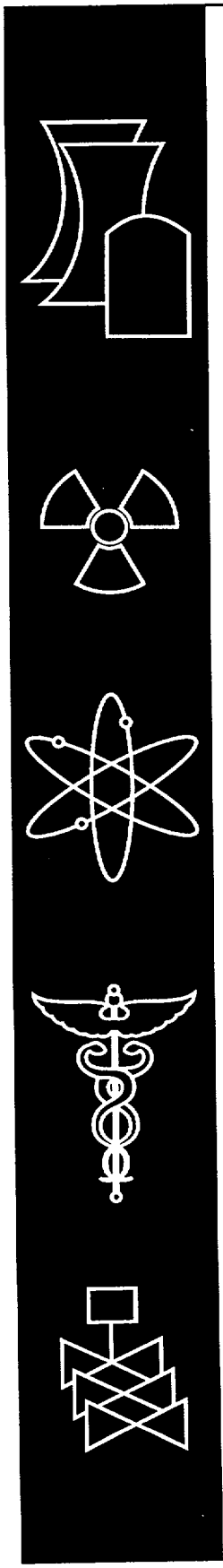
NUREG-0700
Rev. 2



# Human-System Interface Design Review Guidelines

U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Washington, DC 20555-0001

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# Human-System Interface Design Review Guidelines

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## ABSTRACT

The U.S. Nuclear Regulatory Commission (NRC) staff reviews the human factors engineering (HFE) aspects of nuclear power plants in accordance with the *Standard Review Plan* (NUREG-0800). Detailed design review procedures are provided in the *HFE Program Review Model* (NUREG-0711). As part of the review process, the interfaces between plant personnel and plant's systems and components are evaluated for conformance with HFE guidelines. This document, *Human-System Interface Design Review Guidelines* (NUREG-0700, Revision 2), provides the guidelines necessary to perform this evaluation. The review guidelines address the physical and functional characteristics of human-system interfaces (HSIs). Since these guidelines only address the HFE aspects of design and not other related considerations, such as instrumentation and control and structural design, they are referred to as HFE guidelines. In addition to the review of actual HSIs, the NRC staff can use the NUREG-0700 guidelines to evaluate a design-specific HFE guidelines document or style guide. The HFE guidelines are organized into four basic parts, which are divided into sections. Part I contains guidelines for the basic HSI elements: displays, user-interface interaction and management, and controls. These elements are used as building blocks to develop HSI systems to serve specific functions. Part II contains the guidelines for reviewing six such systems: alarm system, group-view display system, soft control system, computer-based procedure system, computerized operator support system, and communication system. Part III provides guidelines for the review of workstations and workplaces. Part IV provides guidelines for the review of HSI support, i.e., maintainability of digital systems.

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# PREFACE

## INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) staff reviews the human factors engineering (HFE) aspects of nuclear power plants in accordance with the *Standard Review Plan* (NUREG-0800). Detailed design review procedures are provided in the *HFE Program Review Model* (NUREG-0711). As part of the review process, the plant's human-system interfaces (HSIs) are evaluated.

The HSIs are the parts of a nuclear power plant with which personnel interact in performing their functions and tasks. Major HSIs include alarms, information displays, and controls. These are other types of HSIs are described in the next section. Each type of HSI is made up of hardware and software components and is characterized in terms of its important physical and functional characteristics. The review guidelines contained in this document address these physical and functional characteristics of HSIs. Since these guidelines only address the HFE aspects of design and not other related considerations, such as instrumentation and control and structural design, they are referred to as HFE guidelines.

Personnel use of HSIs is influenced directly by (1) the organization of HSIs into workstations (e.g., consoles and panels); (2) the arrangement of workstations and supporting equipment into facilities such as a main control room, remote shutdown station, local control station, technical support center, and emergency operations facility; and (3) the environmental conditions in which the HSIs are used, including temperature, humidity, ventilation, illumination, and noise. HFE guidelines are provided in this document for the review of these design considerations as well.

As per the review procedures described in NUREG-0711, the guidelines contained in this document can be used to review the design of HSIs and review a design-specific HFE guidelines document or style guide.

## DESCRIPTION OF THE HFE GUIDELINES

The HFE guidelines are organized into four basic parts, which are divided into sections. Part I contains guidelines for the basic HSI elements: information display, user-interface interaction and management, and controls. These elements are used as building blocks to develop HSI systems to serve specific functions. The guidelines address the following aspects of these HSI elements:

- Information Display – This section provides HFE guidelines for the review of visual displays. Following a section of general guidelines, guidelines are 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, and coding), data quality and update rate, and display devices (such as video display terminals and large board displays).
- User-Interface Interaction and Management – This section provides HFE guidelines for the review of the modes of interaction between plant personnel and the HSI. Topics include dialogue formats (such as menus, direct manipulation, and command language), navigation, display controls, entering information, system messages, and prompts. This section also contains guidelines concerning methods for ensuring the integrity of data accessed through the user interface. Guidelines cover prevention of inadvertent change or deletion of data, minimization of data loss due to computer failure, and protection of data, such as setpoints, from unauthorized access.
- Controls – This section provides HFE guidelines for the review of information entry, dialogue types, display control, information manipulation, and system response time. Review guidelines are also

provided for conventional control devices such as pushbuttons and various types of rotary controls. Considerations of display-control integration are also included here.

Part II contains the guidelines for reviewing seven systems: alarm system, safety function and parameter monitoring system, group-view display system, soft control system, computer-based procedure system, computerized operator support system, and communication system. The guidelines include the functional aspects of the system, as well as any unique considerations for display, user-system interaction, and control that may be needed to review the system. The guidelines address the following aspects of these HSI systems:

- Alarm System – This section provides HFE guidelines for the review of alarm system design implementation. The guidelines address the selection of alarm conditions, choice of setpoints, alarm processing, alarm availability (such as filtering and suppression of alarms), unique aspects of the display of alarm information (such as organization, coding, and alarm message content), and alarm controls.
- Safety Function and Parameter Monitoring System – This section provides HFE guidelines for the review of displays of critical safety functions and safety parameters.
- Group-View Display System – This section provides HFE guidelines for the review of group-view displays, including their functional characteristics and user-system interaction aspects, as well as their physical characteristics.
- Soft Control System – This section provides HFE guidelines for the review of the information display and user-system interaction aspects of soft control systems.
- Computer-Based Procedure System – This section provides HFE guidelines for the review of computer-based procedure systems, including the representation of information, the functional capabilities, users' interaction with the systems, backup provisions, and the integration of such system with other HSI elements.
- Computerized Operator Support System – This section provides HFE guidelines for the review of the aids provided to personnel for situation analysis and decision making. Guidelines are provided that address functional requirements such as explanation and simulation facilities, and the desirable characteristics of their user interfaces.
- Communication System – This section provides HFE guidelines for the review of speech and computer-mediated communication between plant personnel, e.g., preparing, addressing, transmitting, and receiving messages.

Part III provides guidelines for the review of workstations and workplaces. Workstations, including consoles and panels, are locations where HSIs are integrated together to provide an area where plant personnel can perform their tasks. Workstations are located at workplaces, such as the main control room and remote shutdown facilities. The guidelines address the following:

- Workstation Design – This section provides HFE guidelines for the review of the design of workstation features such as control-display integration and layout, labeling, and ergonomics, e.g., vision and reach.
- Workplace Design – This section provides HFE guidelines for the review of general workplace considerations. Guidelines are provided both for the control room and for operator interface areas out in the plant. The guidelines address design features such as the overall layout of the workstations and other equipment such as group-view displays within the workplace, provision of support equipment

such as ladders or tools, and environmental characteristics including temperature, ventilation, illumination, and noise

Part IV provides guidelines for the review of HSI support, i.e., maintaining digital systems. The guidelines address the following:

- Maintainability of Digital Systems – This section provides HFE guidelines for the review of the maintainability aspects of digital systems.

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

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

**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, or 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, alarms, display control options, instructions, error messages, and menus. Display formats should be consistent with accepted usage and existing user habits.[5908,0700]

Each guideline is composed of the following parts:

*Guideline Number* – Within sections/subsections, individual guidelines are numbered consecutively from 1 to n. Each guideline has a unique number that indicates its section/subsection location, followed by a dash and then its serial 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 unique, descriptive title.

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

*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 assist the reviewer in the interpretation or application of the guideline.

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

## SUPPORTING APPENDICES

This document contains two appendices that provide additional guidelines.

Appendix A provides High-Level Human-System Interface Design Review Principles. These principles represent generic HSI characteristics necessary to support personnel performance. While these principles are not detailed review *guidelines*, they serve several purposes. First, they were used to develop many of the detailed review guidelines in this document (see source documents). Second, as general principles, they can be used to support the evaluation of aspects of the HSI not well defined by the detailed guidelines. Thus, for example, they can be used in reviewing novel HSI designs, such as display formats not identified in the guidelines. Third, they can support the evaluation of the significance of individual discrepancies in the guideline.

Appendix B contains some additional guidelines for selected HSI topics that address important considerations in the design of those topics. The purpose of these guidelines is explained below.

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

## DESIGN REVIEW SOFTWARE

In addition to a hard-copy document, the guidelines are also available in a computer-based design review application, referred to as the Interactive Design Evaluation Aid. The application simplifies many design review and document maintenance tasks, such as guideline access, HSI review, editing, compilation of individual guidelines for a specific review, and incorporation of new guidelines.

## Guideline Source Documents


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6690 O'Hara, J., Brown, W., and Stubler, W. (2002). *Human-System Interface Management: Human Factors Review Guidance* (NUREG/CR-6690). Washington, D.C.: U.S. Nuclear Regulatory Commission.

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5680 Echeverria, D et al. (1994). *The Impact of Environmental Conditions on Human Performance* (NUREG/CR-5680). Washington, D.C.: U.S. Nuclear Regulatory Commission

1472 U.S. Department of Defense (2000). *Human Engineering Design Criteria for Military Systems, Equipment and Facilities* (MIL-STD 1472F). Washington, D.C.: U.S. Department of Defense.

3659 Kinkade, R.G. and Anderson, J. (1984). *Human Factors Guide for Nuclear Power Plant Control Room Development* (EPRI NP-3659). Electric Power Research Institute, Palo Alto, CA.

## ACRONYMS

| | |
|---|---|
| ACR | advanced control room |
| ANSI | American National Standards Institute |
| ARP | alarm response procedure |
| ATE | automated test equipment |
| CBP | computer-based procedure |
| CIE | Commission Internationale de l'Eclairage |
| COL | combined operating license |
| COSS | computerized operator support system |
| CR | control room |
| CRT | cathode ray tube |
| DCRDR | detailed control room design review |
| DRG | Design Review Guideline |
| EMI | electromagnetic interference |
| EOF | emergency operations facility |
| EOP | emergency operating procedure |
| EPRI | Electric Power Research Institute |
| FCC | Federal Communications Commission |
| HED | human engineering discrepancy |
| HFE | human factors engineering |
| HFE PRM | Human Factors Engineering Program Review Model |
| HRA | human reliability analysis |
| HSI | human-system interface |
| I&C | instrumentation and control |
| KBS | knowledge-based system |
| LCS | local control station |
| LED | light-emitting diode |
| LOS | line of sight |
| MCR | main control room |
| MFTA | modulation transfer function area |
| MPCD | minimum perceptible color difference |
| MUX | multiplexer |
| NPP | nuclear power plant |
| NRC | U.S. Nuclear Regulatory Commission |
| P&ID | piping and instrumentation diagram |
| PBP | paper-based procedure |
| PRA | probabilistic risk assessment |
| RF | radio frequency |
| SAR | safety analysis report |
| SDCV | spatially-dedicated, continuously visible display |
| SGTR | steam generator tube rupture |
| SPDS | safety parameter display system |
| TMI | Three Mile Island |
| TSC | technical support center |
| UCS | uniform color space |
| UHF | ultra high frequency |
| URD | utility requirements document |
| V&V | verification and validation |
| VDU | video display unit |
| WBGT | wet-bulb globe temperature |

# Part I
# Basic HSI Elements

# SECTION 1: INFORMATION DISPLAY

# 1 INFORMATION DISPLAY

Information is at the center of human performance in complex systems. This section addresses the way in which information is presented by a display system.

Information displays are built around information requirements; i.e., the information operators need to monitor and control the plant. The determination of what information is needed is referred to as information requirements analysis.

While requirements identify what information is needed by the user, the way in which that information is presented is called information representation, and is composed of the following considerations: Formats, elements, page, networks, data quality and update rates, and display devices (see Figure 1.A). Display formats are the types of information presentations that designers select to convey information to operators. Examples are trend displays and piping and instrumentation displays. Formats are made up of display elements, such as alphanumeric characters, icons, arrows, and axes. An important consideration when using information is its quality (how valid the information is) and update rate (how current the information is). Designers will frequently group several formats together to form display pages, i.e., the information contained on one display screen. NPPs may have hundreds or thousands of such pages within the plant information network and operators choose the pages they want to view on the available display devices, such as CRTs. CRs also contain devices that are dedicated to display specific parameters, such as meters. Each of these specific aspects of information display is described below. General guidance for reviewing information displays is given in Section 1.1.

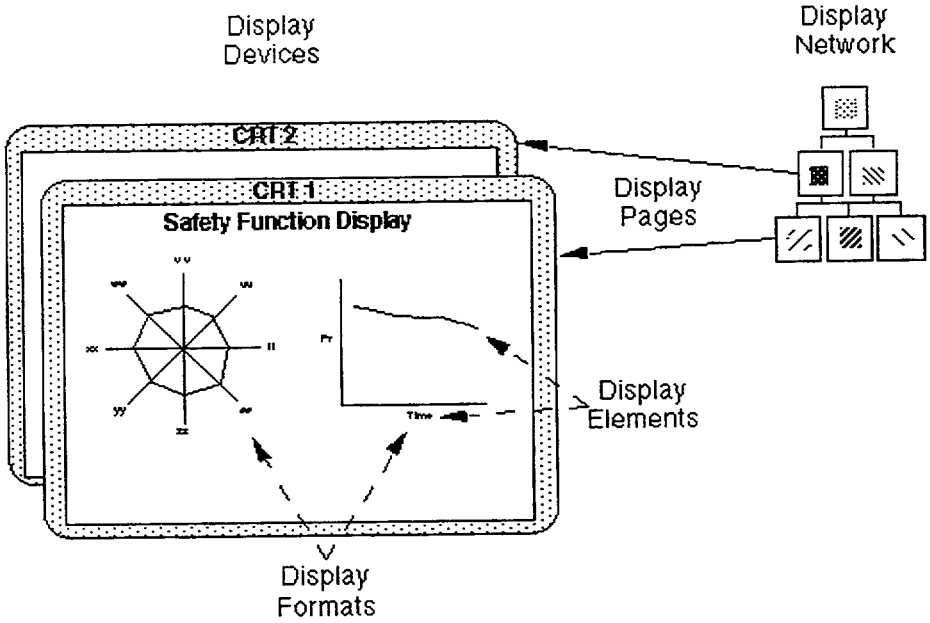


**Figure 1.A Information display characterization (not shown is data quality and update rates)**

## DISPLAY FORMATS

Display format refers to methods of information presentation consisting of an organized arrangement of smaller display elements. They are the most significant "unit of analysis" of the information system because the selection of format greatly influences the ability of operators to easily and correctly

understand the information presented. Display formats range in complexity from simple, such as data fields and tables, to more complicated forms, such as configural and mimic displays. The ability of computer graphics to portray an essentially limitless set of novel graphic forms has offered great possibilities to provide operators with enhanced representations of the plant. The formats addressed in the design review guidelines are:

**Continuous text displays**

This format consists of alphanumeric character strings (e.g., words and numbers) arranged in uninterrupted linear arrays, such as sentences and paragraphs. Examples include a text-based description of a plant system and an instructional step in a computer-based procedure display. Review guidelines are presented in Section 1.2.1.

**Tables and lists**

A table is a display containing alphanumeric characters arranged by rows and columns. A list is a display containing alphanumeric strings arranged in a single column by rows. Review guidelines are presented in Section 1.2.2.

**Data forms and fields**

A data field is a space in a display containing information (e.g., the current value of a variable). Some data fields may accept input entered by the user. A data form is a display containing one or more data fields. Review guidelines are presented in Section 1.2.3.

**Bar charts and histograms**

A bar chart is graphic figure in which numeric quantities are represented by the linear extent of parallel lines (or bars), either horizontally or vertically. A histogram is a type of bar chart used to depict the frequency distribution for a continuous variable. The variable may be grouped into classes. Review guidelines are presented in Section 1.2.4.

**Graphs**

A graph is a display that represents the variation of a variable in comparison with that of one or more other variables. For example, pressure may be plotted as a function of temperature. Review guidelines are presented in Section 1.2.5. Certain types of graphs (see Integral and Configural Displays, below) use emergent features to portray higher-level information; review guidelines for such displays are given in Section 1.2.10.

**Pie charts**

A pie chart is a circular chart divided into sections (as pieces of a pie) to represent graphically the relative proportions of different parts of a whole. The segments may represent magnitudes or frequencies. Review guidelines are presented in Section 1.2.6.

**Flowcharts**

A flowchart is a diagram that illustrates sequential relations among elements or events. Flowcharts are often shown as boxes connected by arrows. Review guidelines are presented in Section 1.2.7.

**Mimics and diagrams**

A mimic is a display format combining graphics and alphanumerics used to integrate system components into functionally oriented diagrams that reflect component relationships. For example, a mimic display may be used to provide a schematic representation of a system. A diagram is a special form of a picture in which details are only shown if they are necessary for a task. For example, an electrical wiring diagram

for a facility would show wiring but not necessarily furniture or plumbing. Review guidelines are presented in Section 1.2.8.

### Maps

A map is a graphical representation of an area or a space, such as the layout of a room or a facility. Review guidelines are presented in Section 1.2.9.

### Integral and Configural Displays

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

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

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

Review guidelines for both of these display types is provided in Section 1.2.10.

### Graphic instrument panels

These are formats in which graphical objects are arranged to resemble instruments in a control panel. For example, an individual indicator may appear as a circular meter containing a numerical scale and an indicating needle. Review guidelines are presented in Section 1.2.11.

### Speech displays

These are displays that provide information in the form of human speech (either computer-generated or a recorded human voice). Messages are conveyed to the user through audio devices, such as speakers and headsets. Review guidelines are presented in Section 1.2.12.

## DISPLAY ELEMENTS

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

### Alphanumeric characters

These are symbols consisting of letters, digits, and usually other symbols, such as punctuation marks. Review guidelines are presented in Section 1.3.1.

### Abbreviations and acronyms

An abbreviation is a shortened form of a word or phrase used for brevity (e.g., the word "pressure" might be abbreviated as "press"). An acronym is a word formed from the initial letter(s) of each of the successive or major parts of a compound term. For example, the acronym SART is sometimes used to represent the alarm system control operations: silence, acknowledge, reset, and test. Review guidelines are presented in Section 1.3.2.

### Labels

A label in a descriptor containing one or more character strings that is intended to support users in identifying structures or components. Review guidelines are presented in Section 1.3.3.

### Icons and symbols

An icon is a pictorial, pictographic, or other nonverbal representation of objects or actions. A symbol is a representation of something by reason of relationship, association, or convention. Symbols used in information displays may be alphanumerical characters or abstract shapes. Review guidelines are presented in Section 1.3.4.

### Numeric data

These are data represented in numerical form (as opposed to text form). Examples include numerical representations of plant variables or control setpoints. Review guidelines are presented in Section 1.3.5.

### Scales, axes, and grids

Scales, axes, and grids are used to graphically represent data. Axes are the graphical representation of orthogonal dimensions in the form of lines (e.g., the horizontal and vertical axes of a plot may be the X and Y dimensions, respectively). A scale is a graduated series of demarcations indicating the divisions of an axis. A grid is a network of uniformly spaced horizontal and vertical lines for locating points by means of coordinates. Review guidelines are presented in Section 1.3.6.

### Borders, lines, and arrows

Borders, lines, and arrows are basic elements used to present information graphically. Lines are used to connect objects or to provide a demarcation between objects. A border is a set of demarcation lines that frame an object or group of objects. Arrows are lines that indicate direction. Review guidelines are presented in Section 1.3.7.

### Color

Color is an aspect of objects or light sources that may be described in terms of hue, lightness (or brightness), and saturation. Coding based on the use of color is an important means for representing information in displays. Review guidelines are presented in Section 1.3.8.

### Size, shape, and pattern coding

These are three methods for coding information in graphical displays. Size coding allows objects to be compared and contrasted based on relative size. Shape coding allows objects to be compared and contrasted based on similarities and differences in their outlines (shape). Pattern coding supports comparisons and contrasts of objects based on similarities in such characteristics as size, color, position, and orientation. Review guidelines are presented in Section 1.3.9.

### Highlighting by brightness and flashing

Highlighting is a means of directing the user's attention to a feature of the display. Highlighting that is based on brightness attempts to increase an object's salience by making it appear brighter than other

objects. Flashing increases salience by increasing and decreasing in alteration the brightness of an object or its background. Review guidelines are presented in Section 1.3.10.

### Auditory coding

This is a type of information coding that conveys meaning through the use of sounds, such as auditory tones. Review guidelines are presented in Section 1.3.11.

## DATA QUALITY AND UPDATE RATE

The ability of personnel to use information depends to a great degree upon the quality of the data presented, including the frequency with which it is updated. Data quality considerations include the ways in which data from plant sensors are processed and checked for accuracy (e.g., analytical redundancy and data verification). It also includes the ways in which data quality (i.e., accuracy) is communicated to the user. Data update rate refers to the frequency with which data sensors are sampled and the contents of a display are refreshed. Review guidelines are presented in Section 1.4.

## DISPLAY PAGES

Display pages are defined sets of information intended to be presented as a single unit. Typical NPP display pages may combine several different formats on a single video display unit (VDU) screen, such as combining bar charts and digital displays within a representation of a piping and instrumentation diagram. The content of a display page, i.e., the integration of formats that make up the page, is usually intended to provide an organized view of some aspect of the process. For example, a page may provide a high-level status overview of the primary system. Display pages typically have a label and designation within the computer system so they can be accessed by operators as a single "display." Review guidelines are presented in Section 1.5.

## DISPLAY DEVICES

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

### Video display units

A video display unit (VDU) is an electronic device for the display of visual information in the form of text and/or graphics. Examples include CRTs and flat panel displays (e.g., light-emitting diode panels, plasma panels, thin film electroluminescent panels, electrochromics, electrophoretic panels, and liquid crystal panels). Review guidelines are presented in Section 1.6.1.

### Large-screen displays

A large-screen display is a device, which due to its large size, can be simultaneously viewed from multiple workstations and locations in a control room. Review guidelines are presented in Section 1.6.2.

### Printers, recorders, and plotters

These are devices that present information in a hardcopy (e.g., paper or other media) form. A printer is a device that writes output data from a system. Recorders and plotters are used to write trend data in graphical form. Review guidelines are presented in Section 1.6.3.

### Meters

A meter is an indicator that typically features a numerical scale and a needle. Two types of meters are fixed-scale (i.e., the needle moves across the scale) and moving-scale (i.e., the scale moves behind the needle). Review guidelines are presented in Section 1.6.4.

### Light indicators

These are display devices containing lamps that indicate status or states through the presence or absence of illumination. For example, an illuminated light indicator may be used to show that a breaker is closed. Review guidelines are presented in Section 1.6.5.

### Numeric readouts

A numeric readout is a display device that presents data as a string of numerals (digits). Review guidelines are presented in Section 1.6.6.

## DISPLAY NETWORKS

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

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

### Hierarchical Structure

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

### Relational Structure

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

### Sequential Structure

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

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

HFE review guidelines are not currently available for display network design.

In the course of developing the guidance for information systems, several considerations were identified that are important to crew performance and safety, but for which the technical basis was insufficient to develop specific HFE guidelines. These aspects of information system design should be addressed on a case-by-case basis using the design process considerations presented in Appendix B1.

