Style Guide

Technical Report

Non-Proprietary

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Revision History

Revision	Page (Section)	Description
0	All	Issue for Standard

ABSTRACT

Style guide is a document that contains guidelines that have been tailored so they describe the implementation of human factors engineering guidance to a specific design, such as for a specific plant control room.

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List of Acronyms

ANSI	American National Standards Institute
ARP	alarm response procedure
ANSI	American National Standard Institute
CBP	computer-based procedure
EO	electrical operator
EOF	emergency operating facility
ESCM	ESF-CCS soft control module
FPD	flat panel display
HFE	human factors engineering
HSI	human-system interface
HSIS	human-system interface system
HVAC	heating ventilation and air-conditioning
I&C	instrumentation and control
IHA	important human action
LCS	local control station
LOS	line of sight
LCPs	local control panels
LDP	large display panel
MCR	main control room
RCS	reactor coolant system
RO	reactor operator
RSR	remote shutdown room
SDCV	spatially dedicated, continuously visible
SPDS	safety parameter display system
SS	shift supervisor
STA	shift technical advisor
TO	turbine operator
TSC	technical support center
VDU	visual display units

1.0 INTRODUCTION

This human factors engineering (HFE) Guideline has been developed to take an advantage of the human-system interface (HSI) design of the control room in Nuclear Power Plants. The HFE guideline provides design guidance to assure that the HSI design is sufficient and consistent, thus contributing to operational safety.

1.1 Scope

The HFE Guideline contains the design guidance of the APR1400 HSI systems including local control stations (LCSs) associated with important human actions (IHAs), as well as environmental conditions in the following areas:

1) Main control room (MCR),
2) Remote shutdown room (RSR),
3) Technical support center (TSC), and
4) Emergency operating facility (EOF)

1.2 Purpose

The purpose of this document is to provide APR1400 HSI designers with design guidance regarding how the human factors principles may be best of benefit in developing the designs of individual HSI resources. Each HSI designer should be cognizant of the incorporation for all related HFE principles in the design of each HSI resource or control facility. Also, this document is applicable to the related design and engineering work.

2.0 INFORMATION DISPLAYS

2.1 General Guidelines

2.1.1 General Display Guidelines

a) 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.

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

c) Numeral and Letter Styles - Numeral and letter styles should be simple and consistent.

d) 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).

e) Display Title - Every display page should begin with a title or header at the top, briefly describing the contents or purpose of the display.

f) 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.

g) 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.

h) 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.

i) Indication of Transformations Needed - If it is necessary to multiply or divide the displayed

readings by powers of 10 to determine quantitative value, the operation required and result derived must be clearly indicated appropriate Display Format.

j) Display Information Consistent with Control Requirements - Displays should be consistent in word choice, format, and basic style with requirements for data and control entry.

k) Normal Value Reference Index - Displays should contain reference(s) to the values of normal operating condition(s).

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

m) 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.

n) Graphic Display Enhancement with Numeric Values - When precise reading of a graphic display is required, the display should be annotated with actual data values to supplement their graphic representation.

o) Freeze Feedback - If a display has a freeze capability, the display should have an obvious reminder that it is in the freeze mode.

p) Dictionary of Display Element Definitions - The user should have access to a dictionary that contains definitions for all display element conventions through an on-line help or off-line.

q) Labeling Scrollable and Multi-page Displays - General labels and row/column labels should remain along the top (or bottom) and left (or right) edges of the display.

r) Data Overlays - Displayed information which temporarily overlays and obscures other display data should not erase the overlaid data.

s) Physical Overlays - Overlays should not distract or interfere with the observation or interpretation of displayed information.

t) Hardcopy of VDU Displays - Users should be able to obtain a hardcopy of any VDU display without altering the display content.

u) Representation of Individual Parameters - Each relevant process parameter should be represented by a perceptually distinct element within the display.

v) 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.

w) Coherence Mapping - The characteristics and features of the display used to represent the process should be readily perceived and interpreted by the operator.

x) Salience Levels - The salience of graphic features should reflect the importance of the information.

y) 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.

z) Analytical Redundancy - Analytical redundancy should be considered to help ensure the appropriateness of displayed values.

aa) Failure Recognition - Information system failure should be indicated.

bb) 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 operator's tasks.

cc) Correspondence Between Screen and Document - When users will transfer data from hard copy documents, the screen layout should correspond to the hard copy in the order and grouping of data items. For this case, it is desirable that the displayed form look as

much like the source document as possible.

dd) Display Failure Indications - Displays should be designed so that a loss of power or signal to the display or display circuitry is readily distinguished from the range of possible readings for the displayed parameter.

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

2.1.2 General Information Guidelines

a) Redundancy - Redundancy in the presentation of information items should be limited to cases where needed for backup or to avoid excessive operator movement. But, if redundancy gain effects are certain, the redundancy should be used. When the same message is expressed more than once, it will be more likely to be interpreted correctly (Redundancy gain). Specially, this will be particularly true if the same message is presented in alternative physical forms (e.g., tone and voice, voice and print, print and picture, color and shape) (Use multiple resources).

b) 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.

c) 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.

d) Display Information in Directly Usable Form - Information should be displayed to users in directly usable form consistent with the task requirements. For this, integral and configural display formats should be considered.

e) 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.

f) Appropriate Use of Configural Displays - Configural formats should be used when

operators must rapidly transition between high-level functional information and specific parameter values.

1) 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.
2) 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.
3) Salience of Emerging Features: Each emergent feature should be clearly distinguishable for other emergent features and from information on individual parameters.
4) 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.
5) Representation of Individual Parameters: Each relevant process parameter should be represented by a perceptually distinct element within the display.
6) Use of Lower-Level Information: The display should support the user in performing tasks requiring lower-level information.
7) Complexity: The emergent features and their interactions should not be so complex as to be susceptible to misinterpretation.

g) Display Information Consistent with User Conventions - Information should be displayed consistently according to standards and conventions familiar to users.

h) Range of Conditions Displayed - The display system should correctly display information about the plant's safety status including severe accident symptoms.

i) 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.

j) Rapid Recognition of Safety Status Change - User comprehension of a change in the safety status from critical safety function displays should be achieved in a matter of seconds.

k) 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 to control room operators.

l) Critical Safety Function Display Visibility - Critical safety function displays should be readable from the consoles of users needing access to these displays.

m) Critical Parameter Monitoring Support - The system should assist the user in monitoring critical parameters, especially parameters that change very rapidly or very slowly, by alerting the user when values are out of range.

n) Display Enhancement with Time Data - When task performance requires or implies the need to assess currency of information within a display, the information should be annotated with time information.

o) Freezing Rapidly Changing Information - When the display is changing so rapidly that the information is difficult to read, the user should have the capability of viewing the information in a supplemental display.

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

q) Information Display Density - Display packing density should not exceed 50 %. Density should be minimized for displays of critical information. Displays consisting largely of alphanumeric generally should not exceed 25 % density. Displays composed largely of graphics may be more dense. When a display contains too much information for presentation in a single frame, and cannot be refined to accommodate the desired data, it should be organized into separate screens, multi-paged screens, or scrolled/paged lists. However, such steps should not be performed if they cause otherwise unitary tasks to require extensive screen switching.

r) Actual Equipment Responses - Indication devices for remotely instrumented equipment should present actual status/response of the physical plant equipment wherever practical. If this is not practical, indication of ordered action or control power status should be

labeled to denote the specific nature of the indication.

2.1.3 General Coding Guidelines

A. Coding Display Items Requiring Rapid Discrimination - Coding should be provided when a user must distinguish rapidly among different categories of displayed data.

B. Meaningful Codes - Meaningful or familiar codes should be used, rather than arbitrary codes.

C. Consistent Coding Across Displays - Consistent meanings should be assigned to codes, from one display to another.

D. Readability of Coded Information - Coding should not interfere with the readability of displayed information.

E. Coding and Transmission Time - Coding should not increase transmission time.

F. 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.

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

2.1.4 General Information Format Guidelines

a) Simple - A simpler format tends to be easier to use. Thus, uninformative aspects of format should be avoided. For example, unnecessary dividing lines or uninformative words add "visual noise" to a presentation (rather than useful information or "visual signal"). They compete with the informative items for the attention and processing capacity of the operator. Similarly, redundant information should be limited to where it is 1) required for backup, 2) useful in a specific context, or 3) desirable to avoid operator movement (in either physical or virtual workspace).

b) Meaningful - A format should be inherently meaningful. This means more than simply providing information; it implies that the information can be readily understood.

c) Unambiguous - An item is ambiguous if its intended meaning is uncertain or obscured. In coding, this can occur if the encoding/decoding rules are not crisply specified and applied. In messages, this occurs if there is insufficient information in a presentation, e.g., combining "high water temperature" and "low oil pressure" into a single "engine trouble" light in an automobile's dashboard. Note that a prerequisite to designing unambiguous indications is to know how the information element is actually used. An engine trouble light is more appropriate if the driver's response is expected to be "stop the motor and have the car taken to a mechanic" and not "stop the motor, let the motor cool off, check the fluid level, check belts and pump..." etc.

d) Consistent - Meanings and relationships should be consistent among similar elements in similar contexts. If they are not, then users must learn and remember the separate cases, and keep them organized by an additional layer of unnecessary detail. This is mentally laborious and error-prone.

e) Compatible - Where relationships cannot be entirely consistent between contexts, they still should be compatible (i.e., should not conflict) with one another. For example, VDU screens may use the color red to denote active components, while red may also be applied to the color coding of equipment danger tags and placards. Because the two contexts of use are separate, no conflict is identified, Compatibility between the motion of a control and associated display is particularly important: the design of these two components and their relationships can tolerate some inconsistency, but they must never be incompatible.

f) Readable - Visual information needs to be readable. This requires that characters and symbols are legible, and that the symbols are combined into terms and messages by well-known or easily learned rules.

g) Salient - The relative salience between items should correspond to their relative informativeness or significance. Items must be relatively noticeable, so that they can compete effectively with their surrounds for the user's attention. For example, an alarm must be intrusive to perform its function, while component label needs only to be noticeably located and readably sized. Since excess salience can produce distraction and

possibly stress, it is no more desirable than inadequate salience. In addition, if everything is emphasized, then nothing stands out. Note that selecting an appropriate salience level for an item requires some knowledge of the item's surrounds.

h) Cognizance of Users, Tasks, and Working Environment - Displays should be consistent with the knowledge and abilities of the various users (operators and maintainers), their tasks (goals, problems, procedures, equipment), and the working environment (normal and emergency conditions, other external restraints, etc.).

2.2 Display Network

a) Hierarchical Structure - Information should be organized like inverted tree in which the lower branches provide increasingly specific categories related to the more general categories contained in the higher branches and trunk. Hierarchical structure should be described in term of depth and breath. Hierarchical structure should represent functional or physical relationships.

b) Relational Structure - Relation display network structures should have multiple links between nodes, which are based on a variety of relationships.

c) Sequential Structure - A sequential display network structures should organize display pages in a series, representing dependant relationships.

2.3 Display Format

2.3.1 Continuous Text Displays

a) Standard Text Format - A standard text display format should be used from one display to another.

b) Consistency Between VDU-Based Text and Printed Text - VDU displays of textual data, messages, or instructions should generally follow design conventions for printed text.

c) Sentences Begin with Main Topic - The main topic of each sentence should be located near the beginning of the sentence.

d) Clarity of Wording - Text displays should employ simplicity and clarity of wording.

e) Distinct Wording - Distinct words rather than contractions or combined forms should be used, especially in phrases involving negation

f) Concise Wording - The text should be worded concisely to aid comprehension.

g) Affirmative Sentences - Affirmative statements rather than negative statements should be used.

h) Active Voice - Sentences should be composed in the active rather than the passive voice.

i) Temporal Sequence - When a sentence describes a sequence of events, it should be phrased with a corresponding word order.

j) 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.

k) Line Length - Continuous text should be displayed in wide columns, containing at least 50 characters per line.

l) Minimal Hyphenation - In display of textual material, words should be kept intact, with minimal breaking by hyphenation between lines.

m) Conventional Punctuation - Conventional punctuation should be used in textual display.

n) Inter-Line Spacing - The minimum space between lines should be one-half character height.

o) Combining Text with Other Data - Text should be formatted in a few wide lines rather than in narrow columns of many short lines, when it is combined with graphics or other data in a single display, thus limiting the available space.

p) 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.

q) 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.

r) 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.

s) 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.

t) Hardcopy for Lengthy Text Displays - When a user must read lengthy textual material, that text should be available in printed form.

u) Spacing between Paragraphs - Displayed paragraphs of text should be separated by at least one blank line.

2.3.2 Table and List

a) Logical Organization - Information should be organized in some recognizable logical order to facilitate scanning and assimilation.

b) 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.

c) Row and Column Labels - Each row and column should be uniquely and informatively labeled and should be visually distinct from data entries.

d) 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.

e) 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.

f) 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.

g) Consistent Character Appearance - The font and size of alphanumeric characters should be consistent within a table and between related tables.

h) Justification of Alphabetic Data - Columns of alphabetic data should be displayed with left justification to permit rapid scanning.

i) 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.

j) Arabic Numerals for Numbered List Items - Arabic rather than Roman numerals should be used when listed items are numbered.

k) Numbered Items Start with "1" - Item numbers should begin with one rather than zero.

l) Repeated Elements in Hierarchic Numbering - Complete numbers should be displayed for hierarchic lists with compound numbers, i.e., repeated elements should not be omitted.

m) Single-Column List Format - Lists should be formatted so that each item starts on a new line.

n) Marking Multi-line 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.

o) 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.

p) 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.

q) 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.

r) Continuous Numbering in Multi-page 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.

s) 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.

2.3.3 Data Form and Fields

2.3.3.1 Data Forms

a) Consistent Format Across Displays - The ordering and layout of corresponding data fields across displays should be consistent from one display to another.

b) Consistency of VDU and Hardcopy Formats - The format of a VDU data form should be similar to that of commonly used hardcopy source documents.

c) 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.

d) 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.

e) 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.

f) 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.

g) 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.

h) 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.

2.3.3.2 Data Fields

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

b) 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.

c) Separation of Fields Label and Data Entry Area - The label and the data entry area should be separated by at least one character space.

d) Data Field Separation - At least three character spaces should appear between the longest data field in one column and the rightmost label in an adjacent column.

e) 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.

f) 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 character space should be left between each label and the data field.

g) Highlight Active Data Entry Field - The current field to be entered should be highlighted.

h) Data Entry Cues - If appropriate, labels should be used to help cue the user as to the expected data entry.

i) Labeling Groups Data Fields - A field group heading should be centered above the labels to which it applies.

j) Data Field Group Separation - At least five character spaces should appear between

groups of data fields.

2.3.4 Graphs

2.3.4.1 General Graph Guidelines

a) Orientation and Origin - If data are limited as positive number, the graph's origin should be in the lower left of the display. If the data range both positive and negative, the origin should appear in an intermediate position, dividing the axis in proportion to the anticipated ranging.

b) Interpreting Graphs - Graphs should convey enough information to allow the user to interpret the data without referring to additional sources.

c) 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.

d) Old data Renewal - Old data points should be removed after some fixed period of time.

2.3.4.2 Scatter Plot and Trend Graph

a) Trending Time Intervals - Trend displays should be capable of showing data collected during time intervals of different lengths.

b) Multiple Trend Lines - When the user must compare data represented by separate curves, the curves should be displayed in one combined graph.

c) Grouping Scatter plots to Show Multiple Relations - When relations among several variables must be examined, an ordered group (matrix) of scatter plots should be displayed, each showing the relation between just two variables.

2.3.4.3 Flowcharts

a) Logical Ordering of Decision Options - The available decision options should be displayed in logical order.

b) Single Decision At Each Step - Only a single decision should be required at each step.

c) 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.

d) Availability of Supplemental Information - While flowcharts should display only the data immediately required by the user, more detailed data should be available with a single action.

e) Conventional Path Orientation - Flowcharts should be designed so that the path of the logical sequence is consistent with familiar orientation conventions.

f) Flowchart Symbol Set - There should be a standard set of flowchart symbols.

g) Consistency - Words and phrases used for the same purpose should be consistent throughout a flowchart, an application, and related applications.

h) Highlighting - Paths or portions of a flowchart that deserve particular attention should be highlighted.

2.3.4.4 Bar Charts and Histograms

a) General Bar Graphs - Bar graphs should be used for comparing a single measure across multiple entities, or for comparing samples of a variable at discrete intervals.

b) Labeling Single Bars - Each bar on the display should have a unique identification label.

c) Labeling Paired Bars - When bars are displayed in pairs, they should be labeled as a unit, with individual distinguishing labels for each bar.

d) Consistent Orientation of Bars - in a related series of bar charts, a consistent orientation of the bars (vertical or horizontal) should be adopted.

e) Highlighting - If one bar represents data of particular significance, then that bar should be highlighted.

f) Zero Reference on Deviation Bar Charts - The zero reference should be the center of the deviation bar chart.

g) 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.

h) Indication of Magnitude for Deviation Bar Charts - The magnitude of each variable should be displayed when a deviation bar display is used as a primary display format for safety function parameters.

i) 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.

2.3.4.5 Segmented Curve Graphs

a) Depicting Bands in Segmented Curve Graphs - All segments in a segmented curve graph should be related to the total value.

b) 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.

c) 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.

d) Coding to Distinguish Curves - Coding should be used when multiple functions are displayed in a single graph.

e) Display of Projected Values - Curves representing planned, projected, or extrapolated data should be distinctive from curves representing actual data.

f) 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.

2.3.4.6 Linear Profile Chart

a) Coding Linear Profile Charts - The area below the profile line should be shaded to provide a more distinguishable profile.

b) Labeling Linear Profile Charts - Labels should be provided along the bottom to identify each parameter.

2.3.5 Diagrams and Mimics

2.3.5.1 Diagrams

a) Large Diagrams -When a diagram is too large to view all at once, it should be presented in separate sections, with an overview that indicates the separate sections have consistent notation throughout the diagram provide an easy means for users to move among the sections.

b) Highlighting Portions of Diagrams - When portions of a diagram require special attention, those portions should be highlighted.

c) Component Identification - System components represented on mimic lines should be identified.

d) Line Points of Origin - All flow path origin points should be labeled or end at labeled components.

e) Line Termination Points - All flow path line destination or terminal points should be labeled or end at labeled components.

f) Directional Arrowheads - Flow directions should be clearly indicated by distinctive arrowheads.

g) Line Coding - Flow lines should be coded (e.g., by color and/or width) to indicate important information.

h) Overlapping Lines - Overlapping of flow path lines should be avoided.

i) 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.

2.3.5.2 Mimics

a) Aids for Evaluation - When users must evaluate information in detail, computer aids for calculation and visual analysis should be provided.

b) 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.

c) Conventional Use of Arrows - In flow charts and other graphics displays, arrowheads should be used in a conventional fashion to indicate directional relations in the sequential links between various elements.

d) Restricted Use of Borders - Unnecessary borders should not be used in the display.

e) Bordering Single Blocks - A border should be used to improve the readability of a single block of numbers or letters.

f) 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.

2.3.6 Menus

2.3.6.1 Menu Structure

a) Indicating Current Position in Menu Structure - When hierarchic menus are used, the user should have some indication of current position in the menu structure.

b) Distinct Subordinate Menus - If hierarchical branching is used, each subordinate menu

should be visually distinct from each previous super ordinate menu.

c) Control Options Distinct from Menu Branching - The display of hierarchic menus should be formatted so that options which actually accomplish control entries can be distinguished from options, which merely branch to other menu frames.

d) Consistent Entry Prompt - When permanent menus are used, there should be one standard design for the input prompt that is used across all tasks.

e) Menu Color - If menu options are grouped in logical subunits, the same color for menus should be used within the same group.

f) Explanatory Title for Menu - An explanatory title should be provided for each menu that reflects the nature of the choice to be made.

g) Function of Menu - Menus should be designed so that the function of the menu is evident to the user.

h) Non-Selectable Menu Items - When menu items are not selectable, they should be identified as such to the user.

i) Breadth and Depth of Menu Items - Menus should have breadth from 3 to 8 items and depth of less than 3.

j) Highlighting When Cursor Passes Over Item - for all types of menus, menu items that are available to be selected should be highlighted whenever the cursor passes over them and the selection button is down.

k) Consistent Location for Menus - Menus should be displayed in consistent screen locations for all modes, transactions, and sequences.

l) Representation of Menu Structure - A visual representation of the menu structure should be provided.

2.3.6.2 Menu Selection

a) 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.

b) 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 multi-page menu.

c) Visual Representation of Path - Users should be able to access a visual representation of their paths through a hierarchy of menus.

d) 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.

e) Complete Display of Menu Options - A menu should be designed to display all options appropriate to any particular transaction.

f) Options Display Dependent on Context - Menus should display as selectable only those options that are actually available in the current context.

g) 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.

2.3.6.3 Menu Option

A. Arrangement of Menu Options

1) Logical Ordering of Menu Options - Menu options should be ordered and grouped logically.

2) Default Ordering of Menu Options - Where ordering cannot be determined by the above, alphabetic ordering should be used.

3) No Scrolling Menus or Menu Bars - All menu items should be visible to the user without scrolling.

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.

5) Fixed Menu Order - The order of options on menus should be fixed.

B. Wording and Coding Menu Options

1) Worded as Commands - The wording of menu options should consistently represent commands to the computer, rather than questions to the user.

2) Terminology - The wording of options should use terminology familiar to the user but should distinguish each option from every other option in the menu.

3) Consistent with Command Language - When menu selection is used in conjunction with command language interaction, the wording of menu options should be consistent with the command language.

4) Terse Wording - Options should be tersely worded, preferably a single word.

C. Option Organization

1) Visual Grouping of Menu Options - If meaningful categories cannot be developed for menu options then visual groups should be created for long menus.

2) Sequencing of Options within Groups - 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.

3) 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.

4) 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.

5) 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.

2.3.6.4 Menu Types

A. System Menu

1) System Menu - Each system should provide a system menu that includes options to end a session, print selections, review system status, define user preferences, manage alerts, change a password, access peripherals, and perform file management.

2) Organization of a System-Level Menu - The options of a system-level menu should be grouped, labeled, and ordered in terms of their logical function, frequency of use, and criticality.

3) Availability of System-Level Menu Options - Appropriate system-level menu options should always be available.

B. Hierarchical Menus

1) Top-Level Menu - A user should be able to return easily to the top-level menu in a hierarchical menu structure at any time.

2) Return to Next Higher Level - A user should be able to return to the next higher-level menu from anywhere in a hierarchical menu structure with one simple control action.

3) Lower-Level Menus - The options contained in a menu below the top level should be logically related to each other.

4) Menu Titles as Options - Designers should use a subset of menu titles in the pull-down menu as the option items in the hierarchical menu.

5) Organizing and Labeling Hierarchical Menus - Hierarchical menus should be organized

and labeled to guide the user within the hierarchical structure.

6) Consistent Design and Use - The display format and selection logic of hierarchic menus should be consistent at every level.

7) Minimum Number of Levels - A hierarchical menu structure should minimize the number of selections required to reach the desired option. This implies the use of broad, shallow structures as opposed to narrow, deep ones.

8) Indicating Current Position in Menu Structure - An indication of the user's current position in a hierarchical menu structure should be provided.

9) Hierarchical Menus in Graphical User Interfaces - Hierarchical menus designed in a GUI should be as simple as possible avoiding complex graphical structures.

C. Pull-Down Menus

1) When to Use - Pull-down menus should be used rather than pop-up menus if the position of the cursor on the screen is not important for information or option retrieval.

2) Consistent Location - Pull-down menus should always appear immediately below the option whose selection leads to their appearance.

3) Menu Width - The menu should be wide enough to accommodate the longest option and its keyboard accelerator, if present.

4) Titles - The title of a pull-down menu should be the option on the menu bar with which the pull-down menu is associated.

5) Unique Title - The title of a pull-down menu should be unique in the menu bar and, to the extent possible, describe or identify the options in the pull-down menu.

6) Outlining - Pull-down menus should be outlined with a border or drop shadow.

7) Cascading Pull-Down - When a pull-down option leads to a second-level, cascading pull-down, the option label should be followed with a right-pointing arrow.

8) Separators to Divide Groups of Options - Separators should offset choice groups.

9) Number of Options - The number of options in a pull down menu should not be more than 10 or less than 3.

10) Presentation of Options - The options in a pull-down menu should be displayed one option per line.

11) Types of Pull-Down Menu Options - The options in a pull-down menu should be one of five types: commands, names of windows or forms that will be displayed, names of other menus, sets of exclusive options, or sets of nonexclusive options.

- Execution of Commands - Command options should be executed as soon as the user selects them.
- Names of Windows or Forms that will be displayed - When names of windows or forms that will be displayed are used as options in pull down menus, they should be identified by a special symbol, for example, an ellipsis (...).
- Names of Other Menus - When names of other menus are used as options in a pull-down menu, they should be identified by a special symbol, for example, an arrow or triangle that points to the location where the menu will appear.
- Sets of Exclusive Options - Sets of exclusive options should be identified by special symbol, for example, a filled circle for the selected option and an open circle for the unselected options.
- Sets of Nonexclusive Options - Sets of nonexclusive options should be identified by special symbols, for example, a marked square for the selected option(s), if any, and an open square for the unselected option(s), if any.

12) Distinguishing Unavailable Options - When a pull down menu contains options that are temporarily unavailable, the unavailable options should be displayed but clearly distinguishable from available options.

13) Option Selection - A user should be able to select an option on a pull-down menu by moving the pointer onto the desired item and selecting it.

14) Exclusive Option Selection - When only one option in a menu can be selected, a selection indicator should move to the chosen item and remain until another item is

selected with the indicated menu item remaining in effect until another item is chosen.

15) Options Requiring More User Information - When menu items on a pull-down menu require additional user information before the transaction can be completed, the designer should follow each such item with ellipses (…).

D. Cascading Menus

1) When to Use - Cascaded menus should be considered when the menu bar is crowded and the grouping of options is obvious to the user.

2) Cascading Menus - Cascading menus should follow the same guidelines as hierarchical menus.

3) Cascade Indicator - Every cascaded menu item that leads to cascading menus should be marked with a cascade indicator after the menu item name.

4) Number of Levels - Because cascaded menus require the user to remember where options are located or buried (the original menu may be partially hidden by the new cascaded menu), the number of levels should be limited to one.

E. Pop-Up Menus

1) Pop-Up Menus - Pop-up menus should follow the guidelines for standard pull-down menus, except they do not have a title.

2) Attribute Lists - Pop-up menus should not be used for accumulating attribute lists such as text style choices.

3) Actions - Pop-up menus should not be used as a means of providing more commands; therefore, they should not contain actions (verbs).

4) Distinguishing the Pop-Up Menu - The pop-up menu should be made distinct from the screen background by giving it a contrasting yet complementary background or by giving it a solid-line border.

5) Pop-Up Menu Location - A pop-up menu should be placed near the pointer used to select it and near the object or higher-level menu that is being manipulated.

6) Selecting an Option Using a Pointing Device - A user should be able to select an option on a pop-up menu by moving the pointer onto the desired option and clicking the appropriate button.

7) Selection Highlighting - When an option in a pop-up menu remains on display after it has been selected, it should remain highlighted.

8) Pop-Up Menus Leading To Cascading Menus - When an option in a pop-up menu leads to a cascading menu, a right pointing triangle should be placed after the option label.

9) Options Leading to Cascading Menus - Selected options that lead to a cascading menu should remain highlighted and serve as the title for the cascading menu.

F. Toggled Menus

1) Toggled Menu Options - Toggled menu options should be used for two and only two opposite commands that are accessed frequently.

2) Naming Toggled Menu Options - Toggled menu options should begin with verbs that clearly state the outcome of selecting that menu item.

G. Graphic Menus

1) 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.

2) 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.

3) "Opening" An Icon - A user should be able to "open" an icon with a simple, explicit

action.

4) Size of Icons - Icons on the screen that are displayed for selection should be separated by a minimum of 5 millimeters on a side and separated by at least 3 millimeters.

5) 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.

2.3.6.5 Menu Bar

a) Systematic Organization of Items on Menu Bar - The categories listed across the menu bar should be organized systematically.

b) 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.

c) 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.

2.3.6.6 Function Keys for Menu

a) Logical Pairing of Double-Keyed Functions - If double (control/shift) keying is used, the functions paired on one key should be logically related.

b) 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.

c) Labeling Multifunction Keys - If a key is used for more than one function, the function currently available should always be indicated to the user.

d) 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.

e) 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.

f) 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.

2.3.7 Windows

2.3.7.1 General Windows Guidelines

a) Window Selection and Display - User should be able to select separate data windows that will share a single display screen.

b) Window Demarcation - Windows should be visually separated from each other and from their background, preferably by borders or similar demarcation.

c) Window Position - It should not be possible to position windows in such a way that menu bars, access to the command area, or caution and warning messages are obscured.

d) Alerting User to Information Availability - The system should alert the user to critical information that becomes available in an inactive or non-displayed window.

2.3.7.2 Window Components

A. Title Bar and Title

1) See 2.1.1 General Display Guidelines

B. Border

1) Window Identification - Windows should be identified by a label consistently located at

the top of the window's border.

2) Multi-Modal Window Designation - If windows are capable of different modes, the system should provide immediate and unambiguous feedback concerning which mode is active.

C. Scroll-Bar

1) Directional Preference for Scrolling - When there is a choice, vertical (top-to-bottom) scrolling should be used instead of horizontal (left to right) scrolling.

2) Scroll-Bars on Active Windows - Scroll-bars should be displayed in full contrast for the active window only (the window that displays the user's current input.

3) Vertical Scroll-Bar Size - A vertical scroll-bar should be the height of the scrollable portion of the window.

4) Horizontal Scroll-Bar size - A horizontal scroll-bar should be at least one-half the width of the scrollable portion of the window.

5) Changing Scroll-Bar Components - Scroll-bar components should change when the window size or information position changes reflecting the present status.

6) Arrows to Indicate Direction of Scrolling - Directional arrows should be provided in small boxes distinct from the scroll area to indicate the direction that scrolling may be performed.

7) Subdued Directional Arrows - The appropriate directional arrow should be subdued or grayed out if no information is currently available through scrolling in a particular direction.

8) Scroll Area or Container - The scroll-bar should be contained a filled-in bar, which contrasts with the window and the screen body background.

9) Scroll-Bar Entire-Entity Indicator - A scroll-bar should contain a vertical or horizontal line or area along which the scroll box can move, the length of which represents the

entire entity.

10) Scroll Box - A scroll-bar should contain a movable symbol such as a box or rectangle that contrasts with the scroll area.

11) Scroll Box Position - The scroll box should indicate by its spatial position the relative location in the file of the information being viewed.

12) Scroll Box Size - The size of the scroll box should indicate proportionately the amount of the document displayed in the window relative to the percentage of available information in the file being viewed.

13) Indicating Selected Scroll Box - When the scroll box has been selected, it should be indicated to the user in some visually distinctive way.

14) Scroll Box Operations - Users should be able to drag the scroll box continuously along its line or area using a pointing device.

15) Stepping Through Units Using a Scroll-Bar - A scrollbar should contain two symbols that allow a user to step forward or backward through the entire entity a unit at a time (e.g., one page at a time).

D. Control Bar

1) Position - Fixed control bars should located at a fixed position within the application window, and movable control bars should be placed in a supplemental window or a dialog box, able to be moved to a position selected by the user.

2) Display of Control Bars - Users should be allowed to specify which control bars, if any, they wish to display.

3) Location Relative to Window - A window should never conceal the movable control bar with which it is associated.

4) Movable Control Bar Components - A small title bar and control menu box should be provided for each movable control bar.

5) Display of Control Bar - Users should be provided with a means to control whether or not to display the control bar.

E. Push Buttons

1) Same Buttons in Different Windows - When the same buttons are used for different windows, they should be placed consistently in the same location.

2) Consistent Order - Push button order should be consistent throughout an application.

3) Button Order - Buttons should be ordered from left to right (or top to bottom for vertical rows) according to frequency of use, sequence of use, or with positive actions at the left or top and negative or canceling actions at the right or bottom.

4) Grouping Related Buttons - Related push buttons should be placed together.

5) Visibility of Buttons - When push buttons are required for system interaction, they should always be visible on a primary display.

F. Action Icons

1) Action Icons - When a window includes action icons, they should be arranged along the left margin of the window.

2) Action Icons Bound to Window - When a window includes action icons, a user should not be able to move the icons outside the window.

2.3.7.3 Window Types

A. Primary and Secondary Windows

1) Primary Windows - A primary window should contain a title bar, a border, window controls, and a working area or client area.

2) Application Primary Window - Every application should initially display a primary

window.

3) When to Display a Primary Window - Applications should display a primary window as soon as the application starts, without leaving the screen blank.

4) Multiple Primary Window Capability - As necessary for performance of the intended user tasks, an application should be capable of having multiple primary windows open at the same time.

5) Independence of Primary Windows - Primary windows should be independent of one another in the application.

6) Secondary Windows - A secondary window should contain a title bar, a working area, and any of the other window components appropriate to the application.

7) When to Use - A secondary window should be used to temporarily add data (e.g., help screens, menus, or other features) to a display as a means to control or display divergent information or to segregate and control separate operations.

8) Secondary Window Constraints - A secondary window should be associated with a particular primary or other secondary window.

9) Calling Up Other Secondary Windows - A secondary window should be able to call up additional secondary windows to further the interaction.

10) Placement of Secondary Windows - When present, a secondary window should appear within the borders of and on top of (superimposed on) a portion of its "parent" window.

11) Closing a Secondary Window - Closing a secondary window should not affect the parent window.

12) Removing Secondary Windows - A secondary window should be removed when its parent window is removed.

13) Number of Secondary Windows - The number of secondary windows should be limited

to avoid creating navigation problems for the user.

14) Secondary Windows Covering Primary Window - Secondary windows should not cover any part of the primary window that a user needs to see or use to do his or her task.

15) Modeless Secondary Windows - Modeless secondary windows should provide dialogs that do not require immediate attention and commands that do not need to be done before moving on.

16) Modal Secondary Windows - Designers should only use modal secondary windows for serious problems for which an explicit response is required of the user before continuing.

17) Moving Modal Secondary Windows - Modal secondary windows should not be movable.

B. Application Windows

1) Switching Windows - The user should be able to use either the mouse or the keyboard to switch from one application window to another and from one secondary window to another within the same application.

2) Location of Title in Window Title Bar - The window title should appear left or centered in the window title bar, except the window title is placed on the fixed frame.

3) Capitalization of Title - The window title should be in mixed-case letters.

C. Data Entry Windows

1) Data-Entry Window Elements - A data-entry window should contain a title that describes the purpose or contents of the window, a set of labeled fields, vertical or horizontal scroll-bars or both if the contents do not fit in the window's working area, and controls appropriate to the task.

2) Data Window Organization - The organization of a data entry window should be consistent with the task it represents.

3) Multi-Page Data Entry Windows - Every effort should be made to minimize the number of pages in data entry windows, particularly if the user is expected to change pages frequently while entering data. When the contents of a set of data-entry fields do not fit the window working area, a. the window should provide users the ability to page, scroll, or both, through the entire set; and b. if the fields are arranged in rows, columns, or both, the labels of the rows or columns should remain in place when the rows or columns scroll or page.

4) Push Buttons in Data-Entry Windows - When a data entry window contains push buttons, the buttons should be placed in a row at the bottom of the working area, visually separated from the data fields.

5) Controls for Data-Entry Windows - A data entry window should contain the controls appropriate to the task.

6) Saving Entered Data - When a user has finished making entries in a data-entry window, he or she should be able to save the entries by taking an explicit action such as selecting a Save menu option or activating an Apply or OK push.

2.3.7.4 Message Windows

A. Request Message Window

1) Request Message Window Use - A request message window should be used when it is necessary to request information from a user before processing can proceed.

2) Request Message Window Components - A request message window should contain a title, a question symbol, a message indicating the information required and all of the following push buttons that apply in the order in which they are listed: OK, Apply, Reset, Cancel, and Help.

B. Information Message Window

1) Information Message Window Use - An information message window should be used to convey non-critical information that requires acknowledgement.

2) Information Message Windows - Information message windows should be modal and require acknowledgement.

