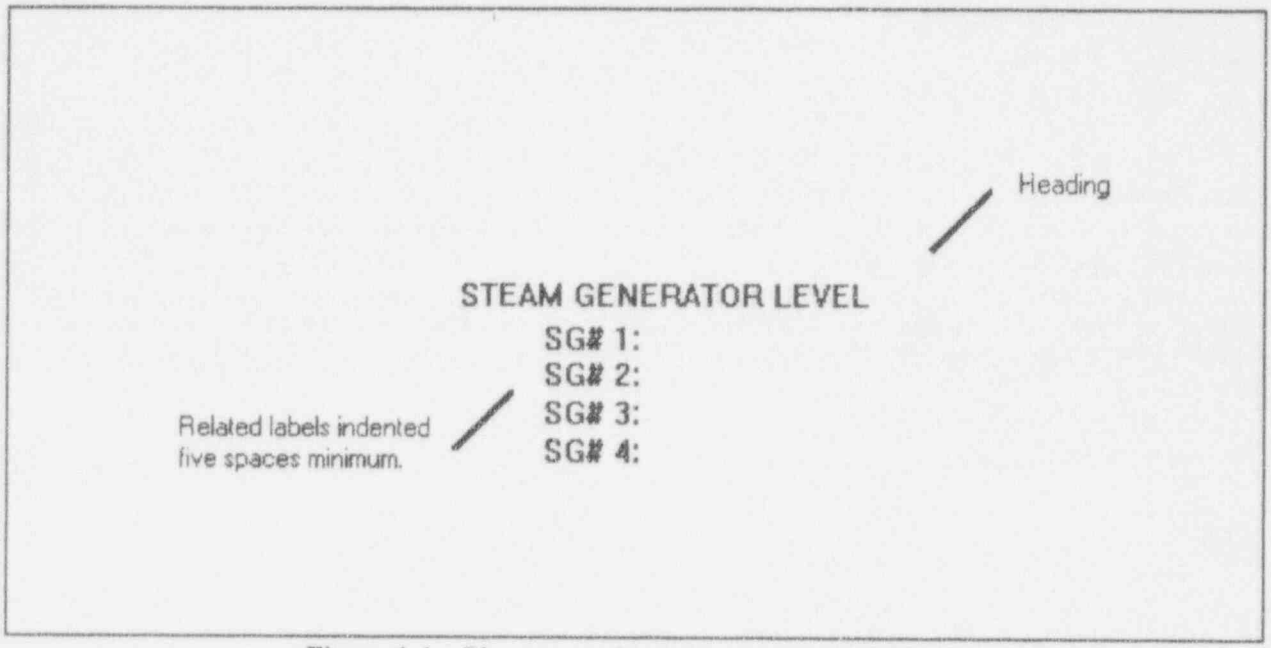

Figure 1.1. Placement of headings above data fields

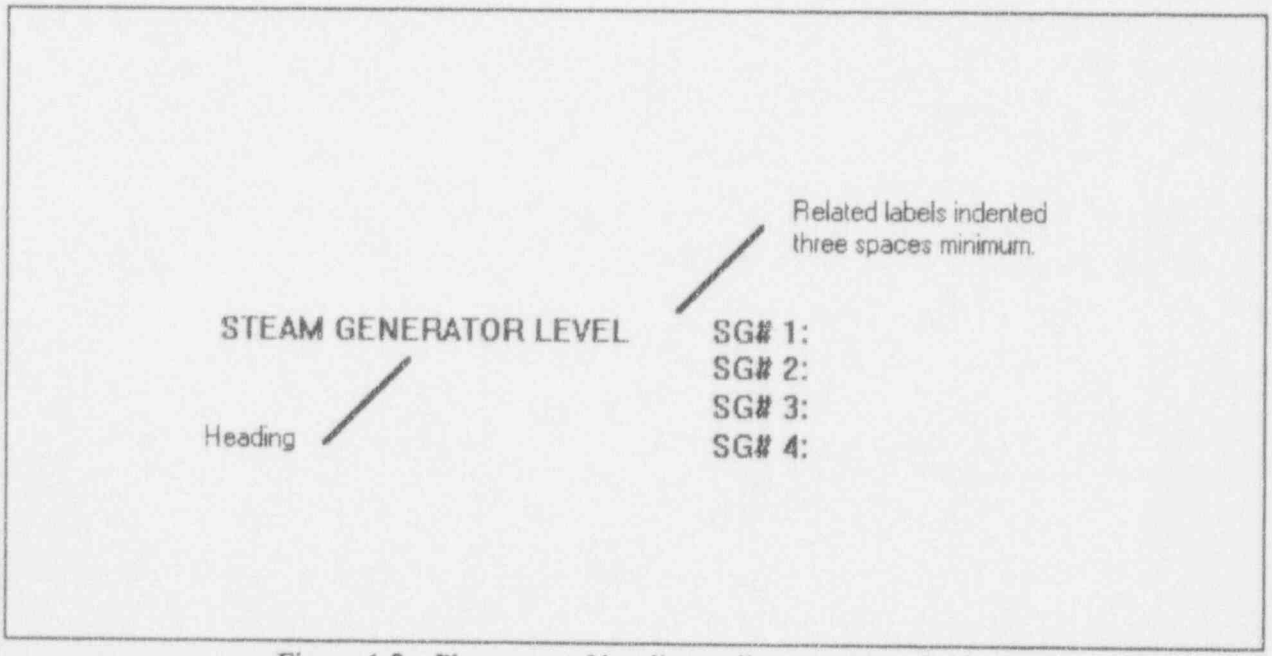

Figure 1.2. Placement of headings adjacent to data fields

1.2.4-1 Labeling Single Bars

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

ADDITIONAL INFORMATION: The label provides a positive identification of the parameter each bar represents. An operator should not have to memorize the position of each parameter on the display.[B]

1.2.4-2 Labeling Paired Bars

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

ADDITIONAL INFORMATION: Direct labeling of bars will permit efficient information assimilation by a user. If the user has to refer to a separately displayed legend, interpretation of the chart will be slower and more subject to error.[E]

1.2.4-3 Bar Spacing

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.

ADDITIONAL INFORMATION: A horizontal bar chart is illustrated in Figure 1.3. 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).[A,C,E]

1.2.4-4 Consistent Orientation of Bars

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

ADDITIONAL INFORMATION: 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.[A,E]

1.2.4-5 Highlighting

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

ADDITIONAL INFORMATION: 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.[E]

1.2.4-6 Zero Reference on Deviation Bar Charts

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

ADDITION INFORMATION: A example of a deviation bar chart appears in Figure 1.4.[G]

1.2.4-7 Normal Range on Deviation Bar Charts

On a deviation bar chart, the range of normal conditions for positive or negative deviations should represent no more than 10% of the total range.

ADDITION INFORMATION: A example of a deviation bar chart appears in Figure 1.4.[G]

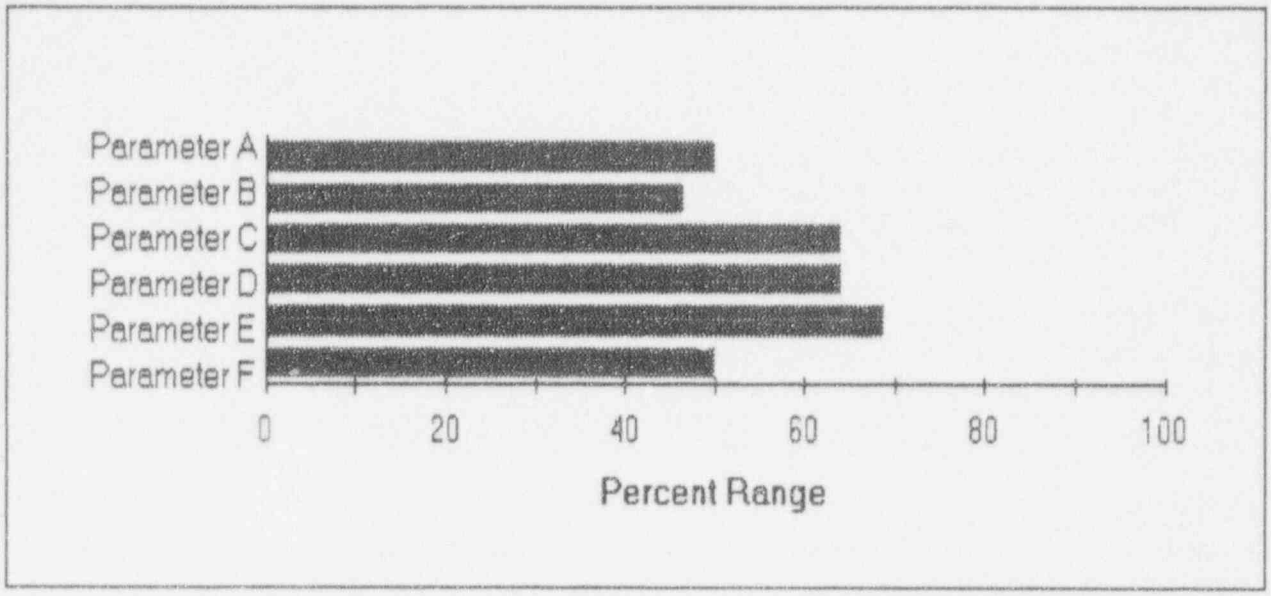

Figure 1.3. Example of a horizontal bar chart

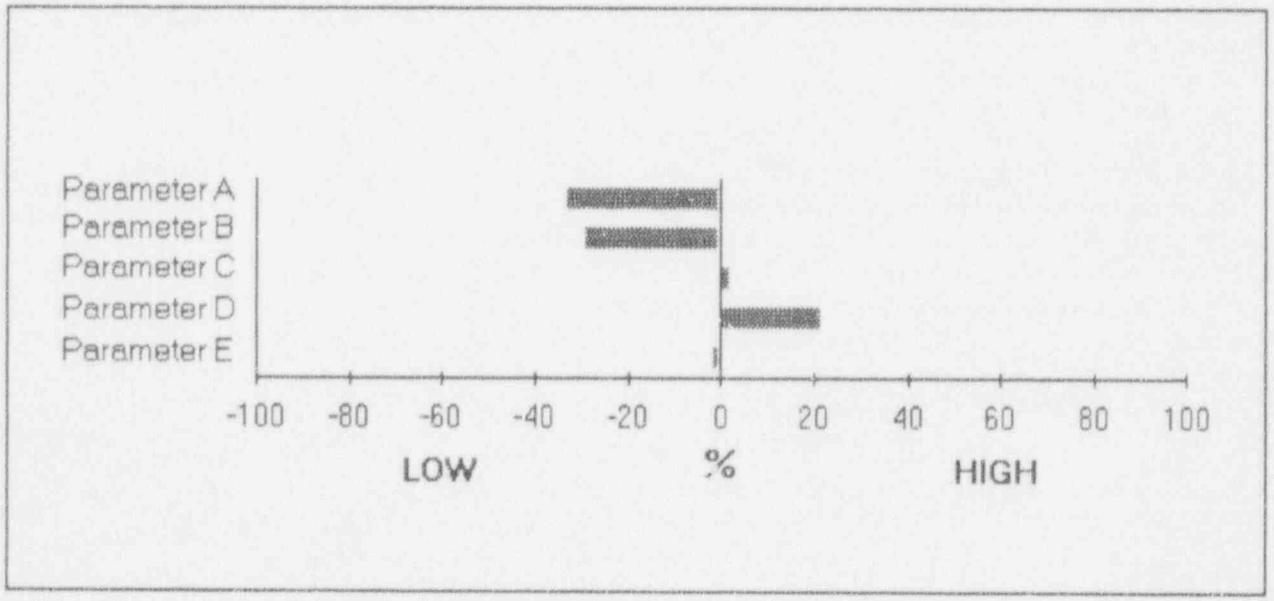

Figure 1.4. Example of a deviation bar chart

1.2.4-8 Indication of Magnitude on Deviation Bar Charts

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

ADDITIONAL INFORMATION: The actual values of critical parameters should appear on the deviation bar display in addition to percent deviation.[G]

1.2.4-9 Coding Segmented Bar Charts

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.

ADDITIONAL INFORMATION: An example of a segmented bar chart appears in Figure 1.5.[A,E]

1.2.4-10 Ordering Data in Segmented Bars

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.[A,E]

ADDITIONAL INFORMATION: Sometimes there are independent logical grounds for the ordering of data categories. 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.[A,E]

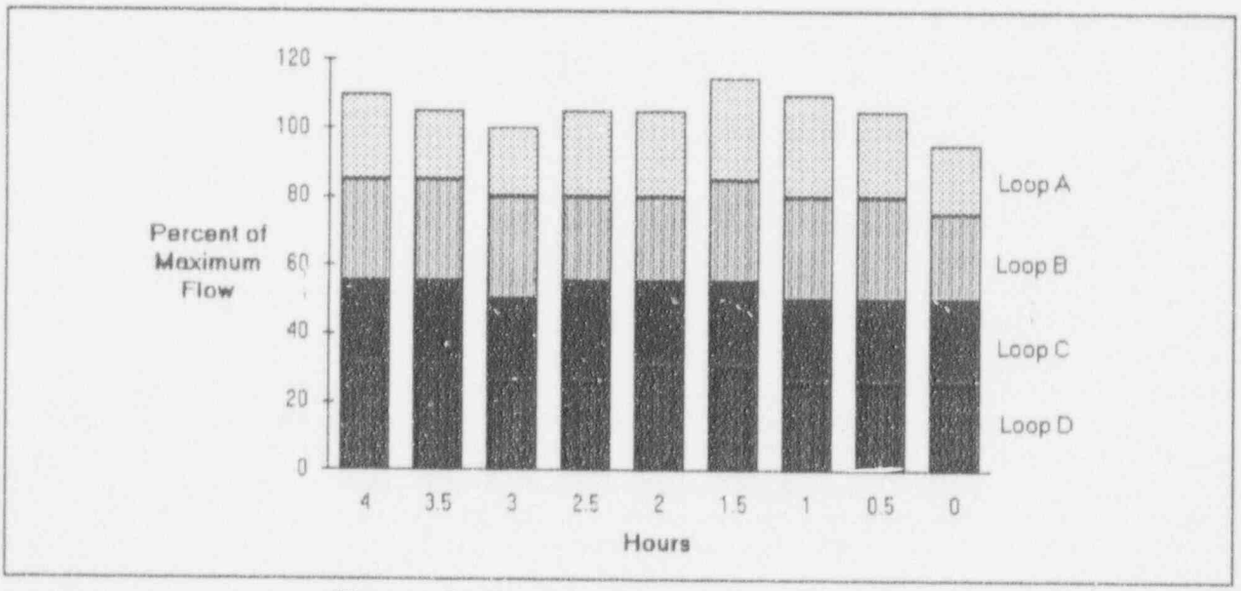

Figure 1.5. Example of a segmented bar chart

1.2.5-1 Interpreting Graphs

Graphs should convey enough information to allow the user to interpret the data without referring to additional sources.[A]

1.2.5-2 Labeling Curves

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.

ADDITIONAL INFORMATION: As an exception, where displayed curves are too close for direct labeling, an acceptable alternative might be to distinguish the various curves in some way, perhaps by color coding or line coding, and identify their codes in a separate legend. Direct labeling will permit users to assimilate information more rapidly than displaying a separate legend.[A]

1.2.5-3 Legend Ordering

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.[A,E]

1.2.5-4 Coding to Distinguish Curves

When multiple functions are displayed in a single graph, coding should be used.

ADDITIONAL INFORMATION: Coding should be provided particularly if curves approach and/or intersect one another. Coding is required to distinguish one curve from another.[A,E]

1.2.5-5 Consistent Line Coding

Line coding should be used consistently across graphs.[A,E]

1.2.5-6 Highlighting Significant Curves

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

ADDITIONAL INFORMATION: 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, dotted, etc.), then one curve might be highlighted by displaying it in a different color.[A,E]

1.2.5-7 Trending Time Intervals

Trend displays should be capable of showing data collected during time intervals of different lengths.

ADDITIONAL INFORMATION: A short time base of just a few minutes is needed to study fast changing trends, while other trends may not show significant changes for several hours.[B]

1.2.5-8 Multiple Trend Lines

When the user must compare data represented by separate curves, the curves should be displayed in one combined graph.

ADDITIONAL INFORMATION: Combined plots should be related, so the user can correlate changes in one variable with changes in other key variables. Only those curves requiring comparison should be combined, since, as the number of curves on a graph increases, the user's task of comparison will become more difficult.[A,C,D,E]

1.2.5-9 Stability of Trend Data

Trend rates should not fluctuate as a result of minor fluctuations in data or oscillatory behavior which may be superimposed on a well-defined trend.[O]

1.2.5-10 Indication of Non-Representative Trend Data

When a simple quantitative rate-of-change value is used, an indication should be provided to inform the user when, as a result of minor fluctuations or oscillations, the rate value does not accurately represent the trend.[O]

1.2.5-11 Display of Projected Values

Curves representing planned, projected, or extrapolated data should be distinctive from curves representing actual data.

ADDITIONAL INFORMATION: Curves representing projected data, for example, could be depicted as broken, dashed or dotted lines while curves representing actual data could be represented as solid lines.[A,E]

1.2.5-12 Curve Averaging

Combining several individual curves into a single average curve should only be done when users do not need to know the pattern of individual curves or when curves differ in the basis of minor irregularities.

ADDITIONAL INFORMATION: Curve averaging should be performed with caution since averages tend to "wash out" local variations.[A,E]

1.2.5-13 Repeating Display of Cyclic Data

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

ADDITIONAL INFORMATION: This will allow users to scan any critical portion of the displayed cycle without having to return visually to the beginning of the plot. How much extension is desirable will depend on the particular application.[A,E]

1.2.5-14 Target Area Definition

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

ADDITIONAL INFORMATION: Monitoring a pressure-temperature display, which presents a saturation curve that bisects the subcooled water region and the superheated steam region, is an example of a task situation where graphic depiction of a target area should be provided. This sort of display is best used for detecting deviations from normal if a target area can be defined. By plotting a brief time history, one may be able to predict where the values are headed. Care should be taken to distinguish the current value from past values, especially when the values change slowly. This can be done by placing a symbol or code for the current value.[B]

1.2.5-15 Minimize Clutter

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

ADDITIONAL INFORMATION: Ideally, as one new point is plotted the oldest point should be removed, thereby maintaining a constant number of displayed points.[B]

1.2.5-16 Linear Profile Pattern Recognition

The graph should form recognizable geometric patterns for specific abnormal conditions.

ADDITIONAL INFORMATION: An example of a linear profile graph appears in Figure 1.6. The irregular profile is indicative of abnormal operating conditions.[B]

1.2.5-17 Coding Linear Profile Charts

The area below the profile line should be shaded to provide a more distinguishable profile.[B]

1.2.5-18 Labeling Linear Profile Charts

Labels should be provided along the bottom to identify each parameter.[B]

1.2.5-19 Circular Profile Chart

The circular profile chart should form a recognizable geometric pattern for specific abnormal conditions.

ADDITIONAL INFORMATION: Under normal operating conditions, the profile should be circular (see Figure 1.7). An irregular profile is indicative of an abnormal operating condition. As the user becomes experienced with the circular profile, the asymmetrical polygons that result from off-normal situations should become more familiar. For example, a steam generator tube rupture may result in an hourglass shape or a loss-of-coolant accident might produce a cloverleaf design.[B]

1.2.5-20 Labeling Circular Profile Displays

Labels should be provided to identify each radial line (see Figure 1.7).[B]

1.2.5-21 Coding Circular Profile Displays

The area within the profile should be shaded to enhance the operator's perception of plant status (see Figure 1.7).[B]

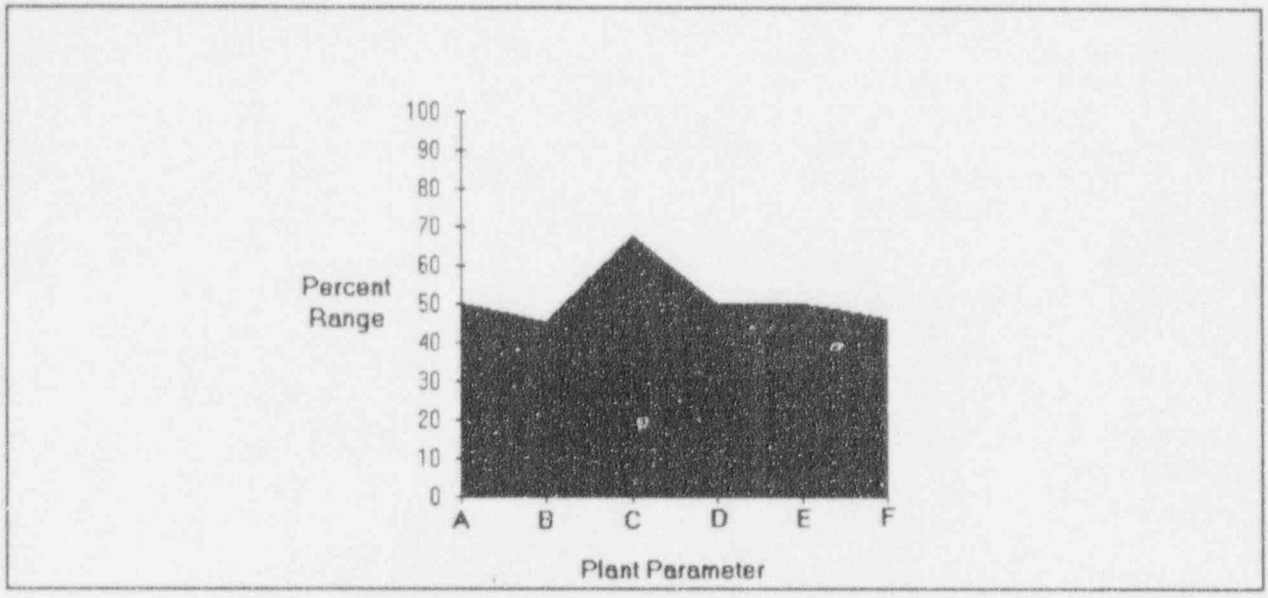

Figure 1.6. Example of a linear profile chart

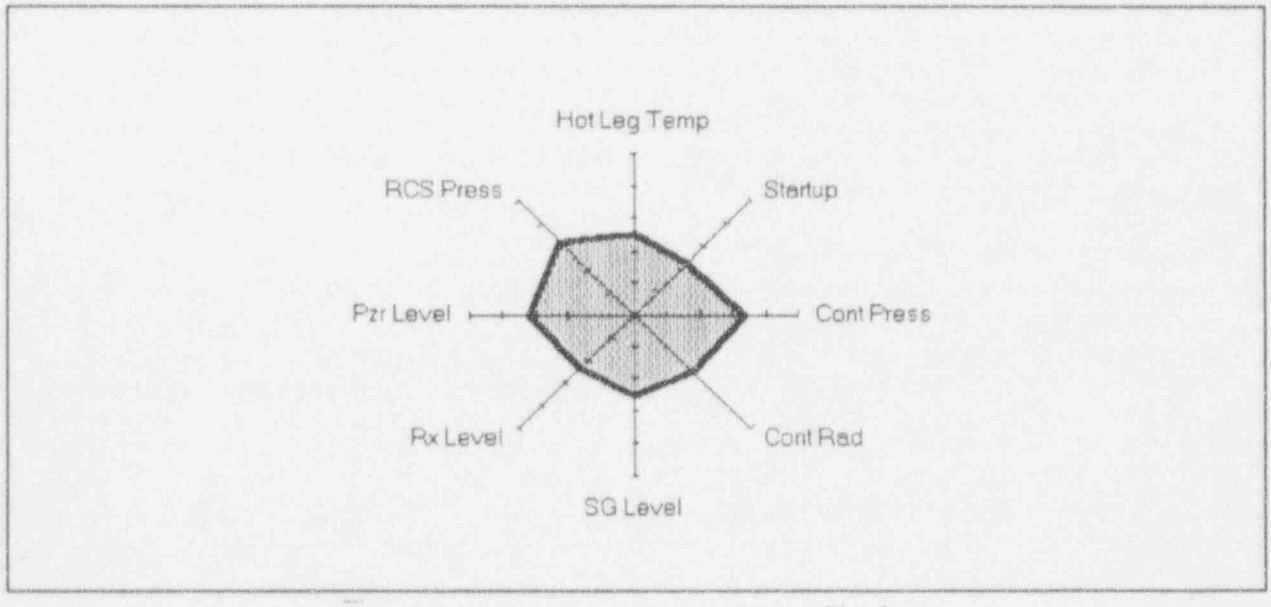

Figure 1.7. Example of a circular profile chart

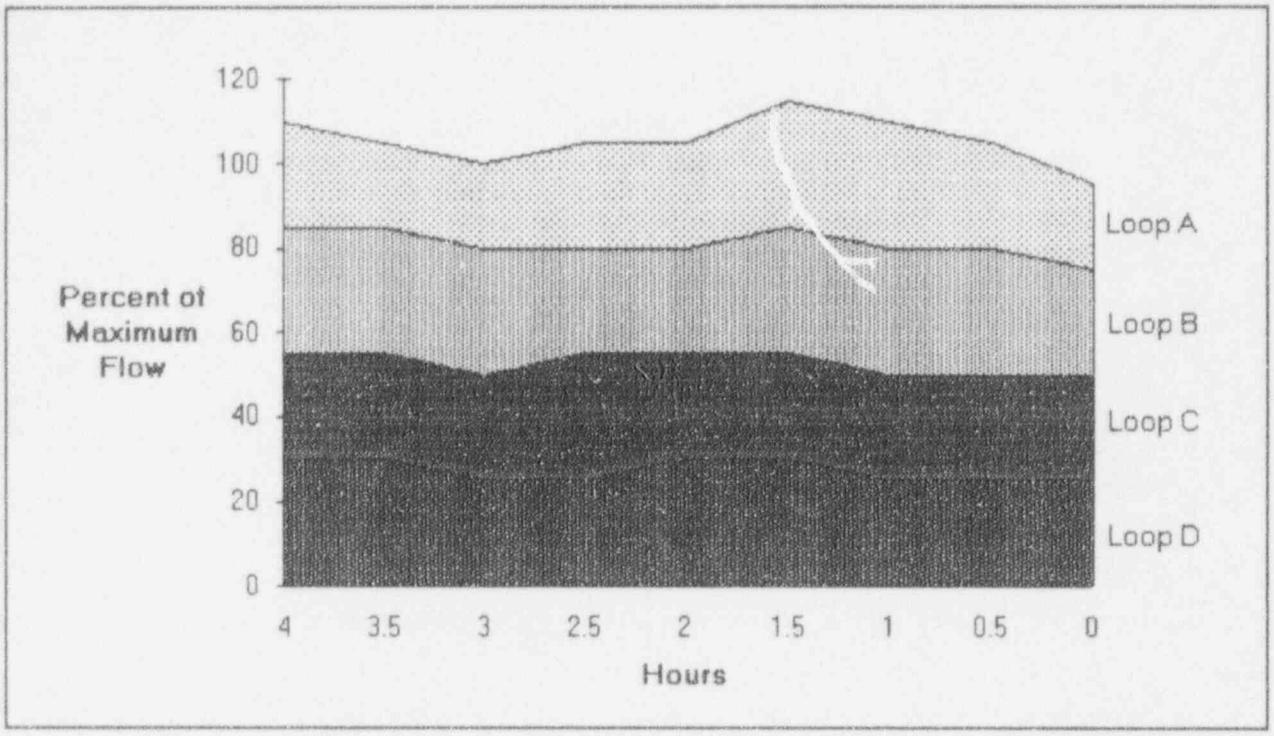

Figure 1.8. Example of a segmented curve graph

1.2.5-22 Depicting Bands in Segmented Curve Graphs

All segments in a segmented curve graph should be related to the total value.

ADDITIONAL INFORMATION: A segmented curve graph contains a series of bands depicting the components of a total series (see Figure 1.8). The values of the bands, segments, or strata are plotted on an X-Y plot. Each of the bands are added to one another so that the topmost boundary represents the sum of all bands. For example, segmented curve graphs can be used to show how much each pump is contributing to total flow. This format is most useful when all elements contribute equally to the total under normal circumstances. Segmented curve graphs should not be used when changes in the movement of a series are abrupt, or where accurate reading of a component is of paramount importance.[B]

1.2.5-23 Ordering Data in Segmented Curve Graphs

The data categories in a segmented curve graph should be ordered so that the least variable curves are displayed at the bottom and the most variable at the top.

ADDITIONAL INFORMATION: Sometimes there are independent logical grounds for the ordering of data categories. If a segmented curve graph that is constructed on a logical basis produces confusing irregularity of curves, then it might be better to display the data in some other graphic format. Any irregularity in the bottom curve will "propagate" throughout the curves above it, which will make it difficult for a user to examine irregularities in the upper curves.[A,E]

1.2.5-24 Coding Segmented Curve Graphs

The different bands of segmented curve graph should be visually distinctive by coding, such as by the texturing or shading bands.[A,E]

1.2.5-25 Labeling Segmented Curve Graphs

Where space permits, the different bands of segmented curve graph should be labeled directly within the textured or shaded bands.[A,E]

1.2.5-26 Highlighting Scatterplots

If some plotted points represent data of particular significance, they should be highlighted to make them visually distinctive from others.

ADDITIONAL INFORMATION: Significant data points might be highlighted by bolding, color, blinking, shape coding, or other means, or might be designated by supplementary display annotation.[A,E]

1.2.5-27 Grouping Scatterplots to Show Multiple Relations

When relations among several variables must be examined, an ordered group (matrix) of scatterplots should be displayed, each showing the relation between just two variables.

ADDITIONAL INFORMATION: The ordering of several scatterplots in a single display might help a user discern relations among interacting variables.[A,E]

1.2.5-28 Interactive Analysis of Grouped Scatterplots

When scatterplots are grouped in a single display to show relations among several variables, an interactive aid should be provided for analysis so that if a user selects a set of data in one plot then the corresponding data points in other plots will be highlighted.

ADDITIONAL INFORMATION: Data selection might be accomplished with a superimposed box of controllable size to define the data set of interest. That technique can exploit the capabilities of interactive graphics to permit a range of data analysis not possible when using printed graphs.[E]

1.2.6-1 Partitioning

Partitioning should be limited to five segments or less.[A]

1.2.6-2 Labeling Pie Charts

Pie chart segments should be labeled directly rather than by a separate legend. If a segment is too small to contain the label, the label should be placed outside the segment with a line from it to the segment.

ADDITIONAL INFORMATION: The label should be in a normal orientation for reading text.[E]

1.2.6-3 Numeric Annotation of Labels

If the task requires precise values, numbers should be added to pie chart segment labels to indicate the percentage and/or absolute values.

ADDITIONAL INFORMATION: Alternative display formats are preferred when users require precise data.[E]

1.2.6-4 Highlighting

If a particular segment of a pie chart requires emphasis, it should be highlighted by special hatching or displaced slightly from the remainder of the pie.[A,E]

1.2.7-1 Logical Ordering of Decision Options

The available decision options should be displayed in logical order.

ADDITIONAL INFORMATION: For example, if options represent stages of a process, those stages should be listed in the order in which they would actually occur. The ordering of options should not be determined merely by the amount of space that is conveniently available to display them.[A,E]

1.2.7-2 Single Decision at Each Step

Only a single decision should be required at each step.

ADDITIONAL INFORMATION: Decisions should not be combined to reduce flowchart size.[A,E]

1.2.7-3 Consistent Ordering of Decision Options

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.

ADDITIONAL INFORMATION: For example, "yes" might always be on the left and "no" on the right. Consistent ordering will permit a user to review a flowchart more quickly.[A,E]

1.2.7-4 Availability of Supplemental Information

While flowcharts should display only the data immediately required by the user, more detailed data should be available with a single action.[D]

1.2.7-5 Conventional Path Orientation

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

ADDITIONAL INFORMATION: For example, from left to right and from top to bottom.[A,D,E]

1.2.7-6 Flowchart Symbol Set

There should be a standard set of flowchart symbols.[D]

1.2.8-1 Level of Detail

Mimics and diagrams should contain the minimum amount of detail required to yield a meaningful pictorial representation.

ADDITIONAL INFORMATION: An example of a mimic display is shown in Figure 1.9. Unnecessary graphic detail (such as shadowed symbols or very detailed icons) should be avoided.[B]

1.2.8-2 Component Identifiers

Component representations should be identified.[B]

1.2.8-3 Line Points of Origin

All flow path line origin points should be labeled or begin at labeled components.[B]

1.2.8-4 Line Termination Points

All flow path line destination or terminal points should be labeled or end at labeled components.[B]

1.2.8-5 Directional Arrowheads

Flow directions should be clearly indicated by distinctive arrowheads.[B]

1.2.8-6 Line Coding

Flow paths should be coded (e.g., by color, width) to indicate important information.

ADDITIONAL INFORMATION: For example, color can be used to differentiate process flow paths: blue may be used to code water lines; white, steam lines; yellow, oil lines; etc. In general, features of the flow path that change (e.g., the open/close status of valves) should be coded so as to be more salient than static features.[B]

1.2.8-7 Overlapping Lines

Flow path lines should not overlap.

ADDITIONAL INFORMATION: Cross-overs should be clearly indicated so that they do not appear as connections.[B]

1.2.8-8 Symbol-Data Integration

Where symbols are used to represent equipment components and process flow or signal paths, numerical data should be presented reflecting inputs and outputs associated with equipment.[B]

1.2.8-9 Aids for Analysis

When users must analyze information in detail, computer aids should be provided.

ADDITIONAL INFORMATION: For examining the internal structure of a depicted object, for example, it might be helpful to allow a user to request auxiliary displays of specified cross-sections or transect diagrams. For more detailed structural analysis of depicted objects, it might be necessary to provide computer aids for calculating area, volume, stresses, heat transfer, etc.[A,E]

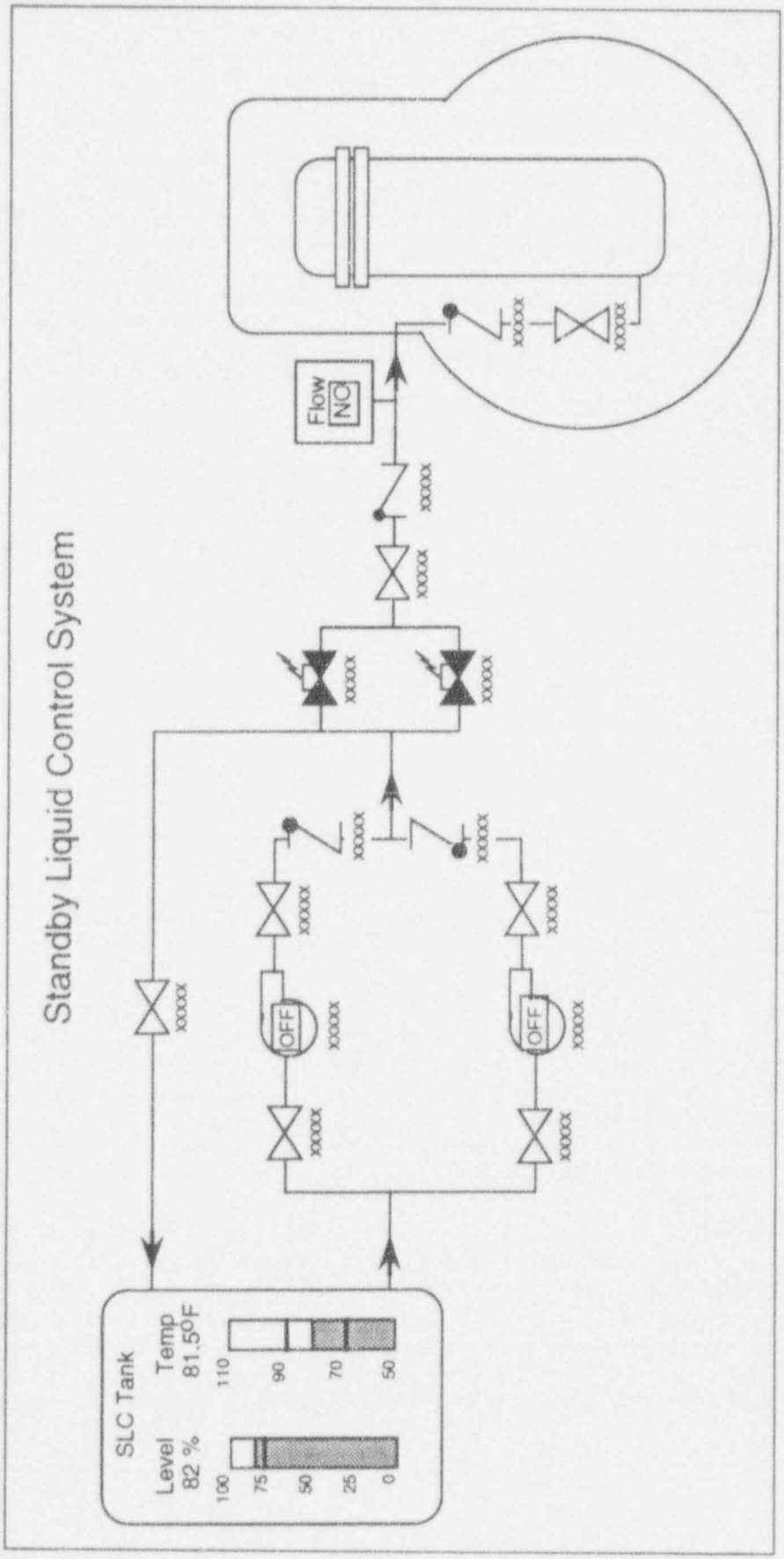

Figure 1.9. Example of a mimic display

1.2.9-1 Feature Identification

Significant features of a map should be labeled directly on the display unless cluttering or obscuring of other information would result.

ADDITIONAL INFORMATION: Labels on a map should be positioned consistently in relation to the displayed features they designate. For example, equipment names might always be placed immediately above the corresponding symbols showing their locations. As a practical matter, map displays can get very crowded. It may not always prove feasible to maintain a consistent placement for labels, with the result that designers will be tempted to put labels wherever they will fit. In such a crowded display, labels may obscure map features, and vice versa. Locating and reading labels will be slowed,particularly when map features are displayed closely adjacent to the beginning of labels. Under these circumstances, some other approach to map labeling should be considered to avoid crowding.[A,E]

1.2.9-2 Consistent Orientation

When several different maps will be displayed, a consistent orientation should be used so that the top of each map will always represent the same direction.

ADDITIONAL INFORMATION: In common use, most maps are oriented so that North is upward.[A,D,E]

1.2.9-3 User Selectable Orientation

The user should be able to select different orientations and reference points.

ADDITIONAL INFORMATION: The system should provide the user with a listing the common orientations and reference points. If the map display can be displayed at other workstations, only the display at the user's workstation should be affected by the selection. The selected orientation should be clearly indicated, e.g., with a label.[D]

1.2.9-4 Panning Map Displays

When a map exceeds the capacity of a single display frame, users should be able to pan the display over the mapped data in order to examine different areas of current interest.

ADDITIONAL INFORMATION: Panning is preferred to breaking map displays into discrete pages. Some graphic indicator of the position in the overall display of the visible section should be provided when a user pans over an extended display in order to view different sections.[A,E]

1.2.9-5 Area Coding

Codes, such as texture patterns, color, or tonal variations, should be used when different areas of a map must be defined, or when geographic distribution of a particular variable must be indicated.

ADDITIONAL INFORMATION: It may be desirable to limit area coding to one variable in order to assure effective information assimilation. Another approach might be to allow a user to specify which variable will be coded on a map and to change that selection at will depending upon current task requirements. In some special applications, however, it may be feasible to superimpose several kinds of area coding to permit multivariate data analysis by skilled users.[E]

1.2.9-6 Color Tonal Codes

Tonal codes (different shades of one color) rather than spectral codes (different colors) should be used when users must make relative judgments for different colored areas of a display.