# 1 INFORMATION DISPLAY
## 1.1 General Display Guidelines

### 1.1-1 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 (see Table 1.1).

*Additional Information:* Table 1.1 provides some formats and conditions for their appropriate use in the context of five representative user tasks. Display formats should be task dependent. While the table identifies several classical display formats, novel formats can be acceptable if their support for the users' tasks can be demonstrated. Since tasks can vary, advanced HSIs should provide the user with the flexibility to display information in alternative formats that reflect changes in task requirements.[5908, 0700]

**Table 1.1 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 coordinate system |

# 1 INFORMATION DISPLAY
## 1.1 General Display Guidelines

### 1.1-2 Display Conventions
Consistent interface design conventions should be evident for all display features (such as labels).
*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.[5908]

### 1.1-3 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, and other information should incorporate the task-oriented terminology of the users, and avoid unfamiliar terms used by designers and programmers.[5908]

### 1.1-4 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.[5908]

### 1.1-5 Correspondence Mapping
There should be an explicit mapping between the characteristics and functions of the system to be represented and the features of the display representation, i.e., changes in the appearance of the display form should have a one-to-one relation with the plant states it represents. These changes should result from explicit rules relating the physical form of the display and its meaning to the plant state represented.
*Additional Information:* Correspondence mapping addresses how well the display communicates meaningful information about the plant to operators. The physical form and functions of the display should be explicitly tied to the plant's functions and states. The display form and function must consider the instrumentation and the data processing that drive the display format. If a single display can lead to more than one interpretation, it is ambiguous and can be easily misunderstood. Changes in the graphic display should be unambiguously related to the plant's state. The same graphic change should not be associated with more than one interpretation.[6633]

### 1.1-6 Levels of Abstraction
Displays should provide information at the levels of abstraction necessary to meet the operators' requirements relative to their task goals.
*Additional Information:* Information should be presented in accord with the operator's goals and the information needed to address them.[6633]

### 1.1-7 Coherence Mapping
The characteristics and features of the display used to represent the process should be readily perceived and interpreted by the operator.
*Additional Information:* Coherence mapping addresses how comprehensible the representation is to the operator. Unambiguous relationships between the display and the process are of little value if they also are not readily perceived by the operators and easily understood.[6633]

### 1.1-8 Understandability of Higher-Level Information
The methods by which lower-level data are analyzed to produce higher-level information and graphical elements should be understandable to users.

*Additional Information:* Users must be able to judge the acceptability of higher-level information and how it relates to lower-level information.[6633]

### 1.1-9 User Verification of Higher-Level Information

Operators should have access to the rules or computations that link process parameters and graphical features, and to an explanation of how the information system produces higher-level information.
*Additional Information:* When graphical features change in ways not completely understood by operators, they should be able to access the rules that produce the graphic forms. Operators should be able to review any analysis performed by the information system.[6633]

### 1.1-10 Alert to Higher Level Displays

While viewing secondary (lower-level) displays, a perceptual (audible or visual) cue should be provided by the system to alert the user to return to the primary (higher-level) display if significant information in that display requires user attention.[0800]

### 1.1-11 Display of Goal Status

The information system should provide for global situation awareness (i.e., an overview of the status of all the operator's goals at all times) as well as supplying details about the current specific goal.
*Additional Information:* Situation assessment can suffer when operators focus on some information and fail to attend to other important data.[6633]

### 1.1-12 Display of Information to Support Planning

The HSI should present information to support users in planning for and coordinating concurrent tasks.
*Additional Information:* Providing information that gives advanced notification of plant conditions or the need for action can help users prioritize and plan tasks. It can also reduce the mental workload and improve the utilization of cognitive resources for primary tasks. Examples of HSI features that can provide advanced warnings and indications include: checklists and computer-based aids that allow the user to look ahead at future activities (e.g., computer-based procedures that show upcoming steps); trend and predictor displays; and alarms and displays that provide early warnings of developing conditions. This information should be presented in ways that reduce distraction, since distracting stimuli can impose high demands on attention resources.[6690]

### 1.1-13 Display of Future Status

The information system should support the user's ability to project future states of the system when this is required to safely operate the plant.
*Additional Information:* Situation assessment involves not only understanding the current state of the plant, but also projecting its future state. Displays such as trend graphs can support these projections.[6633]

### 1.1-14 Status at a Glance

Information display systems should allow users to immediately assess overall plant status and detect conditions that require attention without performing interface management tasks.

*Additional Information:* The presentation area of computer-based display devices allows only a limited amount of information to be presented at one time. If personnel are unable to view information without deliberately performing interface management tasks, they may be less willing to search for particular information. They also may be less likely to encounter the information casually, as one might when scanning a conventional control panel. This effect can interfere with awareness of developing plant conditions that have not yet exceeded the threshold of the alarm system. Without this awareness, the user may not form the intention to monitor these conditions. Salient indications of anomalies are particularly important for highly reliable automated systems, which users may fail to investigate due to their low failure rate.[6690]

### 1.1-15 Actual System/Equipment Status

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

*Additional Information:* Demand information shows that equipment has been commanded (by control settings or otherwise) to a particular state or level. It shows only what is demanded, not what is actually being realized. Status information shows the state or level actually in effect. To prevent operator confusion, it is essential that displays be identified as to whether they reflect demand or actual status.[0700]

### 1.1-16 Display of Parameters and Variables Important to Safety

Plant parameters and variables important to safety should be displayed in a way that is convenient and readily accessible.[0800]

### 1.1-17 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.[5908]

### 1.1-18 Critical Value Reference Index

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

*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.[5908, 0800]

### 1.1-19 Limit Marks for Critical Variables

Limit marks should be used to indicate operational limits for critical plants parameters.

*Additional Information:* Limit marks are demarcations of established limits of operation, such as those for technical specifications, process limits, and safety system actuation setpoints.[0800]

### 1.1-20 Choice of Status Setpoints

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

*Additional Information:* Status setpoints are criterion values used to indicate a change in a status of a variable, such as to indicate the approach to an unsafe operating condition. Status setpoints should be chosen specifically for their suitability for that function. Poorly chosen setpoints can result in frequent false indications or the failure to recognize a serious condition.[0800]

### 1.1-21 Analytical Redundancy

Analytical redundancy should be considered to help ensure the appropriateness of displayed values.
*Additional Information:* Analytical redundancy is the calculation of expected parameter values using a model of system performance. The expected value is then represented in the display, along with the actual value. Deviations between the two indicate some disturbance or abnormality of the system.[6633]

### 1.1-22 Indication of Proper Display Operation

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 can be used to indicate whether a computer display is functioning. A built-in testing feature that is activated either automatically or by the user may be used to assess operability of the display system.[0800, 0700]

### 1.1-23 Indication of Display Failure

Information system failures (due to sensors, instruments, and components) should result in distinct display changes, which directly indicate that depicted plant conditions are invalid.
*Additional Information:* The information system should be designed so that failures in instrumentation are readily recognized by operators. When panel instruments, such as meters, fail or become inoperative, the failure should be apparent to the user (e.g., through off-scale indication). This may be more difficult to determine in complex graphics, and thus, should be carefully evaluated.[6633]

### 1.1-24 Annotating Displays 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.[5908]

### 1.1-25 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 (i.e., a 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.[5908]

### 1.1-26 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 user in an attention-grabbing mode, such as with a flashing message.[5908]

### 1.1-27 Navigational Links to Related Information

Navigational links to and from high-level and lower-levels of information and to reference and supporting information should be provided when needed for operators' tasks.[6633]

# 1 INFORMATION DISPLAY
## 1.1 General Display Guidelines

### 1.1-28 Grouping of Related Information
Related information should be organized into groups.
*Additional Information:* Information needed by the operator to accomplish a task should be grouped and perceptually related, when possible. To minimize the disadvantages of divided attention, the number of attention shifts should be minimized, both within a display page and between them.[6690, 6633]

### 1.1-29 Spatial Proximity for Related Information
Information that must be compared or mentally integrated should be presented in the close spatial proximity.
*Additional Information:* If possible, the information items should be contained in the same display page and grouped together. Spatial proximity may also be achieved by presenting the display pages in adjacent display windows or on adjacent display devices that can be viewed together.[6690]

### 1.1-30 Chromatic Proximity for Related Information
If information must be mentally integrated, similar color codes should be used for the information items.
*Additional Information:* Information items may be easier to identify if a similar color coding scheme has been applied to them. This may be particularly important if the information items are spatially separated.[6690]

### 1.1-31 Similar Physical Dimensions for Related Information
Information that must be compared or mentally integrated should use similar physical dimensions to convey meaning.
*Additional Information:* Physical dimensions are physical characteristics that are varied to convey information, such as indicating the magnitude of a variable via the length of a line versus the volume of a shape. When the same type of physical dimension is used to convey meaning then less mental workload is needed to interpret and integrate the information.[6690]

### 1.1-32 Similar Presentation Formats for Related Information
Information that must be compared or mentally integrated should be presented using similar presentation formats (e.g., analog versus digital).
*Additional Information:* Presentation format refers to analog versus digital form. Information items may be easier to identify and mentally integrate if they are presented in the same format, such as when both are in an analog form or both are presented as digital values. When information is presented in different formats (i.e., different perceptual coding is used) additional mental workload is required to translate and integrate the information.[6690]

### 1.1-33 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.[5908, 0700]

### 1.1-34 Indication of Transformations Needed
Scale multiplication factors (i.e., powers of 10), if used, should be clearly indicated on the display.[0700]

### 1.1-35 Annotating Graphic Displays 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.[5908]

**1.1-36 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.[5908]

**1.1-37 Sensitivity**
Display dynamic sensitivity should be selected to minimize the display of normal random variations in equipment performance.[0700]

**1.1-38 Numeral and Letter Styles**
Numeral and letter styles should be simple and consistent.
*Additional Information:* See Section 1.3.1, Alphanumeric Characters, for more guidelines regarding lettering style.[0700]

**1.1-39 Display Flexibility**
Users should be able to control the amount, format, and complexity of displayed data to meet task requirements.[5908]

**1.1-40 Range of Conditions Displayed**
The display system should correctly display information about the plant's safety status including severe accident symptoms.[0800]

**1.1-41 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 that is relatively uniform in appearance except for just a few highlighted items. For some purposes, location coding (i.e., displaying important items consistently in a particular location) might be a sufficient means of highlighting, as when an error message appears in a space otherwise left blank. However, auxiliary codes may still be needed to highlight important items, even if they are positioned consistently. For example, line coding by color or bolding might be used to highlight displayed paths, and/or the boxes or other graphic elements representing displayed states. (Color coding may be particularly appropriate in flowcharts, because of the effective primacy of color for guiding the visual scanning required to trace paths.)[5908]

**1.1-42 Salience Levels**
The salience of graphic features should reflect the importance of the information.
*Additional Information:* The most salient features of a graphic display should be those aspects of the representation that are most important. Less important information should not be more perceptually salient than more important information.[6633]

### 1.1-43 Readability of Coded Information
Coding should not interfere with the readability of displayed information.[5908]

### 1.1-44 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.[5908]

### 1.1-45 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.[5908]

### 1.1-46 Coding Display Items Requiring Rapid Discrimination
Coding should be provided when a user must distinguish rapidly among different categories of displayed data.
*Additional Information:* Graphic coding methods (e.g., symbols, boxes, underlines, use of color as a background to grouped items) can greatly aid users' utilization of information.[5908, 0700]

### 1.1-47 Meaningful Codes
Meaningful or familiar codes should be used, rather than arbitrary codes.[5908]

### 1.1-48 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.[5908, 0700]

### 1.1-49 Coding and Transmission Time
Coding should not increase transmission time.[5908]

### 1.1-50 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, and coding techniques. A legend on the display may be provided for display conventions.[5908]

### 1.1-51 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.[0800]

### 1.1-52 Hardcopy of VDU Displays
Users should be able to obtain an accurate and complete hardcopy of any VDU display.

# 1 INFORMATION DISPLAY
## 1.1 General Display Guidelines

*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, the hardcopy should be reformatted to maintain readability and clarity.[5908, 0700]

### 1.1-53 Display Area
Sufficient viewing area should be provided to display all important information so that repetitive transitions between displays are not required.
*Additional Information:* Lack of display area is a frequent complaint. The number of VDUs in a control room often is determined before there is sufficient knowledge about what information users need for their tasks.[6690]

### 1.1-54 Predefined Displays
Predefined information groupings should be available.
*Additional Information:* Arranging displayed information may disrupt ongoing tasks or introduce new opportunities for error if the operator fails to recognize that the arrangement of displayed information has been changed. Predetermined information groupings may help reduce interface management demands.[6690]

### 1.1-55 Indicating Locations for Important Information
The system should support the user in identifying displays and indicators that should be monitored during upset conditions.
*Additional Information:* The HSI design should help users determine where to look next within the display system for changes in information that are important to their tasks.[6690]

# 1 INFORMATION DISPLAY
## 1.2 Display Formats
### 1.2.1 Continuous Text Displays

#### 1.2.1-1 Standard Text Format
A standard text display format should be used from one display to another.[5908]

#### 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.[5908]

#### 1.2.1-3 Sentences Begin with Main Topic
The main topic of each sentence should be located near the beginning of the sentence.[5908]

#### 1.2.1-4 Clarity of Wording
Text displays should be worded simply and clearly.[5908]

#### 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.'[5908]

#### 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.[5908]

#### 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.[5908]

#### 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."[5908]

#### 1.2.1-9 Active Voice
Sentences should be composed in the active rather than the passive voice.
*Additional Information:* Sentences in the active voice will generally be easier to understand. For example, "Press RESET to clear the screen" is preferred over "The screen is cleared by pressing RESET."[5908]

#### 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 preferred over reverse order, which may confuse a user. For example, "Start the pump before opening the valve" is preferred over "Before opening the valve, start the pump."[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**1.2.1-14 Conventional Punctuation**
Conventional punctuation should be used in textual display.
*Additional Information:* Sentences, for example, should end with a period.[5908]

**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. Full justification slows reading time and 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.[5908, 0700]

**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.[5908]

**1.2.1-17 Inter-Paragraph Spacing**
Displayed paragraphs of text should be separated by at least one blank line.[5908]

**1.2.1-18 Combining Text with Other Data**
Text should be formatted in a few wide lines rather than in narrow columns of many short lines when space is limited owing to the display of graphics or other data.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 1.2.1-22 Attention Symbols in Alphanumeric Displays

When a special symbol, such as an asterisk, is used to draw attention to a selected item in alphanumeric displays, the symbol should be separated from the beginning of the word by a space.[5908]

### 1.2.1-23 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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. When columns are not separated by vertical lines, the columns should be separated by at least two character widths.[5908, 0700]

### 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.[5908]

### 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.[5908]

### 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. In addition, 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.[5908]

### 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.[5908]

### 1.2.2-11 Arabic Numerals for Numbered List Items

Arabic rather than Roman numerals should be used when listed items are numbered.
*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.[5908]

### 1.2.2-12 Numbered Items Start with '1'

Item numbers should begin with one rather than zero.[5908]

### 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.[5908]

### 1.2.2-14 Repeated Elements in Hierarchic Numbering

Complete numbers should be displayed for hierarchic lists with compound numbers, 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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; dates might be shown as MMM:DD:YYYY. The convention chosen should be familiar to the prospective users.[5908, 0700]

### 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.[5908]

### 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 formats of these forms should be compatible.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 1.2.3-9 Justification: Data Field 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.[5908]

### 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.[5908]

### 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 other data.[5908]

### 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/YYYY): __/__/__."[5908]

### 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.[5908]

### 1.2.3-14 Data Form Entry Error

Data entered that does not match the predefined format of the data form should be highlighted and signaled to the user.
*Additional Information:* A beep, for example, can be used to signal an error.[5908]

### 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 it 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.[5908]

### 1.2.3-16 Labeling Groups of Data Fields

A field group heading should be centered above the labels to which it applies.[5908]

### 1.2.3-17 Data Field Group Separation

At least five spaces should appear between groups of data fields.[5908]

### 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.[5908]

**STEAM GENERATOR LEVEL**

**SG# 1:**

**SG# 2:**

**SG# 3:**

**SG# 4:**

**Figure 1.1 Placement of heading above data fields**

### 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.[5908]

**STEAM GENERATOR LEVEL** **SG# 1:**

**SG# 2:**

**SG# 3:**

**SG# 4:**

**Figure 1.2 Placement of heading adjacent to data fields**

### 1.2.3-20 Logical Organization of Data Entry Forms

A data entry form should have a logical organization.

*Additional Information:* Data entry forms contain multiple fields in which the user enters information, usually via typing, to request information from the system. Logical organizations of entry fields may include conventional order (a generally accepted or customary ordering), sequence of use, frequency of use, data comparison (entries that must be compared are grouped together), functional grouping (related functions are grouped together), importance (task-critical items are located prominently), and general to specific (detailed fields proceed from more general topics, as in a hierarchical organization). Logical organizations can support user comprehension of the layout of the data entry form and facilitate its use. When it is not necessary to enter information in all fields to complete a transaction, placing the most frequently used entry fields at the top of the form can reduce the length of transitions across the data form.[6546]

### 1.2.3-21 Minimizing the Number of Pages for a Data Form

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

*Additional Information:* Movement between individual display pages delays the transaction and causes the user to divert attention from the data entry task to the form navigation task. To reduce movement between individual pages, the number of display pages required for the completion of a transaction should be minimized by integrating required data entry fields into fewer pages.[6546]

### 1.2.3-22 Cursor Positioning

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

*Additional Information:* Subsequently, the cursor should be positioned at the first character location of each entry field accessed on the data form.[6546]

### 1.2.3-23 Movement Between Entry Fields

The user should be able to move from one entry field to the next using a simple action that requires minimal focused attention.

*Additional Information:* User should not have to divert attention from the data entry task to focus on the task of moving from one data entry field to another. For example, operating a tab key requires less attention and precise control than positioning a cursor using a pointing device.[6546]

### 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. A user should not have to memorize the position of each parameter on the display.[5908]

### 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 make the information easier to use. If the user has to refer to a separately displayed legend, interpretation of the chart will be slower and more subject to error.[5908]

### 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).[5908]

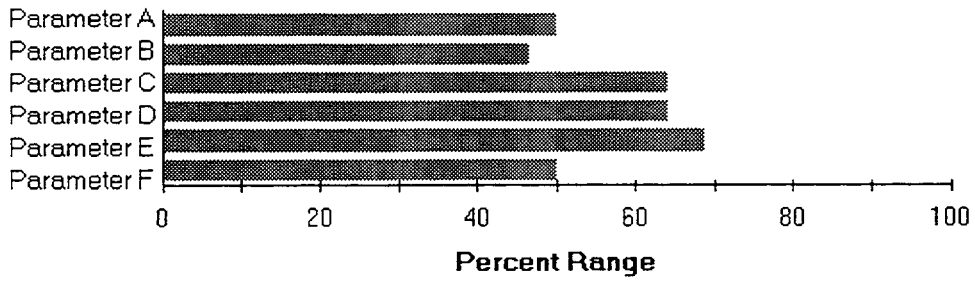


**Figure 1.3 Example of a horizontal bar chart**

### 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.[5908]

### 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.[5908]

### 1.2.4-6 Zero Reference on Deviation Bar Charts

The zero reference should be the center of the deviation bar chart.
*Additional Information:* An example of a deviation bar chart appears in Figure 1.4.[0800]

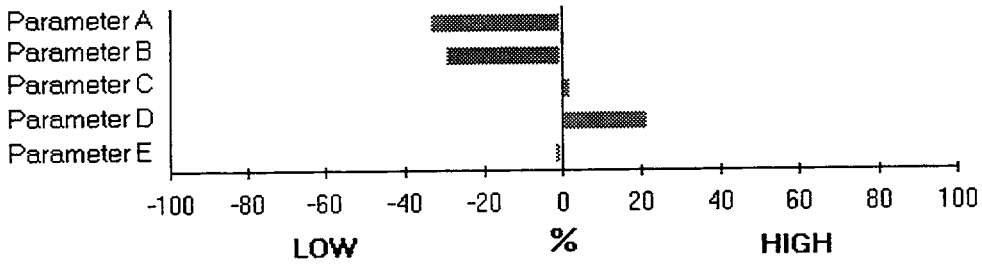


**Figure 1.4 Example of a deviation bar chart**

### 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 percent of the total range.
*Additional Information:* An example of a deviation bar chart appears in Figure 1.4.[0800]

### 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 main 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.[0800]

### 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.[5908]

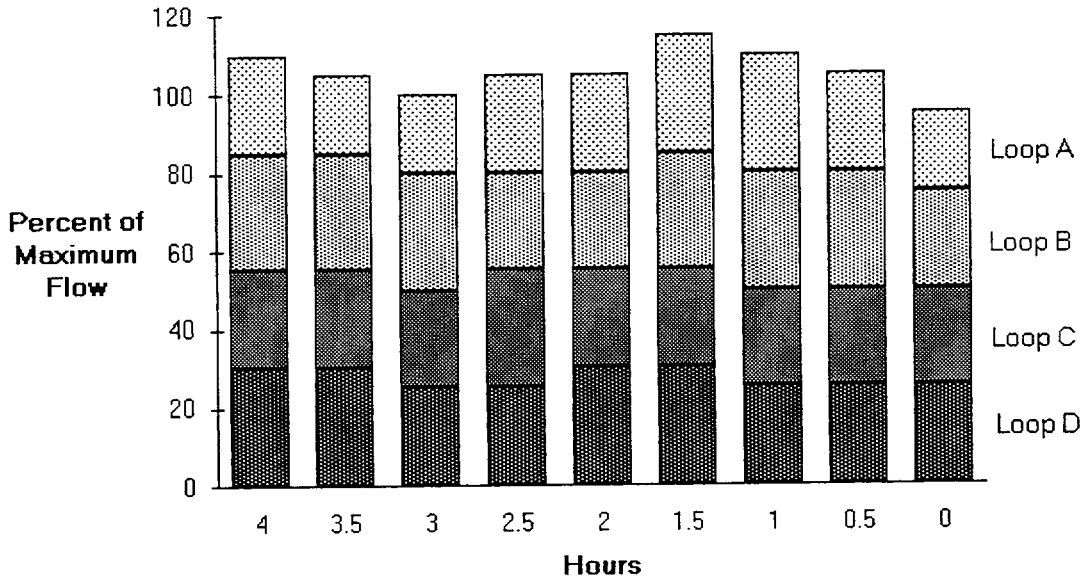


**Figure 1.5 Example of a segmented bar chart**

### 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.

*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.[5908]

### 1.2.5-1 Interpreting Graphs
Graphs should convey enough information to allow the user to interpret the data without referring to additional sources.[5908]

### 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.[5908]

### 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.[5908]

### 1.2.5-4 Coding to Distinguish Curves
Coding should be used when multiple functions are displayed in a single graph.
*Additional Information:* Coding should be provided particularly if curves approach and/or intersect one another. Coding is required to distinguish one curve from another.[5908]

### 1.2.5-5 Consistent Line Coding
Line coding should be used consistently across graphs.[5908]

### 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, or dotted), then one curve might be highlighted by displaying it in a different color.[5908]

### 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.[5908]

### 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.[5908]

### 1.2.5-9 Stability of Trend Data

Trend rates should not fluctuate as a result of minor fluctuations in data or oscillatory behavior that may be superimposed on a well-defined trend.[0800]

### 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.[0800]

### 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.[5908]

### 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 on the basis of minor irregularities.
*Additional Information:* Curve averaging should be performed with caution since averages tend to 'wash out' local variations.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

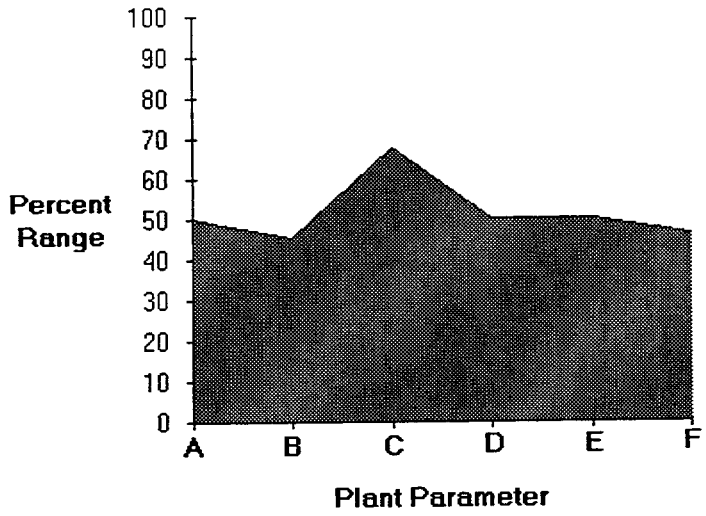


**Figure 1.6 Example of a linear profile chart**

### 1.2.5-17 Coding Linear Profile Charts

The area below the profile line should be shaded to provide a more distinguishable profile.[5908]

### 1.2.5-18 Labeling Linear Profile Charts

Labels should be provided along the bottom to identify each parameter.[5908]

### 1.2.5-19 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 1.7). The values of the bands, segments, or strata are plotted on an X-Y plot. 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.[5908]