3) Information Message Window Components - An information message window should contain an information symbol, a message, and the following push buttons below the message in the order listed: OK and Help.

4) Information Message Window Behavior - Information message windows should not appear to the user to interrupt processing by the application.

C. Confirmation Message Window

1) Confirmation Message Window Use - Confirmation message windows should be used to request clarification of a previous user action.

2) Requiring User Response - The application should suspend processing until the user responds to a confirmation message window.

3) Confirmation Message Window Components - Confirmation message windows should contain a question symbol, a message, and one of the following sets of push buttons below the message in the order listed: {Yes, No, and Help} or {Yes, No, Cancel, and Help}.

D. Warning Message Window

1) Warning Message Window Use - Critical messages warning users of destructive consequences of actions should be displayed in warning message windows.

2) Suspending Processing - When a warning message window appears, processing should be suspended until a user responds to the message.

3) Warning Message Window Contents - Warning message windows should contain a warning symbol, a message, and one of the following sets of push buttons below the message in the order listed: {Yes, No, and Help} or {OK, Cancel, and Help}.

4) Accompanying Audible Warning Signals - Warning messages should be accompanied by an audible signal.

5) Caution and Warning Window Priority - Caution and warning windows should be front most on the display.

E. Dialog Boxes

1) Modeless Dialog Boxes -Modeless dialog boxes should be used for getting user input and for making changes to a document.

2) Modal Dialog Boxes - Modal dialog boxes should be used to make the user give necessary information before carrying out the current operation.

3) Movable Modal Dialog Boxes - Movable modal dialog boxes should be used when input is needed from the user and for making changes to a document while allowing the user to switch to another application.

4) Dialog Boxes (Control Windows) - Sets of controls that perform similar or related functions should be grouped and presented together in a dialog box (also called a control window).

5) Format - A dialog box should have a border and a title that clearly indicates the function of the set of controls.

6) Unavailable Controls - When a control is temporarily unavailable, it should be displayed at reduced intensity.

7) Push Buttons for Control Functions - Each function of a dialog box should have a push button.

8) Size of Control Windows - Control windows should be smaller than application windows.

9) Visibility of Control Windows - Control windows (dialog boxes), when activated, should

be visible on a primary display.

10) Dialogs Covering Underlying Information - When covering underlying information is a problem, the application should use movable dialog boxes.

11) Movable Dialog Box Format - A movable dialog box should contain a title bar consisting of a control menu and a title.

12) Fixed Dialog Box Format - A dialog box that is immovable should not contain a title bar.

13) Use of Fixed vs. Movable Dialog Boxes - An application should primarily use movable dialog boxes; the user can reposition these to view obscured data.

14) Alert Box Use - Alert boxes (a type of modal dialog box) should be used for communicating error conditions or preventing any other activity until the user responds to the error condition.

15) Indication of Alert Severity - An icon should be provided within the alert box that indicates the degree of severity of the alert message.

F. Error Dialog Box

1) Error Dialog Box Components - An error message window should contain an error symbol, a message, and the following push buttons below the message in the order listed: OK, Cancel, and Help.

2) Error Dialog Box Modality - Error windows should be modal, requiring user acknowledgement in order to continue.

3) Use of an Error Dialog Box - When an error is detected in a system that uses windows, a dialog box should appear that specifies the error.

4) Placement of Error Dialog Box - An error dialog box should not be placed in front of the error.

5) Error Acknowledgement - After the user acknowledges the error, the dialog box should

disappear and the actual field that contains the error should be highlighted.

2.3.7.5 Window States

A. Open Window

1) Input from System - An open window should be capable of receiving input from the system.

2) Visibility - An open window should be completely visible on the screen at the time it is opened and when it is active.

3) 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).

4) 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.

B. Closed Windows

1) When a primary window is closed, it and any of its secondary windows should be removed from the screen.

C. Active Windows

1) Indicates Active Window - If several windows are displayed at once, the window(s) in which action can be taken should be indicated.

2) Window Activates Upon Opening - The action that opens a window should automatically make that window active.

3) Obscuring The Active Window - A temporary window object should not obscure critical control information and command entry interfaces of the active window.

4) Active Windows Priority - Under normal operating conditions, active windows should be front most on the display.

5) Distinguishing Active Windows - An active window should be distinguishable from inactive windows.

6) Overlapping Windows - When windows are allowed to overlap, the active window should be in front of and not overlapped by other windows.

7) Making A Window Active - When a window is made active, all other windows should be made inactive, although there may still be operations (e.g., background processing) occurring in the inactive windows.

8) 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).

9) Activating A Previously Opened Window - The user should be able to put a window in the interactive state by performing any of a set of simple actions in that window or related to that window.

D. Input Focus

1) One Input Focus - Regardless of the number of windows open in an application, only one window at a time (the active window) should be able to receive input from a pointing device or the keyboard.

2) User Assignable Input Focus - Users should be able to assign input focus to any open window of the current application either with a pointing device or from the keyboard.

3) Assigning Input Focus with a Pointing Device - Users should be able to assign input focus to any window that is wholly or partially visible by moving the pointer onto any visible portion (and clicking the appropriate button where explicit input focus is necessary).

4) Window with Input Focus - When any portion of a window was obscured by another

window, upon activation, the window with input focus should be made wholly visible.

5) Moving Input Focus Using the Keyboard - Users should be able to press a single key or specific key combination to move the input focus forward or backward through the open windows one window at a time in the order in which they were opened.

6) Single Object Focus - Only one object in the window having input focus should be able to receive input from a pointing device or the keyboard.

7) Indicating the Object having Input Focus - When an object has input focus, that object should be indicated with a location cursor or highlighting.

8) Location of Input Focus in a Window - When a window first appears, the location cursor or highlighting should be placed on the object that users are most likely to select, for example, a text field or a default push button.

9) Windows Regaining Input Focus - When a window has lost and then regained input focus, the location cursor or highlighting should be placed on the object that last had input focus in the window.

10) Assigning Input Focus to an Object - Users should be able to assign input focus to an object within a window using either the pointing device or the keyboard.

2.3.7.6 Window Operation

A. Minimizing Windows

1) Minimize Window - When a user minimizes an open window, the window should be replaced by the window's icon.

2) Uniqueness of Icons Representing Minimized Windows - Any window that can be minimized should have a unique icon or label that serves as an identifier of the window it represents.

3) Processes Occurring in Minimized Windows - Any processing occurring in a window should continue after the window is minimized.

4) Minimize Operation - Where applicable, the application should provide a minimize operation that changes a window into an icon button at the bottom of the screen.

5) Minimizing a Window Using a Pointing Device - When a window can be minimized, a user should be able to minimize the window by moving the pointer onto the Minimize control in the title bar and clicking the appropriate button or by selecting Minimize from the window menu or control menu.

6) Minimized Window Menu - A minimized window should have a menu that contains the same options as its window system menu with the exceptions of the Resize and Minimize options.(When a window menu includes Resize and Minimize options, these options should appear on the menu as unavailable.)

7) Selecting Options from a Minimized Window Menu - A user should select a minimized window menu item using standard option selection methods.

8) Removing Minimized Window Menu - A user should be able to remove a minimized window menu by moving the pointer off the menu and clicking the appropriate button.

9) Location of Minimized Windows - Unless specified otherwise by the application, the icons representing minimized windows should be placed in the lower left corner of the screen, arrayed in a row from left to right in the order in which they are created.

B. Maximizing Windows

1) Maximizing a Window - When the user clicks on the maximize button, the application should enlarge the window to its largest size or to encompass the entire display screen, which ever is smaller.

2) Maximize Button on Maximized Windows - When a window is maximized, the Maximize button should assume a Restore function and the button should take on the Restore icon and function.

3) Maximize - When the window can be resized, the application should provide a Maximize operation that enlarges a window to its maximum size.

C. Restoring Windows

1) The Restore Function - A click on the Restore button should change the window and any associated secondary windows to the size and location where they had been prior to last being maximized or minimized.

2) Status of Restored Window - A restored window should have active status.

3) Restoring the Window - A user should be able to restore a window and any secondary windows that were displayed when the window was minimized. This was done by moving the pointer and clicking on the icon (or button) representing the minimized window or displaying the menu of the minimized window and selecting Restore.

4) Equivalence of Input Device - It should be possible to restore a minimized window by either using the pointing device.

5) Restoring Window to Default Size - Where applicable, the application should provide a Restore operation that enables a user to restore a minimized or maximized window to its default size.

6) Restore Option on Full Sized Windows - The restore option should be unavailable when the window is its default size.

D. Closing Windows

1) Users should be able to close a window with a single action.

E. Moving Windows

1) Easy Shifting Among Windows - If several windows are open, several easy means should be provided for a user to shift among them.

2) Movable Windows - Windows movement capability should be provided such that the user can move windows to different areas of the display.

3) Smooth Window Movement - Movement of a window should appear to be smooth and continuous to the user.

F. Resizing Windows

1) Resize - Where applicable, the application should provide a Resize operation that enables a user to change the size of a window.

2) Moved or Resized Windows - When a window has been moved or resized or both and is then closed and reopened during an application session, it should reappear in the size and location it had when it was closed.

3) Default Location for Moved or Resized Windows - When a window has been moved or resized in the current session, it should appear in its default location at the next application session, as much as possible.

4) Obscuring Critical Information - Critical information should not be obscured during window resizing.

5) Resizing a Window Using a Pointing Device - When a pointing device is available, a user should be able to resize a resizable window by (1) moving the pointer onto the window's border, (2) pressing and holding the appropriate button on the pointing device, (3) dragging the border to the desired position, and (4) releasing the button resulting in the window being displayed in its new size.

6) Changing Window Using a Pointer - When dragging the border of a window, the window itself or an outline of the window should move with the pointer, indicating the changing size of the window, while leaving the window displayed in its original position.

7) Resizing in One Direction - Resizing a window by placing the pointer onto an edge of the window (top, bottom, or sides) should permit changing its size in one direction only.

8) Resizing in Two Directions - Resizing a window by placing the pointer onto a corner should permit changing the size of a window in two directions at once.

9) Standard Sizing Buttons - Standard buttons should be provided by which the user may control the size of the window (from minimum through variable to maximum).

10) Reformatting of Text, Graphics and Icons - Upon resizing of a window, text, graphics, or icon layouts should reformat so that they remain visible.

11) Only Borders Affected - When a user resizes a window, only the border(s) affected should move, not the objects within the borders.

12) Proportional Image Size Change - When the size of a window changes but the content remains the same, the image size should change proportionately as the window size changes.

13) Scroll Bars - When a window becomes too small to display its objects, vertical or horizontal scroll-bars or both should be added.

2.3.8 Label

a) Group Labels - Each individual aspect of a display (e.g., data group, field, or message) should contain a distinct, unique, and descriptive label.

b) Meaningfulness - Labels should be meaningful words or accepted technical terms.

c) Label Format - Label formats should be consistent across and within displays.

d) Consistent Wording Labels - Labels should be worded consistently, so that the same item is given the same label whenever it appears.

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

f) Label Separation - Labels should be separated from one another by at least two standard character spaces.

g) 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.

h) Label Content for User Options - When presenting a list of user options, labels should reflect the question or decision being posed to the user.

i) Abbreviation in Labeling - a shortened form of a word or phrase shouldn't be used in labeling but the limited text field. The general practice of abbreviations and acronyms is described in Section 2.4.1.3 (refer to Part 1 to Appendix A for standard abbreviations).

2.4 Display Element

2.4.1 Alphanumeric Data

a) Font Style - A clearly legible font should be utilized.

b) Use of Capitals - Capitalization should only be used for: headlines, key phrases or acronyms, short items to draw the user's attention to important text (e.g., field labels or a window title), the first letter in a sentence, or a single character in each word in a title or label.

c) Mixed Case - Mixed case should be used for continuous text, messages, menu descriptions, button descriptions, or screen identification.

d) Consistent Style - Varying sizes or styles of fonts should not be used for any reason other than coding (for example, text as labels, text as data, text as command input).

e) Consistent Fonts - Selected fonts should be used in a consistent fashion throughout the interface, and upper and lower case should be provided with full descenders.

f) Distinguishability of Characters - Fonts used should enable positive absolute discrimination (i.e., discrimination without relative comparisons) of similar characters such as:

I and 1 ; O and 0 ; S and 5 ; U and V ; Y and 7 ; D and 0 ; Z and 2 ; g and 9 ;
I and L ; O and Q ; T and Y ; X and K ; Y and 4 ; D and O ; T and 7 ; UV and W

2.4.1.1 Characters

a) VDU Viewing Distance - The viewing distance should be 13-30 inches (33 to 80 cm), with 18-24 inches (46-61 cm) preferred.

b) Character Height (Information FPD) - The character height and numerals should be at least 12 minutes of arc from the longest anticipated viewing distance. To calculate the minimum character height needed to meet this guidance for a given viewing distance, the formula is :

0.003491 x Reading Distance = Minimum Character Height (@ 12 min. of arc)

c) Character Height (LDP) - The character height and numerals should be at least 11 minutes of arc from the longest anticipated viewing distance. To calculate the minimum character height needed to meet this guidance for a given viewing distance, the formula is :

0.003199 x Reading Distance = Minimum Character Height (@ 11 min. of arc)

d) 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.

e) Stroke Width - Stroke width should be 1/6 to 1/12 of character height for standard applications of text and print.

f) Inter-Character Spacing - Horizontal separation between characters or symbols should be between 10 and 65 percent of character or symbol height.

g) 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.

h) 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.

i) Inter-Paragraphs Spacing - Displayed paragraphs of text should be separated by at least one blank line.

2.4.1.2 Numeric Data

a) Number System - Numeric data should be displayed in the decimal, rather than binary, octal, hexadecimal, or other number system.

b) Numeric Coding - The number of characters used in numeric codes should not be more than six.

c) Numerical Precision - Numbers should be specified at the appropriate precision.

d) Spelled Numbers - Numbers that are spelled out should be consistently spelled under the same conditions.

e) Leading Zeros - Leading zeros in numeric entries for whole numbers should be suppressed. 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).

f) Maintaining Significant Digits - A number should be displayed at the number of significant digits required by users to perform their tasks.

g) Display Range - Numeric displays should accommodate the variable's full range.

h) Rate of Display Change - Digital displays should change slowly enough to be readable.

2.4.1.3 Abbreviations and Acronyms

a) Approved Abbreviations List - Acronyms and abbreviations should be combined and maintained on a single list in Appendix A, Part 1. The approved Abbreviations List will support consistent development of meaningful terms for use by operators, maintainers, designers, engineers, technicians, and other O&M domains.

b) Management of The Approved Abbreviations List - The Approved Abbreviations List should be controlled and updated as necessary to incorporate new terms. The list management process should avoid extraneous terms that will not be used in plant labeling, procedures, tech specs, or other O&M domains.

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

d) Abbreviation Rule - When defining abbreviations which are not common to the user population, a simple rule should be used that users understand and recognize. And the abbreviation rule should be employed consistently. Generally, truncated abbreviations, in which the first letters of the word are presented (e.g., reinforcement is abbreviated by reinf), are processed better than contracted abbreviations, in which letters within the word are deleted (e.g., rnfnt).

e) Distinctive Abbreviations - Abbreviations should be distinctive so that abbreviations for different words are distinguishable.

f) Punctuation of Abbreviation - Abbreviations and acronyms should not include punctuation.

g) 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.

h) 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.

i) 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.

j) Abbreviations in Text Displays - when two words or more in text displays are abbreviated, standard abbreviations should be used in Part 1 to Appendix A. When a word is abbreviated, its first letter should be an uppercase and the rest be lower-cases (refer to Part 1 to Appendix A for standard abbreviations).

2.4.2 Icons and Symbols

a) Symbol Size - Icons and symbols should be large enough for the user to perceive the

representation and discriminate it from other icons and symbols. 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.

b) Graphical Symbols - Shapes codes and pictorial analogs should be used to provide visually direct representation of components and systems. Graphical symbols should be highly legible, and either be based on established conventions (e.g., P&IDs), or be easily learned. Representative symbols used in APR1400 are presented in Appendix C.

c) Appropriate Use of Icons - The primary use of icons in graphic displays should be to represent actual objects or actions.

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

e) Simple Design - Icons should be simple, closed figures when possible.

f) 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.

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

h) Orientation - Icons and symbols should always be oriented "vertical" or "horizontal".

i) No Alternating Words and Symbols - Words and symbols should not be used alternately.

j) Highlighting - An icon or symbol should be highlighted when the user has selected it.

k) Special Symbols - When special symbols are used to signal critical conditions, they should be used for only that purpose.

l) Interpretation - A symbols and icons should give the clear meaning of the object in the context to the viewer.

2.4.3 Scale

a) Scale Zone Banding - Zone banding with color or graphics to denote normal, abnormal, or other categorical operating ranges of a parameter should, if applied, be conspicuous, distinct, and not interfere with the quantitative reading of the display. Zone banding should not be used unless parameter zones can be reliably and usefully defined, and where relevant mode dependencies in the interpretation and display of the parameter can be accommodated.

b) Linear/Nonlinear 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.

c) Logarithmic or other nonlinear scales should be reserved for devices that require at least three orders of magnitude of precise range, and for which nonlinear scaling is deemed conventional or appropriate (e.g., source range reactor power).

d) Engineering Units - Engineering units should be provided on all applicable parameter displays unless percentage scaling is specified (graphical displays may specify dual scales). Engineering units on displays should conform to and be maintained on the APR1400 Engineering Units list. Control of the list should strive to maximize the mutual consistency of the entries, within the constraints of customer requirements and operating conventions.

e) Orientation of Scales - Numbers on a scale should increase clockwise, left to right, or bottom to top.

f) Scale Intervals - Nine should be the maximum number of tick marks between numbers.

g) Axis Labels - Axes should be clearly labeled with a description of what parameter is represented by the axis.

h) Identification of Units of Measurement - The units of measurement represented by the scale should be included in the axis label.

i) Scaling Conventions - Conventional scaling practice should be followed, in which the

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

j) Scales Consistent with Function - The scales should be consistent with the intended functional use of the data.

k) 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.

l) 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.

m) 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.

n) Indication of Scale - When a graphic display has been expanded from its normal coverage, some scale indicator of the expansion factor should be provided.

o) Manual Rescaling - Users should be able to manually change the scale for the purpose of maintaining an undistorted display for different operating conditions.

p) 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.

q) 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.

r) Numbering Grids - Graphs should be constructed so that the numbered grids are bolder than unnumbered grids.

s) 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.

2.4.4 Cursor

2.4.4.1 Appearance

a) Distinctive Cursor - Cursors should have distinctive visual features (shape, blink, or other means of highlighting).

b) Display of Cursor - The cursor should not move beyond the display boundaries or disappear from sight.

c) Stable Cursor - The displayed cursor should be stable.

d) Initial Cursor Placement - On the initial appearance of a data entry display, the cursor should appear automatically at some consistent and useful location.

2.4.4.2 Controls

a) Cursor Control - The user should be able to adjust the sensitivity of the cursor movement to be compatible with the required task and user skills.

b) 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.

c) 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.

2.4.4.3 Movement

a) Responsive Cursor Control - For arbitrary position designation, moving a cursor from one position to another, the cursor control should permit both fast movement and accurate placement.

b) 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.

2.4.4.4 Pointing Cursors

a) 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.

b) Pointing Cursor Blink - The pointing cursor should not blink.

c) Pointing Cursor: Image Quality - Pointing cursors should maintain image quality throughout an entire range of motion within the display. The position of the pointing cursor should be clearly visible during movement from one screen position to another. Flicker should be minimized.

d) Pointing Cursor Design - to the greatest degree possible, pointing cursors should be completely graphic and should not contain a label.

e) 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.

2.5 Display Coding

2.5.1 Color Coding

2.5.1.1 General Color Coding Guidelines

a) Redundant Coding Dimensions - Color should not be the only dimension used to encode and display a set of distinctions. One or more redundant dimensions (e.g., shape, fill, intensity, blink, etc.) should be used in combination with color.

b) Use of Color - Where color is used for coding, it should be employed conservatively and consistently.

c) 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.

d) Color Contrast - The color of the control should contrast with the panel background.

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

f) Color Coding for Discrete Data Categories

1) One Meaning Per Color - Each color should represent only one category of displayed data, if possible.
2) Retain Meaning of Colors - When the user community has previously established meanings for various colors, the designer should retain those meanings. Thus, a color should not signify a different condition than it signified in the previous system.
3) 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.

g) Unplanned Patterns from Color Coding - Color coding should not create unplanned or obvious new patterns on the screen.

2.5.1.2 Color Assignments

a) Control and Information Displays - The following color set will be used in the context of control and indication display Other color schemes not specified in this guideline may be used provided that it can be demonstrated by the supplier so that the standards of USNRC NUREG-0700, Rev.2 are met:

Grey (R128, G128, B128)
VDU and LDP background, pop-up menu, alarm list window background, grid line

Dark Grey (R95, G91, B82)
Selector and controller label background, parameter value background, uncontrollable and non-instrumented equipment, board and dynamic data background, display page background, Recessing Effect Color by Selecting

Light Grey (R204, G204, B204)
Button background, display page title, date and time, CEA drop status indication, background color

White (R255, G255, B255)
Dynamic data (e.g., process parameter values), rectangle-shaped line color of selectable touch target, selected mode indication, trend line (flow)

Black (R0, B0, G0)
Label, process line, graphical line, trend background, indicator background in uncontrollable equipment

Spring Green (R0, G215, B145)
Component Status: off / Inactive / De-energized / Flow Preventive (e.g., Valve Closed, Breaker Open, Pump off, etc.)

Orange (R255, G135, B0)
Upper and lower limit range of indicator, neutral position of soft control, medium temperature for core, trend line (pressure), mode condition, trouble/disable, ESFAS Condition, Manual Permissive

Dark Red (R255, G0, B0)
Component Status: on / Active / Energized / Flow Permissive (e.g., Valve Open, Breaker Shut, Pump on, etc.), medium value of indicator, high temperature for core, tagged, trend line (temperature)

Yellow (R252, G227, B112)
Alarm

Med blue (R50, G110, B200)
Soft control switch frame, electrical signal link, measuring point indication, bar for level, trend line

Med Gray (R166, G166, B166)
Tag No. in uncontrollable component

Royal Blue (R64, G105, B225)
Scan off

Cyan (R0, G255, B255)
Trend line (level)

Steel grey (R142, G162, B171)
Soft control background, display handling menu background

Light Brown (R107, G56, B56)
Demarcations (e.g., uncontrollable area, grouping)

b) Personnel Safety and Physical Hazards - The following specifications are general. They are not incompatible with applicable OSHA standards in 10 CFR 1910 Sections144, "Safety Color Code for Marking Physical Hazards" and the color assignments in 2.5.1.2.

Spring Green	Safe; Go
Amber and Orange	Caution; Attention
Dark Red	Danger; Stop; Fire Hazard, Fire Safety Radiation Hazard

2.5.1.3 Color Selection

a) Red-Green Combination - Whenever possible, red and green colors should not be used in combination.

b) Pure Red - Dominant wavelengths above 650 nanometers in displays should be avoided.

c) Pure Blue - Pure blue on a dark background should be avoided for text, for thin lines, or for high-resolution information.

2.5.2 Highlighting

2.5.2.1 General Highlighting Guidelines

a) 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.

b) Minimal Highlighting - Highlighting of information should be minimized.

c) Consistency - A particular highlighting method should be used consistently.

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

2.5.2.2 Brightness

a) 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 the VDUs.

b) 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.

c) Brightness Coding Intensities - Brightness intensity coding should be employed only to differentiate between an item of information and adjacent information. No more than two levels of brightness should be used.

d) Brightness inversion - When a capability for brightness inversion is available, it may be used for highlighting critical items that require user attention.

2.5.2.3 Flashing

a) Appropriate Use of Flash Coding - Flashing should be used when a displayed item implies a need for attention or action, but not in displays requiring attention to detail or reading of text. No more than 2 flash rates should be used. Where one rate is used, the rate should be 3 - 5 flashes per second. Where two rates are used, the second rate should be not greater than 2 per second.

b) 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.

c) Small Area - Only a small area of the screen should flash at any time.

d) Long-Persistence Phosphor Displays - Flashing should not be used with long-persistence phosphor displays.

e) Flash Rate for Critical Information - When two rates are used, the higher rate should apply to the more critical information.

2.5.3 Auditory Coding

a) Appropriate Use of Auditory Signal - Auditory signals should be provided to alert the operator to situations that require attention, such as an incorrect input action by the operator or a failure of the HSI to process an input from the operator.

b) Dedicated Use - Systems used to transmit non-verbal auditory signals should be used only for that purpose.

c) Localization - Auditory signals should provide localization cues that direct operators to those control room consoles where operator attention is required.

d) Selection - Auditory signals should be selected to avoid interference with other auditory sources, including verbal communication.

e) Signal Priority Distinction - Caution signals should be readily distinguishable from warning signals and used to indicate conditions requiring awareness, but not necessarily immediate action.

f) Association with Visual Warnings - Auditory alerts, as well as caution and warning sounds, should accompany visual displays.

g) 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.

h) 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.

i) 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.

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

k) 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.

l) 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.

m) Direction of Sound - Sound sources (speakers or buzzers) should direct sound toward the center of the primary operating area.

n) Audibility - Auditory alert and warning signals should be audible in all parts of the control room.

o) Signal Intensity - The intensity of auditory signals should be set to unmistakably alert and get an operator's attention. Auditory signal intensities should not exceed 90 dB(A), except for evacuation signals, which may be up to 115 dB(A).

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

q) 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.

r) Distinctive Coding - Coding methods should be distinct and unambiguous, and should not conflict with other auditory signals.

s) Not Contradictory - Similar auditory signals must not be contradictory in meaning with one another.

t) Pulse Coding - Auditory signals may be pulse coded by repetition rate. Repetition rates should be sufficiently separated to ensure operator discrimination.

u) Coding by Intensity - Coding by intensity is not recommended.

v) Testing - It should be possible to test the auditory signal system.

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

x) 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).

2.5.4 Size, Shape, and Pattern

a) Simple Pattern Codes - When patterns are used to code displayed areas, simple rather than elaborate patterns should be used.

b) 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.

c) Limited Use of Size Coding - Size coding should be used only for applications where displays are not crowded.

d) 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.

e) Establishing Standards for Shape Coding - When shape coding is used, codes should be based on conventional meanings.

f) Clearly Discriminable Shapes - Shapes used in coding for data groups should be clearly discriminable.

2.5.5 Axes, Lines, Curves and Areas

a) Consistent Scaling - When operators must compare graphical data across displays, the scales should be the same on each.

b) Grid Lines - If the operator must use a graph to precisely extract point values, then scale graduation on axes should be extended to form a two-dimensional grid. Grid lines should be unobtrusive (i.e., low intensity) and should not obscure data elements. Grid lines should be displayed or suppressed at the option of the operator.

c) Labeling of Axes - The horizontal (X) axis should be used to plot time or the causal variable; the vertical (Y) axis should be used to plot the monitored parameter (the dependent variable).

d) Consistent Line Coding - Line coding should be used consistently across graphs.

e) Target Area Definition - The target area, preferred combination of X- and Y-axis values, should be graphically defined, except embedded trend or mimic trend.

2.6 Display Pages

a) Multi-Page - When a form is too large to fit in the available screen area, it should be broken into pages, and each page should be labeled with its number and the total number (e.g., Page 1 of 3).

b) Consistent Orientation - A consistent orientation for display framing should be used.

c) 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.

d) Paging Controls - Users should be allowed to move easily from one page to another for displays which are partitioned into separately displayable pages.

e) Evident Direction of Paging - The direction that a user must page (toward the top or bottom, left or right) should be evident to the user before s(he) begins to page.

f) Paging in One or Multiple Page Increments - Users should be able to page in one page or multiple page increments.

g) 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.

h) 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.

i) Navigational Cues - During navigation, displays should support users' comprehension of the relationships between successive views or destinations. The system should provide visual cues to indicate the operator's present location in the screen hierarchy. Specifically, titles should include the screen page name, high-level functional group (e.g., RCS (PRI)).

j) Minimal Navigation Path Distance - Short navigation paths should be provided between display pages that will be used one after the other.

2.7 Controls

2.7.1 Push Buttons

a) Consistent Appearance - The size and shape of the push button should be coded according to the purpose of the push button. The same usage of the push button should have the same size and shape.

b) Minimum Push Button Size - The size should accommodate the largest label.

c) Labels - A push button should have either a text or graphic label.

d) Consistent Labels - Push button labels should be consistent throughout an application and related applications.

e) Text Label Length - Push button labels should be short and unambiguous.

f) Push Button Label - The push button label should describe the results of pressing the button and reflect the action that will be taken by the application rather than the user.

g) Activating a Push Button - A user should be able to activate a push button by moving the pointer onto the button and pressing the appropriate pointer button.

h) Activated Push Buttons - The push button should be highlighted while the pointer button is depressed.

i) Activating Controls Using Push Buttons - The control should be activated when the pointer button is released, and the push button is reverted to its normal appearance.

j) Activating Buttons Using the Keyboard - A user should be able to activate a push button using the keyboard.

k) Information Prior to Push Button Action - When the user must supply additional information before the system can carry out a push button action, the designer should provide ellipses (…) after the push button caption to indicate that a dialog box (or control window) will be presented.

2.7.2 Radio Buttons

a) When to Use - Radio buttons should be used if it is required that one and only one of a set of mutually exclusive options be selected.

b) Number of Radio Buttons - An individual radio button should always be part of a mutually exclusive group of two or more radio buttons.

c) Selecting a Radio Button Inactivates Other Radio Buttons - A radio button that is active should cause all of the other radio buttons in its group to be inactive.

d) Selecting a Radio Button Using a Pointing Device - A user should be able to select a radio button using a pointing device by moving the pointer onto the radio button and clicking the appropriate device button.

e) Selecting a Radio Button Using the Keyboard - A user should be able to select a radio button using the keyboard by moving a location cursor to the desired button (e.g., using the arrow keys) and pressing the Enter key.

f) Exclusive Selection - Selecting one radio button item should deselect any other radio button in its group previously selected.

g) Identifying a Set of Radio Buttons - A box should be drawn around a group of radio buttons to visually separate the group from other interface features.

h) Selected Button Highlighted - Selecting a button that is already highlighted should not change its state.

i) Radio Button Labels - Labels should be provided for each set of radio buttons.

j) Labeling Individual Radio Buttons - Radio buttons and labels should be left justified in the columnar format.

k) Labeling Single Panels of Radio Buttons - When a screen or window contains only one panel of radio buttons, the screen or window title should serve as the panel label.

l) Selection Area - The selection target area for radio buttons should include the radio button and its label.

m) Moving a Cursor to an Option - Moving the cursor to an option should highlight the label by reverse video, reverse color, or a dashed box around the label.

n) Sets of Radio Buttons - Radio button sets should contain from two to seven items, but the user should always have at least two radio buttons in each set.

o) Unavailable Options - When a particular option is not available, it should be displayed as subdued or grayed-out in relation to the brightness of the available options.

2.7.3 Check Boxes

a) When to Use - Check boxes should be provided if a user must be able to select any number including none of a set of options.

b) Effect of Activating a Check Box - A check box that is activated should not change the status of any other choice in the group.

c) Selecting Check Boxes - Users should be able to toggle selected and unselected states on a check box using either a pointing device or the keyboard.

d) Check Box States - Check boxes should have two states, selected and unselected.

e) Labeling Check Boxes - Labels should be provided for each set of check boxes.

f) Consistent Labeling - Label style and orientation for check boxes should remain consistent for groups of check boxes within an application and across related applications.

g) Arrangement of Check Boxes - Check boxes should be arranged in logical order so that the most frequently used boxes are at the top or at the left, depending on how the boxes are oriented.

h) Alignment of Check Boxes - Check boxes should have a columnar orientation with the boxes aligned to the left.

i) Alignment of Check Boxes When Space Is Limited - When there is limited space, a horizontal orientation should be used with adequate separation (three character spaces) between each box.

j) Check Box Height and Width - When grouping check boxes, the boxes should be equal in height and width.

2.7.4 List Boxes

a) When to Use - List boxes should be used when choices are displayed for the user.

b) Long Lists in List Boxes - Long lists in list boxes should be accompanied by scrolling capability.

c) Inactive List Boxes -The label and list items for an inactive list box should be dimmed.

d) Standard Single-Selection List Boxes - Standard list boxes should always remain the same size.

e) List Box Height - The list box should be high enough to accommodate three to eight list items if possible within the height of a dialog box.

f) List Box Width - A list box should be a few spaces wider than the average width of the items in the list.

g) Items Too Wide for List Box - When an item is too wide for the list in a list box, a horizontal scroll-bar should be placed at the bottom of the list.

h) Drop-Down List Box - A drop-down list box should have a fixed width.

i) Drop-Down List Height when Closed - A drop-down list should be only tall enough to show one item when closed.

j) Drop-Down List when Open - The height of an opened drop-down list should be enough to accommodate three to eight items.

k) Drop-Down List with more than Eight Items - Dropdown lists containing nine or more items should have a vertical scroll-bar.

l) Extended-Selection List Boxes - Extended-selection lists should be used when the user might select more than one list entry at a time from a list in which related items are contiguous.

m) Multiple-Selection List Boxes - Multiple-selection lists should be used when users might select several entries at a time from a list in which related items are not contiguous.

n) Text Boxes - The user should be able to accept, edit, delete, or replace the current text in a text box.

o) Entering Characters in the Text Box - The system should allow the user to enter characters in a text box by pressing character keys.

p) Multi-Line Text Boxes - Data in a multi-line text box that are too wide to fit on a single line should wrap to the following line.

2.7.5 Combo Boxes

a) Combo Boxes - Combo boxes should be used when the user needs to be able to either select one of the displayed responses or enter a new response.

b) Typing Options into Combo Boxes - A combo box should allow the user to enter a response if the desired option is not displayed in the list.

c) Scroll-Bar on Combo Box List - The scroll-bar should only be used on a combo box list if the list is expected to display more entries than can be shown at one time.

d) Ordering Items In Combo Boxes - List entries should be organized in alphabetical order unless an application requires a different organization.

e) Moving the Selection in the List - A user should be able to move up and down the list of a combo box with input focus by using the up and down arrow keys.

f) Moving Left and Right in an Edit Field - The user should be able to move the cursor left or right in the edit field of the combo box by using the left or right arrow keys.

g) Drop-Down Combo Boxes - Drop-down combo boxes should be used instead of standard combo boxes when the space is limited.

h) Width of Drop-Down Combo Box - The list segment of an open drop-down combo box should extend to the right border of the down arrow button.

2.7.6 Spin Boxes

a) Spin Box Options - A spin box should be used for a limited set of discrete, ordered options and to display values that consist of several subcomponents.

b) Entering Values into Spin Boxes - The spin box should allow the user to enter a new value into the text box that is not available presently as one of the options.

c) Increasing and Decreasing Spin Box Values - The user should be able to increase the value in a spin box by clicking the UP ARROW key or decrease the value by clicking the DOWN ARROW key.

d) Arrows on a Spin Box - Spin box arrows should operate like scroll-bar arrows for a concealed descending list.

3.0 INTERACTION

3.1 General Interaction Guidelines

3.1.1 General Organization Guidelines

a) Readily Usable Form - Data presented to the user should be in a readily usable and readable form, such that the user does not have to transpose, computer, interpolate or translate into other units, number bases or meaningful language. for example, reactor startup rate is displayed, and operators are not required to evaluate it from reactor power readings; likewise, reactor heat-up rate should be explicitly displayed, rather than evaluated by operators from the temperature readings.

b) Data Grouped by Function - Sets of data that are associated with specific questions or related to particular functions may be grouped together to signify those functional relationships.

c) Tabular Data - Tabular data should be displayed in rows and columns. If the data has order, the order should be retained and made evident. If the table has objects with attributes, the objects should be assigned to rows, the attributes to columns.

d) Spatial Demarcation - Empty screen areas, lines, and spaces should be the primary means of organizing and separating data. Critical information should have extra space used to demarcate its position, if possible. If empty space is not effective for the application, then straight, simple lines with minimal bends should be used for demarcation.

e) Integral and Configural Dimensions - When several information is closely related and needed to be integrated in some tasks, the information can be displayed using integral or configural dimensions. "Integral relationship" is defined by a strong interaction among dimensions such that the unique perceptual identities of individual dimensions are lost (e.g., box, triangle instead of lines). In a "configural relationship", each dimension maintains its unique perceptual identity, but new emergent properties are also created as a consequence of the interaction between them (e.g., symmetry, closure, and vertices).

f) Recurring Data Fields - Data fields that appear in multiple locations within a system

should have consistent names, and should have consistent relative position within similar displays.

g) Selection of Dialogue Types - The selection of dialogue types should be based on anticipated task requirements, user skills, and anticipated system response time.