ADDITIONAL INFORMATION: People can order categories along a continuous dimension to match tonal variations in one color, whereas people do not have a natural means of ordering different colors. This recommendation represents an exception to other guidelines advocating distinctive code values. Coding by tonal variation should be considered only for applications where perception of relative differences along a single dimension is more important than perception of absolute values.[E]

1.2.9-7 Ordered Coding

Where different areas of a map are coded by texture patterns or tonal variation, the darkest to lightest shades correspond to the extreme values of the coded variable.

ADDITIONAL INFORMATION: Orderly assignment of code values will help users perceive and remember the categories represented by the code.[E]

1.2.9-8 Mapping Nongeographic Data

In applications where the geographic distribution of nongeographic data must be displayed, other graphic elements should be added to a map for that purpose.

ADDITIONAL INFORMATION: A display for radioactive control, for example, might superimpose plume tracks on a background of geographic coordinates, with supplementary annotation and/or coding to indicate track identification, speed, heading, altitude, etc. Alphanumeric characters might be added to a map to show data, but those will not aid a direct visual comparison across areas in the same way that graphic symbols can do. Moreover alphanumeric data may be confused with labels and other kinds of annotation. For example, a symbol might be displayed in different sizes to indicate a particular measure in different localities, or small stacked bars might be superimposed on the different areas of a map to indicate the local distribution of some data measure.[A,E]

1.2.9-9 Highlighting Data Change

When changes in mapped data are significant for a user's task, auxiliary graphic elements should be included to highlight those changes.

ADDITIONAL INFORMATION: For example, auxiliary coding might be needed to indicate vehicular movement on a map of showing evacuation routes.[E]

1.2.9-10 Aids for Analyzing Maps

When the use of mapped data may be complex, computer aids should be provided for data analysis.

ADDITIONAL INFORMATION: Computer aids should be provided when a user must judge distances accurately on a map or other graphic display for that judgment. For exact measurement, it might be better to allow a user to select (point at) any two points and have the computer "read-out" their separation distance directly. The same technique might be used to determine the direction (bearing) between two points.[A,E]

1.2.10-1 Display Range Coding

Zones indicating operating ranges should be color coded by edge lines or wedges for circular scales.

ADDITIONAL INFORMATION: Zones can be used to indicate operating ranges, off-normal levels, dangerous levels, etc.[B]

1.2.10-2 Location of Zero

When check-reading positive and negative values, the zero or null position should be at 12 o'clock or 9 o'clock.

ADDITIONAL INFORMATION: With a matrix of circular displays, deviations from a 9 o'clock null position are easily detected in check reading. Zero should appear at the 12 o'clock position on multi revolution dials.[B]

1.2.10-3 Pointer Orientation

The pointer on fixed scales should extend from the right of vertical scales and from the bottom of horizontal scales.[B]

1.2.10-4 Pointer Obscurement

The pointer on fixed scales should extend to but not obscure the shortest graduation marks.[B]

1.2.10-5 Tick Mark Separation

Tick marks should be separated by at least 0.07 in. (1.75 mm) for a viewing distance of 28 in. (71 cm) under low illumination.

ADDITIONAL INFORMATION: Low illumination is less than less than 1.0 ft-L (3.5 cd/m^2).[B]

1.2.10-6 Number of Tick Marks

Scales should not be cluttered with more marks than necessary for precision.[B]

1.2.11-1 Limits on Speech Messages

Speech should be limited to provide only a few messages.

ADDITIONAL INFORMATION: Speech messages would not be useful, for example, if many messages might be given at one time, or for conveying a lengthy list of menu options.[E]

1.2.11-2 Message Repeat Capability

The user should be able to have speech messages repeated.[E]

1.2.11-3 Simple Spoken Messages

Messages should be short and simple.

ADDITIONAL INFORMATION: If a user does not understand a written message, it can be reread. That is not as easy with spoken messages, even though a REPEAT function should be provided. A better approach is to restrict use of speech outputs to short and simple messages. If a user who may not be watching a display must be given long or complex messages, it is probably better to provide a simple auditory signal such as a chime, and then display the messages visually for the user to read. In general, users will understand complex messages better when they see them displayed than when they hear them.[E]

1.2.11-4 Type of Voice

A distinctive and mature voice should be used.[A]

1.2.11-5 Delivery Style

Spoken warning signals should be presented in a formal, impersonal manner.[C]

1.2.11-6 Word Selection

Words in a speech message should be concise, intelligible, and appropriate for the information presented.

ADDITIONAL INFORMATION: Where possible, words that rhyme or may confuse message interpretation should not be part of the spoken lexicon, or should not be presented within the same message. Use of slang should be avoided. Words with more than one syllable should be used. Alphanumeric data should be presented using phonetic alphabets, e.g., "Whiskey Zebra three two seven" should be used in preference to "WZ327" where the "Z" and "3" are too phonetically similar.[A]

1.2.11-7 Speech Message Priority

A speech message priority system should be established such that more critical messages override the presentation of any message occurring below it on the priority list.

ADDITIONAL INFORMATION: If two or more incidents or malfunctions occur simultaneously, the message having the higher priority should be given first. The remaining messages should follow in order of priority. In the event of a complete subsystem failure, the system should integrate previous messages via electronic gating and report the system rather than the component failure.[C]

1.2.11-8 Distinctive Spoken Warnings

If speech is used to provide warnings as well as other forms of user guidance, spoken warnings should be easily distinguishable from routine messages.

ADDITIONAL INFORMATION: For example, speech output used to identify emergency conditions might use some distinctive voice and/or preface each warning message with some other distinctive auditory alert signal. In some applications, computer-generated speech might be useful for providing a few short and simple warnings. However, if speech output is also used for other purposes, then the warning messages must be distinctive.[E]

1.2.11-9 Intensity of Speech Presentation

Speech signal intensity should be clearly audible for the expected ambient noise environment.

ADDITIONAL INFORMATION: For critical messages, speech should be at least 20 db above the speech interference level at the operating position of the intended receiver. Signal to noise ratios should be at least 5:1. Audio signal power should be approximately 300 milliwatts at the listeners ear. Speech signals should fall within the range of 200 to 6100 Hz.[A,C]

1.3.1-1 Conventional Use of Mixed Case

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

ADDITIONAL INFORMATION: Reading text is easier and faster when capitalization is used conventionally to start sentences and to indicate proper nouns and acronyms. There are several exceptions, however. An item intended to attract the user's attention, such as a label or title, can be displayed in upper case. Also, upper case should be used when lower case letters will have decreased legibility, e.g., on a display terminal that cannot show true descenders for lower case letters.[A,D,E]

1.3.1-2 Font Style

A clearly legible font should be utilized. Fonts should have true ascenders and descenders, uniform stroke width, and uniform aspect ratio.

ADDITIONAL INFORMATION: Preference should be given to simple styles. Script and other highly stylized fonts (e.g., shadow, calligraphy) should be avoided. Avoid typefaces that: have extended serifs, internal patterns, or stripes; are italicized, stenciled, shadowed or 3-dimensional; appear like handwritten script or like Old English script; are distorted to look tall and thin or wide and fat. The basic evaluation criterion for font selection should be legibility.[B,D]

1.3.1-3 Distinguishability of Characters

For a given font, it should be possible to clearly distinguish between the following characters: X and K, T and Y, I and L, I and 1, O and Q, S and 5, and U and V.[B]

1.3.1-4 Character Size for Text Readability

For reading of continuous text, the minimum character height should be 16 minutes of arc (4.7 mrad) and the maximum character height should be 24 minutes of arc (7 mrad).

ADDITIONAL INFORMATION: Character heights of 20 to 22 minutes of arc (5.5 to 6.5 mrad) are preferred for reading tasks. Characters should not be larger than 45 minutes of arc (13 mrad) when groups of characters are displayed. Minutes of arc can be converted into height as follows

$$\text{Height} = 2\pi D(MA)/21600$$

where

MA is minutes of arc, and
D is the distance from the user to the screen.[F,D]

1.3.1-5 Character Height-to-Width Ratio

For fixed (as opposed to proportionally spaced) presentations, the height-to-width ratio should be between 1:0.7 to 1:0.9.

ADDITIONAL INFORMATION: For proportionally spaced presentations, a height-to-width ratio closer to 1:1 should be permitted for some characters, for example, the capital letters M and W. The height-to-width ratio of a given character is the vertical distance between the top and bottom edges, and the left and right edges of a nonaccented capital letter. Some letters, however, are customarily seen as narrower than others. For example, in a given character set the letter I, and sometimes the letter J, appear narrower than M and 2. Lowercase letters may similarly vary in width. Accordingly, the height-to-width ratio of a given character set should be the modal character width - that is, the width that occurs most often - in the set of capital letters. These measurements are to be made at the same luminance level as the resolution measurement (see 1.5.1-1).[F]

1.3.1-6 Character Format/Aspect Ratio

A 4x5 (width-to-height) character matrix should be the minimum matrix used for superscripts and for numerators and denominators of fractions that are to be displayed in a single character position.

ADDITIONAL INFORMATION: A 5x7 (width-to-height) character matrix should be the minimum matrix used for numeric and uppercase-only presentations. The vertical height should be increased upward by two dot positions if diacritical marks are used. A 7x9 (width-to-height) character matrix should be the minimum matrix for tasks that require continuous reading for context, or when individual alphabetic character legibility is important, such as in proofreading. The vertical height should be increased upward by two dot (pixel) positions if diacritical marks are used. If lower case is used, the vertical height should be increased downward by at least one dot (pixel) position, preferably two or more, to accommodate descenders of lower case letters. Stroke width should be greater than 1/12 of the character height. A stroke width may be more than one pixel wide.[F]

1.3.1-7 Inter-Character Spacing

Between-character spacing should be a minimum of 10 percent of character height.[F]

1.3.1-8 Brightness Ratio

The characters should be at least twice as light (or dark) as the background.[D]

1.3.2-1 Meaningful Abbreviations

When abbreviations are used, those abbreviations should be meaningful and commonly recognized.

ADDITIONAL INFORMATION: When abbreviation is necessary due to space constraints, the words chosen for abbreviation should be those that are commonly known in their abbreviated form, and/or those words whose abbreviations can be unambiguously interpreted. To indicate that there is low pressure in the condensate storage tank, the use of "CST Pressure Low" would be acceptable, but "Condensate Storage Tank Prssr Lw" is not a good abbreviation.[E]

1.3.2-2 Abbreviation Rule

When defining abbreviations which are not common to the user population, a simple rule should be used that users understand and recognize.

ADDITIONAL INFORMATION: Abbreviation by truncation is the best method, except when word endings convey important information. When a truncation rule is used, abbreviations are easy to derive and easy for a user to decode. If an abbreviation deviates from the consistent rule, it may be helpful to give it some special mark whenever it is displayed.[E]

1.3.2-3 Distinctive Abbreviations

Abbreviations should be distinctive so that abbreviations for different words are distinguishable.[A,C,E]

1.3.2-4 Minimal Punctuation of Abbreviations

Punctuation of abbreviations and acronyms should be minimized.

ADDITIONAL INFORMATION: For example, SPDS is preferred over S.P.D.S. Punctuation should be retained when needed for clarity, e.g.,"4-in. diameter pipe" rather than "4 in diameter pipe."[A,E]

1.3.2-5 Short Abbreviations for Arbitrary Codes

When arbitrary codes must be remembered by the user, characters should be grouped in blocks of three to five characters, separated by a minimum of one blank space or other separating character such as a hyphen or slash.

ADDITIONAL INFORMATION: Arbitrary codes are alphanumeric characters without natural organization. When a code is meaningful, such as a mnemonic abbreviation or a word, it can be longer.[A,D,E]

1.3.2-6 Avoid O and I in Arbitrary Codes

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.[D]

1.3.2-7 Combining Letters and Numbers in Arbitrary Codes

When codes combine both letters and numbers, letters should be grouped together and numbers grouped together rather than interspersing letters with numbers.

ADDITIONAL INFORMATION: For example, letter-letter-number ("HW5") will be read and remembered somewhat more accurately than letter-number-letter ("H5W").[A,D,E]

1.3.3-1 Group Labels

Each individual aspect of a display (e.g., data group, field, or message) should contain a distinct, unique, and descriptive label.[A,C,D,E]

1.3.3-2 Meaningfulness

Labels should be meaningful words or accepted technical terms.

ADDITIONAL INFORMATION: Labels should describe the contents of the display accurately and concisely, without unnecessary words or characters. Whenever space permits, the label should consist of the entire word or sequence of words that describes the displays. If abbreviations are necessary, their meanings should be readily understood by users.[D,E,A]

1.3.3-3 Label Formats

Label formats should be consistent across and within displays.[A,C,D,E]

1.3.3-4 Consistent Wording of Labels

Labels should be worded consistently, so that the same item is given the same label whenever it appears.

ADDITIONAL INFORMATION: Consistent grammatical format for different labels should also be employed; i.e., single words or phrases for some labels and short sentences for others, or verbs for some and nouns for others should not be used.[E]

1.3.3-5 Distinctive Labels

Labels should be uniquely and consistently highlighted, capitalized, or otherwise emphasized to differentiate them from other screen structures and data.

ADDITIONAL INFORMATION: The technique used should be easily distinguished from that used to highlight or code emergency or critical messages, such as by bolding, underlining and use of capitals.[A,C,D,E]

1.3.3-6 Label Separation

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

1.3.3-7 Normal Orientation for Labels

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

ADDITIONAL INFORMATION: Users should be presented with horizontally displayed labels, even for the vertical axis of a graph. A conventional text orientation of labels will permit faster, more accurate reading. While it may be possible to tilt the page to read a disoriented label on a printed page, a user usually cannot tilt a VDU display screen.[E]

1.3.3-8 Label Content for User Options

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

1.3.3-9 Graphic Objects

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

ADDITIONAL INFORMATION: When possible, the label should be on the component if it does not obscure the component. If multiple component parts of the graphic object are close to the label, a line should point from the label to the associated part.[D]

1.3.4-1 Appropriate Use of Icons

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

ADDITIONAL INFORMATION: Icons may be used to graphically represent operations, processes and data structures, and may be used as means of exercising control (e.g., by selecting an icon and commanding operations) over system functions, components, and data structures.[A,D]

1.3.4-2 Iconic Representation

Icons should be designed to look like the objects, processes, or operations they represent, by use of literal, functional, or operational representations.

ADDITIONAL INFORMATION: Some pictorial symbols have conventional meanings within a user population, which must be followed to ensure their correct interpretation. Examples of representations: literal, a figure of a pump; functional, a figure of a file cabinet; operational, a hand on a switch.[A,C,E]

1.3.4-3 Simple Design

Icons should be simple closed figures when possible.

ADDITIONAL INFORMATION: When icons are too visually complex, they are not quickly recognized. This eliminates the primary advantage of using icons i.e., quick recognition. Simple, closed figures are processed more efficiently than are open figures.[D]

1.3.4-4 Use of Abstract Symbology

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

1.3.4-5 Distinguishability

Each icon and symbol should represent a single object or action, and should be easily discriminable from all other icons and symbols.

ADDITIONAL INFORMATION: The distinguishing feature between icons should be the external geometric configuration of the icon.[D]

1.3.4-6 Consistent Use of Special Symbols

Special symbols to signal critical conditions should be used exclusively for that purpose.[A,B,E]

1.3.4-7 Upright Orientation

Icons and symbols should always be oriented "upright."[B]

1.3.4-8 No Alternating Words and Symbols

Words and symbols should not be used alternately.

ADDITIONAL INFORMATION: Alternate use of symbols and words could cause confusion and impair task performance.[B]

1.3.4-9 Size

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

1.3.4-10 Highlighting

An icon or symbol that the user has selected should be highlighted.[D]

1.3.4-11 Labeling Icons

Icons should be accompanied by a text label.

ADDITIONAL INFORMATION: To the extent that it does not clutter or cause distortion of the icon, the label should be incorporated into the icon itself. When icons are designed such that the label is inside the icon, the number of perceptual objects is reduced, resulting in enhanced processing of the label and the icon. The text label may be omitted for icons having unambiguous meanings to users, e.g., standard P&ID symbology.[D]

1.3.4-12 Labels for Control Option Icons

If icons are used to represent control action options, a label indicating the action should be associated with the icon.[A,E]

1.3.5-1 Number System

Numeric data should be displayed in the decimal, rather than binary, octal, hexadecimal or other number system.[C]

1.3.5-2 Leading Zeros

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

ADDITIONAL INFORMATION: For example, 28 should be displayed rather than 0028. A leading zero should be provided if the number is only a decimal, with no preceding integer (i.e., 0.43 rather than .43).[C,D]

1.3.5-3 Maintaining Significant Digits

A number should be displayed at the number of significant digits required by users to perform their tasks.

ADDITIONAL INFORMATION: Arbitrary conventions should not require that displays present more (or fewer) significant digits than necessary.[B]

1.3.5-4 Display Range

Numeric displays should accommodate the variable's full range.

ADDITIONAL INFORMATION: The full range of the variable means highest and lowest values that the variable is expected to take on, under any conditions (normal operations, emergency operations, etc) for the tasks the display is designed to support.[B]

1.3.5-5 Rate of Display Change

Digital displays should change slowly enough to be readable.[B]

1.3.5-6 Direction of Change in Digital Display

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

ADDITIONAL INFORMATION: Rapidly changing digital values are difficult to read, and directional indicators will help the operator interpret the direction of trend.[B]

1.3.5-7 Direct Display of Differences

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

ADDITIONAL INFORMATION: If it is important for the user to be aware of a discrepancy between two sets of data, the difference should be highlighted on the display.[C]

1.3.5-8 Orientation of Numbers

All numbers should be oriented upright.[B]

1.3.6-1 Numbering of Scales

Numbers on a scale should increase clockwise, left to right, or bottom to top.[B]

1.3.6-2 Scale Intervals

Nine should be the maximum number of tick marks between numbers.[B]

1.3.6-3 Scaling in Standard Intervals

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.

ADDITIONAL INFORMATION: Users will find it difficult to interpret scales based on odd intervals. It is not advisable to let the computer divide available scale space automatically if that results in a scale labeled in unfamiliar intervals such as 6 or 13. In special instances, the X-axis might be scaled in odd intervals to show customary divisions, such as the 12 months in a year.[A,D,E]

1.3.6-4 Circular Scales

For one-revolution circular scales, zero should be at 7 o'clock and the maximum value should be at 5 o'clock, with a 10-degree break in the arc.[B]

1.3.6-5 Axis Labels

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

ADDITIONAL INFORMATION: Labels should be displayed in upright orientation on both the X- and Y-axis for ease of reading.[A,E]

1.3.6-6 Identification of Units of Measurement

The units of measurement represented by the scale should be included in the axis label.[A,E]

1.3.6-7 Scaling Conventions

Conventional scaling practice should be followed, in which 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 a caused effect.

ADDITIONAL INFORMATION: When the X-axis represents time intervals, the labeled scale points should represent the end of each time interval. This consistent usage will aid interpretation of all data plots, including scatterplots, line graphs, and bar charts.[A,D,E]

1.3.6-8 Consistent Scaling

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

ADDITIONAL INFORMATION: Note that in many applications it may prove more effective to display data for comparison in a single combined chart, rather than requiring users to compare data across a series of charts. Users will find it difficult to compare data sets that are scaled differently. Moreover, users may overlook differences in labeling, and assume that the same scale has been used even when displayed scales are actually different from one another.[A,C,E]

1.3.6-9 Scales Consistent with Function

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

ADDITIONAL INFORMATION: For example, the monitoring of neutron flux at reactor trip must have a variable scale of 0 to 100% of the design value and a time scale resolution of seconds. However, post-trip monitoring may have a variable scale of 0 to 10% with a time scale resolution of minutes. Finally, operational log data of neutron flux may have a time scale resolution of hours.[B]

1.3.6-10 Linear Scaling

A linear scale should be used for displayed data, in preference to logarithmic or other non-linear methods of scaling, unless it can be demonstrated that non-linear scaling will facilitate user interpretation of the information.

ADDITIONAL INFORMATION: Most users are more familiar with linear scales and will interpret linear scales more accurately than other methods of scaling. However, since logarithmic scales show percentage change rather than arithmetic change, they may be appropriate for some special applications.[A,G,E]

1.3.6-11 Numeric Scales Start at Zero

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

ADDITIONAL INFORMATION: Numerical scales generally 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 organization would be: a) if the numbers are used for naming categories, b) if zero is not a possible number on the scale, or c) 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.[A,D,E]

1.3.6-12 Display of Origin

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.

ADDITIONAL INFORMATION: When the data include 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.[A,E]

1.3.6-13 Single Scale On Each Axis

Only a single scale should be shown on each axis, rather than including different scales for different curves in the graph.

ADDITIONAL INFORMATION: Single-scale graphs will generally permit more accurate reading than graphs displaying several scales. Many users will be confused by multiple-scale graphs and make errors when interpreting them. Moreover, by changing the relative scale factors of multiple-scale graphs it is possible to change radically their apparent meaning and bias interpretation by users.[A,C,D,E]

1.3.6-14 Scaling Against a Reference Index

If different variables on a single graph require different scales, they should be scaled against a common baseline index, rather than showing multiple scales.

ADDITIONAL INFORMATION: Rather than showing power in megawatts and profits in dollars, both might be graphed in terms of percent change from a baseline. An indexed chart can permit comparisons among different variables when multiple scales would otherwise be needed. However, care should be taken in selecting an appropriate baseline against which to index, in order to ensure that comparisons will not be biased. Index scaling may also be appropriate for showing the effect of a single variable whose units of measurement change in real value with time.[A,E]

1.3.6-15 Indication of Scale

When a graphic display has been expanded from its normal coverage, some scale indicator of the expansion factor should be provided.[A,E]

1.3.6-16 Manual Rescaling

Users should be able to manually change the scale for the purpose of maintaining an undistorted display for different operating conditions.[G]

1.3.6-17 Indication of Automatic Rescaling

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 operator confusion if the change in scale is not recognized.[G]

1.3.6-18 Aids for Scale Interpolation

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

ADDITIONAL INFORMATION: It might suffice, for example, to allow users to request a fine grid as an optional display feature. It might be better to display vertical and horizontal rules that a user could move to intersect the axes of a chart. It might prove best simply to let a user point at any data item and have the computer label that item with a readout of its exact value(s).[C,E]

1.3.6-19 Unobtrusive Grids

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

ADDITIONAL INFORMATION: Grid lines should be thinner than data curves, and should be invisible behind depicted objects and areas. Heavy vertical grid lines may conceal the height of plotted peaks. Electronic displays offer more flexibility than printed graphs. Grids can be displayed or suppressed by user selection. For reading the value of a particular data point, perhaps no grid is needed at all. A user might simply ask the computer to display the value of any selected point.[A,C,D,E]

1.3.6-20 Numbering Grids

Graphs should be constructed so that the numbered grids are bolder than unnumbered grids.[B]

1.3.6-21 Discontinuous Axes

When data comparisons of interest fall within a limited range, the scaled axis should emphasize that range, with a break in the displayed axis to indicate discontinuity with the scale origin.

ADDITIONAL INFORMATION: Note, however, that a broken axis distorts the displayed value in relation to a base value and so risks confusing users. In effect, a user will expect that a scale marked in regular intervals will continue in a consistent fashion. If an axis must be broken, label that break clearly, perhaps with some indicator that extends across the displayed graph.[A,D,E]

1.3.6-22 Duplicate Axes

When scaled data will contain extreme values, duplicate axes should be displayed, so that the X-axis appears at both the top and bottom, and the Y-axis at both the left and right sides of the graph.

ADDITIONAL INFORMATION: Extreme data values may be located far from conventionally placed axes. When duplicate axes are displayed at the top and right side, users will find it easier to read the extreme values.[A,D,E]

1.3.6-23 Restricted Use of Three-Dimensional Scaling

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

ADDITIONAL INFORMATION: Showing a Z-axis on a VDU display that is limited to two actual dimensions will confuse many users. If three-dimensional scaling is employed, a consistent method of representation (e.g., isometric or orthographic projection, perspective drawing, or triangular coordinate grid) should be used. It is often possible in graphic display to show a third dimension through use of auxiliary coding (e.g., color or shape coding, or supplementary annotation), which may prove more effective than trying to represent a third spatial dimension pictorially.[A,E]

1.3.7-1 Line Types

Meaningful differences between lines appearing in graphic displays, such as flow paths, should be depicted by using various line types, e.g., solid, dashed, dotted, and widths.

ADDITIONAL INFORMATION: Three or four line types may be readily distinguished, and two or three line widths may be readily distinguished.[A,E]

1.3.7-2 Conventional Use of Arrows

In flow charts and other graphics displays, arrowheads should be used in a conventional fashion to indicate directional relations in the sequential links between various elements.[D,E]

1.3.7-3 Restricted Use of Borders

Unnecessary borders should not be used in the display.

ADDITIONAL INFORMATION: Borders can add visual clutter to a display and add to information processing time. Borders should only be used for functional purposes, such as to facilitate grouping.

1.3.7-4 Bordering Single Blocks

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

1.3.7-5 Distinctive Borders Around Critical Information

If several labels or messages are clustered in the same area, distinctive borders should be placed around the critical ones only.[B]

1.3.8-1 Conservative Use of Color

Where color is used for coding, it should be employed conservatively.

ADDITIONAL INFORMATION: Casual, arbitrary use of colors on every display may cause displays to appear "busy" or cluttered. Casual use of color will also reduce the likelihood that significant color coding on particular displays will be interpreted appropriately and quickly by a user.[A,B,E]

1.3.8-2 Color Coding for Discrete Data Categories

When a user must distinguish rapidly among several discrete categories of data, a unique color should be used to display the data in each category.

ADDITIONAL INFORMATION: Color coding of discrete categories is particularly useful when data items are dispersed on a display. With some display equipment now providing a wide range of different colors, designers may be tempted to exploit that capability by using many different colors for coding. The capability to display many colors may be useful for depicting complex objects, and for providing tonal codes to show the relative values of a single variable. However, such a capability is not useful for coding discrete categories, except that it may allow a designer to select more carefully the particular colors to be used as codes.[A,D,E]

1.3.8-3 Color Coding for Relative Values

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.

ADDITIONAL INFORMATION: For example, in displaying tank depth, a saturated blue might be used to show the deepest point, with gradually desaturated blues to show decreasing depth. Differences in color should not be used to represent differences in quantities. For example, the color should not change from blue to red as volume increases in the Refueling Water Holdup Tank.[E]

1.3.8-4 Color Coding to Draw Attention

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

ADDITIONAL INFORMATION: Both intensity and saturation should be used to draw a user's attention to critical data. Although saturated and/or intense hues are useful for drawing a user's attention, their overuse will result in a display which is garish and difficult to view for long periods.[A,E]

1.3.8-5 Color Selection

Colors for coding should be based on user conventions with particular colors.

ADDITIONAL INFORMATION: Color codes should conform to color meanings that already exist in the user's job. Color codes employing different meanings will be much more difficult to use. Table 1.3 provides general nuclear plant color meanings.[A,B,E]

1.3.8-6 Saturated Blue for Background Color

Saturated blue should only be used for background features in a display and not for critical data.

ADDITIONAL INFORMATION: Saturated blue symbols appear dimmer than others, and users have greater difficulty focusing on saturated blue.[E]

Table 1.3. Associations and Related Characteristics for Colors Typically Used in Panel Design and Related Applications in Nuclear Power Plants

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	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.

1.3.8-7 Easily Discriminable Colors

When selecting colors for coding discrete categories of data, those colors should be easily discriminable.

ADDITIONAL INFORMATION: Table 1.4 identifies the wavelengths of colors that are easily discriminable. For example, on a light background: red, dark yellow, green, blue and black -- on a dark background: desaturated red, green and blue, plus yellow and white. 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.[A,E]

1.3.8-8 Unique Assignment of Color Codes

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

ADDITIONAL INFORMATION: Color will prove the dominant coding dimension on a display. If several different categories of data are displayed in red, say, they will have an unwanted visual coherence which may hinder proper assimilation of information by a user.[E]

1.3.8-9 Minimum Color Differences

When color coding is used for discriminability or conspicuity of displayed information, all colors in the set should differ from one another by a minimum of 40ΔE (CIE L*u*v*) distances.

ADDITIONAL INFORMATION: 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 CRTs.

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:

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

where $L^* = 116(Y/Y_0)^{1/3} - 16;\ 1.0 > Y/Y_0 > .01$

$u^* = 13L^* (u' - u'_0)$

$v^* = 13L^* (v' - v'_0)$

$u' = 4X / (X + 15Y + 3Z)$

$v' = 9Y / (X + 15Y + 3Z)$

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

For reference white, D6500 K° $u'_0 = 1.98$ and $v'_0 = .468$

For reference white, 9300 K° + 27 MPCD $u'_0 = 1.81$ and $v'_0 = .454$

(MPCD = Minimum Perceptible Color Difference)

Y is luminance in candela/meter^2. Y_0 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. Y_0 in this use of the ΔE (CIE L*u*v*) distance metric is defined differently than suggested by the CIE.[F]

1.3.8-10 Color Contrast

For adequate legibility, colored symbols should differ from their color background by a minimum of 100 ΔE (CIE Yu'v') distances.

ADDITIONAL INFORMATION: The legibility of characters in color on a colored background can be assessed with a metric, ΔE (CIE Yu'v'), derived from the 1976 CIE UCS color diagram. As with the ΔE (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 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 1.3.8-9)
$\Delta v'$ = difference between v' coordinates of text and background (see 1.3.8-9).

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

1.3.8-11 Redundant Color Coding

Color coding should be redundant with some other display feature.

ADDITIONAL INFORMATION: Displayed data should provide necessary information even when viewed on a monochromatic display terminal or hard-copy printout, or when viewed by a user with color vision impairment.[A,B,E]

1.3.8-12 Unplanned Patterns from Color Coding

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

Table 1.4. Representative Set of Candidate Colors that Should be Considered for Use in Panel Design and Related Applications

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/

1.3.9-1 Limited Use of Size Coding

Size coding should be used only for applications where displays are not crowded.

ADDITIONAL INFORMATION: Size coding is achieved by varying the size of displayed alphanumerics, labels, and other symbols.[E]

1.3.9-2 Size Variations

A maximum of three size levels should be used. The major dimensions of the larger symbol should be at least 150 percent of the major dimension of the smaller symbol.

ADDITIONAL INFORMATION: An increase in symbol height must usually be accompanied by a proportional increase in width to preserve a constant aspect ratio and so facilitate symbol recognition.[A,E]

1.3.9-3 Size Coding Proportional to Data Value

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.

ADDITIONAL INFORMATION: A user's judgement of the "size" of a symbol will correspond more closely to its area than to its diameter.[B]

1.3.9-4 Geometric Area Coding

For area coding, the maximum number of levels should be six (preferably no more than three).[B]

1.3.9-5 Length Coding

For length coding, the maximum number of levels should be six (preferably no more than three).[B]

1.3.9-6 Establishing Standards for Shape Coding

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

ADDITIONAL INFORMATION: Coding with geometric shapes should be used to help users discriminate different categories of data on graphic displays. Although shape codes can often be mnemonic in form, their interpretation will generally rely on learned association as well as immediate perception. Existing user standards must be taken into account.[B,C,D,E]

1.3.9-7 Clearly Discriminable Shapes

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

ADDITIONAL INFORMATION: For example, the elements of one group in a display might be triangles and the elements of a second group might be circles. Approximately 15 different shapes can be readily distinguished, provided the shapes are properly designed.[D]

1.3.9-8 Simple Pattern Codes

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

ADDITIONAL INFORMATION: To aid visual discrimination and identification, simple patterns, such as hatching, should be employed rather than complex patterns.[E]

1.3.9-9 Darkest/Lightest Correspond to Extreme Values

Where patterns are used, values should be selected so that the darkest and lightest shades correspond to the extreme values of the coded variable.[A]

1.3.10-1 Easily Recognizable Highlighting

Highlighting should be easily recognizable and be used to attract the user's attention to active fields, special conditions, or as a means to provide feedback.[A]

1.3.10-2 Minimal Highlighting

Highlighting of information should be minimized.

ADDITIONAL INFORMATION: A rule of thumb for displays of nominal conditions is to limit the maximum amount of highlighting to 10% of the display information. If highlighting is to be used to attract the user's attention, the highlighting technique should be distinctive. If a large portion of a display is highlighted, the highlighting will no longer be distinctive.[D]

1.3.10-3 Consistency

A particular highlighting method should be used consistently.[D]

1.3.10-4 Removing Highlighting

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

ADDITIONAL INFORMATION: If highlighting identifies an error, that highlighting should be removed when the error is corrected.[A,E]

1.3.10-5 Appropriate Use of Brightness Coding

Coding by differences in brightness should be used for applications that require discrimination between only two categories of displayed items.

ADDITIONAL INFORMATION: Brightness should be treated as a two-valued code, bright and dim. For example, a data form might display dim labels and bright data items, in order to facilitate data scanning. Brightness coding should not be used in conjunction with shape or size coding.[B,E]

1.3.10-6 Significance of Brightness Levels

High brightness levels should be used to signify information of primary importance, and lower levels should be used to signify information of secondary interest.[B]

1.3.10-7 Brightness Coding Intensities

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

ADDITIONAL INFORMATION: The intensities used should not be less than 6 ft-L (20 cd/m^2). Intensity coding should not be used for displays with a maximum display luminance of less than 18 ft-L (60 cd/m^2) or more than 29 ft-L (100 cd/m^2).[B,E]

1.3.10-8 Image Reversal

Image reversal should be used primarily for highlighting in dense data fields or to indicate selection of on-screen objects and information.[B]

1.3.10-9 Appropriate Use of Flash Coding

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

ADDITIONAL INFORMATION: 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.[A,B,D,E,F]

1.3.10-10 Flash Coding for Text

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.[A,D,E]

1.3.10-11 Small Area

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

1.3.10-12 Coding by Flash Rate

No more than two flash rates should be used.

ADDITIONAL INFORMATION: 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.[A,D,E,F]

1.3.10-13 Flash Suppression

Event acknowledgement or flash suppression keys should be provided.[A]

1.3.10-14 Long-Persistence Phosphor Displays

Flashing should not be used with long-persistence phosphor displays.[B]

1.3.11-1 Appropriate Use of Auditory Signals

Audio signals should be provided to warn personnel of impending danger, to alert an operator to a critical change in system or equipment status, and to remind the operator of a critical action or actions that must be taken.

ADDITIONAL INFORMATION: An alerting/warning system or signal should provide the operator with a greater probability of detecting the triggering condition than his normal observation would provide in the absence of the alerting/warning system or signal.[B,C,E]

1.3.11-2 Signal Priority Distinction

Caution signals should be readily distinguishable from warning signals and used to indicate conditions requiring awareness, but not necessarily immediate action.[C]

1.3.11-3 Association with Visual Warnings

Auditory alerts, as well as caution and warning sounds, should accompany visual displays.

ADDITIONAL INFORMATION: The audio signal should be used to alert and direct operator attention to the appropriate visual display.[C,D]

1.3.11-4 Unique Signal-Event Association

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

1.3.11-5 Total Number of Simple Signals

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

1.3.11-6 Use with Several Visual Displays

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.[C]

1.3.11-7 Confusible Signals

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

ADDITIONAL INFORMATION: Examples of such signals include trains of impulses that resemble electrical interference, or signals similar to noise generated by air conditioning or other equipment. 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.[C]

1.3.11-8 Signal Compatible with Environment

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

ADDITIONAL INFORMATION: Audio signals should not startle listeners, add significantly to overall noise levels, or prevent communication among users.[A,B]

1.3.11-9 Turning Off Non-Critical Auditory Signals

Noncritical auditory signals should be capable of being turned off at the discretion of the user.

ADDITIONAL INFORMATION: A simple, consistent means of acknowledging and turning off warning signals should be provided.[A,D]

1.3.11-10 Indicating Who is to Respond

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

1.3.11-11 Frequency of Auditory Signals

The frequency of an audio signal should be within the range of 200 to 5000 Hz, and preferably between 500 and 3000 Hz.

ADDITIONAL INFORMATION: 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.[B]

1.3.11-12 Signal Bending Around Obstacles

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

1.3.11-13 Detecting Small Changes in Intensity

When small changes in signal intensity must be detected, the signal frequency should be from 1000 to 4000 Hz.[B]

1.3.11-14 Signal Travel Over 1000 ft

When an audio signal must travel over 1000 ft., its frequency should be less than 1000 Hz.[B]

1.3.11-15 High or Unknown Noise Environments

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.[B]

1.3.11-16 Masking

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

1.3.11-17 Failure of Auditory Signals

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.[C]

1.4.1-1 Display Update Rate Requirements

The maximum update rate should be determined by the time required for the user to identify and process the changed feature of the display.

ADDITIONAL INFORMATION: The minimum and maximum update rate should be determined by the rate of change in the data, the requirements of the task, and the user's ability to process the information.[C,D]

1.4.1-2 User Control of Display Update Rate

The user should be capable of controlling the rate of update.[C,D]

1.4.1-3 Changing Values

Changing alphanumeric values which the user must reliably read should not be updated more often than once per second.

ADDITIONAL INFORMATION: Changing values which the viewer uses to identify rate of change or to read gross values should not be updated faster than 5 times per second, nor slower than 2 per second, when the display is to be considered as real-time.[C]

1.4.1-4 Initial Erasure to Replace Changed Data

When the computer generates a display to update changed data, the old items should be erased before adding new data items to the display.

ADDITIONAL INFORMATION: This practice will avoid any momentary user confusion that might result from seeing portions of old data being overwritten and partially overlapped by new data.[E]

1.4.1-5 Display Motion

Items on a graphic display should not move faster than 60 degrees of visual angle per second, with 20 degrees per second preferred.

ADDITIONAL INFORMATION: During motion, gross visual attributes and spatial orientation are usually preserved while small details may be lost or processing slowed. Perception of fast moving stimuli may be incomplete.[D]

1.4.1-6 Data Sampling Rate

The sampling rate for each critical plant variable should result in no meaningful loss of information in the data presented.[G]

1.4.1-7 Time Delay

The time delay from when the sensor signal is sampled to when it is displayed should be consistent with the user's task performance requirements.[G]

1.4.1-8 Accuracy

Each variable should be displayed with an accuracy sufficient for the users to perform their tasks.

ADDITIONAL INFORMATION: The reviewer should determine the required accuracy by means of task analysis or through discussions with users.[G]

1.4.1-9 Data Verification for Critical Plant Variables

Redundant sensor readings should be compared before displaying the critical plant variable.[G]

1.4.1-10 Analytical Redundancy
Analytical redundancy among different critical plant parameters should be used.
ADDITIONAL INFORMATION: Analytical redundancy refers to the use of inputs from multiple sensors to validate the data from single sensors.[9]

1.4.1-11 Data Quality Display
The user should be informed when display data are not validated.[9]

1 INFORMATION DISPLAY
1.5 Display Devices
1.5.1 Video Display Units

1.5.1-1 VDU Resolution
The display should have adequate resolution; i.e., users can discriminate all display elements and codes from maximum viewing distance.

ADDITIONAL INFORMATION: The Modulation Transfer Function Area (MTFA)is a measure of resolution; it should have a value of at least 5. This value may be directly developed from microphotometric measurements, or for monochrome VDU displays, it may be estimated using as follows:

$$MTFA = 10A, \text{ where } A = b_0 + b_1V_D + b_2W_D + b_3A_B + b_4V_DA_B + b_5W_DA_B + b_6L_MA_B + b_7V_DL_MA_B,$$

where $b_0 = 1.48$ $b_1 = 0.60$ $b_2 = -1.07$ $b_3 = -1.62$
$b_4 = -0.17$ $b_5 = 0.59$ $b_6 = 0.48$ $b_7 = 0.06$

where V_D = Viewing Distance in meters (m), when $0.30 \text{ m} < V_D < 1.02 \text{ m}$,
W_D = the full width of the Gaussian spot at the half-amplitude point in mm, when $0.15 \text{ mm} < W_D < 0.76 \text{ mm}$,
$A_B = \log_{10}$ of the reflected luminance (in cd/m^2) from the display screen, when $0 < A_B < 1.7$ ($= 50 \text{ cd/m}^2$), and
$L_M = \log_{10}$ of the peak display luminance (in cd/m^2), when 1.3 ($= 20 \text{ cd/m}^2$) $< LM < 2.54$ ($= 343 \text{ cd/m}^2$).[F]

1.5.1-2 VDU Contrast
The contrast ratio of the display should be greater than 3:1; a contrast ratio of 7:1 is preferred.