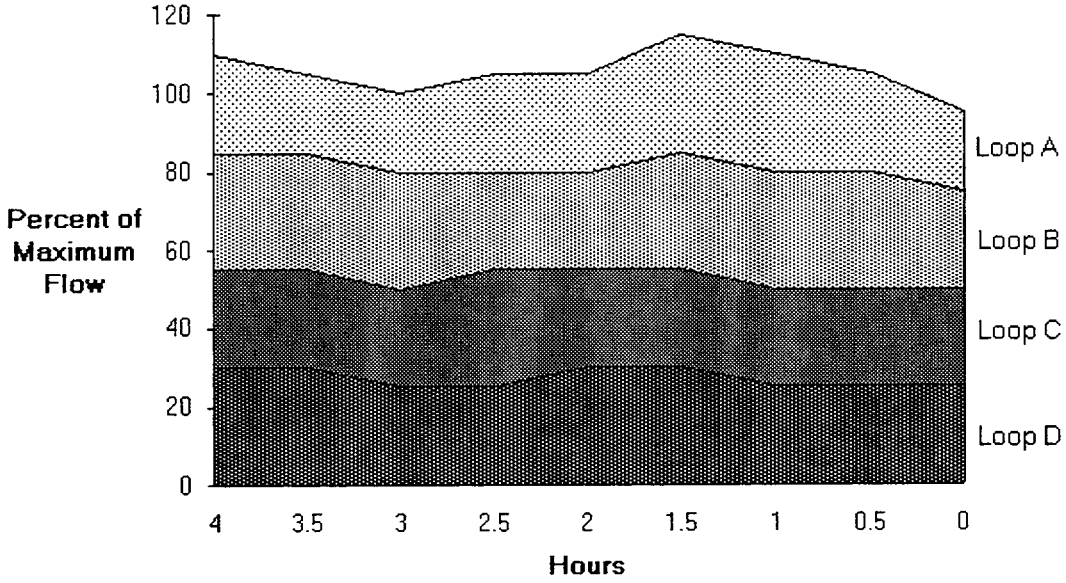


**Figure 1.7 Example of a segmented curve graph**

### 1.2.5-20 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 evaluate irregularities in the upper curves.[5908]

### 1.2.5-21 Coding Segmented Curve Graphs

The different bands of segmented curve graphs should be made visually distinctive by coding, such as by the texturing or shading of bands.[5908]

### 1.2.5-22 Labeling Segmented Curve Graphs

Where space permits, the different bands of segmented curve graphs should be labeled directly within the textured or shaded bands.[5908]

### 1.2.5-23 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.[5908]

### 1.2.5-24 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.[5908]

**1.2.5-25 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.[5908]

### 1.2.6-1 Partitioning
Partitioning should be limited to five segments or less.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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. Another scheme is always to have the desirable path lead downward and the 'problem' paths lead out to the side. Consistent ordering will permit a user to review a flowchart more quickly.[5908]

### 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 by means of a simple action.[5908]

### 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.[5908]

### 1.2.7-6 Flowchart Symbol Set

There should be a standard set of flowchart symbols.[5908]

### 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 1.8. Unnecessary graphic detail (such as shadowed symbols or very detailed icons) should be avoided.[5908]

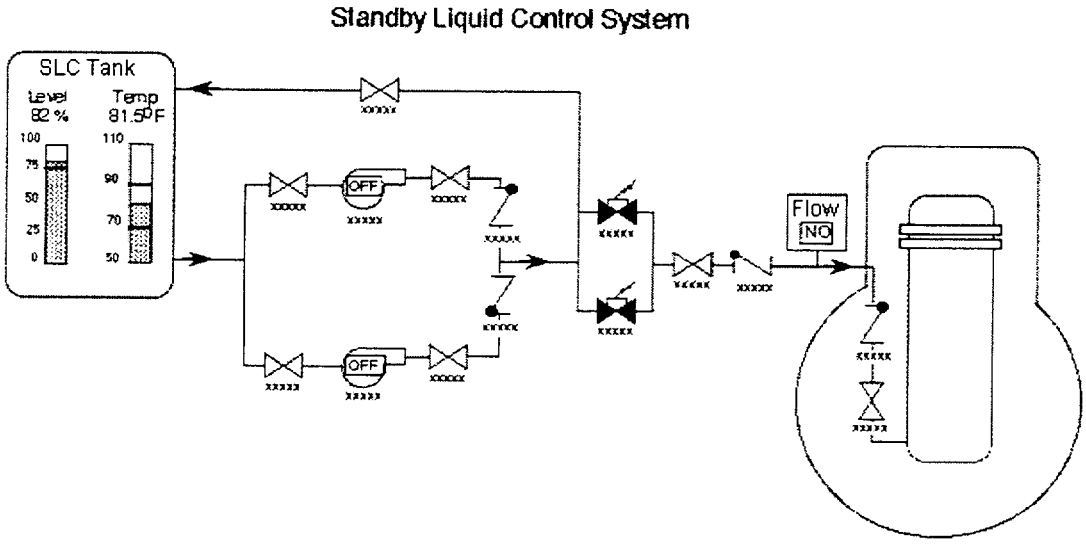


**Figure 1.8 Example of a mimic display**

### 1.2.8-2 Component Identification

Plant components represented on mimic lines should be identified.

*Additional Information:* Symbols used on mimic displays should conform to the guidelines in Section 1.3.4, Icons and Symbols.[0700, 5908]

### 1.2.8-3 Line Points of Origin

All flow path line origin points should be labeled or begin at labeled components.[5908, 0700]

### 1.2.8-4 Line Termination Points

All flow path line destination or terminal points should be labeled or end at labeled components.[5908, 0700]

### 1.2.8-5 Directional Arrowheads

Flow directions should be clearly indicated by distinctive arrowheads.[5908, 0700]

### 1.2.8-6 Line Coding

Flow paths should be coded (e.g., by color and/or 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; and yellow, oil lines. 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.[5908, 0700]

### 1.2.8-7 Overlapping Lines

Overlapping of flow path lines should be avoided.
*Additional Information:* Cross-overs should be clearly indicated so that they do not appear as connections.[5908, 0700]

### 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.[5908]

### 1.2.8-9 Aids for Evaluation

When users must evaluate information in detail, computer aids for calculation and visual analysis 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, and heat transfer.[5908]

### 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.[5908]

### 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.[5908]

### 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 of 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 1.2.9-7 Ordered Coding

Where different areas of a map are coded by texture patterns or tonal variation, the darkest or 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.[5908]

### 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.[5908]

### 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 showing evacuation routes.[5908]

### 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 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.[5908]

### 1.2.9-11 Map and Label Orientation

If the map orientation can be changed, the map labels and symbols should remain oriented to the user's position.[6546]

### 1.2.9-12 Map Decluttering

The user should be able to rapidly remove non-critical information from a map or map overlay display.[6546]

### 1.2.10-1 Appropriate Use of Integral Displays

Integral formats should be used to communicate high-level, status-at-a-glance information where users may not need information on individual parameters to interpret the display.
*Additional Information:* Since integral displays do not display individual parameters, they are most appropriate for general status monitoring.[6633]

### 1.2.10-2 Appropriate Use of Configural Displays

Configural formats should be used when operators must rapidly transition between high-level functional information and specific parameter values.
*Additional Information:* Configural displays provide lower-level information, such as parameter values, and higher-level information conveyed through emergent features. Since both are present in a single display, operators can easily move between them.[6633]

### 1.2.10-3 Reference Aids for Object Displays

A perceptually distinct reference aid should be provided in an object display to support operators in recognizing abnormalities in the object's characteristics.
*Additional Information:* When a change in an object's characteristics (e.g., its shape) is the perceptual feature that indicates a fault or abnormal condition, perceptual cues can assist operators in detecting the change. If shape is used, the graphic display should include the normal reference point to which operators can compare the current shape. Reference points are especially useful when the abnormality is slow to evolve, and the integral object is changing slowly.[6633]

### 1.2.10-4 Representation of Emergent Features

The display elements should be organized so that the emergent features that arise from their interaction correspond to meaningful information about the process or system, e.g., when the aspect of the system represented by the emergent is disturbed, the disturbance is visible in the emergent feature.
*Additional Information:* An emergent feature is a high-level, global perceptual feature generated by interactions among individual parts or graphical elements of a display (e.g., lines, contours, and shapes) to produce perceptual properties, such as symmetries, closure, and parallelism. Displays cannot always be organized to provide emergent features, but they should be considered where feasible.[6633]

### 1.2.10-5 Levels of Emerging Features

The emergent features or patterns within the display should be nested (from global to local) in a way that reflects the hierarchical structure of the process.
*Additional Information:* High-order aspects of the process (e.g., at the level of functional purpose or abstract function) should be reflected in global display features; lower-order aspects of the process (e.g., functional organization) should be reflected in local display features.[6633]

### 1.2.10-6 Salience of Emerging Features

Each emergent feature should be clearly distinguishable for other emergent features and from information on individual parameters.
*Additional Information:* For example, users' perception of plant status can be enhanced by shading the area within a feature.[5908, 6633]

### 1.2.10-7 Reference Aids for Configural Displays

A perceptually distinct reference aid should be provided in a configural display to support operators in recognizing abnormalities in emergent features.

*Additional Information:* When a change in an object's characteristics (e.g., its shape) is the perceptual feature that indicates a fault or abnormal condition, perceptual cues can assist operators in detecting the change. If shape is used, the display graphic should include the normal reference point against which operators can compare the current one. Reference points are especially useful when the abnormality is slow to evolve, and the integral object is slowly changing. Recognition of abnormalities can also be aiding by having normal conditions represented by regular, symmetrical shapes and abnormal conditions indicated by asymmetrical shapes. [5908, 6633]

### 1.2.10-8 Representation of Individual Parameters

Each relevant process parameter should be represented by a perceptually distinct element within the display.[6633]

### 1.2.10-9 Use of Lower-Level Information

The display should support the user in performing tasks requiring lower-level information.
*Additional Information:* When the operator must perform tasks using lower level information, the display should provide such support. For example, if precise information about a variable is desirable, then a scale or digital information should be provided. Scales should be labeled with the names of the displayed parameters.[5908, 6633]

### 1.2.10-10 Complexity

The emergent features and their interactions should not be so complex as to be susceptible to misinterpretation.
*Additional Information:* The value of emergent features is that they provide a direct perception of higher-level information. They substitute perception for mental calculation. The shift toward perceptual cognition requires careful design, so that misunderstandings are unlikely to occur.[6633]

### 1.2.11-1 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, and dangerous levels.[5908]

### 1.2.11-2 Location of Zero

When check-reading positive and negative values on rotary meters (circular displays), 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.[5908]

### 1.2.11-3 Pointer Orientation

The pointer on fixed scales should extend from the right of vertical scales and from the bottom of horizontal scales.[5908]

### 1.2.11-4 Pointer Obscurement

The pointer on fixed scales should extend to but not obscure the shortest graduation marks.[5908]

### 1.2.11-5 Tick Mark Separation

Tick marks should be separated by at least 0.07 inches (1.75 millimeters) for a viewing distance of 28 inches (71 centimeters) under low illumination.
*Additional Information:* Low illumination is less than 1.0 ft-L (3.5 $cd/m^2$).[5908]

### 1.2.11-6 Number of Tick Marks

Scales should not be cluttered with more marks than necessary for precision.[5908]

### 1.2.12-1 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.[5908]

### 1.2.12-2 Message Repeat Capability

The user should be able to have speech messages repeated.[5908]

### 1.2.12-3 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.[5908]

### 1.2.12-4 Type of Voice

A distinctive and mature voice should be used.[5908]

### 1.2.12-5 Delivery Style

Spoken messages should be presented in a formal, impersonal manner.[5908]

### 1.2.12-6 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.[5908]

### 1.2.12-7 Speech Message Priority

A speech message priority system should be established such that more critical messages override the presentation of messages having lower priority.
*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.[5908]

### 1.2.12-8 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.[5908]

### 1.2.12-9 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 listener ear. Speech signals should fall within the range of 200 to 6100 Hz.[5908]

### 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. In addition, 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.[5908]

### 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; or are distorted to look tall and thin or wide and fat. The basic evaluation criterion for font selection should be legibility.[5908, 0700]

### 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, O and 0, S and 5, and U and V.[5908]

### 1.3.1-4 Character Size for Text Readability

The height of characters in displayed text or labels should be at least 16 minutes of arc and the maximum character height should be 24 minutes of arc.
*Additional Information:* Character heights of 20 to 22 minutes of arc are preferred for reading tasks. Slightly smaller characters are acceptable in high-contrast panel labels (see Section 11.3.1.5, Label Lettering). Characters should not be larger than 45 minutes of arc when groups of characters are displayed. Minutes of arc can be converted into height as follows:

$$\text{Height} = 6.283D(MA)/21600$$

where MA is minutes of arc, and D is the distance from the user to the screen.[5908]

### 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 are 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 Guideline 1.6.1-1).[5908]

### 1.3.1-6 VDU Character Format

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.[5908]

**1.3.1-7 Inter-Character Spacing**

Horizontal separation between characters or symbols should be between 10 and 65 percent of character or symbol height.

*Additional Information:* Separation should not be less than 25 percent of character height when any of the following degraded conditions exists: (1) when character width is less than 85 percent of height; (2) when character luminance in less than 12 ft-L; (3) when luminance contrast is less than 88 percent; (4) when display is more than 35 degrees left or right of the straight-ahead line of sight; and (5) when the visual angle subtended by the character or symbol height is less than 15 minutes of arc.[5908, 0700]

### 1.3.2-1 Avoiding Abbreviations

Abbreviations should be avoided (except when terms are commonly referred to by their initialisms, e.g., SPDS).

*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. If the user enters an abbreviation for a command name, the system should use the same abbreviation when referring to that command in messages or prompts. The use of abbreviations or contractions in output text should be avoided.[5908, 0700]

### 1.3.2-2 Abbreviation Rule

When defining abbreviations that 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.[5908]

### 1.3.2-3 Distinctive Abbreviations

Abbreviations should be distinctive so that abbreviations for different words are distinguishable.[5908]

### 1.3.2-4 Punctuation of Abbreviations

Abbreviations and acronyms should not include punctuation.

*Additional Information:* For example, SPDS is preferred over S.P.D.S. Punctuation should be retained when needed for clarity, e.g., '4-inch diameter pipe' rather than '4 in diameter pipe.'[5908]

### 1.3.2-5 Easily Remembered 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.[5908]

### 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.[5908]

### 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').[5908]

### 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.[5908, 0700]

### 1.3.3-2 Meaningfulness of Labels
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.[5908]

### 1.3.3-3 Label Formats
Label formats should be consistent across and within displays.[5908]

### 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.[5908]

### 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.[5908, 0700]

### 1.3.3-6 Label Separation
Labels should be separated from one another by at least two standard character spaces.[5908]

### 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.[5908, 0700]

### 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.[5908, 0700]

### 1.3.3-9 Labels for Graphical Objects
The label for a specific graphical object (e.g., an icon) should be placed in close proximity to the 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.[5908]

### 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.[5908]

### 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; and operational, a hand on a switch.[5908]

### 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 (i.e., ones with a continuous outside border) are processed more efficiently than are open figures.[5908]

### 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.
*Additional Information:* Symbols used on displays should not be inconsistent with those of other information sources used in the work area, such as P&IDs and logic diagrams.[5908]

### 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.[5908]

### 1.3.4-6 Consistent Use of Special Symbols

Special symbols to signal critical conditions should be used exclusively for that purpose.[5908]

### 1.3.4-7 Upright Orientation

Icons and symbols should always be oriented 'upright.'[5908]

### 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.[5908]

### 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.

*Additional Information:* When a displayed symbol of complex shape is to be distinguished from another symbol shape that is also complex, the symbol should subtend not less than 20 minutes of arc at the required viewing distance. VDU-displayed symbols that must be distinguished from other complex shapes should have a minimum of 10 resolution elements for the longest dimension of the symbol.[5908, 0700]

### 1.3.4-10 Highlighting

An icon or symbol should be highlighted when the user has selected it.[5908]

### 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.[5908]

### 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.[5908]

### 1.3.5-1 Number System

Numeric values should ordinarily be displayed in the decimal number system.
*Additional Information:* Maintenance, troubleshooting, or configuration tasks may use other systems (e.g., binary, octal, or hexadecimal).[5908]

### 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 a decimal with no preceding integer (i.e., 0.43 rather than .43).[5908]

### 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. The number of significant digits must be supported by the accuracy of the underlying sensors, instruments, and electronics.[5908]

### 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 or emergency operations) for the tasks the display is designed to support.[5908]

### 1.3.5-5 Rate of Display Change

Digital displays should change slowly enough to be readable.[5908]

### 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 user interpret the direction of trend.[5908]

### 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.[5908]

### 1.3.5-8 Orientation of Numbers

All numbers should be oriented upright.[5908]

### 1.3.6-1 Orientation of Scales

Numbers on a scale should increase clockwise, left to right, or bottom to top.[5908]

### 1.3.6-2 Scale Intervals

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

*Additional Information:* Major and minor graduations should be used if there are up to four graduations between numerals. Major, intermediate, and minor graduations should be used if there are five or more graduations between numerals. The use of these graduations on a conventional meter face is shown in Figure 1.9. Table 1.2 shows graduation dimensions as a function of viewing distance for a conventional meter face.[5908, 0700]

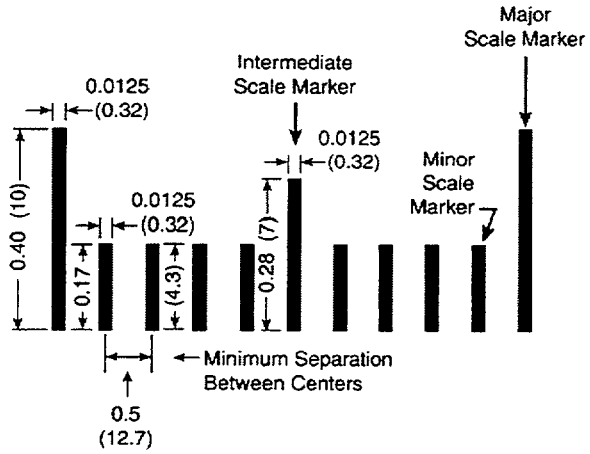


**Figure 1.9 Graduation dimensions for 3-foot viewing distance**

### 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.[5908, 0700]

### 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.[5908]

### 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.[5908]

**Table 1.2 Index heights for various viewing distances**

| VIEWING DISTANCE feet (m) | INDEX HEIGHT inches (mm) | | |
|---|---|---|---|
| | MAJOR | INTERMEDIATE | MINOR |
| 1.5 (0.5) | 0.22 (5.5) | 0.16 (4) | 0.09 (2) |
| 3 (0.9) | 0.40 (10) | 0.28 (7) | 0.17 (4) |
| 6 (1.8) | 0.78 (20) | 0.56 (14) | 0.34 (8.5) |
| 12 (3.7) | 1.57 (40) | 1.12 (28.5) | 0.65 (16.5) |
| 20 (6.1) | 2.63 (67) | 1.87 (47.5) | 1.13 (28.5) |

### 1.3.6-6 Identification of Units of Measurement

The units of measurement represented by the scale should be included in the axis label.[5908]

### 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 the 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.[5908]

### 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.[5908, 0700]

### 1.3.6-9 Scales Consistent with Function

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

*Additional Information:* Scales should be selected to (1) span the expected range of operational parameters, (2) employ appropriate scale ranging techniques, or (3) be supported by auxiliary wide-range instruments. For example, the monitoring of neutron flux at reactor trip must have a variable scale of 0 to 100 percent of the design value and a time scale resolution of seconds. However, post-trip monitoring may have a variable scale of 0 to 10 percent with a time scale resolution of minutes. Finally, operational log data of neutron flux may have a time scale resolution of hours.[5908, 0700]

**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.[0800, 5908, 0700]

**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: (1) if the numbers are used for naming categories, (2) if zero is not a plausible number on the scale, or (3) if the scale contains negative numbers. If for any reason the zero point is omitted, the display should include a clear indication of that omission, and the scales on which quantities are to be compared should be the same.[5908]

**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.[5908]

**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.[5908]

**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.[5908, 0700]

### 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.
*Additional Information:* Scale ranges may be expanded (or contracted) by multiplying or dividing indicated scale values by powers of ten. All such scales should be clearly marked as to whether the indicated values should be multiplied or divided, and the factor to be used (e.g., 10, 100, or 1000).[5908]

### 1.3.6-16 Manual Rescaling

Users should be able to manually change the scale to maintain an undistorted display under different operating conditions.[0800]

### 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 confusion if the change in scale is not recognized.[0800]

### 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).[5908]

### 1.3.6-19 Unobtrusive Grids

When grid lines are displayed, they should be unobtrusive and not obscure data elements (e.g., curves and plotted points).
*Additional Information:* Grid lines should be thinner than data curves, and should be invisible behind depicted objects and areas. Heavy grid lines may conceal details of plotted data. 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.[5908]

### 1.3.6-20 Numbering Grids

Graphs should be constructed so that the numbered grids are bolder than unnumbered grids.
*Additional Information:* If 10-grid intervals are used, the fifth intermediate grid should be less bold than the numbered grid, but bolder than the unnumbered grids.[5908, 0700]

### 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, the break should be labeled clearly, perhaps with some indicator that extends across the displayed graph.[5908]

### 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.[5908]

### 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.[5908]

### 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 line displayed on a VDU will appear continuous if the separation between resolution elements is less than one minute of arc. To provide the illusion of continuity, graphic lines should contain a minimum of 50 resolution elements per inch.[5908, 0700]

### 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.[5908]

### 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.[5908]

### 1.3.7-4 Bordering Single Blocks

A border should be used to improve the readability of a single block of numbers or letters.[5908]

### 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.[5908]

### 1.3.8-1 Use of Color

Where color is used for coding, it should be employed conservatively and consistently.
*Additional Information:* The number of colors used for coding should be kept to the minimum needed for providing sufficient information. Once colors are assigned a specific use or meaning, no other color should be used for the same purpose. 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.[5908, 0700]

### 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 (e.g., setpoint values and actual values) 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. 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.[5908]

### 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. Gradual color changes should not be used when absolute values are important, or to code data into discrete categories. For example, gradual color changes should not be used to indicate the level of a storage tank as it is drained or filled. Instead, a set of discrete codes indicating dangerous and acceptable levels may be more appropriate.[5908]

### 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 that is garish and difficult to view for long periods.[5908]

### 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.[5908, 0700]

### 1.3.8-6 Pure Blue

Pure blue on a dark background should be avoided for text, for thin lines, or for high-resolution information.[5908]

### 1.3.8-7 Easily Discriminable Colors

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

**Table 1.3 Associations and related characteristics for colors typically used in panel design**

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

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

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

*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, and 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. Since the perception of color depends on ambient lighting, the use of color should be evaluated in situ under all expected lighting conditions.
When color coding is used for discriminability or conspicuity of displayed information, all colors in the set should differ from one another by E distances (CIE L*u*v*) of 40 units or more.
This approach will make available at least 7 to 10 simultaneous colors. Increasing ambient illuminance decreases color purity and, consequently, color discriminability. Accordingly, color measurements should be made under the presumed ambient lighting conditions in which the display will be used. The discriminability of pairs of colors depends on their differences in chrominance and luminance. While an entirely satisfactory metric does not exist which combines these attributes into a single assessment of total color difference, an estimate can be derived by calculating the weighted difference between the locations of the colors in the 1976 CIE Uniform Color Space (CIE UCS L*u*v). Note that this estimate should be used only to ensure discriminability of colors of relatively high luminance. Severe nonlinearities in the UCS limit the usefulness of this metric for colors having small luminance differences. In addition, the specification of small color differences should be treated with caution due to the inherent lack of color uniformity on most VDUs. For full color displays, the reference white can be taken as the white on the display obtained with full-intensity red, D6500 K° or 9300 K°. The difference formula is given in Equation 1.1.[5908]

**Table 1.4 Representative set of candidate colors for use in panel design**

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

### 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, for example, in red, they will have an unwanted visual coherence that may hinder proper assimilation of information by a user.[5908]

### 1.3.8-9 Color Contrast

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

*Additional Information:* For adequate legibility, colored symbols should differ from their color background by an E distance (CIE Yu'v') of 100 units or more. The E distances (CIE Yu'v') are derived from the 1976 CIE UCS color diagram. As with the (CIE L*u*v) distances, caution should be used in assessing legibility for characters in colors having small luminance differences. This caution applies not only to characters in color but also to small luminance differences in background colors and for very small luminance differences between characters in color and background in color. Unusually large or small characters may lead to erroneous estimates of legibility. The elements required for the calculation are the luminance in $cd/m^2$ (Y) and the UCS coordinates (u',v') of the text and background. The metric is given in Equation 1.2.[5908]

### 1.3.8-10 Redundant Color Coding

Color coding should be redundant with some other display feature.

*Additional Information:* Pertinent information should be available from some other cue in addition to color. Displayed data should provide necessary information even when viewed on a monochromatic display terminal or hardcopy printout, or when viewed by a user with color vision impairment.[5908, 0700]

### 1.3.8-11 Unplanned Patterns from Color Coding

Color coding should not create unplanned or obvious new patterns on the screen.[5908]

### 1.3.8-12 Red-Green Combinations

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

*Additional Information:* Use of red symbols on a green background should especially be avoided.[0700]

### 1.3.8-13 Chromostereopsis

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

*Additional Information:* Such a presentation may result in chromostereopsis (an uncomfortable three-dimensional effect).[5908]

### 1.3.8-14 Pure Red

Dominant wavelengths above 650 nanometers in displays should be avoided.[5908]

**Equation 1.1 Calculation of Color Differences**

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° $u'_0 = .198$ and $v'_0 = .468$
For reference white, 9300 K° + 27 MPCD $u'_0 = .181$ and $v'_0 = .454$
(MPCD = Minimum Perceptible Color Difference)

Y is luminance in $cd/m^2$. $Y_0$ 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 $\Delta E$ (CIE $L^*u^*v^*$) distance metric is defined differently than suggested by the CIE.