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

i) 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.

3.1.2 General User Interface Guidelines

a) Consistent Procedures - Procedures for entering commands or information should be consistent in form and consequences.

b) 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.

c) Wording Consistent with User Guidance - The wording and required format of information or command entry functions should be consistently reflected in the wording of user guidance, including all labels, messages, and instructional material.

d) 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.

e) Unnecessary Entry of Information - A user should not be required to re-enter information already available to the system.

f) 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.

g) Control by Explicit User Action - Users should be allowed to control the processing of

information or commands by explicit action.

h) 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.

i) 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.

j) 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.

k) 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.

l) Indicating Appropriate Control Options - Users should be provided with a list of the control options that are specifically appropriate for any transaction.

m) Only Available Options offered - Only control options that are actually available for the current transaction should be offered to users.

n) Provide Further Available Action - Transactions should never leave the user without further available action and should provide next steps or alternatives.

o) 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.

p) Highlighting Selected Data - When a user is performing an operation on some selected display item, that item should be highlighted.

q) 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.

r) User Transaction Interrupts - User interrupts and aborts should not modify or remove stored or entered data.

s) User Control of Entry - Users should be allowed to control the pace and sequence of their entry of information or commands.

t) User-Specified Transaction Timing - When appropriate to task requirements, users should be allowed to specify the timing of transactions.

u) 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.

v) 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.

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

x) Offer Information Feedback - For every user action, there should be system feedback.

y) Design Dialogs to Yield Closure - Sequences of actions should be organized into groups with a beginning, middle, and end. The information feedback at the completion of a group of actions gives operators the satisfaction of accomplishment, a sense of relief, the signal to drop contingency plans and options from their minds, and an indication that the way is clear to prepare for the next group of actions.

z) Support Internal Locus of Control - System should give experienced operators the sense that they are in charge of the system and that the system responds to their actions. Surprising system actions, tedious sequences of data entries, inability or difficulty in obtaining necessary information, and inability to produce the action desired all build anxiety and dissatisfaction.

3.1.3 General User Input Guidelines

a) Feedback for User Entries - The computer should acknowledge every entry immediately.

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

c) 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.

d) Entry via Primary Display - When data entry is a significant part of a user's task, entered data should appear on the user's primary display.

e) Entry of Corrections - The same explicit ENTER action should be required for entry of corrections as used for the original entry.

f) Editing Capabilities During Text Entry - Users should be able to perform simple editing during text entry without having to invoke a separate edit mode.

g) 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.

h) Optional Versus Required Entry - Optional versus required data entries within fields on input forms should be distinct.

i) Distinctive Display of Control Information - All displays should be designed so that features relevant to user entries are distinctive in position and/or format.

j) 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.

k) Record of Prior Entries - Users should be permitted to request a summary of prior entries to help determine present status, and should be allowed to review any parameters that are currently operative.

l) 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.

m) 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.

n) Automatic Justification of Entries - Automatic justification of tabular data entries should be provided.

o) Maintaining Significant Zeros - When a user must enter numeric values that will later be displayed, all significant zeros should be maintained.

p) 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.

q) Overwriting Characters - Data entry by overwriting a set of characters within a field should be avoided.

r) Consistency of Data-Entry Transactions - Similar sequences of actions should be used under all conditions; similar delimiters, abbreviations, and so on should be used.

s) Minimal Input Actions by User - Redundant data entry should be avoided. When the same information is required in two places, the system should copy the information for the user.

t) Minimal Memory Load on Users - When doing data entry, users should not be required to remember lengthy lists of codes and complex syntactic command strings.

u) Compatibility of Data Entry with Data Display - The format of data-entry information should be linked closely to the format of displayed information.

3.2 Managing Display and Data

3.2.1 Display Selection and Navigation

a) Initial Cursor Position - When a form first appears, the cursor should be placed automatically in the first position of the first field, where practical.

b) Navigation with A Pointer - When fields may not necessarily be traversed in a set order, a pointing device in addition to keyboard should also be available for selecting fields.

c) Easy Cursor Movement - The system should provide one or more easy ways to move the cursor among fields.

d) Movement with Keyboard - When the primary means of entering data in fields is the keyboard, the cursor movement methods should include keyboard keys such as the Tab key(s) and the arrow keys.

e) Movement with Pointing Device - When a pointing device is available, a user should be able to move the cursor to any field by moving the pointer into the field and clicking the appropriate button.

f) Multiple Devices - When both a keyboard and pointing device is available, cursor movement should be allowed using either device.

g) No Automatic Movement - The cursor should not be moved automatically among fields with movement occurring only upon explicit user action, such as pressing the Tab key.

3.2.2 Orientation Features

a) 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.

b) Cues to Display Network Structure - The display system should provide information to support the user in understanding the display network structure.

c) 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.

d) Perceptual Landmarks - Easily discernable features should appear in successive views and provide a frame of reference for establishing relationships across views.

e) Location Cues - Cues should be provided to help the user retain a sense of location

within the information structure.

f) Directional Cues - Directional cues should be provided.

g) Display Page Titles - Display page title and identifying information should be used to communicate the position of a display in a larger information space.

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

i) Understanding Successive Views - A hypertext information system should show how a destination node is related to the point of departure.

3.2.3 Retrieval Features

a) Flexibility in Display System Interaction -The display network should provide more than one way to access displays.

b) Minimal Navigation Path Distance - Short navigation paths should be provided between display pages that will be used one after the other.

c) Short Navigational Distances in Hierarchies - Navigation distances should be kept short.

d) Relatedness of Successive Views - During navigation, displays should support users' comprehension of the relationships between successive views or destinations.

e) Time to Complete Navigation - The time required to complete a display navigation action should be minimized.

f) Detection of Navigation Targets - Navigation targets should be easily detectable.

g) Support for 'Top-Down' Strategies for Navigating Hierarchies - Use of top-down navigation strategies should be supported.

h) Support for 'Bottom-Up' Strategies for Navigating Hierarchies - The display system should support users in identifying reversal points.

3.2.4 Display Update, Freeze and Data Quality

a) 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.

b) 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.

c) Labeling Display Freeze - When a display is "frozen," the display should be appropriately labeled to remind users of its "frozen" status.

d) 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.

e) 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.

f) Data Sampling Rate - The sampling rate for each critical plant variable should result in no meaningful loss of information in the data presented.

g) 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.

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

i) Display Heartbeat Symbols

1) Representation of Display Feature - A display feature should be provided to indicate to the user that the system is operating properly (or that a system failure has occurred).

2) Location - The Display Heartbeat symbols should appear consistent, and in a similar location on similar screens.

3.2.5 Display Suppression

a) Temporary Suppression of Displayed Data - The user should be able to temporarily suppress standard data displays.

b) 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.

c) 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.

3.2.6 Display Control

a) Display Control - Users should be able to specify the information to be displayed and select the format in which it is presented.

b) Display of Control Options - Screen control locations and control options should be clearly and appropriately indicated.

c) 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 .

d) Show Changing Scale - When a display is expanded from its normal coverage, a scale indicator of the expansion factor should be provided.

e) 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.

3.2.7 Prevention, Detection and Correction of Errors

3.2.7.1 General Prevention, Detection and Correction of Errors Guidelines

a) 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.

b) 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.

c) Timely Validation of Sequential Transactions - in a repetitive data entry task, the data for one transaction should be validated, and the user should be allowed to correct errors before beginning another transaction.

d) Non-Disruptive Error Message - If data validation detects a probable error, an error message should be displayed to the user at the completion of data entry.

e) 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.

f) 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.

g) User Validation - The user should be able to obtain a paper copy (screen dump) of the contents of alphanumeric or graphic displays.

3.2.7.2 Correcting Information and Command of Errors

a) Immediate Error Correction - When the system detects an error in a user input, the user should be allowed to make an immediate correction.

b) Replacing Erroneous Commands - If a user makes a command entry error, after the error message has been displayed, the user should be allowed to enter a new command.

3.2.7.3 Confirming Entries

a) User Confirmation of Destructive Entries - When a control entry will cause any extensive change in stored information, procedures, and/or system operation, and particularly if that change cannot be easily reversed, the user should be notified and confirmation of the action should be required before implementing it.

b) Informing Users of Potential Information Loss - for conditions which may require special user attention to protect against information loss, an explicit alert and/or advisory message should be provided to prompt appropriate user action.

c) Preventing Data Loss At LOG-off - When a user requests LOG-off, pending transactions should be checked and if any pending transaction will not be completed, or if data will be lost, an advisory message requesting user confirmation should be displayed.

3.2.7.4 Protecting Data

a) Protection from Computer Failure - Automatic measures should be provided to minimize data loss from computer failure.

b) Protection from Interrupts - When a proposed user action will interrupt a current transaction sequence, automatic means to prevent data loss should be provided.

c) Protection from Data Change - When information must not be changed, users should not be permitted to change controlled items.

d) Explicit Action to Select Destructive Modes - Users should take explicit action to select any operational mode that might result in data loss.

e) Protection from Interference by Other Users - Data should be protected from inadvertent loss caused by the actions of other users.

f) Segregating Real from Simulated Data - When simulated data and system functions are displayed or provided (perhaps for user training), real data should be protected and real system use should be clearly distinguished from simulated operations.

3.3 System Response

The system response should be generated by OS (Operating System).

3.3.1 General System Response Guidelines

a) System Message Generation - System message should be generated by an operating system.

b) Standard Display Location - System messages should appear in standard locations.

c) Consistent Format for System Messages - Consistent grammatical construction should be used in system messages.

d) Familiar Wording - System messages should use familiar terminology and choose user-centered phrasing, and use a positive tone: avoid condemnation.

e) Concise Wording of System Messages - System messages should be concise and clearly worded.

f) Speaking Directly to Operators - Wording for system messages should be directed at the operator.

g) Only Necessary Information Displayed - No extraneous information should be displayed. But, the information should be as specific and precise as possible. Thus, the information is constructive: Indicate what the user needs to do.

h) Anthropomorphism - Presenting the system as a person should be avoided. Do not use "I" when the computer responds to human actions. Use "you" to guide users, or just state facts.

3.3.2 Advisory Message

a) Distinctive and Consistent Advisory Messages - Advisory messages should be distinctive.

b) Redundant Display - Important information should be presented through both visual and auditory means.

c) Informing Operators of Potential Data Loss - Protection against data loss should be provided.

d) Time-Consuming Processes - Users should be informed when a command will be time-consuming to process.

3.3.3 Error Message

a) Informative Error Messages - When the computer detects an entry error, an error message should be displayed stating the error and possible subsequent operations.

b) Task-Oriented Error Messages - Wording for error messages should be appropriate to the task.

c) Neutral Wording for Error Messages - Error messages should use neutral wording.

d) Non-Disruptive Error Messages - The computer should display an error message only after completion of an entry.

e) 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.

f) Advisory Error Messages - Where data or control entry is made from a small set of alternatives, error messages should indicate the correct alternatives, where practical (e.g., logon and setpoint input errors).

g) Displaying Erroneous Entries - When an entry error has been detected, the erroneous entry should remain displayed until the error has been corrected.

h) 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.

i) Error Message Placement - Error messages should be presented at the point of the error or in a consistent area of the display.

j) Documenting Error Messages - As a supplement to on-line guidance, system documentation should include a listing and explanation of all error messages.

3.3.4 User Guidance and Help

a) On-Line/off-line Guidance - Reference material describing system capabilities, procedures, and commands and abbreviations, should be available on-line or off-line.

b) Access to Guidance - Explicit actions should be required to access or suppress user guidance.

3.3.5 System Response Times

a) Appropriate Computer Response Time - The speed of computer response to user entries should be appropriate to the transaction involved.

b) Response Time Consistent with Requirements - System response times should be consistent with operational requirements.

c) 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.

d) Variability of Response Time - Response time deviations should not exceed more than half the mean response time.

e) Maximum System Response Times - Maximum system response times for real-time systems should not exceed the values presented in Table 3.3.5.

Table 3.3.5 Maximum and preferred system response times for User Command

User Activity	Response Time (sec)	
	Maximum	Preferred
Control Activation (for example, keyboard entry, cursor controller	0.10	< 0.10

movement)		
System Activation (system initialization)	3.0	< 0.50
Request for given service Simple Complex Loading and Restart	2.0 5.0 15-60.0	< 0.25 < 2.0 < 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
Response to complex inquiry in graphic form	2-10.0	< 0.25
Response to graphic manipulation	2.0	< 0.25
Response to user intervention in automatic process	4.0	< 1.50

3.4 System Security

3.4.1 User Identification

a) Automated Security Measures - When required, automated measures to protect data security should be provided, relying on computer capabilities rather than on more fallible human procedures.

b) Notification of Threats to Security - Messages or signals should be provided in order to notify users (and system administrators) of potential threats to data security (i.e., of attempted intrusion by unauthorized users), where practical.

c) Auxiliary Tests to Authenticate User Identify - When system security requires more stringent user identification than is provided by password entry, auxiliary tests should be devised that authenticate user identity without imposing impractical demands on the user's memory, where practical.

d) Easy LOG-ON - The LOG-ON process and procedures for user identification should be as simple as possible, consistent with protecting data from unauthorized use.

e) Private Entry of Passwords - When a password must be entered by a user, password entry should not be displayed.

f) User Choice of Passwords - When passwords are required, users should be allowed to choose their own passwords and to change their passwords as needed.

g) Limiting Unsuccessful Log - ON Attempts - A maximum limit on the number and rate of unsuccessful LOG-ON attempts should be imposed, where practical.

h) Continuous Recognition of User Identity - Once a user's identity has been authenticated, any authorized data access/change privileges are for that user should continue throughout a work session.

i) Single Authorization for Data Entry/Change - User authorization for data entry/change should be established at initial LOG-ON.

j) Log-on - When users must log-on to a system, log-on should be a separate procedure that is completed before a user may select any operational options.

k) Log-on Frame - The log-on frame should appear as soon as possible on the display with no additional user involvement.

l) Log-on Delays - Log-on delays should be accompanied by an advisory message to tell the user its current status and when the system will become available.

m) Immediate Start of Productive Work - after completing the sign-on process, the user should be able to start productive work immediately.

n) Log-off - If there are pending actions and the user requests a log-off, the system should inform the user that these actions will be lost and allow the user to cancel either the pending actions or the log-off.

i. Saving Open Files in Automatic Log-off - Where possible, in the event of automatic log-off, open files should be saved to some defined file name.

3.4.2 Information Access

b) Encryption - When sensitive data may be exposed to unauthorized access, a capability for encrypting those data should be provided.

c) Ensuring Reversible Encryption - Encrypted data should be protected from any change that might prevent successful reversal of their encryption.

d) Display Suppression for Security - When confidential information is displayed at a work station that might be viewed by casual onlookers, the user should be provided with some rapid means of temporarily suppressing a current display if its privacy is threatened, and then resuming work later.

e) Protecting Printed Data - As required for security, procedures to control access to printed data should be established, rather than simply prohibiting the printing of sensitive data.

f) Protecting Display Formats - Display formatting features, such as field labels and delimiters, should be protected from accidental change by users.

g) Protecting Displayed Data - When protection of displayed data is essential, computer control over the display should be maintained.

h) Automatic Records of Data Access - When records of data access are necessary, the records should be maintained automatically.

4.0 DISPLAY AND CONTROL DEVICES

4.1 Display Device

4.1.1 Information FPD

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

b) Geometric stability - The display should be free of "jitter".

c) 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.

d) VDU Image Linearity - The display should be free of geometric distortion.

e) Luminance Uniformity - All luminances that are supposed to be the same should appear the same.

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

g) VDU Luminance Control - A control to vary the VDU luminance from 10 percent of minimum ambient luminance to full luminance should be provided.

h) Refresh Rate - To avoid visible flicker, the refresh rate of VDU screens should be at least 55 Hz, and should be at least 70 Hz (100 Hz for dark characters on light background).

i) Luminance - The minimum level of luminous intensity (see Definitions) for characters on a VDU screen should be 70 cd/m^2 (20 fL), and the preferred display luminance should be 80 to 160 cd/m^2 (47 fL). VDUs should provide a brightness adjustment to the user, but should limit minimum brightness to a visible level.

4.1.2 LDP (Large Display Panel)

a) Provision - A Large Display Panel (LDP) comprised of single or multiple screens should

be provided in the control room to support operators in performing rapid assessment of plant status and in maintaining awareness of the big picture.

b) Dedicated Display - The LDP should include both fixed (dedicated) and variable display regions. The LDP design should preclude information in dedicated regions from being obscured, modified or deleted during LDP use.

c) Variable Display Region - The management of variable display region is performed by the reactor operator (RO), turbine operator (TO), electrical Operator (EO), and shift supervisor (SS). The selected display from operation console should be projected in the variable display.

d) Alarm Indications - The LDP should allow operators to verify either the existence or absence of the dedicated alarm conditions that are displayed on the LDP. Alarm acknowledgment, including the LDP, should be integrated across display systems.

e) Printout - Hard copy of the current indications on the LDP should be available on demand.

f) Visibility - The LDP should provide unimpaired visibility from all consoles.

g) Readability - The LDP should be designed for readability from the RO, TO, EO, SS, and shift technical advisor (STA) consoles.

h) Timing Issues - The LDP data should be updated promptly so that agreement with other general display systems is maintained. Relevant timing issues should be considered, including rate of display update, display heartbeat, and system response time.

i) LDP Maintenance - Choice of LDP technology and installation of hardware should consider impact of maintenance and repair requirements on continuous LDP availability.

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

k) Projected Display Luminance Ratio - The luminance ratio provided by the projection system should be adequate for the type of material being projected.

l) 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.

m) Minimum Viewing Distance - The display should not be closer to any observer than half the display width or height, whichever is greater.

n) Interruption of View - Large screen displays should be located relative to critical observers so that the view is not obscured by other people.

o) Consistent Representation - LDP representation should be consistent to other display's one (VDU display, Soft Control) in the symbol, the state indicator, the spatial layout, and so on.

p) Resolution - Users should be able to resolve all important display detail at the maximum viewing position.

q) Projected Display Luminance Ratio - The luminance ratio provided by the projection system should be adequate for the type of material being projected. The contrast ratio is defined as image or subject luminance divided by the non-image 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:

1) For viewing charts, printed text, and other line-work via slides or opaque projectors, the minimum contrast ratio is 5:1.
2) 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.
3) For images that show a full range of colors (or grays in black-and-white photographs), the minimum contrast ratio is 100:1.

r) 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.

4.1.3 Conventional Display Devices

4.1.3.1 Light Indicators

a) Precautions to Assure Availability - Dual-bulb (including LED) assemblies should be used.

b) Precautions to Assure Unambiguous Sensing by Operators - Lights should not appear to be glowing when in fact they are off, or vice versa.

c) Precautions to Avoid Misinterpretation - System/equipment status should be inferred by illuminated indicators, and never by the absence of illumination.

d) Identification of Meaning - Where meaning is not apparent, labeling must be provided close to the light indicator showing the message intended by its glowing.

e) 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.

f) Visibility Factors - When using legend light indicators, make sure contrast and ambient/transilluminated conditions are considered.

g) Legend Design - General legend design should be consistent throughout the control room.

h) Distinguishability from Legend Pushbuttons - Illuminated legend indicators should be readily distinguishable from legend pushbuttons by form, size, or other factors.

i) Color Coding - The color of the legend background under transillumination should conform to the general color code established for the control room.

4.1.3.2 Meters and Gauges

a) Display Range Coding - Zones indicating operating ranges should be color coded by edge lines or wedges for circular scales.

b) 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.

c) Number of Tick Marks - Scales should not be cluttered with more marks than necessary for precision.

d) Distinctiveness - Zone markings should be conspicuous and distinctively different for different zones.

e) Consistency - to facilitate reading of meters and prevent misreading, the orientation of scale markings should be consistent.

f) 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.

g) Pointer Characteristics

1) Tip Style - The pointer tip should be simple, and mounted to minimize parallax.
2) Pointer Visibility - Pointer/background contrast and pointer size should be adequate to permit rapid recognition of pointer position.

h) Numeral Orientation - The individual numerals on any scale should be vertically oriented with respect to the reader.

i) Numeric Readouts

1) Orientation - Multi-digit numbers formed by several elements (e.g., drums and LED arrays) should be read horizontally from left to right.
2) 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.
3) Display of Changing Values - Numerals should not follow each other faster than one per second when the operator is expected to read the numerals consecutively.

4.1.3.3 Printers

a) Placement of Printers - in principle, printers should be located within the primary operating area because they must be verified and attended by the operator.

b) Legibility - Print output should be free from character line misregistration, character tilt, smear, or glare.

c) Contrast - A minimum contrast ratio of 4:1 should be provided between the printed material and the background on which it is printed.

d) Illumination - The printer should be provided with internal illumination if the printed matter is not legible in the planned operational ambient illumination.

e) Visibility - When used for real-time applications, the printed matter should not be hidden, masked or obscured in a manner that impairs direct reading.

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

g) Take-Up Provision - A take-up device should be provided for printed material.

h) Indication of Supply of Materials - A positive indication should be provided of the remaining supply of printing materials (e.g., paper, toner, and ribbons).

i) Quality of Expendable Materials - Pens, inks, and paper should be of a quality to provide clear, distinct, and reliable marking.

j) Availability of Expendable Material - Paper, ink, and other operator-maintained expendables should be provided and accessible in the control room.

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

l) Smudging/Smearing - The hardcopy should be resistant to smudging or smearing when handled by users.

m) Job Aids - Graphic overlays should be provided where these may be critical to proper interpretation of graphic data as it is being generated.

4.2 Control Devices

4.2.1 General Control Devices Guidelines

a) Appropriate Use of Input Devices - Input and control devices provided for interacting with the HSI should be appropriate for the user's task requirements.

b) Input Device Stability - Input and control devices should be stable during normal usage, i.e., they should not slip or rock, unless such actions are a part of the controller operation.

c) Location - Controls should be operable from the location where the operator is most likely to need to interact with the system.

d) Speed - Controls should provide rapid positioning of cursors or selection of choices.

e) Accuracy - Device or method accuracy should be commensurate with the functions to be served.

f) Displacement - Control design should allow the operator freedom of movement to perform other duties.

g) Range and Precision - Control should provide the sufficient range and precision required by the task.

h) Economy - Each control or input device should be necessary, use minimal space, and be the simplest effective control for the task concerned.

i) Human Suitability - Controls and input devices should be suitable for operator use in a control room environment.

j) Compatibility with Emergency Gear - If used while wearing protective equipment (e.g., oxygen masks and protective gloves), controls and input devices should be easy to identify and activate, or use.

k) Control Activation - Controls and input devices should require distinct or sustained effort for activation.

l) Sequential Activation - When a strict sequential activation is necessary, controls should be provided with locks to prevent the controls from passing through a position.

m) Population Stereotypes - to minimize operator error, control movements should conform to population stereotypes.

n) Consistency - The coding system should be uniform throughout the control room.

o) Size Coding Uniformity - Controls used for performing the same function on different items of equipment should be the same size.

p) Shape Coding - When possible, controls should be differentiated by shape.

q) Color Coding Contrast - The color of the control should contrast with the panel background.

r) Location Coding by Function - Controls should be located so as to be easily related to functions and functional groupings.

s) Location Coding Across Panels - Controls with similar functions should be in the same location from panel to panel.

t) Feedback - Visual or auditory feedback should be provided to indicate that the system has received a control input.

u) Display & Control Compatibility - Control device movement and display response should conform to the user population stereotypes.

1) The control location should be close to (and, in fact, closest to) the entity being controlled, or the display of that entity.
2) The direction of movement of a control should be congruent with the direction both of movement of the feedback indicator and of the system movement itself.
3) The User Population Stereotypes.

Function	Control Action
On/Start	Up, Right, Forward
Run	Clockwise, Pull
Off/Stop	Down, Left, Backward, Counterclockwise, Push
Right	Clockwise, Right
Left	Counterclockwise, Left
Raise	Up
Lower	Down
Increase	Forward, Up, Right, Clockwise
Decrease	Backward, Down, Left, Counterclockwise

v) Prevention of Accidental Activation - Interface hardware should be designed and located so that accidental activation is unlikely and particularly for devices whose accidental activation may cause equipment damage, personnel injury, or degraded system readiness or performance.

1) Location - Instrument and interface devices should be located so that personnel are not likely to strike them accidently while conducting normal movements or activities in the vicinity. Sensing, control, or display devices should not be located near high-traffic paths.
2) Resistance - Control devices should provide sufficient resistance (e.g., via spring-loading, viscous damping, etc.) so that a definite or sustained effort is required for activation. This force should not be excessive, as it will hinder intented operation.
3) Dead-man Controls - Where appropriate (e.g., rod motion controls), devices should be configured to return the system to a conservative, unchanging, or otherwise stable state when operating force is removed from the control, so that operator inattention will be less likely to result undesired system condition.
4) Barriers and Recesses - Control may be surrounded by or recessed within physical barriers.
5) Cover Guards - A hinged or removable cover may be placed over a control. Covers on backlit pushbuttons should be clear.
6) Locks - A control device may incorporate a locking mechanism, often under administrative or automatic control. These include lock wire, keylock, control power disable or transfers (through switches, breakers, or software), and permissive interlocks. Locking devices should not interfere with the anticipated use of the control.

4.2.2 Input Device

4.2.2.1 Keyboards

A. Numeric Keypads

Numeric keypads should be organized and oriented as shown in Figure 3.3 in NUREG-0700 in all applications (either hardware or software). The unoccupied spaces to the left and right of the 0 can be used for additional features (e.g., decimal point, exponents, etc.).

B. Alphanumeric Keyboards

1) General Keyboard Layout - An ANSI standard (QWERTY) layout should be used for the typing keyboard.

2) Numeric Keypad - When users must enter numeric data, keyboards should be equipped with a numeric keypad.

3) Numeric Keypad Layout - Keypads used for numeric entry should be consistently designed.

4) Cursor Control Capability - Horizontal and vertical cursor control keys should be provided for text processing applications.

5) Cursor Key Layout - Cursor control keys should be arranged in a two-dimensional layout so that their orientation is compatible with the cursor motion they produce.

6) Overlays - Mechanical overlays, such as coverings over the keyboard, should be not used.

7) Keyboard Surfaces - A matte finish should be used for keyboard surfaces.

8) Keyboard Slope Adjustment - The slope of the keyboard should be adjustable by the operator.

9) Standard Keyboard Placement - The operator should be able to reposition the standard keyboard on the worksurface.

10) Keytop Symbol Marking - Key symbols should be etched (to resist wear) and colored with high contrast lettering.

11) Keying Feedback - The actuation of a key should be accompanied by tactile or auditory feedback or both.

12) Repeat Capability - A repeat capability for alphanumeric, symbol character, and cursor keys should be provided.

13) Multiple-Key Rollover - Multiple-key (N-key) rollover capability should be provided for the reduction of keying errors.

14) Keystroke Commands - When it is necessary to distinguish command entries from text input, a specially designated key should be one of the keys used for keystroke commands.

15) Simultaneous Keystrokes - Keystroke commands should require the user to press both keys simultaneously, not in close temporal sequence.

16) Inadvertent Operation - Keys with major or fatal effects should be located so that inadvertent operation is unlikely.

17) Alternate Key Definitions - When the keyboard is redefined, a display of the alternate characters and their locations should be available to the operator.

18) Destructive Key Functions - Destructive keys/keyboard functions (e.g., DELETE, BACKSPACE, ESCAPE, QUIT, RESET etc.) should be least accessible, and located away from frequently used keys (e.g., DELETE should not be adjacent to RETURN).

19) Cursor Movement Keys - Cursor movement keys, if used, should be arranged to be spatially compatible with the direction of actual cursor movement

C. Function Keys

1) Availability - Fixed function keys should be available to control functions that are often utilized and continuously available.

2) Inactive Function Keys - Unneeded function keys, either fixed or programmable, should be disabled so that no other action occurs upon their depression except an advisory message.

3) Inactive Keys - Non-active fixed function keys should not be present on the keyboard.

4) Grouping - Fixed function keys should be logically grouped and placed in distinctive locations on the keyboard.

5) Function Labels - Key assignments should be displayed at all times, preferably through direct marking.

6) Consistency - Fixed function keys should be used consistently throughout the system.

7) Actuation - Fixed function keys should require only a single actuation to accomplish their function.

8) Repeat for Special Functions - Function keys (except for the delete key) should not repeat upon prolonged depression.

9) Status Display - When the effect of a function key varies, the status of the key should be displayed.

10) Easy Return to Initial Functions - Where the functions assigned to a set of function keys change as a result of user selection, the user should be given an easy means to return to the initial functions.

11) Reprogrammable or Inactive Default Functions - When keys with labeled default functions are reprogrammed or turned off, a visual indication should alert the user that the standard function is not currently accessible via that key.

12) Shifted Characters - Shift keys should be not required to operate variable function keys.

13) 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.

14) Distinctive Labeling of Function Keys - Each function key should be labeled informatively to designate the function it performs.

15) Distinctive Location - Function Keys should be grouped in distinctive locations on the keyboard to facilitate their learning and use.

16) 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.

17) Single Keying for Frequent Functions - Keys controlling frequently used functions should permit single key action and should not require double (control/shift) keying.

18) Consistent Functions in different Operational Modes - When a function key performs different operational modes, equivalent or similar functions should be assigned to the same keys.

19) User definition of Macro Commands - Users should be allowed to assign a single to a defined series of control entries, and then to use that named "macro" for subsequent command entry.

20) Limiting User-Definition of Macros and Programmable Keys - The use of user definable macros and programmable function keys should be limited.

4.2.2.2 Trackballs and Mice

a) Dynamic Characteristics - The controller should be able to produce any combination of x and y axis output values.

b) Positive Centering - If there is a "home position," the capability for an automatic return to that point should be provided.

c) Single Monitor/Single Controller Cursor Travel Limits - In a single monitor/single controller

environment, movement of the controller should drive the follower to the edge of the screen only and not off the screen.

d) Separation of Selectable Screen Items - Selectable screen items or regions should be separated from each other by a sufficient distance to minimize inadvertent activation of adjacent items or regions.

e) Selectable Tracking Speed - The controller tracking speed (control-display ratio) should be user selectable from a predefined list of alternatives; there should be a moderate default speed.

f) Selectable Inter-Click Interval - If multiple clicks are required on a selection button, the user should be able to select the inter-click interval from a predefined list of alternatives. There should be a moderate default setting.

g) Limb Support for Trackballs and Mice - When trackballs and mice are used to make precise or continuous adjustments, hand, wrist, or arm supports should be provided.

h) Mouse Shape - The mouse should have no sharp edges but should be shaped roughly as a rectangular solid.

i) Use of Mouse by Either Hand - The controller should be operable with either the left or right hand.

4.2.2.3 ESCM (Engineered Safety Features - Component Control System Soft Control Module)

a) Shape - Touch targets should be rectangular, with the height less than or equal to the width.

b) Appropriate Use of Touch-Screens - Touch screens are not recommended if the task requires holding arm up to the screen for long periods of time.

c) Feedback - Two forms of feedback should be provided: (1) feedback concerning the position of the follower, and (2) feedback that the pointer has actuated and the input has been received by the system.

d) ESCM Resolution - See 4.1.1 Information FPD a).

e) Follower Visibility - for touch screens and light pens, the follower should be visible on screen while the pointer is touching the screen.

f) Serial Command Response - The system should accept only one command at a time.

g) Feedback for Multiple Consoles - Discriminable audible beeps (used to supply feedback) should be used when more than one touch screen, light pen, or graphics tablet is employed.

h) Neutral Tint of Touch Overlays - Touch screen overlays should have a neutral tint to avoid alteration of color codes.

i) Touch Screen Luminance Transmission - Touch screen displays should have sufficient luminance transmission to allow the display with touch screen installed to be clearly readable in the intended environment.

j) Dimensions and Separation of Touch Zones - To allow for finger size and parallax inaccuracy, the dimensions of response areas of touch screens should be a maximum height and width of 40 mm (1.5 inch) and a minimum height and width of 15 mm (0.6 inch), with a maximum separation distance of 6 mm (0.25 inch) and minimum of 3 mm (0.1 inch).

4.2.3 Conventional Control Device

4.2.3.1 Pushbuttons

a) Dimension and Orientation - The legend switch dimensions should conform to user dimensions. Orientation should conform to the user population stereotype.

b) Position - Pushbuttons in a row or matrix should be positioned in a logical order, or in an order related to the procedural sequence.

c) Pushbutton Surface - The surface of a pushbutton should offer slip resistance or be concave.

d) Discriminability - Legend pushbuttons should be readily distinguishable from legend lights.

e) Barriers - Barriers should be used when legend pushbuttons are contiguous.

4.2.3.2 Rotary Controls

A. General

1) Direction of Activation - Rotary control settings should increase in value with a clockwise rotation.

2) Rotary Control Shape Coding - Shape coding should be employed if rotary controls used for widely different functions are placed on the same panel.

3) Coding Specifications - Shape-coded rotary controls should be visually and tactually identifiable.

4) Rotating Knob Shape Options - Rotating knob controls for different types of control actions should be distinguishable by sight and touch and not easily confused with each other.

5) Rotary Action Control - Rotary action controls should be used in situations where linear or pushbutton controls would be subject to inadvertent activation and fixed protective structures are impractical or inappropriate.

B. Rotary Selector Controls

1) Selection - Rotary selector controls should be used when three or more detented positions are required, and may also be used for two-detented position operation.

2) Positioning - Detents should be provided at each control position to ensure proper positioning of a discrete rotary control.

3) Readability - Rotary controls should have a moving pointer and fixed position settings to maximize readability.

4) Position Indication - Position indication should be provided.

5) Momentary Contact Rotary Selector Controls - Knobs for spring-loaded momentary contact rotary selector controls should be large enough to be easily held against the spring torque, without fatigue, for as long as necessary to accomplish the control action.

C. Rocker Switches

1) Orientation - Rocker switches should ordinarily be oriented vertically.

2) Indication of Activation - Activation should be indicated by a snap feel, an audible click or an integral light.

3) Resistance - Control resistance should gradually increase, then drop to zero when the control snaps into position.

4) Inadvertent Activation - If it controls a critical function, the switch should be protected by channel guards or other means to prevent inadvertent activation.

5.0 HSI SYSTEMS

5.1 Soft Control for Information FPD and ESCM

5.1.1 General Soft Control Design Guidelines

a) Coordinating Soft Control Use Among Operators - If a soft control can be accessed from more than one location in the HSI, protective measures should ensure its coordinated use among multiple operators.

b) Operation with Protective Clothing - Soft controls should be designed to accommodate any protective clothing that operators may be required to wear.

c) Availability - Soft control access should be available from Information FPD, ESCM, and Computer-Based Procedures (CBPs) displays at the associated console.

d) Format Chaining - Soft control access from Information FPD, ESCM, and CBPs displays uses format chaining. Chaining should leave a highlight trail on the Information FPD or CBPs display indicating 1) the selected component, and 2) the selected functional group, as appropriate for the chain link.

e) Adequate Display Space - Adequate display space should be provided so that short-term monitoring and control tasks do not interfere with longer-term tasks.

f) No Activation When Display is Inoperable - Operators should not be able to activate a soft control if its display is not working.

g) Representing Relationships between Control Components - The display capabilities of soft controls should allow operators to quickly assess the status of individual control components and their relationships with other components.

h) Making Options Distinct - The user interface should be designed so that operators can, at a glance, distinguish options by such characteristics as context, visually distinct formats, and separation.

i) Depicted as Unavailable - Components within a functional group outside the confirmed

channel should be depicted as unavailable.

j) Soft control Codes & Conventions - Soft control display codes & conventions should be same as related Information FPD, ESCM, and CBPs display. For example, graphical depiction of components on the soft control should be similar in shape, orientation etc. to the VDU image of the larger system.