ADDITIONAL INFORMATION: Either display polarity - that is, dark characters on a light background - or light characters on a dark background is acceptable provided it meets the requirements for resolution, percent raster modulation and percent active area, luminance, and contrast. Contrast ratio is calculated as follows:

$$CR = Lmax/Lmin$$

where

Lmax is the higher luminance of the background or of the character, and
Lmin is the lower luminance of the two.

These values include the contribution from ambient light. Small characters, i.e., characters between 10 and 17 minutes of arc (3 and 5 mrad) should have minimum luminance modulation (M) of:

$$M = 0.3 + 0.07\,(20 - S)$$

where S is the vertical size of the character set, in minutes of arc, and
Luminance modulation, $M = (Lmax-Lmin)/(Lmax + Lmin)$.[F]

1.5.1-3 Flicker
The display should be "flicker free."[B]

1.5.1-4 Geometric stability
The display should be free of "jitter."

ADDITIONAL INFORMATION: Variations in the geometric location of a picture element should be no more than 0.0002 inch per inch (0.0002 mm per mm) of viewing distance over a period of one second. This may be expressed as

$$VD \times 0.0002 \geq (H^2 + V^2)^{0.5}$$

where VD is the viewing distance
H and V are the maximum excursions of picture element centers, horizontally and vertically.[F]

1.5.1-5 Image Continuity

The display should maintain the illusion of a continuous image, i.e., users should not be able to resolve scan lines or matrix spots.

ADDITIONAL INFORMATION: It does not matter if the raster is scanned or directly addressed.[B]

1.5.1-6 CRT Image Linearity

The display should be free of geometric distortion.

ADDITIONAL INFORMATION: Linearity, the horizontal displacement of a symbol position relative to the symbol positions directly above and below the symbol position, should vary by not more than five percent of the symbol box height. The vertical displacement of a symbol position, relative to the symbol positions to the right and left of the symbol position, should vary by not more than five percent of the symbol box height. Nonlinearity of any column or row should be not more than two percent of the length of the column or row. Lines and columns should be parallel and orthogonal one to the other within the limits of the linearity requirement. This may be expressed as:

$$0.04 \text{ (Shorter edge/Longer edge)} \geq |\text{Diagonal1/Diagonal2}| - 1$$

The size of a specific symbol anywhere on the display should not vary by more than 10 percent, regardless of its location within the image area. This is expressed as follows:

$$2(h_2 - h_1)/(h_2 + h_1) \leq 0.1 \text{ and } 2(w_2 - w_1)/(w_2 + w_1) < 0.1$$

where

h is the height of the symbol and
w is the width of the symbol.

When all the character positions on the screen are filled with "Hs" or "Ms" of the same character set, h_1 is the height of the smallest character, h_2 is the height of the largest character, w_1 is the width of the smallest character, and w_2 is the width of the largest character.[F]

1.5.1-7 VDU Display Luminance

The display should have adequate luminance.

ADDITIONAL INFORMATION: Either the character or its background, whichever is of higher luminance, should achieve a luminance of at least 10 ft-L (35 cd/m^2) or more. The preferred display luminance is 23 to 47 ft-L (80 to 160 cd/m^2).[B]

1.5.1-8 Luminance Uniformity

All luminances that are supposed to be the same should appear the same.

ADDITIONAL INFORMATION: Luminance uniformity, the variation from the center to the edge of the active area of the display, should not vary more than 50 percent of the center luminance. Unintended luminance variations, within half a degree of arc, calculated from the design viewing distance anywhere on the display, should be less than 50 percent. For an intended uniform luminance, the variation in luminance from the center of the display to the edge or any portion thereof should not vary by more than 50 percent of the center luminance. This measurement is to be made in a dark room.[F]

1.5.1-9 VDU Controls

Frequently used controls should be easily visible and accessible to the VDU user from the normal working position.

ADDITIONAL INFORMATION: The controls should be designed so that they are not accidentally actuated. They should give a clear indication of their function and current setting. A monochrome CRT display should have a means of controlling luminance.[F]

1.5.1-10 VDU Luminance Control

A control to vary the VDU luminance from 10% of minimum ambient luminance to full CRT luminance should be provided.[C]

1.5.2-1 Control of Critical Information Display

Control of large-screen group display systems should be such that critical information cannot be modified or deleted inadvertently or arbitrarily.

ADDITIONAL INFORMATION: Control of changes in the display should be under the control of designated users who operate according to pre-established procedures, upon command of a person in charge, or both. When an individual must make changes that are of interest only to him or her, a separate, remote display (such as a console VDU) should be provided.[C]

1.5.2-2 Resolution

Users should be able to resolve all important display detail at the maximum viewing position.[C]

1.5.2-3 Size of Characters

The height of letters and numerals should not subtend less than 15 minutes (4.5 mrad) of visual angle as measured at the maximum viewing distance.

ADDITIONAL INFORMATION: In no instance should the height of letters and numerals subtend less than 10 minutes (3 mrad) as measured at the longest anticipated viewing distance.[C]

1.5.2-4 Contrast Polarity

Contrast should be either light on a dark background or vice-versa, except where superposition is used.

ADDITIONAL INFORMATION: For subtractive superposition (at the source), data should be presented as dark markings on a transparent background. For additive superposition (at the screen), data should be presented as light markings on an opaque background. Colored markings against colored backgrounds of comparable brightness should be avoided.[C]

1.5.2-5 Projected Display Luminance Ratio

The luminance ratio provided by the projection system should be adequate for the type of material being projected.

ADDITIONAL INFORMATION: The contrast ratio is defined as image or subject luminance divided by the nonimage or background luminance. Under optimal ambient lighting conditions, the contrast ratio for optically projected displays should be 500:1. Minimum contrast ratios are as follows: a) For viewing charts, printed text and other linework via slides or opaque projectors the minimum contrast ratio is 5:1. b) For projections which are limited in shadows and detail, such as animation and photographs with limited luminance range, the minimum contrast ratio is 25:1. c) For images which show a full range of colors (or grays in black-and-white photographs), the minimum contrast ratio is 100:1.[C]

1.5.2-6 Projected Display Image Luminance

Image luminance and light distribution should be uniform. The luminance of the screen center at maximum viewing angle should be at least half its maximum luminance.[C]

1.5.2-7 Minimize Keystone Effects

If projected displays are used, projector and screen should be arranged so as to minimize "keystone effect," i.e., distortion of projected data proportions due to non-perpendicularity between projector and screen.[C]

1.5.2-8 Minimum Viewing Distance

The display should not be closer to any observer than 1/2 the display width or height, whichever is greater.[C]

1.5.2-9 Interruption of View

Large screen displays should be located relative to critical observers so that the view is not obscured by other people.[C]

1.5.2-10 Seating Area

Off-centerline viewing should not exceed 10 degrees (175 mrad) for any workstation.[C]

1.5.3-1 Legibility
Print output should be free from character line misregistration, character tilt or smear.[C]

1.5.3-2 Contrast
A minimum contrast ratio of 4:1 should be provided between the printed material and the background on which it is printed.[C]

1.5.3-3 Illumination
The printer should be provided with internal illumination if the printed matter is not legible in the planned operational ambient illumination.[C]

1.5.3-4 Visibility
When used for real-time applications, the printed matter should not be hidden, masked or obscured in a manner that impairs direct reading.[C]

1.5.3-5 User Annotation Capability
When used in real-time applications, printing devices should be mounted so that the users may write on or mark the printed matter (e.g., paper, metalized paper) while still in the printer.[C]

1.5.3-6 Take-up Provision
A take-up device for printed material should be provided.[C]

1.5.3-7 Indication of Supply of Materials
A positive indication of the remaining supply of printing materials (e.g., paper, toner, ribbon) should be provided.[C]

1.5.3-8 Smudging/Smearing
The hardcopy should be resistant to smudging or smearing when handled by users.[C]

1.5.3-9 Job Aids
Graphic overlays should be provided where these may be critical to proper interpretation of graphic data as it is being generated.
ADDITIONAL INFORMATION: Such aids should not obscure or distort the data.[C]

The guidelines for audio display devices are contained in Section 6.2 (Speech-Based Communication).

2 USER-SYSTEM INTERACTION

2.1 General User Input Guidelines

2.1-1 Selection of Dialogue Types

The selection of dialogue types should be based on anticipated task requirements, user skills, and anticipated system response time.

ADDITIONAL INFORMATION: Dialogue types are related to task requirements in Table 2.1.[C,A]

2.1-2 Consistent Procedures

Procedures for entering commands or information should be consistent in form and consequences.

ADDITIONAL INFORMATION: Menu selection techniques, user input procedures, editing and error correction procedures are examples of user actions for which conventions are required. Consistent procedures will help users develop consistent habits of operation, can reduce the likelihood of user confusion and error, and are especially important for any transaction that risks data loss.[C,E]

2.1-3 Consistent Wording of Commands

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.

ADDITIONAL INFORMATION: The same kind of action should be referred to by the same word in any context. For example, EDIT should not be used in one place, MODIFY in another, UPDATE in a third, all referring to the same kind of action. Commands should be congruent with one another, following natural language patterns; if one command is UP, its complement should be DOWN. Other natural complements include OPEN-CLOSE, RUN-STOP, ON-OFF, IN-OUT, RAISE-LOWER, etc. For instructional material, such as display labeling, on-line guidance, and other messages to users, consistent terminology should be used to refer to entry of commands or information.[A,C,E]

2.1-4 Wording Consistent with User Guidance

The wording and required format of information or command entry functions should be consistently reflected in the wording of user guidance, including all labels, messages, and instructional material.

ADDITIONAL INFORMATION: For example, when the computer displays a file name, that name should be shown in a format that would be acceptable if the name were included in a command entry. For example, if a user must complete a control form to specify printer settings, the words used as labels on that form should also be used in any error messages and HELP displays which may guide that process.[E]

2.1-5 Minimal Demands on the User

Entry of information or commands should not require the user to remember special codes or sequences or to perform translations or conversions.

ADDITIONAL INFORMATION: The user should not have to transform units at time of data entry. For example, user entries should be in the same units that are used in control room displays and procedures; the user should not be required to convert from gallons per minute to gallons per hour. Command names should specifically describe the functions being implemented and should reflect the user's operational language.[A]

2.1-6 Minimal User Actions

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

ADDITIONAL INFORMATION: The user interface should permit completion of a task with the minimum number of actions. For example, a user should be able to print a display by simple request, without having to take a series of other actions first, such as calling for the display to be filed, specifying a file name, then calling for a print of that named file. For long, multipage displays, it should be possible to request a particular page directly, without having to take repetitive NEXT PAGE or PREV PAGE actions. This guidance does not apply to potentially destructive functions; extra user actions required to invoke such functions serve to make them less likely to be inadvertently activated.[A,E]

Table 2.1. Dialogue Type Selection

	Question and Answer	Form Filling	Menu Selection	Function Keys	Command Language	Query Language	Constrained Natural Language
Arbitrary control/data entry sequences							
Poorly defined/broad interface definition							
Unpredictable information retrieval							
Wide range of control entries							
Frequent control/transactions							
Small/constrained command choice set							
Complex control							
Large command set							
Routine data entry							
Entry order constrained							
Data entry flexibility needed							
Little arbitrary data input							
Slow computer response time							
Fast computer response time							
Highly trained users							
Moderately trained users							
Little training							

2.1-7 Unnecessary Entry of Information

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

ADDITIONAL INFORMATION: A user should need to enter any particular information only once, and the computer should access that information if needed thereafter for the same task or for different tasks. Requiring re-entry of data requires unnecessary effort on the part of users and increases the possibility of entry errors. The computer should automatically access or compute information that can be derived from existing computer records.[A,E]

2.1-8 Availability of Information

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

ADDITIONAL INFORMATION: Required annotation will vary with the application. Some annotation may be so commonly needed that it should be continuously displayed, e.g., document name, page number, indication of control mode (if any), etc. Other annotation might be displayed only at user request, such as document status (date last changed, last printed, etc.) which might be displayed in an optional window overlay, and format control characters which might be visible in an optional display mode. For example, the user might wish to see format control characters, such as tab and margin settings.[A,E]

2.1-9 Logical Transaction Sequences

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.

ADDITIONAL INFORMATION: A logical unit to the user is not necessarily the same as a logical unit of the computer software that mediates the transaction sequence. It might be, for example, that a user should enter ten items of data in a single transaction, because those data all come from one particular paper form, even though the computer will use five of those items for one purpose and five items for another in its subsequent internal processing.[A,E]

2.1-10 Flexible User Entry

Flexible means of entering information or commands should be provided so that users can accomplish necessary transactions, and can obtain guidance as needed in connection with any transaction.

ADDITIONAL INFORMATION: The user should be able to go forward or back at will when scanning a multipage display. If user interface design permits only forward steps, so that the user must cycle through an entire display series to reach a previous page, that design is deficient.[A,E]

2.1-11 Control by Explicit User Action

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

ADDITIONAL INFORMATION: The processing of an entry or the cancellation of an ongoing process should not occur as a side effect of some other action. For example, when a user is keying an extended data entry, the computer should not interrupt the user to require immediate correction of any entry error, but instead should wait for the user's ENTER action. Also, when a user is composing a command to accomplish some transaction, the computer should not interrupt the user by responding as soon as it recognizes a partial entry, but instead should wait for the user's ENTER action. In automated process control applications, emergency conditions may take precedence over current user transactions, and a computer-generated warning might interrupt user actions. In routine, repetitive data entry transactions, successful completion of one entry may lead automatically to initiation of the next. Computer detection of problems with current user entries can usually be negotiated at the conclusion of a transaction, before it is implemented. Nondisruptive alarms or advisory messages can be displayed to report computer monitoring of external events so that the user can choose when to deal with them.[E]

2.1-12 Compatibility with User Expectations

The results of any entry should be compatible with user expectations, so that the system changes in a "natural" way in response to user actions.

ADDITIONAL INFORMATION: The result of an entry should be consistent with the user's view of the system. For example, a control entry of NEXT PAGE should show the next frame of a current display, and should not jump off to some other internally defined "page" in the computer's data base. When the completion of a control entry is indicated by a special function key, that key should be labeled ENTER (or some functionally equivalent word) and should result in computer acknowledgment of the entry.[D,E]

2.1-13 Feedback for User Entries

The computer should acknowledge every entry immediately.

ADDITIONAL INFORMATION: For every entry action by the user there should be some obvious reaction from the computer. The absence of computer response is not an acceptable means of indicating that an entry is being processed. "Immediately" as used in this guideline must be interpreted in relation to the response time requirements of different dialogue types. For example, execution of a requested transaction might produce an immediately apparent result, as when a user requests NEXT PAGE and the next page is displayed. A message might indicate completion of a transaction, as when a user requests a printout at a remote facility and the computer displays a confirming message "RAD WASTE file has been sent to printer"; or, a message might indicate that execution is in progress or deferred, as when a user enters data and the computer displays an interim message "RAD WASTE file is being updated." A message might indicate that the control entry requires correction or confirmation, as when a user requests a file display and the computer displays an error message "RAD WASTE file not recognized." In a menu selection context, it may suffice simply to highlight the selected option label (e.g., by brightening or inverse video) when that would provide an unambiguous acknowledgment.[A,D,E]

2.1-14 Periodic Feedback

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

ADDITIONAL INFORMATION: In addition to the indication that the system has received the menu-based command, feedback about completion of the command should also be communicated. Completion of the action commanded by the menu item will be sufficient feedback, provided that the action has a result that is visible to the user. However, if the completion of the menu item has no visible result, the additional feedback that the command was completed should be communicated by a message in the Message Area.[D]

2.1-15 Indicating Completion of Processing

When processing in response to an entry is lengthy, the user should be given some positive indication of subsequent completion.

ADDITIONAL INFORMATION: Completion of the action commanded by the menu item will be sufficient feedback, provided that the action has a result that is visible to the user. However, if the completion of the menu item has no visible result, the additional feedback that the command was completed should be communicated by a message. If a user is currently involved in some new transaction, then completion of processing for a prior transaction should be indicated by nondisruptive display of an appropriate advisory message. If the outcome of a completed transaction implies the need for further user action, that should be indicated to the user.[D,E]

2.1-16 Indicating Control Lockout

If entries must be delayed pending computer processing of prior entries, then the delay should be indicated to the user.

ADDITIONAL INFORMATION: If processing delay results in control lockout, this could be signaled by a change in the appearance of the cursor, accompanied by an auditory signal. In some applications it may be desirable to ensure that the keyboard and other control devices are automatically locked until the user can begin a new transaction. This would be true when processing the current transaction will affect the results of subsequent user actions. In other applications, it may be possible to permit users to continue work while previous transactions are still being processed. Deletion or change of a displayed cursor in itself may not be a sufficient indicator of keyboard lockout. Auditory signals will be particularly helpful to a skilled touch-typist, who may not look at the display when transcribing data entries. Following control lockout, computer readiness to accept further entries should be indicated to the user.[E]

2.1-17 Interrupt to End Control Lockout

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.

ADDITIONAL INFORMATION: Such an interrupt capability will be especially helpful if a user recognizes that an error has been made and wants to stop an unneeded transaction, acting like an UNDO command.[E]

2.1-18 Entry via Primary Display

When data entry is a significant part of a user's task, entered data should appear on the user's primary display.

ADDITIONAL INFORMATION: As a negative example, entry via typewriter is acceptable only if the typewriter itself, under computer control, is the primary display medium. When the primary display is basically formatted for other purposes, such as a graphic display for process control, a separate window or area on the display may have to be reserved for data entry.[A,E]

2.1-19 Entry of Corrections

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

2.1-20 Editing Capabilities During Text Entry

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

ADDITIONAL INFORMATION: While entering text, users should have some capability for text selection (by cursor movement) and deletion (e.g., by use of destructive backspace). The intent of this guideline is not to endorse modeless over moded text editors. In fact, when experienced users perform editing tasks, a moded editor may offer some advantages. However if a moded editor is provided, users should be able to do some simple editing such as correcting typographical errors and making simple word changes without having to invoke that editor. When users will compose text on-line, consider providing a modeless editor rather than a moded editor. Modeless editors offer some advantages for text composition, when users will frequently alternate between text entry and editing.[A,E]

2.1-21 Entries Distinct from Text

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

ADDITIONAL INFORMATION: The user should not be able to enter controls as text, or vice versa. Errors can be avoided by having keyed entries made only in a reserved window in the display, or by using function keys rather than text entry.[A,E]

2.1-22 Variable Length Data Area

Users should not have to remove unused underscores or otherwise enter keystrokes for each position within a variable length entry area.[A]

2.1-23 Optional Versus Required Entry

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

2.1-24 Display of User Annotations

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

ADDITIONAL INFORMATION: This recommendation refers to additions such as marginal notes on printed displays. Other annotation such as format control characters might be shown in a special display mode where text has been expanded to permit annotation between lines. For example, continuous annotation might be displayed in the top and/or bottom lines of a page, separated from the text by blank lines; optional annotation might be displayed in window overlays.[A,E]

2.1-25 Flexible Interaction Design

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.

ADDITIONAL INFORMATION: Entry functions that may need to be changed include the types of dialogue that are provided, procedures for transaction selection and interrupt, methods for context definition and error management, and alarm control.[E]

2.1-26 Guidance Information

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

2.1-27 Entry Procedures Matched to User Skill

The means of entering information or commands should be compatible with user skills, permitting simple step-by-step actions by beginners, but permitting more complex entries by experienced users.

ADDITIONAL INFORMATION: Most systems will have users with varying levels of experience. Any particular user may become more expert with increasing experience, or perhaps less expert after a long period of disuse. Accommodating users of varying expertise requires a mixture of different dialogue types, with some means for smooth transition from one mode of dialogue to another. For instance, as a user comes to learn menu codes, s/he might be allowed to enter those codes without necessarily displaying a menu, i.e., those codes might also serve as commands.[E]

2.1-28 Stacked Control Entries

Users should be allowed to key a sequence of commands or option codes as a single "stacked" control entry.

ADDITIONAL INFORMATION: In particular, users should be allowed to enter stacked entries from any menu so that an experienced user can make any specific control entry without having to view subsequent menus. Control entry stacking may be helpful when a user is being prompted to enter a series of parameter values, and knows what several succeeding prompts will request and what values to enter. Control entry stacking will permit a transition from simple step-by-step control entry by novice users, as in menu selection and question-and-answer dialogues, to the entry of extended command-language statements by experienced users. Entry stacking is especially helpful in time-shared systems where computer response to any user entry may be slow.[A,E]

2.1-29 Consistent Order in Entry Stacking

For control entry stacking, entries should be required to be in the same order as they would normally be made in a succession of separate control entry actions.[E]

2.1-30 Abbreviation in Entry Stacking

For control entry stacking, command names, their abbreviations, or option codes should be accepted just as if those control entries had been made separately.

ADDITIONAL INFORMATION: In some applications, it might prove helpful if the computer were to display its interpretation of a stacked entry for user review and confirmation.[A,E]

2.1-31 Minimal Punctuation of Stacked Entries

Users should be allowed to stack control entries without any punctuation other than spaces between words or option codes.[A,E]

2.1-32 Standard Delimiter in Entry Stacking

If punctuation other than spaces is needed to separate entries in a stacked control entry, a single standard symbol should be used for that purpose.

ADDITIONAL INFORMATION: A slash (/) is often used to separate stacked entries. Whatever symbol is adopted as a delimiter for control entries should preferably be the same as any delimiter that might be used when making data entries. Note that even when a standard symbol is consistently used to punctuate stacked entries, entry will be slower and less accurate than if only spaces are used for punctuation.[A,E]

2.1-33 Distinctive Display of Control Information

All displays should be designed so that features relevant to user entries are distinctive in position and/or format.

ADDITIONAL INFORMATION: Relevant features include displayed options, command entry areas, prompts, advisory messages, and other displayed items (titles, time signals, etc.) whose changes signal the results of user entries.[A,E]

2.1-34 Displayed Context

If the consequences of a user entry will differ depending upon context established by a prior action, then some continuous indication of current context should be displayed for reference by the user.

ADDITIONAL INFORMATION: The user should not have to query the system to determine the current mode. For example, if activating a DELETE key establishes a mode, so that subsequent selection of a PAGE key will erase a page of data rather than simply advancing to display the next page, then some indication of that established DELETE mode should be displayed to the user.[A,E]

2.1-35 Consistent Display of Context Information

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

ADDITIONAL INFORMATION: The system should indicate current position within a sequence.[A,E]

2.1-36 Record of Prior Entries

Users should be permitted to request a summary of prior entries to help determine present status, and should be allowed to review any parameters that are currently operative.

ADDITIONAL INFORMATION: Summarizing prior entries will be particularly helpful in tasks where the sequence of user actions is variable, where a user must know what was done in order to decide what to do next. Summarizing prior entries may not be needed for routine transactions if each step identifies its predecessors explicitly, although even in those circumstances a user may be distracted and at least momentarily become confused. A capability for parameter review may likewise be helpful even when a user selects all parameters personally.[A,E]

2.1-37 Standard Display Area for Command Entry

A command entry area in a consistent location should be provided on every display, preferably at the bottom.

ADDITIONAL INFORMATION: Adjacent to the command entry area there should be a display window reserved for prompting entries, for recapitulation of command sequences (with scrolling to permit extended review), and to mediate question-and-answer dialogue sequences (i.e., prompts and responses to prompts).[A,C,E]

2.1-38 General List of Options

A general list of basic options should be provided and always be available to serve as a "home base" or consistent starting point for user input.

ADDITIONAL INFORMATION: Return to this starting point can be accomplished by an OPTIONS function key, or by an explicit option on every display, or by a generally available implicit option. Such a capability may be helpful even when all dialogue is user-initiated. It might be the general menu for a menu selection dialogue, or might be a standard starting point for composing command entries. However a user should not be required to return to a display of general options in order to make an entry. If a user remembers option codes or commands, ideally those entries could be made from any point in a transaction sequence.[A,E]

2.1-39 Displaying Option Codes

When users must select options by code entry, the code associated with each option should be displayed in a consistent and distinctive manner.

ADDITIONAL INFORMATION: In many applications an equal sign is used to designate option codes, such as N = Next page, P = Prev page, etc.[E]

2.1-40 Organization and Labeling of Listed Options

The general options list should show control entry options grouped, labeled and ordered in terms of their logical function, frequency and criticality of use, following the general guidelines for menu design.[A,E]

2.1-41 Indicating Appropriate Control Options

Users should be provided a list of the control options that are specifically appropriate for any transaction.

ADDITIONAL INFORMATION: Transaction-specific options might be listed in the working display if there is space for them. Otherwise, they might be displayed in an overlay window at user request. Control options that are available for almost any transaction should be treated as implicit options, which need not be included in a list of transaction-specific options unless they are particularly appropriate to the current transaction.[A,E]

2.1-42 Only Available Options Offered

Only control options that are actually available for the current transaction should be offered to users.

ADDITIONAL INFORMATION: If certain options are not yet implemented, as during system development, or are not available for any other reason, those should be annotated on the display.[A,E]

2.1-43 Provide Further Available Action

Transactions should never leave the user without further available action and should provide next steps or alternatives.

ADDITIONAL INFORMATION: A number of basic actions (e.g., "Continue", "Abort", "Go to Main directory", etc.) should be available to users at any point in their interaction with the system.[A]

2.1-44 Prompting Command Entries

Users should be provided with whatever information may be needed to guide command entries at any point in a sequence of transactions, by incorporating prompts in a display and/or by providing prompts in response to requests for HELP.[A,E]

2.1-45 Control by Simultaneous Users

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

ADDITIONAL INFORMATION: This requires careful interface design for applications where joint, coordinated actions must be made by a group of users.[A,E]

2.1-46 Highlighting Selected Data

When a user is performing an operation on some selected display item, that item should be highlighted.

ADDITIONAL INFORMATION: This practice will help avoid error, if a user has misunderstood or perhaps forgotten which item was selected.[A,E]

2.1-47 User Control of Processing

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

ADDITIONAL INFORMATION: In most applications, a user should be able to interrupt or terminate processing once it has been initiated. The functions in Table 2.2 should be provided (as appropriate to task requirements).[A,E]

Table 2.2. Functions for the Control of Processing Commands

Function	Result	Application Example
END	conclude a repetitive sequence of actions	in a repetitive sequence of data entries, where completing one transaction cycles automatically to begin the next, END might break the cycle and permit the user to select other transactions
PAUSE/ CONTINUE	interrupt and later resume a sequence of transactions without any change to data entries for the interrupted transaction.	a user might interrupt a current task to read an incoming message
SUSPEND	preserve current status when a user leaves the system, and permit resumption at that point when the user later logs back onto the system	a user might postpone completion of a task until needed data become available

2.1-48 Distinctive Interrupt Options

If different kinds of user interrupt are provided, each interrupt function should be designed as a separate control option with a distinct name.

ADDITIONAL INFORMATION: The means of invoking interrupt functions should be clear to the user. For example, it is undesirable to have a single INTERRUPT key which has different effects depending upon whether it is pushed once or twice. Users would be confused by such an expedient and uncertain about what action has been taken and its consequences.[A,E]

2.1-49 User Transaction Interrupts

User interrupts and aborts should not modify or remove stored or entered data.[A]

2.1-50 User Control of Entry

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

ADDITIONAL INFORMATION: The functions in Table 2.3 should be provided (as appropriate to task requirements).[A,E]

Table 2.3. Functions for the Control of Entering Information

Function	Result	Application Example
CANCEL	erase any changes just made by the user and restore the current display to its previous version	correction of erroneous input prior to actually entering the information in a data file
BACKUP	return to the display for the last previous transaction	in a sequence of related data entries, on several display frames, return to the previous frame, where data items could then be erased or could be edited individually
REVIEW	return to the first display in a defined transaction sequence, permit the user to review a sequence of entries and make necessary changes	in a sequence of related data entries, on several display frames, return to the first frame, from which data could be reviewed and edited as needed throughout the sequence of frames
RESTART	canceling any entries that have been made in a series of entries and returning to the beginning of the sequence	in a sequence of related data entries on a form-filling display, erase all data entries and return to the first field on the form

2.1-51 User-Specified Transaction Timing

When appropriate to task requirements, users should be allowed to specify the timing of transactions.

ADDITIONAL INFORMATION: Users should be able to specify when a requested transaction should start or should be completed, or to schedule the periodic transactions. In many applications users will wish specified transactions performed as quickly as possible. In some applications, however, users may have good reasons to delay initiation (or completion) of transactions. For example, a user might wish to specify that a requested data analysis routine be deferred until some later time, to ensure that interim updates to the data will be taken into account.[A,E]

2.1-52 Indicating PAUSE/SUSPEND Status

If PAUSE or SUSPEND options are provided, some indication of the status should be displayed whenever such an option is selected by a user.

ADDITIONAL INFORMATION: If appropriate (i.e., for a paused transaction), the action that will permit resumption of the interrupted transaction should be indicated to the user.[A,E]

2.1-53 Consistent CONTINUE Option

At any step in a defined transaction sequence, if there is only a single appropriate next step, then a consistent control option to continue to the next transaction should be provided .

ADDITIONAL INFORMATION: CONTINUE or NEXT or STEP are all suitable names for this option. If data entry is involved, then users should be required to take an explicit ENTER action to signal data entry, rather than simply selecting CONTINUE.[A,E]

2.1-54 Data Manipulation

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

ADDITIONAL INFORMATION: The USI should contain sufficient memory to accommodate the user's requirements.[A]

2.1-55 Default Values

When likely default values can be defined for the information to be entered in a particular task, those default values should be offered to speed entry.

ADDITIONAL INFORMATION: When defaults are defined that may vary from one transaction to another, users should be informed of the current default logic. For example, "Press ENTER to see more options." If a consistent default is adopted throughout interface design, that default need not be explicitly indicated for each individual transaction. Here the phrase "null control entry" refers to pressing an ENTER key without first keying a command or option code (and without any accompanying data). It does not refer to defaults for optional parameters that might accompany a valid control entry, whose values might be displayed only at user request. It is not necessary that any defaults be defined for null control entries. In such cases, the computer might simply respond "ENTER alone is not recognized here.[A,E]

2.1-56 Display of Default Values

At the start of an input transaction, currently defined default values should be displayed in their appropriate data fields.

ADDITIONAL INFORMATION: It may be helpful to mark default values in some way to distinguish them from new data entries.[A,E]

2.1-57 Easy Confirmation to Enter Default Values

Users should be provided with some simple means to confirm acceptance of a displayed default value.

ADDITIONAL INFORMATION: Similar techniques, e.g., tabbing past the default field, should be used when a user must review the accuracy of previously entered data.[A,E]

2.1-58 User Definition of Default Values

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

ADDITIONAL INFORMATION: Users should be allowed to replace any default value with a different entry, without thereby changing the default definition for subsequent transactions.[A,E]

2.1-59 Indicating Control Defaults

When keyed command or option code entries are used and a default is defined for a null control entry, the default should be indicated to the user.

2.1-60 Single Method for Input

Input transactions and associated displays should be designed so that a user can stay with one method of entry, and not have to shift to another.

ADDITIONAL INFORMATION: As a positive example, minimize shifts from lightpen to keyboard entry and then back again. As a negative example, a user should not have to shift from one keyboard to another, or move from one work station to another, to accomplish different input tasks.[A,E]

2.1-61 Upper and Lower Case Equivalent

For interpreting user-composed control entries, upper and lower case letters should be treated as equivalent.

ADDITIONAL INFORMATION: Users find it difficult to remember whether upper or lower case letters are required, and so the interface design should not try to make such a distinction.[E]

2.1-62 Justification of Entries

Unless otherwise required by processing or display requirements, alpha input should be left justified, and numeric input should be right justified for integer data or decimal point justified for decimal data.

ADDITIONAL INFORMATION: Optional entry or omission of a decimal point at the end of an integer should be allowed as equivalent alternatives.[A]

2.1-63 Automatic Justification of Entries

Automatic justification of tabular data entries should be provided.

ADDITIONAL INFORMATION: A user should not have to enter blanks or other extraneous formatting characters to achieve proper justification. For example, if a user enters "56" in a field four characters long, the system should not interpret "56 __ __" as "5600". For general numeric data, optional entry or omission of leading zeros should be allowed as equivalent alternatives. If a user enters "56" in a field that is four characters long, the system should recognize that entry rather than requiring an entry of "0056". Special cases may represent exceptions to this rule, such as entry of serial numbers or other numeric identifiers.[A,E]

2.1-64 Maintaining Significant Zeros

When a user must enter numeric values that will later be displayed, all significant zeros should be maintained.

ADDITIONAL INFORMATION: Zeros should not be arbitrarily removed after a decimal point if they affect the meaning of the number in terms of significant digits.[A,E]

2.1-65 Significance of Numeric Values

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

2.1-66 Overwriting Characters

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

ADDITIONAL INFORMATION: If a user chooses to alter the contents of a field, the displayed previously existing entry (e.g., a default value or label) should be cleared from the input field.^

2.2.1-1 Layered Command Language

A command language should be designed so that its functions are organized in groups (or "layers") for ease in learning and use.

ADDITIONAL INFORMATION: A user should be able to display the next of a set of received messages with some simple command such as READ NEXT, although a complete command to retrieve any message might include potential specification of which message, from which message list, in which format, to which output device. The fundamental layer of the language should be the easiest, allowing use of the system by people with little training and/or limited needs. Successive layers of the command language can then increase in complexity for users with greater skills. In effect, simple versions of commands can be recognized by defaulting all of the optional parameters. Control forms might be used to display default options for complicated commands.[A,C,E]

2.2.1-2 General List of Commands

A general list of basic commands, with appropriate command format guidance, should be provided to serve as a "home base" or consistent starting point for composing command entries.

ADDITIONAL INFORMATION: Such a general list of commands might provide more comprehensive user guidance than is possible when prompting command entry from a working display.[A,E]

2.2.1-3 Distinctive Meaning for Commands

Words in a command language should be distinctive from one another, and emphasize significant differences in function.

ADDITIONAL INFORMATION: In general, commands should not have semantically similar names, such as SUM and COUNT, or ERASE and DELETE, or QUIT and EXIT.[C,E]

2.2.1-4 Distinctive Spelling for Commands

Words and abbreviations in a command language should have distinctive spelling, so that simple spelling errors will be recognized as such rather than invoking a different command.

ADDITIONAL INFORMATION: If one command name is DELETE, abbreviated DEL, then another command should not be named DELIVER, with an abbreviation of DELR. Instead, ERASE could be substituted for DELETE, or SEND for DELIVER. When a system has only a few commands, all of those commands should be distinctive. When a system has many commands, it may not be possible to ensure that each is distinctive. In that case, it is important to ensure that any commands which are destructive or time-consuming are made distinctive.[C,E]

2.2.1-5 Abbreviation of Commands

Users should be allowed to abbreviate commands.

ADDITIONAL INFORMATION: Users should be required to enter only as many characters as needed to uniquely identify the desired command. For example, if a "P" uniquely identifies a print command (i.e., no other commands start with "P") then a user should be able to enter PRINT, or PR, or P to initiate printing.[A,C,E]

2.2.1-6 Recognizing Command Synonyms

The computer should recognize a variety of synonyms for each word defined in the command language.

ADDITIONAL INFORMATION: The synonyms that are likely to be used can be determined by analysis of error records in prototype testing. This flexibility can allow infrequent users to interact with a system more efficiently. The user may be required to verify commands recognized in this way.[E]

2.2.1-7 Interpreting Misspelled Commands

Where the set of potential command entries is well defined, the computer should recognize and execute common misspellings of commands, rather than requiring re-entry.

ADDITIONAL INFORMATION: Misspelled command entries should be tolerated within the limits of computer recognition. The user may be required to verify commands recognized in this way. The computer can interrogate a user as necessary to resolve ambiguous entries.[E]

2.2.1-8 Recognizing Alternative Syntax

The computer should recognize probable alternative forms of command syntax.

ADDITIONAL INFORMATION: Users might be allowed to use different punctuation and/or to list command modifiers in different orders. For example, the computer might accept alternative methods of specifying a request, such as "SG3 LVL", "LVL SG3", or "LVL/SG3".[E]

2.2.1-9 User-Assigned Command Names

A command language should have flexibility to permit a user to assign personal names to frequently used commands.

ADDITIONAL INFORMATION: Frequently used commands should be easy for a user to enter. For users who must move back and forth between different systems with differently defined command languages, some flexibility in command naming will permit those users to establish their own consistent terminology. Where this capability exists, several cautions should be observed. Before users can be allowed to adopt their own assigned command names, the computer must check those names to prevent duplication. Also, there is a potential risk of confusion if users forget what names they have specified for commands and data files. The computer should maintain a current index of command and file names for on-line user reference.[E]

2.2.1-10 User-Requested Prompts

Users should be allowed to request computer-generated prompts as necessary to determine required parameters in a command entry, or to determine available options for an appropriate next command.

ADDITIONAL INFORMATION: Users might request prompting by using a HELP function key, or perhaps simply keying a question mark in the command entry area.[C,E]

2.2.1-11 Minimal Punctuation

Users should be allowed to enter commands without any punctuation other than the spaces between words.

ADDITIONAL INFORMATION: Command entry will be faster and more accurate when spaces are used rather than any other kind of punctuation.[A,C,E]

2.2.1-12 Ignoring Blanks in Command Entry

Single and multiple blanks between words should be treated as equivalent when processing command entries.

ADDITIONAL INFORMATION: People cannot readily distinguish one blank space from several, and so the computer should not impose such a distinction.[A,E]

2.2.1-13 Standard Delimiter

If command punctuation other than spaces is required, a single standard delimiter symbol should be used for that purpose.

ADDITIONAL INFORMATION: Command punctuation other than spaces may be required as a delimiter to distinguish optional parameters, or to separate entries in a stacked command. For example, a slash (/) might be a good choice. Whatever symbol is adopted as a delimiter for command entries should preferably be the same as any delimiter that might be used when making data entries. Note, however, that even if some single delimiter is specified for consistent use in command punctuation, command entry will be slower and less accurate than if no delimiter at all were required.[E]

2.2.1-14 Graphic Examples in Guidance Information

Where possible, guidance information should be accompanied with graphic examples of command content and syntax.[C]

2.2.2-1 Logical Ordering of Menu Options

Menu options should be ordered and grouped logically.

ADDITIONAL INFORMATION: If no logical structure is apparent, then the options should be displayed in order of their expected frequency of use, with the most frequent listed first. When applicable, a menu should indicate logically related groups of options, rather than an undifferentiated string of alternatives. For example, in vertical listing of options, subordinate categories might be indented. Logical grouping of menu options will help users learn system capabilities. When logical grouping requires a trade-off against expected frequency of use, that trade-off should be resolved consistently for those functions throughout the menu structure. Where ordering cannot be determined by the above, alphabetic ordering should be used.[A,C,D,E]

2.2.2-2 Labeling Grouped Options

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.[D,E]

2.2.2-3 Hierarchic Menus for Sequential Selection

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, a file directory, etc., 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, an imposed structure for sequential access may prove more efficient, as when a user can make preliminary letter choices to access a long alphabetic list. 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.[A,C,E]

2.2.2-4 Consistent Design of Hierarchic Menus

The display format and selection logic of hierarchic menus should be consistent at every level.[A,E]

2.2.2-5 Labeling in Hierarchic Menus

Hierarchic menus should be organized and labeled to guide operators within the hierarchic structure.