**Equation 1.2 Calculation of Color Contrast**

The metric is as follows:

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

where $Y_M$ = the maximum luminance of text or background

$\Delta Y$ = difference in luminance between text and background

$\Delta u'$ = difference between u' coordinates of text and background (see 1.3.8-7)

$\Delta v'$ = difference between v' coordinates of text and background (see 1.3.8-7).

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

### 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.[5908]

### 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.[5908]

### 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 judgment of the 'size' of a symbol will correspond more closely to its area than to its diameter.[5908]

### 1.3.9-4 Length Coding
For length coding, the maximum number of levels should be six (preferably no more than three).[5908]

### 1.3.9-5 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.[5908]

### 1.3.9-6 Clearly Discriminable Shapes
Shapes used in coding for data groups should be clearly discriminable.
*Additional Information:* When shape coding is used, the shapes should vary widely and the number of basic shapes should be limited. 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. Under adverse viewing conditions, no more than 6 shapes should be used. When needed, other highlighting and graphic techniques (color, filled vs. unfilled, and other 'modifiers') should be used to display different states or qualities of the basic symbol.[5908, 0700]

### 1.3.9-7 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.[5908]

### 1.3.9-8 Pattern Coding of Extreme Values
Pattern density should vary with the value of the coded variable so that the least dense pattern is associated with one extreme and the most dense pattern with the other extreme.[5908]

### 1.3.10-1 Easily Recognizable Highlighting

Highlighting should be easily recognizable and used to attract the user's attention to special conditions, items important to decision-making or action requirements, or as a means to provide feedback.[5908, 0700]

### 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 percent of the displayed information. If a large proportion of the displayed items are highlighted, the highlighting will no longer be effective for directing the user's attention.[5908]

### 1.3.10-3 Consistency

A particular highlighting method should be used consistently.
*Additional Information:* Highlighting methods associated with emergency conditions should not also be used in association with normal conditions.[5908, 0700]

### 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.[5908]

### 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 on a VDU and up to three on a transilluminated display.
*Additional Information:* Brightness coding should not be used in conjunction with shape or size coding.[5908, 0700]

### 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.[5908]

### 1.3.10-7 Intensity Levels for Brightness Coding

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$^2$).[5908]

### 1.3.10-8 Inverse Video

Inverse video should be used primarily for highlighting in dense data fields or to indicate selection of on-screen objects and information.[5908, 0700]

### 1.3.10-9 Appropriate Use of Flash Coding

Flashing should be used when a displayed item implies an urgent need for attention or action, but not in displays requiring attention to detail or reading of text.
*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.[5908, 0700]

**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.[5908]

**1.3.10-11 Small Area**
Only a small area of the screen should flash at any time.[5908]

**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. When a single blink rate is used, the rate should be roughly 2-3 blinks per second with a minimum of 50 msec 'on' time between blinks.[5908, 0700]

**1.3.10-13 Flash Suppression**
Event acknowledgement or flash suppression keys should be provided.[5908]

**1.3.10-14 Long-Persistence Phosphor Displays**
Flashing should not be used with long-persistence phosphor displays.[5908]

**1.3.10-15 Flash Rate for Critical Information**
When two rates are used, the higher rate should apply to the more critical information.[0700]

### 1.3.11-1 Appropriate Use of Auditory Signals

Auditory signals should be provided to alert the user to situations that require attention, such as an incorrect input action or a failure of the HSI to process an input from the user.
*Additional Information:* An auditory signal should provide users with a greater probability of detecting the triggering condition than their normal observations would provide in the absence of the auditory signal.[5908]

### 1.3.11-2 Dedicated Use

Systems used to transmit non-verbal auditory signals should be used only for that purpose.[0700]

### 1.3.11-3 Localization

Auditory signals should provide localization cues that direct users to those control room workstations where attention is required.[0700]

### 1.3.11-4 Selection

Auditory signals should be selected to avoid interference with other auditory sources, including verbal communication.[0700]

### 1.3.11-5 Signal Priority Distinction

Advisory or caution signals should be readily distinguishable from warning signals and used to indicate conditions requiring awareness, but not necessarily immediate action.[5908]

### 1.3.11-6 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 attention to the appropriate visual display.[5908]

### 1.3.11-7 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.
*Additional Information:* The meaning of each auditory signal should be clear and unambiguous.[5908, 0700]

### 1.3.11-8 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.[5908]

### 1.3.11-9 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.[5908]

### 1.3.11-10 Confusable Signals

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

*Additional Information:* Auditory signals intended to alert the user to a malfunction or failure must be different from routine signals such as bells, buzzers, and normal operating noises. 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.[5908, 0700]

**1.3.11-11 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.[5908]

**1.3.11-12 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.[5908]

**1.3.11-13 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.[5908]

**1.3.11-14 Direction of Sound**
Sound sources (speakers or buzzers) should direct sound toward the center of the main operating area.[0700]

**1.3.11-15 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.[5908]

**1.3.11-16 Audibility**
Auditory alert and warning signals should be audible in all parts of the control room.
*Additional Information:* The guideline applies to warnings that need to be heard by all members of the operating crew. Some signals may be pertinent to a particular functional role and therefore may need to be heard only at workstations supporting that function. Where there is a concern that important information might be missed if the workstation is temporary not staffed, a general alert can be added if there is no response at the workstation for a specified period.[0700]

**1.3.11-17 Signal Intensity**
The intensity of auditory signals should be set to unmistakably alert and get a user's attention.
*Additional Information:* A signal should generally yield a 20dB signal-to-noise ratio in at least one octave band between 200 and 5000 Hz. This level should apply throughout the main operating area. (A 20dB differential may not be necessary for all signals and all environments.) Auditory signal intensity should not cause discomfort or 'ringing' in the ears. Auditory signal intensities should not exceed 90 dB(A), except for evacuation signals, which may be up to 115 dB(A).[0700]

**1.3.11-18 Signal Travel Over 1000 Feet**
When an audio signal must travel over 1000 feet, its frequency should be less than 1000 Hz.[5908]

**1.3.11-19 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.[5908]

**1.3.11-20 Masking**
Audio warning signals should not interfere with any other critical functions or warning signals, or mask any other critical audio signals.[5908]

**1.3.11-21 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.
*Additional Information:* Failure of auditory signal circuitry should not adversely affect plant equipment.[5908, 0700]

**1.3.11-22 False Alarms**
Auditory alarm systems should be designed so that false alarms are avoided.[0700]

**1.3.11-23 Distinctive Coding**
Coding methods should be distinct and unambiguous, and should not conflict with other auditory signals.[0700]

**1.3.11-24 Not Contradictory**
Similar auditory signals must not be contradictory in meaning with one another.[0700]

**1.3.11-25 Pulse Coding**
Auditory signals may be pulse coded by repetition rate. Repetition rates should be sufficiently separated to ensure discrimination.[0700]

**1.3.11-26 Frequency Change Coding**
If modulation of the frequency (Hz) of a signal denotes information, center frequencies should be between 500 and 1000 Hz.[0700]

**1.3.11-27 Discrete Frequency Coding**
If discrete-frequency codes are used for audible signal coding, frequencies should be broad band and widely spaced within the 200 to 5000 Hz range (preferably between 500 and 3000 Hz).
*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. No more than 4 separate frequencies should be used.[5908, 0700]

**1.3.11-28 Coding by Intensity**
Using the intensity of a sound to convey information is not recommended.[0700]

**1.3.11-29 Testing**
It should be possible to test the auditory signal system.[0700]

### 1.4-1 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. See Guideline 1.4-3.[5908]

### 1.4-2 User Control of Display Update Rate

The user should be capable of controlling the rate of information update on the display, but the allowable rate should not exceed that capable of being met by the information source and the processing equipment.[5908]

### 1.4-3 Changing Values

Changing alphanumeric values that 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.[5908]

### 1.4-4 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.[5908]

### 1.4-5 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.[5908]

### 1.4-6 Data Sampling Rate

The sampling rate for each critical plant variable should result in no meaningful loss of information in the data presented.[0800]

### 1.4-7 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.[0800]

### 1.4-8 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.[0800]

### 1.4-9 Invalid Data

Variables that are subject to validation (e.g., checks for accuracy) should be identified and an indication should be provided when these data are invalid.

*Additional Information:* When data fails to meet the specified criteria for validity and thus is suspected of being of poor quality, an indication of validation failure should be provided.[0800]

### 1.4-10 Unvalidated Data

When checks for accuracy could not be performed, the unvalidated status of the data should be clearly indicated.

*Additional Information:* When checks for accuracy cannot be performed (e.g., a processor or redundant sensors are not available) the data is unvalidated. (Unvalidated data may be determined to be either valid or invalid as a result of the data validation process.) Under some conditions, unvalidated data may be useful to trained users in determining the safety status of the plant and determining whether human intervention is needed. Clear indications of the data's unvalidated status should be provided so the user can exercise judgment in interpreting it.[0800]

### 1.4-11 Data Entered by Personnel

Data entered by personnel should be identified such that it is easily distinguished from sensor data or validated data.[0800]

### 1.5-1 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, or 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, alarms, display control options, instructions, error messages, and menus. Display formats should be consistent with accepted usage and existing user habits.[5908, 0700]

### 1.5-2 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 blank spaces, lines, or some other form of visual demarcation. Areas used to display data, control options, and instructions should be distinct from one another.[5908, 0700]

### 1.5-3 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:* The title may be incorporated as part of the display itself, as a window title, or as a label mounted on the display device. If the title is incorporated into the display, there should be at least one blank line between the title and the body of the display.[5908]

### 1.5-4 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 abbreviation that 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.[5908]

### 1.5-5 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 have not been well established.[5908]

### 1.5-6 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 user action; displays should not be overloaded with extraneous information. Information not needed for the current task (e.g., patent notices, manufacturer's trademark or address) should not be displayed. In general, the fewest lines or objects in a graphical display should be used.[5908, 0700]

### 1.5-7 Redundancy

Redundancy in the presentation of information items should be limited to cases where needed for backup or to avoid excessive movement.[0700]

### 1.5-8 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. Displays consisting largely of alphanumerics generally should not exceed 25 percent density. Displays composed largely of graphics may be more dense. 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).[5908]

### 1.5-9 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 display pages. When dividing a display, it is important to keep task-related data together to avoid (1) requiring the user to frequently switch back and forth between pages when performing the task or (2) requiring users to remember information from one page while looking at another.[5908]

### 1.5-10 Numbering Pages of Multipage Displays

Users working with 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 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.[5908]

### 1.5-11 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. Sectional coordinates should be used when large schematics must be panned or magnified.[5908, 0700]

### 1.5-12 Grouping of Information in a Display

Information on a display should be grouped according to principles obvious to the user, e.g., by task, system, function, or sequence, based upon the user's requirements in performance of the ongoing task (see Table 1.5).

*Additional Information:* Table 1.5 provides grouping principles and examples of their appropriate uses. Grouping conventions should be used consistently within sets of displays of a particular type. For example, grouping by function may take precedence over other grouping methods for mimic-type plant displays. Grouping for data comparison may take precedence over other grouping methods for displays that present only text. Since users' tasks can vary, advanced HSIs should provide the user with the flexibility to group information by alternative grouping principles to reflect changes in task requirements.[5908]

**Table 1.5 Information grouping principles**

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

### 1.5-13 Demarcation of Groups

When information is grouped on a display, the groups should be made visually distinct by such means as color coding or separation using blanks or demarcation lines.[5908]

### 1.5-14 Display Background Color

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

*Additional Information:* Patterned backgrounds should be avoided. Background color can influence the way a user perceives a color symbol (e.g., shapes and 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.[5908]

### 1.5-15 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.[5908]

### 1.5-16 Data Overlays

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

*Additional Information:* Overlay displays that are generated by the display system can allow additional information to be shown when needed and then removed to reduce visual clutter. Overlays are acceptable when they improve the user's interpretation of displayed information. They should not distract the user or interfere with the observation of displayed information.[5908, 0800]

### 1.6.1-1 VDU Resolution

The display should have adequate resolution; i.e., users should be able to discriminate all display elements and codes from maximum viewing distance.

*Additional Information:* The Modulation Transfer Function Area (MTFA) is a measure of resolution; it should have a value of at least 5. This value may be directly developed from microphotometric measurements, or for monochrome VDU displays, it may be estimated using the formula given in Equation 1.3.[5908]

**Equation 1.3 Calculation of Modulation Transfer Function Area**

This value may be directly developed from microphotometric measurements, or for monochrome VDU displays, it may be estimated using as follows:

$$MTFA = 10A$$

where $A = b_0 + b_1V_D + b_2W_D + b_3A_B + b_4V_DA_B + b_5W_DA_B + b_6L_MA_B + b_7V_DL_MA_B$,

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

where $V_D$ = Viewing Distance in meters (m), when $0.30\ m < V_D < 1.02\ m$,

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

### 1.6.1-2 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 (1.6.1-1) and luminance (1.6.1-7). When ambient illumination in the vicinity of the VDU is high, dark characters on a light background are preferred. Contrast ratio is calculated as follows:

$$CR = Lmax/Lmin$$

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

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

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

where S is the vertical size of the character set, in minutes of arc, and Luminance modulation is calculated $M = (Lmax-Lmin)/(Lmax + Lmin)$.[5908, 0700]

### 1.6.1-3 Flicker

The display should be 'flicker free.'

*Additional Information:* The regeneration rate should be above the critical frequency for fusion so that flicker is not perceptible.[5908, 0700]

### 1.6.1-4 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

$$VD \times 0.0002 >= (H^2 + V^2)^{\wedge}0.5$$

where VD is the viewing distance and H and V are the maximum excursions of picture element centers, horizontally and vertically.[5908]

### 1.6.1-5 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.[5908]

### 1.6.1-6 VDU 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:

$$0.04 \text{ (Shorter edge/Longer edge)} >= |\text{Diag1/Diag2}| - 1$$

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

$$2(h2 - h1)/(h2 + h1) <= 0.1 \text{ and } 2(w2 - w1)/(w2 + w1) < 0.1$$

where h is the height of the symbol and w is the width of the symbol. When all the character positions on the screen are filled with 'H's or 'M's of the same character set, h1 is the height of the smallest character, h2 is the height of the largest character, w1 is the width of the smallest character, and w2 is the width of the largest character.[5908]

### 1.6.1-7 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$^2$).[0700, 5908]

### 1.6.1-8 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.[5908]

**1.6.1-9 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.[5908, 0700]

**1.6.1-10 VDU Luminance Control**

A control to vary the VDU luminance from 10 percent of minimum ambient luminance to full luminance should be provided.[5908, 0700]

**1.6.1-11 Display Devices for Reducing Interface Management Demands**

The number of display devices provided in the HSI should be sufficient to maintain interface management demands at a level that does not impair user performance

*Additional Information:* The number of display devices should not be so high that the devices cannot fit within the recommended viewing areas of workplace design and, thus, cannot be easily monitored or operated effectively by the users. However, the number of display devices should not be so low that the interface management demands required for accessing and using displays detracts from the user's overall performance on primary tasks.[6546]

**1.6.1-12 Display Devices for Concurrent Tasks**

The number of display devices provided in the HSI should be sufficient to support all tasks that must be performed concurrently by each user.

*Additional Information:* Table 6.1 describes some tasks supported by display devices that should be addressed by requirements for the necessary number of display devices.[6546]

### 1.6.2-1 Resolution
Users should be able to resolve all important display detail at the maximum viewing position.[5908]

### 1.6.2-2 Size of Characters
The height of letters and numerals should not subtend less than 15 minutes of visual angle as measured at the maximum viewing distance.[5908]

### 1.6.2-3 Superposed Characters
The contrast polarity of superposed characters should be appropriate for the method of projection.
*Additional Information:* For subtractive superposition (at the source), characters should be presented as dark markings on a transparent background. For additive superposition (at the screen), characters should be presented as light markings on an opaque background. Colored markings against colored backgrounds of comparable brightness should be avoided.[5908]

### 1.6.2-4 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:

- For viewing charts, printed text, and other linework via slides or opaque projectors, the minimum contrast ratio is 5:1
- For projections that are limited in shadows and detail, such as animation and photographs with limited luminance range, the minimum contrast ratio is 25:1
- For images that show a full range of colors (or grays in black-and-white photographs), the minimum contrast ratio is 100:1[5908]

### 1.6.2-5 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.[5908]

### 1.6.2-6 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.[5908]

### 1.6.3-1 Placement of Printers
Printers should be located within the main operating area because they must be verified and attended by the user.[0700]

### 1.6.3-2 Legibility
Print output should be free from character line misregistration, character tilt, smear, or glare.
*Additional Information:* Hard-finish matte paper should be used to avoid smudged copy and glare.[5908, 0700]

### 1.6.3-3 Contrast
A minimum contrast ratio of 4:1 should be provided between the printed material and the background on which it is printed.[5908]

### 1.6.3-4 Illumination
The printer should be provided with internal illumination if the printed matter is not legible in the planned operational ambient illumination.[5908]

### 1.6.3-5 Visibility
When used for real-time applications, the printed matter should not be hidden, masked or obscured in a manner that impairs direct reading.
*Additional Information:* The user should always be able to read the most recently printed line. Data should be visible through the window of the printer and not require opening a cover to expose it.[5908, 0700]

### 1.6.3-6 User Annotation Capability
Recording devices used in real-time applications should allow users to write on or mark the printed matter while it is still in the printer or plotter.
*Additional Information:* For example, it should be convenient to annotate recordings with date and time markings, with paper speed if varied from normal, with parameter identification, or with any other relevant information.[5908]

### 1.6.3-7 Take-up Provision
A take-up device should be provided for printed material.
*Additional Information:* The take-up device should require little or no attention and should have a capacity at least equal to the feed supply.[5908, 0700]

### 1.6.3-8 Indication of Supply of Materials
A positive indication should be provided of the remaining supply of printing materials (e.g., paper, toner, and ribbons).[5908, 0700]

### 1.6.3-9 Quality of Expendable Materials
Pens, inks, and paper should be of a quality to provide clear, distinct, and reliable marking.
*Additional Information:* For example, ink should not clog pens or smudge on the paper.[0700]

### 1.6.3-10 Availability of Expendable Material
Paper, ink, and other user-maintained expendables should be provided and accessible in the control room.[0700]

### 1.6.3-11 Ease of Routine Replenishment
Printer design should permit quick and easy replenishment of paper, toner, ribbons, or ink.

*Additional Information:* Procedures for reloading expendable materials should be displayed on an instruction placard attached to the printer or plotter.[0700]

**1.6.3-12 Smudging/Smearing**
The hardcopy should be resistant to smudging or smearing when handled by users.[5908]

**1.6.3-13 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.[5908]

**1.6.3-14 Scale Design**
Plotter scales should be numbered and marked according to the principles of display design and scale marking given in Sections 1.1, General Display Guidelines, and 1.3.6, Scales, Axes, and Grids.[0700]

**1.6.3-15 Scale Compatibility**
Scales printed on the recording paper should be the same as the scales shown on the recorder.[0700]

**1.6.3-16 Tearing-Off Continuous Recordings**
It should be easy for users to tear off records printed on rolled paper.[0700]

**1.6.3-17 Paper-Speed Adjustability**
Provide a high paper-speed option to run out records for detachment and a selection of lower speed options to permit adjustment of the time scale so that rate-of-change information can be indicated.[0700]

**1.6.3-18 Labeling**
Labels should identify the parameters recorded.
*Additional Information:* With multiple-pen recorders, parameters should be listed in the order of the associated scales on the recorder.[0700]

**1.6.3-19 Ink Colors**
Each pen should use a different colored ink to permit channel identification.
*Additional Information:* Colors selected should be distinctly different and should afford good contrast with the paper.[0700]

**1.6.3-20 Channel Overload**
The recorder should not be loaded beyond its designed channel capacity because this adds complexity to the analysis and prolongs sampling cycle time.[0700]

**1.6.3-21 Channel Identification on Instrument**
Discrete recorders should be equipped to display the channel being plotted in an easily viewed manner.
*Additional Information:* Viewing from odd and inconvenient angles should not be imposed.[0700]

**1.6.3-22 Channel Identification on Recording**
Number-printing mechanisms should be designed and maintained to provide clear, sharp, and small numbering to avoid crowding of data and consequent analysis problems.[0700]

### 1.6.3-23 Channel Selection Capability

Provisions should be made to select any single channel for immediate display without awaiting completion of a sampling cycle.[0700]

### 1.6.4-1 Circular Scales
Scale values should increase with clockwise movement of the pointer.[0700]

### 1.6.4-2 Vertical Straight Scales
Scale values should increase with upward movement of the pointer.[0700]

### 1.6.4-3 Horizontal Straight Scales
Scale values should increase with pointer movement to the right.[0700]

### 1.6.4-4 Pointer Tip Form
Pointer tips should be simple.
*Additional Information:* Pointer tips should be selected to minimize concealment of scale graduation marks or numerals.[0700]

### 1.6.4-5 Pointer Positioning Relative to Scale
Pointer tip should extend to within about 1/16 inch of (but not overlap) the smallest graduation marks on the scale.
*Additional Information:* Overlap of the pointer and scale graduation marks is acceptable, if the pointer does not obscure graduations or numerals and impair reading accuracy. Pointers should be mounted to avoid parallax errors.[0700]

### 1.6.4-6 Pointer Visibility
Pointer/background contrast and pointer size should be adequate to permit rapid recognition of pointer position.[0700]

### 1.6.4-7 Zone Markings
Zone markings should be conspicuous and distinctively different for different zones (see Figure 1.10).
*Additional Information:* Zone marking should not interfere with reading of quantitative markings. Differently colored bands are often used to indicate, e.g., the normal operating range, upper/lower limits, and danger range of a parameter. If color is used for coding, color should be related to meaning (see Guideline 1.3.8-5).[0700]

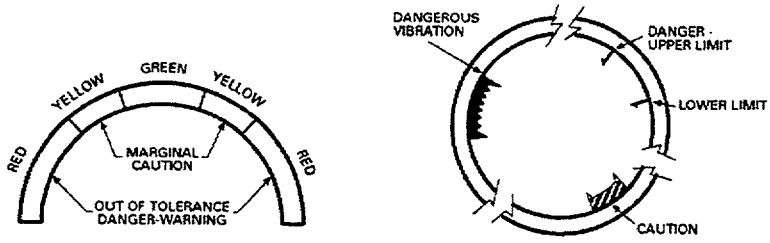


**Figure 1.10 Zone markings**

### 1.6.4-8 Consistency
To facilitate reading of meters and prevent misreading, the orientation of scale markings should be consistent.

*Additional Information:* The factors that are significant here are the orientation of numerals and of scale end-points on dials.[0700]

**1.6.4-9 Numerical Orientation**
Individual numerals on any type of fixed scale should be vertical.
*Additional Information:* This holds true for circular as well as linear scales.[0700]

**1.6.4-10 Zero-Point Orientation**
Where pointer movement is more than 360 degrees, the zero point should be located at the 12 o'clock position.
*Additional Information:* Where positive and negative values are displayed around a zero or null position, the zero or null point should be located at the 12 o'clock position.[0700]

**1.6.4-11 End-Point Indication on Partial-Revolution Scales**
Where the scale covers less than a full rotation of the pointer, scale end-points should be indicated by a break in scale.
*Additional Information:* The break should be at least one numbered interval in length. The break should be oriented at the 6 o'clock position.[0700]

**1.6.4-12 Moving-Scale Meters Versus Fixed-Scale Moving-Pointer Types**
Moving-scale fixed-pointer meters should be avoided in favor of the more effective fixed-scale moving-pointer types.
*Additional Information:* Moving-scale fixed-pointer meters are infrequently seen in nuclear power plant control rooms.[0700]

### 1.6.5-1 Precautions to Assure Availability

Dual-bulb or dual-filament light assemblies should be used.
*Additional Information:* Bulb-test capability should be provided. Design should encourage immediate replacement of burned-out bulbs by providing for rapid and convenient bulb replacement with power on and without hazard to personnel or equipment.[0700]

### 1.6.5-2 Unambiguous Light Status

Lights should not appear to be energized when they are off, or vice versa.
*Additional Information:* Ambient light sources should be selected, located, or controlled to avoid reflections or refractions. See Section 12.1.2.3, Illumination.[0700]

### 1.6.5-3 Positive Status Indication

System/equipment status should be conveyed by illuminated indicators, and never by the absence of illumination.[0700]

### 1.6.5-4 Use as Alerting Indicators

Alerting the users to unfavorable status should be a function of the alarm system and not assigned to light indicators.[0700]

### 1.6.5-5 Identification of Meaning

Where the meaning of a light indicator is not apparent, labeling should be provided close to the indicator showing the condition that the light represents.[0700]

### 1.6.5-6 Light Intensity

The illuminated indicator should be at least 10 percent greater in light intensity than the surrounding panel as measured by a spot photometer.[0700]

### 1.6.5-7 Visibility of Light Indicators

When using legend light indicators, make sure contrast and ambient/transilluminated conditions are considered.
*Additional Information:* Light intensity of the illuminated indicators should be at least 10 percent greater than the surrounding panel as measured by a spot photometer. Legends should be legible under ambient illumination with indicator lights off. Legend lettering should contrast well with background under both ambient and transilluminated lighting.[0700]

### 1.6.5-8 Legend Design

General legend design should be consistent throughout the control room.
*Additional Information:* Lettering should be simple, and should follow Guidelines 1.3.1-2 and 1.3.1-4 for style and size. Symbolic legends should be clear and unambiguous as to their meaning. Text should be short, concise, and unambiguous. Legend messages should contain no more than three lines of text. Nomenclature and abbreviations should be standard and consistent with usage throughout the control room and in the procedures. Legends should be worded to tell the status indicated by glowing of the light.[0700]

### 1.6.5-9 Distinguishability from Legend Pushbuttons

Illuminated legend indicators should be readily distinguishable from legend pushbuttons by form, size, or other factors.