5.1.2 Selection Display and Input for Soft Control

5.1.2.1 Selection Display

a) Visually Distinct Selection Displays - Displays used for selecting components and variables should be visually distinct to support choice of the correct display.

b) Visually Distinct Components - The representation of components and variables within selection displays should be visually distinct to support their correct selection.

c) Identification of Loops on Multiple-Loop Controllers - The loops of multiple-loop controls should be distinctly marked to prevent the selection or use of the wrong loop.

5.1.2.2 Input Fields

a) Cues for Matching Input Fields to Selection Displays - An operator looking at the input field for providing a control input should be able to determine which plant component or variable is being controlled.

b) Labeling of Input Fields - The input field should be labeled with sufficient information to uniquely identify its corresponding component.

c) Coordination of Soft Controls with Process Displays - Displays should be readily accessible from the input field so the operator can readily verify that the control actions have had the intended effect on plant systems and processes.

5.1.2.3 Input Formats

a) Appropriate Use of Discrete-Adjustment Interfaces - Discrete-adjustment interfaces

should be used for selecting among a set of individual settings or values.

b) Labeling Selection Options in Discrete-Adjustment Interfaces - The selection options in discrete input formats should be clearly labeled.

c) Feedback for Discrete-Adjustment Interface with Multiple Settings - Discrete-adjustment interfaces should indicate which setting was selected.

d) Feedback for Discrete-Adjustment Interface with Continuous Operation - If a discrete-adjustment interface has continuous operation, it should provide continuous feedback on the current state.

e) Appropriate Use of Continuous-Adjustment Interfaces - Continuous-adjustment interfaces should be used when precise adjustments along a continuum are needed or when many discrete settings are present.

f) Appropriate Use of Soft Sliders - A soft slider should be considered as an input device when the range of possible values and the ratio of a value to that range need to be displayed.

g) Indicating the Range of Values on Soft Sliders - The range of values should be indicated on horizontal sliders with the low value on the left and the high value on the right, and on vertical sliders with the low value on the bottom and the high value on the top.

h) Displaying the Digital Value on Soft Sliders - The numerical value to which a soft slider is set should be presented in digits on the soft slider.

i) Dimensions of Soft Sliders - The physical dimensions of the soft slider should allow the operator to read the current and target positions and position the slider with the required precision, accuracy, and response time.

j) Depicting Critical Ranges on Soft Sliders - When part of the range of values depicted by a soft slider represents critical information, such as alarm limits, those values should be coded to facilitate recognition.

k) Appropriate Use of Arrow Buttons - A set of arrow buttons should be considered as the

input device when it is desirable to incrementally increase or decrease a variable from its previous value.

l) Indicating Current Value for Arrow Buttons - Arrow buttons should have a display indicating the current value of the variable being controlled.

m) Uniform Changes in Values Via Arrow Buttons - Each press of an arrow button should change the current value uniformly.

n) Feedback Regarding Arrow Button Actuation - Arrow buttons should provide salient feedback when they are actuated.

o) Apparent Operation of Arrow Buttons - Labeling and other coding should be used when the operation of the arrow buttons is not apparent.

p) Reference Values for Continuous Variable Inputs - Reference values should be provided to help the operator judge the appropriateness of values when entering continuous variable inputs.

5.1.3 Interaction Methods

5.1.3.1 General Interaction Methods Guidelines

a) Minimizing Soft Control Modes - The excessive use of modes in soft controls should be avoided.

b) Distinctive Indication of Soft Control Modes - When multiple modes exist, they should be distinctively marked so the operator can determine the current mode at a glance.

c) Coordination of Destructive and Safety-Significant Commands Across Modes - A command that produces a benign action in one mode should not cause a different action with serious negative consequences in another mode.

d) Unique Commands for Destructive and Safety-Significant Commands - Unique commands associated with actions that have important consequences should not be easily confused with other commands used in the same or different modes.

e) Discrimination of Interface Management Actions and Process Control Actions - The design of the user interface should clearly distinguish between interface management actions and process control actions.

f) Reducing the Likelihood of Unintended Actuation - for actions that can have significant negative consequences, the user interface should be designed to reduce the likelihood of unintended actuation by requiring deliberate action for their execution.

g) Feedback for Selected Actions Before Execution - The HSI should give the operator feedback indicating the action that was selected and allow the action to be canceled before it is executed.

h) Use of Error-Mitigation Approaches - Error-mitigation approaches should not be the sole means for achieving error tolerance, but should be used in conjunction with other means for error prevention and system-assisted error detection.

i) Undo Features - If undo features are provided they should be consistently available.

5.1.3.2 Sequential Actions

a) Indicating the Status of Sequential Actions - HSI system should support operators in rapidly assessing the status of sequential actions in progress.

b) Drawing Attention to Points Where Similar Sequences Diverge - The design of the HSI should draw the operator's attention to points where operational sequences that have multiple steps in common begin to diverge from each other.

c) Operator Interruption of Transaction Sequences - The HSI should allow the operator to interrupt or terminate a current transaction sequence.

d) Interrupted Sequence Prompt - The HSI should support the operator in maintaining awareness or recalling tasks that were interrupted or suspended by giving a reminder.

e) Resumption of Interrupted Sequences - A minimum number of actions should be required for the operator to resume a control-action sequence that was temporarily suspended.

5.1.3.3 Verification and Confirmation Steps

a) Separate Action for Verification Steps - Verification steps should be separate from input actions.

b) Confirmation of Goals - When feasible, confirmation steps should draw operator attention to the goal of the action, not just to the action.

5.1.3.4 Interlocks, Lockouts, and Lockins

a) Use of Interlocks, Lockouts, and Lockins - Interlocks, lockouts, and lockins should be provided to restrict personnel actions that may affect plant safety.

b) Operator Override of Interlocks, Lockouts, and Lockins - The design of interlocks, lockouts, and lockins should not limit the operators' authority unless there is a clear safety reason.

c) Visibility of Interlocks, Lockouts, and Lockins - Interlocks, lockouts, and lockins should be designed to indicate which actions are being blocked and what conditions activated the block.

d) Automatic Logging of the Activation of Interlocks, Lockouts, and Lockins - The activation of an interlock, lockout, or lockin should be automatically logged.

e) No Automatic Actuation of Blocked Actions - An interlock, lockout, or lockin should not initiate an action that was previously blocked merely because the status of the triggering condition has changed.

5.1.3.5 Error Detection and Correction

a) Warning Message Content - Warning messages should draw operators' attention to the goal of the action, not just to the action.

b) Automatic, Self-Correct Features for Interface Management Action - Automatic, self-correcting features should only be used for interface management actions, such as

retrieving displays.

c) Undo Capabilities for Self-Correct Features - Automatic, self-correcting features should only be used if they include good "Undo" capabilities, so that inappropriate changes made by the system can be reversed by the user.

d) User of Inspection and Transfer Steps - Inspection and transfer steps should be considered if inputs are complex, or if incorrect inputs can seriously affect safety.

5.1.3.6 Selecting Plant Variables or Components

a) Identification of Plant Variables and Components - The HSI should support the identification of plant variables and components based on recognition rather than relying strictly upon recall.

b) Simple Input Actions for Selection - The operator should be able to select a component or variable from a display by using simple input actions.

c) Minimize Action-Sequence Errors for Selecting Plant Variables - If a sequence of actions is required to select a component or variable, the HSI should be designed to prevent misordered action-sequence errors.

d) Minimize the Number of Retrieval Steps for Controls that are Used Together - When a group of controls must be used together, their retrieval should require a minimal number of actions.

5.1.3.7 Control Inputs

a) Automatic Reset of Multi-Variable Controls - If an input device controls more than one variable, the operator should not have to reset the device to match the value of the new variable before executing a control action.

b) Numerical Input Values - The HSI should provide feedback to support the operator in verifying the correctness of numerical values entered.

5.1.3.8 Handing stored Data

a) Minimize the Use of Irreversible Actions - The design of the HSI should minimize the use of irreversible actions for handling stored data.

b) Deferring Execution of Operations that are Destructive to Stored Information - Whenever practical, irreversible operations that destroy stored information should be deferred and require a separate action for their execution rather than being carried out immediately.

5.1.3.9 System Response

a) Actuation Feedback - Soft controls should provide feedback about their operating state after activation.

b) Operator Notification of Automatic Mode Changes - Systems that can change mode automatically should provide feedback to make the operator aware of the current mode.

c) Delaying System Response - Where appropriate, systems that are sensitive to incorrect inputs should be designed to limit the rate at which these inputs can affect the process.

5.2 CBPs (Computer-Based Procedures)

5.2.1 Representation of Procedures

5.2.1.1 Identification of Procedures

a) Procedure Title and Identification Information - Each procedure should contain identifying information including title, procedure number, revision number, date, and organizational approval.

b) High-Level Goals - Each procedure should state its high-level goals and applicability, including its procedure category, e.g., emergency or abnormal.

5.2.1.2 Basic Steps of Procedures

a) Concise Steps - Procedure steps should be concise.

b) Short Sentences - Procedure steps should be written as short sentences.

c) Active Voice - Procedure steps should be written in active voice.

d) Positive Commands - Procedure steps should be written as positive commands.

e) Simple Wording - Short, simple words from standard Korean should be used.

f) Standard Punctuation - Punctuation should conform to standard Korean usage.

g) Consistent Word References - Words, phrases, and equipment names and numbers should be used consistently within and among procedures, drawings, other HSIs, and equipment labels.

h) Abbreviations and Acronyms - Abbreviations and acronyms should be used consistently and limited to those well known to the users.

i) Units of Measures - Numerical information should include units of measure.

j) Numerical Precision - Numbers should be specified at the appropriate precision.

k) Number Ranges - Ranges of numbers should be specified, rather than error bands.

l) Use Arabic Numerals - Arabic numerals should be used.

m) Spelled Numbers - Numbers that are spelled out should be consistently spelled under the same conditions.

n) Presentation of Conditional Steps - Conditional steps should be shown in traditional text formats following the guidance in Appendix A of USNRC NUREG-0899, Rev.0.

o) Specification of Preconditions for Steps - The procedure should specify any conditions that must be met before an action can be undertaken.

5.2.1.3 Warnings, Cautions, Notes, and Supplementary Information

a) Parallel Display with Procedure Step - The warnings and cautions applicable to a single step (or to a series of steps) should be displayed when the step(s) is on the screen.

b) Position Before Action Steps - Warnings, cautions, and notes should be presented so that they will be read before the applicable action steps.

c) Action References - Warnings, cautions, and notes should not include implied or actual action steps.

d) Distinction from Other Procedure Elements - Warnings, cautions, and notes should be uniquely presented, so that they are easily distinguished from each other and from other display elements.

e) Supplementary Information - All supplementary information (such as tables and figures) required for a procedure step and available to the CBPs should be shown on the screen concurrently with the step, or on another easily viewed display.

5.2.1.4 Lists of Procedures

a) Appropriate Application of Lists - Groups of three or more related items (e.g., actions, conditions, components, criteria, and systems) should be presented as a list.

b) Distinction from Other Procedure Elements - Formatting should be used to differentiate items in a list from other procedure elements.

c) Identification of Precedence - The presence or absence of precedence among items in lists should be indicated.

d) List Overviews - Overviews should introduce each list.

e) Assuring Users' Attention - The method for assuring that each item in a list has received the users' attention should be consistent.

5.2.1.5 Organization and Formatting of Procedures

a) Hierarchical, Logical Organization - The procedures should be organized in a hierarchical,

logical, consistent manner.

b) Organization of Procedure Steps - Each procedure should be organized into sections of related steps.

c) Organization Format of Procedures - The procedure's format should reflect its organization.

d) Format of Procedures - A consistent format should be used to display procedures.

e) Partitioning Procedures - A consistent approach to partitioning procedures should be used.

f) Organization of Display Screen - Each display screen should locate information and HSI features consistently.

g) Continuously Presented Procedure Information - The procedure's title and identification should be continuously presented.

h) Continuously Presented Status of High-Level Goals - The status of high-level procedure goals should be continuously presented.

5.2.2 Functionality of Procedures

5.2.2.1 Supervision and Control of Procedures

a) Users' Control of Procedure Path - Users should be in control of the sequence of steps that are followed.

b) Users' Control of Pace of Procedures - Users should be in control of the pace at which procedure steps are followed.

c) Understandability of Analysis of Procedure Steps - The methods by which CBPs analyze procedure steps should be consistent with the methods by which users analyze steps in procedure logic steps, so that the results are understandable.

d) Users' Verification of CBPs Information - The users should be able to verify the system's

assessment of plant status.

e) Users' Override of CBPs - Users should be able to override any CBPs information, calculation, evaluation, or assessment.

5.2.2.2 Monitoring and Assessment of Procedures

a) Automatic Identification of Procedures - The CBPs should alert users when entry conditions to a procedure are satisfied.

b) Automatic Monitoring of Plant Parameters and Equipment Status - The CBPs should automatically provide accurate and valid information on the values of parameters and status of equipment, when they are available to the system.

c) Frequent Monitoring - The CBPs should frequently monitor procedure-defined parameters.

d) Automatic Calculation of Procedure-Referenced Values - The system should undertake calculations, such as subcooling margin, that are required when using procedures.

e) Analysis of Step Logic - The CBPs should evaluate the logic of each procedure step and show the results to the user.

f) Continuous Analysis of Non-Current Step Logic - Steps of continuous applicability, time-dependent steps, and process-dependent steps should be monitored by the CBPs and the user should be alerted when conditions in those steps become effective.

g) Coding of Logical Analysis - When procedure's step logic indicates a violation of the step, the information should be coded to make that step more salient to users.

h) Analysis of Cautions - The conditions described in cautions should be automatically monitored by the CBPs system, and the user should be alerted when the caution is in effect.

i) Coding Applicable Cautions - CBPs should use coding to indicate when a caution is in effect.

j) Users' Acknowledgment of Procedure Analyses - User should make some from of acknowledgment of procedure steps and recommendations for terminations and transitions.

k) Identification of User Input Requirements - The CBPs should provide users with clear, timely indications when they need to input any information not available to it.

l) Adjustable Level of Detail - Users should be able to choose the level of detail with which procedures are presented.

m) Context-Specific Guidance - Procedure guidance should be context sensitive where possible.

n) Assessment of High-Level Goal Status - The CBPs should continuously assess and present the status of higher-level safety goals, such as critical safety functions, and alert the user to any challenges.

o) Assessment of Conditions Terminating A Procedure - The CBPs should automatically identify when conditions are met for transitioning or exiting from a procedure.

5.2.2.3 Monitoring Users' Actions

a) Monitoring Users - User responses to procedures should be monitored and recorded by the CBPs.

b) Alert Users to Deviations in Procedure - Users should be alerted if their input is incorrect, or when their actions are not consistent with CBPs evaluations.

5.2.2.4 Planning and Implementation

a) Display of Action Status - The status of procedure-related actions should be displayed by the CBPs.

b) Timing of Procedures - The CBP's timing, such as status update rates, screen changes, and navigation features, should be consistent with the time demands of the task.

5.2.3 Management and Support of Procedures

5.2.3.1 Path Monitoring of Procedures

a) Monitoring Step Status - There should be an indication of whether or not a step was completed.

b) Alert User to Incomplete Procedure Steps - Users should be alerted to incomplete procedure steps.

c) Coding Current Location - The current procedure step(s) should be indicated.

d) Automatic Path Monitoring - The pathway taken through procedures should be stored and made available to users.

e) Indication of Multiple Active Procedures - The user should be informed when multiple procedure steps are to be followed concurrently. A list of all currently active procedures should be available.

5.2.3.2 Procedure Navigation

a) Flexible Navigation - Navigation support should allow users to freely and easily move between procedure steps, to other parts of the same procedure, and to other procedures.

b) Support Parallel Access to Information - The CBPs should have the ability to access more than one piece of information at once.

c) Navigational Links to Related Information - Navigational links to cross-referenced information and to notes, cautions, warnings, reference material, and communication and help facilities should be provided.

d) Access to Contingency Actions - Users should be able to easily access appropriate contingency actions.

5.2.3.3 Help

a) Explanation Facilities - CBPs should have facilities to enable the user to determine how CBPs functions are performed.

b) Help Facilities - Help for performing procedure specified activities should be provided.

c) Note Taking - There should be a way for users to record their notes and comments in the CBPs.

5.2.4 Backup for CBPs

a) Paper-Based Procedure Availability - Paper-Based Procedure (PBP)s should be available in the event of CBPs failures.

b) Consistency of PBPs and CBPs - The content and presentation of procedure information in PBPs and CBPs should be consistent.

c) Support for Transfer to PBPs - Upon transfer to PBPs, a means should be provided to support the user's determination of currently open procedures, location in the procedures, completed and not completed steps, and currently monitored steps.

5.2.5 Integration of CBPs with Other HSI Components

The detailed CBPs design should be fully consistent with the rest of the HSI.

5.3 Alarm System

5.3.1 General Alarm System Design Guidelines

a) Alarm Selection - The following criteria should be included in the basis for selecting alarm conditions: -Monitoring critical safety functions and key parameters, -Preventing personnel hazards, -Avoiding significant damage to equipment having a safety function, -Assuring that technical specifications are met, -Monitoring emergency procedure decision points, and -Monitoring plant conditions appropriate to plant modes ranging from full power to shutdown.

b) Timely Warning - Alarm set points should be determined to ensure that the operating crew

can monitor and take appropriate action for each category of alarms, e.g., respond to out-of-tolerance conditions, in a timely manner.

c) Setpoint Determination and Nuisance Alarm Avoidance - The determination of alarm setpoints should consider the trade-off between the timely alerting of an operator to off-normal conditions and the creation of nuisance alarms caused by establishing setpoints so close to the "normal" operating values that occasional excursions of no real consequence are to be expected.

d) Darkboard Configuration - Candidate alarms and setpoints should be chosen so that no alarms are active for the normal operating conditions of the plant.

e) Assured Functionality Under High Alarm Conditions - The alarm processing system should ensure that alarms which require immediate operator action or indicate a threat to plant critical safety functions are presented in a manner that supports rapid detection and understanding by the operator under all alarm loading conditions.

f) Alarm Reduction - The number of alarm messages presented to the crew during off-normal conditions should be reduced by alarm processing techniques (from a no-processing baseline) to support the crew's ability to detect, understand, and act upon all alarms that are important to the plant condition within the necessary time.

g) Alarm Signal Validation - Sensor and other input signals should be validated to ensure that spurious alarms are not presented to plant personnel, due to sensor or processing system failure.

h) Parameter Stability Processing - The alarm system should incorporate the capability to apply time filtering and/or time delay to the alarm inputs to allow filtering of noise signals and to eliminate unneeded momentary alarms.

i) Alarm-Status Separation - Status indications, messages that indicate the status of plant systems but are not intended to alert the operator to the need to take action, generally should not be presented via the alarm system display because they increase the demands on the operators for reading and evaluating alarm system messages.

j) First-Out Processing - as an aid to diagnostic procedures and root cause analysis,

provision should be made for identifying the initiating event associated with automatic plant trips through the use of first-out alarms.

k) Mode Dependence Processing - If a component's status or parameter value represents a fault in some plant modes and not others, it should be alarmed only in the appropriate modes.

l) System Configuration Processing - If a component's status or parameter value represents a fault in some system configurations and not others, it should be alarmed only in the appropriate configurations.

m) Logical Consequences Processing - If a single event invariably leads to subsequent alarmed events that are the direct consequence of this event, only the alarm message associated with the main event may be presented and the other alarm messages suppressed, so long as this does not interfere with the operators' use of alarm information.

n) Intelligibility of Processed Alarm Information - Processing methods should not be so complex that operators have difficulty evaluating the meaning or validity of the resulting alarm messages.

o) Location of Alarm System Displays and Controls - Alarm displays and controls should be located in close proximity so that the display can be read while operating the controls.

p) Location of First-Out Alarms - First-out displays should be located at the main console for the system and/or at a plant overview display visible to the crew.

q) Location for Prompt Response - Alarm displays and controls should be arranged and located such that the operating crew member(s) who must respond to an alarm can access the alarm information in sufficient time to respond adequately.

r) Location for Access to Process Controls and Displays - Visual alarm panels should be located near the controls and displays which are required for corrective or diagnostic action in response to the alarm.

s) Alarm Prioritization

1) Prioritization Criteria - Alarm messages should be presented to the operators in prioritized from based on prioritization dimensions that include, for example, urgency (immediacy of required operator action) and challenges to plant safety.
2) Access to Suppressed Alarms - When alarm suppression is used, the operator should be able to access the alarm information that is not displayed.

5.3.2 Auditory Alert Subsystem

a) Audio Signal for Alarms - An auditory signal should be used to alert the operator to the existence of a new alarm, or any other condition of which the operator must be made immediately aware.

b) Audible Signals for Alarm States - The tones used for incoming alarms should be separate and distinct from tones used to signify "clearing" alarms.

c) Reset of Auditory Alert - The auditory alert mechanism should automatically reset when it has been silenced.

d) Interference Among Signals - Audio alarm signals should not conflict with other auditory codes or signals.

e) Manual Disable/Adjustment of Signal Intensity - Manual disable or adjustment of auditory signal intensity (loudness) should be avoided.

f) Sound Sources - The number and placement of loudspeakers should be such that auditory signals are free of distortion and are equally audible at any operator work station in the primary operating area.

g) Auditory Signal Discriminability - Each audio signal should be unambiguous and easily distinguishable from every other tone in the control room.

h) Audio Pattern Codes - If sequences of tones are used to represent information, the patterns should be easily recognizable.

i) Intensity Coding - Coding of auditory signals by intensity (loudness) should not be used. Auditory signals should capture operator's attention without unduly startling them (i.e.,

alerts should interrupt, not disrupt, attention).

j) Reminder Audible Signals - If the tone associated with an unacknowledged alarm automatically turns of after an interval of item, a reminder tone should be presented to alert the user to the continued presence of an unacknowledged alarm.

5.3.3 Visual Display Subsystem

5.3.3.1 General Visual Display Subsystem Design Guidelines

a) Display Functions - The alarm display should support the operator's ability to rapidly discern:

1) Priority (e.g., urgency for operator action and importance to plant safety),
2) Distinct alarm states: new, acknowledged, and cleared,
3) The first-out alarms for reactor trip,
4) The need to access other displays to verify or clarify the alarm state, and
5) The difference between alarms which can be canceled through ongoing corrective actions (i.e., by operations personnel) and alarms that require significant maintenance intervention.

b) Coordination of Alarm Alerting and Informing Functions - When alarm alerts are displayed separately from detailed alarm information, the design should support the operator in making rapid transitions between alerts and detailed information.

c) Presentation of Alarm Priority with Detailed Alarm Information - When alarm alerts are displayed separately from detailed alarm information, the detailed alarm information display should provide an indication of the priority and status of alarm condition.

d) Use of Spatially-Dedicated, Continuously-Visible Displays - Spatially-dedicated, continuously-visible (SDCV) alarm displays should be considered for:

1) USNRC Regulatory Guide 1.97 Category 1 parameters,
2) Alarms that require short-term response by the operator,
3) Main alarms used by operators in diagnosing and responding to plant upsets, and
4) Main alarms used by operators to maintain an overview of plant and system status.

e) Alarm Coding Consistency - Coding (e.g., flash-rate and color coding) conventions should be consistently applied throughout alarm displays (e.g., on tiles and on VDUs).

f) Multi-Unit Alarms - Alarms for any shared systems in multiple-unit plants should be duplicated in all control rooms.

g) Coding Effectiveness - The coding scheme used by the alarm system should assure rapid detection and interpretation by the operators under all control room operating conditions.

h) Visual Coding for Alarms - Visual coding should be used to direct operator attention to alarms and to indicate their status.

i) Redundant Coding Dimensions - Redundant codes (e.g., fast flashing or bright) should be used for alarms that require rapid operator action.

j) Color Detectability - Low-intensity (e.g., dark red) indications in the periphery of the visual field should be avoided where color coding is used, since they may not be readily detected.

k) Spatial Coding - Spatial coding may be used to indicate alarm importance.

l) Suppressed Visual Codes - If the visual coding used to indicate alarm status is automatically suppressed or delayed during high alarm volume conditions or the presence of more important alarms, they should be automatically presented after the more important alarms have been addressed.

5.3.3.2 Display of High-Priority Alarms

a) Importance/Significance - Alarms that have higher importance or greater safety significance should be given greater priority in their presentation than less important or significant alarms.

b) Coding of Alarm Priority - A method of coding the visual signals for the various priority levels should be employed.

5.3.3.3 Display of Alarm Status

a) Indication of Alarm Status - New, acknowledged, and cleared alarm states should have unique presentations to support the operators' ability to rapidly distinguish them.

b) New Alarms - New alarms should be indicated both by visual (e.g., flashing) and audible means.

c) Notice of Undisplayed New Alarms - If the operator is not currently viewing the VDU display where new, unacknowledged alarm messages appear, the alarm system should notify the operator that a new alarm message is available, the priority of the alarm message, and the location where the alarm message can be found.

d) Acknowledged Alarms - After the operator has acknowledged an alarm (e.g., pressed the acknowledge button), the alarm display should change to a visually distinct acknowledged state and the alerting function (e.g., audible tone) should cease.

e) Clearing Alarms/Ringback - If the operator is required to take action when an alarm clears (i.e., the parameter returns to the normal range from an abnormal range), the return to normal conditions should be indicated by visual and audible means.

f) Cleared Alarms That Re-Enter the Abnormal Range - If an alarm has cleared but was not reset and the variable re-enters the abnormal range, then the condition should be presented as a new alarm.

5.3.3.4 Display of Shared Alarms

a) Minimize Shared Alarms - Alarms that are triggered by any one of an aggregate of individual alarms (e.g., 'Pump Trouble') and which require the operators to perform additional actions to determine the cause should be limited.

b) Access to Shared Alarm Information - The system should allow users to access the individual alarm information when a shared alarm activates.

c) Shared Alarm Reflash - If a new parameter deviation has occurred before a preceding alarm has cleared, the shared alarm should return to the new alarm state (e.g., flashing).

5.3.3.5 Alarm Messages

a) Alarm Information Content - The alarm should provide the following information:

1) Alarm title or legend,
2) Plant system or component involved (e.g., reactor coolant pump A),
3) Parameter involved (e.g., temperature, pressure, voltage),
4) Status of parameter (e.g., high, low, or inadequate),
5) Alarm source, i.e., the particular sensor or group of sensors supplying the signal,
6) Alarm priority, and
7) Setpoint and parameter values.

b) Alarm Text/Legend - Alarm text should be clearly understandable, use standard terminology, and address conditions specifically.

c) Alarm Messages - SDCV Tile Format - The format of messages on alarm tiles or tile-like displays should be consistent for all alarms.

d) Alarm Source - The content of each message should provide information that identifies the alarm source.

e) Alarm Priority - Each alarm message should indicate its priority.

f) Setpoint Values - If an alarm condition requires verification before action is taken, the relevant setpoint limits should be included in the alarm message when alarm information is presented on VDU or is printed.

g) Parameter Values - Deviant parameter values should be included in the alarm message where alarm information is presented on VDU or printer displays.

h) Required Immediate Operator Actions - Immediate operator actions should be presented or made available directly upon operator request when alarm information is presented on VDU or printer displays.

i) Reference to Procedures - Where alarm information is presented on VDU or printer

displays, references to alarm response procedures should be provided.

5.3.3.6 Organization of Alarms

A. SDCV (Spatially Dedicated, Continuously Visible) Alarm Displays

1) Functional Grouping of Alarms - Alarms within a display should be grouped by function, system, or other logical organization.

2) Separation of Functional Groups - Alarm functional groups should be visually distinct from one another.

3) Group Labels - System/functional groups should be clearly delineated and labeled such that the operating crew can easily determine which systems have alarms that have not yet cleared and which system is affected by a particular incoming alarm.

4) Logical Arrangement of Alarms - Alarms should be ordered to depict naturally occurring relationships.

5) Alarm Display Identification Label - Each group of alarm displays should be identified by a label above the display.

B. Alarm Message Lists

1) Listing by Priority - Lists of alarm messages should be segregated by alarm priority with highest priority alarms being listed first.

2) Message Listing Options - In addition to priority grouping, operators should have the capability to group alarm messages according to operationally relevant categories, such as function, chronological order, and status (unacknowledged, acknowledged/active, cleared).

3) Message Overflow - Alphanumeric alarm messages that overflow the first page of alarm messages should be kept on subsequent alarm pages.

5.3.4 Operator Response Subsystem

5.3.4.1 General Alarm Control Design Guidelines

a) Provisions for Control Functions - Separate controls should be provided for silence, acknowledgment, reset (acknowledging an alarm that has cleared and returning it to normal).

b) Distinct Coding of Control Functions - Alarm system controls should be distinctively coded for easy recognition.

c) Consistent Layout of Control Group - Each set of alarm system controls should have the functions in the same relative locations.

d) Defeating Controls - Alarm system control designs should not allow the operator to defeat the control.

e) Access to New Undisplayed Alarms - A VDU-based alarm system should provide rapid access to any new alarm messages that are not shown on the current display.

5.3.4.2 Alarm Control Type

A. Silence Controls

1) Automatic Silencing - Auditory signals should be silenced automatically without manual operation after a specified period of time.

B. Acknowledge Controls

1) Effect of Acknowledge Function - An alarm acknowledgement function should terminate the flashing of an alarm and have it continue at steady illumination until the alarm is cleared.

2) Acknowledgement Locations - Acknowledgement should be possible only from locations where the alarm message can be read.

3) Acknowledgement of Alarm Messages - Non-SDCV alarms should only be

acknowledged when the alarm message is on the screen.

C. Reset Controls

1) Effect of Reset Function - The reset function should place the alarm system in an unalarmed state after an alarm has cleared.

2) Appropriate Use of Manual Reset - A manual reset sequence should be used where it is important to explicitly inform operators of a cleared condition that had once been deviant.

3) Appropriate Use of Automatic Reset - An automatic reset sequence should be available where operators have to respond to numerous alarms or where it is essential to quickly reset the system.

4) Reset Function Location - The reset function should be effective only from locations at which plant personnel know which alarm that they are resetting.

5.3.4.3 Alarm Response Procedures (ARP)

a) ARP Scope - ARPs should be available for alarm conditions that require an operator response which affects the plant process control system or plant equipment.

b) ARP Access - Operators should have immediate access to ARPs from the location at which the alarm message are read.

c) ARP Content - ARPs should contain the following information:

1) The system/functional group to which the alarm belongs,
2) The exact alarm text or legend,
3) The alarm source (i.e., the sensor(s) sensing the signal, including processing or signal validation logic, and the actuating device(s) for the alarm with a reference to a schematic diagram on which such devices can be found),
4) Alarm setpoints,
5) Priority,
6) Potential underlying causes for the alarm (e.g., low water level - feed flow deficient in

the long - term),

7) Required immediate operator actions, including actions the operator can take to confirm the existence of the alarm condition,
8) Actions which occur automatically when the alarm occurs (and which the operator should verify as having taken place),
9) Follow-up actions, and
10) Pertinent references.

d) Information Consistency with The HSI - Information in ARPs should be consistent with information on consoles, in the alarm system, in I&C procedures used to calibrate alarm setpoints, in controlling documents that determine setpoints (e.g., Technical Specifications and accident analyses), in P&IDs, and in other plant procedures.

e) ARP Format - The ARP format should:

1) Highlight the ARP identifier on each page of the procedure,
2) Highlight important items,
3) Locate information categories in the same position on each page,
4) Consistently present information throughout the ARP, and
5) Minimize the need for operators to page back and forth to obtain the information.

5.3.5 Automatic Features

a) Automated Alarm System Configuration - If the alarm system automatically changes operational configurations under some alarm situations, then these configuration changes should be coupled with an alert to the operator and an indication that the configuration has changed.

b) Operator-Selectable Alarm System Configuration - If the alarm system provides operator-selectable operational configurations, then these configuration changes should be coupled with an indication of the present configuration.

c) Acknowledgement of Alarm System Configuration Changes - Operator acknowledgement (or confirmation) should be required if a significant alarm system configuration change is to be made either automatically or by operator selection.

d) Operator-Defined Alarms/Setpoints - The alarm system may provide temporary, operator-defined alarms and operator-defined set points for specific conditions where such alarms are determined to be of assistance to the operators in selected evolutions (e.g., temporary alarms to support increased monitoring of a problem component, or at other times when the operator wants to know of a parameter trend that is approaching a limit).

e) Interference of Operator-Defined Alarms/Setpoints with Existing Alarms - Operator-defined alarms and setpoints should not override or interfere with the existing alarms and setpoints.

f) Control of Operator-Defined Alarms/Setpoints - The alarm system should provide clear indication of operator defined alarms and setpoints as distinct from the alarm/setpoints designed into the system.

g) Automatic Mode-Defined Setpoints - If an alarm system provides automatic adjustment of setpoints for different plant modes or conditions, it should be evaluated whether operator acknowledgement/confirmation of the significant changes is necessary.

5.3.6 Reliability, Test, Maintenance, and Failure Indication

5.3.6.1 Reliability

a) Design for Reliability - The alarm system should be designed so that no single failure will result in the loss of a large number of alarms.

b) VDU Reliability - Where alarms are presented on a VDU as the primary display, operators should be able to access the alarms from more than one VDU.

5.3.6.2 Test

a) Testing Capabilities - Test controls should be available to initiate operational test conditions for all essential aspects of the alarm system (including processing logic, audible alarms, and visual alarm indications).

b) Testing Requirement - Periodic testing of the alarm system should be required and controlled by administrative procedure.

5.3.6.3 Maintenance

a) Design for Maintainability - The alarm system should be designed so that maintenance activities can be performed with minimal interference with the activities of the operators.

b) Tagged-Out Alarms - Tagging out an alarm (taking it out of service) should require disabling of the associated visual and audio signals.

c) Out-of-Service Alarm Indication - Cues for prompt recognition of an out-of-service alarm should be designed into the system.

5.3.6.4 Failure Indication

Operators should be given prompt indication of a failure of the alarm system or its major subcomponents.

5.4 Communication System

5.4.1 General Communication Design Guidelines

a) Accessibility - Communications functions and/or equipment should be accessible from the user's normal working location.

b) Instructions - Instructions should be provided for use of each communication system, including suggested alternatives if a system becomes inoperable.

c) Outgoing Emergency Messages - Priority procedures should be established for the transmission of emergency messages from the control room by any of the communication systems.

d) Incoming Emergency Messages - Procedures should be established for handling communications during an emergency, and these procedures must be known by all operators.

e) Minimal User Actions - Communication procedures should be designed to minimize

required user actions.

f) Communication Flexibility - Users should have flexibility in communications methods.

g) Speech Transmission and Reproduction

1) Signal Processing - If the environment or the speech transmission equipment is such that the signal-to-noise ratio of the speech is degraded, signal processing techniques should be used to maintain speech intelligibility.
2) Squelch Control - When communication channels are to be continuously monitored, each channel should be provided with a signal-activated switching device (squelch control) to suppress channel noise during no-signal periods.
3) Periodic Maintenance Tests - Periodic tests should be performed on all communication systems to ensure that messages remain intelligible under changes in ambient noise levels that may have occurred since the last check.

h) Equipment Configuration

1) Equipment should be comfortable for prolonged use.
2) If not cordless, devices should have cords long enough to prevent restriction of access to the console's far reaches. Cords should be non-kink or retractable.
3) Communications devices should be located so their cords will not tend to traverse traffic paths in normal use.
4) Phone and handset storage cradles should be designed or located to prevent their contents from being easily dislodged.
5) Regular telephone style handsets should be equipped with cradle allowing the handset to be properly held on the operator's shoulder while keeping both hands free.
6) Multiple commutations devices of similar general type at a station should be visually and/or audibly distinctive, to reduce confusion during periods of peak loading. Code assignments should be standardized for the entire facility.

i) Equipment Controls

1) Push-talk keys should be equally usable with either a left-or right-handed grip.
2) Channel gain and ring loudness should be adjustable at receiving stations/devices. Minimum settings of fixed installation devices should produce audible output levels

under normal ambient noise levels.

j) Noise Testing

1) Noise testing must be performed under conditions matched to actual plant operating conditions.
2) Periodic maintenance tests and criteria should be specified in all communications systems detailed design documentation sufficient to ensure that the systems will be effective under anticipated worst-case conditions.
3) All communications systems and appropriate components (i.e., amplifiers, speakers, level gains, and other hardware whose usability is impact by noise) should be tested and adjustable after installation to accommodate the test results.