ADDITIONAL INFORMATION: Operators will learn menus more quickly if a map of the menu structure is provided as HELP.[E]

2.2.2-6 Menu Selection by Keyed Entry

When menu selection is a secondary (occasional) means of control entry, and/or only short option lists are needed, then selection by keyed entry should be provided.

ADDITIONAL INFORMATION: An option might be selected by keying an associated code which is included in the displayed menu listing. Alternatively, if menu labels can be displayed near a screen margin, then an option might be selected by pressing an adjacent multifunction key.[A,E]

2.2.2-7 Explicit Option Display

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.

ADDITIONAL INFORMATION: A complete display of control options will sometimes leave little room for display of data. If an extensive menu must be added to a working data display, that menu should be provided as a separate window that can temporarily overlay displayed data at user request, but can then be omitted again by further user action.[A,E]

2.2.2-8 Systematic Organization of Items on Menu Bar

The categories listed across the menu bar should be organized systematically.

ADDITIONAL INFORMATION: 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.[D]

2.2.2-9 Category Labels on Menu Bar

Category labels on menu bars should 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.

ADDITIONAL INFORMATION: 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.[D]

2.2.2-10 Height of Menu Bar

The height of a menu bar should be sufficient to contain standard text characters which serve as menu category labels, as well as space above and below the text characters.[D]

2.2.2-11 Consistent Display of Menu Options

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

ADDITIONAL INFORMATION: As a negative example, if +PRINT is the last option in one menu, the same print option should not be worded +COPY at the beginning of another menu.[A,D,E]

2.2.2-12 Standard Area for Code Entry

When menu selection is accomplished by code entry, a standard command entry area (window) should be provided where users enter the selected code.

ADDITIONAL INFORMATION: That entry area should be in a fixed location on all displays. In a customary terminal configuration, where the display is located above the keyboard, command entry should be at the bottom of the display, in order to minimize user head/eye movement between the display and the keyboard. Experienced users might key coded menu selections in a standard area identified only by its consistent location and use. If the system is designed primarily for novice users, however, that entry area should be given an appropriate label, such as "ENTER choice here: ___".[A,C,D,E]

2.2.2-13 Consistent Location for Menus

Menus should be displayed in consistent screen locations for all modes, transactions, and sequences.

ADDITIONAL INFORMATION: This applies to pop-up, pull-down, and windowed menus, and to menu bars.[C]

2.2.2-14 Menu Options Worded as Commands

The wording of menu options should consistently represent commands to the computer, rather than questions to the user.

ADDITIONAL INFORMATION: Wording options as commands will permit logical selection by pointing, will facilitate the design of mnemonic codes for keyed entry, and will help users learn commands in systems where commands can be used to by-pass menus. Wording options as commands properly implies that the initiative in command entry lies with the user. Wording options as questions implies initiative by the computer. For example, for option selection by pointing, a "+" (or some other special symbol) might be used consistently to distinguish a selectable control option from other displayed items, e.g., (Good) +PRINT (Bad) PRINT?. For option selection by code entry, the code for each option should be consistently indicated, e.g., (Good) p = Print (Bad) Print? (Y/N).[E]

2.2.2-15 Option Wording Consistent with Command Language

If menu selection is used in conjunction with or as an alternative to command language, the wording and syntactic organization of displayed menu options should correspond consistently to defined elements and structure of the command language.

ADDITIONAL INFORMATION: Where appropriate, cumulative sequences of menu selections should be displayed in a command entry area until the user signals entry of a completely composed command.[C,E]

2.2.2-16 Format Consistency

Where ordering cannot be determined by the above, alphabetic ordering should be used.[C]

2.2.2-17 Consistent Coding of Menu Options

If letter codes are used for menu selection, those letters should be consistently used in designating options from one transaction to another.

ADDITIONAL INFORMATION: Different codes for the same action will tend to confuse users and impede learning. The same code for different actions will tend to induce user errors, especially if those actions are frequently taken. However, this practice may be tolerable when selections are seldom taken, and then always taken from labeled alternatives. The same action should not be given different names (and hence different codes) at different places in a transaction sequence, such as f = Forward and n = Next. The same code should not be given to different actions, e.g., q = Quit and q = Queue.[A,E]

2.2.2-18 Key Coded Menu Selection

The code associated with each option should be displayed in a consistent and distinctive manner.[C]

2.2.2-19 Visual Representation of Path

Users should be able to access a visual representation of their paths through a hierarchy of menus.

ADDITIONAL INFORMATION: How the user's path through the menus is visually represented will depend on the type of menu. For example, if a user progresses through a series of permanent menus, an icon showing the previous menus and current menus, as well as menu selections, might be displayed. If a user progresses through a series of pull down menus, the previous menus might remain displayed with the selected item highlighted and the association between that item and the subsequent menu would be represented by a close spatial relation (e.g., a walking menu).[D]

2.2.2-20 Minimal Steps in Sequential Menu Selection

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.

ADDITIONAL INFORMATION: This represents a trade-off against the need for logical grouping in hierarchic menus. The number of hierarchic levels should be minimized, but not at the expense of display crowding.[E]

2.2.2-21 Return to Higher-Level Menus

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 BACKUP option.[A,C,D,E]

2.2.2-22 Indicating Current Position in Menu Structure

When hierarchic menus are used, the user should have some indication of current position in the menu structure.

ADDITIONAL INFORMATION: One possible approach would be to recapitulate prior (higher) menu selections on the display. If routine display of path information seems to clutter menu formats, then a map of the menu structure might be provided at user request as a HELP display.[A,C,E]

2.2.2-23 Distinct Subordinate Menus

If hierarchical branching is used, each subordinate menu should be visually distinct from each previous superordinate menu. Examples include the display of level numbers, a graphical stacking effect, etc.

ADDITIONAL INFORMATION: Successful user operations depend on a 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.[D]

2.2.2-24 Control Options Distinct from Menu Branching

The display of hierarchic menus should be formatted so that options which actually accomplish control entries can be distinguished from options which merely branch to other menu frames.

ADDITIONAL INFORMATION: In some applications, it may prove efficient to design "hybrid" menus which display one branch of the menu hierarchy elaborated to include all of its control options while other branches are simply indicated by summary labels. In such a hybrid menu, it will help orient users if options that accomplish control actions are highlighted in some way to distinguish them from options which will result in display of other frames of the hierarchic menu.[A,E]

2.2.2-25 Consistent Entry Prompt

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

ADDITIONAL INFORMATION: A consistent prompt unambiguously indicates the need for user input. For example, "ENTER CHOICE: __".[D]

2.2.2-26 Permanent Menus Minimized

The use of permanent menus should be minimized.

ADDITIONAL INFORMATION: Permanent menus require dedicated display space and more paging activity (because the application must return the user to the main menu page at every task change). However, permanent menus might be used (1) whenever it is beneficial to examine every option in detail, (2) when the amount of text in each menu item is large, or (3) when there is no pointing device available.[D]

2.2.2-27 Activation of Pull-down and Pop-Up Menus

Pull-down and pop-up menus should be activated only by a specific user action that requests the display of the menu.

ADDITIONAL INFORMATION: Menus should not appear simply because the cursor has passed over the menu title.[D]

2.2.2-28 User Requested Menus: Pull-Downs and Pop-Ups

User requested menus should be used whenever possible.

ADDITIONAL INFORMATION: 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 cate[illegible]lecting the item, and removing the menu can be accomplished with a minimal number of actions. The primary adv[illegible] 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. The ideal user-requested menu design would provide the user with a reminder of the menu categories and allow the user to select an item with few actions and little movement of a cursor on the screen.[D]

2.2.2-29 Hiding Menus After Selection of an Item

When a pull-down or pop-up menu item has been selected, the menu should revert to its hidden state as the selected command is carried out.[D]

2.2.2-30 Programmable Keys

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.[D]

2.2.2-31 Menu Color

The same color for menus should be used within the same group.[B]

2.2.2-32 Explanatory Title for Menu

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

ADDITIONAL INFORMATION: EXAMPLE: (Good) Organizational Role: r = Responsible, a = Assigned, p = Performing. (Bad) Select: r = Responsible, a = Assigned p = Performing.[E]

2.2.2-33 Letter Codes for Menu Selection

If menu selections are made by keyed codes, each code should be the initial letter or letters of the displayed option label, rather than assigning arbitrary letter or number codes.

ADDITIONAL INFORMATION: Meaningful (as opposed to arbitrary) codes will facilitate learning and reduce errors. For example, m = Male, f = Female is preferable to 1 = Male, 2 = Female. Options might be numbered when a logical order or sequence is implied. When menu selection is from a long list, the line numbers in the list might be an acceptable alternative to letter codes.[A,C,E]

2.2.2-34 Complete Display of Menu Options

A menu should be designed to display all options appropriate to any particular transaction.

ADDITIONAL INFORMATION: A familiar set of general control options (i.e., options that are always implicitly available) may be omitted from individual displays. Such general options might be selected by requesting a general menu, or perhaps by function key or command entry.[A,E]

2.2.2-35 No Scrolling in Menus or Menu Bars

All menu items should be visible to the user without scrolling.

ADDITIONAL INFORMATION: This guideline applies to permanent menus as well as pop-up or pull-down menus and menu bars. The number of categories listed on the menu bar should not exceed the length of the bar.[D]

2.2.2-36 Menu Options Dependent on Context

A menu should be designed to display only those options that are actually available in the current context for a particular user.

ADDITIONAL INFORMATION: If a user selects a displayed option, and is then told that option is not actually available, an undesirable element of unpredictability has been introduced into the interface design. Users may become uncertain and confused about command entry.[A,C,E]

2.2.2-37 Return to General Menu

Users should have to take only one simple key action to return to the general menu at the top level in hierarchic menus.

ADDITIONAL INFORMATION: The user should not have to backtrack to return to the starting level in a hierarchical menu system. This capability can be provided by dedicating a program function key, touch field, or a cursor entry field to display the main menu. This action could be considered analogous to the REVIEW option.[A,B,C,D,E]

2.2.2-38 Stacking Menu Selections

Users should be able to combine a series of selections into a single "stacked" entry.

ADDITIONAL INFORMATION: If necessary, stacked sequential entries might be separated by some character, such as a space, slash, comma or semicolon. It would be preferable, however, if they were simply strung together without special punctuation. Computer interpretation of an unpunctuated string will require letter codes (by preference) or fixed-digit number codes for option selection.[C,D,E]

2.2.2-39 By-Passing Menu Selection with Command Entry

Experienced users should be able to by-pass a series of menu selections and make an equivalent command entry directly.

ADDITIONAL INFORMATION: In effect, a command entry might specify an option anywhere in a hierarchic menu structure, permitting a user to jump down several levels, or to move directly from one branch to another. If a command by-passes only a portion of the complete menu sequence, and so does not yet specify a complete control entry, then the appropriate next menu should be displayed to guide completion of the control entry.[A,C,E]

2.2.2-40 Menu Selection by Pointing

When menu selection is the primary means of command entry, and especially if choices must be made from extensive lists of displayed control options, option selection by direct pointing should be provided.

ADDITIONAL INFORMATION: If a capability for direct pointing is not provided (e.g., if pointing involves separate manipulation of a mouse, or cursor positioning by key action), then for long menus it may prove faster to permit menu selection by keying associated option codes. Pointing directly at a displayed option guarantees good display-control compatibility. Users do not have to note associated option codes and enter them by key actions.[C,E]

2.2.2-41 Acknowledgement of Selection from Keyboard

When a menu item is chosen by a keyboard entry there should be some acknowledgement from the system that the item has been chosen.

ADDITIONAL INFORMATION: Acknowledgement that an item has been chosen is often indicated by highlighting the menu item.[D]

2.2.2-42 Function of Menu Should Be Evident

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

2.2.2-43 Single-Column List Format

When multiple menu options are displayed in a list, each option should be displayed on a new line, i.e., format the list as a single column.

ADDITIONAL INFORMATION: Displaying options in several columns may be used where shortage of display space dictates a compact format. If there are only a few options, those might be displayed in a single row. An exception could be made for hierarchic menus, where a high-level menu might be shown in the left column of a display, accompanied by a lower-level menu in the right column whose options change to reflect whatever selection is currently made from the high-level menu. A single column format will aid scanning, especially for novice users.[A,C,D,E]

2.2.2-44 Single Selection Per Menu

Each menu display should permit only one selection by the user.[A,E]

2.2.2-45 Non-Selection of Conflicting Menu Items

Users should not be able to select menu items that are in conflict.

ADDITIONAL INFORMATION: Menu items that are in conflict might be, for example, two different font sizes in a text input task. Users should, however, be able to select multiple menu items that are not in conflict (e.g., a font size and font type in text input). Each menu item selection would be a separate transaction with the system.[D]

2.2.2-46 Non-Selectable Menu Items

When menu items are not selectable they should be identified as such to the user.[D]

2.2.2-47 Menus Distinct from Other Displayed Information

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.

ADDITIONAL INFORMATION: Menu options should be located consistently in the display and incorporate some consistent distinguishing feature to indicate their special function, perhaps beginning with a special symbol such as a plus sign (+NEXT , +BACK , etc.). "Embedded menus," in which various items within a working display are highlighted in some way to indicate that they can be selected to obtain further information, may also be used[A,E]

2.2.2-48 Breadth and Depth of Menu Items

Menus should have a limited number of items in breadth and in depth.

ADDITIONAL INFORMATION: Moderate menu breadth (e.g., number of menus in a menu hierarchy, number of menu categories in a menu bar, or number of pop-up menus) and depth (e.g., number of items per menu or, in menu bars, per menu category) should be facilitated by the use of a hierarchical menu structure whereby the selection of items from one menu (the parent) activates a second menu (the child) with further options. The parent menu should remain visible during the selection of the child menu. The number of levels in the hierarchy should be limited (for example, to no more than three).[D]

2.2.2-49 Dual Activation for Pointing

If menu selection is accomplished by pointing, dual activation should be provided, in which the first action designates the selected option, followed by a separate second action that makes an explicit control entry.

ADDITIONAL INFORMATION: The two actions of cursor placement and entering should be compatible in their design implementation. If the cursor is positioned by keying, then an ENTER key should be used to signal control entry. If the cursor is positioned by lightpen, provide a dual-action "trigger" on the lightpen for cursor positioning and control entry. On a touch display, the computer might display a separate ENTER box that can be touched by a user to indicate that the cursor has been properly positioned. This recommendation for dual activation of pointing assumes that accuracy in selection of control entries is more important than speed. In some applications that may not be true.[C,E]

2.2.2-50 Large Pointing Area for Option Selection

If menu selection is accomplished by pointing, as on touch displays, 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.

ADDITIONAL INFORMATION: The larger the effective target area, the easier the pointing action will be, and the less risk of error in selecting a wrong option by mistake.[A,E]

2.2.2-51 Highlighting When Cursor Passes Over Item

For all types of menus, menu items that are available to be selected should be highlighted whenever the cursor passes over them and the selection button is down.

ADDITIONAL INFORMATION: As soon as the cursor passes outside the boundaries of the menu item the item should return to its normal state. Unavailable options should not highlight when the cursor passes over them.[D]

2.2.2-52 Number of Options

Each menu option list should have 4 to 8 options.

ADDITIONAL INFORMATION: Menus with fewer than 3 options should be avoided. "Menus" with only one item should not be used.[C,D]

2.2.2-53 Equivalent Keyboard Commands

When equivalent keyboard commands are provided, they should be displayed as part of the menu option label.[C]

2.2.2-54 Numbering Options for Codes

Arbitrary numbers or codes should not be used for keyed entry. Numbering options might be used when the list of items is particularly long, but this should be avoided.[D]

2.2.2-55 ON/OFF Menu Items

For menu items that can be in an "On" or "Off" state, the "On" state should be indicated by making the item perceptually distinct.[D]

2.2.2-56 Selection of ON/OFF Items

Selection of menu items with "On" and "Off" states should change their state.[D]

2.2.3-1 Function Keys for Interim Command Entries

Function keys should be provided for interim command entries, i.e., for actions taken before the completion of a transaction.

ADDITIONAL INFORMATION: Function keys will aid such interim actions as DITTO, CONFIRM, and requests for PRINT, or HELP, and also interrupts such as BACKUP CANCEL, etc. Interim control refers to an action taken by a user while working with displayed data, e.g., while still keying data entries or changes, etc. Function keys will aid interim control entries partly because those entries may be frequent.[E]

2.2.3-2 Distinctive Labeling of Function Keys

Each function key should be labeled informatively to designate the function it performs.

ADDITIONAL INFORMATION: Labels should be sufficiently different from one another to prevent user confusion. For example, two keys should not be labeled ON and DN.[D,E]

2.2.3-3 Distinctive Location

Function keys should be grouped in distinctive locations on the keyboard to facilitate their learning and use.

ADDITIONAL INFORMATION: Frequently used or important function keys should be placed in the most convenient or prominent locations.[A,E]

2.2.3-4 Consistent Assignment of Function Keys

A function assigned to a particular key in a given task context should be assigned to the same key in other contexts.

ADDITIONAL INFORMATION: A particular function should be accessed in the same manner in any context in which it is used. For example, the SAVE function should be invoked using the same key whether the user is saving edited information or new information.[D,E]

2.2.3-5 Single Key for Continuously Available Functions

When a function is continuously available, its function should be assigned to a single key.[A,E]

2.2.3-6 Single Keying for Frequent Functions

Keys controlling frequently used functions should permit single key action and should not require double (control/shift) keying.[A,D,E]

2.2.3-7 Consistent Functions in Different Operational Modes

When a function key performs different functions in different operational modes, equivalent or similar functions should be assigned to the same key.

ADDITIONAL INFORMATION: Functions assigned to a given key in different modes should be related. For example, a particular key might be used to confirm data changes in one mode, confirm message transmission in another, etc. As a negative example, a key labeled RESET should not be used to save data in one mode, dump data in another, and signal task completion in a third.[A,E]

2.2.3-8 Logical Pairing of Double-Keyed Functions

If double (control/shift) keying is used, the functions paired on one key should be logically related.

ADDITIONAL INFORMATION: Functions assigned to a given key should be related. For example, if a particular function key moves the cursor to the upper left corner of a display screen then that same key when shifted might be used to move the cursor to the bottom right corner of the screen. As a negative example, a function key that moves the cursor should not be used when shifted to delete displayed data.[A,E]

2.2.3-9 Consistent Logic for Double Keying

If double (control/shift) keying is used, the logical relation between shifted and unshifted functions should be consistent from one key to another.

ADDITIONAL INFORMATION: Consistency in the underlying logic for double keying will help a user to learn the functions associated with different keys. For example, one consistent logic might be that shifted and unshifted functions are opposite, so that if a particular key moves the cursor forward then that key when shifted would move the cursor backward. Another possible logic might be that shifted and unshifted functions are related by degree, so that if a particular key deletes a single displayed character then that key when shifted would delete a word [A,E]

2.2.3-10 Labeling Multifunction Keys

If a key is used for more than one function, the function currently available should always be indicated to the user.

ADDITIONAL INFORMATION: If a key is used for just two functions, depending upon defined operational mode, then alternate illuminated labels might be provided on the key to indicate which function is current. In those circumstances, it is preferable that only the currently available function is visible, so that the labels on a group of keys will show what can be done at any point. If key function is specific to a particular transaction, an appropriate guidance message on the user's display should be provided to indicate the current function.[E]

2.2.3-11 Easy Return to Base-Level Functions

If the functions assigned to a set of keys change as a result of user selection, the user should be provided with an easy means to return to the initial, base-level functions.

ADDITIONAL INFORMATION: In effect, multifunction keys can provide hierarchic levels of options much like menu selection dialogues, with the same need for rapid return to the highest-level menu. For some applications, it may be desirable to automate the return to base-level assignment of multifunction keys, to occur immediately on completion of a transaction and/or by time-out following a period of user inaction.[A,E]

2.2.3-12 Feedback for Function Key Activation

When function key activation does not result in any immediately observable natural response, users should be provided with some other form of computer acknowledgment.

ADDITIONAL INFORMATION: Temporary illumination of the function key will suffice, if key illumination is not used for other purposes such as indicating available options. Otherwise an advisory message should be displayed.[A,E]

2.2.3-13 Disabling Unneeded Function Keys

When function keys are not needed for any current transaction, they should be temporarily disabled under computer control.

ADDITIONAL INFORMATION: Users should not be required to apply mechanical overlays to indicate that functions are not to be used. If a user selects a function key that is invalid for the current transaction, no action should result except display of an advisory message indicating what functions are available at that point.[E]

2.2.3-14 Indicating Active Function Keys

If some function keys are active and some are not, the current subset of active keys should be indicated in some noticeable way, such as by brighter illumination.

ADDITIONAL INFORMATION: This practice will speed user selection of function keys.[E]

2.2.3-15 Multiple Presses of Function Key

Pressing a function key in a sequence of key presses unrelated to the function should result in a message asking the user if he or she meant to select that function.

ADDITIONAL INFORMATION: It should not result in the action normally produced by the key until the user responds positively to the question.[D]

2.2.4-1 User Definition of Macro Commands

Users should be allowed to assign a single name to a defined series of control entries, and then to use that named "macro" for subsequent command entry.

ADDITIONAL INFORMATION: In this way users can make frequently required but complicated tasks easier to accomplish, when the interface designer has failed to anticipate a particular need. The system should not accept a user designated macro name that is the same as an existing command name.[C,E]

2.2.4-2 Index of Macros

Users should have access to an index of their macros and programmable function keys with their respective composition of commands.

ADDITIONAL INFORMATION: Users should have a means of providing a list of their macro names and functions to other users with whom they will communicate.[D]

2.2.4-3 Limiting User-Definable Macros and Programmable Keys

The use of user definable macros and programmable function keys should be limited.

ADDITIONAL INFORMATION: The advantages may outweigh the disadvantages for some tasks (e.g., software development or modification) whereas, for other tasks (e.g., application specific software) the disadvantages may outweigh the advantages.[D]

2.2.4-4 Modification of Defined Macros

A user should be restricted from modifying a macro or programmable function key as defined by a different originating user.[D]

2.2.4-5 No Duplication of Macro Names

Users should not be allowed to duplicate macro names.

ADDITIONAL INFORMATION: An error message should be provided to the user when he or she attempts to assign a macro a previously-used name.[D]

2.2.5-1 Form Filling for Command Entry

Form filling should be provided as an aid for composing complex command entries.

ADDITIONAL INFORMATION: For example, for a complex data retrieval request, a displayed form might indicate the various parameters that could be specified. For a print request, a displayed form might help a user invoke the various format options that are available.[C,E]

2.2.5-2 Defaults for Command Entry

Form filling should be used as a means of displaying default values for the parameters in complex command entries.

ADDITIONAL INFORMATION: Default parameters permit users to compose potentially complicated entries by relatively simple actions. If defaults have been defined, they should be indicated to users. A displayed form permits a user to review (and confirm or change) default values, just as a user might review displayed defaults for data entry. When only a few parameters are involved, it may be feasible simply to prompt users with guidance messages rather than by displaying a form.[A,E]

2.2.5-3 Consistent Format for Command Forms

Forms for command entry should be consistent in format.

ADDITIONAL INFORMATION: The design of such forms should generally conform to guidelines for the design of information entry forms.[A,C,E]

2.2.5-4 Forms for Information Entry

Form filling should be used for tasks where some flexibility in information entry is needed, such as the inclusion of optional as well as required items, and/or where computer response may be slow.[C,E]

2.2.5-5 Grouping Data Fields

Where no source documents or forms exist to support information entry, then fields should be logically grouped, by sequence and frequency of use, importance, and functional associations.[A]

2.2.5-6 Combined Entry of Related Data

Just one explicit entry action at the end of the transaction sequence should be required, rather than separate entry of each item.

ADDITIONAL INFORMATION: Depending on form design, this practice might involve entering the entire form, or entry by page or section of a longer form. Form design should indicate to users just where explicit entry is required. Single entry of grouped data will generally permit faster input than item-by-item entry, and should prove more accurate as well. This practice permits user review and possible data correction prior to entry, and also helps the user understand at what point grouped data are processed. It will also permit efficient cross validation of related data items by the computer.[A,E]

2.2.5-7 Data Field Labels

For each data field, an associated label should be displayed to help users understand what entries can be made.[E]

2.2.5-8 Minimal Use of Delimiters

Whenever possible, entry of multiple data items should be allowed without keying special separator or delimiter characters.

ADDITIONAL INFORMATION: Formatting characters such as hyphens should be provided by the system. This can be accomplished either by keying into predefined entry fields or by separating sequentially keyed items with blank spaces. In this context, tabbing from field to field is not considered to be keying a special delimiter character. When data items contain internal blanks, the entry fields with a predefined structure should be designed so that users will not have to key any internal delimiters.[A,E]

2.2.5-9 Standard Delimiter Character

When a field delimiter must be used for data entry, a standard character should be employed consistently for that purpose.

ADDITIONAL INFORMATION: A special delimiter character that does not require shift keying should be used. A character that does not occur as part of any data entry (except possibly for entry of running text where its occurrence would not be ambiguous) should be used. For example, a slash (/) may be a good choice.[A,E]

2.2.5-10 Flexible Interrupt

When multiple data items are entered as a single transaction, as in form filling, the user should be allowed to REVIEW, CANCEL, or BACKUP and change any item before taking a final ENTER action.[A,E]

2.2.5-11 Deferring Input of Information

When entry of information in a field is deferred or omitted, the system should identify the field by highlighting or other means. Before the Information is filed or accessed, the user should be reminded that information has not been entered.[A]

2.2.5-12 Use of Tabular Displays

When sets of data items must be entered sequentially, in a repetitive series, a tabular display format should be provided where data sets can be keyed row by row.

ADDITIONAL INFORMATION: Row-by-row entry facilitates comparison of related data items, and permits potential use of a DITTO key for easy duplication of repeated entries. When the items in each data set exceed the capacity of a single row, tabular entry will usually not be desirable, unless there is a simple means for horizontal scrolling.[A,E]

2.2.5-13 Distinctive Label Formats

Distinctive formats should be provided for column headers and row labels, so that users can distinguish them from data entries.[E]

2.2.5-14 Aiding Entry of Duplicated Data

For entry of tabular data, when entries are frequently repeated, users should be provided with some easy means to copy duplicated data.

ADDITIONAL INFORMATION: For example, a DITTO capability will speed data entry, and should prove more accurate than requiring users to rekey duplicated data.[E]

2.2.5-15 Tabbing to Advance to Subsequent Fields

Where the number of fields is limited, screen traversal distances are short, and when data fields will be accessed sequentially, users should be allowed to tab directly from one data field to the next, so that the cursor can move freely back and forth across rows or columns.[A,E]

2.2.5-16 Direct Pointing Devices for Selecting Fields

In complicated forms with many fields, or when field entry will be less predictable (as in data base update), direct pointing devices, such as mouse or lightpen, should be available for selecting fields.

ADDITIONAL INFORMATION: When input is not predictably structured, it may be preferable to move among fields by direct pointing rather than tabbing.[A]

2.2.5-17 Row Scanning Cues

For long forms, those with many rows, some extra visual cue should be provided to help a user scan a row accurately across columns.

ADDITIONAL INFORMATION: Visual aids for scanning rows are probably needed more when a user is reviewing and changing displayed data than for initial data entry. Such aids should be provided consistently, however, so that display formats for both data entry and review will be compatible. For example, a blank line might be inserted after every fifth row, or dots might be placed between columns in every fifth row. As an alternative, a displayed ruler which a user can move from one row to another may be used.[E]

2.2.6-1 When to Use Direct Manipulation

Direct manipulation should be used primarily in tasks with actions and objects that lend themselves to pictographic representation, and in which the actions and objects need not be modified for the successful interpretation of the command by the system.

ADDITIONAL INFORMATION: In command entry by direct manipulation, the techniques for selecting and moving displayed objects would be similar to those described in guidelines for graphic data entry. For example, rather than compose a command or select a function key to file a document, a user might move a displayed icon representing the document to superimpose it on another icon representing a file. An extension of this idea is the use of "embedded menus" in which various items within a working display are highlighted in some way to indicate that they can be selected to obtain further information.[D]

2.2.6-2 Pointing

When user input involves frequent pointing on a display surface, the interface should be designed so that other actions (e.g., display control) are also accomplished by pointing, in order to minimize shifts from one entry device to another.

ADDITIONAL INFORMATION: This recommendation implies extensive use of menus in the margins of a graphic display to permit direct selection of control options by pointing. If screen capacity is too limited to permit simultaneous display of both graphic data and menus, then the designer might provide temporary superposition of menu windows on displayed data, or might provide some separate display device to show current options for control entry. Control entry via keyboard and/or function keys will be less satisfactory. If pointing is performed on some separate input device, such as a stylus on a digitizing tablet, then associated control actions should also be implemented via that device. For graphics software, a pointing action by a user can accomplish several different logical functions: specifying a displayed element ("pick" function); selecting a system-defined object, attribute or action ("button" or "choice" function); or indicating a location in the conceptual drawing space ("locator" function). A designer must distinguish among these functions, although most users will not. Alphabetic entry for titles, labels, and other annotation of graphic displays will be accomplished more quickly by conventional keyboard input than by pointing.[A,C,E]

2.2.6-3 Highlighting the Selected Item

Selection of an icon, menu, or application-specific capability from a function area should be acknowledged by highlighting the selected item.[D]

2.2.6-4 Other Features of the Direct Manipulation Interface

The direct manipulation interface should include (1) windows for containing the data files, (2) menus for additional objects and actions that are not easily represented by pictographic icons.[D]

2.2.6-5 Fast Computer Response with Direct Manipulation

Direct manipulation should not be used when the computer response is slow.

ADDITIONAL INFORMATION: Other modes of interaction should be considered if the system is unable to respond immediately (i.e., within 0.25 sec) to direct manipulation input.[D]

2.2.6-6 Supplementary Verbal Labels

If icons are used to represent control actions in menus, a verbal label should be displayed with each icon to help assure that its intended meaning will be understood.

ADDITIONAL INFORMATION: A redundant verbal label might help make the meaning clear to a user who is uncertain just what a displayed icon means.[C,E]

2.2.6-7 Graphic Display of Control Context

Graphic means for displaying to users the context of current control actions should be provided.

ADDITIONAL INFORMATION: A graphic representation of the currently selected values of functions, elements and attributes affecting control actions might help reduce user errors in command entry. Graphic techniques might be used to display the scope of a proposed control action, such as outlining a group of display elements that will be affected by the action.[E]

2.2.6-8 Graphic Display of Control Prompting

Prompting aids and other guidance pertaining to current control actions should be displayed graphically to the user.

ADDITIONAL INFORMATION: A graphic representation of keypad layout with notes explaining the various key functions might help a novice user to learn the control options available via function keys. A graphic representation of logical combinations specified in query formulation might help reduce errors in the use of query language.[E]

2.2.6-9 "Opening" an Icon

A user should be able to "open" an icon with a simple, explicit action.

ADDITIONAL INFORMATION: The action or information represented by an icon is invoked or accessed by "opening" the icon. This should involve two steps: (1) indicating the object or action to be selected (e.g., moving a pointing cursor or other follower to an icon or function area) and (2) invoking the function through the performance of a specific, well-defined selection action, e.g., a "double click" on the cursor control device button. Note: A "double click" is defined by two clicks within 700 ms of each other.[D]

2.2.6-10 Size of Icons

Items on the screen that are displayed for selection should be a minimum of 5 mm on a side and separated by at least 3 mm.[D]

2.2.6-11 Text Selection Area

When functions are represented by text labels, a large area for pointing should be provided, including the area of the displayed label, plus a half-character distance around the label.[A]

2.2.6-12 Zooming for Precise Positioning

When data entry requires exact placement of graphic elements, users should be allowed to request expansion of the critical display area ("zooming") to make the positioning task easier.[A,C,E]

2.2.6-13 Selecting Graphic Elements

Users should be provided some means for designating and selecting displayed graphic elements for manipulation.

ADDITIONAL INFORMATION: Users should have a means of indicating groups of elements (or parts of a complex element) to which an action will be applied. For example, designation might be by pointing, in the case of a discrete element, or might require some sort of outlining action to delineate portions of a complex figure.[A,C,E]

2.2.6-14 Highlighting Selected Elements

When a user has selected a displayed graphic element, that element should be highlighted in some way so that the user can anticipate the consequences of any proposed action involving that selection.

ADDITIONAL INFORMATION: A dotted border might be displayed around a selected element, or perhaps a selected element might be displayed with video inversion to distinguish it from other elements.[A,E]

2.2.6-15 Displaying Current Attributes

During graphic data entry/editing, the selected attributes that will affect current actions should be displayed for ready reference by the user.

ADDITIONAL INFORMATION: Users may forget what options have been chosen. Displayed reminders will be particularly important in situations where the consequences of a mistaken user action are difficult to reverse, e.g., where it may be hard to erase an incorrectly drawn line. For example, when graphic attributes -- plotting symbols, character size, line type, color, etc. -- are chosen from displayed menus, it might suffice to highlight the currently selected menu options; alternatively, current selections might be shown in some sort of "reminder" window. A few attributes might be shown by the displayed cursor, i.e., by changing cursor shape, size or color depending upon current attribute selections. If rubberbanding is provided to aid line drawing, then that process itself would show the currently selected line type. In some applications, display cues may not be adequate to convey attribute information completely. There may not be sufficient room on the display. Or the attributes may derive from underlying models whose characteristics are too complex for simple display representation. In such cases, users should be able to request auxiliary display of such information to determine the operative context for current actions.[A,C,E]

2.2.6-16 Automatic Data Registration

Automatic registration or alignment of computer-generated graphic data should be provided, so that variable data are shown properly with respect to fixed background or map data at any display scale.

ADDITIONAL INFORMATION: When users are required to enter data via some separate device such as a graphics tablet, rather than directly on the display surface, it may be necessary for a user to participate in some computer-prompted procedure for ensuring data registration. Such a procedure may prove error-prone, however, and should be considered an undesirable expedient.[A,C,E]

2.2.6-17 Automated Data Plotting

When complex graphic data must be entered quickly, computer aids should be provided to automate that process.

ADDITIONAL INFORMATION: Users can create simple graphics or edit stored graphic material fairly quickly, but they can only create complex graphic displays much more slowly. A variety of computer aids can be provided to help enter graphic data. Entry of detailed drawings and/or photographic imagery can be accomplished via a video camera and high-resolution digitizer, perhaps with facilities for a user to edit that process.[A,E]

2.2.6-18 Plotting Stored Data

Automated plotting of computer-stored data should be provided at user request, with provision for subsequent editing by a user.

ADDITIONAL INFORMATION: In many applications, data intended for graphic display will already be stored in the computer. In such cases a user might specify the graphic format required (e.g., a line graph, or, for three-dimensional data, an XYZ plot), and edit elements in the resulting display output, without actually having to re-enter the data. When users do have to enter data for graphic display, they might choose form filling or tabular entry for efficiency in the initial input of data and then invoke graphic capabilities for subsequent data editing. In either case, it is important that previously entered data should be accessible for graphic processing.[A,E]

2.2.6-19 Predefined Graphic Formats

When graphic data must be plotted in predefined standard formats, templates or skeletal displays for those formats should be provided to aid data entry.

ADDITIONAL INFORMATION: In many applications, it may help to provide flexibility so that general prestored formats can be modified by a user and then saved for subsequent use. For example, sample displays might be stored in the computer to aid in creating standard graphs such as bar graphs, or standard diagrams such as organization charts, or page layouts for typesetting, or maps drawn to different scales or with different projections.[A,E]

2.2.6-20 Aids for Graph Construction

When graphs must be constructed for data plotting, computer aids should be provided for that purpose.

ADDITIONAL INFORMATION: Construction aids might include stored templates of different kinds of graphs, prompts to guide users in the definition of scale axes, and aids for format control such as automatic centering of axis labels if requested by a user. Computer aids for graph construction should be designed to allow flexibility in their use. A user should be allowed to position labels and other graphic elements at will, except where operational requirements may impose fixed formats.[A,E]

2.2.6-21 Aids for Scaling

Computer aids should be provided to help users specify appropriate scales for graphic data entry.

ADDITIONAL INFORMATION: The computer should handle scaling automatically, subject to review and change by a user. The computer might provide a general template for the plotting scale and prompt the user as necessary to define the scale more exactly, including specification of the origin, linear or logarithmic axes, scale intervals, minimum and maximum values, and labels for axes. In the process of defining scales the computer might impose rules to ensure that the resulting graphic displays are designed to permit effective information assimilation by their users, e.g., displaying scales with conventional direction, so that numbers increase in value from left to right, or from bottom to top.[A,E]

2.2.6-22 Grouping Elements

Users should be allowed to designate a group of elements to which graphic editing operations will be applied in common.

ADDITIONAL INFORMATION: For example, a user might carefully position two elements with respect to each other, and then wish to move both of them together while preserving their relative positions. Grouping elements might be a temporary action, intended for just a few successive editing operations, or it might be specified more permanently via some sort of "make group" command.[A,E]

No guidelines are currently available in this section.

2.2.8-1 Natural Organization of Data

A query language should reflect a single, natural data structure or organization.

ADDITIONAL INFORMATION: The query language should be congruent with the user's perception of how the data are organized. For example, if a user supposes that all data about a particular person are stored in one place, then the query language should permit such data to be retrieved by a single query, even though actual computer storage might carry the various data in different files.[A,C,E]

2.2.8-2 Task-Oriented Wording

The wording of a query should simply specify what data are requested.

ADDITIONAL INFORMATION: A user should not have to tell the computer how to find the data. This objective has been called "nonprocedurality", meaning that a user should not have to understand computer procedures for finding data.[A,C,E]

2.2.8-3 Flexible Query Formulation

Users should be allowed to employ alternative forms when composing queries, corresponding to common alternatives in natural language.

ADDITIONAL INFORMATION: There are typically a number of equally precise ways of specifying a given condition. Therefore, when quantifying a query, a user should be able to employ equivalent forms, such as "over 50", "more than 50", "51 or more".[A,E]

2.2.8-4 Minimal Need for Quantifiers

A query language should minimize the need for quantifiers in query formulation.

ADDITIONAL INFORMATION: People have difficulty in using quantifiers. Negative quantifiers ("no", "none", "zero", etc.) are particularly difficult for users to deal with. Other potentially confusing quantifiers include indefinite ("some", "any") and interrogative ("how many") forms. If a query language does require quantifiers, it may be helpful to allow a user to select the desired quantifier from a set of sample queries worded to maximize their distinctiveness.[A,E]

2.2.8-5 Logic to Link Queries

A query language should include logic elements that permit users to link sequential queries as a single entry.

ADDITIONAL INFORMATION: Common links for query formulation include "and", "or", etc. However a query language should be designed so that it does not require logical links. Some logical quantifiers ("greater than", "less than", etc.) may confuse users.[A,C,E]

2.2.8-6 Confirming Large-Scale Retrieval

If a query will result in a large-scale data retrieval, the user should be informed and required to confirm the transaction or to narrow the query before processing.

ADDITIONAL INFORMATION: In this regard, it may be helpful to permit a user to set some upper bound for data output, in effect to define what constitutes a "large-scale" retrieval. It may help a user to decide whether to confirm or modify a pending query, if the user can request a partial display of the currently specified data output.[A,C,E]

2.2.9-1 Request for Information

The system should provide the user with a specific request for information.[D]

2.2.9-2 Questions Displayed Singly

Each question should be displayed separately.

ADDITIONAL INFORMATION: Users should not be required to answer several questions at once. A user may become confused in trying to deal with several questions at once, particularly if the number of questions is variable from one transaction to another.[A,C,D,E]

2.2.9-3 Stacking Related Questions

The system should be able to stack questions and their associated answers if a series of questions are concerned with the same topic.[D]

2.2.9-4 Contextual Information Should Be Supplied

The system should provide the user with contextual information required for answering the question.