*Additional Information:* Guidelines for legend pushbuttons are given in Section 3.3.1.3, Legend Pushbuttons.[0700]

**1.6.5-10 Color Coding**
The color of the legend background under transillumination should be clearly identifiable and should conform to the general color code established for the control room.
*Additional Information:* See Section 1.3.8, Color.[0700]

**1.6.5-11 Replacing Indicator Lenses**
Provisions should be made to prevent interchanging indicator lenses.
*Additional Information:* The means for prevented lenses from being interchanged can be mechanical or procedural.[0700]

### 1.6.6-1 Orientation

Multi-digit numbers formed by several elements (e.g., drums and LED arrays) should be read horizontally from left to right.

*Additional Information:* Numbers should not be oriented vertically (i.e., read top to bottom).[0700]

### 1.6.6-2 Width-to-Height Ratio in Drum Displays

To compensate for the distortion imposed by the curved surface of the drum, counter numerals should reflect a width-height ratio of 1:1.

*Additional Information:* Do not use a 3:5 ratio as recommended for numerals of other displays.[0700, 5908]

### 1.6.6-3 Grouping of Numerals

If more than four digits are required, they should be grouped and the groupings separated as appropriate by commas, by a decimal point, or by additional space.[0700]

### 1.6.6-4 Display of Changing Values

Numerals should not follow each other faster than one per second when the user is expected to read the numerals consecutively.

*Additional Information:* Drum displays should change by snap action rather than through continuous movement and should move upward with increasing values. The window through which numerals appear should be sized to allow no more than one digit per drum to appear in the window at any one time.[0700, 3659]

# SECTION 2: USER-INTERFACE INTERACTION AND MANAGEMENT

# 2 USER-INTERFACE INTERACTION AND MANAGEMENT

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

The demands of user-interface interaction and management demands often result from the particular design aspects of the HSI. For example, consider two control rooms that have identical information systems. One control room has eight VDUs on which information can be displayed, while the other has only four. The latter will likely have a higher information management workload because operators will have to more frequently replace one display with another due to its more limited display area. Thus, interface management is a 'cut across' issue for all aspects of the HSI.

The HSI characteristics that support user interface interaction management are described below.

## GENERAL DESIGN REVIEW CONSIDERATIONS

Guidelines reviewing general user input aspects of interfaces are provided in Section 2.1. This section contains guidelines for the review of the general characteristics and functions of the HSI supporting user-interface interaction and management. It covers the selection of appropriate user input formats, such as direct manipulation and menus. It also contains guidelines on basic principles to limit the need for user input and on the performance of interface management tasks.

## USER INPUT FORMATS

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

### Command Language Interfaces

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

Commands used for user-interface interaction and management may be categorized as action and destination commands. Action commands include instructions for specific computer operations such as manipulating information pertaining to interface management and navigating display systems. Some action commands for navigation include Previous/Next Display and Zoom In/Zoom Out; they allow users to move through an information structure in steps. Destination commands include codes for identifying and retrieving specific displays; they allow users to move directly from one location in the display network to another without accessing intervening locations (similar to navigation paths in hypertext systems). The number of destination commands may be high for a display system that contains a large number of selectable display pages. Guidelines reviewing command language interfaces are provided in Section 2.2.1.

### Menus

A menu is a displayed listing of possible options from which a user can choose. Menu interfaces are widely used in many computer-based systems. Because they present the user with a set of options, the user needs to recognize rather than recall the correct one. A wide variety of menu systems exist. Some important characteristics include: type of options, menu structure, presentation format, menu panel design, and interaction method. Guidelines reviewing menu interfaces are provided in Section 2.2.2.

Types of Menus. Some display systems feature full-page menus, which appear as entire display pages that replace the currently displayed page. The pop-up window appears as a window that overlays the currently presented display page. The pull-down window offers additional options to the user. For example, some display systems have a menu bar that extends across one or more borders of the display screen and contains multiple options for selection. When one of these options is selected, a list of additional options appears on the screen. The expanding or pop-out menu is a variation of the pull-down menu in which further lower-level options appear after intermediate-level options are selected. For example, when the cursor is positioned over one of the options of the pop-up menu, an additional list of options appears. Individual options of the pop-out menu may have additional pop-out menus.

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

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

- Categorical – grouped in conceptual relationships between the options.
- Alphabetical – listed in the alphabetical order of the option names.
- Frequency – listed in terms of how often each option is used.
- Sequential – listed in the order in which options are used.
- Mixed – grouped using more than one scheme. For example, the beginning of the menu may contain options that are used very frequently, while the rest of the menu options are arranged alphabetically. (This is not necessarily an acceptable arrangement, but it may exist in a menu structure that is under review.)

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

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

### Function Keys

Function keys are individual keys on a keyboard or pad that are dedicated to particular predefined operations, such as to call up a predefined display. When a function key is pressed, an instruction is sent to the computer system to perform that operation. An important consideration for function-key dialogues is the relationship between the keying operation and the functions executed. Single keying requires pressing an individual key. Double keying requires multiple keys to be pressed at once, such as when a

function key must be pressed in combination with SHIFT, ALT, or CONTROL key. In addition, a function-key dialogue may have multiple modes, and, in each mode, a particular function key may perform a different operation. Guidelines reviewing menu interfaces are provided in Section 2.2.3.

**Macros/Programmable Function Keys**

A macro-command consists of a series of commands that have been grouped and redefined as a single command. When the function key assigned to a particular macro-command is pressed, the series of commands is executed. A programmable function key is a key to which the user can assign functions; it can be assigned to a single function or a macro-command. Macro-commands and programmable function keys are special cases of the function-key dialogue. Their use enables a user to automate aspects of the interface management task. Guidelines reviewing interfaces employing macros and programmable function keys are provided in Section 2.2.4.

**Forms**

A form is a display containing category labels and blank spaces where users enter data. In a form-filling dialogue, the user enters commands or information into the data fields. Forms facilitate the interface management task by reducing the need for the operator to memorize the types of information needed and the permissible entries for each. Command-entry forms are used to aid the user in composing commands. Information-entry forms are used for tasks requiring the user to specify information. Forms may have error checking features, which check entries to determine if they are in the permissible range. Forms may have default information already be entered into data fields to facilitate their use. Guidelines for reviewing interfaces based on forms are provided in Section 2.2.5.

**Direct Manipulation Interfaces**

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

Input is usually provided by using a pointing device to manipulate the graphical object, causing the computer operations to be performed on the object or information it represents. Feedback is represented by a change in the graphic object. For example, when deleting a file, the document icon may disappear into a trash can icon. Guidelines for reviewing direct manipulation interfaces are provided in Section 2.2.6.

**Natural Language Dialogues**

In natural language dialogues, users compose entries using a restricted subset of their natural language. The intent is to take advantage of the highly developed skills that people already have in using their own language, and to avoid the need for users to learn artificial dialogues for communicating with computer. Guidelines for reviewing natural language interfaces are provided in Section 2.2.7.

**Query Language Dialogues**

A query language is a special-purpose language designed to allow the user to direct questions to the computer, usually to interrogate a database. Query languages are artificial in the sense that they contain

terms and grammar that are specifically developed for interacting with the computer. Most queries are entered as text strings via keyboards and are often constructed using keywords (e.g., Select, From, and Where). Then a mapping function uses the keywords to examine the database and find all cases that satisfy the query's criteria. A query language may be limited in size to facilitate learning, but they are generally for experienced users. Guidelines for reviewing query language interfaces are provided in Section 2.2.8.

**Question and Answer Dialogues**

Question and answer is a type of dialogue in which a computer presents one question at a time for a user to answer. While many computer dialogues pose questions in some form, to which the user must reply, the question and answer dialogue is distinguished by its explicit structure. At each step of the human-computer interaction, the system issues a single explicit question as a prompt, to which the user responds with a single answer. Answers are usually alphanumeric text strings entered via a keyboard. They may be terms from predefined dialogues (e.g., Yes/No, Increase/Decrease) from a limited grammar, or an arbitrary data item (e.g., a numerical value for a control setpoint). Question and answer systems may allow abbreviations in responses to reduce the number of keystrokes needed. Based upon the answer received, the system may determine which question to ask next. If the user enters an inappropriate answer, the system may issue an error message and then present the question again. This process may be repeated until the user gives an acceptable response. Guidelines for reviewing question-and-answer interfaces are provided in Section 2.2.9.

**Speech**

A speech interface permits the user to provide spoken input, which a computer interprets as data or commands. Speech commands are interpreted by speech recognition systems, which can be either speaker dependent or independent. The latter have the advantage of allowing anyone to enter a command. The tradeoff is that they are less reliable, meaning that the percentage of utterances misunderstood or not recognized is higher. Speaker-dependent systems require individual operators to train the system on the unique characteristics of their voices; these systems are more reliable. Speech recognition systems can also perform more reliably if a limited vocabulary is used. Guidelines for reviewing speech-based interfaces are provided in Section 2.2.10.

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

**CURSORS**

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

**Appearance**

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

**Controls**

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

### Movement

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

### Multiple Cursors

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

### Pointing Cursors

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

### Text Entry Cursors

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

### Multiple Display Devices

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

Guidelines for reviewing cursors are provided in Section 2.3; each of the above aspects of cursors is covered in a separate subsection.

## SYSTEM RESPONSE

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

### Prompts

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

### Feedback

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

### System Response Time

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

Guidelines on system response are in Section 2.4; each of the above characteristics of system response is covered in a separate subsection.

## DISPLAY MANAGEMENT

### Display Selection and Navigation

Display navigation refers to the operation of searching for information, such as finding a desired display in a display network or finding an item of information within a large display. Display selection refers to the operation of retrieving a desired display or item of information. Guidelines for design features related to selection and navigation are given in Section 2.5.1. Subsections address important aspects (orientation features, retrieval features, and navigation features for large displays); each of these is described below.

Orientation Features

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

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

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

Some important characteristics of overview displays are described below:

- Format – overview displays may be presented in many formats, such as a separate page, a window within a display screen, and as stand-alone reference material.
- Parallel presentation – display systems may vary in the availability of the overview display. The display may be retrievable upon demand or continuously presented.
- Indication of current location – overview displays may indicate of the user's current location within the information structure.

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

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

- Scales, axes, and grids – Scales, axes, and grids are sometimes used to provide spatial references for graphically displays. Axes are the graphical representation of orthogonal dimensions in the form of lines (e.g., horizontal and vertical axes). A scale is a graduated series of demarcations indicating the divisions of an axis. A grid is a network of uniformly spaced horizontal and vertical lines for locating points by means of coordinates. Grids may be applied to large displays to divide them into discrete sections, such as those used in geographical maps. If the grid uses a sequential coordinate system such as numbers or letters, then the user may use the coordinates of the current position to determine how much of the display structure lies in each direction around it. Grids are especially compatible with spatially organized information such as maps and mimic displays.
- Perceptual landmarks – These are easily discernable display features that can support the user's understanding of the arrangement of information within a display. Once a landmark is recognized, patterns are quickly activated to guide subsequent searches in its vicinity. When they appear in successive displays, landmarks can provide a frame of reference for establishing relationships between the displays. In graphical displays, major pieces of equipment, such as the reactor vessel or turbine, may serve as landmarks. Labels and headings provide important landmarks for aiding navigation in displays of tabular data or text (e.g., computer-based procedures).
- Display overlap – A single display that is too large to be shown as a single view on a display device may be divided into sections in which some portions repeat (overlap) across successive views. These repeated features establish across-display relationships (e.g., interfacing piping systems may be depicted on another display) and may call attention to other display frames (e.g., the edge of one display may identify the beginning of an adjacent display containing related information). The overlap may present physical or functional relationships between successive views.

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

Retrieval Features

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

Navigation Features for Large Displays

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

- Scrolling – Scrolling is a display framing technique that allows the user to view a display as moving behind a fixed frame. The scrolling action typically causes the data displayed at one end of the screen to move across it, toward the opposite end. When the data reach the opposite edge to the screen they are removed (i.e., scroll off of the screen). Thus, old data are removed from one end while new data are added at the other. This creates the impression of the display page being on an unwinding scroll, with only a limited portion being visible at any time from the screen; i.e., the display screen is perceived as being stationary while the displayed material moves (scrolls) behind it. Displays may be scrolled in the top-bottom direction, the left-right direction, or both.
- Paging – Paging is a display framing technique that allows the user to view a display as a set of display-size pages that are accessed in discrete steps. Thus, rather than being presented as a scroll, the display page is presented as a set of discrete pages. These pages are often accessed sequentially.
- Hierarchical Paging – With this approach, the large display page is divided into a set of smaller pages organized in a hierarchy. The pages vary in the amount of material included from the large display page and the degree of magnification. As the user moves down the hierarchy, more detailed information is accessed from smaller areas of the large display page.
- Panning – Panning is based on a camera analogy; it is similar to moving a camera across a scene. Panning is movement in the left to right dimension across a display screen or from top to bottom; the latter movement is sometimes referred to as "tilt". The distinction from scrolling is one of perspective; panning is the opposite of scrolling. When panning, the viewer perceives the displayed material as being stationary while the viewing area of the display screen moves across it.
- Zooming – Zooming is also based on a camera analogy; the action is analogous to changing the focal length of a camera lens. Zooming-in is similar to moving closer to an object while zooming-out is similar to moving further away from it. Because the size of the display screen is fixed, the effect of zooming-in is to show a smaller area of the display page at a higher magnification; the effect of zooming-out is to show a larger area at lower magnification. Panning capabilities are often provided in conjunction with zooming capabilities.
- Distortion-Oriented Techniques – These techniques allow a user to view details of an area of a large display page while keeping the rest of the page in view. This is accomplished by presenting the focus area at a higher magnification than the rest of the display page. The result is a distorted view of the large display page because different parts of it give the user contextual information. Key features of the unmagnified global structure inform the user of the existence and location of other parts of the information structure and support the interpretation of local details.

### Windows

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

- Closing/Opening – Windows that are not in use may be closed to reduce clutter in the display screen or opened to allow the user to view and interact with the display contained in the window.
- Sizing – The size of the windows on the display screen may be increased (e.g., to make them easier to view) or decreased (e.g., to reduce clutter).
- Positioning – The windows on the screen may be positioned to improve the user's view or to locate related windows adjacent to one another.
- Layering – Layering refers to moving one window so it appears to be positioned on top of another one. The overlapping may be partial, such that the top window covers all but a portion of the other window, or total, such that it entirely covers the other window. The degree of overlap of one window relative to the others may be changed to improve the user's view of or increase the ease of interaction with its contents.
- Tiling – Tiling refers to a configuration in which windows are positioned beside one another like floor tiles. Windows may be arranged in a tiled format so that they can be viewed without overlaps, and related windows are adjacent to each other.

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

Guidelines relating to the design of windows are in Section 2.5.2.

### Display Control

Display controls allow users to select the information that is presented and the format in which it is displayed. Guidelines for this topic are given in Section 2.5.3.

### Display Update/Freeze Features

The update capability of a display system refreshes the data in a display with current values. A display freeze capability prevents a data display from being refreshed with current data values. The freeze capability may be used to provide a view of the status for a specified time or to allow the user to read a rapidly changing display. Display update capabilities are typically initiated automatically; in some cases, the user may be able to adjust the rate of updating. Display freeze capabilities may be initiated automatically or manually. Important characteristics of these capabilities include the degree of user control, the rate of automatic updates, and the designation of the freeze state. Guidelines for this topic are given in Section 2.5.4.

### Display Suppression Features

Display suppression features temporarily remove information that is less important, irrelevant, or otherwise unnecessary, and then redisplay it when needed. The intent is to reduce visual clutter. Important characteristics include the user's degree control over the display suppression capabilities, dedicated keys for this capability, and the designation of the suppressed state. Guidelines for this topic are given in Section 2.5.5.

### Scrolling and Paging

When the area needed to display information exceeds the space provided by the display device or window, users are able to bring selected portions into view by scrolling or paging. Guidelines for this topic are given in Section 2.5.6.

### Automated Actions

Guidelines for reviewing features that automatically perform window management functions are given in Section 2.5.7.

## INFORMATION MANAGEMENT

Computer-based display systems may have capabilities that allow the users to create, change, store, and retrieve documents via the computer. Their important characteristics include the following:

- Creating and Editing Documents – These include features that support the user in creating and changing documents, such as hyphenation, tabs, margins, line breaks, pagination, manipulation of figures and other graphical objects, cutting and pasting, and manipulation of fonts (e.g., font type, underlining, bold).
- Saving Documents – These include features that allow the user to exit a document and save the changes made when editing it.
- Temporary Editing Buffer – These include features that allow the computer to temporarily store information while the user edits a document.
- Excerpt File – This file 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.

## USER ASSISTANCE

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

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

General guidelines for reviewing user assistance features are given in Section 2.7.1. Guidelines for the following specific types of user assistance are given in later subsections of Section 2.7:

### Advisory Messages

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

### Error Messages

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

### User Input Validation

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

### Entry Confirmation

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

### Data Protection

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

### Correction of Information and Command Entries

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

## INTERFACE FLEXIBILITY

Flexibility is built into most interfaces to enable users to tailor their HSIs to meet current task demands and to adjust them to their personal preferences. Guidelines for reviewing the implementation of interface flexibility are given in Section 2.8.

## SYSTEM SECURITY

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

- User Identification – These are capabilities for establishing the identities of authorized users. Important characteristics include password protection, tests to authenticate user identity, and notifications of potential threats to data security, such as from unauthorized personnel.
- Information Access – These are capabilities that reduce the likelihood of files being accessed and changed. Examples include encryption of sensitive data, indication of the data's security classification, administrative controls regarding access to printed data, automatic records of data access, and the use of read-only files.

Guidelines for reviewing system security features are given in Section 2.9.

In the course of developing the guidance for user-interface interaction and management, several considerations were identified that are important to crew performance and safety, but for which the technical basis was insufficient to develop specific HFE guidelines. These aspects of interface design should be addressed on a case-by-case basis using the design process considerations presented in Appendix B2.

# 2 USER-INTERFACE INTERACTION AND MANAGEMENT

## 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.[5908]

### 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.[5908]

### 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, and RAISE-LOWER. 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.[5908]

### 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 operating procedures, labels, messages, and training 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.[5908]

### 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:* Command names should specifically describe the functions being implemented and should reflect the vocabulary and syntax of user's operational language. 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.[5908, 0700]

### 2.1-6 Minimal User Actions

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

Table 2.1 Dialogue formats for representative user tasks

| Task | Command Language | Menus | Function Keys | Macros and Progr. Keys | Forms | Direct Manipulation | Natural/Query Language | Question/ Answer | Speech |
|---|---|---|---|---|---|---|---|---|---|
| Arbitrary entry sequences | X | | | | | X | | | |
| Reduce hands-on control | | | | | | | | | X |
| Unpredictable retrieval | | | | | | | X | | X |
| Wide range of control entries | X | | | | | | | | |
| Frequent control/ transactions | | | X | X | | | | | |
| Small command set | | X | X | | | | | | |
| Complex control | | | | X | X | X | | | |
| Large command set | | X | | X | | | | | |
| Routine data entry | | | | | | | | X | |
| Entry order constrained | | | | | | | | X | |
| Data entry flexibility needed | | | | | X | | | | |
| Little arbitrary data input | | X | | | | X | | | |
| Slow computer response time | | | | | X | | | | |
| Fast computer response time | | X | | | | X | | X | |
| Highly trained users | X | | | | | | | | |
| Moderately trained users | | | | X | X | | X | | |
| Little training | | X | | | | X | | X | X |

*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.[5908]

**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.[5908]

**2.1-8 Availability of Information**
Information necessary to accomplish a specific entry (e.g., labels, annotations, prompts, or options lists) should be available to the user when that transaction action is appropriate.
*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, and indication of control mode (if any). Other annotation might be displayed only at user request, such as document status (date last changed or last printed), 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.[5908]

**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.[5908]

**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. A user interface design that permits only forward steps is deficient in that the user must cycle through an entire display series to reach a previous page.[5908]

**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.[5908]

### 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 database. 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 2.1-16 Indicating Control Lockout

If entries must be delayed pending computer processing of prior entries, 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 user who may not look at the display when making entries. Following control lockout, computer readiness to accept further entries should be indicated to the user.[5908]

### 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.[5908]

### 2.1-18 Entry via Principal Display

When data entry is a significant part of a user's task, entered data should appear on the user's main display.

*Additional Information:* When the main 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.[5908]

### 2.1-19 Entry of Corrections

The same explicit ENTER action should be required for entry of corrections as used for the original entry.[5908]

### 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.[5908]

**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.[5908]

**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.[5908]

**2.1-23 Optional Versus Required Entry**
Optional versus required data entries within fields on input forms should be distinct.[5908]

**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.[5908]

**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.[5908]

**2.1-26 Guidance Information**
Users should be able to request guidance information regarding requirements for information of command entry (e.g., syntax, parameters, and options).[5908]

**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 users come to learn menu codes, they might be allowed to enter those codes without necessarily displaying a menu, i.e., those codes might also serve as commands.[5908]

**2.1-28 Stacked Entries**
Users should be allowed to key a sequence of commands or option codes as a single 'stacked' 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 entry without having to view subsequent menus. 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. Entry stacking will permit a transition from simple step-by-step 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.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**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 (such as titles and time signals) whose changes signal the results of user entries.[5908]

**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.[5908]

**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.[5908]

**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 the parameters currently in effect.
*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.[5908]

**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).[5908]

**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.[5908]

**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 and P = Previous page.[5908]

**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.

*Additional Information:* In systems in which selection is made by use of a cursor, formats should be organized to minimize positioning movements of the cursor.[5908, 0700]

**2.1-41 Indicating Appropriate Control Options**
Users should be provided with 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.[5908]

**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.[5908]

**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," and "Go to Main directory") should be available to users at any point in their interaction with the system.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**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).[5908]

**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 that 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.[5908]

**2.1-49 User Transaction Interrupts**
User interrupts and aborts should not modify or remove stored or entered data.[5908]

**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 |

**2.1-50 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).[5908]

**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 be completed, or to schedule the periodic transactions. In many applications, users will wish specified transactions be 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.[5908]

**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 |
| BACK | 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 |

### 2.1-52 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.[5908]

### 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.[5908]

### 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 system should contain sufficient memory to accommodate the user's requirements.[5908]

**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."[5908]

**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.[5908]

**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.[5908]

**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. The direct replacement of a default value in a data field with a new value should not change the definition of the default value.[5908, 6546]

**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.[5908]

**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:* For example, shifts from mouse to keyboard entry and then back again should be minimized. Forcing users shift from one keyboard to another, or move from one workstation to another, to accomplish different input tasks should also be avoided.[5908]

**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.[5908]

**2.1-62 Justification of Entries**
Unless otherwise required by processing or display requirements, alphabetic 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.[5908]

**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.[5908]

**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.[5908]

**2.1-65 Significance of Numeric Values**
Numeric values should be displayed to the level of significance required of the data, regardless of the value of individual input data.[5908]

**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.[5908]

**2.1-67 Consistent Location of Interface Management Controls**
Controls used for interface management tasks should have consistent locations.
*Additional Information:* Interface management controls include user interfaces for selecting displays and navigating within displays. Examples include command fields, function buttons, and scroll bars. Consistent locations are one way to uniquely identify interface management controls to support users in identifying and accessing them.[6546]

**2.1-68 Location of Display Page Navigation Controls**
Controls for navigating within a display page should be separate from the main body of the display screen.
*Additional Information:* Examples of controls for navigating within displays include command fields, function buttons, and scroll bars.[6546]

**2.1-69 Set-Up of Computer-Based Systems**
Preset and automated set-up features should be used to ensure that users do not have to perform these functions while operating the plant.