5.4.2 Speech-Based Communication

5.4.2.1 General Requirements

a) Comfort - Communication equipment to be worn should be designed to preclude discomfort.

b) Hands-Free Operation - Communication equipment should be designed to permit hands-free operation.

c) Frequency Response - Microphones and associated amplification equipment should be designed to respond optimally to that part of the speech spectrum most essential to speech intelligibility (i.e., 200 to 6,100 Hz).

d) Microphone Dynamic Range - The dynamic range of a microphone used with a selected amplifier should be great enough to admit variations in signal input of at least 50 dB.

e) Microphone Noise Shields - When ambient noise is high (85 dB(A) or greater), the microphone should be put in a noise shield.

f) Noise-Canceling Microphones - In very loud, low frequency noise environments (100 dB overall), noise-canceling microphones should be used.

g) Speaker Frequency Range - Loudspeakers, earpieces, and headphone elements should respond uniformly (plus or minus 5 dB) over the range 100 to 4,800 Hz.

h) Binaural Headsets For High Noise Environments - If listeners will be working in high ambient noise (85 dB(A) or above), binaural headsets should be provided rather than monaural headsets.

i) Loudspeakers for Multi-Channel Monitoring - When several channels are to be monitored simultaneously by means of loudspeakers, the speakers should be mounted at least 10 degrees apart in the horizontal plane frontal quadrant, ranging radially from 45 degrees left to 45 degrees right of the user's normal forward facing position.

j) Volume Controls - Accessible volume or gain controls should be provided for each communication receiving channel (e.g., loudspeakers or headphones) with sufficient electrical power to drive sound pressure level to at least 100 dB overall when using two earphones.

5.4.2.2 Telephones

a) Handset Size and Shape - The size and shape of handsets should be compatible with operator's hand size and mouth-ear distance (standard telephone dimensions are acceptable).

b) Handset Design - Handset earpieces should maintain firm ear contact while the transmitter is positioned in front of the mouth.

c) Retractable Handset Cords - Cords should be of nonkink or self-retracting type.

d) Handset Cord Length - Cords should be of sufficient length to permit reasonable operator mobility.

e) Handset Cord Position - Cords should be positioned so as to avoid entangling critical controls or endangering passing traffic.

f) Handset Cradles - Vertically mounted handset cradles should be designed and located to prevent the handset from being knocked out of the cradle by passing traffic.

g) Multiple Instruments - Where multiple telephone instruments are located close together (e.g., on a single desk), they should be coded to indicate circuit or function.

h) Press-to-Talk Button - If a press-to-talk button is used, the button should be convenient to both left-and right-hand operation.

i) Switching Mechanism - Switching should be designed and/or programmed to minimize delay in making desired connections under both normal and emergency conditions.

j) Telephone Ringing - The volume of ringing should be adjustable at the individual telephone instrument.

k) Announcing Use - The transmitter should be compatible with the rest of the announcing system when used as the microphone input to the announcing system.

l) Hot Lines - Dedicated hot lines should be provided in the control for direct or minimum-dial connections with the technical support center, emergency facilities and off-site agencies as required. These phones should be conveniently located for the anticipated users, but should not occupy central workspace due to their infrequent use.

5.4.2.3 Radio Transceivers

a) Appropriate Use - Walkie-talkies should be used in both emergency and normal operations for two-way communications beyond the range of installed telephone connections or as a convenient alternative to the sound-powered telephone.

b) Sound Quality - Walkie-talkies should realize the same quality desired throughout all of the communications systems within the engineering constraints imposed by radio frequency spectrum availability and by design for easy portability.

c) Area Coverage - Modulation and a radio frequency should be chosen, as FCC regulations permit, to provide broad-area walkie-talkie communication to the control room.

d) Portability - to the extent permitted by design for effective electrical/radio frequency function, walkie-talkies should be small, light, and easy to carry. The microphone should

be integrated into the transceiver package.

e) Party Identification - Procedures should provide for unambiguous identification of the speaker when there are more than two parties on a channel operating at separate locations.

f) Battery Replenishment - A supply of fresh replacement batteries should be stowed in an accessible, well-marked space.

5.4.2.4 Sound-Powered Phones

a) Feedback - Within engineering constraints imposed by sound-powering, the system should provide in-phase feedback to the user.

b) Switching - When used, patch panels should be conspicuously marked and located in reasonably accessible places.

5.4.2.5 Announcing Systems

a) Intelligibility and Coverage - The system should provide rapidly intelligible messages to all areas where personnel subject to a page may be located.

b) Microphone Characteristics - If the powered telephone system is used to provide microphone input to the announcing system, the telephone system should contain transmitters of quality compatible with that of the announcing system.

c) Loudspeaker Location - Speakers should be provided in the control room and other areas where control room personnel operations might be (e.g., restrooms, eating areas, and locker rooms).

d) Speech Clarity - Since proper speech over an announcing system differs from normal conversation, operators should be familiarized with the proper way to speak on the announcing system.

e) Loudspeaker Volume - Speaker volume should be adjusted to ensure that speaker communications will not prevent detection of auditory alarms.

f) Priority - Control room inputs to the plant announcing system should have priority over any other input.

5.4.2.6 Emergency Communications

a) Backup Equipment - Provisions should be made to assure complete internal and external communications capabilities during emergencies.

b) Equipment Usability - Communications equipment should be usable by personnel wearing protective gear without impediment to their tasks.

c) Voice Communications with Masks - Emergency face masks should be equipped with diaphragms that are specially designed to transmit speech.

5.4.3 Computer-Based Communication

5.4.3.1 General

a) Interactive Communication - Users should be able to communicate interactively with other users who are currently using the same system.

b) Interaction with Ongoing Tasks - Users should be able to communicate with each other without canceling ongoing tasks.

c) Functional Integration - Computer-based communications should be integrated with other information handling functions within a system.

d) Consistent Procedures - Procedures for sending and receiving messages should be consistent from one transaction to another.

e) Control by Explicit User Action - Both sending and receiving messages should be accomplished by explicit user action.

f) Automatic Queuing - The computer should provide automatic queuing of outgoing messages pending confirmation of transmission, and incoming messages pending their

review and disposition.

g) Interrupt - Users should be able to interrupt message preparation, review, or disposition, and then resume any of those tasks from the point of interruption.

h) Message Highlighting - Software capabilities should be provided to annotate transmitted data with appropriate highlighting to emphasize alarm/alert conditions, priority indicators, or other significant information that could affect message handling.

i) Automatic Record Keeping - A log of data transmissions should be automatically maintained.

5.4.3.2 Preparing Messages

a) Automatic Message Formatting - When message formats should conform to a defined standard or structure, prestored formats should be provided to aid users in message preparation.

b) Message Composition Compatible with Data Entry - Procedures for composing messages should be compatible with general data entry procedures, especially those for text editing.

c) Variable Message Length - Users should be able to prepare messages of any length.

d) Incorporate Existing Files - Users should be able to incorporate an existing data file in a message, or to combine several files into a single message for transmission.

e) Message Editing - Users should be able to save and edit messages prior to transmission.

5.4.3.3 Sending Messages

a) Destination Selection - Users should be able to specify the destination(s) to which messages will be transmitted.

b) Address Directory - Users should be provided with a directory showing all acceptable forms of message addressing for each destination in the system, and for links to external systems.

c) Aids for Directory Search - Computer aids should be provided so that a user can search an address directory by specifying a complete or partial name.

d) Extracting Directory Addresses - Users should be able to extract selected addresses from a directory or select a distribution list for direct - insertion into a header in order to specify the destination(s) for a message.

e) Automatic Addressing of Reply - The appropriate address(es) should be provided automatically for users responding to messages.

f) Assignment of Priority - When messages will have different degrees of urgency, the sender of a message should be allowed to designate its relative priority.

g) Information about Communication Status - Users should be allowed access to status information concerning the identity of other system users currently on-line, and the availability of communication with external systems.

h) Sender Identification - When a message is sent, the computer should show the sender's address, and the date and time of message creation and/or transmission.

i) Deferring Message for Automatic Transmission - Users should be able to defer the transmission of prepared messages, to be released by a later action.

j) Automatic Feedback - Automatic feedback for data transmission confirming that messages have been sent or indicating transmission failures should be provided to permit effective user participation in message handling.

k) Saving Undelivered Messages - If message transmission is not successful, automatic storage of undelivered messages should be provided.

l) Message Cancellation - Users should be able to recall any message whose transmission has been initiated, if it has not yet been received by its addressee(s).

m) User Review of Data Before Transmission - When human judgment may be required to determine whether data are appropriate for transmission, users (or a system

administrator) should be provided some means to review outgoing messages and confirm their release before transmission.

n) Saving Transmitted Data Until Receipt is Confirmed - A copy of any transmitted message should be saved automatically until correct receipt has been confirmed.

5.4.3.4 Receiving Messages

a) Message Notification at Logon - When users log on to a system, they should be notified of any transmissions received since their last use of the system.

b) Display of Messages - The display of messages from other users should be visually and spatially distinct from the display of system messages.

c) Nondisruptive Message Notification - Notification of incoming messages should be nondisruptive.

d) Indicating Priority of Received Messages - Where incoming messages will have different degrees of urgency, recipients should be notified of message priority and/or other pertinent information.

e) Filters for Message Notification - Users should be able to specify "filters" based on message source, type, or content, that will control what notification is provided for incoming messages.

f) Time-Stamp Messages - Messages should be time-stamped.

g) Indication of Message Size - Some indication of message size should be included at the beginning of each message.

h) Indication of Message Overflow - The user should be informed when a message has been truncated, such as when a message exceeds the available space.

i) Message Storage and Retrieval - Messages should be stored in a message queue that is available to the user.

j) Information about Queued Messages - Users should be able to review summary information about the type, source, priority, and size of queued incoming messages.

k) User Selection of Messages - The user should be allowed to select any message from an ordered queue with a simple action.

l) Annotating Received Messages - Users should be able to append notes to a received message, and ensure that the annotation will be displayed so that it will be distinct from the message itself.

m) Specifying Device Destination - Users should be able to choose the method of receipt, i.e., what device (file, display, printer) will be the local destination. If a specified receiving device is not operable, such as a printer that is not turned on, the user should be advised.

6.0 WORKSTATION AND WORKPLACE DESIGN

6.1 Console Design

6.1.1 General Console Design Guidelines

a) Availability of Indications and Controls - Control rooms should have all the controls and displays needed to detect abnormal conditions and bring the facility to a safe condition, as required by Availability Analysis.

b) Accessibility of Instrumentation and Controls - The operators should not need to leave the controlling workspace to attend to instrumentation on back panels during operational sequences which require continuous monitoring or timely control actions. Actions that must be taken promptly to assure plant safety should be capable of being performed directly from the control room.

c) Operator Freedom of Movement - Operators should be able to move freely in the control room without overcoming obstacles such as filing cabinets, storage racks, or maintenance equipment. Adequate space should be available for the operator to freely get in and out from console operating positions.

d) Communications - Dimensions and placement of desks, consoles and panels should not hinder voice communication between the primary operator and any other person in the primary operating area in not hindered or compromised.

e) Field of View - Operators at desks/consoles in the controlling workspace should have an unobstructed view of all controls and displays on the consoles and the LDP.

f) Procedure Laydown Space - Procedure laydown space should be assigned for each console.

g) Dimensions - The guidelines apply to both operation and safety consoles.

6.1.2 Sit-Down Console Design

6.1.2.1 Sit-Down Console Dimension

a) Console Height to See Over - Console height should be no more than approximately 76.3 cm (30 inches) above the seat to accommodate the 5th percentile adult male when the seated operator must see over the console. Assuming seat height is adjusted to 40.6 cm (16 inches), maximum console height therefore should be 116.9 cm (46 inches) above the floor.

b) Seated Clearance - A seated operator should have at least 91 cm (36 inches) separating a console and any surface or fixed object behind him. The seated operator should also have at least 76 cm (30 inches) of space for lateral movement.

c) Seat Position - Workstation seat position should not be permanently fixed, so that operators can adjust their location at the console. See also Section 6.1.2.3, Chairs.

d) Leg and Foot Room - Sufficient leg and foot room should be provided to enable seated operators to avoid awkward and uncomfortable positions.

e) Writing Space - Writing spaces should be at least 41 cm (16 inches) deep and 61 cm (24 inches) wide. If appropriate space is not provided on the panel for writing, a desk or other writing surface should be provided in the immediate work area. Writing space should supplement procedure laydown space.

f) Control Height - All controls on a sit-down console should be within the reach radius of the 5th percentile male.

g) Benchboard Slope - The benchboard slope, in conjunction with its depth, should be such that all controls are within the functional reach radius of the 5th percentile male all displays and markings can be read.

h) Display Height and Orientation - All displays, including alarm indicators, should be within the upper limit of the visual field (70 degrees above the horizontal line of sight) of the 5th percentile male, and should be mounted so that the angle from the line of sight to the display face is 45 degrees or greater.

i) Location of Frequently Monitored Display - Video displays which require frequent or continuous monitoring, or which may display important (e.g., alarm) information, should

be located not more than 35 degrees to the left or right of the operator's straight-ahead Line Of Sight (LOS), and not more than 25 degrees above 5th percentile male and 40 degrees below the 95th percentile male horizontal LOS, as measured from the normal operator workstation.

j) Location of Infrequently Monitored Display - Video displays which do not require frequent or continuous monitoring, and which will not display important (e.g., alarm) information, should be located not more than 95 degrees to the left or right of the operator's straight-ahead LOS, as measured from normal operator work stations which permit full operator head and eye rotation.

k) VDU Viewing Distance - The viewing distance should be 33-80 cm (13-31 inches), with 46-61 cm (18-24 inches) preferred.

l) Use of Procedures and Other Reference Materials at Consoles - Provision should be made so that the procedures, manuals, and other reference materials can be consulted easily while task sequences are performed at the consoles.

6.1.2.2 Desks

a) Working Space - Desks should provide enough clear working space for all materials required for task performance.

b) Chair Positions - The desk should allow for different chair positions as required, with adequate knee space.

c) Operator Comfort - The relationships of working surface height and area, knee room, and chair height should allow operators to work comfortably.

6.1.2.3 Chairs

a) Backrests - Console chairs should have firm back rests, supporting the lumbar and cervical regions.

b) Mobility - Chairs should pivot so that operator can readily adjust position.

c) Armrests - Console chairs should have armrests.

d) Cushioning - Console chairs should be well cushioned, with remaining resilience when the seat is occupied.

e) Seat Adjustability - For chairs at sit-down stations, seat height should generally be adjustable from 38-45 cm (15 to 18 inches).

f) Footrests - An adjustable footrest or heel catch should be provided to support the feet at a level no more than 18 inches below the seat surface. If a footrest is part of the chair, a circular design is recommended, diameter 18 inches. The footrest might be provided on the console base.

6.1.3 Stand-Up Console Design

6.1.3.1 Stand-Up Console Dimension

a) Standing Clearance - A single operator standing between two consoles should have at least 125cm (50 inches) between the consoles within which to move. Two operators working between two consoles should have at least 250 cm (96 inches) between the consoles.

b) Control Height - The highest control on a stand-up console should be within the highest reach of the 5th percentile male without stretching or using a stool or ladder, while the lowest controls should be within the lowest reach of the 95th percentile male without bending or stooping.

c) Benchboard Slope - The benchboard slope, in conjunction with its depth, should result in all controls being within the reach radius of the 5th percentile male.

d) Control Distance from the Front Edge of the Console - Controls should be set back a minimum of 7.6 cm (3 inches) from the front edge to protect against accidental activation.

e) Display Height and Orientation - All displays, including alarm indicators, should be within the upper limit of the visual field (85 degrees above the horizontal line of sight) of the 5th percentile male, and should be mounted so that the angle from the line of sight to the

display face is 45 degrees or greater .

f) Location of Infrequently Monitored Display - Video displays which do not require frequent or continuous monitoring, and which will not display important (e.g., alarm) information, should be located not more than 95 degrees to the left or right of the operator's straight-ahead LOS, as measured from normal operator workstations which permit full operator head and eye rotation.

6.1.4 Labeling, Demarcation, and Painting (coating)

Hierarchical labeling employing clearly visible lettering should be used. Labels should conform to good human factors practices in general, as outlined in USNRC NUREG-0700 (Rev.2). Painting should enhance system discrimination and minimize glare. Silk-screened lettering may be used on some panel and console inserts.

6.1.4.1 Hierarchical Labeling

a) To prevent panel clutter and unnecessary repetition, a hierarchical labeling scheme should be used.

b) System or subsystem name should be presented on an overall label for groups of controls and indications within these demarcated areas, and the system name should not be repeated on each individual identifying label.

c) As labels go up the hierarchy, letter height and stroke width should increase.

6.1.4.2 General Labeling and Demarcation

Label colors, letter heights and stroke widths should be designed per Appendix 4U for APR1400. Demarcation is also discussed in this Appendix D.

6.1.4.3 Label Material

a) Labels should be engraved on a low-glare, non-warping material.

b) Material should be non-flammable and reasonable equivalent consisting of a sandwich

arrangement where the outer layers are the background color and the inner is the letter color which is engraved down to.

6.1.4.4 Attachment

a) Labels should be attached so as to be solidly anchored under all temperature and wear conditions and not easily removable.

b) Labels on the panel, console and cabinet should not be attached with screws or other methods to prevent permanent damage of panel metal, and to prevent label warping.

c) Labels on the panel, console and cabinet should be attached with double sided tape, covering the entire rear surface of the nameplate. The tape should be Scotch 666 or equivalent (long lasting). A proven, durable glue or other attachment method which covers the entire back side of the label may be used provided it is demonstrated to be sturdy and long-lasting.

6.1.4.5 Placement and Language

a) Labels should be in English and located to facilitate easy reading.

b) Identification labels should be placed above the panel element they describe.

1) Data and information labels for specific components should be below or adjacent right, with reference to the elements they describe. Other information labels (such as mimic destinations and sources) may be placed in any appropriate location.
2) Labels should not be mounted on controls if it will cause them to be obscured by the operator hand.
3) Labels should be placed close to the panel components they describe.
4) Labels should be oriented horizontally and be non-curved.

6.1.4.6 Nomenclature and Style

c) Labels should use plant standard nomenclature and abbreviations.

d) Labels should use consistent nomenclature throughout the MCR, RSR and safety-related

Local Control Panel. Only standardized symbols should be employed.

e) Control direction should be indicated on labels by an arrow, where appropriate.

f) Labels should use sans-serif lettering.

6.1.4.7 Format

a) Labels should use consistent identification format as follows.
line 1 - System or Subsystem Name (if needed) - or Component Name
line 2 - Component (Element) Name and Variable
line 3 - Component Number

b) The engraving should be centered on the label.

6.1.4.8 Panel Paint (coating)

The color of NSSS and BOP cabinets located in the MCR should be distinct from the console (e.g., Warm Grey (Munsell No 8.4Y 8.3/0.5) is recommended).

6.2 Environment Design

6.2.1 Temperature

The MCR should maintain temperatures of 20-26 °C (68-79 °F) for all seasons. Temperature difference from the head level to the floor level should not exceed 6 °C (10 °F).

6.2.2 Humidity

Humidity should be maintained at 20 to 60 % relative humidity. Humidity levels should not be adversely impacted by seasonal/climatic fluctuation. Therefore, humidification may be required during winter months and dehumidification during warmer months.

6.2.3 Ventilation

The ventilation system should be capable of introducing outdoor air into the MCR at a rate of at

least 0.42 cubic meters per minute (14.8 cubic feet per minute) per occupant. Heating Ventilation and Air-Conditioning (HVAC) ducts should be designed such that hot or cold air should not blow directly on operators.

6.2.4 Lighting and Illumination

6.2.4.1 General Lighting and Illumination Guidelines

a) Supplemental Light - Supplemental lighting should be provided for personnel performing specialized visual tasks in areas where fixed illumination is not adequate.

b) Task Area Luminance Ratios - to ensure effective visual performance, the task area luminance ratios should not be exceeded as belows.

Areas	Luminance Ratio
Task Area (TA) vs. Adjacent darker surroundings	3:1
TA vs. Adjacent lighter surroundings	1:3
TA vs. more remote darker surfaces	10:1
TA vs. more remote lighter surface	1:10
Luminaries vs. Adjacent surface	20:1
Anywhere within normal field of view	40:1

c) Shadowing - To reduce operator fatigue and eyestrain, shadows should be avoided.

d) Color - Surface colors should be recognizable under both normal and emergency lighting conditions.

e) Ambient Illumination and VDUs - The ambient illumination in the VDU area that is necessary for other visual functions (e.g., setting controls, reading instruments) should not degrade the visibility of signals on the VDU.

f) Use of Colored Ambient Illumination - Colored ambient illumination should not be used if color coding is used in the workplace.

g) Illuminance of Areas Immediately Surrounding VDUs - There should be no light source (direct or reflected) in the immediate surrounding area of the VDU that is of greater

luminance than the VDU.

6.2.4.2 Task Area Lighting (optimal lighting)

1 foot candle (f/c) is counted as 10 lux (lx).

a) Operation Console - 300 to 1000 lx (700 lx)

b) LDP Area - 50 to 100 lx (100 lx)

c) Safety Console & Auxiliary Panel - 250 to 750 lx (500 lx)

d) Remote Shutdown Room - 300 to 1000 lx (700 lx)

e) Technical Support Center - 700 lx

f) Instrument Shops, Labs, etc. - 700 lx

g) Meeting Room near MCR - 400 to 900 lx (700 lx)

6.2.4.3 Emergency Lighting

a) MCR and RSR ceiling - The ceiling should have a "luminous ceiling" effect achieved through indirect lighting.

b) Essential (diesel-powered) Lighting - Essential lighting should be provided at designated egress ways and the MCR, and the RSR during a loss of normal lighting. Essential lighting levels should always exceed or equal minimum battery pack lighting levels.

c) Emergency lighting - Emergency lighting should provide light to the MCR and RSR at minimum levels specified below:

1) In the MCR - 100 to 300 lx (200 lx)
2) In the RSR - 100 to 300 lx (200 lx)

6.2.4.4 Reducing Glare and Reflectance

a) Low reflectance flooring should be used.

b) Wall coverings should be low glare.

c) Panel paint should be of a neutral color such as beige and should be formulated for a flat or semi-gloss finish.

d) VDU screens and other indicator surfaces employing glass or plexiglass transparent coverings should utilize low glare materials or other glare reduction techniques (e.g., hoods, polarized glare filters, screen coatings, etc.).

e) Labels should use low-glare material.

f) Bare metal surfaces (e.g., indicator bezels) should have a non-reflective matte or brushed finish.

6.2.5 Auditory Environments

6.2.5.1 Noise

A. Noise Levels in Main Control Rooms and Workspaces

1) Background Noise - Background noise should not impair verbal communication between any two points in the primary operating area.
2) Further Reductions - Where communications between the primary operating area and other control room locations are necessary, and voice transmission systems are not provided, further reductions in background noise should be implemented.
3) Noise Distractions - Noise distractions generated either inside or outside the control room should be minimized.
4) Limit - Nominal background noise levels should be less than 65 dB(A).
5) Reverberation Time and Sound Absorption - The acoustical treatment of the control room should limit reverberation time of fewer one second or less.

B. Noise Levels in Equipment Spaces

1) Unprotected Continuous Occupancy - Nominal background noise levels should be less than 80 dB(A). Higher noise levels may require ear protection, limited stay times, or both.
2) Unprotected Peak Levels - Park impulse or impact noise should not exceed 115 dB(A). Higher noise levels may require ear protection, limited stay times, or both.

6.3 Local Control Panel

This HFE guideline is applicable to the LCSs associated with IHAs.

7.0 MAINTAINABILITY OF DIGITAL SYSTEM

7.1 General Maintainability Guidelines

7.1.1 Minimizing Maintenance Demands

a) Minimizing Testing and Servicing - Requirements for periodic or repetitive testing and servicing of components should be avoided where the possibility of human errors may affect safety.

b) Equipment Independence for Maintenance - Units of equipment should be as independent as is practical, such that maintenance of one unit has minimal effects on the other equipment.

c) Minimize Maintenance Time - Equipment should be designed to minimize the time required for maintenance if having the equipment out of service can affect safety.

d) Ease of Fault Detection - The design of equipment should facilitate rapid, positive fault detection and isolation of defective items.

e) Equipment Verification - When feasible, equipment should permit verification of operational status before its installation and without the need for disassembly.

f) Fault Detection Without Disassembly - Equipment should permit fault detection and isolation without removing components, through the use of BIT, integrated diagnostics, or standard test equipment.

g) Design for Repair by Module Replacement - To reduce the likelihood of personnel errors in normal repairs conducted in difficult field environments, the design should support simple modular replacement in the field, and their repair in the shop.

h) Overall Accessibility - Equipment that is to be maintained should be visually and physically accessible to the maintainer.

i) Standardized Designs for Construction - Equipment used in assembling equipment, such as connectors, should be standardized as much as possible.

j) Design Flexibility - Equipment design should provide flexibility to allow future design modifications to be made without imposing high demands on personnel for installation and maintenance.

k) Minimize Maintenance Equipment and Tools - Units of equipment should be designed to minimize the numbers and types of auxiliary equipment and tools required to service them.

l) Use Common Test Equipment and Tools - Whenever possible, systems and units of equipment should be designed so they can be maintained with common test equipment and tools.

m) Need for Special Skills - Equipment should be designed to minimize the need for special skills on the part of the maintainers.

n) Need for Special Training - Equipment should be designed to minimize the need to specially train the maintainers.

7.1.2 Continuous Operation and On-Line Maintenance

a) Local Indication of Redundant Equipment Status - If equipment can automatically transfer operation between redundant units, local personnel who maintain that equipment should be informed of the transfer and the status of the redundant units.

b) Degraded Operation - Status and fault information should be provided to maintenance personnel and operators for equipment awaiting maintenance while operating in a degraded mode.

7.1.3 Supporting the Operator Role in Maintenance

a) Monitoring and Trending Equipment Degradation - To support personnel awareness of impending equipment failures, monitoring and trending capabilities should be provided where possible to identify the degradation of equipment.

b) Operator Assistance in Testing and Repair - Where practical, equipment should be

designed to facilitate testing and repairs without requiring the assistance of the on-shift operator.

c) Operator Indication of Testing or Repair Activities - The operators should be provided with on indication that testing or repairs are underway.

d) Indication for Equipment That Is Out of Service - Means for indicating the status of equipment that is out of service should be provided.

7.1.4 Protecting Personnel from Hazards

a) Designing for Safety of Maintainers - Equipment should not present hazards to maintainers as they follow maintenance procedures.

b) Covering Exposed Parts - Protrusions and corners on equipment that maintainers might come into contact with should be covered with rubber or other appropriate materials.

c) Energy Dissipation Before Maintenance - Parts that retain hazardous levels of electrical potential or heat should be equipped with means to dissipate energy before to maintenance.

d) Protecting Maintainers from Heat and Electrical Shock - Equipment or parts that retain hazardous levels of heat or electrical potential during maintenance should be located where maintainers will not touch them during their work, or they should be shielded.

e) Avoidance of Hazards for Adjustment Controls, Test Points, and Service Points - Adjustment controls and test and service points should be located away from hazards.

7.1.5 Protecting Equipment and Components form Hazards

a) Protecting Equipment from Hazards - Equipment should be protected from potential exterior hazards resulting from personnel actions.

b) Avoiding Damage to Protruding Parts - Irregular protrusions on a unit of equipment should be easily removed to prevent damage by personnel during installation and maintenance.

c) Avoiding Damage When Opening and Closing Equipment - The parts and wiring of a module should be located and arranged so that personnel do not damage them when the module or the unit of equipment of which they are part is opened and closed.

d) Avoiding Damage When Maintaining Internal Components - Parts that are susceptible to damage by personnel should be located or shielded so that they will not be damaged during maintenance.

7.2 Instrument Cabinets and Racks

a) Instrument Racks - Instrument racks should support maintenance and testing by providing adequate physical and visual access to their contents.

b) Cabinet Lighting - Cabinets requiring maintenance inside the enclosure should have permanent lighting.

c) Minimizing Field-Run Wiring - The amount of field-run wiring should be minimized to avoid errors in identifying and connecting wires.

d) Protective Electrical Grounds for Cabinets - A protective ground should be provided.

7.3 Equipment Packaging

7.3.1 Modularization

a) Modularization - Units of equipment should be divided into as many modules as are practical and feasible to support personnel performance during maintenance.

b) Physical and Functional Interchangeability - If modules are physically interchangeable, they should also be functionally interchangeable to avoid errors in installing the wrong module.

c) Distinguishing Non-interchangeable Modules - The appearance of non-interchangeable modules should be distinguishable, and the difference should be apparent when the module is in its installed position.

d) Replacement of Failed Components - Equipment should be designed so that components that fail frequently can be easily replaced.

e) Maintenance in Installed Location - When possible, modules should be designed so that they can be maintained in their installed position, without requiring disconnection, disassembly, or removal of other modules.

f) Unreliable Components - If a module has parts that are significantly less reliable than the remaining ones, the unreliable parts should be accessible without removing the module.

g) Removal and Testing - Modules should be designed to permit testing when they are removed from their installed position.

h) Installation and Testing - Each module should allow separate installation and functional testing before the complete system is integrated.

i) Installation and Calibration - Modules should require little or no calibration immediately after installation.

j) Interconnectivity - The number of inputs and outputs associated with a module should be minimized, where possible, to reduce the likelihood of errors in installing connections or testing multiple inputs and outputs.

k) Modularization Method - The modularization of digital equipment should be based on a systematic method that can be readily understood by maintenance personnel.

7.3.1.1 Logical Flow Packaging

a) Isolating Module Faults Via Single Input-Output Checks - When logical flow packaging is used to modularize digital equipment, a module should be designed so that only single input and output checks are necessary to isolate a fault in it.

b) Indication of Unidirectional Signal Flow - When logical flow packaging is used to modularize digital equipment, the unidirectional signal flow within a module should be clearly indicated.

7.3.1.2 Circuit Packaging

a) Locating Parts in A Single Module - When circuit packaging is used to modularize digital equipment, all parts of a given circuit or group of logically related parts should be located in a single module to help personnel find and test them.

b) Only One Circuit or Group of Related Parts per Module - When circuit packaging is used to modularize digital equipment, a module should contain only one circuit or group of related parts to support testing and diagnosis.

c) Packaging A Circuit as A Single Terminal-Board or Plug-in Module - When circuit packaging is used to modularize digital equipment, the circuit should be packaged as a single terminal board or plug-in module, when possible, to support its testing and installation.

d) Grouping Circuits to Minimize The Crossing of Signals - When circuit packaging is used to modularize digital equipment, circuit should be grouped to minimize cross-crossing of signals among modules.

7.3.1.3 Component Packaging

a) Grouping Components with Similar Replacement Schedule - When using component packaging to modularize digital equipment, similar parts that are likely to require replacement at approximately the same time should be grouped together.

b) Grouping Components with Similar Servicing Requirements - When component packaging is used to modularize digital equipment, components requiring the same maintenance work should be grouped together, e.g., test points or components requiring a particular cleaning method.

7.3.1.4 Printed Circuit Boards

a) Design for Removal and Replacement - Printed circuit boards should be designed and mounted for ease of removal and the elimination of errors during replacement.

b) Plug-in Printed Circuit Boards - Plug-in printed circuit boards should be structurally rigid and easy to remove and replace, providing finger access and gripping aids if necessary.

c) Feedback When Installing Plug-in Printed Circuit Boards - Feedback should be provided to the maintainer when plug-in printed circuit boards are securely connected.

d) Identification of Printed Circuit Boards and Parts - Printed circuit boards should be marked to identify the board and the parts mounted on it.

7.3.2 Layout

7.3.2.1 Module Accessibility

a) No Interference from Other Parts - Modules should be laid out so that all parts can be removed and replaced without interference from or removal of other parts.

b) No Stacking of Parts -To support accessibility, parts that make up a module should be mounted in an orderly, flat, two-dimensional array and should not be stacked one on top of another.

c) Consistent Orientation - If a module has more than one part of the same type that must be inserted in a particular orientation, all such parts should be oriented in the same direction, where practical.

d) Spacing of Parts - The parts that make up a module should be spaced and oriented so that required tools can be used without difficulty.

e) Separation of Parts and Wiring on Printed Circuit Boards - To support accessibility for testing parts on printed circuit boards, all parts should be mounted on one side of the board and all wiring, including printed circuits, should be located on the other side, where practical.

f) Spacing of Terminals - Terminals to which wires are to be soldered should be far enough apart so that work on one terminal does not damage neighboring terminals or nearby parts.

g) Indicator Lights - If a module has indicator lights, it should be possible to change them from the front panel, without opening or removing the module.

h) Shutoff Switches - If the module contains emergency shutoff switches, they should be positioned within easy reach, and they should be located or guarded to prevent inadvertent operation.

i) Test, Adjustment and Connection Points - Test points, adjustment points, and cable and line connectors should be located where the maintainer can see them easily and operate on them without interference.

7.3.2.2 Grouping

a) Grouping Maintenance Display Devices - All maintenance display devices relevant to a particular task should be grouped together and located where they can easily be seen.

b) Separate Maintenance and Operational Display Devices - If a unit of equipment contains both maintenance and operational display devices, the two types of devices should be separated.

c) Separate Maintenance and Operational Displays in a Display Network - If a display device contains displays for both maintenance and operations personnel, then the maintenance displays should have a separate location in the display network.

7.3.3 Mounting

a) Support for Hinged Mounting - If a module is mounted on hinges, supports should hold the module in the "out" or "open" position.

b) Rests and Stands - If a module contains parts that might be damaged when it is moved into position for maintenance, it should include rests or stands that are integral with the construction of the module to protect those parts.

c) Preventing Mounting Errors by Physical Design - Modules should be designed so that it is physically impossible to mount them incorrectly.

d) Controls - Modules should be mounted so that it is unnecessary to disconnect controls that may be needed for maintenance.

e) Front Access - Replaceable modules should be accessible through the front of the equipment, rather than the back, if the panel or console is not used by operators.

f) Orientation of Modules within Cases - If a module has a case, the proper orientation of the module within its case should be obvious, preferably through the physical design of the case, rather than through labeling.

g) Connectors - Electrical connections between modules should be simple and minimize the demands for manual dexterity.

h) Standard Connectors - Connectors should be standardized as much as possible.

7.4 Fuses and Circuit Breakers

a) Location of Fuses and Circuit Breakers - Fuses and circuit breakers should be grouped in a minimum number of centralized, readily accessible locations for removal, replacement, and resetting.

b) Verification of an Open Circuit - An indication should be given when a fuse or circuit breaker has opened a circuit.

c) Individual Fused Units - Fuses or circuit breakers should be provided so that each unit of a system is separately fused and adequately protected from harmful variations in voltages that personnel may cause.

d) Worker Safety - Fuse installations should be designed so that only the neutral ("cold") terminal of the fuse can be touched.

e) Safeguarding The Circuit - Fuses should be provided that safeguard the circuit if the wrong switch or jack position is used.

f) Easily Removed Fuse Holders - Fuse holder cups or caps should be easily removed by hand.

g) Identifying Fuses and Circuit Breakers - Fuses and circuit breakers should be permanently labeled or marked.

h) Indicating Fuse Ratings - A fuse's rating should be indicated on the fuse and adjacent to the fuse holder.

i) Identifying Affected Circuits - The area of equipment served by a fuse or circuit breaker should be identified.