ADDITIONAL INFORMATION: For example, if the only answer that the system would accept were a percentage, the question should be followed by "(%)". The answer area should follow the contextual information.[D]

2.2.9-5 Unlimited Room for Answers

The system should accept as much information from the user as he or she provides in an answer.

ADDITIONAL INFORMATION: If the information that the system requests is constrained, a data form should be used.[D]

2.2.9-6 Recapitulating Prior Answers

When a series of computer-posed questions are interrelated, answers to previous questions should be displayed when those will provide context to help a user answer the current question.

ADDITIONAL INFORMATION: Another way to request a related series of user entries is to use a form-filling dialogue rather than question-and-answer.[A,C,E]

2.2.9-7 Removing and Recalling Questions

The user should have the ability to remove a question and answer from the screen or recall a question and answer to the screen.[D]

2.2.9-8 Sequence Compatible with Source Documents

When questions prompt entry of data from a source document, the question sequence should match the data sequence in the source document.[A,C,E]

2.2.9-9 Question Mark Delimiter

A question mark should be the delimiter of the questions and answer dialogue.

ADDITIONAL INFORMATION: In general, space for answering the question should be provided closely following the question mark. However, when additional information needed for the answer follows the question, the space for answering the question should be placed after the additional information.

2.2.10-1 Speech Input

Spoken input should be used only when entry cannot be accomplished through more reliable methods such as keyed entry or pointing.

ADDITIONAL INFORMATION: Current speech recognition devices are not well developed and tend to be error prone. Thus there should be some good reason for choosing speech input over more conventional data entry methods. Speech input might be appropriate if a user cannot use his/her hands for some reason.[E]

2.2.10-2 Limited Vocabulary for Speech Input

The vocabulary used for spoken input should be constructed so that only a few options are needed for any transaction.

ADDITIONAL INFORMATION: To increase the likelihood that a user's valid entries are correctly identified by the system, the user's vocabulary should be predictable. This does not necessarily mean that the vocabulary must be small, though recognition systems that can only accommodate small vocabularies are more prevalent and less expensive. A vocabulary is predictable when a user's choice of inputs at any given time is small, so that the system will be more likely to make a correct match in interpreting an entry.[E]

2.2.10-3 Feedback and Error Correction for Speech Input

Feedback and simple error correction procedures should be provided for speech input, so that when a spoken entry has not been correctly recognized by the computer, the user can cancel that entry and speak again.

ADDITIONAL INFORMATION: Simple error correction is particularly important with spoken input, since speech recognition systems are prone to error except under carefully controlled conditions.[A,E]

2.2.10-4 Alternative Entries for Speech Input

When speech input is the only form of input available, alternatives forms for critical entries should be allowed, so that if the system cannot recognize an entry after repeated attempts, another entry form can be substituted.

ADDITIONAL INFORMATION: Because speech recognition systems are affected by normal variations in a user's voice, and by changes in the acoustic environment, a spoken entry that was accepted yesterday might not be accepted today. Thus for important entries a user should be able to use an alternative word. For example, "Exit" might be defined as an acceptable substitute for "Finished". Spelling a word letter-by-letter is not an acceptable alternative, since speech recognition systems may have trouble correctly identifying similar sounding letters.[E]

2.2.10-5 Activation and Deactivation

Speech recognition systems should have an external, non-speech means of activation and deactivation (e.g., PAUSE and CONTINUE options) so that conversation between users is not taken as command input.

ADDITIONAL INFORMATION: If possible, a standby mode should be provided from which spoken commands to activate/deactivate may be invoked. External, non-speech means of activation and deactivation can include use of a keyboard.[D,E]

2.2.10-6 Vocabulary Items

The vocabulary items should (1) consist of words that are meaningful and familiar to the user, (2) be phonetically distinct from one another; and (3) consist of 2-5 syllables.

ADDITIONAL INFORMATION: Items of 2-5 syllables in length are generally better recognized than one-syllable items.[D,E]

2.2.10-7 Vocabulary Sets

Application vocabularies should be divided into sets based on the hierarchy of the application and recognition accuracy requirements.

ADDITIONAL INFORMATION: This improves recognition by reducing the number of choices that the recognizer has to consider to return the correct item.[D]

2.2.10-8 Testing the Recognition of Individual Vocabulary Items

The user should be able to test the recognition of any individual vocabulary item without the entire interactive system being on-line. Feedback on the word recognized and the corresponding confidence score should be available immediately after each use of a word.[D]

2.2.10-9 User-Adjustable Features

When the consequences of errors are not significant, the speech amplitude and rejection levels required for input should be user-adjustable.[D]

2.2.10-10 Word Boundaries

Where word boundaries (pauses between words) are required for system interpretation, boundaries of 100 milliseconds or more should be allowed by the system.[A]

2.2.10-11 Confidence Rating

An indication of the similarity of each spoken command to the recorded template should be available to the user.[D]

2.2.10-12 Speaker-Dependent Voice Recognizer

If an application functions with a speaker-dependent voice recognizer, the user should be able to retrain or update any or all vocabulary templates at any time.

ADDITIONAL INFORMATION: A user's voice changes over time, even in the course of an hour of continuous use. Several factors have the ability to alter the voice temporarily. To maintain good performance under these conditions, the user must have the ability to modify the template set.[D]

2.3.1-1 Distinctive Cursor

Cursors should have distinctive visual features (shape, blink, or other means of highlighting).

ADDITIONAL INFORMATION: A cursor is the most immediate and continuously available form of user guidance, since it will generally mark the current focus of user attention. Different cursor formats may denote different operational conditions. If that is done, each of those different cursors should be distinctive from other displayed items, and from each other. An underscore cursor would be difficult to see on a display of underscored text, or on a graphical display containing many other lines. If multiple cursors are used on the same display (e.g., one for alphanumeric entry and one for line drawing), then each cursor should be distinguishable from the others.[D,E]

2.3.1-2 Display of Cursor

The cursor should not move beyond the display boundaries or disappear from sight.[E]

2.3.1-3 Non-Distracting Design

The cursor should not be so distracting as to impair the searching of the display for information unrelated to the cursor.[B]

2.3.1-4 Stable Cursor

The displayed cursor should be stable.

ADDITIONAL INFORMATION: The cursor should remain where it is placed until moved by the user (or by the computer) to another position. The intent of the recommendation here is to avoid unwanted "drift". Some special applications, such as aided tracking, may benefit from computer-controlled cursor movement.[E]

2.3.1-5 Initial Cursor Placement

On the initial appearance of a data entry display, the cursor should appear automatically at some consistent and useful location.

ADDITIONAL INFORMATION: In a form-filling display, the cursor should be placed in the first entry field. When menu selection is by pointing, the system should place the cursor automatically at the first listed option. When menu selection is by code entry, the cursor should be automatically placed in the command entry area. For some applications, it may increase the efficiency of command entry if a null entry is recognized as a default to the first displayed option (assuming that the first option is the most likely choice).[E]

2.3.1-6 Consistent HOME Position

When there is a predefined HOME position for the cursor, that position should be consistently defined on all displays of a given type.

ADDITIONAL INFORMATION: The HOME position of the cursor should also be consistent in the different "windows" or sections of a partitioned display. For example, HOME might be in the upper left corner of a text display, or at the first field in a form-filling display, or at the center of a graphic display.[A,C,E]

2.3.1-7 Automatic Return of Cursor

When the user must repeatedly return the cursor to the origin or other specific screen location, automatic return or repositioning of the cursor should be provided.[D]

2.3.2-1 Cursor Control - General

The user should be able to adjust the sensitivity of the cursor movement to be compatible with the required task and user skills.[E]

2.3.2-2 Compatible Control of Cursor Movement

Control actions for cursor positioning should be compatible with movements of the displayed cursor, in terms of control function and labeling.

ADDITIONAL INFORMATION: For cursor control by key action, a key labeled with a left-pointing arrow should move the cursor leftward on the display. For cursor control by joystick, leftward movement of the control (or leftward pressure) should result in leftward movement of the cursor, etc.[A,C,E]

2.3.2-3 Easy Cursor Positioning

Users should be provided with an easy, accurate means of positioning a displayed cursor to point at different display elements and/or display locations.

ADDITIONAL INFORMATION: Cursor positioning is a frequent user action during graphic data entry. An easy means for controlling cursor movement is essential for efficient performance.[E]

2.3.2-4 Consistent Positioning

Where cursor positioning is incremental by discrete steps, the step size of cursor movement should be consistent horizontally (i.e., in both right and left directions), and vertically (in both up and down directions).[E]

2.3.2-5 Cursor Control Key Functions

At the minimum, keys for cursor control should allow horizontal and vertical cursor movement.

ADDITIONAL INFORMATION: Ideally, keys for cursor control should allow both horizontal and vertical movement, and movement along the diagonals.[D]

2.3.2-6 Cursor Control at Keyboard

When position designation is required in a task emphasizing keyed data entry, cursor control should be provided by some device integral to the keyboard (function keys, joystick, "cat", etc.).

ADDITIONAL INFORMATION: Separately manipulated devices (lightpen, "mouse", etc.) will tend to slow the user.[A,E]

2.3.2-7 Location of Cursor Control Keys

If cursor movement is accomplished by depressing keys, the keys should be located on the main keyboard.[E]

2.3.3-1 Cursor Movement

If the cursor is moved by depressing a key, releasing the key should cause the cursor to stop moving.[E]

2.3.3-2 Responsive Cursor Control

For arbitrary position designation, moving a cursor from one position to another, the cursor control should permit both fast movement and accurate placement.

ADDITIONAL INFORMATION: Ideally, when the user moves a pointing device the displayed cursor should appear to move instantly. Rough positioning should take no more than 0.5 seconds for full screen traversal. Fine positioning may require incremental stepping of the cursor, or a control device incorporating a large control/display ratio for small displacements, or a selectable vernier mode of control use. For any given cursor control action, the rate of cursor movement should be constant, i.e., should not change with time. Slow visual feedback of cursor movement can be particularly irritating when a user is repeatedly pressing a cursor control key, or perhaps holding the key down. In that case, slow feedback may cause the user to misjudge location and move the cursor too far.[E]

2.3.3-3 Precise Pointing

When fine accuracy of positioning is required, as in some forms of graphic interaction, the displayed cursor should include a point designation feature.

ADDITIONAL INFORMATION: Precise pointing will also require a cursor control device capable of precise manipulation. Touch displays, for example, will not permit precise pointing. A cross may suffice (like cross-hairs in a telescope), or perhaps a notched or V-shaped symbol (like a gun sight).[E]

2.3.3-4 Selectable Rate Aiding

The user should be able to turn rate aiding of the cursor movement on or off.

ADDITIONAL INFORMATION: With rate aiding the speed of follower movement is proportional to the speed of input movement. The default should be to have rate aiding off (zero-order control-display relation).[D]

2.3.3-5 User Selectable Speed

Users should be able to select at least two speeds (normal and fast) for the movement of the cursor when the keys for cursor control are held down.[D]

2.3.3-6 Variable Step Size

When character size is variable, the incremental cursor positioning should vary correspondingly, with a step size matching the size of currently selected characters.[A,E]

2.3.3-7 Easy Cursor Movement to Data Fields

If a cursor must be positioned sequentially in predefined areas, such as displayed data entry fields, this should be accomplished by simple user action.

ADDITIONAL INFORMATIO' Automatic cursor advance is generally not desirable. Programmable tab keys are customarily used for this purp e.[A,E]

2.3.3-8 Explicit Activation

Users should be required to take a separate, explicit action, distinct from cursor positioning, for the actual entry (enabling, activation) of a designated function.

ADDITIONAL INFORMATION: This guidance may not apply to tasks in which rapid, continuous entry is required (e.g., line drawing or tracking).[C,E]

2.3.3-9 Display Format Protection

When there are areas of a display in which data entries cannot be made (blank spaces, protected field labels, etc.), those areas should be insensitive to pointing actions and the cursor should be prevented from entering those areas.

ADDITIONAL INFORMATION: Automatic format protection will generally make cursor positioning easier for a user, since the cursor will not have to be stepped through blank areas, and much routine cursor control can be accomplished with only casual reference to the display. When a user may have to modify display formats, then this automatic format protection can be provided as a general default option subject to user override.[A,E]

2.3.3-10 Free Cursor Movement

For text editing, users should be allowed to move the cursor freely over a displayed page of text to specify items for change, and to make changes directly to the text.

ADDITIONAL INFORMATION: Free cursor movement and changes made directly to the text are characteristics usually associated with so-called screen-based editors and not associated with line- or command-based editors. Screen-based editors are preferred by users and are potentially more efficient.[E]

2.3.3-11 Proportional Spacing

If proportional spacing is used for displayed text, computer logic should make necessary adjustments automatically when the cursor is being positioned for data entry or data change.

ADDITIONAL INFORMATION: Without automatic computer aids, a user probably will not handle proportional spacing accurately.[E]

2.3.3-12 Cursor Movement by Units of Text

Users should be able to move the cursor by specific units of text, as well as one character at a time.

ADDITIONAL INFORMATION: Cursor positioning will be easier if appropriate function keys can be provided. A SENTENCE key that allows a user to move directly to the next displayed sentence will be more convenient than some double-keying logic such as CONTROL-S.[E]

2.3.3-13 Data Entry Independent of Cursor Placement

An ENTER action for multiple data items should results in entry of all items, regardless of where the cursor is placed on the display.

ADDITIONAL INFORMATION: A user may choose to move the cursor back to correct earlier data items, and may not move the cursor forward again. The computer should ignore cursor placement in such cases.[E]

2.3.4-1 Minimal Use of Multiple Cursors

Multiple cursors on a single display should be used only when it can be demonstrated that they are required by the task.

ADDITIONAL INFORMATION: Multiple cursors may confuse a user, and so require special consideration if used in interface design. Multiple cursors might be useful to mark a user's place when manipulating data in multiple display windows. In graphic interaction, one cursor might be used for line drawing and a different cursor for alphanumeric data entry (labels, etc.).[A,E]

2.3.4-2 Multi Monitor/Multi Controller Cursor Characteristics

In a multitasking environment with multiple monitors, controllers, or cursors, the location of the active cursor should be obvious to the user.

ADDITIONAL INFORMATION: If there are two pointing cursors -- one on each of two monitors -- the active cursor should be apparent to the user. If there is a single cursor that moves between two monitors, its path should be continuously trackable. As the cursor crosses from one monitor to the other it should either maintain its vertical coordinate for side by side monitors and horizontal for stacked monitors or should jump between uniquely specified locations on each screen.[D]

2.3.4-3 Distinctive Multiple Cursors

If multiple cursors are used, they should be visually distinctive from one another.[A,E]

2.3.4-4 Compatible Control of Multiple Cursors

If multiple cursors are controlled by different devices, their separate controls should be compatible in operation.

ADDITIONAL INFORMATION: Assume that one cursor is moved upward on a display by forward motion of a joystick. Then a second cursor should also be moved upward by forward motion -- perhaps by forward motion of a second joystick or by forward motion of a thumbwheel or other device.[A,E]

2.3.4-5 Distinctive Control of Multiple Cursors

If multiple cursors are controlled by a single device, a clear signal should be provided to the user to indicate which cursor is currently under control.[A,E]

2.3.4-6 Multiple Pointing Cursor Control Devices

When there are multiple cursor control/pointing devices, a unique pointing cursor shape should be associated with each device.[D]

2.3.4-7 Unique Shapes

Cursors of different shapes should be used for different purposes.

ADDITIONAL INFORMATION: The shape of a cursor should reflect the state of the system or processing mode. A specific cursor should be uniquely assigned to a specific purpose to provide state or mode information to the user. A straight line cursor might be used as the placeholder cursor to indicate entry position in a word processing task, an arrow might be used as a pointing cursor to indicate screen structures, and an X -shaped pointing cursor might be used when the user cannot interact with the system. Within this general framework, the number of cursor shapes used should be kept to a minimum.[D]

2.3.5-1 Pointing Cursor Visibility

The pointing cursor should be visible to the user at all times and may obscure characters unless it interferes with performance within an application.

ADDITIONAL INFORMATION: To maintain pointing cursor quality, the cursor should obscure other characters, not vice versa.[D]

2.3.5-2 Pointing Cursor Blink

The pointing cursor should not blink.[D]

2.3.5-3 Pointing Cursor: Image Quality

Pointing cursors should maintain image quality throughout an entire range of motion within the display. The position of the pointing cursor should be clearly visible during movement from one screen position to another. Flicker should be minimized.[D]

2.3.5-4 Pointing Cursor Design

To the greatest degree possible, pointing cursors should be completely graphic and should not contain a label.

ADDITIONAL INFORMATION: However, if a pointing cursor includes a label, the text should be large enough to be readable.[D]

2.3.5-5 Pointing Cursor: Size Constancy

The pointing cursor should maintain its size across all screen and display locations.[D]

2.3.5-6 Pointing Cursor: Movement

The movement of the pointing cursor should appear to the user to be smooth and continuous with smooth and continuous movement of the cursor control device. The pointing cursor should not move in the absence of any input from the user.[D]

2.3.6-1 Text Entry Cursor Visibility

The text entry cursor should only be visible when text entry is possible.[D]

2.3.6-2 Identification of Text Entry Cursor

At the initiation of a task, an application, or a new display, the user should be able to immediately determine the location of the text entry cursor. Following the initial placement of the text entry cursor, the position of the cursor should be under the user's control.

ADDITIONAL INFORMATION: For example, the cursor might be placed initially at the first data field in a data form, at the upper left corner of a blank display in a word processing task, and immediately following the last character of a word processing display containing alphanumeric characters.[D]

2.3.6-3 Text Entry Cursor Blink

If text entry cursor blinking is to be used to direct the user's attention, the default blink rate should be 3 Hz.

ADDITIONAL INFORMATION: A blinking cursor need not obscure characters -- for example, the blinking cursor may be an underline that does not cover the entire character.[D]

2.3.6-4 Nonobscuring Text Entry Cursor

The placeholding cursor should not obscure any other character displayed in the position designated by the cursor.

ADDITIONAL INFORMATION: As an example, a block cursor might employ brightness inversion ("reverse video").[A,E]

2.3.6-5 Number of Text Entry Cursors

There should be only one text entry cursor per window.[D]

2.3.6-6 Text Entry Cursor Size

The text entry cursor should assume the height and/or width of the text characters adjacent to it.[D]

2.4.1-1 Standard Display Location

System messages should appear in standard locations.

ADDITIONAL INFORMATION: Messages may be provided in window overlays.[E]

2.4.1-2 Consistent Format for System Messages

Consistent grammatical construction should be used in system messages.[E]

2.4.1-3 Familiar Wording

System messages should use familiar terminology.

ADDITIONAL INFORMATION: For example, "Data requires special access code; call Data Base Admin, X 9999 for access." is preferable to "IMS/VS DBMS private data; see OP-DBSA-0/99-99.[E]

2.4.1-4 Concise Wording of System Messages

System messages should be concise and clearly worded.[E]

2.4.1-5 Speaking Directly to Operators

Wording for system messages should be directed at the operator.

ADDITIONAL INFORMATION: For example, "Press ENTER to continue." is preferable to "The operator should press ENTER to continue."[E]

2.4.1-6 Only Necessary Information Displayed

No extraneous information should be displayed.

ADDITIONAL INFORMATION: Only relevant data to a task or operation should be displayed.[E]

2.4.1-7 Anthropomorphism

Presenting the system as a person should be avoided.

ADDITIONAL INFORMATION: System messages such as, "I AM LOADING YOUR FILE NOW. I'LL TELL YOU WHEN I'M DONE." should not be used.[A]

2.4.2-1 Prompting User Entries

Operators should be provided information needed to guide entries during log-on/off, command or information entry, etc.

ADDITIONAL INFORMATION: Prompts may be incorporated in a display and/or provided in response to requests for HELP. Where six or fewer control options exist, they should be listed. Where more input options exist, an example of the type of entry that is required should be presented. If a default value has been defined for null entry, that value should be included in the prompting information.[E]

2.4.2-2 Prompting Address Entry

When a operator must specify the address for a message, prompting should be provided.

ADDITIONAL INFORMATION: Prompting might consist of a series of questions to be answered, an address form to be completed by the operator, or reminders of command entries required.[E]

2.4.2-3 Standard Symbol for Prompting Entry

Standard symbols should be used for input prompting.

ADDITIONAL INFORMATION: The symbol(s) chosen should be reserved for that use.[E]

2.4.2-4 Prompting Command Correction

When a command entry is not recognized or inappropriate, operators should be prompted to correct, rather than re-enter the command.

ADDITIONAL INFORMATION: A faulty command should be able to be retained in the command entry area of the display, with the cursor automatically positioned at the incorrect item, with an advisory message describing the problem.[E]

2.4.2-5 Prompting Field Length

Cues should be provided to indicate the size of a fixed-length data entry field.

ADDITIONAL INFORMATION: Underscoring gives a direct visual cue as to the number of characters to be entered, and the operator does not have to count them. For example, "Enter ID: _ _ _ _ _ _ _ _ _" is preferable to "Enter ID (9 characters)."[E]

2.4.2-6 Data Format Cuing in Labels

Additional cuing of data format should be included in a field label when that seems helpful.

ADDITIONAL INFORMATION: For example, "DATE (MM/DD/YY) : _ _/_ _/_ _."[E]

2.4.2-7 Operator-Requested Prompts

Operators should be able to request computer generated prompts to determine required parameters or available options for a command.

ADDITIONAL INFORMATION: Using a HELP function key, or perhaps simply keying a question mark in the command entry area, are satisfactory methods to request prompting.[E]

2.4.2-8 Prompting Data Entry

Prompting should be provided for required formats and acceptable values for data entries.[E]

2.4.2-9 Graphic Display of Control Prompting

Graphic means may be provided for displaying to operators prompting aids and other guidance pertaining to current control actions.

ADDITIONAL INFORMATION: For example, a guidance display providing a graphic representation of keypad layout with notes explaining the various key functions can help an operator to learn the control options available via function keys.[E]

2.4.3-1 Feedback During Data Entry

Feedback should be displayed for all user actions during data entry; keyed entries should be displayed stroke by stroke.

ADDITIONAL INFORMATION: For reasons of data protection, it may not be desirable to display passwords and other secure entries.[A,E]

2.4.3-2 Feedback for Completion of Data Entry

The computer should acknowledge completion of a data entry transaction with a confirmation message if data entry was successful, or else with an error message.

ADDITIONAL INFORMATION: Successful data entry should not be signaled merely by automatic erasure of entered data from the display, except possibly in the case of repetitive data entries. For single data entry transactions, it may be better if entered data is left on the display until the user takes an explicit action to clear the display.[A,E]

2.4.3-3 Feedback for Repetitive Data Entries

For a repetitive data entry task that is accomplished as a continuing series of transactions, successful entry should be indicated by regenerating the data entry display, automatically removing the just-entered data in preparation for the next entry.

ADDITIONAL INFORMATION: Automatic erasure of entered data represents an exception to the general principle of control by explicit user action. In addition to erasure of entered data, a message confirming successful data entry might be displayed. Such a message may reassure uncertain users, especially in system applications where computer performance is unreliable.[E]

2.4.4-1 Distinctive and Consistent Warnings

Warnings (or warning messages) should be distinctive.

ADDITIONAL INFORMATION: The salience of the message presentation should be appropriate to its content. For example, warning messages might be marked with a blinking symbol and/or displayed in red, and be accompanied by a distinct auditory signal. Caution and error messages might be marked with a different special symbol and/or displayed in yellow.[B]

2.4.4-2 Redundant Display

Caution and warning information should be presented through both visual and auditory means.

ADDITIONAL INFORMATION: The visual display of emergency information should be redundant, using pictures, schematics, color, and text. Emergency information should be accompanied by an auditory alerting tone.[D]

2.4.4-3 Warning Operators of Potential Data Loss

Provisions to prompt against data loss should be provided.

ADDITIONAL INFORMATION: During log-off, the system should check pending transactions to determine if data loss seems probable. If so, the computer should prompt for confirmation before the log-off command is executed.[B]

2.4.4-4 Time-consuming processes

Warning should be provided when a command will be time-consuming to process.

ADDITIONAL INFORMATION: Typical response times for various types of commands are given in Section 2.4.7. Warnings may be provided when response time will exceed the maximum amounts given.[C]

2.4.5-1 Informative Error Messages

When the computer detects an entry error, an error message should be displayed stating the error and possible subsequent operations.

ADDITIONAL INFORMATION: Error messages should explicitly provide as much diagnostic information and remedial direction as can be inferred reliably from the error condition. Where clear inference is not possible, probable helpful inference(s) may be offered. For example, "Code format not recognized; enter two letters, then three digits." is preferable to "Invalid input." Operators should not have to search through reference information to translate error messages.[E]

2.4.5-2 Task-Oriented Error Messages

Wording for error messages should be appropriate to the task.

ADDITIONAL INFORMATION: Error messages should specifically describe the error and available remedies in language that reflects the user's point of view, not the programmer's. For example, "Trend Point number not recognized, check the number." is preferable to "Entry error - Status Flag 4."[E]

2.4.5-3 Neutral Wording for Error Messages

Error messages should use neutral wording.

ADDITIONAL INFORMATION: Error messages should not imply blame to the operator, personalize the computer, or attempt to make a message humorous. For example, "Entry must be a number." is preferable to "Illegal entry." or "I need some digits."[E]

2.4.5-4 Non-Disruptive Error Messages

The computer should display an error message only after completion of an entry.

ADDITIONAL INFORMATION: An error message should not be generated as wrong data are keyed, but only after an explicit ENTER action has been taken.[E]

2.4.5-5 Invalid Action

Where an entry is invalid or inoperative at the time of selection, no action should result except a display of an advisory message indicating the error and the appropriate functions, options, or commands.

ADDITIONAL INFORMATION: For example, attempting to print a document from within an edit mode.[A]

2.4.5-6 Advisory Error Messages

Where data or control entry is made from a small set of alternatives, error messages should indicate the correct alternatives.[E]

2.4.5-7 Displaying Erroneous Entries

When an entry error has been detected, the erroneous entry should remain displayed until the error has been corrected.

ADDITIONAL INFORMATION: The error itself will provide information as to the nature of the error. Displayed error messages should be removed after the error has been corrected.[C,E]

2.4.5-8 Cursor Placement Following Error

In addition to providing an error message, the location of a detected error should be marked by positioning the cursor at that point on the display, i.e., at that data field or command word.

ADDITIONAL INFORMATION: Displaying the cursor at a non-routine position will help emphasize that an error has occurred, and direct the user's attention to the faulty entry.[E]

2.4.5-9 Indicating Repeated Errors

If a operator repeats an error, a noticeable change should exist in the displayed error message.

ADDITIONAL INFORMATION: The user may not be aware of the error if there is no change in the displayed message. In response to a repeated error, the system might display the same verbal message but with changing annotation.[E]

2.4.5-10 Errors in Stacked Commands

If an error is detected in a group of entries, the system should process correct commands until the error is displayed.[A,B]

2.4.5-11 Multilevel Error Messages

Following the output of a simple error message, operators should be able to request a more detailed explanation of the error.

ADDITIONAL INFORMATION: A more complete discussion of each error should be made available on-line.[E]

2.4.5-12 Cautionary Messages

When a data or command entry error is suspected but cannot be determined (in terms of system error logic), a cautionary message asking confirm should be displayed.

ADDITIONAL INFORMATION: The user should be alerted to entries that may be in error. For example,: "Cooldown rate of 200 °F per hour degrees is outside the normal range; confirm or change entry.[E]

2.4.5-13 Multiple Error Messages

Notification should be made for each error when multiple errors are detected.

ADDITIONAL INFORMATION: The user should be made aware of the detection of multiple entries in order to facilitate corrections. For example, "DATE should be numeric [+ 2 other errors]". The computer should place the cursor in the data field referred to by the displayed error message, with other error fields highlighted. There should also be means to request sequential display of the other error messages.[E]

2.4.5-14 Error Message Placement

Error messages should be presented at the point of the error or in a consistent area of the display.[D]

2.4.5-15 Documenting Error Messages

As a supplement to on-line guidance, system documentation should include a listing and explanation of all error messages.[E]

2.4.6-1 On-Line Guidance

Reference material describing system capabilities, procedures, commands and abbreviations, etc. should be available on-line.

ADDITIONAL INFORMATION: Design of user guidance should be consistent with system security restrictions.[E]

2.4.6-2 Access to Guidance

Explicit actions should be required to access or suppress user guidance.[D]

2.4.6-3 HELP Request

At any point in an interaction, users should be able to access on-line user guidance by means of a simple action that is consistent throughout the interface.

ADDITIONAL INFORMATION: Users should have multiple methods of requesting help. For example, a user might (1) select Help in a pull-down menu, (2) type a "Help" command, and/or (3) press a Help Function Key.[E]

2.4.6-4 HELP Guidance

Advisory messages or prompts should be available to guide users in accessing help messages.

ADDITIONAL INFORMATION: An on-line HELP index should be provided.[A]

2.4.6-5 Synonyms for Standard Terminology

When a user requests HELP on a topic, the computer should accept synonyms and abbreviations.[E]

2.4.6-6 Context-Sensitive HELP

The information presented in response to a HELP request should be tailored to the task context.

ADDITIONAL INFORMATION: If an error in command entry is made, HELP should display information concerning that command, its function, its proper structure and wording, required and optional parameters, etc.[E]

2.4.6-7 Clarifying HELP Requests

When a request for HELP is ambiguous in context, the computer should initiate a dialogue to specify what data, message or command requires explanation.

ADDITIONAL INFORMATION: In order to define the needed information, the user might be allowed to point at a displayed item about which HELP would then be provided.[E]

2.4.6-8 Automatic HELP

When appropriate, HELP should be automatically provided.

ADDITIONAL INFORMATION: Automatic HELP might be provided following frequent errors in a specific interaction with the system. Users should be able to suppress automatically-presented HELP displays with a single action.[D]

2.4.6-9 Multilevel HELP

When a HELP display provides summary information, more detailed explanations should be available.[E]

2.4.6-10 Browsing HELP

Users should be able to browse on-line HELP.[E]

2.4.6-11 Return from HELP

The user should be able to easily return to the task after accessing HELP.^

2.4.7-1 Appropriate Computer Response Time

The speed of computer response to user entries should be appropriate to the transaction involved.

ADDITIONAL INFORMATION: Appropriate response times for selected activities are shown in Table 2.4. In general, the response should be faster for those transactions perceived by a user to be simple. For example, computer response to a likely control entry, such as NEXT PAGE, should be within 0.5-1.0 second; response to other simple entries should be within 2 seconds; error messages should be displayed within 2 seconds.[E]

2.4.7-2 Display Average System Response Time

Average system response time, if affected by the number of on-line users, should be displayed at time of log-on.

ADDITIONAL INFORMATION: This message should not be in code but should contain specific information concerning current response time and the periods when response time is relatively quick (e.g., "Average response to simple commands is 10 to 15 seconds; system response time is usually 1 to 2 seconds between 1100 and 1200 and after 1600 hours").[A]

2.4.7-3 Response Time Consistent with Requirements

System response times should be consistent with operational requirements.

ADDITIONAL INFORMATION: Required user response times should be compatible with required system response time. Required user response times should be within the limits imposed by total user tasking expected in the operational environment.[C]

2.4.7-4 Processing Delay

Where system overload or other system conditions will result in a processing delay, the system should acknowledge the data entry and provide an indication of the delay to the user.

ADDITIONAL INFORMATION: If possible, the system should advise the user of the time remaining for the process or of the fraction of the process completed.[A]

2.4.7-5 Indicating Completion of Processing

When processing in response to a control entry is lengthy, the user should be given a positive indication of subsequent completion time, and appropriate related information.

ADDITIONAL INFORMATION: Appropriate related information includes a message stating the need for further user action is required.[A,E]

2.4.7-6 Response Time Induced Keyboard Lockout

If computer processing time requires delay of concurrent user inputs and no keyboard buffer is available, keyboard lockout should occur until the computer can accept the next transaction. An alert should be displayed to indicate to the user that lockout has occurred.[C]

2.4.7-7 Keyboard Restoration

When the computer is ready to continue following response time-induced keyboard lockout, a signal to so indicate should be presented.

ADDITIONAL INFORMATION: For example, cursor changes back to normal shape.[C]

Table 2.4. Preferred and Maximum System Response Time

User Activity		Maximum Response Time (sec.)	Preferred Response Time (sec.)
Control Activation (for example, keyboard entry, cursor controller movement)		0.10	< 0.10
System Activation (system initialization)		3.0	< 0.50
Request for given service:	Simple	2.0	< 0.25
	Complex	5.0	< 2.0
	Loading and Restart	15-60.0	< 6.0
Error Feedback (following completion of input)		2.0	< 0.25
Response to I.D.		2.0	< 0.25
Information on next procedure		< 5.0	< 2.0
Response to simple inquiry from list		2.0	< 0.25
Response to simple status inquiry		2.0	< 0.25
Response to complex inquiry in table form		2-4.0	< 0.25
Request for next page		0.5-1.0	< 0.25
Response to "execute problem"		< 15.0	< 6.0
Light pen entries		1.0	< 0.25
Drawings with light pens		0.1	< 0.10
Response to complex inquiry in graphic form		2-10.0	< 0.25
Response to dynamic modeling		---	---
Response to graphic manipulation		2.0	< 0.25
Response to user intervention in automatic process		4.0	< 1.50

2.4.7-8 Variability of Response Time

Response time deviations should not exceed more than half the mean response time.

ADDITIONAL INFORMATION: For example, if the mean response time is 4 seconds, the variation is limited to a range of 2 to 6 seconds.[D]

2.4.7-9 Maximum System Response Times

Maximum system response times for real-time systems should not exceed the values presented in Table 2.4.[C]

2.5.1-1 Information for Navigating

The user interface should provide users with information and actions needed to navigate the interface.
ADDITIONAL INFORMATION: A graphic display might be provided to indicate, upon request, the user's position within hierarchies such as menus. This display might be contained in a window separate from the application that it represents. Movement from any position in the hierarchy to any other position might be accomplished by using the cursor control device to select the desired position in the window display.[D]

2.5.1-2 Navigation Among Displays

Users should be able to easily move among displays.[D]

2.5.1-3 Sequential Steps on Multipage Displays

When actions on a new display in a sequence require completion of actions on a previous display, the user should be able to move to the new display only when all of the conditions have been met or when an intentional override procedure has been confirmed.[D]

2.5.1-4 Navigation Messages

A message should be available that provides explicit information to the user on how to move from one frame to another or how to select a different display.[B]

2.5.2-1 Display Control

Users should be able to specify the information to be displayed and select the format in which it is presented.[A]

2.5.2-2 Display of Control Options

Screen control locations and control options should be clearly and appropriately indicated.[A]

2.5.2-3 Information Displayed as Available

Information that the user must manipulate should be displayed as it becomes available.[A]

2.5.2-4 Zooming for Display Expansion

The user should be provided with a zooming capability that allows the user to expand the display of any selected area.[E]

2.5.2-5 Functional Labeling for Display Framing

User instructions, key labels, etc., should refer to display framing in functional terms and avoid wording that implies spatial orientation.

ADDITIONAL INFORMATION: Examples of framing in functional terms are: "forward" and "back", or "next" and "previous". Control of display framing functions might be implemented by keys marked with arrows, to avoid verbal labels altogether.[E]

2.5.2-6 Easy Paging

When requested data exceeds the capacity of a single display frame, users should be given some easy means to move back and forth over displayed material by paging or panning/scrolling.

ADDITIONAL INFORMATION: Dedicated function keys can provide for paging forward and back.[A,E]

2.5.2-7 Show Changing Scale

When a display is expanded from its normal coverage, a scale indicator of the expansion factor should be provided.

ADDITIONAL INFORMATION: A linear indicator of current map scale might be shown in the margin, or perhaps simply a numeric indication of the display expansion factor (e.g., : x4 :).[E]

2.5.2-8 Show Overview Position of Visible Section

When a display is panned and/or expanded from its normal coverage, some graphic indicator of the position in the overall display of the currently visible section should be provided.[E]

2.5.2-9 Return to Normal Display Coverage

If a user is allowed to pan over an extended display, or zoom for display expansion, an easy means for the user to return to normal display coverage should be provided.

ADDITIONAL INFORMATION: For example, return to normal display coverage might be accomplished by a function key labeled RETURN, or perhaps RESET.[A,E]

2.5.3-1 Automatic Display Update

Users should be able to request automatic update (computer regeneration) of changed data, and should be able to control the update rate.[E]

2.5.3-2 Readability of Changing Data

Changing data values that must be read should be displayed in a fixed position and updated no more than once per second. If users need only to monitor general trends in changing data values, and do not need to take exact readings, faster update rates may be acceptable.[E]

2.5.3-3 Visual Integration of Changing Graphics

When a user must visually integrate changing patterns on a graphic display, the data should be updated at a rate appropriate to human perceptual abilities for that kind of data change.

ADDITIONAL INFORMATION: Slowly developing patterns may be seen more easily with time compression, i.e., with rapid display of sequentially stored data frames. Fast changing data may require time expansion, i.e., slowed output, to aid pattern perception. In some applications it is permissible to allow a user to control the speed for update of displayed data.[E]

2.5.3-4 Refresh Rate for Free-drawn Graphics

For free-drawn graphics, the refresh rate on the monitor should be high enough to produce the appearance of a continuous track.[D]

2.5.3-5 Display Freeze

The user should be able to "freeze" automatically updated data at any point. This is necessary in order for the user to examine changed data more deliberately.[A,E]

2.5.3-6 Labeling Display Freeze

When a display is "frozen," the display should be appropriately labelled to remind users of its "frozen" status.[A,E]

2.5.3-7 Signaling Changes to Frozen Data

When a display being updated in real-time has been frozen, the user should be warned if some significant, but not displayed, change should be detected in the computer processing of new data.[A,E]

2.5.3-8 Resuming Update After Display Freeze

When the user elects to resume update after a display being updated in real time has been frozen, the resumed display update should be positioned at the current real-time point.

ADDITIONAL INFORMATION: In some applications, a user might wish to resume display update at the point it is stopped, and so the display change would lag real-time data change. Or, a user might choose to see a speeded "replay" of interim changes to regain current display status.[A,E]

2.5.4-1 Temporary Suppression of Displayed Data

The user should be able to temporarily suppress standard data displays.[A,E]

2.5.4-2 Labeling Display Suppression

A data display that has been suppressed should be annotated with an appropriate label to remind users that data have been suppressed.[E]

2.5.4-3 Signaling Changes to Suppressed Data

Users should be warned if some significant (but not displayed) change is detected in the computer processing of new data when data have been suppressed from a display.[A,E]

2.5.4-4 Resuming Display of Suppressed Data

Data that has been suppressed from a display should be able to be quickly restored to its complete, originally generated form.[A,E]

2.5.4-5 Dedicated Function Key

Function keys used to restore suppressed data should have no other use.

ADDITIONAL INFORMATION: For instance, if a user must press RETURN to restore suppressed data, that key only restores the data and does not also move a displayed cursor to some other position.[A,E]

2.5.5-1 Continuous Text Data

Paging and windowing should not used when searching through continuous text data.[A]

2.5.5-2 Consistent Orientation

A consistent orientation for display framing should be used.

ADDITIONAL INFORMATION: Users can either 1) conceive the display frame as a window moving over a fixed array of data, here called "panning", or 2) conceive data as moving behind a fixed display frame, commonly called "scrolling.[A,E]

2.5.5-3 Panning with Free Cursor Movement

In applications where a user moves a cursor freely about a page of displayed data, panning should be adopted rather than scrolling as the conceptual basis of display framing.[E]

2.5.5-4 Framing Consistently for All Data

Framing functions should be performed consistently so that panning and/or zooming affect all displayed data in the same way.