*Additional Information:* Preset features are ready to use without a separate set-up operation. Automated set-up features are performed by the system rather than by personnel. The demands associated with setting up a computer-based system prior to its use can distract the user from primary tasks. Preset and automated set-up features should be used to minimize system set-up demands that may interfere with primary tasks.[6546]

**2.1-70 Reminders for Interrupted Tasks**
The HSI should provide visual and/or auditory reminders for interrupted tasks.[6546]

**2.1-71 Access to Suspended Tasks**
The HSI should provide simple mechanisms for retrieving displays and controls for tasks that have been suspended.
*Additional Information:* Extensive effort should not be required to either retrieve the display or reconfigure the display so that work may resume on a suspended task.[6546]

**2.1-72 Entry of Data Separators and Delimiters**
The user should not be required to enter data separators or delimiters, such as dashes and slashes.
*Additional Information:* The entry of data separators and delimiters can be time consuming and error prone.[6546]

**2.1-73 Entry of Measurement Units**
The user should not be required to enter units of measure.
*Additional Information:* The entry of dimensional units (e.g., 'gpm') can be time consuming and error prone.[6546]

**2.1-74 Minimize Cursor Travel**
Travel distance for cursors across and between display pages and windows on a display screen should be minimized.
*Additional Information:* Unnecessary cursor movement can increase information access cost and divert mental resources from more important tasks by requiring the user's attention and time for execution.[6546]

**2.1-75 Default Configuration for Decluttering**
Displays that can provide decluttering capabilities should also provide a means for the user to rapidly return the display to its original configuration.[6546]

### 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.[5908]

### 2.2.1-2 General List of Commands

A general list of basic commands, with appropriate command format guidance, should be available to the user.[5908]

### 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.[5908]

### 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 that are destructive or time-consuming are made distinctive.[5908]

### 2.2.1-5 Abbreviation of Commands

Users should be allowed to abbreviate commands.

*Additional Information:* Entries should not exceed 7 characters. 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.[5908, 0700]

### 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. It may be useful, for example, for the system to accept "UP" as well as "RAISE."[5908]

### 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.[5908]

### 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."[5908]

### 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. In addition, 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

**2.2.1-14 Illustrations in Guidance Information**
Where possible, guidance information should be accompanied with graphical illustrations of command content and syntax.[5908]

**2.2.1-15 User-Defined Abbreviations and Aliases**
Experienced users should be able to define abbreviations or aliases for commands.
*Additional Information:* Abbreviations and aliases can reduce the time required to enter commands.[6546]

**2.2.1-16 Aiding Command Recall**
The system should provide features that support users in recalling command names.
*Additional Information:* Some of the features that can provide such support include:

- User-requested prompts – These are prompts invoked by the user (e.g., via on-line help or function keys) which may indicate the allowable parameters of a command entry or available command options.
- User-assigned command names – Some display systems allow the users to assign names to commands. This capability may support recall, for example, when users must use more than one display system having differently defined commands. By providing some flexibility in renaming the commands, users can enhance the consistency between the dialogues.
- Layering of commands – Command dialogues may be designed so that functions are organized in related groups or layers.[6546]

**2.2.1-17 Accepting Minor Variations**
The system should tolerate minor variations in input commands for interface management functions.
*Additional Information:* Examples of this capability include recognition of command synonyms, interpretation of slightly misspelled commands, ability to ignore unnecessary blank spaces, and recognition of simplified command formats (i.e., minimal use of punctuation and delimiters).[6546]

**2.2.2.1-1 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.[5908]

**2.2.2.1-2 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:* If menu options are variable, common elements should maintain their physical relationship to other recurring elements. For example, if the SEND command appears above EXIT in one menu, it should not appear below EXIT in another menu, or be denoted differently (e.g., by the word SUBMIT).[5908]

**2.2.2.1-3 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.[5908]

**2.2.2.1-4 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: __."[5908]

**2.2.2.1-5 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 when (1) it is beneficial to examine every option in detail, (2) the amount of text in each menu item is large, or (3) there is no pointing device available.[5908]

**2.2.2.1-6 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.[5908]

**2.2.2.1-7 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 category, selecting the item, and removing the menu can be accomplished with a minimal number of actions. The primary advantage of a pop-up menu over a pull-down menu is that, depending on the specific implementations, the user may have immediate access to the menu at the screen location of the selection action. 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.[5908]

**2.2.2.1-8 Hiding Menus After a Command is Carried Out**
When a pull-down or pop-up menu item(s) has/have been selected, the menu should revert to its hidden state as the selected command is carried out.[5908]

**2.2.2.1-9 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.[5908]

**2.2.2.1-10 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. When instructions to the user accompany a list of options, the instructions should precede presentation of the list.[5908, 0700]

**2.2.2.1-11 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.[5908]

**2.2.2.1-12 Option Display Dependent on Context**
Menus should display as selectable only those options that are actually available in the current context.
*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. There should be some indication of which options are currently available; see Guideline 2.2.2.5-8.[5908, 0700]

**2.2.2.1-13 Function of Menu Should Be Evident**
Menus should be designed so that the function of the menu is evident to the user.[5908]

**2.2.2.1-14 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 or +BACK). "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.[5908]

**2.2.2.1-15 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).[5908]

**2.2.2.1-16 Number of Options**
Each menu option list should have 4 to 8 options.
*Additional Information:* Menus with only two options should be avoided. "Menus" with only one item should not be used.[5908]

**2.2.2.1-17 Equivalent Keyboard Commands**
When equivalent keyboard commands are provided, they should be displayed as part of the menu option label.[5908]

**2.2.2.1-18 Continuous Presentation of Menu**
If continual or frequent reference to menu options is necessary, then the menu should be permanently presented in an area of the screen where it will not obscure other data.
*Additional Information:* If only occasional reference to menu options is necessary, the menu may be presented upon demand.[6546]

**2.2.2.1-19 Providing Default Options**
If one option on a menu is selected more often than the others, then it should be highlighted.
*Additional Information:* Search and selection is enhanced by highlighting and preselecting the default option. For example, the cursor may be automatically positioned over the default option, or the text string for the default option may automatically appear in the input field.[6546]

**2.2.2.1-20 Option Previews**
Where discrimination among options may be difficult for users, menus can provide a preview of options.
*Additional Information:* This will support the user in determining which of the current options should be selected.[6546]

**2.2.2.1-21 Visual Grouping of Menu Options**
If meaningful categories cannot be developed for menu options then visual groups should be created for long menus.
*Additional Information:* Non-categorized menus may be divided into arbitrary visual groupings through the use of space or lines. The groups should be as equal in size as possible. Each group should consist of four to seven options. The use of visual grouping can facilitate visual search.[6546]

**2.2.2.1-22 Critical or Frequently Chosen Options**
Options that are critical or frequently chosen should be quickly accessible using as few steps as possible.
*Additional Information:* Immediate access may be provided through such approaches as dedicated buttons and placing the option on multiple menus.[6546]

**2.2.2.1-23 Initial Cursor Position**
When a menu is first displayed, the cursor should be positioned so that it may be readily located and used.

*Additional Information:* Cursor positioning can reduce unnecessary visual search and cursor movement. If the cursor appears within the menu, then the cursor should be placed beside the option with the highest probability of selection. If the options are about equally likely, then the cursor should be placed beside the first option.[6546]

**2.2.2.1-24 Menu Macro Capability**

A menu macro capability should be provided if it produces faster access.

*Additional Information:* A menu macro capability allows a navigation path to be recorded. The path can then be executed by the user through a command. This capability can reduce the number of navigation steps, compared to accessing a series of menus in sequence. It may provide faster access to information for experienced users.[6546]

**2.2.2.1-25 Use of Multiple Paths**

Multiple navigation paths should be provided to items in the display system.

*Additional Information:* Multiple navigation paths should accommodate a range of user experience in navigating the display system. Highly experienced users should be allowed to use shortcuts, such as 'type-ahead' or 'jump-ahead' to reduce the number of interface management actions required to navigate through the display selection system.[6546]

**2.2.2.1-26 Representation of Menu Structure**

A visual representation of the menu structure should be provided.

*Additional Information:* Where space allows, some aspects of the menu structure should be presented visually so the user is not required to remember it. That is, information should be provided in the user interface to augment or substitute for the user's knowledge of the display navigation structure.[6546]

**2.2.2.1-27 Indicating Selectable Menu Items**

Menu systems should clearly indicate which options are selectable.

*Additional Information:* Two techniques for preventing users from selecting inappropriate options are to present (1) only relevant options and exclude the others, and (2) all options, using a code to designate those that are relevant or available. Three considerations regarding the appropriateness of these methods include the type of options presented (e.g., actions versus destinations), the number of options associated with each node, and the number of options that are applicable to multiple nodes. For example, there may be many options representing destinations in the information structure and only a few of them may be relevant to a particular location in the display network (e.g., the number of parent and descendant nodes that can be accessed from a given node is small compared to the total number of nodes in the network). Thus, for menus containing destination options, it would seem practical to present only the relevant options, rather than all options, and use a code to designate those that are relevant or available. Compared to destination options, options that indicate actions may be more limited in number. In addition, action options may apply to multiple nodes (e.g., the same set of actions may be applicable to a large number of display pages). In such cases, it may be possible to present all options and use a code to designate those that are appropriate. Presenting the irrelevant or unavailable action options using a low-salience code may reinforce learning of the locations of options on the menu panels and, thus, decrease option selection time. The relative advantages of these two methods are not fully understood. In addition, the effects of using both methods in combination (e.g., for menu systems that contain both action and destination options) are not fully understood.[6546]

#### 2.2.2.2-1 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.[5908]

#### 2.2.2.2-2 Default Ordering of Menu Options

Where ordering cannot be determined by the above, alphabetic ordering should be used.[5908]

#### 2.2.2.2-3 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.[5908]

#### 2.2.2.2-4 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.[5908]

#### 2.2.2.2-5 Fixed Menu Order

The order of options on menus should be fixed.

*Additional Information:* The order of options on a menu should not change automatically, such as based on their frequency of use.[6546]

**2.2.2.3-1 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.[5908]

**2.2.2.3-2 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, or a file directory, it might be reasonable for the user to be required to scan multiple display pages to find a particular item. Even in such cases, however, 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.[5908]

**2.2.2.3-3 Consistent Design of Hierarchic Menus**
The display format and selection logic of hierarchic menus should be consistent at every level.[5908]

**2.2.2.3-4 Labeling in Hierarchic Menus**
Hierarchic menus should be organized and labeled to guide users within the hierarchic structure.
*Additional Information:* users will learn menus more quickly if a map of the menu structure is provided as HELP.[5908]

**2.2.2.3-5 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).[5908]

**2.2.2.3-6 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.[5908]

**2.2.2.3-7 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 BACK option.[5908]

**2.2.2.3-8 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.[5908]

**2.2.2.3-9 Distinct Subordinate Menus**
If hierarchical branching is used, each subordinate menu should be visually distinct from each previous superordinate menu.
*Additional Information:* Examples include the display of level numbers and a graphical stacking effect. Successful user operations depend on 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.[5908]

**2.2.2.3-10 Control Options Distinct from Menu Branching**
The display of hierarchic menus should be formatted so that options that actually accomplish control entries can be distinguished from options, which merely branch to other menu frames.
*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 that will result in display of other frames of the hierarchic menu.[5908]

**2.2.2.3-11 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.[5908]

**2.2.2.3-12 Use of Broad, Shallow Menu Structures**
Broad and shallow menu structures, rather than narrow and deep menu structures should be used.
*Additional Information:* Examples of a broad, shallow menu structure and narrow, deep menu structure are provided in Figure 2.1.[6546]

**2.2.2.3-13 Minimizing Menu Choices In the Middle of a Menu Structure**
The number of menu choices should be minimized on menus located midway in a hierarchical menu structure.
*Additional Information:* Users are more likely to get lost in the middle levels of a menu structure.[6546]

**2.2.2.3-14 Direct Selection of Submenus**
Users should be able to select a menu or submenu directly, without going through intermediate selection steps.
*Additional Information:* One method for avoiding intermediate selection steps is to allow users to select nodes directly from a representation of the menu structure.[6546]

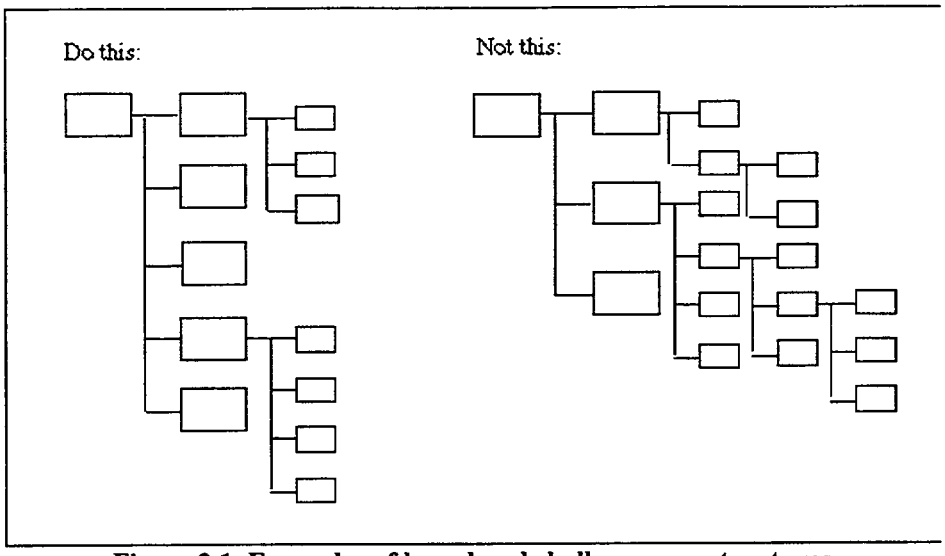


**Figure 2.1 Examples of broad and shallow menu structures**

#### 2.2.2.4-1 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).[5908]

#### 2.2.2.4-2 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.[5908]

#### 2.2.2.4-3 Height of Menu Bar

The height of a menu bar should be sufficient to contain standard text characters that serve as menu category labels, as well as space above and below the text characters.[5908]

### 2.2.2.5-1 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 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.[5908]

### 2.2.2.5-2 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: ___."[5908]

### 2.2.2.5-3 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.[5908]

### 2.2.2.5-4 Bypassing Menu Selection with Command Entry

Experienced users should be able to bypass 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 bypasses 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.[5908]

### 2.2.2.5-5 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.[5908]

### 2.2.2.5-6 Acknowledgment of Menu Selection

When a menu item is chosen, the system should display some acknowledgment of that entry.
*Additional Information:* Acknowledgment that an item has been chosen is often indicated by highlighting the menu item.[5908]

**2.2.2.5-7 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.[5908]

**2.2.2.5-8 Non-Selectable Menu Items**
When menu items are not selectable, they should be identified as such to the user.
*Additional Information:* Options that are temporarily not available may still appear in a menu; see Guideline 2.2.2-36. If non-available options must be displayed, they should be visually distinct from the options that are available. For example, options that are temporarily unavailable may be coded (e.g., presented in gray) to indicate their status.[5908]

**2.2.2.5-9 Separate Selection and Activation Actions**
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 light pen, the pen should have a dual-action "trigger" 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.[5908]

**2.2.2.5-10 Large Pointing Area for Option Selection**
If menu selection is accomplished by pointing, the acceptable area for pointing should be as large as consistently possible, including at least the area of the displayed option label plus a half-character distance around that label.
*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.[5908]

**2.2.2.5-11 Selection of ON/OFF Items**
Selection of menu items with "On" and "Off" states should change their state.[5908]

**2.2.2.5-12 Indicating Selected Menu Items**
Menu systems should provide feedback indicating which options have been selected so far.[6546]

**2.2.2.5-13 Indicating Selectable Area**
Menu systems should provide feedback indicating when a pointing device has entered the selectable area of an option.[6546]

**2.2.2.5-14 Indicating Completion of Selection**
Menu systems should provide feedback indicating when the selection process is ended.[6546]

### 2.2.2.6-1 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, facilitate the design of mnemonic codes for keyed entry, and help users learn commands in systems where commands can be used to bypass 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).[5908]

### 2.2.2.6-2 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.[5908]

### 2.2.2.6-3 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.[5908]

### 2.2.2.6-4 Key Coded Menu Selection

The code associated with each option should be displayed in a consistent and distinctive manner.

*Additional Information:* Periods should be placed after item selection designators. Selection designators should be separated from text descriptors by at least one blank space.[5908, 0700]

### 2.2.2.6-5 Menu Color

If menu options are grouped in logical subunits, the same color should be used for menus within the same group.[5908]

### 2.2.2.6-6 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.[5908]

### 2.2.2.6-7 Highlighting When Cursor Passes Over Item

Menu items that are available should be highlighted whenever the cursor passes over them.

*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.[5908]

### 2.2.2.6-8 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 more prominent.[5908]

### 2.2.2.6-9 Indication of Active Menu Selection

The active menu selection should be indicated to the user.
*Additional Information:* More than one method of indication should be used if possible, such as changes in font size and color.[6546]

### 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 and CANCEL. Interim control refers to an action taken by a user while working with displayed data, e.g., while still keying data entries or changes. Function keys will aid interim control entries partly because those entries may be frequent.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 2.2.3-6 Single-Keying for Frequent Functions

Frequently used functions should be executed by means of a single key action and should not require chord-keying (e.g., use of the shift key).[5908]

### 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, and confirm message transmission in another. 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.[5908]

### 2.2.3-8 Logical Pairing of Chord-Keyed Functions

If chord-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.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**2.2.3-13 Disabling Unneeded Function Keys**

Function keys that are not needed for a current transaction should be temporarily disabled.

*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.[5908]

### 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.[5908]

### 2.2.3-15 Response to Inappropriate Function Key Input

The system should prompt the user for confirmation if a function key is pressed in a context unrelated to the function.
*Additional Information:* The function should not be executed unless the action is confirmed.[5908]

### 2.2.3-16 Layout Compatible with Use

The layout of function keys should be compatible with their use.
*Additional Information:* Key arrangement should reflect the general principles of organization, such as importance, frequency, and order of use. For example, keys for emergency functions should be given a prominent location.[6546]

### 2.2.4-1 User Definition of Macro Commands

Users should be allowed to assign a single name to a defined series of 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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 if the user attempts to assign a previously used name to a macro.[5908]

### 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.[5908]

### 2.2.5-2 Defaults for Command Entry

Appropriate and readily modified default parameters should be displayed in forms used for composing 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

**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.[5908]

**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, modify, or cancel the items before entering the form.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**2.2.5-16 Direct Pointing Devices for Selecting Fields**
Direct pointing devices, such as a mouse or light pen, should be available (1) for selecting fields in complicated forms, or (2) when field entry will be less predictable (as in database update).

*Additional Information:* When input is not predictably structured, it may be preferable to move among fields by direct pointing rather than tabbing.[5908]

### 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 that a user can move from one row to another may be used.[5908]

### 2.2.5-18 Providing Default Information

If certain information is used frequently, then it should be automatically entered into the form as a default.[6546]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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 second) to direct manipulation input.[5908]

### 2.2.6-6 Supplementary Text Labels

If icons are used to represent control actions in menus, a text label should be displayed with each icon to help assure that its intended meaning will be understood.

*Additional Information:* A redundant text label might help make the meaning clear to a user who is uncertain just what a displayed icon means.[5908]

### 2.2.6-7 Graphic Display of Control Context

Graphic means should be provided for displaying the context of current control actions to users.
*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.[5908]

### 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.[5908]

### 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 milliseconds of each other.[5908]

### 2.2.6-10 Size of Icons

Items on the screen that are displayed for selection should be a minimum of 0.2 inch (5 millimeters) on a side and separated by at least 0.1 inch (3 millimeters).[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

**2.2.6-14 Highlighting Selected Elements**
All items currently selected should be highlighted in some way so that the user can anticipate the consequences of any proposed action.
*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.[5908]

**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, or color -- 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.[5908]

**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:* The computer-prompted registration procedures required when devices such as graphics tablets are used to enter data are often error-prone. The design should therefore either permit direct entry of properly registered data on the display surface or have an accurate and easy-to-use registration procedure.[5908]

**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 creating complex graphic displays takes more time. A variety of computer aids can be provided to help enter graphic data. For example, entry of detailed drawings and/or photographic imagery can be accomplished via a video camera and high-resolution digitizer, with facilities provided for a user to edit the result.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**2.2.6-23 Immediate Effect of Direct Actions**
The effects of operations performed on direct manipulation interfaces should be immediately visible.
*Additional Information:* Immediate responses to actions are essential to the user having a sense of acting on the objects of the task domain themselves, rather than upon a representation of the objects through some intermediary.[6546]

### 2.2.6-24 Explicit Messages for Errors Related to Processes

Explicit error messages should be provided for incorrect actions related to the process (as opposed to the interface).

*Additional Information:* In some cases, error messages may not be needed in direct manipulation interfaces because results of actions are immediately visible or because some types of errors may be eliminated. However, the design strategy of relying on the ability of users to detect errors from the behavior of the user interface, rather than providing error messages, has some potential problems. Direct manipulation interfaces have their own problems, which may lead to new types of errors. Some of these errors may be difficult to detect if they are legal operations with respect to the user interface but undesirable actions with respect to the task domain (e.g., plant operation).[6546]

### 2.2.6-25 Meaning of Icons

Representations used as icons should require minimal interpretation.[6546]

### 2.2.7-1 Use of Natural Language Interface

A natural language interface should not be the sole means of taking actions that may have to be done very quickly or reliably.[6546]

### 2.2.7-2 Output of Natural Language System

The outputs of a natural language system should be consistent with the types of entries required of users.
*Additional Information:* Users of natural language interfaces may model their entries after the system's outputs.[6546]

### 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.[5908]

### 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.[5908]

### 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," or "51 or more."[5908]

### 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," or "zero") are particularly difficult for users to deal with. Other potentially confusing quantifiers include indefinite ("some" or "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.[5908]

### 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' and 'or.' However, a query language should be designed so that it does not require logical links. Some logical quantifiers ('greater than' or 'less than') may confuse users.[5908]

### 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.[5908]

### 2.2.8-7 Use of Query Language Interface

A query language interface should not be the sole means of taking actions that may have to be done very quickly or reliably.

## 2 USER-INTERFACE INTERACTION AND MANAGEMENT
### 2.2 User Input Formats
#### 2.2.8 Query Language

*Additional Information:* Query language dialogues are usually used for retrieving data from databases and, as a result, may have fewer applications in NPPs than other interaction formats that may be used for a broader range of activities. The use of query languages can be a difficult task since users must apply a specially developed grammar to construct queries. Consequently, query languages have decreased in popularity as human-computer interfaces for non-programmers. Other types of user interfaces, such as menus and direct manipulation interfaces, are considered easier to use.[6546]

### 2.2.9-1 Request for Information
The system should provide the user with a specific request for information.[5908]

### 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.[5908]

### 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.[5908]

### 2.2.9-4 Constraints on Answer Should Be Indicated
The system should indicate any constraints that apply to the user's response.
*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.[5908]

### 2.2.9-5 Unlimited Room for Answers
The system should accept as much data as the user is willing to provide in an answer.
*Additional Information:* If the information that the system requests is constrained, a data form should be used.[5908]

### 2.2.9-6 Recapitulating Prior Answers
When a series of computer-posed question 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.[5908]

### 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.[5908]

### 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.[5908]

### 2.2.9-9 Question Mark Delimiter
A question mark should be the delimiter of the question 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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 system has to evaluate.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 2.3.1-2 Display of Cursor

The cursor should not move beyond the display boundaries or disappear from sight.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 2.3.2-4 Consistent Positioning
Where cursor positioning is incremental by discrete steps, the step size of cursor movement should be consistent horizontally and vertically.[5908]

### 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.[5908]

### 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, and trackball).
*Additional Information:* Separately manipulated devices (light pen or mouse) will tend to slow the user.[5908]

### 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.[5908]

### 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.[5908]

### 2.3.3-2 Responsive Cursor Control
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.[5908]

### 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:* A cross may suffice (like cross-hairs in a telescope), or perhaps a notched or V-shaped symbol (like a gun sight). Precise pointing will also require a cursor control device capable of precise manipulation. Touch displays, for example, will not permit precise pointing.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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 Information:* Automatic cursor advance is generally not desirable. Programmable tab keys are customarily used for this purpose.[5908]

### 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 guideline may not apply to tasks in which rapid, continuous entry is required (e.g., line drawing or tracking).[5908]

### 2.3.3-9 Display Format Protection

When there are areas of a display in which data entries cannot be made (such as in field labels or in blank spaces that are part of data formatting), the cursor should 'step over' those areas, and they should be insensitive to pointing actions.