7.5 Labeling and Marking

a) Standard Labels - Equipment labels should be standardized as much as possible.

b) Information Content of Labels and Markings for Modules - Modules should be labeled or marked to supply information needed by maintainers.

c) Visibility of Labels and Markings - Labels and markings on parts or in cabinets should be placed so that the maintainer can see them without having to move or remove anything.

d) Consistent Placement of Labels and Markings - Labels and markings should be consistently placed in relation to the parts to which they refer.

e) Luminescent Labels - If labels must be read under very low ambient light, they may be marked in phosphorescent colors.

f) Electrical Parts - Small electrical parts that are attached to mounting boards, such as resistors and capacitors, should be labeled or marked on the mounting boards.

g) Identification of Parts - Parts should be identified with labels or markings.

h) Identification of Terminals on Terminal Strips or Blocks - The terminals of terminal strips or blocks should be labeled on the strip or block, or on the chassis, adjacent to the terminals.

i) Identification of Terminals on Parts - When parts have terminals (e.g., transformers, relays, and capacitors), each terminal should be identified by an adjacent label.

j) Identification of Parts Accessible from Both Sides - Receptacles that are accessible from both sides of a board or panel should be identified on both sides.

k) Durability of Markings - Markings should be durable enough to last the life of the equipment.

l) Marking Stacked Parts - If parts or modules are stacked, marking should permit identification of the individual parts or modules.

m) Marking Enclosed or Shielded Parts, Modules, Test Points, and Service Points - Enclosed or shielded parts, modules, test points, and service points should be marked both outside the enclosure or shield, and inside it.

n) Hazard Warnings - If there is any hazard from a part or module, a warning or caution label should be provided on it, on the case or cover, or both.

o) Labeling Symmetrical Parts - Parts that are symmetrical should be labeled or marked to indicate their proper orientation for mounting.

p) Insertion Holes - If a module has holes through which parts must be aligned and then inserted, labels showing the proper orientation of the part should be placed adjacent to the holes.

q) Auxiliary Information for Parts - Parts to which auxiliary information applies should be labeled with that information.

7.6 Adjustment Controls

a) Misalignment - Controls and displays should be designed to prevent misalignment that might be caused by vibration, service use, or accidental contact.

b) Controls and Feedback - Each adjustment control should provide feedback.

c) Simultaneous Access to Controls and Displays - Maintainers should have simultaneous access to an adjustment control and its associated display or other source of feedback.

d) Differentiating Maintenance Controls from Operational Controls - Maintenance and operational controls should be clearly differentiated.

e) Location of Maintenance and Operational Controls - The maintenance and operational controls should not appear on the same panel if maintenance and operation of a unit of equipment are performed by different sets of people.

f) Independence of Adjustment Controls - Where possible and practical, the adjustment of one control should be independent of the adjustments of others.

g) Sequential Adjustments - If the adjustment of one control affects the adjustment of another, the controls should be arranged in sequential order, and labeled or marked to indicate the order of adjustment.

h) Functionally Related Adjustments - If a single control is used to affect multiple variables, then the user interface should be designed to prevent mode errors.

i) Degree of Adjustment - Controls should accommodate the degree of adjustment required; that is, gross adjustment, fine adjustment, or both.

j) Mechanical Stops - Adjustment controls intended to have a limited range of motion should have mechanical stops.

k) Previous Settings - If a task requires that a maintainer be able to quickly return a control to its previous setting, the control should have a scale and pointer, or equivalent.

l) Preventing Inadvertent Adjustment - Adjustment controls should be located and mounted so that they cannot be adjusted inadvertently.

m) Critical or Sensitive Adjustments - Critical or sensitive adjustments should incorporate features, such as locking devices, to prevent inadvertent or accidental adjustment.

n) Hand or Arm Support - If an adjustment control or the maintainer will be subject to vibration during adjustment, a suitable hand or arm support should be provided.

7.7 Test Points and Service Points

7.7.1 General Test Points and Service Points Guidelines

a) Ease of Servicing - Equipment should be designed so that it can be serviced in its installed position to prevent errors associated with disassembling and reassembling it.

b) Appropriate Use of Test Points - Test points should be provided on units of equipment as required to support personnel in checking, adjusting, and troubleshooting it.

c) Single Adjustment Control Per Test Point - A test point should not have more than one associated adjustment control.

d) Ground Points - Special grounding points should be provided, as needed, in locations in which surfaces have poor electrical grounding characteristics.

7.7.2 Location, Arrangement, and Marking

a) Test Points for Units of Equipment - Where possible, each input to and output from a unit of equipment should have test points to support testing and diagnosis of faults.

b) Tracing Signals - Test points should be provided to permit the systematic tracing of signals and voltages through a unit of equipment to support fault detection and diagnosis.

c) Test and Service Point Accessibility - All test and service points should be visible and physically accessible to the maintainer for checking and troubleshooting.

d) Proximity of Controls, Displays, and Test Points - Test points should be located in physical and visual proximity to the controls and displays used to make the adjustments.

e) Proximity of Controls, Displays, and Service Points - Service points should be located in physical and visual proximity to the controls used when adjusting them.

f) Test and Service Point Location - Test and service points should be provided, designed, and located in accordance with their frequency of use and any time-limits on maintenance.

g) Compatibility of Test and Service Points - Test and service points should be designed for compatibility with checking, troubleshooting, and servicing procedures, and with test and service equipment.

h) Distinctive Connections - Each type of test or service equipment should have distinctively different connectors or fittings to minimize the likelihood of error.

i) Distinguishable Marking - Test and service points should be designed and marked so that they are easily distinguishable from each other.

7.7.3 Accessibility

a) Access Openings for Test Equipment - Access openings necessary to connect test equipment should accommodate maintainers, equipment, and required tools.

b) Test Probe Guides - Suitable guides for test probes should be provided when test points are located internally to an enclosure.

7.8 Test Equipment

7.8.1 General Test Equipment Guidelines

a) Built-in Test Capabilities - All test capabilities for a unit of equipment should be built in, to the extent feasible, to reduce the likelihood of testing errors.

b) Appropriate Use of Alarms - If critical equipment is not regularly monitored, an alarm should be provided to indicate malfunctions or conditions that would cause personnel injury or equipment damage.

c) Accuracy of Test Equipment - The accuracy of test equipment should be consistent with testing requirements.

d) Instructions - Clearly written and easily understandable operating instructions for the test equipment should be available to the maintainer.

e) Labels - Equipment labels should identify all items the maintainer must be able to recognize, read, or use.

f) Minimizing Errors - The test equipment should be designed to minimize the occurrence of errors by the maintainer.

g) Minimizing Hazards - When possible, fail-safe features should be incorporated in test equipment to minimize dangers to maintainers or equipment.

7.8.2 Automatic Test Equipment

7.8.2.1 General

a) Automated Aids - Fault isolation, inspection, and checkout tasks should be automated to the extent practical to support personnel performance.

b) On-Line Diagnostics - Computer systems should have on-line diagnostic capabilities, if the detection and diagnosis of computer faults is required.

7.8.2.2 Test Intervals

a) Continuous on-Line Self-Testing - The capability for continuous on-line self-testing should be provided when practicable to support prompt detection of faults.

b) Periodic Testing - The capability for periodic functional testing that is manually initiated but executed automatically should be provided when personnel require control of the test intervals.

7.8.2.3 Bypasses for Plant and Test Equipment

a) Automatic Bypass - When a test is initiated manually, the correct bypasses required for testing should be established automatically, and the operators should be aware of all of them, where practical.

b) Indicators for Test and Bypass Status - Local indication of pass or fail for test and bypass status should be provided for periodic functional tests.

c) Removal of Automatic Bypass - When a periodic functional test sequence is completed, all bypasses established to allow the test to be performed should be automatically, to relieve the operator of this task, where practical.

d) Bypassed Diagnosis Routines - to support the diagnosis of faults, diagnosis routines that are bypassed during maintenance should be run again before equipment is put back in service.

7.8.2.4 Failure Indications

a) Loss of Redundancy - If part of a redundant system, unit of equipment, module, or component becomes inoperable, an alarm signaling the loss of redundancy should be provided to the user immediately.

b) Overload Indications - Overload indications should be provided for equipment subject to this condition.

c) Identification of in-Tolerance Ranges - When practical, the ranges for which test values are within acceptable tolerance limits should be indicated on built-in test equipment.

d) Out-of-Range Indicators - If equipment has failed or is not operating within tolerance limits, an indication should be provided.

e) Power Failure Indicators - If a power failure occurs, an indication should be given.

f) Open Circuit Indicators - If a fuse or circuit breaker has opened a circuit, there should be an indication.

g) Power-on Indicator - A power-on indicator that extinguishes with loss of power should be provided.

7.8.2.5 Display of Test Results

a) Inclusion of Fault Messages - Fault messages should only be shown if they add value to the maintenance process.

b) Direct Interpretation of Test Results - Messages provided by test equipment should require a minimum amount of interpretation.

c) Identification of Failure Location - Test features should identify the location of the detected failure to the lowest replaceable module.

d) Identification of Out-of-Tolerance Signals on Collating Test Equipment - If equipment fails a test performed by collating test equipment, the test equipment should indicate which signal(s) are out of tolerance.

7.8.3 Test Equipment Hardware

7.8.3.1 General Test Equipment Hardware Guidelines

a) Requirements for Test Equipment and Bench Mockups - Test equipment and bench mockups should be treated like any other equipment with respect to the HFE design requirements for units, covers, cases, cables, connectors, test points, displays, and controls.

b) Selector Switches - Selector switches should be used rather than many, individual plug-in connections as long as the effects of switching do not degrade the desired information.

c) Minimizing Test Equipment Accessories - The number and types of test equipment accessories, such as connectors and test cables, should be minimized.

d) Minimizing Test Equipment Controls, Displays, and Modes -Test equipment should be simple to operate and have a minimum number of controls, displays, and modes.

e) Reducing The Number and Complexity of Steps - The number and complexity of steps required to operate the test equipment should be minimized.

f) Individual Operation - Test equipment should be designed for operation by one person, if practical.

g) Calibration Check - Test equipment should be easily calibrated or equipped with a simple

check to indicate whether or not it is out-of-calibration or malfunctioning.

h) Avoid Temporary Equipment Configurations for Testing - The use of temporary equipment configurations for periodic, functional testing of equipment should be avoided, where practical.

7.8.3.2 Portable Test Equipment

a) Portable Diagnostic Tools - Portable diagnostic equipment should be provided to aid in fault isolation when built-in equipment is not practical.

b) Ease of Connection - Portable test equipment should allow rapid and error-free connection to the equipment being tested.

c) Calibration Information - If maintenance personnel are required to verify that test equipment has been calibrated, then this information should be available to them.

7.8.3.3 Built-in Test Panel

a) Test Point Connections - Test points should permit the connection of the appropriate test equipment, such as voltage meters.

b) Test Point Indication Labeling and Demarcation - Test points should be clearly indicated on the test panel.

8.0 REFERENCES

1. Code of Federal Regulations

1) 10 CFR 29, Occupational Health and Safety Administration, Washington, DC: Office of the Federal Register (1990)

2. USNRC NUREGs

1) NUREG-0700, Human System Interface Design Review Guideline, Appendix A, Rev.2, USNRC (2002)
2) NUREG-0899, Guidelines for the Preparation of Emergency Operating Procedures, Washington, DC: Rev.0, USNRC (1982)
3) NUREG/CR-3517, Recommendations to the USNRC on Human Engineering Guidelines for Nuclear Power Plant Maintainability, Washington, DC: USNRC (1985)
4) NUREG/CR-5908, Advanced Human-System Interface Design Review Guideline. Washington, DC: USNRC (1994)
5) NUREG/CR-6633, Advanced Information Systems Design : Technical Basis and Human Factors Review Guidance, Washington, DC : USNRC (2000)
6) NUREG/CR-6634, Computer-Based Procedure Systems : Technical Basis and Human Factors Review Guidance, Washington, DC : USNRC (2000)
7) NUREG/CR-6635, Soft Controls : Technical Basis and Human Factors Review Guidance, Washington, DC : USNRC (2000)
8) NUREG/CR-6636, Maintainability of Digital Systems : Technical Basis and Human Factors Review Guidance, Washington, DC : USNRC (2000)
9) NUREG/CR-6684, Advanced Alarm Systems: Revision of Guidance and Its Technical Basis, Washington, DC : USNRC (2000)
10) NUREG/CR-6691, The Effects of Alarm Display, Processing, and Availability on Crew Performance, Washington, DC : USNRC (2000)

3. Industry Standards

1) ANSI/HFS 100-1988, American National Standard for Human Factors Engineering of Visual Display Terminal Consoles, Santa Monica, CA: Human Factors Society (1988)
2) IEEE 1023-2004, Guide for the application of Human Factors Engineering to Systems,

Equipment, and Facilities of Nuclear Power Generating Stations (2004)

3) DOT/FAA/CT-01/08, Computer-Human Interface Guidelines : A Revision to Chapter 8 of the Human Factors Design Guide., Federal Aviation Administration (2001)
4) MIL-STD-1472E, Department of Defense Design Criteria Standard, Human Engineering (1999)
5) NASA-STD-3000, Man-Systems Integration Standards, Houston, Rev.B, TX: National Aeronautics and Space Administration (1989)
6) NP-4350, Human Engineering Design Guidelines for Maintainability, Palo Alto, CA: Electric Power Research Institute (1985)
7) UCRL-15673, Human Factors Design Guidelines for Maintainability of Department of Energy Nuclear Facilities, Washington, DC: Department of Energy (1985)
8) USE-1000, Space Station Freedom Program Human-computer Interface Guide, Houston, TX: National Aeronautics and Space Administration (1988)

4. Others

1) Human Performance Engineering: A guide for system designers, Englewood Cliffs, NJ: Prentice Hall. Bailey, R.W. (1982)
2) Engineering Data Compendium: Human Perception and Performance, Wright-patterson AFB, OH: Armstrong Aerospace Medical Research Laboratory, Boff, K. R., & Lincoln, J. E. (1988)
3) Computer Abbreviations: Evidence and a Synthesis Human Factors, 27, 2, 143-156, Ehernreich (1985)
4) User-Computer Interface in Process Control: A human factors engineering handbook, Idaho Falls, ID: Idaho National Engineering Laboratory. Gilmore, W. E., Gertman, D. I., & Blackman, H. S. (1989)
5) Handbook of Human-Computer Interaction. New York, NY: North-Holland, Helander, M. (Ed.) (1988)
6) The Depth/breadth Tradeoff in the Design of Menu-driven user interfaces, International Journal of Man- Machine Studies, 20, 201-213. Kiger, J. I. (1984)
7) The Case Against User Interface Consistency. Communications of the ACM, 32, 10, 1164-1173, Ledgard, H. P. (1989)
8) The Role of Hierarchical Knowledge Representation in decision making and System Management IEEE Transactions on Systems, Man, and Cybernetics, SMC-15, 2, 234-243. Rasmussen, J. (1985)
9) Ergonomic Design for People at Work Rochester, NY: Eastman Kodak Company.

Rodgers, S. H. (Ed.) (1983)

10) Handbook of Human Factors, New York, in NY: Wiley. Salvendy, G. (Ed.) (1982)

11) Human Factors in Engineering and Design, New York, NY: McGraw-Hill. Sanders, M. S., & McCormick, E. J. (1987)

12) The Visual Display of Quantitative Information, Chesire, CT: Graphics Press. Tufte, E. R. (1983)

13) Human Engineering Guide to Equipment Design, Washington, DC: Department of Defense Van Cott, H. P., & Kinkade, R. G. (Ed.s) (1972)

14) Effects of Key Layout, Visual Feedback, and Encoding Algorithm on Menu Selection with LED-based Touch Panels (Tech Report HFL-604-02). Beaverton, OR: Tektronix, Weiman, N., Beaton, R. J., Knox, S. T., & Glasser, P. C. (1985)

15) National Anthropometric Survey of Korea. Korea Research Institute of Standards and Science (2005)

16) Software-System Safety and Computers Chapter 17, Nancy Leveson, Addison Wesley Publishing Company, (1995)

17) Control Room Systems Design for Nuclear Power Plants, Section 5, IAEA TECDOC-812, IAEA, July (1995)

APPENDICES

APPENDIX A

This Appendix is divided into the following three Parts:

Part 1: Standard Abbreviation List (except HSI system abbreviation list) which is composed of standard abbreviations and acronyms for instruments, controls, systems, emergency procedures, engineering units, engineering documents and procedures, and other relevant terms pertinent to I&C system.

Part 2: Physical Units and Abbreviations of the Information FPD and/or Qualified Indication and Alarm System (QIAS).

Part 3: Table of System Mnemonics which contains the approved list of system codes that are used in the System Functional Descriptions. System abbreviations can be found in Part 1 of this Appendix.

APPENDIX A - Part 1
Standard Abbreviation List

Standard Service Designation	Abbreviation
Abnormal	ABNL
Abnormal Operating Procedures	AOP
Abnormal Operations - Aux Trip Data	AOATD
Abnormal Operations - CEAC Inop Data	AOCID
Abnormal Operations - COLSS OOS Data	AOCOD
Abnormal Operations - Dropped/Slipped CEA	AOD/SC
Above	ABOV
Absolute	ABS, A
Absorber	ABSR
Accelerate	ACCEL
Acceptable Quality Level	AQL
Access	ACCS
Accident	ACC
Accumulated	ACUMD
Accumulator	ACUM
Acknowledge	ACK
Acoustic Leak Monitoring System	ALMS
Activated	ACTVD
Active	ACTV
Actuation	ACT
Additive	ADD
Addressable Constants	ADCON
Adjacent	ADJCNT
Adjust	ADJ
Administration	ADMIN, Admin
Adsorber	ADSR
Advanced Boiling Water Reactor	ABWR
Advanced Control Room	ACR
Advanced Light Water Reactor	ALWR

Standard Service Designation	Abbreviation
Advanced Pressurized Water Reactor	APWR
AFAS Signal Pertaining To Steam Generator 1	AFAS-1
AFAS Signal Pertaining To Steam Generator 2	AFAS-2
After	AFT
Air Circuit Breaker	ACB
Air Cleaning Unit	ACU
Air Handling Unit	AHU
Air Heater	AH
Air Quality Control System	AQCS
Air Supply Unit	ASU
Alarm	ALM, Alm
Alarm Response Procedure	ARP
Alarm Text	ALMTXT
Algorithm	ALGO
All Rod In	ARI
All Rod Out	ARO
All Volatile Treatment	AVT
Alternate	ALTE
Alternate AC Diesel Generator Building	AACDGB
Alternate AC Diesel Generator System	AACDGS
Alternate Alternating Current	AAC
Alternate Protection System	APS
Alternating Current	AC
Alternator	ALT
Aluminium	AL
Ambient	AMB
American Concrete Institute	ACI
American Insitute of Steel Construction	AISC
American National Standard Institute	ANSI
American Nuclear Society	ANS
American Society of Civil Engineers	ASCE

Standard Service Designation	Abbreviation
American Society of Mechanical Engineers	ASME
American Society of Testing and Materials	ASTM
Ammeter	AMM
Ammonia	AMMON, NH3
Ampere Transfer	A/T
Ampere(s)	AMP(S)(Amp)
Amplifier	AMPL
Analog	ANLG
Analog Input/Output Board	VAIC
Analog Output Board	VAOC
Analog To Digital	A/D
Analog To Digital Converter	ADC
Analysis	ANAL
Analysis Indicator	AI
Analysis Light Indication	ALI
Analyzer	ANZR
And	&
Anion	ANI
Annunciator	ANN
Anticipated Operational Occurrence	AOO
Anticipated Operational Transient	AOT
Anticipated Transient Without Scram	ATWS
Application	APP, App
Approved Vendor List	AVL
Approximately	APPROX
Architect Engineering	A/E
Area Radiation	AR
Area Radiation Monitor	ARM
Argon	ARG
As Low As Reasonably Achievable	ALARA
Assembly	ASSY

Standard Service Designation	Abbreviation
Atmosphere	ATMOS
Atmospheric Dump Valve	ADV
Atomic Energy Bureau	AEB
Atomic Energy Commission	AEC
Atomic Mass Unit	AMU
Auctioneered	AUCTD
Audible	AUD
Auto Sequential	ASQ
Auto Startup System	ASS
Auto Turbine Startup	ATS
Automatic	AUTO
Automatic Bus Transfer	ABT
Automatic Generation Control System	AGCS
Automatic Motion Inhibit	AMI
Automatic Withdrawal Demand	AWD
Automatic Withdrawal Prohibit	AWP
Autostart	AUTOST
Auxiliary	AUX, Aux
Auxiliary Boiler Building	ABB
Auxiliary Boiler Fuel Oil Storage Tank	ABFOST
Auxiliary Buidling Clean Area	ABCLA
Auxiliary Buidling Controlled Area	ABCOA
Auxiliary Building	AB
Auxiliary Building Floor Drains	ABFD
Auxiliary Feedwater	AF
Auxiliary Feedwater Actuation Signal	AFAS
Auxiliary Feedwater Pump	AFP
Auxiliary Feedwater Pump Turbine System	AFPTS
Auxiliary Feedwater Storage and Transfer System	AFSTS
Auxiliary Feedwater Storage Tank	AFST
Auxiliary Feedwater System	AFWS

Standard Service Designation	Abbreviation
Auxiliary Power	AP
Auxiliary Process Cabinet-Non Safety	APC-N
Auxiliary Process Cabinet-Safety	APC-S
Auxiliary Relay Cabinet	ARC
Auxiliary Steam	AS
Auxiliary Steam System	ASS
Auxiliary Transformer	AUXT
Availability Verfication	AV
Available	AVAIL, Avail
Average	AVG, Avg
Average Power Range	APR
Axial	AX
Axial Flux Difference	AFD
Axial Power Distribution	APD
Axial Shape Index	ASI
Azimuthal	AZ
Back	BCK, Bck
Back-Up	BCKUP
Backup System	BS
Backward	BWD, Bwd
Backwash	BKWH
Balance	BAL
Balance of Plant	BOP
BANK	BNK
Barrier	BARR
Base Load Operation	BLO
Basin	BSN
Battery	BATT
Bearing	BRG
Bearing Oil Transfer and Purification System	BOTPS
Before	BFR

Standard Service Designation	Abbreviation
Beginning of Cycle	BOC
Beginning of Life	BOL
Between	BTWN
Bistable	BISTAB
Bleed	BLD
Bleed Trip Valve	BTV
Block	BLK
Blocked	BLKD
Blowdown	BLOWDN
Blowdown System	BDS
Blower	BLWR
Blowing	BLWG
Body Wave Magnitude	Mb, Mb
Boiler	BLR
Boiling Water Reactor	BWR
Booster	BSTR
Boration	BORAT
Boric Acid	BA
Boric Acid Batching Eductor	BABE
Boric Acid Batching Tank	BABT
Boric Acid Concentrator	BAC
Boric Acid Condensate Ion Exchanger	BACIX
Boric Acid Filter	BAF
Boric Acid Makeup Pump	BAMP
Boric Acid Storage Tank	BAST
Boron	BOR,B
Boron Dilution Alarm System	BDAS
Boron Injection	BI
Boron Management System	BMS
Boronometer	BOR
Bottled Gas	BG

Standard Service Designation	Abbreviation
Bottom	BOT
Bottom-Up Suitability Verification	BUSV
Boundary Point Power Corelation Coefficient	BPPCC
Box	BX
Breaker	BKR
Breathing	BR
Breathing Air System	BAS
Bridge	BRDG
British Thermal Unit	BTU
Building	BLDG
Burner	BNR
Bushing Current Transformer	BCT
Bypass	BYP, Byp
Bypass Feedwater Valve	BFWV
Bypass Feedwater Valve Position Demand	BVPD
Bypass Feedwater Valve Position Signal	BVPS
Bypassed & Inoperable Status Indication System	BISIS
Bypassed And Inoperable Status Indication	BISI
Cabinet	CAB, Cab
Cable	CBL
Calculation	CALC
Calibration	CALB, CALIB
Capacity	CAPY
Carbon	C
Carbon Adsorber	CA
Carbon Dioxide	CO2
Carbon Dioxide System	CDS
Casing	CSG
Category	CAT
Cathode Ray Tube	CRT
Cathodic Protection	C PROT

Standard Service Designation	Abbreviation
Cation	CTN
Caustic	CAUS
Cavity	CVTY
CCW Heat Exchanger Building	CCWHXB
CEA Core Motion Inhibit	CMI
CEA Position Display System	CPDS
CEA Position Isolation Assembly	CPIA
CEA Withdrawal Prohibit	CWP
CEA Withdrawal Prohibit Bypass	CWP/B
CEDM Control System	CEDMCS
Celsius	℃
Center	CTR
Central Alarm Station	CAS
Central Processing Unit	CPU
Centrifugal	CENT
Centrifugal Charging Pump	CCP
Certified Material Test Report	CMTR
Chamber	CHMB
Channel	CH, Ch
Channelized Gateway	CG
Charcoal	CHAR
Charged Particle Equilibrium	CPE
Charger	CHR
Charging	CHRG
Check	CHK, CK
Chemical	CHEM
Chemical Addition Unit	CAU
Chemical and Volume Control System	CVCS
Chemical Feed and Handling System	CFHS
Chemical Waste Drain Header	CWDH
Chemical Water Drain	CHWD

Standard Service Designation	Abbreviation
Chest	CHST
Chest Warm	CHSTWM
Chilled	CHLD
Chilled Water Coil	CWC
Chiller	CHLR
Chloride	CHLOR
Chlorination	CHLORTN
Chlorine	CL, Cl
Circuit Breaker	CB
Circuit(s)	CKT(S)
Circulating	CIRC
Circulating Water	CW
Circulating Water (System)	CW(S)
Circulating Water Intake Structure	CWIS
Circulating Water System	CWS
Clarifier	CLRF
Clean Up	CU
Cleaning	CLNG
Close	CLS
Closed	CLSD
Closed Circuit Television	CCTV
Closed Circuit Television System	CCTVS
Coagulant	COAG
Coalescer	CLSCR
Code of Federal Regularion	CFR
Coefficient	COEFF
Cold Hydrostatic Test	CHT
Cold Leg Temperature	Tcold, Tc
Collection	COLLN
Collector	COLL
Combined Operating License	COL

Standard Service Designation	Abbreviation
Combustible	COMB
Combustible Gas Control System	CGCS
Combustion Engineering	CE
Combustion Engineering Owner's Group	CEOG
Command	CMD
Common	CMN
Common Mode Failure Analysis	CMFA
Communication	COM
Compartment	CMPMT
Compensated	CMPN
Compensated Ionization Chamber	CIC
Component	COMP
Component Control System	CCS
Component Cooling Water (System)	CCW(S)
Component Cooling Water System	CCWS
Compound Building	CPB
Composite Data	CPSD
Comprehensive Vibration Assessment Program	CVAP
Compressor	COMR
Computed	CMPTD
Computer	CPTR
Computer Aided Design	CAD
Computer Aided Test	COMAT
Computerized Procedure System/ Counts Per Second	CPS
Comupterised Operator Support System	COSS
Concentration	CONC
Conceptual Design Summary Report	CDSR
Condensate	COND
Condensate Polishing Plant	CPP
Condensate Pump	COP
Condensate Storage and Transfer System	CSTS

Standard Service Designation	Abbreviation
Condensate Storage Tank	CST
Condenser	CNDSR
Condenser Tube Cleaning System	CTCS
Condition	CONDN
Conductivity	CDTY
Conduit	CNDT
Confirm Switch	CS
Connection	CONN
Constant Axial Offset Control	CAOC
Construction	CONSTR
Construction Permit	CP
Containment	CNMT
Containment Fan Cooler System	CFCS
Containment Filtered Vent System	CFVS
Containment Hydrogen Recombiner System	CHRS
Containment Isolation	CI
Containment Isolation Actuation Signal	CIAS
Containment Isolation System	CIS
Containment Isolation Valve	CIV
Containment Monitoring System	CMS
Containment Purge Isolation Actuation Signal	CPIAS
Containment Spray Actuation Signal	CSAS
Containment Spray Pump	CSP
Containment Spray System	CSS
Containment Sprsy (System)	CS(S)
Containment Temp & Press Control	CTPC
Containment Vent Header	CVH
Continuous Blowdown	CBD
Control And Instrument Diagram	C&ID
Control Channel Gateway	CCG
Control Element Assembly	CEA

Standard Service Designation	Abbreviation
Control Element Assembly (Calculator)	CEA(C)
Control Element Assembly Calculator	CEAC
Control Element Assembly Motion Inhibit	CEAMI
Control Element Drive Mechanism	CEDM
Control Element Drive Mechanism (Control System)	CEDM(CS)
Control Logic Diagram	CLD
Control Module Contains the Controller	UCVG
Control Room	CR
Control Room Design Review	CRDR
Control Room Emergency Ventilation Actuation System	CREVAS
Control Valve	CV
Control Wiring Diagram	CWD
Control(ler)	CTRL(R)
Controlled	CTRLD
Convection	CONV
Converter	CVTR
Conveyer	CNVR
Coolant	CLNT
Cooler	CLR
Cooling	CLG, Clg
Cooling Water Treatment	CWT
Core Damage Frequency	CDF
Core Exit Thermocouple	CET
Core Exit Thermocouple(s)	CETC, CET(S)
Core Heat Removal	CHR
Core Operating Limit Supervisory System	COLSS
Core Protection Calculator	CPC
Core Protection Calculator System	CPCS
Corrected	CORR
Cost Schedule	C/S
Count Per Minute	CPM

Standard Service Designation	Abbreviation
Coupling	CPLG
Cover	CVR
CPC Operation Mode Directory	CPC OMD
CRAC Subgroup Comarison Directory	CEACSC
Crew Task Analysis	CTA
Critical Decision Method	CDM
Critical Function Monitoring (System)	CFM(S)
Critical Function/Success Path Monitoring	CF/SPM
Critical Heat Flux	CHF
Critical Heat Flux Ratio	CHFR
Critical Power Production Function	CPPF
Critical Safety Function	CSF
Cross Channel Comparison	CCC
Cross Check	XCHK
Crossconnect	XCON
Crossover	XOVER
Crosstie	XTIE
Cubicle	CUB
Cubicle Cooler	CC
Current	CURR
Current Indicator	II
Current Technical Specification	CTS
Current Transformer	CT
Cutout	CTOUT
Cyclic Redundancy Check	CRC
Cylinder	CYL
Damper	DMPR
Data Acquisition System	DAS
Data Link	DL
Data Management System	DMS
DC Power System	DCPS

Standard Service Designation	Abbreviation
Deaerator	DEAER
Deaerator Storage Tank	DST
Deborating Ion Exchanger	DIX
Decarbonator	DECAR
Decay Heat Removal System	DHRS
Decontamination	DECON
Decontamination Factor	DF
Decrease	DECR
Deenergize	DENERG
Deep Dose Equivalent	DDE
Defense-in-Depth	DID
Degasfier	DEGAS
Degrees	DEG
Delay	DLY
Demand	DEM
Demineralized Water Tank	DWT
Demineralizer	DEMI, DEMIN
Density	DNS
Departure from Nucleate Boiling Ratio	DNBR
Dependent	DEP
Descrete Input/Output Board	VCRC
Design Acceptance Criteria	DAC
Design Base Drawing	DBD
Design Basis Accident	DBA
Design Basis Event	DBE
Design Change Notice	DCN
Design Criteria Manual	DCM
Design Document Control Center	DDCC
Design Information Transmittal	DIT
Design Review Guideline	DRG
Detail Control Room Design Review	(D)CRDR

Standard Service Designation	Abbreviation
Detail Design Guidance	DDG
Detection	DETN
Detector	DET
Deviation	DEV
Dewatering	DEWATER
Diagnostic	Diagno
Diagnostic Actions	DA
Diesel	DSL
Diesel Fuel Oil Transfer System	DFOTS
Diesel Generator	DG
Diesel Oil	DO
Differential	DIFF, Diff
Differential Pressure	DP,ΔP
Differential Pressure Control Station	PDK
Differential Pressure Indicator	PDI
Digital	DIG
Digital Data Processing System	DDPS
Digital Electrohydraulic	DEH
Digital To Analog	D/A
Dilute	DIL
Dilution	DILU
Direct Current	DC
Direct Digital Control	DDC
Direct Vessel Injection	DVI
Disabled	DIS
Discharge	DSCH, Dsch
Disconnect	DISCON
Disconnect Switch	DS
Disengage	DISENG
Display	DISP
Dissolved Oxygen	DO2

Standard Service Designation	Abbreviation
Distributed Control System	DCS
Distribution	DISTR, Distr
Diverse Protection System	DPS
Diversion	DIVE
Division	DIV
Division Of Responsibility	DOR
DNBR Pretrip Setpoint	DNBRPT
DNBR/LDP Trend	D/L TRD
Domestic	DOMES
Domestic Water System	DWS
Doosan Heavy Industries And Construction Company	-
Downcomer Feedwater Bypass Valve	DFBV
Downcomer Feedwater Control Valve	DFCV
Downstream	DNSTRM
Drain	DRN
Drain Pump	DRNP
Drain Tank	DT
Drain Valve	DV
Drawing Comment Distribution Form	DCDF
Drive	DRV
Dropped Rod (CEA) Contact	DRC
Drum	DRM
Duct	DCT
Duplex	DPLX
Duration	DURAT
Early Fault Detection	EFD
Early Valve Actuation	EVA
Earthing Switch	ES
East	E
Eccentricity	ECC
Effective Full Power Day	EFPD

Standard Service Designation	Abbreviation
Effective Full Power Hour	EFPH
Efficiency	EFF
Effluent	EFLU
Electric Power Research Institute	EPRI
Electrical Equipment Classification of Class 1E	1E
Electrical Equipment Classification of Non-Class 1E	NON-1E
Electrical Penetration Assembly	EPA
Electrical To Pneumatic	E/P
Electrical Trip Solenoid	ETS
Electrical, Electric	ELECT
Electricite de France	EdF
Electrohydraulic	EH
Electrohydraulic Control	EHC
Electromagnetic Compatibility	EMC
Electromagnetic Interference	EMI
Electronic	ELECTRN
Electronic Overspeed System	EOS
Electronic Private Auto Branch Exchange	EPABX
Element	ELE
Elementary Wiring Diagram	EWD
Elevation	EL
Elevator	ELVTR
Emergency	EMRG
Emergency Bearing Oil Pump	EBOP
Emergency Contingency Action	ECA
Emergency Core Cooling System	ECCS
Emergency Diesel Generator	EDG
Emergency Diesel Generator Building	EDGB
Emergency Diesel Generator System	EDGS
Emergency Oil	EO
Emergency Operating Procedure	EOP

Standard Service Designation	Abbreviation
Emergency Operation Facility	EOF
Emergency Planning Zone	EPZ
Emergency Procedure Guideline	EPG
Emergency Response Capability	ERC
Emergency Response Facility	ERF
Emergency Response Guideline	ERG
Emergency Seal Oil Pump	ESOP
Emergency Trip	ET
Emergency Turbine Protection Board	VPRO
Encapsulation	ENCAPS
Enclosure	ENCLSR
End of Cycle	EOC
End of Life	EOL
Energize	ENERG
Energy Management System	EMS
Engaged	ENGD
Engine	ENG
Engineered Safety Feature	ESF
Engineered Safety Feature (System)	ESF(S)
Engineered Safety Feature-Component Control System	ESF-CCS
Engineered Safety Features Actuation System	ESFAS
Engineering	ENGR
Engineering Change Notice	ECN
Engineering Group Leader	EGL
Engineering Group Supervisor	EGS
Environmental Monitoring	EM
Environmental Report	ER
Equilibrium Shape Index	ESI
Equipment	EQUIP, EQPT, Equip
Equipment Drain Tank	EDT
Equipment Qualification	EQ

Standard Service Designation	Abbreviation
Equipment Vibration Monitoring System	EVMS
Error	ERR
ESF Signal Can Be Overriden	ESF-2
ESF Signal Cannot Be Overriden	ESF-1
ESF-CCS Soft Control Module	ESCM
Essential	ESSEN, Essen
Essential All Rods Out	EARO
Essential Central Chilled Water Makeup Pump	ECWMP
Essential Central Chilled Water Pump	ECWP
Essential Chilled Water System	ECWS
Essential Component Cooling	ESCC
Essential Service Water (System)	ESW(S)
Essential Service Water System	ESWS
Estimated Critical Boron Concentration	ECBC
Estimated Critical Position	ECP
Estimated Critical Rod Position	ECRP
ESW Intake Structure	ESWIS
European Utility Requirement	EUR
Evacuation	EVAC
Evaporator	EVAP
EX2100	EX2K
Excess	EXCS
Excess Flow Check Valve	EFCV
Excess Steam Demand Event	ESDE
Exchanger	EXCH
Exciter	EXC
Exclusion Area Boundary	EAB
Excore Neutron Flux Monitoring System	ENFMS
Exhaust	EXH, Exh
Exhaust Hood	EXHD
Exhauster	EXHSTR