ADDITIONAL INFORMATION: For example, on a situation display, zooming should be used to expand background data such as geographic boundaries to the same scale as the expansion of overlaid "active" data.[E]

2.5.5-5 Paging Controls

Users should be allowed to move easily from one page to another for displays which are partitioned into separately displayable pages.[E]

2.5.5-6 Horizontal Scrolling

The user should have the ability to shift the text information s. n when the user cannot view all of the characters in the horizontal line.

ADDITIONAL INFORMATION: This shift should be accomplished with a single action (e.g., by moving a scroll icon on a horizontal scroll bar).[D]

2.5.5-7 Appropriate Scrolling/Paging Structures

Structures for horizontal scrolling/paging should appear only on displays for which horizontal movement is appropriate. Similarly, structures for vertical scrolling/paging should appear only on displays for which vertical movement is applicable.[D]

2.5.5-8 Common Display Structure

Display structure used for scrolling and paging should be common to all files.[D]

2.5.5-9 Scrolling/Paging Techniques

Users should have the ability to scroll or page using several different techniques.

ADDITIONAL INFORMATION: For example, paging by means of moving a page icon on the scroll bar or by the use of a dedicated function key for paging forward and a dedicated function key for paging back through a file. Scrolling might be performed by a scroll bar, keyboard arrow keys, and keystroke commands.[D]

2.5.5-10 One Structure for Vertical, One for Horizontal Movement

Only one scrolling/paging structure should be used for vertical movement in a display and one for horizontal movement in a display.

ADDITIONAL INFORMATION: The placement of the scrolling/paging structures should clearly indicate the function for vertical or horizontal movement. For example, one scroll bar might be placed along one of the side borders of the display for vertical scrolling and another scroll bar might be placed along the top or bottom (opposite the menu bar) of the display for horizontal scrolling.[D]

2.5.5-11 Labeling Scrolling Function

The function of the scrolling/paging structure should be clearly indicated by either a textual or graphic label.

ADDITIONAL INFORMATION: For example, a graphic label for the scroll bar might be a scroll icon.[D]

2.5.5-12 Evident Direction of Paging

The direction that a user must page (toward the top or bottom, left or right) should be evident to the user before he or she begins to page.

ADDITIONAL INFORMATION: For example, scroll arrows on a scroll bar might point in the direction that corresponds to the paging direction.[D]

2.5.5-13 Paging in One or Multiple Page Increments

Users should be able to page in one page or multiple page increments.

ADDITIONAL INFORMATION: For example the user might page multiple pages directly by moving the page icon on the scroll bar at which time the display might move to the location in the file that corresponds to the page number on the page icon.[D]

2.5.5-14 Discrete Paging

When moving over multiple pages, the movement should be discrete with no display of intermediate pages between the starting page and the selected page.[D]

2.5.5-15 Indicate Absolute and Relative Positions of User

Scrolling/paging structures should indicate both the absolute and relative positions of the user in the data file.

ADDITIONAL INFORMATION: For example, a page icon on the scroll bar might (1) indicate the absolute position by containing the page number in the data file and (2) indicate the relative position by means of the spatial location of the icon on the scroll bar.[D]

2.5.5-16 Graphic Indication of Scroll Position

Large display outputs which are viewed by continuous panning/scrolling should be provided with a graphic indicator inset at the margin of the display frame to indicate current location.[E]

2.5.5-17 Scroll by Line or Display Unit

The scroll motion rate should allow the user to scroll by line or by display unit.

ADDITIONAL INFORMATION: Either technique provides a smooth flow of text.[D]

2.5.5-18 Display Window

ROLL and SCROLL commands should refer to the display window, not the text/data.

ADDITIONAL INFORMATION: The display window should appear to the user to be an aperture moving over stationary text.[D]

2.5.5-19 Parameters Refer to Data not Window

The parameters of roll/scroll functions should refer to the data being inspected, not to the window.

ADDITIONAL INFORMATION: From a data orientation, "roll up 5 lines" means that the top five lines of data would disappear and five new lines would appear at the bottom; the window through which the data is viewed remains fixed. However, when a windowing orientation is established, the wording of scroll functions refers to the display page (or window) and not to the displayed data. In that case, the command "Up 10" would mean that ten lines of data will disappear from the bottom of the display and ten earlier lines will appear at the top.[B]

2.5.6-1 Window Identification

Windows should be identified by a label consistently located at the top of the window's border.
ADDITIONAL INFORMATION: Labels should remain on the screen while the data scrolls underneath them.[A]

2.5.6-2 Window Selection and Display

Users should be able to select separate data windows that will share a single display screen.[A,E]

2.5.6-3 Displaying Multiple Windows

When multiple windows are open simultaneously, the user should have the capability to easily tile, layer, or sequentially view the windows (see Figure 2.1).
ADDITIONAL INFORMATION: Depending upon user needs, data windows might appear simultaneously as segments of a joint display (i.e., tiled), might be overlaid in varying degrees so as to obscure one another (i.e, layered), or might be displayed sequentially at the user's option. In the latter condition, multiple display windows will differ little from multiple display pages, except perhaps in speed of sequential access.[A,D,E]

2.5.6-4 Managing Open Windows

The system should keep track of the windows that are open (but not necessarily active or displayed), and provide a means of displaying the list of open windows to the user.
ADDITIONAL INFORMATION: Open windows, for example, could be listed in a menu or as a graphic.[A]

2.5.6-5 Window Demarcation

Windows should be visually separated from each other and from their background, preferably by borders or similar demarcation.[A]

2.5.6-6 Distinction Between Window Types

Window types should be perceptually distinct (see Figure 2.1).
ADDITIONAL INFORMATION: For example, active windows in both the tiled and layered window environments should be perceptually distinct from inactive window types.[D]

2.5.6-7 Active Windows Priority

Under normal operating conditions, active windows should be frontmost on the display.[D]

2.5.6-8 Caution and Warning Window Priority

Caution and warning windows should be frontmost on the display.[D]

2.5.6-9 Default Window Size

The size and shape of the initial presentation of a window should be consistent with its contents (amount of information, number of menus, data fields, etc.)
ADDITIONAL INFORMATION: When a window temporarily obscures other displayed data, the obscured data should not be permanently erased but should reappear if the overlay is removed.[A,E]

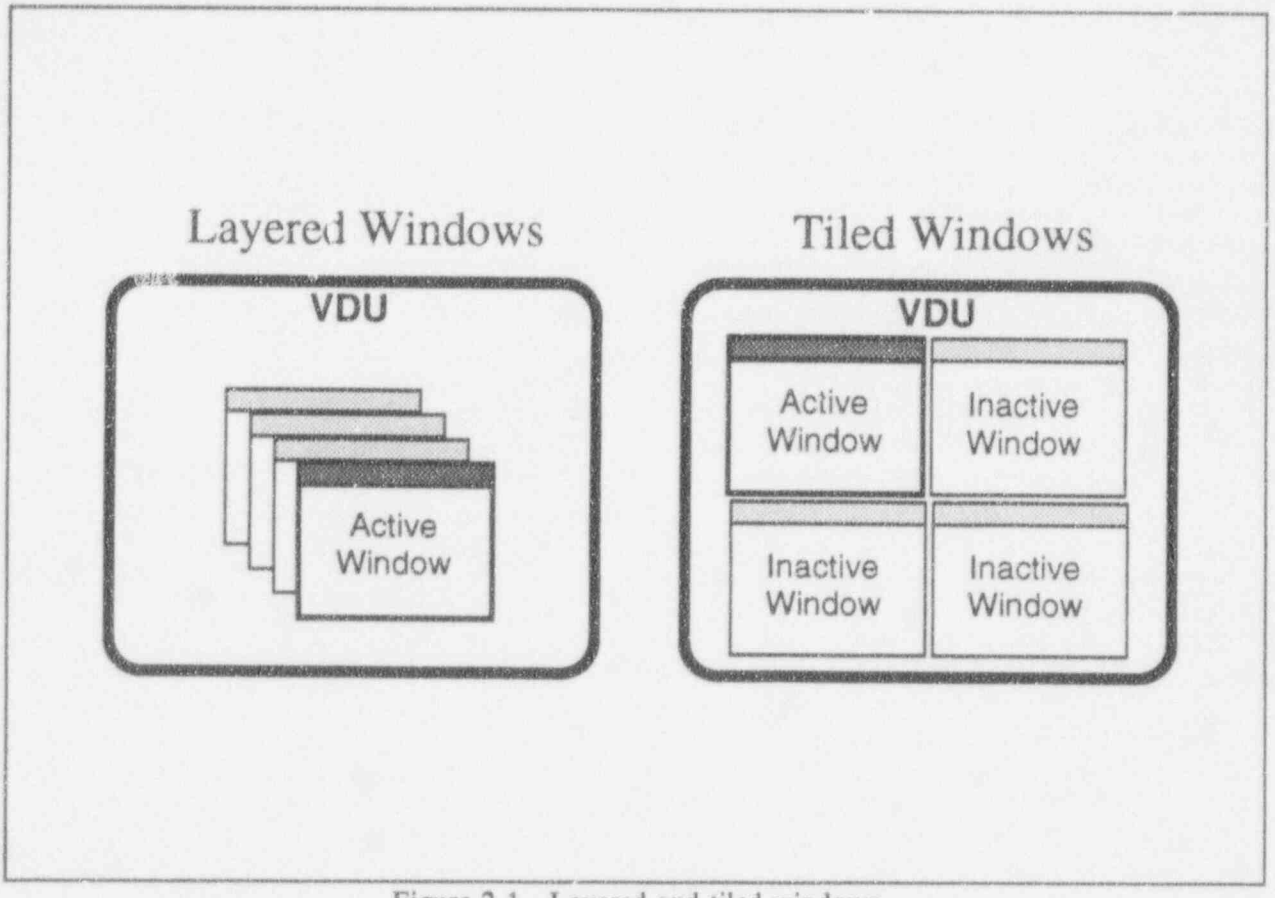

Figure 2.1. Layered and tiled windows

2.5.6-10 Minimum Height for Text Windows

The default height for text windows and windows used for scanning data should be at least four lines of information.

ADDITIONAL INFORMATION: Window sizes of four lines provide better performance than those with fewer than four lines. Windows with more than four lines show little advantage over windows with four lines.[A,D,E]

2.5.6-11 Minimum Width for Text Windows

The default width for a generic text window should enable 50-80 characters to be displayed.

ADDITIONAL INFORMATION: When users read continuously scrolling text (at a rate set by the user), line lengths of 52 to 78 characters provide the fastest performance.[D]

2.5.6-12 Consistent Window Control

User control of windows should operate consistently from one display to another for each type of window.

ADDITIONAL INFORMATION: Control of predefined windows may simply involve "opening" and "closing" them, by selection of displayed program labels or function keys. Control of user-defined windows may require user specification of window contents, window size and positioning on the display. Such window control must be learned by a user, and consistent design of control logic aids that learning.[A,E]

2.5.6-13 Window Control Functions

As appropriate to the user task, windows should be capable of the following operations: scrolling/panning, resizing, moving, hiding, activating, deactivating, copying to/from, zooming in/out, tabbing, and undo-last.

ADDITIONAL INFORMATION: Some tasks will require fewer window operations than others. For example, a window that simply presents a one-line status message from the system that the user will only read and not respond to might need to only have the ability to be closed. It might not need to be movable, adjustable in size, etc.[A]

2.5.6-14 Consistent Control Within Windows

When control actions such as command entry may be taken by a user working within a window, those control actions should be consistent from one window to another.

ADDITIONAL INFORMATION: Cursor positioning controls should operate consistently within all windows. If controls in one window operate differently than in another, user confusion will be unavoidable.[E]

2.5.6-15 Window Opening Methods

The user should be able to open a window by performing any of a set of simple actions.

ADDITIONAL INFORMATION: Typical methods of opening windows include: issuing a command to open a specific window, selecting a window title from a list on a menu, or selecting an icon for the window.[D]

2.5.6-16 Closing Windows

Users should be able to close a window with a single action.[D,E]

2.5.6-17 Easy Shifting Among Windows

If several windows are open, several easy means should be provided for a user to shift among them.

ADDITIONAL INFORMATION: Typical methods of shifting among open windows include: clicking a mouse button, the tab key, cursor keys, or a function key. The most direct method might be to allow a user to select a window by pointing anywhere within its displayed borders, but that action might be confused with the selection of a particular item within the window.[A,E]

2.5.6-18 Activating a Previously Opened Window

The user should be able to put a window in the interactive state by performing any of a set of simple actions in that window or related to that window.

ADDITIONAL INFORMATION: A window might be activated by moving the pointing cursor to the window and performing any action, including pressing a key or a button on a cursor control device, issuing a command to open a specific window; selecting a window title from a list on a menu, or selecting an icon representing the window.[D]

2.5.6-19 Activation of Window Cursor

The action that puts a window into the interactive state should automatically place the placeholding cursor in that window so that the user can provide inputs through that window.[D]

2.5.6-20 Multi-Modal Window Designation
If windows are capable of different modes, the system should provide immediate and unambiguous feedback concerning which mode is active [A]

2.5.6-21 Movable Windows
Window movement capability should be provided such that the user can move windows to different areas of the display.[D]

2.5.6-22 Window Position
It should not be possible to position windows in such a way that menu bars, access to the command area, or caution and warning messages are obscured.[D]

2.5.6-23 Smooth Window Movement
Movement of a window should appear to be smooth and continuous to the user.[D]

2.5.6-24 Indicate Active Window
If several windows are displayed at once, the window(s) in which action can be taken should be indicated.
ADDITIONAL INFORMATION: Adding windows to a display can increase the conceptual complexity of control actions as well as the difficulty of data assimilation. A prominent cursor might be displayed in the currently active window, or perhaps the displayed border of an active window to indicate to a user which window is currently "active.[A,E]

2.5.6-25 Update of Hidden Windows
A window that is not displayed should be capable of receiving information from the system.
ADDITIONAL INFORMATION: Parameters should continue to be updated whether or not the display page on which they are reported is currently displayed.[A]

2.5.6-26 Alerting User to Information Availability
The system should alert the user to critical information that becomes available in an inactive or non-displayed window.[A]

2.5.6-27 Window Activates Upon Opening
The action that opens a window should automatically make that window active.[D]

2.5.6-28 Varying Window Size
Users should be able to change the horizontal and vertical dimensions of a window independently or together.[D]

2.5.6-29 Accessibility to Partially Removed Windows
Windows partially moved off the display should be made readily accessible with a single action.[D]

2.5.6-30 Scrollable Windows
The user should have the ability to scroll through the contents of a window both horizontally and vertically.[D]

2.5.6-31 User Control of Automatic Update

Automatically updated windows should have display freeze capability.

ADDITIONAL INFORMATION: When a window displays automatically updated information, the user should have control over the rate at which automatically updated screens are scrolled.^

2.6.1-1 Natural Units of Text

Users should be allowed to specify segments of text in whatever units are natural for entry/editing.

ADDITIONAL INFORMATION: For unformatted ("free") text, natural units will be characters, words, phrases, sentences, paragraphs, and pages. For specially formatted text, such as computer program listings, other logical units (e.g., lines, procedures, and subprograms) may be ur...[A,E]

2.6.1-2 Text Displayed as Printed

Users should be allowed to display text exactly as it will be printed.

ADDITIONAL INFORMATION: Accurate display is particularly necessary when the format of printed output is important, as when printing letters, tables, etc. Ideally, text displays should be able to represent all the features that are provided in printed output, including upper and lower case, underlining, bolding, subscripting, superscripting, special symbols, and different styles and sizes of type. When those features are important, the necessary display capability should be provided. For special formatting features that are not frequently used, it may be sufficient to use extra symbols to note text features that cannot be directly displayed. In that case, care should be taken that such annotation does not disturb the spacing of displayed text. This may require two display modes, one to show text spacing as it will be printed and the other to show annotations to the text. A corollary to this recommendation is that changes made to displayed text should appear as a user makes them. Some line-based editors show changes only after a document has been filed and later recalled for display, which does not represent good user interface design.[A,E]

2.6.1-3 Format Control by User

Easy means should be provided for users to specify required format control features (e.g., margin and tab settings) during text entry/editing.

ADDITIONAL INFORMATION: Required format features will vary depending on the application. The intent of this guideline is that all required format features should be easy to control. Any format features which are provided but are optional for the user's task should not be made easy to use at the expense of required format features. One convenient method of margin and tab control is to allow users to mark settings on a displayed "ruler" that extends the width of a page and is continuously displayed at the top of the screen.[A,E]

2.6.1-4 Establishing Predefined Formats

When text formats must follow predefined standards, the standard format should be provided automatically and not rely on users to remember and specify proper formats.

ADDITIONAL INFORMATION: For example, standard formats might be required for letters, memos, or other transmitted messages.[A,E]

2.6.1-5 Storing User-Defined Formats

When text formats cannot be predicted in advance, users should be able to specify and store for future use the formats that might be needed for particular applications.

ADDITIONAL INFORMATION: For example, a special format might be adopted for generating a particular report at periodic intervals.[A,E]

2.6.1-6 Consistent Word Spacing

Unless otherwise specified by the user, entered text should be left-justified to maintain constant spacing between words, leaving right margins ragged if that is the result.[A,E]

2.6.1-7 Hyphenation by Users

In the entry/editing of text, automatic pagination and line breaks by the computer should keep words intact, and hyphenation should only be introduced where specified by users.

ADDITIONAL INFORMATION: Where compound words have been hyphenated by a user, the computer should break the compound after the hyphen for pagination or line breaks unless otherwise specified by the user. Compound words formed with slashes (e.g., "entry/editing") might be treated in a similar manner.[A,E]

2.6.1-8 Changing Physical Characteristics of Text

The user should have the ability to change the physical characteristics of text.

ADDITIONAL INFORMATION: The physical characteristics under the user's control might include font type, size, and capitalization; the ability to change the font style (e.g., by underlining, italicizing, and/or bolding characters or strings of characters), and/or to alter tab position in any part of a text file.[D]

2.6.1-9 Tabs

A tab function should be available for paragraph indentation and for moving the cursor to a preselected location.

ADDITIONAL INFORMATION: The user should be able to set tabs at locations across a display, consistent with the spacing provided by the space bar. The symbols indicating the location of tabs should be invisible to the user by default but should become visible with a single action by the user (for example, by making a screen ruler appear on the display or displaying the tab symbols within the text field).[D]

2.6.1-10 Tab Controls

For editing programs or tabular data, cursor tab controls or other provisions for establishing and moving readily from field to field should be provided.[D]

2.6.1-11 Margins

The user should have the ability to change margins for a text file.

ADDITIONAL INFORMATION: This capability should include changing margins so that the user cannot view all of the characters in the horizontal line. Rationale: Users may need to have a double page size for the equivalent of a 14 x 17 page.[D]

2.6.1-12 Automatic Line Break

For entry/editing of unformatted text, an automatic line break ("carriage return") should be provided when text reaches the right margin, with provision for user override.

ADDITIONAL INFORMATION: For specially formatted text, such as computer program listings, users may need to control line structure themselves and hence need to override any automatic line break. Even when entering unformatted text, a user will sometimes wish to specify a new line at some particular point, if only for aesthetic reasons.[A,E]

2.6.1-13 Automatic Pagination Aids

Automatic pagination for text entry/editing should be provided, allowing users to specify the page size.

ADDITIONAL INFORMATION: For short documents, automatic pagination may not be needed. If automatic repagination is not provided, a warning message should be presented to the user.[A,E]

2.6.1-14 User Control of Pagination

When automatic pagination is provided, users should be allowed to override that pagination in order to specify page numbers at any point in a document.

ADDITIONAL INFORMATION: When producing a large document, a user may wish to split it into several separate text files for convenience in editing, and hence need to control the page numbering of those component sections. In general, a user will want flexibility in assembling different computer files to create a composite document. For example, a user might wish to number the first page of a document "23", or perhaps skip a page number in the middle of a document.[A,E]

2.6.1-15 Controlling Integrity of Text Units

When automatic pagination is provided, users should be allowed to specify how many lines in a paragraph can stand alone at the bottom or top of a page ("widows" and "orphans"), and to specify any text that should not be divided between two pages, such as lists or tables.[A,E]

2.6.1-16 Protecting Text During Page Overruns

When a user is inserting text into a document that has already been paginated, no text should be lost if the user inserts more text than a page can hold.

ADDITIONAL INFORMATION: It is difficult for a user to keep track of page size, particularly if the size of the display screen is less than the full page specified for printed text. A user will often not know when more text has been inserted into a page than there is room for. The computer should accommodate text insertions with automatic repagination.[A,E]

2.6.1-17 Head-and Foot-of File

The means should be provided to readily move the cursor to the head or the foot (end) of the file.[D]

2.6.1-18 Inserting

When inserting words or phrases, items to be inserted should be displayed as the final copy will appear.[A]

2.6.1-19 String Search

Users should be allowed to specify a string of text and request the computer to advance (or back up) the cursor automatically to the next (or last previous) occurrence of that string.

ADDITIONAL INFORMATION: An automatic string search capability will generally speed cursor placement in comparison with incremental positioning, particularly when moving over large portions of a document. Expert users may also wish to incorporate special characters in string search, including format control characters such as those for tabbing, bolding, etc.[A,E]

2.6.1-20 Multiple Methods of Searching

Users should have multiple methods for searching for lines or alphanumeric strings.[D]

2.6.1-21 Search for Line Numbers

Users should have the ability to search for and move to a specific line number in a file.[D]

2.6.1-22 Upper and Lower Case Equivalent in Search

Unless otherwise specified by a user, upper and lower case letters should be treated as equivalent in searching text.

ADDITIONAL INFORMATION: For example, "STRING", "String", and "string" should all be recognized/accepted by the computer when searching for that word. In searching for words, users will generally be indifferent to any distinction between upper and lower case. The computer should not compel a distinction that users do not care about and may find difficult to make. The computer should also ignore such other features as bolding, underlining, parentheses and quotes when searching text.[A,E]

2.6.1-23 Specifying Case in Search

When case is important, users should be allowed to specify case as a selectable option in string search.

ADDITIONAL INFORMATION: Users may also wish to specify features such as bolding, underlining, and quotes when searching text. For example, when searching a document in which all the headings are capitalized, a user might wish to find a string only when it appears in a heading.[A,E]

2.6.1-24 Global Search and Replace

When systematic editing changes will be made throughout a long document, a "global search and replace" capability should be provided.

ADDITIONAL INFORMATION: Global search and replace is where the system replaces all occurrences of one text string with another. Global search and replace could be designed in two different ways. One user might want the computer to make all changes automatically. Another user might want to review and confirm each change. Ideally, both options should be available.[A,E]

2.6.1-25 Case in Global Search and Replace

If a global search and replace capability is provided, the case of the replacement string should match the case of the old string, unless otherwise specified by the user.

ADDITIONAL INFORMATION: If a word is replacing the first word in a sentence, the first letter of the new word should be capitalized. If it is replacing a word that is entirely in lower case, then the new word should also be in lower case. The user should be able, however, to replace a word with incorrect case with a correct version.[A,E]

2.6.1-26 Moving Text

Users should be allowed to select and move text segments from one place to another within a document.

ADDITIONAL INFORMATION: A user should not have to re-enter (i.e., rekey) text that is already available to the computer. One convenient method of allowing the user to both move and copy text is to provide a "cut and paste" facility in which the "cut" text remains in a storage buffer and can be "pasted" more than once. For copying, the user can cut text, paste it back into its original location, and paste it again at a new location.[A,E]

2.6.1-27 Pasting Text into a Graphical File and Vice Versa

The user should be able to paste (1) alphanumeric data cut or copied from a text file or table into a graphical display and (2) graphical data into a text or tabular file.[D]

2.6.1-28 Cutting Graphical Objects and Areas of Graphical Displays

Users should be able to cut both graphical objects and areas of a graphical display.[D]

2.6.1-29 Viewing Text Prior to Pasting

Users should be able to view text that has been cut or copied prior to pasting.[D]

2.6.1-30 Placing Cut Text in Compatible Files

Users should be able to insert copied text at any location in the current file or other files created with the same application.

ADDITIONAL INFORMATION: One means of implementing this feature is a temporary editing buffer into which the system would place cut text.[D]

2.6.1-31 Placement of Pasted Text

The pasted text should be inserted at the location immediately before the cursor (in a text file), or at the approximate location of the cursor (in a graphical file).

ADDITIONAL INFORMATION: At the end of the paste process, the cursor should have the same text following it as before the process.[D]

2.6.1-32 Pasting the Same Text More than Once

Pasting the most recently cut or copied text should have no effect on a users' ability to paste the same text again.

ADDITIONAL INFORMATION: The user should be able to paste the most recently cut or copied text as many times as he or she chooses. The text to be pasted is replaced only when new text is cut or copied.[D]

2.6.1-33 Cutting Without a Gap in the Text

No gap should be left in the file at the point from which cut text was removed.

ADDITIONAL INFORMATION: The cursor should remain in the same location as prior to the cut.[D]

2.6.1-34 Storing Frequently Used Text

Users should be allowed to label and store frequently used text segments, and to later recall (copy into current text) stored segments identified by their assigned labels.

ADDITIONAL INFORMATION: For example, much text processing involves repetitive elements specific to different applications, such as signature blocks, technical terms, long names, formulas or equations.[E]

2.6.1-35 Vertical Scrolling When Selecting Text

If the selected text, table, or graphics area extends beyond the bottom of the displayed page, the screen should automatically scroll until the user stops selecting.[D]

2.6.1-36 Non-Contiguous Blocks of Text

Users should not be able to select non-contiguous blocks of text when cutting and pasting.

ADDITIONAL INFORMATION: Cutting and pasting (operations which frequently follow selecting) is ambiguous with non-contiguous blocks, especially with respect to the spatial relation between the two non-contiguous blocks when they are pasted into a text file at a new location or into a new text file.[D]

2.6.2-1 Saving to a Data File

The user should be able to save the information entered into a file by a single action that will permit the user to continue interacting with that file.

ADDITIONAL INFORMATION: This action replaces the previous information stored in the file with the newly saved information.[D]

2.6.2-2 Exit With Save

After finishing the interaction with any type of file, the user should be able to save the information and stop interacting with the file by a single action.[D]

2.6.2-3 Exiting a File

After finishing the interaction with any type of file, the user should be able to stop interacting with the file by a single action (e.g., selecting a menu item) without saving the changes to the file.

ADDITIONAL INFORMATION: Commands for exiting are different from those for saving and exiting with a save.[D]

2.6.2-4 Distinct Commands for Exit With and Without Save

The command used to "exit with save" should differ from the commands for "save" (without exit) and for "exit without save."[D]

2.6.2-5 Protection Against Exiting a File Without Saving

The user should be protected against exiting a file without the opportunity to save the file contents.

ADDITIONAL INFORMATION: The system should require users to verify that they want to exit and lose their most recent inputs.[D]

2.6.2-6 Recovery of Replaced File

Information from a file that has been modified and stored with the "save" or "exit with save" actions should be retrievable with a single action.[D]

2.6.2-7 Automatic Saving of a File

The system should save a file automatically at frequent intervals while being edited.

ADDITIONAL INFORMATION: Users should be aware of automatic file saving operations.[D]

2.6.2-8 Automatic Backup

Users should have the option of invoking an automatic backup function that retains previous versions of files. The specific number of previous versions saved should be selectable by the user.[D]

2.6.2-9 Access of Modified Information After Exit Without Save

Information from a file that has been modified by new input should be retrievable with a single action even after exiting without saving new input.

ADDITIONAL INFORMATION: The modified file is accessible for a period of time after the "exit" actions.[D]

2.6.3-1 Automatic Placement of Cut Data in Buffer

When selected data is cut or copied from a text file, tabular file, and/or graphics file and placed in a temporary editing buffer, the data should be placed in the buffer automatically, with the only specific action required by the user being the cut or copy action.

ADDITIONAL INFORMATION: If a temporary editing buffer is used, data pasted into a text file, tabular file, and/or graphics file is pasted from that buffer.[D]

2.6.3-2 Contents of Temporary Buffer

The contents of the temporary editing buffer should remain intact after the application from which the contents were taken is closed.[D]

2.6.3-3 Default Conditions of Buffer

The default condition should be that additions to the temporary editing buffer are not cumulative.

ADDITIONAL INFORMATION: New data placed in the buffer replaces old data.[D]

2.6.3-4 Access to Contents of Temporary Buffer

The user should be able to access the contents of the temporary editing buffer in a window with a single action.

ADDITIONAL INFORMATION: Access to the contents of the temporary editing buffer permits the user to read the contents, but not operate on them.[D]

2.6.4-1 Accessing Information Across Applications

The capability to accept and maintain information, independent of application, should be provided for holding relevant information across displays or applications.

ADDITIONAL INFORMATION: An example of this capability is the scrapbook or excerpt file.[D]

2.6.4-2 Excerpt File

Users should have the capability to create multiple Excerpt Files.[D]

2.6.4-3 Integrating Data

The user should have the capability to integrate new data with data already in the file.

ADDITIONAL INFORMATION: Integrating data might include (1) pasting the new data following data already in the file, (2) pasting the new data before data already in the file, and (3) interleaving new data in data already in the file. Each of these capabilities should be available through a single user action.[D]

2.6.4-4 Copying Excerpt File

The user should be able to cut or copy data from the Excerpt File and paste it to any other file.[D]

2.6.4-5 Saving Excerpt File

The user should be able to save the Excerpt File.[D]

2.7.1-1 Automatic Data Validation

Software for automatic data validation should be provided to check any item whose entry and/or correct format or content is required for subsequent data processing.[A,E]

2.7.1-2 Validation

Data entries should be validated by the system for correct format, legal value, or range of values. Where repetitive entry of data sets is required, data validation for each set should be completed before another transaction can begin.[A]

2.7.1-3 Stroke-By-Stroke Echo

Data being entered through a keyboard should be echoed on the screen on a stroke by stroke basis, except when applied to passwords or other security measures.[A]

2.7.1-4 System Validation

Where possible, when a command entry does not meet validation logic, a cautionary message should be displayed asking the user to confirm data entry.

ADDITIONAL INFORMATION: For example, during reactivity control, the following type message may be displayed: "A negative value has been entered in the field 'Control Rods.' Please enter a positive number between 1 and 32.[A]

2.7.1-5 Data Verification by User Review

When verification of prior data entries is required, users should be allowed to review and confirm the data, rather than re-entering the data.

ADDITIONAL INFORMATION: For routine verification, data review by the user will be quicker than re-entry, with less risk of introducing new errors. For special verification, as when computer processing has detected doubtful and/or discrepant data entries, the user should be alerted with an appropriate advisory message.[E]

2.7.1-6 Cross Validation of Related Data

For the entry of related data items, automatic cross validation should be provided to ensure that the data set is logically consistent.

ADDITIONAL INFORMATION: Such cross checking is a significant advantage of on-line data processing, providing computer aids to help users detect logical errors.[E]

2.7.1-7 Displaying Default Values

Currently operative default values should be displayed for data entry, so that users can review and confirm them for computer processing.[E]

2.7.1-8 Non-Disruptive Error Messages

If data validation detects a probable error, an error message should be displayed to the user at the completion of data entry.

ADDITIONAL INFORMATION: An ongoing transaction should not be interrupted.[A,E]

2.7.1-9 Timely Validation of Sequential Transactions

In a repetitive data entry task, the data for one transaction should be validated and the user should be allowed to correct errors before beginning another transaction.

ADDITIONAL INFORMATION: This is particularly important when the task requires transcription from source documents, so that a user can detect and correct entry errors while the relevant document is still at hand.[A,E]

2.7.1-10 Optional Item-by-Item Validation

Optional item-by-item data validation within a multiple-entry transaction should be provided.

ADDITIONAL INFORMATION: This capability, which might be termed an "interim ENTER," may sometimes help a novice user who is uncertain about the requirements imposed on each data item.[A,E]

2.7.1-11 Deferral of Required Data Entry

If a user wishes to defer entry of a required data item, the user should be required to enter a special symbol in the data field to indicate that the item has been temporarily omitted rather than ignored.[E]

2.7.1-12 Reminder of Deferred Entry

If a user has deferred entry of required data but then requests processing of entries, that omission should be signaled to the user and immediate entry (or perhaps further deferral) of missing items should be allowed.[E]

2.7.1-13 User Validation

The user should be able to obtain a paper copy (screen dump) of the contents of alphanumeric or graphic displays.[A]

2.7.2-1 Acknowledging Corrections

All error corrections by the user should be acknowledged by the system either by indicating a correct entry has been made or by another error message.[C]

2.7.2-2 UNDO to Reverse Control Actions

Any user action should be immediately reversible by an UNDO command.

ADDITIONAL INFORMATION: UNDO itself should be reversible, so that a second UNDO action will do again whatever was just undone. Even with an UNDO capability, however, a user may make an irretrievable mistake, if succeeding actions intervene before a prior destructive action is noticed. If a user is overhasty in confirming a destructive action, and realizes the mistake right away (i.e., before taking another action), then an UNDO action might be taken to reverse the damage.[E]

2.7.2-3 User Review and Editing of Entries

For all inputs, whether data entries or commands, users should be allowed to edit composed material before requesting computer processing.

ADDITIONAL INFORMATION: Input editing will allow users to correct many errors before computer processing. When an error is detected, a user will be able to fix it by editing, i.e., without having to retype any correct items (which might introduce further errors).[E]

2.7.2-4 Immediate Error Correction

When the system detects an error in a user input, the user should be allowed to make an immediate correction.

ADDITIONAL INFORMATION: It is helpful to correct data entry errors at the source, i.e., while a user still has the entry in mind and/or source documents at hand. When a user cannot correct an entry, as when transcribing from a source document that itself contains an error, it may help to allow the user to defer entry of the wrong item. Alternatively, the user might wish to cancel the transaction.[E]

2.7.2-5 Editing Entries After Error Detection

Following error detection, users should be allowed to edit entries by rekeying only those portions that were in error.

ADDITIONAL INFORMATION: If a user must re-enter an entire data set to correct one wrong item, new errors may be made in previously correct items.[E]

2.7.2-6 Explicit Entry of Corrections

Users should be required to take an explicit ENTER action for computer processing of error corrections.

ADDITIONAL INFORMATION: The action taken to accomplish corrections should be the same action that was taken to enter the data originally.[E]

2.7.2-7 Automated Correction Aid

When inappropriate or unrecognized commands are detected, a list of permissible commands, or commands predicting what the user is attempting should be provided.[D]

2.7.2-8 Flexible BACKUP for Error Correction

Users should be allowed to BACKUP easily to previous steps in a transaction sequence in order to correct an error or make any other desired change.

ADDITIONAL INFORMATION: For example, a user might wish to BACKUP through the defined sequence of a question-and-answer dialogue in order to change a previous answer.[E]

2.7.2-9 Errors in Stacked Commands

If an error is detected in a stacked series of command entries, the computer should either consistently execute to the point of error, or else consistently require users to correct errors before executing any command.

ADDITIONAL INFORMATION: In most applications, partial execution will probably prove desirable. The point here is that an interface design decision should be made and then followed consistently.[E]

2.7.2-10 Partial Execution of Stacked Commands

If only a portion of a stacked command can be executed, the user should be notified and provided appropriate guidance to permit correction, completion, or cancellation of the stacked command.

ADDITIONAL INFORMATION: Note that stacked commands can fail because of error in their composition, or for other reasons such as unavailability of required data.[E]

2.7.2-11 Replacing Erroneous Commands

If a user makes a command entry error, after the error message has been displayed the user should be allowed to enter a new command.

ADDITIONAL INFORMATION: A user should not be forced to correct and complete an erroneous command. In considering a command entry error message, a user may decide that the wrong command was chosen in the first place, and wish to substitute another command instead.[E]

2.7.2-12 Correcting Command Entry Errors

If a command entry is not recognized, the user should be allowed to revise the command rather than rejecting the command outright.

ADDITIONAL INFORMATION: Misstated commands should not simply be rejected. Instead, software logic should guide users toward proper command formulation.[A,E]

2.7.3-1 User Confirmation of Destructive Entries

When a control entry will cause any extensive change in stored information, procedures and/or system operation, and particularly if that change cannot be easily reversed, the user should be notified and confirmation of the action should be required before implementing it.

ADDITIONAL INFORMATION: What constitutes "potentially destructive" requires definition in the context of each system operation. When user entries or changes will be nullified by an abort action, the user should be requested to confirm the abort. Confirmation messages should be simple, positive, and direct.[E]

2.7.3-2 Warning Users of Potential Information Loss

For conditions which may require special user attention to protect against information loss, an explicit alert and/or warning message should be provided to prompt appropriate user action.

ADDITIONAL INFORMATION: The prompt for a CONFIRM action should warn users explicitly of any possible data loss. For example, the message, "CONFIRM deletion of entire FEEDWATER file??" is preferable to "CONFIRM DELETE." If a complete file is to be deleted, sufficient information, (name, description, size, date established, data last changed, etc.) should be displayed to verify the file for deletion.[E]

2.7.3-3 Preventing Data Loss at LOG-OFF

When a user requests LOG-OFF, pending transactions should be checked and if any pending transaction will not be completed, or if data will be lost, an advisory message requesting user confirmation should be displayed.

ADDITIONAL INFORMATION: A user may sometimes suppose that a job is done before taking necessary implementing actions.[E]

2.7.3-4 Displaying Data to be Changed

If a user requests change (or deletion) of a stored data item that is not currently being displayed, both the old and new values should be displayed so that the user can confirm or nullify the change before the transaction is completed.

ADDITIONAL INFORMATION: For proposed deletion of significant amounts of data, such as entire files, it will probably not be feasible to display all of the data. In such instances, sufficient information should be provided so that the user can identify those files s/he has selected for deletion. The user should be clearly warned of the potential data loss and required to confirm the destructive action before it will be executed. This practice will tend to prevent inadvertent change, including changes resulting in loss of needed data. User attempts at selective data change without displayed feedback will be prone to error.[E]

2.7.4-1 Protection from Computer Failure

Automatic measures should be provided to minimize data loss from computer failure.

ADDITIONAL INFORMATION: An automatic capability is needed because users cannot be relied upon to remember to take necessary protective measures. Though not strictly a feature of user interface design, reliable data handling by the computer will do much to maintain user confidence in the system. Conversely, data loss resulting from computer failure will weaken user confidence, and reduce user acceptance where system use is optional. For example, depending upon the criticality of the application, different protective measures may be justified, including periodic automatic archiving of data files, maintenance of transaction logs for reconstruction of recent data changes, or even provision of parallel "backup" computing facilities.[E]

2.7.4-2 Protection from Interrupts

When a proposed user action will interrupt a current transaction sequence, automatic means to prevent data loss should be provided.

ADDITIONAL INFORMATION: If potential data loss cannot be prevented, the user should be warned. Interrupts should not be permitted without user confirmation. Some interrupt actions such as BACKUP, CANCEL, or REVIEW, will by their definition cause only limited data change, and so need no special protection. However, if an interrupt action may cause extensive data change (e.g., RESTART, LOG-OFF), then the user should be required to confirm that action before processing. If a user should interrupt a series of changes to a data file, then the computer might automatically save both the original and the changed versions of that file for subsequent user review and disposition.[E]

2.7.4-3 Protection from Data Change

When information must not be changed, users should not be permitted to change controlled items.

ADDITIONAL INFORMATION: It is not enough simply to instruct users not to make changes in displayed information.[E]

2.7.4-4 Explicit Action to Select Destructive Modes

Users should take explicit action to select any operational mode that might result in data loss.

ADDITIONAL INFORMATION: Destructive modes should not be established automatically. In many applications, it may be better not to provide any destructive mode. Instead of providing a DELETE mode, for example, require that DELETE be a discrete action subject to confirmation by the user when the requested data deletion is extensive.[E]

2.7.4-5 Safe Defaults

If automatic defaults are provided for control entries, those defaults should protect against data loss, or at least not contribute to the risk of data loss.