*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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 2.3.3-13 Data Entry Independent of Cursor Placement

An ENTER action for multiple data items should result 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.[5908]

### 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).[5908]

### 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.[5908]

### 2.3.4-3 Distinctive Multiple Cursors

If multiple cursors are used, they should be visually distinctive from one another.[5908]

### 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 trackball or other device.[5908]

### 2.3.4-5 Distinctive Control of Multiple Cursors

When multiple cursors are controlled by a single device, the cursor currently being controlled should be clearly indicated.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 2.3.5-2 Pointing Cursor Blink

The pointing cursor should not blink.[5908]

### 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.[5908]

### 2.3.5-4 Pointing Cursor Design

To the greatest degree possible, pointing cursors should be completely graphic and should not contain a label.[5908]

### 2.3.5-5 Pointing Cursor Size Constancy

The pointing cursor should maintain its size across all screen and display locations.[5908]

### 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.[5908]

### 2.3.6-1 Text Entry Cursor Visibility

The text entry cursor should only be visible when text entry is possible.[5908]

### 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.[5908]

### 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.[5908]

### 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").[5908]

### 2.3.6-5 Number of Text Entry Cursors

There should be only one text entry cursor per window.[5908]

### 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.[5908]

### 2.3.7-1 Cursor Motion Across Contiguous Similar Displays

When displays are the same size and are located adjacent to each other, the cursor should appear to move in a smooth, continuous motion from one display device to the next.[6546]

### 2.3.7-2 Cursor Motion Across Physically Separated Dissimilar Displays

When display devices are physically separated, have different orientations, or different sizes, techniques should be employed to help the user keep track of the cursor's position.

*Additional Information:* When display devices are physically separated or dissimilar the cursor motion between them may not be perceptually smooth. That is, the user must translate motion on one display into a different motion in the other or follow the cursor as it 'jumps' across the space separating the displays. These factors may cause the user to lose track of the cursor's location. Various techniques can be used to support the user in following the cursor motion between display screens. The cursor can be made to always enter the other display at a uniquely specified entry point. This method allows the user to anticipate the cursor's location on the other display, which may reduce the time associated with finding it. However, the user must first locate the specified entry point. When display screens have different proportions of height and width, then the user may have difficulty understanding how the cursor position on the edge of one display screen corresponds to a position on the other screen. In such cases, computational techniques can be applied that compensate for the differences in screen sizes to make cursor motion appear more continuous. Alternatively, the small-screen display might overlap a smaller portion of the large-screen display, such that a one-to-one relationship in cursor motion is maintained.[6546]

### 2.4.1-1 Prompting User Entries

Users should be provided with clear and specific information to guide entries during logon/logoff or command or information entry.
*Additional Information:* Prompts may be incorporated in a display and/or provided in response to requests for HELP. Where six or fewer control options exist, they should be listed. Where more input options exist, an example of the type of entry that is required should be presented. If a default value has been defined for null entry, that value should be included in the prompting information.[5908, 0700]

### 2.4.1-2 Prompting Address Entry

When a user 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 user, or reminders of command entries required.[5908]

### 2.4.1-3 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.[5908]

### 2.4.1-4 Prompting Command Correction

When a command entry is not recognized or inappropriate, users 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. It should be possible for the user to correct individual errors without affecting adjacent valid entries.[5908, 0700]

### 2.4.1-5 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 user does not have to count them. For example, "Enter ID: _ _ _ _ _ _ _ _ _" is preferable to "Enter ID (9 characters)."[5908]

### 2.4.1-6 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/YYYY) : _ _/_ _/_ _ _ _."[5908]

### 2.4.1-7 User-Requested Prompts

Users 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.[5908]

### 2.4.1-8 Prompting Data Entry

Prompting should be provided for required formats and acceptable values for data entries.[5908]

### 2.4.1-9 Graphic Display of Control Prompting

Graphic means may be provided for displaying 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 a user to learn the control options available via function keys.[5908]

### 2.4.2-1 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.[5908]

### 2.4.2-2 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.[5908]

### 2.4.2-3 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.[5908]

### 2.4.3-1 Response Time Appropriate to Transaction

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 to 1.0 second; response to other simple entries should be within 2 seconds; error messages should be displayed within 2 seconds.[5908]

**Table 2.4 Maximum and preferred system response times**

| User Activity | Response Time (sec) Maximum | Preferred |
|---|---|---|
| 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 |

### 2.4.3-2 Response Time Appropriate to Tasks

When information from different locations must be compared or mentally integrated, the system response time for information retrieval should be minimized.
*Additional Information:* The system response time for display navigation actions, such as selecting displays or zooming and panning within a display, contributes to the information access cost. Performance of mental integration tasks can be impaired when information access costs increase because mental resources are diverted to the information retrieval task. In addition, as system response time increases, the likelihood that information will be lost from working memory increases.[6546]

**2.4.3-3 Display Average System Response Time**
Average system response time, if affected by the number of on-line users, should be displayed at time of logon.
*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").[5908]

**2.4.3-4 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.[5908]

**2.4.3-5 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.[5908]

**2.4.3-6 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 that further user action is required.[5908]

**2.4.3-7 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.[5908]

**2.4.3-8 Keyboard Restoration**
A signal should be presented when the computer is ready to continue following response time-induced keyboard lockout.
*Additional Information:* For example, the cursor changes back to its normal shape.[5908]

**2.4.3-9 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.[5908]

**2.4.3-10 Maximum System Response Times**
Maximum system response times for real-time systems should not exceed the values presented in Table 2.4.[5908]

**2.5.1.1-1 Organization of the Display Network**

The organization of the display network should reflect an obvious logic based on task requirements and be readily understood by users.

*Additional Information:* 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 them 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. One way of providing a logical, explicit structure for the display network is by providing a consistent hierarchical organization. When each major branch of the network has the same, corresponding set of descendant branches, users can apply their understanding of the layout of one branch to predict how information is organized in similar branches of the network.[6546]

**2.5.1.1-2 Cues to Display Network Structure**

The display system should provide information to support the user in understanding the display network structure.

*Additional Information:* By understanding how information is organized in the display network, the user is better able to determine where to look to find needed information. Examples of cues that support comprehension of network structure include: a view of the overall structure of the display network, navigational landmarks that identify key nodes of the network, and representations of the network that spatially distribute the nodes in a consistent, predictable manner. An information space that has no explicit structure is difficult, if not impossible, to search exhaustively. If an organized exhaustive search of the information space is to be attempted, an organizing structure must be imposed on it. An indication of structure such as a grid should be provided, especially when the space does not contain inherent regular features to define it.[6546]

**2.5.1.1-3 Overview of Display Network**

A display should be provided to show an overview of the structure of an information space, such as a display network or a large display page.

*Additional Information:* Overview displays can support visualizing portions of the organization that are not currently in view and help users to understand the relationships between current and target positions relative to each other and the overall organization. For example, the overview may depict the arrangement of a display network and important display pages within the network. Overview displays, as used in this context, should not be confused with displays that provide summarize important plant status information.[6546]

**2.5.1.1-4 Perceptual Landmarks**

Easily discernable features should appear in successive views and provide a frame of reference for establishing relationships across views.

*Additional Information:* Designers can support wayfinding in computer-based display systems by incorporating features that serve similar functions as the wayfinding features of the physical environment. For example, display networks divide the plant information into discernable places, such as individual displays. A display network is usually based on an underlying organizational principle (e.g., hierarchical, sequential, or relational). In graphical displays, major pieces of equipment, such as the reactor vessel or turbine, may serve as landmarks. Wayfinding may be enhanced when these organizational principles can be readily understood by the user.[6546]

**2.5.1.1-5 Location Cues**

Cues should be provided to help the user retain a sense of location within the information structure.

*Additional Information:* Hypertext-based information structures are often characterized by links that are based on conceptual relationships between the information content (relational links) rather than on structural relationships (e.g., relationships that result from a regular hierarchical structure). In such documents, the user can rely on the familiar structure of the document for orientation, instead of having an understanding of the link structure. For example, having arrived at a location from a conceptually related location elsewhere in a document, a user can relate the current location to the overall structure of the document by noting which volume, section, and subsection is currently accessed, even thought that hierarchy was not actually traversed.[6546]

**2.5.1.1-6 Directional Cues**
Directional cues should be provided.
*Additional Information:* If adequate directional cues are not provided, disorientation will result which will inhibit both wayfinding performance and the acquisition of representational knowledge.[6546]

**2.5.1.1-7 Scales, axes, and grids**
Scales, axes, and grids should be used for spatial representations (such as maps) that exceed a display page.
*Additional Information:* A scale is a graduated series of demarcations indicating the divisions of an axis. Axes are the graphical representation of orthogonal dimensions in the form of lines (e.g., horizontal and vertical axes). A grid is a network of uniformly spaced horizontal and vertical lines for locating points by means of coordinates. Grids may be applied to large displays to divide them into discrete sections, such as those used in geographical maps. If the grid uses a sequential coordinate system such as numbers or letters, then the user may use the coordinates of the current position to determine how much of the display structure lies in each direction around the current location. Grids are especially compatible with spatially organized information such as maps and mimic displays.[6546]

**2.5.1.1-8 Display Page Titles and Identification Codes**
Display page title and identifying information should be used to communicate the position of a display in a larger information space.
*Additional Information:* For example, if display pages are functionally related, their names may be designed to reflect this relationship. Some process control display systems assign a unique numerical or alphanumerical code to each display page. The coding scheme may include prefixes and suffixes to indicate relationships between displays. The prefix identifies the major branch of the menu system (e.g., a major plant system). The suffix indicates the level in the branch. For example, if a four-digit numerical coding scheme is used, the first digit may be used to indicate major branches (e.g., 1000, 2000, 3000), and the second digit to indicate the next lower level of branch (i.e., the second level of branches within the 2000 branch would be 2100, 2200, 2300). This pattern may continue for the remaining digits of the coding scheme.[6546]

**2.5.1.1-9 Orientation Coding**
Orientation coding, such as different background colors and patterns, may be applied to display pages to differentiate them from displays in other parts of the display network.[6546]

**2.5.1.1-10 Display Overlap**
There should be physical or functional overlaps between displays that prevent the displays from appearing as disjointed views.

*Additional Information:* To achieve physical overlap, some portions of a display page may be repeated on other displays. This overlap should include only those features needed to establish across-display relationships and to call attention to other data and display frames. Functional overlap may be achieved by providing pointers to data on related displays. For example, a flowchart or mimic display may include pointers to relevant items in other displays. As another example, displays that present the same plant data at different levels of abstraction can include functionally overlapping information that connects the displays.[6546]

**2.5.1.1-11 Explicit Indication of Context**

If the interpretation of displayed data depends on its context (i.e., the location in the display network), an explicit indication of the context should appear in the display.

*Additional Information:* Knowing one's location in the display network may not be necessary for accessing the next desired location, but it may be important for interpreting the displayed information.[6546]

**2.5.1.1-12 Understanding Successive Views**

A hypertext information system should show how a destination node is related to the point of departure.

*Additional Information:* Disorientation can occur when users do not understand the relationships between successive views of a display system. In hypertext-based information systems, disorientation can occur when making transitions between nodes of the information structure if the relationship between the information in the current and previous nodes is not clear. The basis for a link should be apparent to the user through explanatory text or graphical display techniques. Disorientation may also occur when looking at an overview display after making a transition between nodes. Successive views of the overview display may look quite different due to the complexity of the links between the nodes. For example, when a new node is selected, a new set of relational links may be presented in the overview display.[6546]

**2.5.1.2-1 Flexibility in Display System Interaction**
The display network should provide more than one way to access displays.
*Additional Information:* The range of methods available for interacting with the display network should not increase the level of mental workload of the user, such as through multiple methods that are inconsistent.[6546]

**2.5.1.2-2 Minimal Navigation Path Distance**
Short navigation paths should be provided between display pages that will be used one after the other.
*Additional Information:* Minimizing the navigation distance can reduce the amount of time that information must be held in working memory, thereby reducing cognitive demands on the user. One approach may be to provide broad, shallow menu structures rather than narrow, deep ones. However, the former may be impractical if the total number of menu items is large and the display devices have limited space for presenting them. In such cases, additional navigational mechanisms should be considered such as direct keyword retrieval. Other features for reducing navigation distance should be used such as navigation shortcuts (e.g., buttons for jumping to the top of the menu or major branches without accessing intermediate nodes) and buttons for accessing previous displays.[6546]

**2.5.1.2-3 Short Navigational Distances in Hierarchies**
Navigation distances should be kept short.
*Additional Information:* The interface should be designed to shorten although not necessarily minimize navigation distance. The main menu button is an example of a way to shorten the distance to the top of the menu. Offering direct access to display pages via entry of keywords may impose high cognitive demands when navigating large display networks. It may be more favorable as a supplemental navigation tool for experienced users for frequently accessed displays.[6546]

**2.5.1.2-4 Relatedness of Successive Views**
During navigation, displays should support users' comprehension of the relationships between successive views or destinations.
*Additional Information:* The central processing demands associated with the move may be greater when the current and target positions cannot be seen at the same time on the display page. In such cases, cognitive demands may be imposed for developing a mental representation of the display page and for determining the relationship between the starting and target locations. If the navigation moves proceed as a series of discrete steps, then additional demands may be imposed in developing an understanding of the relationships between each of these discrete views. These processing demands may interfere with the cognitive task involved with information integration.[6546]

**2.5.1.2-5 Time to Complete Navigation**
The time required to complete a display navigation action should be minimized.
*Additional Information:* Moving from one location to another on the display page requires time. It may be affected by such factors as the number of steps in a navigation move, the length of the navigation moves, and the display system's response time. As the length of time increases there is an increased likelihood that the information held in working memory will be lost. Therefore, the amount of time needed to complete a navigation move should be minimized. This may be accomplished by reducing the response time of the display system or reducing the number of actions required to complete a navigation move.[6546]

**2.5.1.2-6 Detection of Navigation Targets**
Navigation targets should be easily detectable.

*Additional Information:* When moving from one location to another on the display page, cognitive demands are imposed on perceptual processes for detecting the target information item. These demands may increase the amount of time required to complete the navigation move and, therefore, increase the likelihood that the information held in working memory will be lost. Therefore, the HSI should be designed to facilitate target detection. For example, the targets should be visually distinct from the background. In addition, the scrolling, panning, or zooming motions should be sufficiently slow when approaching the target so the user can recognize the target.[6546]

**2.5.1.2-7 Lateral Moves in a Hierarchy**
Users should be able to make lateral transitions among locations within a particular level of the site, rather than vertical transitions from the higher-level, central location.
*Additional Information:* This may be accomplished by using Next and Previous keys to sequentially access each of the locations at a particular level.[6546]

**2.5.1.2-8 Simultaneous Display of Related Items**
Users should be able to display related items so they may be viewed simultaneously.
*Additional Information:* If there is a large number of such items, the display may be too large to be viewed at one time and, consequently, will have to be scrolled. However, this may still be more effective than trying to integrate information while making frequent transitions between locations.[6546]

**2.5.1.2-9 Support for 'Top-Down' Strategies for Navigating Hierarchies**
Use of top-down navigation strategies should be supported.
*Additional Information:* Determining relationships between the top-level display and the target may be less demanding than determining the relationship between a start and target screen and then identifying a path through intermediate displays. Therefore, providing features such as the main menu button will aid navigation.[6546]

**2.5.1.2-10 Support for 'Bottom-Up' Strategies for Navigating Hierarchies**
The display system should support users in identifying reversal points.
*Additional Information:* The identification of reversal points can encourage and facilitate the use of bottom-up strategies.[6546]

**2.5.1.2-11 Representation of Distance**
The display system should be represented so that the user's perception of the relatedness of displays is consistent with distance in the structure of the display hierarchy.
*Additional Information:* Designers should strive for compatibility between cognitive (i.e., the user's perception) and organizational distance (as defined by the structure of the display network).[6546]

**2.5.1.2-12 Distortion-Based Orientation**
If user orientation is based on seeing landmarks that are beyond what can fit on a single display, distorted views can be presented to facilitate user recognition of location.

*Additional Information:* These techniques allow a user to view details of an area of a large display page while keeping the rest of the display page in view. This is accomplished by presenting the focus area at a higher level of magnification than the rest of the display page. The resulting display provides a distorted view of the large display page because different portions of the display are presented in different levels of magnification. Local details are emphasized to support interactions, such as the retrieval of detailed information or display selection. The presence of the unmagnified area (the area outside of the focus area) provides the user with contextual information. Showing key features of the global structure in the unmagnified area informs the user of the existence and location of other parts of the information structure and supports the interpretation of local details. [6546]

**2.5.1.2-13 Visually Identifying Hypertext Links**
The visual coding of selectable items should not add visual clutter or decrease the overall effectiveness of the coding scheme.[6546]

**2.5.1.2-14 Typographically Identifying Hypertext Links**
Codes such as bold, italics, and underline should not be used to identify selection points if other conventional uses of these codes in the text, such as to emphasize certain words, is likely to confuse the user.[6546]

**2.5.1.2-15 Identifying Hypertext Links by Cursor Coding**
A selection point should not be identified solely by changes in the cursor.
*Additional Information:* Coding the cursor to indicate links can have disadvantages. First, the changes in the cursor are momentary; they only occur when the cursor is positioned near a link. This reduces the ability of users to anticipate the link. Second, the visual codes, such as changing the shape from a pointer to a set of cross hairs, may be less salient than coding applied directly to the link text. These factors may increase attentional demands for locating links.[6546]

**2.5.1.2-16 Evaluating Hypertext Links**
The user should be able to evaluate the information to which a link refers prior to actually retrieving it.
*Additional Information:* The act of deciding whether to access a particular node imposes a cognitive burden that may interfere with other important tasks. In addition, unproductive searches may interfere with the user's responses or result in the user becoming lost in the information structure during time-critical situations. Therefore, some indication of the nature of the target information (e.g., a 'preview') should be provided.[6546]

**2.5.1.2-17 Navigating Individual Hypertext Nodes**
The amount of information presented at a single node should be consistent with the user's ability to readily navigate to the needed information.
*Additional Information:* There are tradeoffs associated with node size. When the nodes are larger than the display screen, the user may have to scroll, pan, or zoom to view its information. However, when smaller nodes are used, information may be spread over multiple nodes requiring the use of multiple links to access required information. Limited guidance exists on the tradeoff between the demands of manipulating large nodes and accessing multiple nodes. The approach chosen should take into account such factors as the how navigation functions are implemented, the system's response to navigation inputs, and the ways in which links are defined. It should aim to reduce the cost to the user of accessing the information. For example, if scrolling the contents of a node involves a demanding motor task combined with visual search, users may prefer to access additional links to smaller nodes rather than being presented with a single large node. However, if a significant amount of time is needed to access each link, users may prefer fewer, larger nodes. Large nodes may also be acceptable if the system identifies the desired information within the node, rather than just displaying the beginning of the node.[6546]

### 2.5.1.2-18 Backtracking Capabilities in Hypertext Interfaces

Backtrack capabilities should always be available in hypertext interfaces and should function in the same way.

*Additional Information:* Backtrack capabilities, which almost all hypertext systems feature, are vital for allowing users to become reoriented. Some hypertext systems use this capability inconsistently, especially where multiple means are provided for accessing information. This inconsistency can cause problems.[6546]

### 2.5.1.2-19 Multiple Hypertext Navigation Methods

When multiple methods are provided for navigating in a hypertext system, they should function similarly.

*Additional Information:* Users should not have to apply different strategies to accomplish the same task.[6546]

### 2.5.1.3-1 Integrating Information within Large Display Pages

When users are required to integrate information across a large display, the HSI should be designed to minimize navigation burdens for paging, scrolling, and zooming.

*Additional Information:* Minimizing the navigation burdens can make available more cognitive resources for the information integration task. Table 2.5 provides means for reducing navigation demands in large displays that require operations such as zoom, pan, and scroll.[6546]

**Table 2.5 Reducing navigation demands in large displays**

| |
|---|
| *Minimize the complexity of the navigation moves* – Simplifying the navigation action may reduce the demands imposed on cognitive resources, especially central cognitive processes (e.g., determining relationships between the current and desired locations) and response processes (e.g., manipulating the navigation control). The least demands are associated with displays that require no panning, scrolling, or zooming. More demands are associated with displays that require motion in one dimension (e.g., panning in either the vertical or horizontal direction, but not both). Still more demands may be associated with displays that require motion in multiple dimensions (e.g., panning in both the vertical and horizontal directions or panning plus zooming). Therefore, displays should be designed to minimize the number of dimensions that must be manipulated to access the information. |
| *Support comprehension of navigation moves* – The central processing demands associated with the move may be greater when the current and target positions cannot be seen at the same time on the display page. In such cases, cognitive demands may be imposed for developing a mental representation of the display page and for determining the relationship between the starting and target locations. If the navigation moves proceed as a series of discrete steps, then additional demands may be imposed for developing an understanding of the relationships between each of these discrete views. These processing demands may interfere with the cognitive task involved with information integration. The use of design approaches for supporting visual momentum can be applied to large displays to support the user's understanding of the relationships of information items in a display space and reduce information access costs. |
| *Minimize the amount of time needed to complete a display navigation move* – Moving from one location to another on the display page requires time. It may be affected by such factors as the number of steps in a navigation move, the length of the navigation moves, and the display system's response time. As the length of time increases there is an increased likelihood that the information held in working memory will be lost. Therefore, the amount of time needed to complete a navigation move should be minimized. This may be accomplished by reducing the response time of the display system and reducing the number of actions required to complete a navigation move. |
| *Minimize the difficulty of target detection* – When moving from one location to another on the display page, cognitive demands are imposed on perceptual processes for detecting the target information item. These demands may increase the amount of time required to complete the navigation move and, therefore, increase the likelihood that the information held in working memory will be lost. Therefore, the HSI should be designed to facilitate target detection. For example, the targets should be visually distinct from the background. In addition, the scrolling, panning, or zooming motions should be sufficiently slow when approaching the target so the operator can recognize the target. |

**2.5.1.3-2 Consistent Framing for Pan and Zoom**
Framing functions should be performed consistently for panning and zooming operations so that the same area of the display remains in view when switching between zoom and pan modes.[6546]

**2.5.1.3-3 Selecting the Center for Zoom and Pan Operations**
Prior to executing a zoom or pan operation, the user should be able to select a particular position on the display to become the center for that operation.[6546]

**2.5.1.3-4 Default Configuration for Zoom, Pan, and Scroll**
Displays that can be navigated via zoom, pan, or scroll operations should provide a means for the user to rapidly return the display to the default or starting configuration.[6546]

**2.5.1.3-5 Size Compensation for Zoom**
When users zoom a display, the system should compensate for changes in the size of symbols, labels, and other graphical objects.
*Additional Information:* This compensation should maintain these objects at a legible size without allowing them to become unnecessarily large and, thus, cluttering the display. When zooming out on a display page, symbols may be aggregated and presented as a single object to reduce visual clutter, if it is not necessary for users to act on them individually while viewing the display at this level of magnification.[6546]

**2.5.1.3-6 Minimize Scrolling Demands**
Displays should be designed to preclude the need for excessive scrolling.
*Additional Information:* If possible, use a single screen for the full display, unless it causes reading difficulty due to such factors as display crowding.[6546]

**2.5.1.3-7 Column Width of Scrolled Text**
If text is meant to be scanned while it is scrolled, the column width should be 35 or fewer characters across.
*Additional Information:* This value pertains to text that the user must scan while it is scrolled. Text displays in which the user alternates between scrolling and reading may have wider columns.[6546]

### 2.5.2-1 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 changes.[5908]

### 2.5.2-2 Window Selection and Display

Users should be able to select separate data windows that will share a single display screen.[5908]

### 2.5.2-3 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 2.2).
*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.[5908]

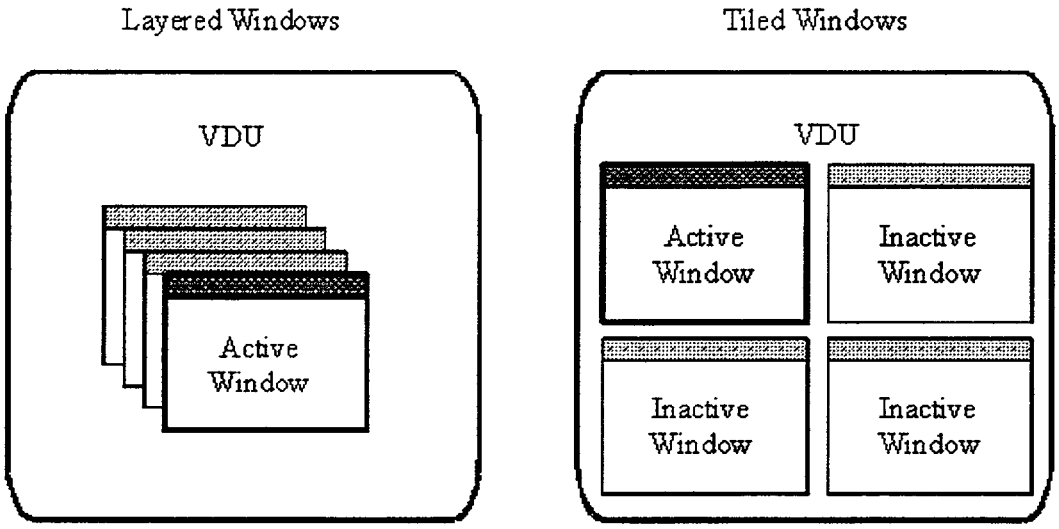


**Figure 2.2 Layered and tiled windows**

### 2.5.2-4 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.[5908]

### 2.5.2-5 Window Demarcation

Windows should be visually separated from each other and from their background, preferably by borders or similar demarcation.[5908]