Standard Service Designation	Abbreviation
Expansion	EXP
External	EXTER
External Reactor Vessel Cooling	ERVC
Extraction	EXT
Extraction Steam System	ESS
Extractor	EXTRR
Eye Movement Tracking	EMT
Facility	FAC
Fahrenheit	˚F
Failed As Is	F.A.I
Failed Closed	F.C., F-C
Failed Open	F.O.
Failure	FAIL
Failure Mode and Effects Analysis	FMEA
Fault	FALT
F-Correction	F-COR
Feedback	FDBK
Feeder	FDR
Feedwater	FW
Feedwater Pump	FWP
Feedwater Control (System)	FWC(S)
Feedwater Control System	FWCS
Feedwater Flow	FWF
Feedwater Isolation Valve	FIV
Feedwater Line Break	FWLB
Feedwater Pump Turbine System	FPTS
Feedwater System	FS
Fiber Optic Modem	FOM
Field	FLD
Field Change Notice	FCN
Field Change Request	FCR

Standard Service Designation	Abbreviation
Field Programmable ROM	FPROM
Filter	FLTR
Final Safety Analysis Report	FSAR
Fire Detection & Alarm System	FDAS
Fire Protection (Panel)	FP(P)
Fire Protection System	FPS
Fire Pump & Water Treatment Building	FPWTB
First	1ST, 1st
Fixed Incore Detector Amplifier System	FIDAS
Fixed In-Core Monitoring System	FIMS
Flame	FLM
Flange	FLNG
Flash	FLSH
Flat Panel Display	FPD
Floor	FLR
Floor Response Spectra	FRS
Flow	FLO, Flo, F
Flow Calibration Constant	FCC
Flow Control Valve	FCV
Flow Controller	FC
Flow Element	FE
Flow Indicating Control Station	FIK
Flow Indicator	FI
Flow Integrator Indicator	FQI
Flow Integrator Switch	FQS
Flow Recorder	FR
Flow Transmitter	FT
Flue Gas	FG
Fluid	FLU
Fluoride	FLUO
Flush Water Supply Header	FWSH

Standard Service Designation	Abbreviation
Flux Core Arc Welding	FCAW
Forward	FWD, Fwd
Fouling	FLG
Fraction	FRACT
Freeze	FRZ
Frequency	FREQ
Fresh Water Storage Tank	FWST
Front	FRNT
Front Face	FF
Fuel	FL
Fuel Cycle Analysis	FCA
Fuel Handling Area	FHA
Fuel Handling Area Emergency Ventilation Actuation Signal	FHEVAS
Fuel Handling System	FHS
Fuel Oil	FO
Fuel Oil System	FOS
Fuel Pool Cooling And Cleanup	FPCC
Full	FUL
Full Length CEA	FLCEA
Function	FUNC, FUNCT
Functional Allocation	FA
Functional Analysis Summary	FAS
Functional Control Logic Diagram	FCLD
Functional Interconnection Diagram	FID
Functional Recovery Guidelines	FRG
Functional Recovery Procedure	FRP
Functional Requirement Analysis	FRA
Future	FUT
Gallons Per Minute	GPM
Gas Analyzer	GA
Gas Circuit Breaker	GCB

Standard Service Designation	Abbreviation
Gas Collection Header	GCH
Gas Decay Tank	GDT
Gas Insulated Bus	GIB
Gas Insulated Substation	GIS
Gas Monitor	GM
Gas Stripper	GS
Gas Stripper Effluent	GSE
Gas Stripper Effluent Radiation Monitoring System	GSERMS
Gas Surge Tank	GST
Gas Tungsten Arc Welding	GTAW
Gaseous Radwaste System	GRS
Gaseous Waste Management System	GWMS
Gatehouse	GH
Gearbox	GRBX
Geiger-Muller	G-M
General	GNRL
General Arrangement Changing Request	GACR
General Data	GNRLD
General Design Criteria	GDC
General Electric Company	GE
General Operating Procedures	GOP
Generator	GEN
Generator Circuit Breaker	GCB
Generator End	GNE
Generator Monitor and Trip Board	VGEN
Generator Stator Cooling	GSC
Generator Stator Cooling Exhauster	GSCE
Generic Safety Issue	GSI
Generic Technical Guidance	GTG
Gland	GLND
Gland Seal Steam	GSS

Standard Service Designation	Abbreviation
Gland Seal Water Collection Tank	GSWCT
Glycol	GLY
Governor	GOV
Governor End	GOE
Governor Valve	GV
Graphic User Interface	GUI
Gravity	GRAV
Gray	Gy
Gross Failed Fuel Detector	GFFD
Ground	GND
Group	GRP
Group Controller	GX
Group Position Average	GPA
Group Position Highest	GPH
H2 & Combustible Gas Monitoring System	HCGMS
Halden Reactor Project	HRP
Hand Controller	HC
Hand Indicating Controller	HIC, HIK
Hand Synchronize Switch	HSS
Handle	HDL
Handling	HDLG
Handling Area	H/A
Handswitch	HS
Handwheel	HNDWHL
Hard Copy Procedure	HCP
Header	HDR
Health	HLTH
Health Physics Office	HPO
Heat Exchanger	HX
Heat Loss	HL
Heat Tracing System	HTS

Standard Service Designation	Abbreviation
Heated Junction Thermocouple	HJTC
Heated Junction Thermocouple (System)	HJTC(S)
Heater Drain	HD
Heater Drain System	HDS
Heater(S)	HTR(S)
Heating	HTG
Heating, Ventilating And Air Conditioning	HVAC
Heating, Venting & Air Conditioning System	HVACS
Hertz	HZ
HFE Design & Integration Plan	HFE DIP
HFE Integration Plan	HFE IP
HFE Program Plan	HFE PP
HFE Program Review Model	HFE PRM
High	HI, Hi
High / Low	HI/LO
High Capacity Blowdown	HCBD
High Efficiency Particulate Air	HEPA
High Energy Line Break	HELB
High High Water Level	HHWL
High Level Override	HLO
High Level Waste	HLW
High Pressure	HP
High Pressure Safety Injection	HPSI
High Pressure Stop Valve	HPSV
High Solids Drain Header	HSDH
High Solids Waste Header	HSWH
High Speed Link	HSL
High Voltage	HV
High Volume Purge System	HVPS
High Water Level	HWL
High-High	HI-HI, HH, Hi-Hi

Standard Service Designation	Abbreviation
High-High-High	HI-HI-HI, Hi-Hi-Hi
Hoist	HST
Hoist and Crane System	HCS
Hold(Ing)	HLD(G)
Holdup	HLDUP
Holdup Tank	HT
Horizontal	HOR
Horizontal Multicell Pressure Filter	HMPF
Hot Functional Test	HFT
Hot Leg Temperature	Thot, Th
Hotwater	H/W
Hotwell	HW
Hour	HR, Hr
Hour Average	HA
House	HSE
Housing	HSNG
Human Centered Design Goal	HCG
Human Engineering Discrepancy	HED
Human Error Probability	HEP
Human Factors Engineering	HFE
Human Factors Group	HFG
Human Machine Interface	HMI
Human Performance Measurement	HPM
Human Reliability Analysis	HRA
Human-System Interface	HSI'
Humidifier	HUMF
Humidity	HUMID
Hydraulic	HYD, Hyd
Hydraulic Control Unit	HCU
Hydraulic Fluid Pump	HFP
Hydraulic Grade Line	HGL

Standard Service Designation	Abbreviation
Hydrazine	HYDZ
Hydrogen	H, H2
Hydrogen Monitoring system	HMS
Hydrogen Purge Exhaust System	HPES
Hydrogen Recombiner System	HRS
Hydrogen System	HS
Hydroxide	HYDROX
Hypochlorite	HYCO
I&C Equipment Room	I&C ER
Identification	ID, Id
Igniter, Ignition	IGN
Important to Availability(Software)	ITA
Improved Korean Standard Nuclear Power Plant	KSNP+
Improved Standard Technical Specification	ISTS
Improved Technical Specification	ITS
Impulse	IMP
In Core	IC
In Core Instrumentation	ICI
Inaccessible	INACCES
Inactive	INACT
Inadequate Core Cooling (Monitoring System)	ICC(MS)
Inadvertent Operation of POSRV	IOPOSRV
Inboard	INBD
Inch	IN
Incoming	INC
In-Containment Refueling Water Storage System	IRWSS
In-Containment Refueling Water Storage Tank	IRWST
Incore Instrumentation Cable Tray Assembly	ICICTA
Increase	INCR
Independent	INDP
Indicator	IND

Standard Service Designation	Abbreviation
Individual	INDVL
Induction	INDN
Inerting	INRT
Influent	INFLU
Information Processing System	IPS
Inhibit List	INBLST
Initiate	INIT
Initiated	INTD
Injection	INJ, Inj
Inlet	INLT
Inner	INR
Inoperable	INOP
Input/Output	I/O
Insertion	INSER
Inservice Inspection	ISI
Inside Diameter	ID
Inspection	INSP
Inspections, Test, Analyses, and Acceptance Criteria	ITAAC
Institute For Nuclear Power Operations	INPO
Institute of Electrical and Electronics Engineers	IEEE
Instrument	INST
Instrument Air	IA
Instrument Air Distribution Drawing	IAD
Instrument Air System	IAS
Instrument Installation Details	IID
Instrument Location Drawing	ILD
Instrumentation And Control	I&C
Intake	INTK
Intake Structure	IS
Integrated Head Assembly	IHA
Integrated Process Status Overview	IPSO

Standard Service Designation	Abbreviation
Integrated Surveillance and Control System	ISCS
Integrated System Validation	ISV
Intercept	INTCP
Intercept Valve	IV
Interconnection Wiring Diagrams	IWD
Interface and Test Processor	ITP
Interface Requirement Document	IRD
Intergrated Leak Rate Test	ILRT
Interim Verification & Validation	IVV
Intermediate	INTERM
Intermediate Pressure	IP
Intermediate Range	IR
Intermediate Range Monitor	IRM
Intermediate Range Monitor Subsystem	IRMS
Intermediate Stop Valve	ISV
Intermediate Stop Valve	ISV
Internal	INT
Internals Vibration Monitoring System	IVMS
International Atomic Energy Agency	IAEA
Internationl Commission on Radiological Protection	ICRP
Interoffice Memorandum	IOM
Interposing Logic System	ILS
Iodine	IOD, I
Ion Exchange Drain Header	IDH
Ion Exchanger	IX
Ion Exchanger Drain Header	IEDH
Iron	IRN
Isolated Phase Bus	IPB
Isolation	ISOL, Isol
Isometric Drawing	ISD
Isotope	ISOTPE

Standard Service Designation	Abbreviation
Joint	JT
Joint System Design	JSD
Journal	JRNL
Junction	JUNC
Junction Box	JB
KEPCO Engineering & Construction Company	KOPEC
KEPCO Nuclear Review Board	KNBR
Knowledge-Based System	KBS
Kopec Interactive Document System	KIDS
Korea Atomic Energy Research Institute	KAERI
Korea Electric Power Corporation	KEPCO
Korea Electric Power Industry Code	KEPIC
Korea Nuclear Fuel Company	KNFC
Korea Standards Institute	KSI
Korean Standard Nuclear Power Plant	KSNP
Laboratory	LAB
Large Break Loss of Coolant Accident	LBLOCA
Large Display Panel	LDP
Lead	LD
Leak	LK
Leak Before Break	LBB
Leak Detection System	LDS
Leak Off	LKOFF
Leaving	LVNG
Left	LF
Left Hand	LH
Letdown	LTDN, Ltdn
Letdown Heat Exchanger	LDHX
Level	LVL, L
Level Control Valve	LCV
Level Controller	LC

Standard Service Designation	Abbreviation
Level Indicating Control Station	LIK
Level Indicator	LI
Level Instrument Bridle Drawing	LBD
Level Multipoint Recorder	LJR
Level Recorder	LR
Level Setting Diagram	LSD
Level Switch	LS
Level Transmitter	LT
Licensee Event Report	LER
Light	LGT
Light Emitting Diode	LED
Light Water Reactor	LWR
Lighter	LGTR
Lighting	LTG
Lightning Arrester	LA
Lightning Protection System	LPS
Limit	LMT
Limiter	LMTER
Limited Work Authorization	LWA
Limiting	LMTNG
Limiting Conditions for Operation	LCO
Limiting Safety System Setting	LSSS
Line	LN
Line Of Sight	LOS
Linear	LNR
Linear Variable Differential Transformer	LVDT
Liquid	LIQ
Liquid Crystal Display	LCD
Liquid Radwaste System	LRS
Liquid Waste Management System	LWMS
Load	LOD

Standard Service Designation	Abbreviation
Load Center	LC
Local	LCL
Local Control Panel(S)	LCP
Local Control Station	LCS
Local Leak Rate Test	LLRT
Local Power Density	LPD
Local Power Range Monitor	LPRM
Local Sampling System	LSS
Local Test Switch	LTS
Locally Mounted	LM
Locked	LKD
Locked Closed	L.C.
Locked Open	L.O.
Locked-Out	L-O
Logarithmic	LOG
Long Term Cooling	LTC
Loop	LOP
Loop Controller	LX
Loose Parts Monitoring System	LPMS
Loss of Coolant Accident	LOCA
Loss Of Feedwater	LOF
Loss Of Feedwater Recovery	LOFR
Loss Of Forced Circulation	LOFC
Loss of Offsite Power	LOOP
Loss Of Voltage	LOV
Low	LO, Lo
Low Bearing	LBRNG
Low Low Water Level	LLWL
Low Population Zone	LPZ
Low Power Range	LPR
Low Pressure	LP

Standard Service Designation	Abbreviation
Low Pressure Safety Injection	LPSI
Low Pressure Turbine A	LPA
Low Pressure Turbine B	LPB
Low Pressure Turbine C	LPC
Low Temperature Overpressure Protection	LTOP
Low Voltage	LV
Low Volume Purge System	LVPS
Low Water Level	LWL
Low-Low	LO-LO, LL, Lo-Lo
Low-Low-Low	LO-LO-LO, Lo-Lo-Lo
Lube Oil	LB
Lubricating	LUB
Lubricating Oil	LUBO
Machine	MACH
Main	MN
Main Control Board(S)	MCB(S)
Main Control Room	MCR
Main Control Room System	MCRS
Main Feed Pump	MFP
Main Feed Pump Isolation Valve	MFIV
Main Feed Pump Turbine	MFPT
Main Oil Pump	MOP
Main Power	MP
Main Power Block	MPB
Main Power System	MPS
Main Steam (System)	MS(S)
Main Steam Atmospheric Dump Valve	MSADV
Main Steam Isolation (Actuation) Signal	MSI(A)S
Main Steam Isolation System	MSIS
Main Steam Isolation Valve	MSIV
Main Steam Line	MSL

Standard Service Designation	Abbreviation
Main Steam Line Break	MSLB
Main Steam Safety Valve	MSSV
Main Steam System	MSS
Main Stop Valve	MSV
Main Transformer	MT
Main Turbine and Auxiliary System	MTAS
Maintenance	MAINT
Maintenance and Test Panel	MTP
Maintenance Of Vital Auxiliary	MOVA
Maintenance Vital Dc	MVDC
Makeup	MU
Makeup Demineralizer System	MDS
Makeup Supply Header	MSH
Malfunction	MALF
Manager	MANGR
Manifold	MFLD
Manipulator	MANIP
Man-Machine Interface	MMI
Man-Machine Interface System	MMIS
Manual	MAN
Manual Group	MGP
Manual Individual	MAI
Manual Sequential	MSQ
Manual/Automatic	M/A
Manual/Automatic Indicator Control	MAIC
Manufacturer	MFR
Manufacturing	MFG
Manufacturing License	ML
Margin	MGN
Master	MAST
Master Diagram	MD

Standard Service Designation	Abbreviation
Material Balance Area	MBA
Material Tracking System	MTS
Maximum	MAX, Max
Maximum Credible Accident	MCA
Maximum Permissible Concentration	MPC
Mean Time Between Failure	MTBF
Mean Time Between Forced Outage	MTBFO
Mean Time To Failure	MTTF
Mean Time to Repair	MTTR
Measurement Channel Block Diagram	MCBD
Mechanical	MECH
Mechanical Overspeed Trip	MOST
Megawatts Electric	MWE
Megawatts Thermal	MWT
Memory Address Translator	MAT
Mercury	HG
Meteorological Monitoring System	MMS
Mezzanine	MEZ
Microprocessor	MPROCES
Middle of Cycle	MOC
Midspan	MDSP
Millimeters Mercury Absolute	MM HGA
Mini-Flow	Mini F
Mini-Large Display Panel	Mini LDP
Minimum	MINI, Min
Minimum Critical Heat Flux Ratio	MCHFR
Minimum Inventory	MI
Miscellaneous	MISC
Miscellaneous Building Drain System	MBDS
Miscellaneous Liquid Waste Management System	MLWMS
Mixed Oxide Fuel	MOX

Standard Service Designation	Abbreviation
Moderate Energy Pipe Break	MEPB
Modulation	MOD
Module	MODU
Moisture	MOIST
Moisture Separator Reheater	MSR
Monitor	MON
Monthly Progress Report	MPR
Motor Control Center	MCC
Motor Driven Feed Pump	MDFP
Motor Generator (Sets)	MG(SETS)
Motor Inboard Bearing	MIBRG
Motor Operated Valve	MOV
Motor Outboard Bearing	MOBRG
Motor Suction Pump	MSP
Motor Status	MS
Motoring	MTRG
Mounted	MTD
Mounting Height	MH
Multi Stud Tensioner	MST
Multiplexer	MUX, MX
Multivariable Indicator	UI
Multivariable Light Indication	UL
Multivariable Multifunction	UU
N2 & H2 Storage Cylinder Area	NHSCA
Narrow	NAR
Narrow Range	NR
National Fire Protection Association	NFPA
Natural	NAT
Natural Circulation Cooldown	NCC
Negative	NEG
Net Positive Suction Head	NPSH

Standard Service Designation	Abbreviation
Neutral	NEUL
Neutron	NEUT
Neutron Flux	NF, N
Neutron Flux Alarm and Control	NFANC
Neutron Flux Information (Non-Safety)	NF N1E
Neutron Flux Information (Safety)	NF 1E
Neutron Monitoring System	NMS
New Nuclear Power Plant Units 1&2	NNPP 1&2
Nil-Ductility Temperature	NDT
Nil-Ductility Transition Temperature	NDTT
Nitrogen	N2
Nitrogen System	NS
Noble	NBL
Nonconformance Report	NCR
Non-Destructive Test	NDE/NDT
Non-nuclear Safety	NNS
Non-Post Accident	NPA
Non-Regenerative	NON-REGEN
Non-safety-related	NSR
Non-segregated Phase Bus	NSPB
Normal	NORM
Normal Closed	NC
Normal Open	NO
Normal Operating Guidelines	NOG
Normal Primary Sample Sink	NPSS
Normal Primary Sample Valve And Cooler Rack	NPSVCR
North	N
Not Applicable	N/A
Not Fully Closed	NFC
Not Fully Open	NFO
Nozzle	NOZ

Standard Service Designation	Abbreviation
NSSS Application Software	NAPS
NSSS Integrity Monitoring System	NIMS
NSSS Process Control System	NPCS
Nuclear	NUC
Nuclear Cooling Water System	NCWS
Nuclear Data Link	NDL
Nuclear Instrumentation (System)	NI(S)
Nuclear Power Station	NPS
Nuclear Regulation	NUREG
Nuclear Regulatory Commission	NRC
Nuclear Steam Supply System	NSSS
Nucleate Boiling Ratio	NBR
Number	NUM, #, NO.
Obstruction	OBSTR
Occupational Radiation Exposure	ORE
Office	OFC
Offshore Technical Support	OTS
Oil Circuit Breaker	OCB
Oil Filled	OF
Oil Reset Pistion	ORP
Okay	OK
On Load Tap Changer	OLTC
Open	OPN
Open/Close	O/C
Operating	OPER
Operating Basis Earthquake	OBE
Operating Experience Report(Review)	OER
Operating License	OL
Operating Support Center	OSC
Operation	OP
Operation Basis Accident	OBA

Standard Service Designation	Abbreviation
Operation Basis Incident	OBI
Operation Console	OC
Operation Guideline	OG
Operations And Maintenance	O&M
Operator	OPR
Operator Established Alarm	ESTB
Operator Interface Unit	OIU
Operator Module	OM
Operator Performance Assessment System	OPAS
Orifice	ORIF
Outboard	OUTBD
Outboard Bearing	OBRG
Outer	OUTR
Outlet	OTLT
Outlet Header	OHDR
Out-Of-Sequence	OUT-OF-SEQ
Out-Of-Service	OOS
Outside	OUTS
Outside Air	OA
Outside Diameter	OD
Over	OVR
Overcurrent	OC
Overflow	OVRFLO
Overload	OVRLD
Override	OVRRD
Overspeed	OVRSP
Overview	OVVEW
Oxygen	O2
Package	PCKG
Packing	PKG
Panel	PNL

Standard Service Designation	Abbreviation
Parameter	PARA
Part Length Control Element Assembly	PLCEA
Part Number	P/N
Part Strength	PTS
Part Strength Control Element Assembly	PSCEA
Particle, Particulate	PART
Parts Per Million	PPM
Passive Autocatalytic Recombiner	PAR
Passive Secondary Cooling System	PSCS
Peak Cladding Temperature	PCT
Pegging	PEG
Pellet/Cladding Interaction	PCI
Pendant	PNDT
Penetration	PEN
Percent	%, PCT
Performance	PERF
Permissive	PERM, Perm
Ph Number(Effective Hydrogen Ion Concentration, Measures Acidity/Alkalinit)	PH
Phase	PHAS
Phosphate	PHOS
Pilot	PLT
Pilot Operated Safety and Relief Valve	POSRV
Piping and Instrumentation Diagram	P&ID
Piping Design Table	PDT
Piping System Design Specification	PSDS
Plant Chilled Water System	PCWS
Plant Nuclear Safety Committee	PNSC
Plant Power	PP
Plant Protection System	PPS
Plate	PLTE

Standard Service Designation	Abbreviation
Platen	PLTN
Plenum	PLEN
Pneumatic	PNEU
Point	PNT
Point Identification	Point ID
Point of Adding Heat	POAH
Polisher	PLSHR
Polishing	PLSHNG
Position	POSIT
Positive	POS
Positive Displacement	PD
Post Accident	PA
Post Accident Monitoring (Instrument)	PAM(I)
Post Accident Monitoring System	PAMS
Post Accident Primary Sample Cooler Rack	PPSCR
Post Accident Primary Sample Sink	PPSS
Post Accident Sampling System	PASS
Postweld Heat Treatment	PWHT
Potentiometer	POT
Pounds Per Square Inch Absolute	PSIA
Pounds Per Square Inch Gauge	PSIG
Power	PWR
Power Circuit Breaker	PCB
Power Conditioning Terminal Board	TTPW
Power Control System	PCS
Power Demand Meter	JQI
Power Dependent Insertion Limit	PDIL
Power Factor	PF
Power Indicator	JI
Power Line Disturbance	PLD
Power Load Unbalance	PLU

Standard Service Designation	Abbreviation
Power Operated Relief Valve	PORV
Power Operating Limit	POL
Power Operation - Mode 1 Steady State	POM1SS
Power Operation - NI Calibration Data	PONICD
Power Operations - Shiftly ST Data & Shiftly CR Log Reading	POST/CR
Power Rate Change Indicator	JKI
Power Recorder	JR
Power Spectral Density	PSD
Pre Hold-Up Ion Exchanger	PHIX
Pre Hold-Up Ion Exchanger Strainer	PHIXS
Precipitator	PCP
Prefabrication	Pre-Fab
Preferred	PRFD
Pre-Filter	PRE-FLTR
Pre-Heater	PHTR
Pre-Heating	PHTG
Preliminary Safety Analysis Report	PSAR
Preliminary Task Analysis	PTA
Prepower Dependent Insertion Limit	PPDIL
Preservice Inspection	PSI
Pressure	PRESS, P, Press
Pressure Control (Or Regulating) Valve	PCV
Pressure Controller	PC
Pressure Indicating Control Station	PIK
Pressure Indicator	PI
Pressure Multipoint Recorder	PJR
Pressure Recorder	PR
Pressure Transmitter	PT
Pressurized Heavy Water Reactor	PHWR
Pressurized Water Reactor/ Power	PWR
Pressurizer	PZR

Standard Service Designation	Abbreviation
Pressurizer Level Control System	PLCS
Pressurizer Level Setpoint	PLS
Pressurizer Pressure & Level Control System	PPLCS
Pressurizer Pressure Control System	PPCS
Pressurizer Relief Tank	PRT
Pressurizer Safety Valve	PSV
Pre-Trip	PTRIP, Ptrip
Prevention	PREV
Primary	PRIM
Primary Sample Control Panel	PSCP
Primary Trip Terminal Board	TRPL
Primary Water	PW
Probabilistic Risk Assessment	PRA
Probabilistic Safety Assessment	PSA
Probable Lowest Water Level	PLWL
Probable Maximum Flood	PMF
Probable Maximum Hurricane	PMH
Probable Maximum Precipitation	PMP
Probable Maximum Typhoon	PMT
Probable Maximum Water Level	PMWL
Probable Minimum Surge Level	PMSL
Probe	PROB
Procedure	PROC, Proc
Procedure Editor system	PED
Procedure eXecution System	PXS
Procedure Review Notice	PRN
Process	PROC
Process Representation Value	PRV
Process And Effluent Radiation Monitoring	PRM
Process Control Cabinet	PCC
Process Instrumentation	PI

Standard Service Designation	Abbreviation
Process Protective Cabinet	PPC
Process Radiation monitoring System	PRMS
Process Sampling	PS
Process Sampling System	PSS
Process Value	PV
Process-Component Control System	P-CCS
Processing Unit	PU
Program	PROG
Programmable Logic Controller	PLC
Programmable Read Only Memory	PROM
Programmed Action List	PAL
Project Design Flood	PDF
Project Distribution List	PDL
Project Manager	PM
Project Numbering System	PNS
Proportional	PROP
Protection	PROT
Proximitors	PROX
Public Address System	PAS
Pump(S)	PMP(S)
Purge	PRG
Purification	PURFN
Purification Ion Exchanger	PIX
Purifier	PURF
Purity	PRTY
Pushbutton	PB
Quadrant	QUAD
Quadrant Power Tilt Ratio	QPTR
Qualified Indication and Alarm System	QIAS
Qualified Indication and Alarm System - Non-Safety	QIAS-N
Qualified Indication and Alarm System - PAMI	QIAS-P

Standard Service Designation	Abbreviation
Quality	QLTY
Quality Assurance	QA
Quality Assurance Of Design Procedure	QADP
Quality Assurance Representative	QAR
Quality Control	QC
Quality Surveillance	QS
Quantity	QNTY
Rack	RK
Racked In	R/I
Racked Out	R/O
Radiation	RAD, Rad
Radiation Design Guide	RDG
Radiation Monitoring Cabinet	RMC
Radiation Monitoring System	RMS
Radiation, Radioactive	RAD
Radio Frequency Interference	RFI
Radioactive Concentration Guide	RCG
Radioactive Drain System	RDS
Radioactive Laundry System	RLS
Radioactive Waste	RADWASTE
Radioactivity Light Indication	RL
Radioactivity Recorder	RR
Radwaste Control Console	RCC
Radwaste Control Room	RCR
Radwaste Control Room System	RCRS
Random Access Memory	RAM
Range	RNG
Rate	RT
Ratio	RATO
Raw Water System	RWS
RCP Vibration Monitoring System	RCPVMS

Standard Service Designation	Abbreviation
Reactivity	REACT
Reactor	RX, Rx
Reactor Cavity Cooling System	RCCS
Reactor Cavity Filtration System	RCFS
Reactor Containment Building	RCB
Reactor Containment Fan Cooler	RCFC
Reactor Coolant (System)	RC(S)
Reactor Coolant Drain Tank	RCDT
Reactor Coolant Gas Vent (System)	RCGV(S)
Reactor Coolant Gas Vent System	RCGVS
Reactor Coolant Loop	RCL
Reactor Coolant Pressure Boundary	RCPB
Reactor Coolant Pump	RCP
Reactor Coolant Pump Shaft Speed Sensing System	RCPSSSS
Reactor Coolant System	RCS
Reactor Drain	RD
Reactor Drain Filter	RDF
Reactor Drain Pump	RDP
Reactor Drain Tank	RDT
Reactor Makeup Water (Pump)	RMW(P)
Reactor Makeup Water Tank	RMWT
Reactor Operator	RO
Reactor Power Cutback (System)	RPC(S)
Reactor Power Cutback Control Panel	RPCCP
Reactor Power Cutback System	RPCS
Reactor Pressure Vessel	RPV
Reactor Protection (System)	RP(S)
Reactor Protection System	RPS
Reactor Regulating System	RRS
Reactor Trip Override	RTO
Reactor Trip Switchgear	RTSG

Standard Service Designation	Abbreviation
Reactor Trip Switchgear System	RTSS
Reactor Trip System	RTS
Reactor Vessel	RV
Reactor Vessel Head	RVH
Reactor Vessel Internal	RVI
Reactor Vessel Level	RVL
Reactor Vessel Level Monitoring System	RLMS
Reactor Vibration Monitoring System	RVMS
Rear Face	RF
Receiver	RCVR
Recirculation	RECIRC, Recirc
Recombiner	RCOMB
Record (Er)	RCD(R)
Recycle	RECY
Recycle Drain Header	RDH
Reed Switch Position System	RSPS
Reed Switch Position Transmitter	RSPT
Reference	REF, Ref
Refueling Shutdown Tank	RST
Regenerative Heat Exchanger	RGHX
Regenerator	REGN
Region	RGN
Regulate	REG
Regulator	REGR
Regulatory Guide	RG
Reheater	RHTR
Reinjection	REINJ
Related	RLTD
Relative	REL
Relative Humidity	RH
Relay	RLY

Standard Service Designation	Abbreviation
Relief	RLF
Reload Data Block	RDB
Reload Transition Safety Report	RTSR
Remote	RMT
Remote Cabinet	RC
Remote Control Module	RCM
Remote Sampling System	RSS
Remote Shutdown Console	RSC
Remote Shutdown Room	RSR
Remote Terminal Unit	RTU
Removal	RMVL
Remove	RMV
Representative	REP
Republic Of Korea-Automic Energy Bureau	ROK-AEB
Request	REQ
Request for Additional Information	RAI
Reserve	RES
Reservoir	RSVR
Reset	RSET
Resin	RSN
Resin Additive Tank	RAT
Resin Sluice Header	RSH
Resin Sluice Supply Header	RSSH
Resistance Temperature Detector	RTD
Responsible Engineer	RE
Restricting	RESTR
Return	RTRN
Right	RGT
Riser	RISR
Rod Block Monitor	RBM
Rod Cluster Control Assembly	RCCA

Standard Service Designation	Abbreviation
Roentgen Absorbed Dose	RAD
Roentgen Equivalent Man	REM
Room	RM
Rotor	RTR
Runback	RUNBK
Running	RUN
Safe Shutdown Earthquake	SSE
Safeguard	SFGD
Safety	SAF
Safety Analysis Report	SAR
Safety Depressurization System	SDS
Safety Evaluation Report	SER
Safety Injection (System)	SI(S)
Safety Injection Actuation Signal	SIAS
Safety Injection Pump	SIP
Safety Injection Tank	SIT
Safety Injection/Shutdown Cooling System	SISCS
Safety Parameter And Display Evaluation System +	SPADES+
Safety Parameter Display System	SPDS
Safety Review Guide	SRG
Safety-Relief Valve	SRV
Sample	SAMP
Sand Storm Unit	SSU
Sanitary Sewer System	SSS
Sargent And Lundy	S&L
Saturated	SATD
Saturation	SATN
Scanner	SCAN
Scavenging	SCAV
Scheduled	SCHED
Screen	SCRN

Standard Service Designation	Abbreviation
Screenwash	SCRNWSH
Seal	SL
Seal Injection Filter	SIF
Seal Injection Heat Exchanger	SIHX
Seal Oil	SO
Seal Oil Cooler	SOC
Sealing Steam	SSTM
Seawater Bypass Pump	SBP
SECOND (After First)	2ND
SECOND (Time)	SEC, S
Secondary	SECD
Secondary Chemical Control System	SCCS
Secondary Pressure	PSEC
Section	SECT
Security	SECUR
Seismic	SEIS
Seismic Monitoring System	SMS
Selection	SEL
Separation Setpoint 2	02-Sep
Separator	SEP
Sequence	SEQ, Seq
Sequence of Event	SOE
Service	SERV
Service Air System	SAS
Service Building	SB
Service Water	SWTR
Setpoint	SETPT, Setpt
Severe Accident Management Guideline	SAMG
Sewage	SEW
Shaft	SHFT
Shallow	SHAL

Standard Service Designation	Abbreviation
Shape Annealing Matrix	SAM
Shell	SHL
Shielded Metal Arc Welding	SMAW
Shift Manager	SM
Shift Supervisor	SS
Shift Technical Advisor	STA
Shutdown	S/D
Shutdown Cooling (System)	SDC(S)
Shutdown Cooling Heat Exchanger	SDCHX
Shutdown Cooling Pump	SCP
Shutdown Overview Display Panel	SODP
Side	SD
Sidewall	SWL
Signal	SIG
Silica	SIL
Silicon Controlled Rectifier	SCR
Single Line Diagram	SLD
Situation Awareness	SA
Situation Awareness Global Assessment Technique	SAGAT
Situation Awareness Rating Technique	SART
Skimmer	SKIM
Sludge	SLUG
Sluice	SLU
Small Break Loss of Coolant Accident	SBLOCA
Smoke	SMK
Snubber	SNUB
Sodium	NA
Soft Control	SC
Solenoid	SOL
Solenoid Valve	SOV
Solid Radwaste System	SRS

Standard Service Designation	Abbreviation
Solid State Actuation System	SSAS
Solid State Power Equipment	SSPE
Solid Waste Management System	SWMS
Solution	SOLN
Source	SRCE
Source Range	SR
South	S
South/North	S/N
Sparging	SPRG
Special Light Indication	XL
Specific	SPCF
Specific Gravity	SPGR
Specific Volume	SPVOL
Specification	SPEC
Speed	SPD
Spent Fuel	SF
Spent Fuel Pool	SFP
Spent Fuel Pool Cooling and Cleanup System	SFPCCS
Splicing	SPLCN
Spray Additive	SADD
Spreading	SPRDG
Spring Loaded Safety Valve	SLSV
Sprinkler	SPKLR
Stage	STG
Stainless Steel Liner Plate	SSLP
Stairway	STRWY
Standard	STD
Standard Post Trip Actions	SPTA
Standard Project Flood	SPF
Standard Review Plan	SRP
Standard Safety Analysis Report	SSAR

Standard Service Designation	Abbreviation
Standards, Guidelines and Bases	SGB
Standby	STBY, SBY
Standby Auxiliary Transformer	SAT
Standby Liquid Control	SLC
Start	STRT
Started	STRD
Start Permissive	STPERM
Start-Up	S/U
Startup Field Request	SFR
Startup Status	SUS
Start-Up Transformer	SUT
Startup Work Sheet	SWS
Static	STAC
Static Pressure	SP
Station Air Compressor	SAC
Station Blackout	SBO
Statistical Combination of Uncertainty	SCU
Stator	STR
Stator Cooling Water	SCW
Status	STAT
Steam	STM, Stm
Steam Bypass Control System	SBCS
Steam Feed Bypass Valve	SFBV
Steam Generator	SG
Steam Generator Blowdown	SGBD
Steam Generator Blowdown System	SGBS
Steam Generator Feedwater Pump	SGFP
Steam Generator Feedwater Pump Turbine	SGFPT
Steam Generator Tube Rupture	SGTR
Steam Jet Air Ejector	SJAE
Steam Line Break	SLB