ADDITIONAL INFORMATION: For example, when printout of filed data is requested, one control option might be to delete that file after printing. The default value for such a destructive option should automatically be set to NO whenever the printing options are presented to a user for selection.[E]

2.7.4-6 Protecting Physical Controls

If activation of function keys (and other control devices) may result in data loss, they should be located separately and/or physically protected to reduce the likelihood of accidental activation.[E]

2.7.4-7 Disabling Unneeded Controls

When function keys and other devices are not needed for current control entry, and especially when they may have destructive effects, they should be temporarily disabled by the software so that they cannot be activated by a user.

ADDITIONAL INFORMATION: Some means should also be provided to help users distinguish currently active from disabled controls, such as brightening (active) or dimming (disabled) their associated labels. If labeling is adequate, then user selection of a disabled control need produce no response. If adequate labeling cannot be provided, then user selection of a disabled control should produce an advisory message that the control is not currently active.[E]

2.7.4-8 Distinctive File Names

When data files may be deleted (or overwritten) by name, the names of different files should distinctive.

ADDITIONAL INFORMATION: In many applications, file naming is a user option, and distinctive naming will depend on user judgment. The computer might provide an advisory message if a proposed new file name is similar (e.g., identical in the first 5 letters) to the name of an existing file.[E]

2.7.4-9 Feedback for Mode Selection

When the result of user actions will be contingent upon prior selection among differently defined operational modes, a continuous indication of the current mode should be provided, particularly when user inputs in that mode might result in data loss.

ADDITIONAL INFORMATION: A user cannot be relied upon to remember prior actions. Thus any action whose results are contingent upon previous actions can represent a potential threat to data protection. For example, if a DELETE mode is being used to edit displayed data, some indication of that mode should be continuously displayed to the user.[E]

2.7.4-10 Protection from Interference by Other Users

Data should be protected from inadvertent loss caused by the actions of other users.

ADDITIONAL INFORMATION: When one user's actions can be interrupted by another user, as in defined emergency situations, that interruption should be temporary and nondestructive. The interrupted user should subsequently be able to resume operation at the point of interruption without data loss. When multiple users review, enter, or modify data in a system, they should be able to review and browse data changes or entries made by other users. In systems where information handling requires the coordinated action of multiple users, it may be appropriate that one user can change data that will be used by others. But when multiple users will act independently, then care should be taken to ensure that they will not interfere with one another.[E]

2.7.4-11 Segregating Real from Simulated Data

When simulated data and system functions are displayed or provided (perhaps for user training), real data should be protected and real system use should be clearly distinguished from simulated operations.[E]

2.7.4-12 Data Entry/Change Transaction Records

In situations where unauthorized data changes may be possible, users (or a system administrator) should be able to request a record of data entry/change transactions.

ADDITIONAL INFORMATION: Transaction records might be maintained for purposes of user guidance as well as for data protection.[E]

2.8.1-1 Automated Security Measures

When required, automated measures to protect data security should be provided, relying on computer capabilities rather than on more fallible human procedures.

ADDITIONAL INFORMATION: For protection against unauthorized users, who may be intruders in a system, the need for automated security measures is clear. For legitimate users, the need for data protection is to minimize data loss resulting from potentially destructive equipment failures and user errors. Even careful, conscientious users will sometimes make mistakes, and user interface logic should be designed to help mitigate the consequences of those mistakes.[E]

2.8.1-2 Warning of Threats to Security

Messages and/or alarm signals in order to warn users (and system administrators) of potential threats to data security (i.e., of attempted intrusion by unauthorized users) should be provided.

ADDITIONAL INFORMATION: For protecting data from unauthorized use, it may not be enough merely to resist intrusion. It may also be helpful if the computer can detect and report any intrusion attempts. In the face of persistent intrusion attempts, it may be desirable to institute countermeasures of some sort, such as changing user passwords or establishing other more stringent user authentication procedures.[E]

2.8.1-3 Auxiliary Tests to Authenticate User Identity

When system security requires more stringent user identification than is provided by password entry, auxiliary tests should be devised that authenticate user identity without imposing impractical demands on the user's memory.[R]

2.8.1-4 Easy LOG-ON

The LOG-ON process and procedures for user identification should be as simple as possible consistent with protecting data from unauthorized use.

ADDITIONAL INFORMATION: The LOG-ON process should provide prompts for all user entries, including passwords and/or whatever other data are required to confirm user identity and to authorize appropriate data access/change privileges. Authentication of user identity is generally not enhanced by requiring a user to enter routine data such as terminal, telephone, office or project numbers. In most organizations, those data can readily be obtained by other people. If verification of those data is needed, the user should be asked to review and confirm currently stored values in a supplementary procedure following LOG-ON.[E]

2.8.1-5 Private Entry of Passwords

When a password must be entered by a user, password entry should not be displayed.

ADDITIONAL INFORMATION: Covert entry of passwords will prevent casual eavesdropping by onlookers. This represents an exception to the general recommendation that all entries should be displayed. Special characters (e.g., * or #) may be displayed with each keystroke rather than the actual characters being entered. Alternatively, blanks may be displayed accompanied by an audio cue (e.g., a click or beep) for keystroke feedback.[C,E]

2.8.1-6 User Choice of Passwords

When passwords are required, users should be allowed to choose their own passwords and to change their passwords as needed.

ADDITIONAL INFORMATION: Where data protection is critical, user selected passwords should be tested against a list of common passwords ("me", car types, names spelled backwards "nhoj", birth dates, etc.). A password chosen by a user will generally be easier for that individual to remember. Security is enhanced if users are readily able to change their passwords, e.g., a user may suspect that a password has been disclosed, and thus wish to change it.[E]

2.8.1-7 Limiting Unsuccessful LOG-ON Attempts

A maximum limit on the number and rate of unsuccessful LOG-ON attempts should be imposed.

ADDITIONAL INFORMATION: These limits should provide a margin for user error while protecting the system from persistent attempts at illegitimate access. A record of continuing failure by any particular user to complete successful LOG-ON procedures, including password entry and other tests of claimed user identity, may indicate persistent intrusion attempts or lack of fitness for duty. Repeated LOG-ON failures might thus be grounds for denying access to that user. Access might be denied temporarily for some computer-imposed time interval, or indefinitely pending review by a system administrator. Legitimate users will sometimes have difficulty completing a successful LOG-ON, perhaps due to inattention, or a faulty terminal, or faulty communications. Occasional LOG-ON failures of that kind should be tolerable to the system, with the user simply invited to try again.[E]

2.8.1-8 Continuous Recognition of User Identity

Once a user's identity has been authenticated, whatever data access/change privileges are authorized for that user should continue throughout a work session.

ADDITIONAL INFORMATION: If an identified user is required to take separate actions to authenticate data handling transactions, such as accessing particularly sensitive files or issuing particular commands, the efficiency of system operations may be degraded. Where continuous verification of user identity seems required for data protection, some automatic means of identification might be employed for that purpose.[E]

2.8.1-9 Single Authorization for Data Entry/Change

User authorization for data entry/change should be established at initial LOG-ON.[E]

2.8.1-10 Log-on

When users must log-on to a system, log-on should be a separate procedure that is completed before a user may select any operational options.[E]

2.8.1-11 Log-on Frame

The log-on frame should appear as soon as possible on the display with no additional user involvement.[A]

2.8.1-12 Log-on Delays

Log-on delays should be accompanied by an advisory message to tell the user status and when the system will become available.[A]

2.8.1-13 Immediate Start of Productive Work

After completing the sign-on process, the user should be able to start productive work immediately.[A]

2.8.1-14 Log-off

If there are pending actions and the user requests a log-off, the system should inform the user that these actions will be lost and allow the user to cancel either the pending actions or the log-off.[A]

2.8.1-15 Saving Open Files in Automatic Log-off

Where possible, in the event of automatic log-off, open files should be saved to some defined file name.

ADDITIONAL INFORMATION: For example by concatenation of Users Name + Date.[E]

2.8.1-16 Automatic Logoff
Interactive timesharing systems should allow some specified time between keyboard actions before automatic log-off unless a longer period is requested by the user.^

2.8.1-17 Audible Signal for Automatic Logoff
An audible signal should be presented at specified intervals prior to automatic log-off.^

2.8.2-1 Encryption

When sensitive data may be exposed to unauthorized access, a capability for encrypting those data should be provided.

ADDITIONAL INFORMATION: Since potential exposure may be assumed during any external data transmission, encryption should be imposed routinely by the computer. Users should not be relied upon to request encryption. For protection of data within a shared system, a user might choose to encrypt private files to prevent their reading by other people. In such a case, the user must specify a private encryption "key", which will then serve as the basis for automatic encryption by the computer.[E]

2.8.2-2 Ensuring Reversible Encryption

Encrypted data should be protected from any change that might prevent successful reversal of their encryption.[E]

2.8.2-3 Displayed Security Classification

When displayed data are classified for security purposes, a prominent indication of security classification should be included in each display.

ADDITIONAL INFORMATION: Where a display includes partitioned "windows" of data from different sources, it may be necessary to label security classification separately for each window. Under those conditions, some form of auxiliary coding (e.g., color coding) might help users distinguish a window which contains data at a high security level. This practice will serve to remind users of the need to protect classified data, both in access to the display itself and in any further dissemination of displayed data.[E]

2.8.2-4 Display Suppression for Security

When confidential information is displayed at a work station that might be viewed by casual onlookers, the user should be provided with some rapid means of temporarily suppressing a current display if its privacy is threatened, and then resuming work later.

ADDITIONAL INFORMATION: A suppressed display should not be entirely blank, but should contain an appropriate message indicating its current status, e.g., "Display is temporarily suppressed; enter password to resume work." Such a capability is sometimes called a "security pause". For quick display suppression a function key might be provided. To retrieve a suppressed display and resume work, a user might be required to make a code entry such as a password, in the interests of data protection.[E]

2.8.2-5 Protecting Printed Data

As required for security, procedures to control access to printed data should be established, rather than simply prohibiting the printing of sensitive data.

ADDITIONAL INFORMATION: User requirements for printed data are often unpredictable, and printing restrictions may handicap task performance. Rather than restrict printing, establish appropriate procedures for restricting further distribution of data printouts.[E]

2.8.2-6 Protecting Display Formats

Display formatting features, such as field labels and delimiters, should be protected from accidental change by users.

ADDITIONAL INFORMATION: In many data entry tasks users will be allowed to change data fields but should be prevented from making any structural changes to the display. In applications where a user may have to create or modify display formats, special control actions should be provided for that purpose.[E]

2.8.2-7 Protecting Displayed Data

When protection of displayed data is essential, computer control over the display should be maintained.

ADDITIONAL INFORMATION: It is not enough simply to instruct users not to make changes in displayed data. Users may attempt unwanted changes by mistake, or for curiosity, or perhaps even to subvert the system.[E]

2.8.2-8 Indicating "Read-Only" Displays

When users are not authorized to change displayed data, "read-only" status should be indicated on the display.

ADDITIONAL INFORMATION: In applications where the use of read-only displays is common, then some simple cue in the display header may suffice to indicate that status. In applications where users can usually make additions and/or corrections to displayed data, then any exception to that practice may confuse a user and so should be noted more prominently on the display.[E]

2.8.2-9 Automatic Records of Data Access

When records of data access are necessary, the records should be maintained automatically.

ADDITIONAL INFORMATION: Transaction records and logs should be stamped with user identifiers, time, and date. Provisions should be made to control requests for records and logs of data transactions with classified material. Users should be informed concerning the nature and purpose of automated recording of individual actions. Even cooperative, well-intentioned users can forget to keep manual logs of data access, and will resent the time and effort required to keep such logs. Subversive users, of course, cannot be expected to provide accurate records.[A,E]

3 PROCESS CONTROL & INPUT DEVICES

3.1 General Control Guidelines

3.1-1 Appropriate Use of Input Devices

Input and control devices provided for interacting with the HSI should be appropriate for the user's task requirements.

ADDITIONAL INFORMATION: Control/input devices and conditions for their appropriate use are listed in Table 3.1.

3.1-2 Input Device Stability

Input and control devices should be stable during normal usage, i.e., they should not slip or rock, unless such actions are a part of the controller operation.[B]

3.1-3 Feedback

Visual or auditory feedback should be provided to indicate that a controller input has been registered.

ADDITIONAL INFORMATION: This is especially important when the control surface does not depress or move (such as with a force joystick or touchscreen), thereby providing little tactile feedback to the user.[D]

3.1-4 Accidental Input or Actuation Prevention

The system should be designed to prevent the accidental manipulation of control and input devices which could result in changes to the status of the system functions, components, or data.[C]

Table 3.1. Control and Input Devices for Human-Computer Interaction

Control/Input Device	Conditions for Appropriate Use
Cursor Control Capability (Keys)	• Moving cursor in X and Y dimensions
Touch-Screens	• Moving/holding arm to screen for long periods of time is not required • Screen does not have small poke points relative to size of finger tip • A low level of resolution is required for positioning • Task will not be disrupted by hand temporarily blocking screen • Periodic cleaning is provided
Light Pen	• High positioning precision is not required • Holding arm to screen for long periods of time is not required
Mouse	• Adequate space is available for mouse movement over a pad or desktop • A low to medium level of resolution is required for positioning • Periodic cleaning is provided
Displacement (Isotonic) Joysticks	• Positioning accuracy is more important that positioning speed
Trackball	• Rapid cursor positioning is desirable *or* • A low to high level of resolution is required for positioning *or* • Limited space is available for installing an input device
Graphics Tablets	• A low to medium level of resolution is required (e.g., data pickoff from/entry to a graphic display)
Force (Isometric) Joysticks	• Precise or continuous control of two or more related dimensions

3.2.1-1 General Keyboard Layout

An ANSI standard (QWERTY) layout should be used for the typing keyboard.

ADDITIONAL INFORMATION: Common usage and the ability to transfer from one machine to another has led to the general acceptance of the QWERTY keyboard. Figure 3.1 illustrates the key arrangement.[F]

3.2.1-2 Numeric Keypad

When users must enter numeric data, keyboards should be equipped with a numeric keypad.[C,F]

3.2.1-3 Numeric Keypad Layout

Keypads used for numeric entry should be consistently designed.

ADDITIONAL INFORMATION: Keypad layout should be one of those illustrated in Figure 3.2.[F]

3.2.1-4 Cursor Control Capability

Horizontal and vertical cursor control keys should be provided for text processing applications.

ADDITIONAL INFORMATION: Ideally, keys for cursor control should allow (1) horizontal and vertical movement, (2) movement along the diagonals, and (3) two or more rates of movement that are user selectable. Cursor keys should be dedicated to cursor movement, that is, should not be used for any function but cursor control. If, however, the cursor keys are not dedicated, that is, have collateral functions, their functional status shall be clearly indicated.[D,F]

3.2.1-5 Cursor Key Layout

Cursor control keys should be arranged in a two-dimensional layout (as illustrated in Figure 3.3) so that their orientation is compatible with the cursor motion they produce.

ADDITIONAL INFORMATION: Cursor keys may be arranged in a "box," "cross," or "inverted-T" format. Figure 3.3 illustrates these key arrangements.[D,F]

3.2.1-6 Overlays

Mechanical overlays, such as coverings over the keyboard, should be not used.[C]

3.2.1-7 Keyboard Surfaces

A matte finish should be used for keyboard surfaces.

ADDITIONAL INFORMATION: The spectacular reflectance (gloss) of key caps and visible surfaces should be 45 percent or less when measured with a 60-degree gloss instrument or equivalent device.[B,F]

3.2.1-8 Keyboard Thickness

The thickness of the keyboard, i.e., base to the home row of keys, should be less than 2 in. (50 mm); 1.25 in. (30 mm) or less is preferred.[B]

3.2.1-9 Keyboard Slope Adjustment

The slope of the keyboard should be adjustable by the operator.

ADDITIONAL INFORMATION: Keyboards should be capable of being positioned in slopes of 15 to 25 degrees from the horizontal.[B]

3.2.1-10 Standard Keyboard Placement

The operator should be able to reposition the standard keyboard on the worksurface.[F]

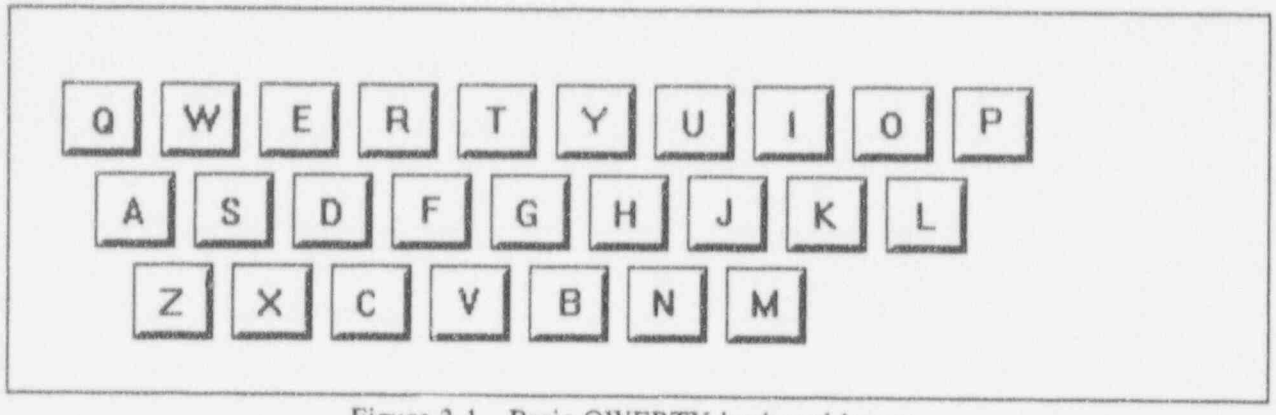

Figure 3.1. Basic QWERTY keyboard layout

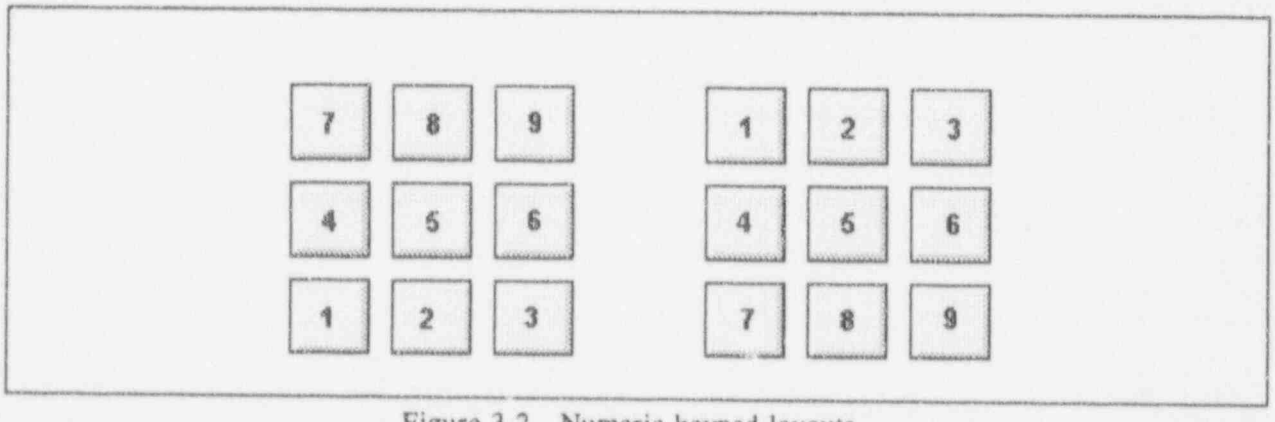

Figure 3.2. Numeric keypad layouts

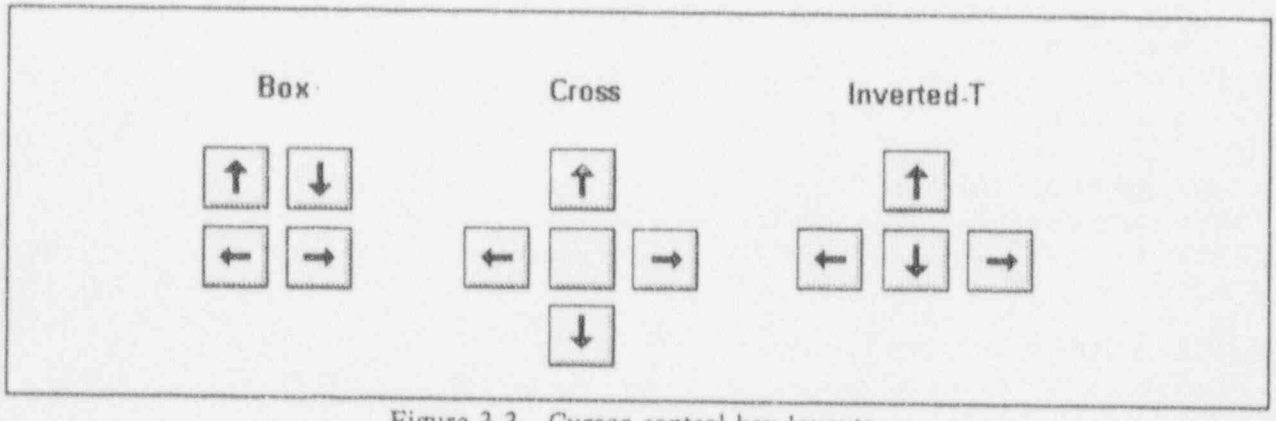

Figure 3.3. Cursor control key layouts

3.2.1-11 Keytop Size

The minimum horizontal strike surface of the keytop should be at least 0.5 in. (12 mm) in width.
ADDITIONAL INFORMATION: The keytop may be of any shape (square, round, rectangular, etc.) provided spacing requirements are not violated.[F]

3.2.1-12 Key Symbol Size and Contrast

Nomenclature for the primary symbols on the keys should be a minimum of 0.1 in. (2.5 mm) in height and has a contrast ratio of 3:1.
ADDITIONAL INFORMATION: Key nomenclature may be darker or lighter than the background.[F]

3.2.1-13 Keytop Symbol Marking

Key symbols should be etched (to resist wear) and colored with high contrast lettering.
ADDITIONAL INFORMATION: Keys should be labeled with a nonstylized font.[B]

3.2.1-14 Key Spacing

Center line distances between adjacent keys should be between 0.71 and 0.75 in. (18 and 19 mm) horizontally and between 0.71 and 0.82 in. (18 and 21 mm) vertically.[F]

3.2.1-15 Key Height

Key height for alphanumeric keyboards should be between 0.35 and 0.5 in. (10 and 13 mm).[C]

3.2.1-16 Key Force

The maximum force required to depress keys should be between .25 and 1.5 N; a key force of between 0.5 and 0.6 N is preferred.
ADDITIONAL INFORMATION: The force required for key displacement should be 0.3 to 0.75 N for repetitive keying tasks.[B,F]

3.2.1-17 Key Displacement

Keys should have a maximum vertical displacement between 0.05 and 0.25 in. (1.5 mm and 6.0 mm); the preferred displacement is between 0.1 and 0.15 inch (2.0 and 4.0 mm).
ADDITIONAL INFORMATION: Displacement variability between keys should be minimized.[B,F]

3.2.1-18 Keying Feedback

The actuation of a key should be accompanied by tactile or auditory feedback or both.
ADDITIONAL INFORMATION: If there is only one, tactile feedback is preferred. Should supplementary auditory feedback be used, the sound should occur at the same point in the displacement for all keys. Supplementary auditory feedback should be adjustable in volume and should be capable of being turned off.[F]

3.2.1-19 Repeat Capability

A repeat capability for alphanumeric, symbol character, and cursor keys should be provided.
ADDITIONAL INFORMATION: The repeat should have a user selectable delay with a default of 0.5 second. In addition, the character should be repeated at a user selectable rate with a default of 0.1 second. The physical release of the key should terminate the repeat.[D]

3.2.1-20 Multiple-Key Rollover

N-key (multiple key) rollover capability should be provided for the reduction of keying errors.[B]

3.2.1-21 Keystroke Commands

A specially designated key (e.g., a Control key) should be one of the keys used for keystroke commands.[D]

3.2.1-22 Simultaneous Keystrokes

Keystroke commands should require the user to press both keys simultaneously, not in close temporal sequence.

ADDITIONAL INFORMATION: Requiring the user to press two keys simultaneously reduces the likelihood of inadvertent input of a command due to a missed keystroke that hits the specially designated key, followed immediately by another keystroke.[D]

3.2.1-23 Inadvertent Operation

Keys with major or fatal effects should be located so that inadvertent operation is unlikely.[B]

3.2.1-24 Alternate Key Definitions

When the keyboard is redefined, a display of the alternate characters and their locations should be available to the operator.[D]

3.2.2-1 Availability

Fixed function keys should be available to control functions that are often utilized and continuously available.

ADDITIONAL INFORMATION: Lockout of fixed function keys should be minimized.[C]

3.2.2-2 Inactive Function Keys

Unneeded function keys, either fixed or programmable, should be disabled so that no other action occurs upon their depression except an advisory message.

ADDITIONAL INFORMATION: At any step in a transaction sequence, function keys which are not used for current inputs should be temporarily disabled under computer control. Mechanical overlays should not be used for this purpose.[D]

3.2.2-3 Inactive Keys

Non-active fixed function keys should not be present on the keyboard.

ADDITIONAL INFORMATION: Such keys should be replaced by a blank keys on the keyboard.[C]

3.2.2-4 Grouping

Fixed function keys should be logically grouped and should be placed in distinctive locations on the keyboard.

ADDITIONAL INFORMATION: Color-coding can be used to highlight functional key groups. When this is done the color of alphanumeric keys should be neutral (e.g., beige, grey).[C]

3.2.2-5 Function labels

Key assignments should be displayed at all times, preferably through direct marking.

ADDITIONAL INFORMATION: Where abbreviations are necessary, standardized abbreviations should be used.[C]

3.2.2-6 Consistency

Fixed function keys should be used consistently throughout the system.[C]

3.2.2-7 Actuation

Fixed function keys should require only a single actuation to accomplish their function.[C]

3.2.2-8 Repeat for Special Functions

Function keys (except for the delete key) should not repeat upon prolonged depression.[D]

3.2.2-9 Status Display

When the effect of a function key varies, the status of the key should be displayed.

ADDITIONAL INFORMATION: Variable function keys should be easily relabeled.[C]

3.2.2-10 Easy Return to Initial Functions

Where the functions assigned to a set of function keys change as a result of user selection, the user should be given an easy means to return to the initial functions.[C]

3.2.2-11 Reprogrammable or Inactive Default Functions

When keys with labeled default functions are reprogrammed or turned off, a visual warning should alert the user that the standard function is not currently accessible via that key.[C]

3.2.2-12 Shifted Characters

Shift keys should be not required to operate variable function keys.[C]

3.2.3-1 Dynamic Characteristics

The controller should be able to produce any combination of x and y axis output values.

ADDITIONAL INFORMATION: The follower (cursor) manipulated by the controller should smoothly track the movement of the controller in the same direction, within +/-10 degrees without backlash, crosscoupling, or the need for multiple corrective movements. While manipulating the control, neither backlash nor cross-coupling should be apparent to the operator.[C,D]

3.2.3-2 Positive Centering

If there is a "home position," the capability for an automatic return to that point should be provided.[C]

3.2.3-3 Single Monitor/Single Controller Cursor Travel Limits

In a single monitor/single controller environment, movement of the controller should drive the follower to the edge of the screen only and not off the screen.[D]

3.2.3-4 Separation of Selectable Screen Items

Selectable screen items or regions should be separated from each other by a sufficient distance to minimize inadvertent activation of adjacent items or regions.[D]

3.2.3-5 Selectable Tracking Speed

The controller tracking speed (control-display ratio) should be user selectable from a predefined list of alternatives; there should be a moderate default speed.

ADDITIONAL INFORMATION: Control ratios and dynamic features should meet the dual requirement of rapid gross positioning and smooth, precise fine positioning. The control/display ratios should take into account both screen size and maximum maneuvering displacement. At a minimum, movement of the controller across the entire maneuvering surface should move the cursor from one side of the screen to the other.[C,D]

3.2.3-6 Selectable Inter-Click Interval

If multiple clicks are required on a selection button, the user should be able to select the inter-click interval from a predefined list of alternatives. There should be a moderate default setting.[D]

3.2.3-7 Limb Support for Trackballs and Mice

When trackballs and mice are used to make precise or continuous adjustments, hand, wrist, or arm supports should be provided.[C]

3.2.3-8 Mouse Shape

The mouse should have no sharp edges but should be shaped roughly as a rectangular solid.[C]

3.2.3-9 Use of Mouse by Either Hand

The controller should be operable with either the left or right hand.[C]

3.2.3-10 Appropriate Use of Displacement (Isotonic) Joysticks

When positioning accuracy is more critical than positioning speed, displacement joysticks should be available (preferred over force joysticks).

ADDITIONAL INFORMATION: Displacement joysticks which are used for rate control should be spring-loaded for return to center when the hand is removed. Displacement joysticks usually require less force than force joysticks and are less fatiguing for long operating periods. Hand operated displacement joysticks may be used as mounting platforms for secondary controls, such as thumb and finger operated switches. Operation of secondary controls has less induced error on the displacement hand grip than on isometric handgrips.[C]

3.2.3-11 Appropriate Use of Force (Isometric) Joysticks

When precise or continuous control in two or more related dimensions is required, force joysticks should be available (preferred over displacement joysticks).

ADDITIONAL INFORMATION: Force joysticks are particularly appropriate for applications: (1) which require precise return to center after each use; (2) in which operator feedback is primarily visual rather than tactile feedback from the control itself; and (3) where there is minimal delay and tight coupling between control and input and system reaction. When positioning speed is more critical than positioning accuracy, force joysticks should be selected over displacement joysticks.[C]

3.2.3-12 Force Joysticks Dynamic Characteristics

The output of the force joystick should be proportional to and in the same direction as the user's perceived applied force. Maximum force for full output should not exceed 27lb (118N).

ADDITIONAL INFORMATION: Movement should be smooth in all directions, and positioning of a follower should be attainable without noticeable backlash, cross-coupling or need for multiple corrective movements. Control ratios, friction and inertia should meet the dual requirements of rapid gross positioning and precise fine position. When used for generation of free-drawn graphics, the refresher rate for the follower on the display should be sufficiently high to give the appearance of a continuous track.[C,D]

3.2.3-13 Displacement Joystick Dynamic Characteristics

The output of the displacement joystick should be proportional to and in the same direction as the displacement of the joystick from the center. Movement should not exceed 45 degrees from the center position.

ADDITIONAL INFORMATION: The resistance should be sufficient to maintain the handle position when the hand is removed. Movement should be smooth in all directions, and positioning of a follower should be attainable without noticeable backlash, cross-coupling, or need for multiple corrective movements. Control ratios, friction and inertial should meet the dual requirements of rapid gross positioning and precise fine positioning. When used for generation of free-drawn graphics, the refresher rate for the follower on the display should be sufficiently high to give the appearance of a continuous track.[C,D]

3.2.3-14 Hand-Operated Joysticks Dimensions and Clearance

The hand grip length should between 4.25 - 7 in. (110 - 180 mm). The grip diameter should not exceed 2 in. (50 mm). Clearances of 4in. (100 mm) to the side and 2 in. (50 mm) to the rear should be provided to allow for hand movement.[C]

3.2.4-1 Appropriate Use of Touch-Screens

Touch screens are not recommended if the task requires holding arm up to the screen for long periods of time.

ADDITIONAL INFORMATION: Tasks involving touch screens should not require frequent, alternating use of touch screen and the keyboard.[B,C,D]

3.2.4-2 Appropriate Use of a Light Pen

A light pen may be used for non-critical input when precise positioning is not required; it should not be used when the task would require holding the pen up to the screen for long periods of time.

ADDITIONAL INFORMATION: Tasks involving light pens should not require frequent, alternating use of the light pen and the keyboard.[C]

3.2.4-3 Appropriate Use of a Graphics Tablet

Grid and stylus devices may be used for data pickoff from a display and entry of points on a display.

ADDITIONAL INFORMATION: Displacement of the stylus from the reference position should cause a proportional displacement of the follower. The grid may be on a transparent medium allowing stylus placement directly over corresponding points on the display or it may be displaced from the display in a convenient position for stylus manipulation. In either case a follower should be presented on the display at the coordinate values selected by the stylus.[C]

3.2.4-4 Activation

Touch screens, light pens, and graphics tablets should be equipped with an actuating/deactuation mechanism.

ADDITIONAL INFORMATION: This is to prevent inadvertent actuation. For most light pen applications, a push-tip switch, requiring 2-5oz (0.5N - 1.4N) of force to actuate, is preferred.[C]

3.2.4-5 Feedback

Two forms of feedback should be provided: (1) feedback concerning the position of the follower, (2) feedback that the pointer has actuated and the input has been received by the system.

ADDITIONAL INFORMATION: Feedback can be in the form of displayed follower (such as circle or crosshair) or highlighting.[C]

3.2.4-6 Dynamic Characteristics

When used as a two-axis controller, movement of the pointer in any direction on the surface of the screen or tablet should result in smooth movement of the follower in the same direction.

ADDITIONAL INFORMATION: Discrete placement of the pointer at any point on the surface should cause the follower to appear at the corresponding coordinates and to remain steady so long as the light pen is not moved. Refresh rate for the follower should be sufficiently high to ensure the appearance of continuous track.[C]

3.2.4-7 Follower Visibility

For touch screens and light pens, the follower should be visible on screen while the pointer is touching the screen.[D]

3.2.4-8 Serial Command Response

The system should accept only one command at a time.[F]

3.2.4-9 Feedback for Multiple Workstations

Discriminable audible beeps (used to supply feedback) should be used when more than one touch screen, light pen, or graphics tablet is employed.[B]

3.2.4-10 Dimensions and Separation of Touch Zones

To allow for finger size and parallax inaccuracy, the dimensions of response areas of touch screens should be a maximum height and width of 1.5 in. (40 mm) and a minimum height and width of 0.6 in. (15 mm), with a maximum separation distance of 0.25 in. (6 mm) and minimum of 0.1 in. (3 mm).[C,D]

3.2.4-11 Touch Screen Resistance

Force required to operate force-actuated touch screens should be a maximum of 5.3 oz (1.5 N) and minimum of 0.9oz (0.25 N).[C]

3.2.4-12 Neutral Tint of Touch Overlays

Touch screen overlays should have a neutral tint to avoid alteration of color codes.[B]

3.2.4-13 Touch Screen Luminance Transmission

Touch screen displays should have sufficient luminance transmission to allow the display with touch screen installed to be clearly readable in the intended environment.[B,C]

3.2.4-14 Light Pen Dimensions and Mounting

The light pen should be between 4.75 - 7 in. (120-180 mm) long with a diameter of 0.3 - 0.75 in. (7-20 mm). A conveniently located clip should be provided to hold the pen when not in use.[C]

3.2.4-15 Graphic Tablet Size and Orientation

Transparent grids which are used as display overlays should conform to the size of the display. Grids which are displaced from the display should approximate the display size and should be mounted below the display in an orientation to preserve directional relationships to the maximum extent.
ADDITIONAL INFORMATION: For example, a vertical plane passing through the north/south axis on the grid should pass through or be parallel to the north/south axis on the display.[C]

Guidelines for speech input devices are included in Section 6.2 (Speech-Based Communication).

4 ALARM SYSTEMS

No guidelines are currently available in this section.

Guidelines for speech input devices are included in Section 6.2 (Speech-Based Communication).

4 ALARM SYSTEMS

No guidelines are currently available in this section.

5 ANALYSIS AND DECISION AIDS

5.1 Knowledge-Based Systems (KBS)

5.1-1 Consistency with User Task Requirements

The support provided by the KBS should be consistent in content and format with the cognitive strategies and mental models employed by the user.

ADDITIONAL INFORMATION: Users should be able understand the analysis logic employed by the KBS. This supports user acceptance and enables users to supervise the KBS in order to properly evaluate and utilize its output.^

5.1-2 Consistency with General HSI

The KBS should be fully integrated with and consistent with the rest of the HSI.

ADDITIONAL INFORMATION: The KBS's depiction of the system should utilize the same nomenclature, abbreviations, acronyms, symbology, iconic representations, coding techniques, etc. as the general information display system.^

5.1-3 Interaction With Ongoing Tasks

Use of the KBS should not require canceling ongoing tasks.^

5.1-4 Critical Information Alert

If critical information becomes available during KBS utilization, the system should alert the user to the critical information^

5.1-5 Minimize Querying of User

KBS querying of the user for information should be minimized.^

5.1-6 Dialog Sequencing Flexibility

The user-KBS dialog should be flexible in terms of the type and sequencing of user input the KBS will accept.^

5.1-7 Strategy Planning Capability

The KBS should provide the capability to plan a strategy for addressing a problem.

ADDITIONAL INFORMATION: The capability provided by the KBS should include: planning aids (such as time lines, worksheets); an evaluation function which assesses the adequacy of the user's plan and recommends revisions where necessary; the ability to form, state and test hypotheses in a manner consistent with the user's plan; and, the capacity to store and recall plans.^

5.1-8 User Supported Strategy Selection

When the KBS is capable of a range of problem solving strategies, it should be capable of accepting direction from the user in terms of which strategy to employ.^

5.1-9 Simulation Mode Command and Identification

If the KBS has a simulation mode, entering the simulation mode should require an explicit command and result in a distinguishable change in system output.

ADDITIONAL INFORMATION: A blinking "Simulation Mode" symbol, for example, can be used to clearly distinguish simulation from other operational modes.^

5 ANALYSIS AND DECISION AIDS
5.1 Knowledge-Based Systems (KBS)

5.1-10 Explanation Capability
The KBS should be capable of interactively explaining its rules, knowledge base, and problem solutions at any point during a user-KBS transaction.
ADDITIONAL INFORMATION: Rules should be represented explicitly in the knowledge base and encoded such that they are accessible to the explanation facility and can be translated for human understanding. The KBS should respond to user requests to clarify questions and assertions. At the request of the user, the system should be capable of displaying rule-based and descriptive explanations.[A]

5.1-11 User Control of Explanation Detail
The level of detail of information presented as part of an explanation or justification should be under the control of the user.[A]

5.1-12 Indication of Certainty
The KBS should represent its certainty in the correctness of analyses and provide the rationale underlying the certainty estimation.
ADDITIONAL INFORMATION: Certainty factors, for example, can be represented as a decimal number from -1 to +1; with -1 indicating absolute certainty that a fact is not true, and +1 indicating absolute certainty that a fact is true.[A]

5.1-13 Inadequate Knowledge Alert
The KBS should alert the user when a problem or situation is beyond its capabilities.
ADDITIONAL INFORMATION: Rule exceptions should be explicitly contained in the knowledge base and available to the user as part of the explanation facility. Where possible, the KBS should inform the user as to what additional knowledge or rules are required to complete the transaction.[A]

5.1-14 Graphic Representation of Rules
The KBS should be able to graphically represent system relationships, its rules network, and reasoning process.[A,B]

5.1-15 Highlight of Status Changes after KBS Utilization
At the completion of a user-KBS session, the KBS should update and highlight changes in the status of important system information.
ADDITIONAL INFORMATION: User acknowledgement may be requested for important changes.[A]

5.1-16 Post Hoc Rule-Event Recall
The KBS explanation facility should have the capability to recall each invoked rule and associate it with a specific event (i.e., question or conclusion) to explain the rationale for the event.
ADDITIONAL INFORMATION: The KBS should automatically record all rules invoked during an analysis.[A]

5.1-17 Rapid Interaction Retrieval
The system should permit rapid retrieval of previous exchanges between the user and the KBS.[A]

5.1-18 Hardcopy of KBS Utilization
The user should be capable of requesting a hardcopy of data including; screen displays (text or graphics), data employed during a consultation, summaries of consultations, lists of rules/facts invoked during a consultation, and summaries of hypotheses tested.[A]

6.0 INTER-PERSONNEL COMMUNICATION

6.1 General Communication Guidelines

6.1-1 Interactive Communication

Users should be able to communicate interactively with other users who are currently using the same system.[E]

6.1-2 Interaction With Ongoing Tasks

Users should be able to communicate with each other without cancelling ongoing tasks.[C]

6.1-3 Accessibility

Communications equipments should be accessible from the user's normal working location.