**2.5.2-6 Distinction Between Window Types**
Window types should be perceptually distinct (see Figure 2.2).
*Additional Information:* For example, active windows in both the tiled and layered window environments should be perceptually distinct from inactive window types.[5908]

**2.5.2-7 Active Windows Priority**
Under normal operating conditions, active windows should be frontmost on the display.[5908]

**2.5.2-8 Caution and Warning Window Priority**
Caution and warning windows should be frontmost on the display.[5908]

**2.5.2-9 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, and data fields).
*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.[5908]

**2.5.2-10 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.[5908]

**2.5.2-11 Minimum Width for Text Windows**
The default width for a generic text window should enable 50 to 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.[5908]

**2.5.2-12 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 option 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.[5908]

**2.5.2-13 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, or adjustable in size.[5908]

**2.5.2-14 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.[5908]

**2.5.2-15 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.[5908]

**2.5.2-16 Closing Windows**
Users should be able to close a window with a single action.[5908]

**2.5.2-17 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.[5908]

**2.5.2-18 Activating a Previously Opened Window**
The user should be able to activate a window 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.[5908]

**2.5.2-19 Activation of Window Cursor**
The action that activates a window should automatically position the placeholding cursor in that window so that the user can provide inputs through that window.[5908]

**2.5.2-20 Multi-Modal Window Designation**
If windows are capable of different modes, the system should provide immediate and unambiguous feedback concerning which mode is active.[5908]

**2.5.2-21 Movable Windows**
Window movement capability should be provided such that the user can move windows to different areas of the display.[5908]

**2.5.2-22 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.[5908]

**2.5.2-23 Smooth Window Movement**
Movement of a window should appear to be smooth and continuous to the user.[5908]

**2.5.2-24 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."[5908]

**2.5.2-25 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.[5908]

**2.5.2-26 Alerting User to Information Availability**
The system should alert the user to critical information that becomes available in an inactive or non-displayed window.[5908]

**2.5.2-27 Window Activates Upon Opening**
The action that opens a window should automatically make that window active.[5908]

**2.5.2-28 Varying Window Size**
Users should be able to change the horizontal and vertical dimensions of a window independently or together.[5908]

**2.5.2-29 Accessibility to Partially Removed Windows**
Windows partially moved off the display should be made readily accessible with a single action.[5908]

**2.5.2-30 Scrollable Windows**
The user should have the ability to scroll through the contents of a window both horizontally and vertically.[5908]

**2.5.2-31 User Control of Automatic Update**
Automatically updated windows should have display freeze capability.[5908]

**2.5.2-32 Multiple Views**
If separate display pages contain information that the user must compare, combine, or otherwise mentally process, then they should be presented simultaneously.
*Additional Information:* Multiple displays can reduce the information access costs associated with alternating between the display pages. This may be accomplished via duplicate display devices or via multiple display windows that can be viewed together on the same display screen.[6546]

**2.5.2-33 Minimize Needs for Window Manipulation**
The amount of resizing, placement, and manipulation of windows required for using the HSI should be minimized.
*Additional Information:* Window controls should be provided to allow users to adjust windows for personal needs. However, unnecessary resizing, placement, and manipulation of windows can increase information access cost and divert mental resources from more important tasks by requiring the user's time and attention. Therefore, the window should be initially presented in the most appropriate form for the user's tasks.[6546]

**2.5.2-34 Obscured Critical Information**
The system should not allow the user to move or resize a window containing non-critical information such that it obscures critical information.[6546]

**2.5.2-35 Positioning Critical Windows**
The system should not allow the user to move a window containing critical information off the display screen.[6546]

**2.5.2-36 Default Window Location**
Windows should have a default location on the display screen.[6546]

**2.5.2-37 Temporarily Obscured Display Data**
Display data that is temporarily obscured by a window object should reappear when the object is removed.
*Additional Information:* If a window object temporarily obscures display data, the data should not be permanently erased.[6546]

**2.5.2-38 Obscuring the Active Window**
A temporary window object should not obscure critical control information and command entry interfaces of the active window.[6546]

**2.5.2-39 Number of Allowable Open Windows**
An upper limit on the number of windows allowed to be open at one time should be defined to ensure that system response time is not compromised.[6546]

**2.5.2-40 Suppression of Window Objects**
An easy means for the user to suppress the display of windows should be provided.
*Additional Information:* Two examples include closing a window and reducing the window to an icon.[6546]

**2.5.2-41 Separate Menu Bars for Applications**
A separate menu bar should be provided for each application window, where different applications are operating concurrently in open windows (e.g., multi-tasking).
*Additional Information:* An example of separate menu bars is shown in Figure 2.3.[6546]

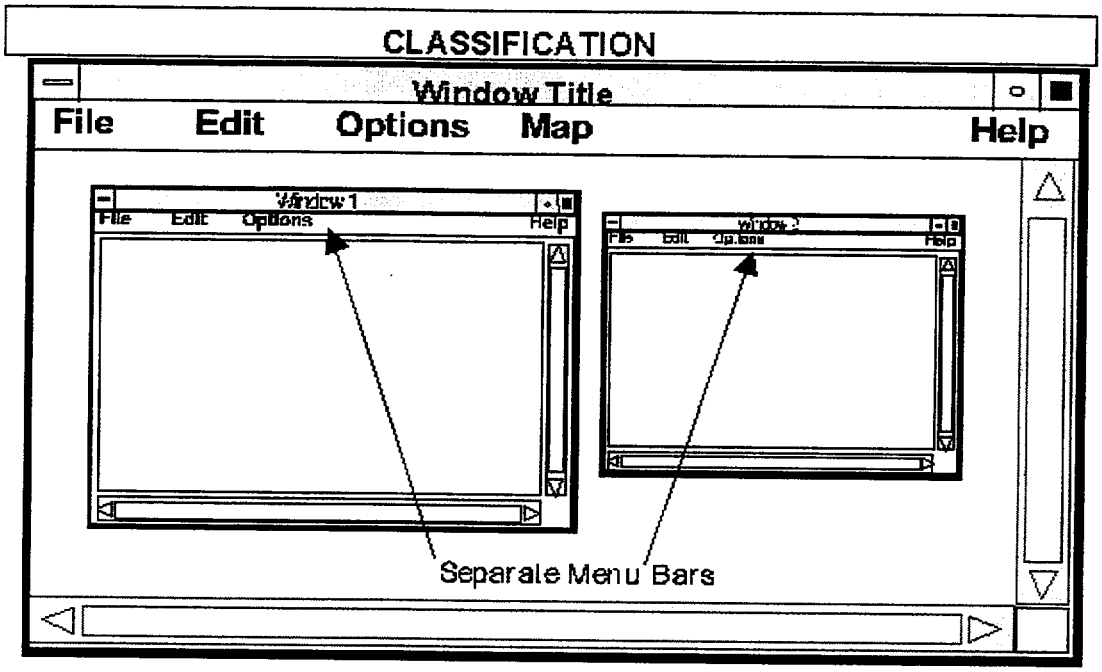


**Figure 2.3 Example of different applications with separate menu bars**

**2.5.2-42 Conveying the Relationship Between Window, Icon, and Action**
The window system should convey to the user the relationship between the window, the icon, and the action when a window is opened or closed.
*Additional Information:* For example, an animated depiction of the window closing may portray the window shrinking to an icon, and vice versa when the window opens (see Figure 2.4).[6546]

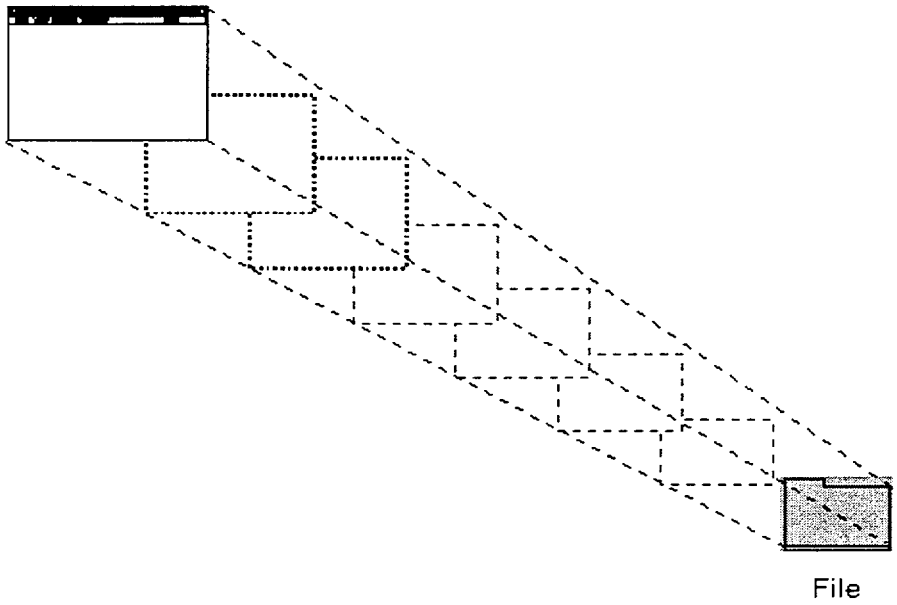


**Figure 2.4 Example of figure animation**

### 2.5.2-43 Labeling Windows

Window objects, dialog boxes, and subordinate windows should be labeled.
*Additional Information:* The labels should convey information important to the use of these items, such as content, purpose, or menu path (e.g., the source or media from which the information originated.)[6546]

### 2.5.2-44 Closing Main Window and Subordinate Objects

When a main application window is closed by the user, all associated subordinate windows and dialog boxes should also close.[6546]

### 2.5.2-45 Matching Selection Items and Window Labels

The titles of subordinate windows should match the menu selection items of the menus from which they are selected.[6546]

### 2.5.2-46 Indication of All Open Windows

The system should indicate all open windows.
*Additional Information:* This indication should allow the user to easily identify all open windows, including any that are hidden. The indication may be presented at the user's request, rather than being continuously displayed. Possible formats include a text list, iconic representation, and network representation. Examples are shown in Figure 2.5.[6546]

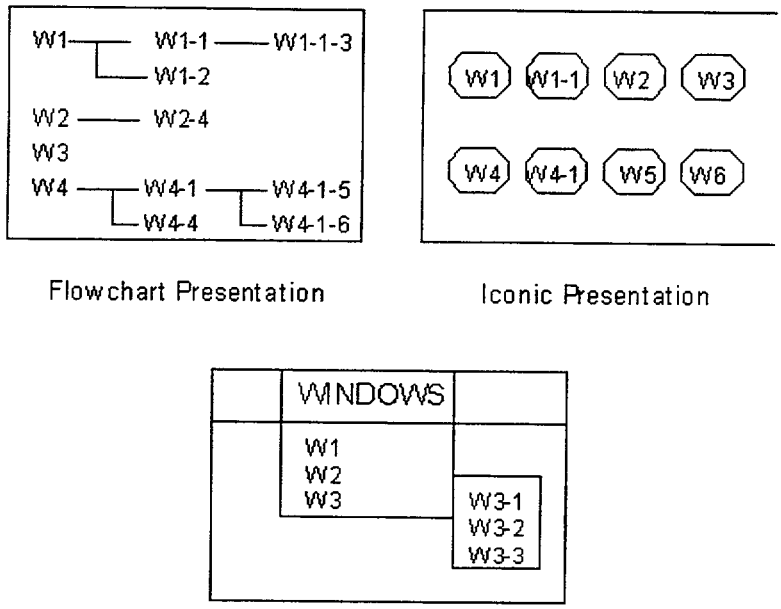


**Figure 2.5 Examples of open window indications**

**2.5.2-47 Window Automation Coordinated with Tasks**
Automated window management should be coordinated with the user's tasks.
*Additional Information:* The system needs to make selections that are relevant to the user's tasks and effectively convey information that resolves questions associated with the user's cognitive demands. This will require that the system contain, or be based on, a good model of the user's functions for the task domain.[6546]

### 2.5.3-1 Display Control
Users should be able to specify the information to be displayed and select the format in which it is presented.[5908]

### 2.5.3-2 Display of Control Options
Screen control locations and control options should be clearly and appropriately indicated.[5908]

### 2.5.3-3 Zooming for Display Expansion
The user should be able to expand the size of any selected area of the display.[5908]

### 2.5.3-4 Functional Labeling for Display Framing
Display framing should be described (e.g., in user instructions and key labels) in functional terms, and wording that implies spatial orientation should be avoided.
*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.[5908]

### 2.5.3-5 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.[5908]

### 2.5.3-6 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 :).[5908]

### 2.5.3-7 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.[5908]

### 2.5.3-8 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.[5908]

### 2.5.4-1 Data Updated as Available
Displayed values should be automatically updated as more current data become available.[5908]

### 2.5.4-2 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.[5908]

### 2.5.4-3 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.[5908]

### 2.5.4-4 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.[5908]

### 2.5.4-5 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.[5908]

### 2.5.4-6 Labeling Display Freeze
When a display is "frozen," the display should be appropriately labeled to remind users of its "frozen" status.[5908]

### 2.5.4-7 Signaling Changes to Frozen Data
When a display being updated in real-time has been frozen, the user should be advised if some significant, but not displayed, change should be detected in the computer processing of new data.[5908]

### 2.5.4-8 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 at which it was stopped, with the display change lagging real-time data change. Alternatively, a user might choose to see a speeded "replay" of interim changes to regain current display status.[5908]

### 2.5.5-1 Temporary Suppression of Displayed Data

The user should be able to temporarily suppress standard data displays.[5908]

### 2.5.5-2 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.[5908]

### 2.5.5-3 Signaling Changes to Suppressed Data

Users should be advised if some significant (but not displayed) change is detected in the computer processing of new data when data have been suppressed from a display.[5908]

### 2.5.5-4 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.[5908]

### 2.5.5-5 Dedicated Function Key

Function keys used to restore suppressed data should have no other use.
*Additional Information:* For instance, if a user presses a key to restore suppressed data, that key should only restore the data, and should not also move the cursor to some other position.[5908]

### 2.5.6-1 Continuous Text Data
Paging and windowing should not be used when searching through continuous text data.[5908]

### 2.5.6-2 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."[5908]

### 2.5.6-3 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.[5908]

### 2.5.6-4 Framing Applied to All Data
Framing functions (e.g., panning, zooming) should affect all displayed data in the same way.
*Additional Information:* For example, when a mimic display is scrolled, background items such as representations of piping and components should move integrally with overlaid "active" data.[5908]

### 2.5.6-5 Paging Controls
Users should be allowed to move easily from one page to another for displays that are partitioned into separately displayable pages.[5908]

### 2.5.6-6 Horizontal Scrolling
The user should have the ability to shift the text information shown 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).[5908]

### 2.5.6-7 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.[5908]

### 2.5.6-8 Common Display Structure
Display structure used for scrolling and paging should be common to all files.[5908]

### 2.5.6-9 Scrolling/Paging Techniques
Users should have the ability to scroll or page using several different techniques.
*Additional Information:* For example, paging should be available 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.[5908]

### 2.5.6-10 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.[5908]

**2.5.6-11 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.[5908]

**2.5.6-12 Evident Direction of Paging**
The direction that users must page (toward the top or bottom, left or right) should be evident to users before they begin to page.
*Additional Information:* For example, scroll arrows on a scroll bar might point in the direction that corresponds to the paging direction.[5908]

**2.5.6-13 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.[5908]

**2.5.6-14 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.[5908]

**2.5.6-15 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 indicate (1) the absolute position by containing the page number in the data file, and (2) the relative position by means of the spatial location of the icon on the scroll bar.[5908]

**2.5.6-16 Graphic Indication of Scroll Position**
Large display outputs that 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.[5908]

**2.5.6-17 Scroll by Line or Display Unit**
The scroll motion rate should allow the user to scroll by line or by display unit.[5908]

**2.5.6-18 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.[5908]

**2.5.6-19 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.[5908]

### 2.5.7-1 Anticipation of Automated Interface Management Actions

Automated interface management features should be designed such that their operation can be anticipated by users.

*Additional Information:* Task performance can be enhanced by HSI features that present task information in ways that support planning and prioritization. If automatic actions cannot be anticipated by the user, additional cognitive resources may be required to continually monitor the automated system.[6546]

### 2.5.7-2 Observability of Automated Interface Management Actions

The operation of automated interface management features should be apparent to the user.

*Additional Information:* Automated interface management features that provide little feedback when they act may require the user to divert attention away from current tasks to determine whether the change has occurred. Understanding of automatic actions can be supported by requiring the user to approve actions prior to execution.[6546]

### 2.5.7-3 Distracting Automated Interface Management Actions

The operation of automated interface management features should not draw excessive attention from the user.

*Additional Information:* HSI features that draw excessive attention or cause distractions may draw cognitive resources away from the user's primary tasks and diminish overall performance.[6546]

### 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 used.[5908]

### 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 and tables. 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.[5908]

### 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 that 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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).[5908]

### 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.[5908]

### 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 by 17 page.[5908]

### 2.6.1-12 Automatic Line Break

For entry/editing of unformatted text, an automatic line break ("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.[5908]

### 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 it is not provided, an advisory message should be presented to the user.[5908]

### 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.[5908]

**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.[5908]

**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 than will fit into a page. The computer should accommodate text insertions with automatic repagination.[5908]

**2.6.1-17 Head- and Foot-of File**
The means should be provided to readily move the cursor to the head (beginning) or the foot (end) of the file.[5908]

**2.6.1-18 Inserting**
When inserting words or phrases, items to be inserted should be displayed as the final copy will appear.[5908]

**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 and bolding.[5908]

**2.6.1-20 Multiple Methods of Searching**
Users should have multiple methods for searching for lines or alphanumeric strings.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**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. However, the user should be able to replace a word with incorrect case with a correct version.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

**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.[5908]

### 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.[5908]

### 2.6.1-32 Pasting the Same Text More than Once

Pasting the most recently cut or copied text should have no effect on the users' ability to paste the same text again.
*Additional Information:* Users should be able to paste the most recently cut or copied text as many times as they choose. The text to be pasted is replaced only when new text is cut or copied.[5908]

### 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 it was prior to the cut.[5908]

### 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.[5908]

### 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 or when the end of the display page is reached.[5908]

### 2.6.1-36 Non-Contiguous Blocks of Text

Users should not be able to select non-contiguous blocks of text when copying, cutting, or 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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."
*Additional Information:* Systems with a single 'exit' command typically protect against exiting without saving by prompting the user to save whenever 'exit' is invoked while there are unsaved changes, and requiring an explicit 'exit without save' choice; see Guideline 2.6.2-5.[5908]

### 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.[5908]

### 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 simple action.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 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.[5908]

### 2.6.4-2 Excerpt File

Users should have the capability to create multiple excerpt files.[5908]

### 2.6.4-3 Integrating Data

The user should have the capability to integrate new data with data already in the excerpt 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.[5908]

### 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.[5908]

### 2.6.4-5 Saving Excerpt File

The user should be able to save the excerpt file.[5908]

**2.7.1-1 Standard Display Location**
System messages should appear in standard locations.
*Additional Information:* Messages may be provided in window overlays.[5908]

**2.7.1-2 Consistent Format for System Messages**
Consistent grammatical construction should be used in system messages.[5908]

**2.7.1-3 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."[5908]

**2.7.1-4 Concise Wording of System Messages**
System messages should be concise and clearly worded.[5908]

**2.7.1-5 Speaking Directly to Users**
Wording for system messages should be directed at the user.
*Additional Information:* For example, "Press ENTER to continue" is preferable to "The operator should press ENTER to continue."[5908]

**2.7.1-6 Only Necessary Information Displayed**
No extraneous information should be displayed.
*Additional Information:* Only relevant data to a task or operation should be displayed.[5908]

**2.7.1-7 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.[5908]

**2.7.1-8 User Control of Automated Guidance/Help**
Experienced users should be able to define when and how guidance will be provided by automated guidance/help systems.
*Additional Information:* The type and degree of guidance needed from guidance/help systems varies with the level of expertise of the user. Less experienced users of the HSI should be provided with few options for controlling the presentation of guidance/help.[6546]

**2.7.1-9 Content of Online Help**
The content of help information should be oriented toward users' completion of their tasks; i.e., the information should be procedural.[6546]

**2.7.1-10 Display of Online Help**
The display of online help should not obscure important information.
*Additional Information:* Online help systems that are window-based can be beneficial because they present help information directly on the task display, allowing users can glance between the help and the task rather than referring to a separate manual or display. However, if multiple windows are already open, the presence of an additional help window may obscure important information.[6546]

### 2.7.1-11 Interaction Styles

Online help should accommodate users' differing levels of expertise and preferred interaction styles.
*Additional Information:* Users may vary in their proficiency and preferences in using some interface management techniques.[6546]

### 2.7.2-1 Distinctive and Consistent Advisory Messages

Advisory messages should be distinctive.

*Additional Information:* The salience of the message presentation should be appropriate to its content. For example, messages regarding potential data loss might be marked with a blinking symbol and/or displayed in red, and be accompanied by a distinct auditory signal (see Guideline 2.7.2-2). Error messages might be marked with a different special symbol and/or displayed in yellow.[5908]

### 2.7.2-2 Redundant Display

Important information should be presented through both visual and auditory means.

*Additional Information:* The visual display of important information should be redundant, using pictures, schematics, color, and text. Such information should be accompanied by an auditory alerting tone.[5908]

### 2.7.2-3 Informing Users of Potential Data Loss

Protection against data loss should be provided.

*Additional Information:* During logoff, the system should check pending transactions to determine if data loss seems probable. If so, the computer should prompt for confirmation before the logoff command is executed.[5908]

### 2.7.2-4 Time-consuming processes

Users should be informed when a command will be time-consuming to process.

*Additional Information:* Typical response times for various types of commands are given in Section 2.4.3, System Response Time. Advisory messages may be provided when response time will exceed the maximum amounts given.[5908]

### 2.7.3-1 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." Users should not have to search through reference information to translate error messages.[5908]

### 2.7.3-2 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."[5908]

### 2.7.3-3 Neutral Wording for Error Messages

Error messages should use neutral wording.

*Additional Information:* Error messages should not imply blame to the user, 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."[5908]

### 2.7.3-4 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.[5908]

### 2.7.3-5 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, no action should occur when attempting to print a document from within an edit mode.[5908]

### 2.7.3-6 Advisory Error Messages

Where data or control entry is made from a small set of alternatives, error messages should indicate the correct alternatives.[5908]

### 2.7.3-7 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.[5908]

### 2.7.3-8 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.[5908]

### 2.7.3-9 Indicating Repeated Errors

If a user 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.[5908]

### 2.7.3-10 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.[5908]

### 2.7.3-11 Multilevel Error Messages

Following the output of a simple error message, users 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.[5908]

### 2.7.3-12 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 for confirmation should be displayed.
*Additional Information:* The user should be alerted to entries that may be in error. For example, "Cooldown rate of 200 degrees per hour is outside the normal range; confirm or change entry."[5908]

### 2.7.3-13 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.[5908]

### 2.7.3-14 Error Message Placement

Error messages should be presented at the point of the error or in a consistent area of the display.[5908]

### 2.7.3-15 Documenting Error Messages

As a supplement to on-line guidance, system documentation should include a listing and explanation of all error messages.[5908]

### 2.7.4-1 Automatic Data Validation
Automatic data validation should be provided to check any item whose entry and/or correct format or content is required for subsequent data processing.[5908]

### 2.7.4-2 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.[5908]

### 2.7.4-3 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.[5908]

### 2.7.4-4 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."[5908]

### 2.7.4-5 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.[5908]

### 2.7.4-6 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.[5908]

### 2.7.4-7 Displaying Default Values
Currently operative default values should be displayed for data entry, so that users can review and confirm them for computer processing.[5908]

### 2.7.4-8 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.[5908]

### 2.7.4-9 Timely Validation of Sequential Transactions
In a repetitive data entry task, the data for each transaction should be validated as it is completed, 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.[5908]

### 2.7.4-10 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.[5908]

### 2.7.4-11 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.[5908]

### 2.7.4-12 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.[5908]

### 2.7.4-13 User Validation

The user should be able to obtain a paper copy (screen dump) of the contents of alphanumeric or graphic displays.[5908]