ADDITIONAL INFORMATION: Where communication requirements necessitate the use of several handsets, accessibility of their standby locations should be determined by operational priority. The most frequently or urgently needed handset should be the most accessible, etc. Color-coding may also be employed where operating personnel will have visual contact with headsets under the working conditions.[C]

6.1-4 Consistent Procedures

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.[E]

6.1-5 Minimal User Actions

Communication procedures 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; interface software might provide automatic insertion into messages of standard header information, distribution lists, etc.[E]

6.1-6 Communication Flexibility

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.[E]

6.0 INTER-PERSONNEL COMMUNICATION
6.2 Speech-Based Communication

6.2-1 Comfort
Communication equipment to be worn should be designed to preclude discomfort.
ADDITIONAL INFORMATION: Metal parts of the headset should not come in contact with the user's skin.[C]

6.2-2 Hands-Free Operation
Communication equipment should be designed to permit hands-free operation.[C]

6.2-3 Microphone Frequency Response
Microphones and associated system-input devices 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.[C]

6.2-4 Microphone Dynamic Range
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.[C]

6.2-5 Microphone Noise Shields
When ambient noise is high (85 dBA or greater), the microphone should be put in a noise shield.
ADDITIONAL INFORMATION: Noise shields should be designed to meet the following requirements: a. A volume of at least 15.25 in^3 (250 cm^3) to permit a pressure gradient microphone to function normally. b. A good seal against the face with the pressure of the hand or the tension of straps. c. A hole or combination of holes covering a total area of 0.1 in^2 (65 mm^2) in the shield to prevent pressure buildup. d. Prevention of a standing wave pattern by shape, or by use of sound absorbing material. e. No impediment to voice effort, mouth or jaw movement or breathing.[C]

6.2-6 Noise Canceling Microphones
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.[C]

6.2-7 Signal Processing
If the environment or the speech transmission equipment are 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 to 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.[C]

6.2-8 Speaker Frequency Range

Loudspeakers for use in multi-speaker installations and multiple channels fed into headphones 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.[C]

6.2-9 Binaural Headsets For High Noise Environments

If listeners will be working in high ambient noise (85 dB(A) or above), binaural rather than monaural headsets should be provided.

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.[C]

6.2-10 Loudspeakers for Multi-Channel Monitoring

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 operator'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 operator 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.[C]

6.2-11 Volume Controls

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.[C]

6.2-12 Squelch Control

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, to deactivate the squelch when receiving weak signals, should be provided.[C]

6.0 INTER-PERSONNEL COMMUNICATION
6.3 Computer-Based Communication
6.3.1 General

6.3.1-1 Functional Integration
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.[E]

6.3.1-2 Control by Explicit User Action
Both sending and receiving messages should be accomplished by explicit user action.[E]

6.3.1-3 Automatic Queuing
The computer should provide automatic queuing of outgoing messages pending confirmation of transmission, and of incoming messages pending their review and disposition.[E]

6.3.1-4 Interrupt
Users should be able to interrupt message preparation, review, or disposition, and then resume any of those tasks from the point of interruption.[E]

6.3.1-5 Message Highlighting
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.[E]

6.3.1-6 Automatic Record Keeping
A log of data transmissions should be automatically maintained.[E]

6.3.2-1 Automatic Message Formatting

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 to generate the necessary format automatically should be provided.[E]

6.3.2-2 Message Composition Compatible with Data Entry

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.[E]

6.3.2-3 Variable Message Length

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.[E]

6.3.2-4 Incorporate Existing Files

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.[E]

6.3.2-5 Message Editing

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.[E]

6.3.3-1 Destination Selection

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 work stations 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.[E]

6.3.3-2 Address Directory

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, work stations, and devices. The directory should include specification of system distribution lists as well as individual addresses.[E]

6.3.3-3 Aids for Directory Search

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.[E]

6.3.3-4 Extracting Directory Addresses

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 which a user might make in manual transcription and entry, as well as being faster.[E]

6.3.3-5 Automatic Addressing of Reply

The appropriate address(es) should be automatically provided for users responding to messages.[E]

6.3.3-6 Assignment of Priority

When messages will have different degrees of urgency, the sender of a message should be allowed to designate its relative priority.[E]

6.3.3-7 Information About Communication Status

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.[E]

6.3.3-8 Sender Identification

When a message is sent, the computer should show the sender's address, and the date and time of message creation and/or transmission.[E]

6.3.3-9 Deferring Message for Automatic Transmission

Users should be able to defer the transmission of prepared messages, to be released by later action.
ADDITIONAL INFORMATION: A user might wish to defer data transmission until some specified date-time or until a specific event has occurred.[E]

6.3.3-10 Automatic Feedback

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, or communication link failure, or some other reason, in order to take appropriate corrective action.[E]

6.3.3-11 Saving Undelivered Messages

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.[E]

6.3.3-12 Message Cancellation

Users should be able to recall any message whose transmission has been initiated, if it has not yet been received by its addressee(s).[E]

6.3.3-13 User Review of Data Before Transmission

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 interests of data protection.[E]

6.3.3-14 Saving Transmitted Data Until Receipt is Confirmed

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.[E]

6.3.4-1 Message Notification at LOG-ON

When users log on to a system, they should be notified of any transmissions received since their last use of the system.[E]

6.3.4-2 Display of Messages

The display of messages from other users should be visually and spatially distinct from the display of system messages.[D]

6.3.4-3 Nondisruptive Message Notification

Notification of incoming messages while the user is logged on 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.[D]

6.3.4-4 Indicating Priority of Received Messages

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.[E]

6.3.4-5 Filters for Message Notification

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.[E]

6.3.4-6 Time-Stamp Messages

Messages should be time-stamped.[D]

6.3.4-7 Indicate Message Size

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.[E]

6.3.4-8 Notification of Incomplete Message

The user should be informed when a message extends beyond the area provided.[D]

6.3.4-9 Message Storage and Retrieval

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 and the time, date, and origin of the message.[D]

6.3.4-10 Information about Queued Messages

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 rely on periodic review to deal with routine messages. Summary information about queued incoming messages should help guide message review.[E]

6.3.4-11 User Selection of Messages

The user should be allowed to select any message from an ordered queue with a single action.[D]

6.3.4-12 Annotating Received Messages

Users should be able to append notes to a received message, and ensure that such 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. But users should be able to append, file, and display in some distinctively separate form, their own comments about received messages. 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 that copy.[E]

6.3.4-13 Specifying Device Destination

Users should be able to choose the method of receipt, i.e., what device (files, display, printer) will be the local destination. If a specified receiving device is not operable, such as a printer that is not turned on, the computer should call that to the user's attention.

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 different 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 hard-copy reference.[E]

7 WORKPLACE DESIGN

7.1 Workstation Configuration

7.1-1 VDU Viewing Distance

The minimum design viewing distance should be equal to or greater than 12 inches (30 cm).

ADDITIONAL INFORMATION: When periods of observation will be short, or when dim signals must be detected, the viewing distance may be reduced to 10 in (25 mm). Displays which must be placed at viewing distances greater than 16 in (40 mm) due to other considerations should be appropriately modified in aspects such as display size, symbol size, brightness ranges, line-pair spacing and resolution.[B,C]

7.1-2 VDU Viewing Angle

The display should not be tilted more than 40 degrees relative to the viewer's line of sight.

ADDITIONAL INFORMATION: The angle formed by the intersection of the line of sight and the line normal to the surface of the display at the point where the line of sight intersects the image surface of the display is no more than 40 degrees.[F]

7.1-3 Glare Off VDUs

Reflected glare off VDU surfaces should be minimized.

ADDITIONAL INFORMATION: The surface of the VDU screen should reduce specular glare. Positioning of VDUs relative to light source affects glare as can use of a shield or filter on the VDU or light source. If glare reduction or contrast enhancement techniques are used, they should not violate the requirements of luminance, contrast, and resolution as stated in this document.[B,C,F]

7.1-4 Glare from Surrounding Worksurfaces

Surfaces adjacent to the VDU should have a dull matte finish to reduce glare.

ADDITIONAL INFORMATION: The luminance range of surfaces immediately adjacent to VDUs should be between 10% and 100% of screen background luminance.[C]

No guidelines are currently available in this section.

7.3-1 Ambient Illumination

The ambient illumination in the VDU area that is necessary for other visual functions (e.g., setting controls, reading instruments) should not degrade the visibility of signals on the VDU.[C]

7.3-2 Use of Colored Ambient Illumination

Colored ambient illumination should not be used if color coding is used in the workplace.

ADDITIONAL INFORMATION: Colored lighting will interfere with color-coded VDU displays and other color coding.[B]

7.3-3 Illuminance of Areas Immediately Surrounding VDUs

There should be no light source (direct or reflected) in the immediate surrounding area of the VDU that is of greater luminance than the VDU.[C]

GLOSSARY

Abbreviation: A shortened form of a word or phrase used for brevity.

Acknowledgment: Providing feedback to the sender that a message has been received.

Acronym: A word formed from the initial letter(s) of each of the successive or major parts of a compound term.

Active Window: The window in which user is currently interacting with the system. Typically, this means that an active window (a) is currently receiving input from the user, (b) has last received input from the user, or (c) has been readied for input through the user's explicit action. The user is generally said to be "working in" the active window (such as processing a document, controlling a system, entering data). (See also inactive and closed windows).

Additive Color Process: Presentation of color images by the simultaneous selective projection of red, green, and blue light on a screen.

Addressing Messages: Preparing header information to specify the destination for data to be transmitted.

Alphabetic: Pertaining to a character set that contains letters and other symbols, excluding numbers.

Alphanumeric: Pertaining to a character set that contains letters, digits, and usually other symbols, such as punctuation marks.

Alphanumeric Code: A set of letters and/or numbers used to identify a group of data (e.g., in a table).

Audio: Pertaining to acoustic, mechanical, or electrical frequencies corresponding to normally audible sound waves.

Auditory: Pertaining to the sense of hearing.

Automatic Mode: A mode in which processing proceeds without human intervention (as contrasted with interactive and manual modes).

Bar Chart: A graphic figure in which numeric quantities are represented by the linear extent of parallel lines (or bars). Bar graphs are useful for showing a comparative measure for separate entities or for a variable sampled at discrete intervals. A graphic means of comparing numbers by rectangles with lengths proportional to the numbers represented.

Binary: (1) Pertaining to a characteristic or property involving a selection, choice, or condition in which there are two possibilities. (2) Pertaining to the number representation system with two values.

Blank: Containing no data; a non-printing graphic character used to separate data; a space for the entry of data.

Buffer: A file or device that temporarily stores data.

Button: A type of hardware control device or a defined control region on the display screen which, when selected, causes some action.

Cancel: A capability that regenerates (or re-initializes) the current display without processing or retaining any changes made by the user.

Category: A grouping of data values along a dimension defined for operational purposes.

Cathode Ray Tube: (CRT) An electronic vacuum tube, such as a television picture tube that can be used to display information, graphic, and video.

Caution Signal: A signal which alerts the operator to an impending condition requiring attention, but not necessarily immediate action (see Warning Signal).

Character: A letter, digit, or other symbol that is used as part of the organization, control, or representation of data.

Character Set: A set of unique representations called characters; e.g., the 26 letters of the English alphabet and the 128 characters of the ASCII alphabet.

Character Width: The horizontal distance between a character's origin (a point on the base line used as a reference location) and the next character's origin.

CIE Distance: Difference between colors expressed as a distance in a three dimensional color space which is based on the response of the human eye to light of different wavelengths.

Clear: A system function which removes the current selection but does not put it into the temporary buffer. A copy is retained, accessible immediately by the Undo command. To place one or more storage locations into a prescribed state, usually zero or the space character.

Click: An input device "button-down" action (e.g., depressing and releasing the button on a mouse or trackball) for the actual entry (enabling, activation) at a designated position. This action is distinct from cursor positioning. Also, the auditory feedback from keyboard entry.

Closed Window: A window which is not visible and which requires some action by the user in order to gain perceptual and functional access. For example, a user may select and open an icon that represents a window or, in contrast, the user might input a command to open a specific window. (See also active and inactive windows).

Coding: Use of a system of symbols, shapes, colors or other variable sensory stimuli to represent specific information. Coding may be used (a) for highlighting (i.e., to attract a user's attention to part of a display), (b) as a perceptual indicator of a data group, or (c) to symbolize a state or attribute of an object (e.g., to show a temperature level or for warning purposes).

Color: The aspect of objects or light sources which may be described in terms of hue, lightness (or brightness), and saturation.

Column: A vertical arrangement of items.

Command: The act of instructing the computer or system to perform an action.

Command Language: A type of dialogue in which a user composes entries, possibly with minimal prompting by the computer.

Concatenation: (1) The process of linking data together. (2) A set of logically related items which are treated as a whole.

Context Definition: Displaying an indication of previous user actions or computer processing that will affect the results of current actions, in order to help a user predict how the system will respond.

Continuous: Marked by uninterrupted extension in space, time, or sequence.

Contrast: Diversity of adjacent parts in color and intensity.

Contrast Ratio: The measured luminance at one point divided by the measured luminance at another, equal to Lt/Lb, (Ls-Lb)/Lb, or (1+Ls)/Lb, where:

Lt = total luminance, or luminance of the image in the presence of background;
Ls = luminance of the symbol without background (luminance emitted by CRT in the case of CRT displays);
Lb = luminance of background.

Contrast ratio, rather than contrast, is often specified by display manufactures because it is numerically larger (by one) than contrast.

Control: A mechanism used to regulate, guide the operation of a component, equipment, subsystem, or system.

Control Entry: User input for sequence control, such as function key activation, menu selection, command entry.

Controlling Transmission: The process of ensuring that data which are sent are saved until they can be delivered or returned to the sender.

Copy: A system function that puts a duplicate of the selection into the temporary editing buffer without disrupting the original data.

CRT: (Cathode Ray Tube) An electronic vacuum tube, such as a television picture tube that can be used to display information, graphic, and video.

Cursor: A display graphic that is used to indicate the position of the user's operation on the display (such as an arrow or flashing bar).

Cut: A system function that removes the current selection from the screen and puts it into the temporary editing buffer, replacing the buffer's previous contents. Cut may be used to either delete or to move a selection.

Data: The raw materials from which a user extracts information. (A user can be a human or another component of the system, such as an expert system.) Data may include numbers, words, and/or pictures.

Database: A structured set of data, manipulated using a data management system.

Data Display: Output of data from a computer to its users. Generally, this phrase denotes visual output, but it may be qualified to indicate a different modality, such as an "auditory display".

Data Entry: User input of data for system storage and/or processing.

Data Item: A set of characters of fixed or variable length that forms a single unit of data. Sometimes a data item might contain only a single character. Data items may be entered by a user or may be displayed by the system.

Data Protection: Functional capabilities that guard against unauthorized data access and tampering, and data loss due to user errors or computer failure.

Data Transmission: Computer-mediated communication among system users, and also with other systems.

Data Validation: Functional capabilities that check data entry items for correct content or format, as defined by software logic.

De-emphasis: The inverse of pre-emphasis, employed for the purposes of restoring original vowel-consonant amplitude relationships in pre-emphasis speech; primarily useful in maintaining the "natural" sound quality.

Default: A value or setting that is used if no alternative is specified. Assumed unless specifically overridden. Defaults represent predetermined, frequently used, values for data or control entries intended to reduce required user entry actions.

Density: (Screen Density) The amount of the display screen that contains information; often expressed as a percentage of the total screen area.

Diagram: A special form of a picture in which details are only shown if they are necessary for the performance of a task. For example, an electrical wiring diagram for a facility would show wiring but not necessarily furniture or plumbing.

Dialogue: A structured series of interchanges between a user and a computer. A dialogue can be initiated by a computer (e.g., question and answer) or by a user (e.g., command language).

Digitizing Tablet: (Graphics Tablet) Device used to convert on image into digital code be drawing or tracing with a pen-like or puck-like instrument. The instrument is moved across the tablet and a series of X-Y coordinates is generated.

Dimension: A scale or categorization along which data may vary, taking different values at different times.

Direct Manipulation Control: Defined by the close temporal and physical relations between the movement of the control device and the cursor, or other screen-based follower (e.g., an icon or a window). Direct manipulation control devices include the mouse, the trackball, and pointing devices.

In general, a direct manipulation device permits the user to move the cursor and to use the cursor to select a display structure (e.g., by clicking on a button on the device).

Direct Manipulation: The user manipulates symbols in the display by directly interacting with the symbol. The direct manipulation is generally performed through the use of a display structure, such as a pointer, and a cursor control device, such as a mouse.

Direction: (1) Explicit instruction. (2) Guidance or supervision of action or conduct. (3) The line or course on which something is moving, aimed, pointing, or facing.

Discrete: Consisting of distinct or unconnected elements.

Display: A specific integrated, organized set of information. A display can be a integration of several display formats (such as a system mimic which includes barcharts, trend graphs, and data fields.

Display Control: Procedures by which a user can specify what and/or how data are shown.

Display Device: The hardware used to provide the display to users. Examples include video display units and speakers for system messages.

Display Elements: The individual components of a display, including labels, abbreviations, acronyms, icons, symbols, numbers, color, graph lines, coding, highlighting.

Display Format: Methods of data presentations, such as trend plots, bar charts, graphs, and tables.

Display Selection: Refers to the specification of data outputs, either by a user or automatically.

Display Structure: Functional or information-presenting aspects of a display that are consistent in appearance and use across applications, e.g., providing reference to the user's location in an information system and display of control options available.

Display Tailoring: Designing displays to meet the specific task needs of a user, rather than providing a general display which can be used for many purposes.

Dot Matrix: A rectangular array of dots or lights from which characters are built.

Drag: The act of moving a follower (such as a cursor) or selected icon through parts of a display (typically using a direct manipulation device such as a mouse).

Dynamic: Marked by continuous activity or change.

Dynamic Display: Contains screen structures which change one or more feature(s), e.g., numerical value, color, shape, or spatial location, in real time or near real time.

Enter Key: Key used to indicate completion of data entry for current field or record.

Enter: An explicit user action that effects computer processing of user entries. For example, after typing a series of numbers, a user might press an ENTER key that will add them to a database, subject to data validation.

Entry: (1) The act of inputting information to the system. (2) Something which has been entered.

Excerpt File: A file which allows the user to move data from one location to another; it differs from a temporary editing buffer in that the excerpt file can be saved. Data can be appended to or interleaved into the existing contents of the excerpt file.

Feedback: System or component response (e.g., visual or aural) which indicates the extent to which the user's desired effect was accomplished. Feedback can be either intrinsic or extrinsic. Intrinsic feedback is that which the individual senses directly from the operation of the control devices (e.g., clicks, resistance, control displacement). Extrinsic feedback is that which is sensed from an external source that indicates the consequences of the control action (e.g., indicator lights, display changes, aural tones).

Field: An area of the display screen reserved for the display of data or for user entry of a data item. In a database, a specified area used for a particular category of data, for example, equipment operational status.

Field Label: A displayed word or phrase that identifies the data display or entry field.

File: A collection of data which is treated as a single unit, e.g., such as that stored in the computer.

Fixed Form: Pertaining to a mode of input in which the user is presented with a set of blanks to be filled in.

Fixed Format: An unchanging description of specification of information content in a particular area.

Fixed Function Key: Key which has a function that cannot be changed by the user or system and that remain constant between applications.

Flowchart: A diagram that illustrates sequential relations among elements or events. Flowcharts are often shown as boxes connected by arrows.

Follower: The on-screen symbol (such as a cursor and arrow pointer) that responds to the movement of computer input device (such as a cursor key, mouse, trackball, and lightpen).

Form: A dialogue technique which presents category labels and requires the user to fill in the blanks. A formatted output to the user with blank spaces for insertion of required or requested information.

Format: The arrangement of data.

Formatting: The process or act of arranging data.

Frequency: Rate of signal oscillation in cycles per second (Hz or Hertz).

Function Areas: Specific screen or panel locations that are reserved for specific purposes.

Function Key: A key whose activation will effect a control entry. Detection of the signal usually causes the system to perform some predefined function for the user.

Function: A software supported capability provided to a user to aid in task performance.

Gloss: The extent to which light incident on a surface at angle x is reflected from that surface at angle - x (minus x) relative to a line perpendicular to the surface). A mirror has maximum gloss.

Gloss Instrument: A device that measures reflected light as a function of illumination and angle of view. The angle for which gloss is measured is typically 60 degrees.

Graph: A display that represents the variation of a variable in comparison with that of one or more other variables.

Graphic Element: A component part of a graphic display, such as a line, a circle, or a scale.

Graphic Interaction: A dialogue in which the user selects displayed control elements by pointing or by other direct manipulation.

Graphical Display: A display which provides a pictorial representation of an object or a set of data. Graphical displays include line, solid object, and perspective drawings; bar, pie, and line charts and graphs; scatterplots; displayed meters; flowcharts and schematic diagrams.

Graphics: Data specially formatted to show spatial, temporal, or other relations among data sets.

Graphics Tablet: (Digitizing Tablet) Device used to convert on image into digital code be drawing or tracing with a pen-like or puck-like instrument. The instrument is moved across the tablet and a series of X-Y coordinates is generated.

Grid: A network of uniformly spaced horizontal and vertical lines for locating points by means of coordinates.

Group: A set of items.

Grouping: The act or process of combining in groups.

Hardcopy: A printed copy of computer output in a visually readable form; for example, printed process displays an alarm listings.

Help: Information provided to guide the user in the operation of the system or displayed at the user's request for on-line guidance.

Hierarchical Branching: A method of structuring menu items that are hierarchically related which provides for selection among alternatives without requiring the opening and closing of a series of menus; the entire hierarchy is contained in one menu.

Hierarchy: The designated order or rank of items; a series of items which are classified by rank or order.

Highlight: A means of directing the user's attention to a feature of the display. Highlighting methods include image reversal (reverse video), brightness/boldness contrast, color, underlining, blinking, flashing arrows, and changes in font. Emphasizing displayed data or format features in some way, e.g., through the use of underlining, bolding, or inverse video.

Histogram: A type of bar chart used to depict the frequency distribution for a continuous variable. The variable may be grouped into classes.

Icon: Pictorial, pictographic, or other nonverbal representation of objects or actions.

Identification: A code number or code name which uniquely identifies a record, block, tile, or other unit of information.

Identifier: A symbol whose purpose is to identify, indicate or name a body of data.

Inactive Window: Windows perceptually and functionally available to the user (the user may be able to see and obtain information from them) but not immediately available in the sense that the user must activate an inactive window before working in it. (See also active and closed windows).

Index: To prepare an ordered reference list. An ordered reference list of the contents of a file or document, together with keys or reference notations for identification or location of those contents.

Information: Organized data that users need to successfully perform their tasks. Information can include (a) a representation of facts, concepts, or instructions in formalized manner suitable for communication, interpretation, or processing by humans or automatic means; and (b) any representations such as characters or analog quantities to which meaning is, or might be, assigned.

Initiating Transmission: The process of actually sending a command, message, or data file. Transmission can either be initiated by the computer, or by a system user.

Input: (1) Information entered into a system for processing. (2) The process of entering information. (3) Pertaining to the devices that enter information.

Input/output: (1) Pertaining to either input or output, or both. (2) A general term for the equipment used to communicate with a computer, commonly called I/O. (3) The data involved in such communication. (4) The media carrying the data for input/output.

Insert Mode: A data entry mode which allows the user to insert new information within existing information. If the cursor is placed within existing information, old characters are moved forward to allow insertion of the new characters.

Interactive Graphics: A mode of input in which the user is graphically (e.g., by plot, histogram) presented data from which he chooses. Once an input has been so selected the user may interact with the system to correct or refine the data.

Interactive Mode: A processing mode in which the user is assumed to be available to the system for inputs or decision making. The user submits one input at a time to the system and each input is processed by the system as soon as possible (as contrasted with manual and automatic modes).

Interface: A shared boundary. The point at which a user and the system interact. An interface might be a hardware component to link two devices or it might be a portion of storage or registers accessed by two or more computer programs.

Interrupt: Stopping an ongoing transaction in order to redirect the course of the processing. Examples of interrupt options are BACKUP, REVIEW, CANCEL, RESTART.

Joystick: A stick-type control device that can provide continuous cursor control in any direction on a display screen.

Justification: The act of adjusting, arranging, or shifting digits to the left, right or center, to fit a prescribed pattern.

Keystroke Command: A single or limited number of keystrokes that a define command. The keystrokes are often initiated by the simultaneous press of a key that signals a keystroke command and the first letter of a one word command. Another version of the keystroke command is the function key.

Keystroke: The act of striking a key.

Keyword: A word exemplifying the meaning or value of the data: (a) one of the significant and informative words in a title or document that describe the content of that document; (b) a symbol that identifies a parameter; or (c) A part of a command operand that consists of a specific character string.

Label: Descriptor that is distinguishable from and helps to identify displayed screen structures or components.

Large-Screen Display: A large display which can be viewed from multiple workstations and locations in a control room. It typically contains important information which should be commonly available to a control room operating crew members.

Layered Windows: Layered windows (in contrast to tiled windows) refers to the on-screen positioning of multiple windows so that windows can overlap and may obscure the contents of the covered windows

Left Justified: The left-hand digit or character (or its sign) occupies the left-hand position of the space allotted for that data.

Legend: An explanatory list of symbols or highlighting used on a graph, chart, diagram, or map.

Legibility: The quality of a display that allows groups of characters and symbols to be easily discriminable and recognized.

Lightpen: A pencil- or pen-like control device which interacts with the computer system through the display device screen either by emitting or sensing light.

Location: A position or site occupied or available for occupancy.

Macro-command: A group of a series of commands redefined as a single command.

Main Menu: A top level menu displayed upon entry into the system.

Manual Mode: A processing mode in which the user is assumed to provide all inputs (as contrasted with interactive and automatic modes).

Matte: A surface that scatters incident light nearly equally in all directions; a surface that lacks gloss.

Medium: The material, or configuration thereof, on which data are recorded, for example, paper tape, cards, magnetic tape.

Menu: A type of dialogue in which a user selects one item out of a list of displayed alternatives. Selection may be made by actions such as pointing and clicking and by depressing a adjacent function key.

Menu Bar: A specialized function area that displays categories of user response alternatives.

Menu Selection: A type of dialogue in which a user selects one item out of a list of displayed alternatives, whether the selection is by pointing, by entry of an associated option code, or by activation of an adjacent function key.

Message: Message refers to data that are transmitted from another user or from the system.

Message Area: A specialized function area for communication from another user or from the system.

Mimic: A display format combining graphics and alphanumerics used to integrate system components into functionally oriented diagrams that reflect component relationships.

Mode: A state of operation in which the system operates in specific, unique ways of has specific, unique characteristics.

Mode Editor: A text editing system in which the interpretation of the same user input varies depending whether the system is in entry mode or edit mode. Specifically, in a mode text editor the user must enter special commands in order to cause subsequent inputs to be entered either as text or as editing commands).

Modeless Editor: A text editing system in which the interpretation of the same user input does not vary; ordinary characters are entered as text, and commands are invoked using special keys.

Monitor: The physical device housing the electronics, display, and display controls for an interactive computer system (see also VDU).

Mouse: A control device whose movements across a flat surface are converted into analogous movements of the cursor across the screen.

Multitasking: The parallel performance of two or more tasks.

N-Key Rollover: A feature of a keyboard input system that stores keystrokes and generates the corresponding characters in the correct sequence despite more than one key being depressed at the same time (as in very rapid typing).

Natural Language: A type of dialogue in which users compose control entries in a restricted subset of their natural language, e.g., english.

Non-disruptive: An action that does not interfere with the ongoing activities of the system or user.

Numeric: Pertaining to numerals or to representation by means of numerals.

Objects: Distinct information whose representation can be displayed and/or manipulated as a single entity. Objects are normally represented by graphic icons and/or names.

Open Window: Windows which are both perceptually and functionally available to the user. Two types of open windows exist: active and inactive. (See also Window)

Open/closed: When a window is opened it appears on the screen. Windows may be closed (removed from the screen) and reopened.

Operand: That which is operated upon. Information entered with a request to define the data in which the processor is to operate and control the execution of the processor.

Operation: (1) A defined action, namely, the act of obtaining a result from one or more operands in accordance with a rule that completely specifies the result for any permissible combination of operands. (2) The set of such acts specified by such a rule, or the rule by itself.

Optical Reader: A device that reads hand written or machine printed symbols into a computing system.

Output: The data which are the product of an information handling operation or series of operations; the data emitted from a storage device; the data being transferred from primary storage (core, drum) to secondary storage (cards, tape); electrical pulses; reports produced by a printer or typewriter unit; a general term for output media such as cards and tape. Contrasts with "Input."

Page: (1) The data appearing at one time on a single display screen. (2) A fixed-length block of data, especially that which fits into a printed record or screen. (3) To summon a particular page or the next logical page.

Paging: A method of viewing and moving through data in which a user conceives of data as being grouped into display sized pages and moves through it by discrete steps. Also, to summon by calling out by name.

Panel: The front face of an assembly, normally used for mounting controls and displays.

Parallax: The apparent change in the relative position of objects at different distances from the observer as the observer's position changes.

Parameter: A variable that is measured.

Paste: A system function that puts the contents of the temporary editing buffer (a selection previously cut or copied) at the insertion point of the current interactive window. The buffer contents are not altered by this operation.

Peak-clipping: A technique for controlling amplitude relationships in speech by limiting the instantaneous peak-amplitudes to improve intelligibility of speech, usually followed by amplification of the signal to increase the amplitude of he clipped peaks to their original level, with proportional increase of the weaker speech sounds.

Pictographic: Pertaining to a picture-like representation of an object.

Pie Charts: A circle divided into sections (as pieces of a pie) in order to represent graphically the relative proportions of different parts of a whole. A circular chart cut by radii into segments illustrating magnitudes or frequencies.

Pop-up Menu: A menu whose items are normally "hidden" from the user's view until they are activated or brought into full view by a complete selection action. Pop-up menus remain visible until another user action takes place to hide the menu or make a selection.

Position: In a string, each location that may be occupied by a character or binary digit, and may be identified by a serial number.

Position Designation: User selection and entry of a position on a display, or of a displayed item. See also "Cursor."

Pre-emphasis: Systematic distortion of the speech spectrum to improve intelligibility of speech sound by attenuating the low-frequency components of vowels (relatively unimportant for intelligibility) and proportionately increasing the amplitude of high-frequency vowel components and consonants (highly important for intelligible speech transmission).

Precision: The degree of discrimination with which a quantity is stated. For example, a three-digit numeral discriminates among 1000 possibilities.

Preparing Messages: Includes specification of contents, format and header information.

Print Queue: An area of computer memory that temporarily stores a file to be printed so that the user can continue interacting with the system while the file prints.

Printer: A device that writes output data from a system on paper or other media.

Processing: The execution of a systematic sequence of operations.

Programmable Function Keys: User programmable keys whose function may vary between applications or between users within an application.

Prompting: The process or act of assisting by suggestion.

Prototype: A model of an interface which includes the functions and capabilities expected in the final system, though not in a finished form.

Pull-down Menu: A menu whose items are normally "hidden" from the users view and accessed by the user holding the selection button down over the desired menu bar label.

Question And Answer: A type of dialogue in which a computer displays questions, one at a time, for a user to answer.

Queue: A waiting line or list formed by items in a system waiting for service; for example, tasks to be performed or messages to be transmitted in message switching system.

Record: A group of related data fields that are operated on as a single entity in a database.

Rejection Level: The minimum level of certainty (represented by a number) required by a speech recognition system for a spoken command to be executed.

Remote: Acting on or controlling indirectly from a distance.

Request: A user input specifying the operation(s) to be performed.

Response Time: The time between the submission of an item of work to a computing system and the return of results.

Retrace: A capability that returns a user to the last previous display in a defined transaction sequence (also called "backup").

Retrieval: The act, method, or procedure for recovering stored data.

Review: A capability that returns a user to the first display in a defined transaction sequence, while retaining any entries made by the user.

Right Justified: To adjust the printing positions of characters on a page so that the right margin of the page is regular. To shift the contents of a register so that the least significant digit is at some specified position of the register.

Row: A horizontal arrangement of characters or other expressions.

Scale: A graduated series or scheme of rank or order.

Scaling: The positioning of displayed data elements with respect to a defined measurement standard.

Scatterplot: A scaled graph which shows relations among individual data points in a two dimensional array.

Screen Dump: An action, usually performed with a keystroke sequence, that causes the exact contents of the current screen display to be captured for printing or storage in a file.

Screen Structure: A generic display element such as a menu bar or title.

Screen: The software controlled, visual interface of a monitor, e.g., the display surface of a CRT.

Scroll: To move data being viewed in a line-by-line manner; to roll upward or downward.

Scrolling: An orientation for display framing in which a user conceives of data as moving behind a fixed display frame. The opposite of panning.

Selecting: A user's action of identifying display elements to the computer in order to ready them for use in some way (e.g., to open a valve by an input device click on a graphic representation of a valve).

Sequence: An arrangement of items according to a specified set of rules.

Sequence Control: Logic and means by which user actions and computer responses are linked to become coherent transactions.

Spacing: The distance between any two objects.

Specular Reflectance: The light incident on a surface at angle x that is reflected at angle - x (minus x).

Speech Display: Speech messages (either computer-generated or recorded human voice) conveyed to the operating crew through audio devices such as speakers and headsets.

Speech Recognition: Permits a user to provide spoken input which a computer interprets as data or commands.

Status Information: Information pertaining to system status which is displayed to a user either automatically or by user request.

Storage: Any device on which data can be entered, held, and retrieved. The act of storing data on such a device.

String: A linear sequence of entities such as characters or physical elements.

Stroke Width: The width of a line comprising a character.

Stylus: Pen-shaped instrument used to "draw" images or point to icons or menu selections.

Subtractive Color Process: The presentation of color images by means of selective absorption of projected light.

Symbol: A representation of something by reason of relationship, association, or convention.

Syntax: The way in which words are put together to form phrases, clauses, or sentences.

System Response Time: The elapsed time between the initiation of a command and the notification to the user that the command has been completed.

Table: A rows and columns structure consisting of functional areas which contain data which may or may not require any input. Tables may be used to present a variety of types of information. A collection of data in a form suitable for ready reference.

Task: A series of transactions that comprises part of a user's defined job. A unit of work for the system.

Task Analysis: A method of detailing the components of a task in terms of the demands placed upon the human operator, the information required by the operator, the extent to which the task requires reliance on or coordination with other personnel, and the relation of the task to other tasks.

Terminal: An input/output device used to enter and display data. Data are usually entered via a keyboard, and are usually displayed via a video screen ("soft copy") or a printer ("hard copy"). A device, usually equipped with a keyboard and some kind of display, which is capable of sending and receiving information over a communication channel.

Terminology: The technical or special terms of expressions used; nomenclature.

Text: The primary display for word processing, consists of alphanumeric character strings in linear arrays, making up words, sentences, and paragraphs. The main body of printed or written matter on a page or in a message.

Text Entry: Initial entry and subsequent editing of textual data.

Tiled Windows: Tiled windows (in contrast to layered windows) refers to the on-screen positioning of multiple windows side-by-side so that no window overlays information on another window.

Tiling: A means of manipulating windows by which multiple windows on the same display abut, but do not overlap. As the number of windows increases in the tiled window environment, the size of each window decreases.

Touch Screen: A control device that allows the user to communicate with the computer by touching a screen.

Touch Zone: An area of a display that a user can activate to perform a predefined operation (e.g., displaying a pop-up window).

Trackball: A control device with which the user can control cursor movement in any direction by rotating a ball.

Transaction: An action by a user followed by a response from the computer. Transaction is used here to represent the smallest functional unit of user-system interaction.

Turnaround Time: (1) The elapsed time between submission of a job to a computing center and the return of results. (2) In communications, the actual time required to reverse the direction of transmission from send to receive when using a half-duplex circuit.

Undo: A capability that reverses the effect of the previous operation.

Update: Regeneration of changing data to show current status, by user request or automatically by the computer.

User Response Time: The speed with which a user can enter commands and control a system regardless of the computer's ability to quickly process the commands.

Validation: (of Information) Functional capabilities that check information entry items for correct content of format as defined by software logic.

Value: Specified data for a particular parameter or variable.

Variable: A quantity that can assume any of the given set of values.

Variable Function Key: A dedicated key which invokes functions of the system; the specific function invoked varies depending, e.g., on the mode of operation selected by the user.

VDU: Video Display Unit.

Visual Angle: A measure in degrees of the size of the retinal image subtended by a viewed object. It represents the apparent size of an object based on the relationship between an object's distance from the viewer and its size (perpendicular to the viewer's line of sight). An object of constant size will subtend a smaller visual angle as it is moved farther from the viewer. Visual angle is typically defined in terns of minutes of visual arc.

Warning Signal: A signal which alerts the operator to a condition requiring immediate action (see Caution Signal).

Window: A geometric area on a computer screen within which the system displays information or receives input from the user.

Window Overlay: A portion of a display that is temporarily used to show added features such as requested data, menus, or user guidance, which may obscure previously-displayed data.

Word: A character string or a bit string considered as an entity.

Word Wrap: Occurs when words displaced from one line are moved to the next line so as to maintain the continuity of the text.

Workstation: The physical console at which a user works.

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NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)

NUREG/CR-5908
BNL-NUREG-52333
Volume 2

2. TITLE AND SUBTITLE

Advanced Human-System Interface Design Review Guideline
Evaluation Procedures and Guidelines for Human Factors Engineering Reviews

3. DATE REPORT PUBLISHED

MONTH: July
YEAR: 1994

4. FIN OR GRANT NUMBER

L1317

5. AUTHOR(S)

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6. TYPE OF REPORT

Technical

7. PERIOD COVERED (Inclusive Dates)

8. PERFORMING ORGANIZATION – NAME AND ADDRESS (If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)

Brookhaven National Laboratory
Upton, NY 11973-5000

Carlow International Incorporated
Falls Church, VA 22042

9. SPONSORING ORGANIZATION – NAME AND ADDRESS (If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)

Division of Systems Research
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

Advanced control rooms will use advanced human-system interface (HSI) technologies that may have significant implications for plant safety in that they will affect the operator's overall role in the system, the method of information presentation, and the ways in which operators interact with the system. The U.S. Nuclear Regulatory Commission (NRC) reviews the HSI aspects of control rooms to ensure that they are designed to good human factors engineering principles and that operator performance and reliability are appropriately supported to protect public health and safety. The principal guidance available to the NRC, however, was developed more than ten years ago, well before these technological changes. Accordingly, the human factors guidance needs to be updated to serve as the basis for NRC review of these advanced designs. The purpose of this project was to develop a general approach to advanced HSI review and the human factors guidelines to support NRC safety reviews of advanced systems. This two-volume report provides the results of the project. Volume 1 describes the development of the Advanced HSI Design Review Guideline (DRG) including (1) its theoretical and technical foundation, (2) a general model for the review of advanced HSIs, (3) guideline development in both hard-copy and computer-based versions, and (4) the tests and evaluations performed to develop and validate the DRG. Volume 1 also includes a discussion of the gaps in available guidance and a methodology for addressing them. Volume 2 provides the guideline to be used for advanced HSI review and the procedures for their use.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)

Control rooms - man-machine systems; control rooms - human factors engineering; control rooms - design, nuclear power plants; control rooms, reactor operators - performance, reactor operators - reliability, interfaces, evaluation, reactor safety, functional models, testing, reviews

13. AVAILABILITY STATEMENT

Unlimited

14. SECURITY CLASSIFICATION

(This Page) Unclassified
(This Report) Unclassified

15. NUMBER OF PAGES

16. PRICE

Federal Recycling Program

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001