Standard Service Designation	Abbreviation
Steam Packing Exhauster	SPE
Steam Reheat Header Drains	SRHD
Steam Seal Feed	SSF
Steam Seal Header	SSH
Steam Valve	STMV
Stop	ST
Stop Valve	SV
Stopped	STOP
Storage	STOR
Strainer	STRN
Stream	STRM
Stress Corrosion Cracking	SCC
Stripper	STRIPR
Structure	STRUC
Stuck	STK
Subcooling	SUBCOOL
Subcooling Margin Monitor	SMM
Subject Workload Assessment Technique	SWAT
Substation	SUBSTA
Success Path Availability	SPA
Success Path Monitoring	SPM
Success Path Performance	SPP
Suction	SUCT
Sudden	SUD
Sulfate	SO4
Sump	SMP
Supervisory	SUPV
Supplementary Protection Logic Assembly	SPLA
Supplier Document Review Form	SDRF
Suppliers's Deviation Disposition Request	SDDR
Supply	SUP, Sup

Standard Service Designation	Abbreviation
Support	SUPRT
Suppression	SUPP
Surface	SURF
Surge	SRGE
Surveillance	SURV
Surveillance/Preventive Maintenance	S/PM
Switch	SWCH, SW
Switchgear	SWGR
Switchyard	SWYD
Switchyard Relay And Control Building	SRCB
Synchronize	SYNC
System	SYS, Sys
System Design Criteria	SDC
System Functional Description	SFD
System Operating Diagram	SOD
System Operating Experience Report	SOER
System Operating Procedures	SOP
Tachometer	TACH
Tank(S)	TK(S)
Task Analysis	TA
Task Complexity Index	TCI
Task Load Index	TLX
Tech Spec Channel Check	TSCC
Technical	TECH
Technical Data Sheet	TDS
Technical Support Center	TSC
Tehnique for Human Error rate Prediction	THERP
Television	TV
Temperature	TEMP, Temp, T
Temperature Average	Tavg, T/avg
Temperature Control Valve	TCV

Standard Service Designation	Abbreviation
Temperature Controller	TC
Temperature Deviation	Tdev
Temperature Indicating Control Station	TIK
Temperature Indicator	TI
Temperature Multipoint Recorder	TJR
Temperature Recorder	TR
Temperature Reference	Tref, T/ref
Temperature Shadowing Reference	TSREF
Temperature Transmitter	TT
Tempering	TMPG
Temporary	TMPRY
Ten Minute Average	PL
Tenth Value Layer	TVL
Terminal	TERM
Terminal Temperature Difference	TTD
Tertiary	TERT
Test	TST
Test Guideline	TG
Test Procedures	TP
Test Response Spectra	TRS
Thermal	THERM
Thermal Power Calibration Constant	TPC
Thermocouple	T/C, TC
Thermoluminescence Dosimeter	TLD
Three Dimensional	3-D
Threshold	THRSHD
Throttle	THROT
Thrust	TRST
Thrust Bearing	TBRNG
Time	TM
Time Delay	TD

Standard Service Designation	Abbreviation
Time Indicator	KI
Timer	TMR
Top-Down Suitability verification	TDSV
Total	TOT
Total Developed Head	TDH
Total Effective Dose Equivalent	TEDE
Total Integrated Dose	TID
Total Loss of Feed Water	TLOFW
Totally Enclosed Fan Cooled	TEFC
Tower	TWR
Tracing	TRAC
Train	TRN
Transducer	XDCR
Transducer Power Supply Cabinet	TPSC
Transfer	XFR
Transformer	XFMR
Transient Operations - Part Strength Monitoring	TOPSM
Transmitter	XMTR
Traveling Screen and Screen Wash System	TSSWS
Travelling	TRAV
Travelling Screen	TRSC
Treatment	TREAT
Trend	TRD
Trip	TRP
Trip Circuit Breaker	TCB
Tripped	TRPD
Tri-Sodium Phosphate	TSP
Trouble	TRBL
Turbid	TRBD
Turbidity	TBDT
Turbine	TBN

Standard Service Designation	Abbreviation
Turbine Building	TB
Turbine Building Closed Cooling Water	TBCCW
Turbine Building Closed Cooling Water System	TBCCWS
Turbine Building Open Cooling Water	TBOCW
Turbine Building Open Cooling Water System	TBOCWS
Turbine Bypass Atmospheric Valve	TBAV
Turbine Bypass Condenser Valve	TBCV
Turbine Bypass Valve	TBV
Turbine End	TBE
Turbine First Stage Pressure	TFSP
Turbine Gear	TRGR
Turbine Generator	TG, T/G
Turbine Generator Building	TGB
Turbine Generator Building Closed Cooling Water System	TGBCCWS
Turbine Generator Building Drain System	TGBDS
Turbine Generator Building Open Cooling Water System	TGBOCWS
Turbine Generator Supervisory Instrumentation	TGSI
Turbine Gland Steam Seal System	TGSSS
Turbine Oil	TO
Turbine Operator	TO
Turbine Shaft Driven Main Oil Pump	TSDMOP
Turbine Side	TS
Turning Gear	TGR
Turning Gear Oil Pump	TGOP
Ulchin Nuclear Power Plant	UCN
Ultimate Heat Sink	UHS
Ultrasonic Resin Cleaner	URC
Unbalance	UNBAL
Uncertaintie(S)	UNCERT(S)
Uncompensated	UNCMPN
Uncompensated Ion Chamber	UIC

Standard Service Designation	Abbreviation
Under Flow Fraction	UFF
Undervoltage	UV, UNDERVOLT
Uninterruptable Power Supplier	UPS
Unit Auxiliary Transformer	UAT
Unload	UNLD
Unresolved Safety Issue	USI
Update Time Dependent Variables	UTDV
Upper	UPPR
Upper Bearing	UBRNG
Upper Cable Spread Room	UCSR
Upstream	UPSTRM
Utility	ULTY
Utility Requirements Document	URD
Vacuum	VAC
Vacuum Circuit Breaker	VCB
Valid	VLD
Valve Position Limiter	VPL
Valve Wide Open	VWO
Valve(S)	VLV(S)
Vapor	VAP
Vaporizer	VAPZ
Varhour Meter	VARHM
Variable	VAR, Var
Variable Over Power Trip	VOPT
Vault	VLT
Ventilation System	VS
Ventillation	VENT
Verification	VERF
Verification and Validation	V&V
Vertical	VERT
Vessel	VESS
Vessel And Closure Head Seating Surface	VSS
Vibration	VIB, Vib
Vibration Monitoring System	VMS
Video Display Unit	VDU
Visual Examination/ Visual Test	VE/VT

Standard Service Designation	Abbreviation
Vital Bus Power Supply System	VBPSS
Vital Power System	VPS
VME Bus Master Controller Board	VCMI
Voltage	VTG
Voltage Direct Current	VDC
Voltage To Current	E/I
Voltage To Freqency Converter	VFC
Voltage To Pulse Rate Converter	VPRC
Voltage Transformer	VT
Voltampere	VA
Voltmeter	VM
Volt-Ohm Meter	VOM
Volts	VOLT, V
Volume	VOL
Volume Control Tank	VCT
Warehouse	WH
Warm-Up	WMUP
Waste	WSTE
Waste Condensate Tank	WCT
Waste Management (System)	WM(S)
Waste Water Transfer System	WWTS
Watchdog Timer	WDT
Water	WTR
Water Chemistry	WC
Water Detection	WD
Water Treatment Building	WTB
Waterbox	WTRBX
Watthour Meter	WHM
Weight	WT
West	W
Wet Lay-Up Subsystem	WLS
Wide Range	WR
Wide Range Boronometer	WRB
Winding	WDG
Window	WDW
Windowbox	WDBX
Withdrawl	W/D

Standard Service Designation	Abbreviation
Without	W/O
Workstation Disable Switch	WDS
Workstation Display	WSD

APPENDIX A – Part 2
Physical Unit and Abbreviations

Physical Quantity	Abbreviation
Ampere	A
Bar	bar
Becquerel	Bq
Becquerel per Centimeter Cubic	Bq/cm^3
Centimeter	cm
Centimeter Cubic Per Gram	cm^3/g
Centimeter H_2O Absolute Per Secon	cmH_2OA/s
Centimeter H_2O (Gauge)	$cmH_2O(G)$
Centimeter H_2O (Gauge) Per Second	$cmH_2O(G)/s$
Centimeter H_2O Absolute	cmH_2OA
Centimeter H_2O (Gauge)	$cmH_2O(G)$
Centimeter Hg (Absolute) Per Second	cmHgA/s
Centimeter Hg (Gauge)	cmHg(G)
Centimeter Hg (Gauge) Per Second	cmHg(G)/s
Centimeter Hg Absolute	cmHgA
Centimeter Per Hour	cm/h
Centimeter Per Second	cm/s
Centimeter Squared	cm^2
Ci	Ci
Count Per Minute	cpm
Counts Per Second	cps
Counts Per Second Per Second	cps/s
Cubic Centimeter	cm^3
Cubic Meter	m^3
Decades Per Minute	dpm
Degree Celsius	^oC
Degree Celsius Per Second	$^oC/s$
Degree Kelvin	K

Physical Quantity	Abbreviation
Delta React/React	ΔK/K
Dk/K/Degree Celsius	ΔK/K/^{o}C
Gamma	γ
Gigawatt-Hour	GW·h
Gram	g
Gram Per Centimeter Cubic	g/cm^3
Hertz	Hz
Hour	h
kcal/cm. Squared-Second	kcal/cm^2·s
kcal/Kilogram-Deg. Celsius	kcal/kg·^{o}C
kcal/Kilogram-Deg.Celsius	kcal/kg·^{o}C
kcal/Meter Cubic-Hour	kcal/m^3·h
kcal/Meter Squared-Hour	kcal/m^2·h
kcal/Meter Squared-Hour-Deg. C	kcal/m^2·h·℃
kcal/Meter-Hour-Deg.C	kcal/m·h·℃
Kg/Cm. Squared	kg/cm^2
Kg/Cm. Squared Absolute	kg/cm^{2}A
Kg/Cm. Squared Absolute Per Second	kg/cm^{2}A/s
Kg/Cm. Squared (Gauge)	kg/cm^{2}G
Kg/Cm. Squared (Gauge) Per Second	kg/cm^{2}G/s
Kiloampere	kA
Kilocalory	kcal
Kilocalory Per Hour	kcal/h
Kilocalory Per Hour-Meter	kcal/h·m
Kilocalory Per Kilogram	kcal/kg
Kilogram	kg
Kilogram Per Meter	kg/m
Kilogram Per Meter-Second	kg/m·s
Kilogram Per Second	kg/s
Kilogram-Meter Squared	kg·m^2

Physical Quantity	Abbreviation
Kilogrma Per Hour	kg/h
Kilovar	kvar
Kilovolt	kV
Kilowatt	kW
Kilowatt Per Liter	kW/L
Kilowatt Per Meter	kW/m
Kilowatt-Hour	kW·h
Liter	L
Liter Per Hour	L/h
Liter Per Minute	L/min
Liter Per Second	L/s
Megavar	Mvar
Megawatt	MW
Megawatt Per Meter	MW/m
Megawatt Per Minute	MW/min
Megawatt-Day Per Metric Ton	MW·d/t
Megawatt-Hour	MW·h
Meter	m
Meter Per Hour	m/h
Meter Per Second	m/s
Meter Squared	m^2
Meter Squared Per Second	m^2/s
Meter per Second Squared	m/s^2
Meter-Kilogram	m·kg
Microampere	μA
Microcurie Per Centimeter Cubic	$\mu Ci/cm^3$
MicroSimense per Centimeter	μS/cm
Micrometer	μm
Milliampere	mA
Millimeter	mm
Millirem Per Hour	mrem/h

Physical Quantity	Abbreviation
Milliroentgen Per Hour	mR/h
Minute	min
Neutron/Cm3-Cm./Second	$n/cm^2 \cdot s$
Ohm	Ω
Part Per Billion	ppb
Part Per Million	ppm
Paskal	Pa
Kilopaskal	kPa
Megapaskal	MPa
Percentage (Dimensionless)	%
Percentage (Dimensionless) Per Second	%/s
Percentage H_2O	$\%H_2O$
Rad	rad
Rem(roentgen equivalent in man)	rem
Revolution Per Minute	rpm
Revolution per Min/Min.	rpm/min
Second	s
Sievert	Sv
Sievert per Hour	Sv/h
Ton (Metric, Tonne)	t
Ton Per Hour	t/h
Volt	V
Volt AC(alternating current)	V AC and Vac
Volt DC(direct current)	V DC and Vdc
Volt-Ampere	V·A
Watt Per Centimeter	W/cm

APPENDIX A – Part 3
Table of System Mnemonics

System Mnemonic	System Description
AB	Boric Acid Processing System
AF	Auxiliary Feedwater System
AL	Acoustic Leak Monitoring System
AP	Auxiliary Power System
AS	Auxiliary Steam System
AT	Auxiliary Feedwater Pump Turbine System
AX	Auxiliary Feedwater Storage and Transfer System
BI	Bypassed And Inoperable Status Indication
CA	Condenser Vacuum System
CC	Component Cooling Water System
CD	Condensate System
CE	Control Element Drive Mechanism(CEDM) Control System
CF	Chemical Feed And Handling System
PC	Containment Isolation System
CL	Chlorination System
CM	Containment Monitoring System
CO	Carbon Dioxide System
CP	Condensate Polishing System
CQ	Communication System
CS	Containment Spray System
CT	Condensate Storage and Transfer System
CV	Chemical And Volume Control System
CW	Circulating Water System
DA	Alternate AC Diesel Generator System
DC	DC Distribution System
DE	Radioactive Drain System
DG	Emergency Diesel Generator System
DH	Decontamination Equipment System

System Mnemonic	System Description
DI	Display System
DM	Miscellaneous Building Drain System
DO	Diesel Fuel Oil Transfer System
DT	Turbine Generator Building Drain System
DV	Feedwater Heater Miscellaneous Drains And Vents
EA	Breathing Air System
EC	Excore Monitoring
ED	Non-Radioactive Equipment Vents and Drains System
EF	Engineered Safety Features Actuation System
EM	Seismic Monitoring System
ER	Emergency Response Facilities
ES	Extraction Steam System
FC	Spent Fuel Pool Cooling And Cleanup System
FD	Fire Detection And Alarm System
FE	Fuel Element System
FH	Fuel Handling And Transfer System
FO	Fuel Oil System
FP	Fire Protection System
FS	Fuel Storage System
FT	Feedwater Pump Turbine System
FW	Feedwater System
GA	Main Genertor And Aux System
GC	Generator Stator Cooling Water System
GD	Grounding System
GG	Generator Gas System
GP	Cathodic Protection System
GS	Turbine Grand Seal System
GW	Gaseous Radwaste System
HC	Hoists and Cranes System
HD	Heater Drains System

System Mnemonic	System Description
HG	Containment Hydrogen Control System
HM	H2 & Combustible Gas Monitoring System
HT	Heat Tracing System
HY	Hydrogen System
IA	Instrument Air System
IC	Incore Instrumentation System
IM	Inadequate Core Cooling Montoring
IW	In-Containment Water Storage System
LD	Leak Detection System
LL	Lighting System
LM	Loose Parts Montoring System
LN	Lighting Protection
LP	Large Display Panel System
LV	Low Voltage System
MB	Wall Mimic Board System
MD	Megawatt Demand Setter System
MI	Miscellanous System
MP	Main Power System
MS	Main Steam System
MV	Vibration Monitoring System
NB	4.16 Non-Class 1E System
NH	480 V Mcc & Low Voltage Non-Class 1E System
NI	NSSS Integrity Monitoring System
NR	Excore Neutron Flux Monitoring System
NT	Nitrogen System
OG	Off Gas (Including Hydrogen Recombiner) System
OT	Bearing Oil Transfer And Purification System
PA	I&C Equipment Room
PF	4.16 kV Class 1E System
PO	Process-Component Control System

System Mnemonic	System Description
PE	Engineered Safety Feature-Component Control System
PG	480 V Load Center Class 1E System
PH	480 V MCC & Low Voltage Class 1E
PI	Control Rod Position Indication
PL	Local Control Panels
PM	Main Control Room Console
PP	Post-Accident Monitoring System
PQ	Plant Security Facility System
PR	Radiation Monitoring System
PS	Process Sampling System
PX	Primary Sampling System
QN	Qualified Indication and Alarm System-Non Safety
RB	Reactor Power Cutback System
RC	Reactor Coolant System
RD	Control Rod Drive System
RG	Reactor Coolant Gas Vent System
RL	Reactor Vessel Level Monitoring System
RP	Reactor Protection System
RR	Reactor Regulating System
RS	Remote Shutdown
RT	Reactor Cavity Filtration System
RW	Radwaste Control Room
RY	Reactor Coolant Pressurizer System
SA	Service Air System
SC	Shutdown Cooling System
SD	Steam Generator Blowdown System
SG	Switchyard AC Power System
SH	KHNP's Office Building Hot Water Supply System
SI	Safety Injection/Shutdown Cooling System
SL	Switchyard DC Power

System Mnemonic	System Description
SP	Safety Depressurization System
SS	Automatic Generation Control System
ST	Sanitary Water Transfer System
SU	Sanitary Water Treatment System
SW	Travelling Screen And Screen Wash System
SX	Essential Service Water System
SY	Switchyard 400kV Power
TA	Main Turbine And Auxiliary System
TB	Hydrogen & Carbon Dioxide Control System
TI	Transmission Interface System
TL	Transmission Line System
TN	T/G I&C System
TO	Turbine Lube Oil System
TR	Waste Water Transfer System
TS	Turbine-Generator Supervisory System
TV	Closed Circuit Television
VB	Compound Building HVAC System
VC	Control Room HVAC System
VD	Emergency Diesel Generator Area HVAC System
VE	Electrical and I&C Equipment Areas HVAC System
VF	Fuel Handling Area HVAC System
VG	ESW Intake Structure/CCW HX Building HVAC System
VH	CW Intake Structure HVAC System
VJ	Cold Machine Shop HVAC System
VK	Auxiliary Building Controlled Area HVAC System
VN	Water/Wastewater Treatment and Chlorination Building HVAC System
VO	Auxiliary Buidling Clean Area HVAC System
VP	Reactor Containment Building HVAC System
VQ	Reactor Containment Building Purge System
VR	Low and Mediem Level Radioactive Waste Storage Building HVAC System

System Mnemonic	System Description
VS	Seawater Bypass Pumps House HVAC System
VT	Turbine Generator Building HVAC System
VU	Miscellaneous Building HVAC System
WB	Seawater Bypass System
WD	Domestic Water System
WH	Turbine Generator Building Open Cooling Water System
WI	Plant Chilled Water System
WL	Raw Water System
WM	Makeup Deminealizer System
WO	Essential Chilled Water System
WQ	Diesel Generator Radiator Cooling System
WT	Turbine Generator Building Closed Cooling Water System
WV	Liquid Radwaste System
WW	Wastewater Treatment System
WX	Solid Radwaste System
WY	Radioactive Laundry System
AN	Alarm System
AR	Area Radiation Monitoring System
CB	Containment Filtered Vent System
CN	Soft Control System
CR	CEA Calculator System
CU	Core Protection Calculator System
CX	Plant Monitoring System
CY	Information Process System
CZ	Computerized Procedure System
DN	Non-Class 1E Diesel Generator System
DP	Diverse Protection System
ET	Unit Aux. and Stand-by Aux. Transformers System
EW	Welder Outlets System
GM	Gas Stripper Effluent Radiation Monitoring System

System Mnemonic	System Description
GT	Gas Turbine Generator System
HF	Human Factors Engineering
HJ	Heated/Unheated Junction Thermocouple System
IL	On-off Control System
IP	Instrument Power System
IS	Plant Security System
IT	Incore Instrumentation System
LR	Local Rack System
MM	Meteorological Monitoring System
NC	NSSS Process Control System
NG	Local Rack System
NH	480V MCC & Low Voltage Non-class 1E System
NM	Dynamic Mock-up System
NP	13.8KV Power System
PB	Plant Protection System
PC	Containment Isolation System
PJ	Plant Control System
PN	NSSS Process Instrumentation System
PZ	Pressurizer Control System
QP	Qualified Indication & Alarm - P System
RA	Reactor Core System
RF	Reactor Cavity Flooding System
RH	RCP Shaft Speed Sensing System
RI	Reactor Internals System
RK	Reactor Trip Switchgear System
SB	Steam Bypass Control System
SM	Static Mock-up System
SU	Sanitary Water Treatment System
SZ	SWYD 154KV Power System
TC	Generator Shaft Seal Oil System
TG	Main Turbine Generator System
TH	Turbine Hydraulic Fluid System
TM	T/G Monitoring & Control System
VA	Auxiliary Building HVAC System

System Mnemonic	System Description
VI	Technical Support Center HVAC System
VM	Internal Vibration Monitoring System
VR	Low & Medium Radio-Active Storage Bldg HVAC System
VY	Emergency Core Cooling System Equipment Room HVAC System

APPENDIX B

GLOSSARY

Abbreviation – A shortened form of a word or phrase used for brevity.

Acronym – A word formed from the initial letter(s) of each of the successive or major parts of a compound term.

Advanced Alarm System – A primarily digital alarm system employing alarm processing logic and advanced control (e.g., on-screen controls) and display (e.g., VDU) technology. (This is in contrast to conventional alarm systems, which are largely based on analog instrument and control technologies.)

Alert – A signal that indicates a condition relating to the effective performance of duties. The condition or message requires the operator or maintainer to take immediate action.

Alphabetic – Pertaining to a character set that contains letters and other symbols, excluding numbers.

Alphanumeric – Pertaining to a character set that contains letters, digits, and usually other symbols, such as punctuation marks.

Alphanumeric Code – A set of letters and/or numbers used to identify a group of data (e.g., in a table).

Alphanumeric keyboard – A keyboard used for typing letters or numbers into the computer.

Analytical Redundancy – The calculation of expected parameter values using a model of system performance.

Anthropometry – A study and measurement of the physical dimensions of the human body

Arrow Buttons – A pair of buttons used to change a value by increments each time they are pressed. Often,

the button that produces an increase is marked with an upward arrow and the button that produces a decrease is marked with a downward arrow.

Audio – Pertaining to acoustic, mechanical, or electrical frequencies corresponding to normally audible sound waves.

Auditory – Pertaining to the sense of hearing.

Bar Chart (graph) – A graphic figure in which numeric quantities are represented by the linear extent of parallel lines (or bars). The length of the line (or bar) is proportional to the numbers represented. Bar charts are useful for comparing separate entities or showing a variable sampled at intervals.

Binary – (1) Pertaining to a characteristic or property involving a selection, choice, or condition in which there are two possibilities. (2) Pertaining to the number representation system with two values.

Brightness – Attribute of a visual sensation according to which an area appears to emit more or less light.

Brightness ratio – The ratio of the luminance of two areas or surfaces.

Button – A type of hardware control device or a defined control region on the display screen which, when selected, causes some action.

Caution Signal – A signal that alerts the operator to an impending condition requiring attention, but not necessarily immediate action (See warning signal).

Cascading Menu – A type of hierarchical menu in which a submenu is attached to the right side of a menu item. Cascading menus can be added to drop-down menus, pop-up menus, or even other cascading menus.

Character Set – A set of unique representations called characters; e.g., the 26 letters of the English alphabet, and the 128 characters of the ASCII alphabet.

Character Width – The horizontal distance between a character's origin (a point on the base line used as a reference location) and the next character's origin.

Character – A letter, digit, or other symbol that is used as part of the organization, control, or representation of data.

Circuit Breakers – Devices that protect equipment from excessive electrical current.

Circuit Packaging – A method for organizing equipment into modules in which all parts of a single circuit or logically related group of parts, and only that circuit or group, are placed in a separate module.

Coding – Use of a system of symbols, shapes, colors or other variable sensory stimuli to represent specific information. Coding may be used (a) for highlighting (i.e., to attract a user's attention to part of a display), (b) as a perceptual indicator of a data group, or (c) to symbolize a state or attribute of an object (e.g., to show a temperature level or for warning purposes).

Cognitive Error – A human error that results from the characteristics of human performance processing such as errors in diagnosis due to information overload.

Coherence Mapping – A map between the features in the representation and the physical and cognitive characteristics of the operator (how comprehensible the representation is to the operator).

Color – The aspect of objects or light sources that may be described in terms of hue, lightness (or brightness), and saturation.

Combo Box – A special type of text box with an attached list of options. Combo boxes allow the user to either select from the given list or type in an alternative response. These are two types of combo boxes, standard and drop-down.

Command Language – A type of dialogue in which a user composes entries, possibly with minimal prompting by the computer.

Computer-Based Procedure Systems – Systems that present plant procedures in computer-based rather than paper-based formats.

Computerized Operator Support Systems – Systems that use computer technology to support operators or maintenance personnel in situation assessment and response planning. They can monitor status and provide recommendations or warnings.

Configural Display – A display in which information dimensions are uniquely represented, but where new emergent properties are created from interactions between the dimensions. Configural display representations often use simple graphic forms, such as a polygon.

Contrast – Diversity of adjacent parts in color and intensity.

Contrast Ratio – The measured luminance at one point divided by the measured luminance at another, equal to Lt/Lb, (Ls-Lb)/Lb, or (1+Ls)/Lb, where
Lt = total luminance, or luminance of the image in the presence of background;
Ls = luminance of the symbol without background (luminance emitted by VDU in the case of VDU displays);
Lb = luminance of background.
Contrast ratio, rather than contrast, is often specified by display manufacturers because it is numerically larger (by one) than contrast.

Control Entry – User input for sequence control, such as function key activation, menu selection, command entry.

Darkboard – An alarm display in which the medium is dark (not illuminated) if all monitored plant parameters are in the normal range. Thus, an illuminated alarm-display device indicates a deviation from normal plant conditions. This is in contrast to many conventional alarm systems, which employ display devices to indicate both normal and abnormal changes in the plant's condition.

Data Entry – User input of data for storage in, and/or processing by, the system.

Decibel (dBA) – Sound level in decibels, measured using A-weighting. The use of A-weighting causes the frequency response of the sound level meter to mimic that of the human ear, i.e., response is maximum at about 2 kHz, less at very low or very high frequencies. A-weighted measurements correlate well with

measures of speech interference and judgments of loudness.

Demarcation – The technique of enclosing functional or selected groups of controls and displays with a contrasting line to emphasize their relatedness.

Density – (Screen Density) The amount of the display screen that contains information; often expressed as a percentage of the total area.

Description Error – An error of execution (slip) that involves performing the wrong set of well-practiced actions for the situation. Description errors occur when the information that activates or triggers the action is either ambiguous or undetected.

Diagram – A special form of a picture in which details are only shown if they are necessary to perform a task. For example, an electrical wiring diagram for a facility would show wiring but not necessarily furniture or plumbing.

Dialogue – A structured series of interchanges between a user and a computer. A dialogue can be initiated by a computer (e.g., question and answer) or by a user (e.g., command language).

Dimension – A scale or categorization along which data may vary, taking different values at different times.

Direct Manipulation – The user manipulates symbols in the display by directly interacting with the symbol. The direct manipulation is generally performed by using a display structure, such as a pointer, and a cursor control device, such as a mouse.

Display – A specific integrated, organized set of information. A display can be an integration of several display formats (such as a system mimic which includes bar charts, trend graphs, and data fields).

Display Device – The hardware used to present the display to users. Examples include video display units and speakers for system messages.

Display Element – A basic component used to make up display formats, such as abbreviations, labels, icons,

symbols, coding, and highlighting.

Display Format – The general class of information presentation. Examples of general classes are continuous text (such as a procedure display), mimics and piping and instrumentation diagram (P&ID) displays, trend graphs, and flowcharts.

Display Network – A group of display pages within an information system and their organizational structure.

Display Page – A defined set of information that is intended to be displayed as a single unit. Typical nuclear power plant display pages may combine several different formats on a single VDU screen, such as putting bar charts and digital displays in a graphic P&ID format. Display pages typically have a label and designation within the computer system so they can be assessed by operators as a single "display."

Display Selection – Refers to the specification of data outputs, either by a user or automatically.

Display Structure – Functional or information-presenting aspects of a display that are consistent in appearance and use across applications, e.g., providing reference to the user's location in an information system and display of control options available.

Emergent Feature – A high-level, global perceptual feature produced by the interactions among individual parts or graphical elements of a display (e.g., lines, contours, and shapes).

Fault-Tolerant Digital Control Systems – Digital systems with redundant processors that use fault diagnostic routines that can detect single faults and isolate the failed equipment. This ensures that the equipment that is still operational takes over the control function.

Field – An area of the display screen reserved for the display of data or for user entry of a data item. In a database, a specified area used for a particular category of data, for example, equipment operational status.

Field Label – A displayed word or phrase that identifies the data display or entry field.

Flowchart – A diagram that illustrates sequential relations among elements or events. Flowcharts are often

shown as boxes connected by arrows.

Form – A dialogue technique that presents category labels and requires the user to fill in the blanks. A formatted output to the user with blank spaces for inserting required or requested information.

Format – The arrangement of data.

Formatting – The process or act of arranging data.

Frequency Modulation – Sinusoidal variation of the frequency of a tone around a center frequency.

Frequency – Rate of signal oscillation in cycles per second (Hz or Hertz).

Function – (1) A software supported capability provided to a user to aid in performing a task. (2) A process or activity that is required to achieve a desired goal; see, e.g., safety function.

Glare – A consequence of bright light sources in the visual field that cause discomfort and/or a decrease in visual functioning. The effect is worse the closer the light source is to the line of gaze.

Glare by Reflection – Glare produced by reflections, particularly when reflected images appear in the same or nearly the same direction as the object viewed.

Gloss – The extent to which light incident on a surface at angle x is reflected from that surface at angle –x (minus x) relative to a line perpendicular to the surface. A mirror has maximum gloss.

Gloss Instrument – A device that measures reflected light as a function of illumination and angle of view. The angle for which gloss is measured is typically 60 degrees.

Graph – A display that represents the variation of a variable in comparison with that of one or more other variables.

Graphic Element – A component part of a graphic display, such as a line, a circle, or a scale.

Graphical Display – A display that provides a pictorial representation of an object or a set of data. Graphical displays include line, solid object, and perspective drawings; bar, pie, and line charts and graphs; scatterplots; displayed meters; flowcharts and schematic diagrams.

Graphics – Data specially formatted to show spatial, temporal, or other relations among data sets.

Grid – A network of uniformly spaced horizontal and vertical lines for locating points by means of coordinates.

Highlight – A means of directing the user's attention to a feature of the display. Highlighting methods include image reversal (reverse video), brightness/boldness contrast, color, underlining, blinking, flashing arrows, and changes in font. Emphasizing displayed data or format features in some way, e.g., by using underlining, bold, or inverse video.

Histogram – A type of bar chart used to depict the frequency distribution for a continuous variable. The variable may be grouped into classes.

Icon – Pictorial, pictographic, or other nonverbal representation of objects or actions.

Identification – A code number or code name that uniquely identifies a record, block, tile, or other unit of information.

Identifier – A symbol whose purpose is to identify, indicate or name a body of data.

Illuminance – The luminous flux incident on a surface, measured in lumens per square meter (lux) or in Footcandles (fc).

Illumination – The amount of light falling on a surface.

Instrument Cabinets and Racks – Enclosures that hold modules, components, and parts. They typically have access doors or removable panels for access to their contents.

Integral Display – A display that depicts the integration of information in such a way that the individual parameters used to generate the display are not explicitly represented in it.

Interrupt – Stopping an ongoing transaction to redirect the course of the processing. Examples of interrupt options are BACKUP, CANCEL, RESTART.

Input Field – The area in a display that is used to enter input. For example, a soft control may have an area in which operators can enter numerical data to adjust control setpoints or commands to execute actions.

Interlock – A feature that requires operator actions to proceed in a specific sequence. For example, action B must be performed after action A, and action C after action B.

Justification – The act of adjusting, arranging, or shifting digits to the left, right, or center to fit a prescribed pattern.

Label – Descriptor that is distinguishable from, and helps to identify, displayed screen structures or components.

Labeling and Marking – The use of labels and demarcations to identify units of equipment, modules, components, and parts.

Layout – The physical arrangement of the parts and components that make up a module or a unit of equipment.

Legend – (1) The textual content of a continuously present, spatially dedicated alarm display. (2) An explanatory list of symbols or highlighting used on a graph, chart, diagram, or map.

Legibility – The quality of a display that allows groups of characters and symbols to be easily discriminated and recognized.

Lightness – Brightness of an area judged relative to the brightness of similarly illuminated area that appears to be white or highly transmitting.

Line of Sight – The optical axis extending from the observers eyes to the target viewed.

Lockin – A feature that keeps an ongoing operation active by preventing personnel actions from terminating it prematurely.

Lockout – A feature that prevents personnel from providing input that may have negative effects. Statically defined lockouts may restrict operators' inputs to a specific, predefined range or set of values. Context-sensitive lockouts may restrict input values based on the current situation.

Luminance – The luminous intensity per unit projected area of a given surface as viewed from a given direction. Measured in candelas per square meter or footlamberts.

Menu – A type of dialogue in which a user selects one item out of a list of displayed alternatives. Selection may be made by actions such as pointing and clicking and by depressing an adjacent function key.

Menu bar – A specialized function area that displays categories of alternatives of user responses.

Metaphor – Use of concepts and properties which are already familiar to the user and form which the user can predict function, behavior and organizational structure of the system.

Mimic – A display format combining graphics and alphanumerics used to integrate system components into functionally oriented diagrams that reflect the components' relationships.

Mistake – An error in intention formation, such as forming one that is not appropriate to the situation. Mistakes are related to incorrectly assessing the situation or inadequately planning a response.

Mode Error – Performing an operation that is appropriate for one mode when the device is in another mode. Mode errors occur when the user believes the device is in one mode when it is in another one.

Numeric – Pertaining to numerals or to representation by means of numerals.

Object Display – A type of integral display that uses a geometric object to represent parameter values graphically, but where the individual information dimensions or data contributing to the object are not displayed.

Parameter – (1) A power-conversion process variable or quantity that can assume any of a given set of physically feasible values. Plant parameters are typically measures of the performance of systems and processes of the plant, e.g., the parameter 'T-hot' is a measure of the temperature of reactor coolant that has passed through the reactor core. (2) A variable that is measured.

Pie Charts – A circle divided into sections (as pieces of a pie) to represent graphically the relative proportions of different parts of a whole. A circular chart cut by radii into segments illustrating magnitudes or frequencies.

Pop-up Menu – A menu whose items are normally "hidden" from the user's view until they are activated or brought into full view by a complete selection action. Pop-up menus remain visible until the user takes another action to hide the menu or make a selection.

Prompting – The process or act of assisting by suggestion.

Pull-down Menu – A menu whose items are normally hidden from the users view and accessed by the user holding the selection button down over the desired menu-bar label.

Radio Buttons – Single, two-state choices, which are mutually exclusive from each other.

Reflash – A method of alarm presentation that can be implemented any time an alarm condition is based on input from more than one plant parameter. Reflash causes an alarm display to re-enter the new alarm state when an associated plant parameter reaches its setpoint. The alarm display cannot return to normal until all related parameters return to their normal ranges.

Reflectance – The ratio of reflected light to incident light.

Ringback – An alarm display feature that provides a distinct cue such as a slow flash or audible tone to

indicate that an alarm condition has cleared, i.e., the monitored parameter(s) has returned to its normal range.

Scale – A graduated series or scheme of rank or order.

Scaling – The positioning of displayed data elements with respect to a defined measurement standard.

Scatterplot – A scaled graph that shows relations among individual data points in a two- dimensional array.

Scrolling Menu – A menu usually containing many options that does not display all of the options at once. It includes a scroll-bar that permits the sequential display of all options. Scrolling menus are also called list boxes and scrolling lists.

Slip – An error in carrying out an intention. Slips result from "automatic" human behavior, when schemas, in the form of subconscious actions that are intended to accomplish the intention, get waylaid en route to execution. Thus, while one action is intended, another is accomplished. An expert's highly practiced behavior leads to the lack of focused attention that increases the likelihood of some forms of slips.

Soft Control – A control device that has connections with the control or display system mediated by software rather than direct physical connections. As a result, the functions of a soft control may be variable and context-dependent rather than statically defined. Also, the location of a soft control may be virtual (e.g., within the display system structure) rather than spatially dedicated. Soft controls include devices activated from display devices (e.g., buttons and sliders on touch screens), multi-function control devices (e.g., knobs, buttons, keyboard keys, and switches that perform different functions depending upon the current condition of the plant, the control system, or the human-system interface), and devices activated via voice input.

Spacing – The distance between any two objects.

Spatially Focused, Variable Location, Serial Display – A display where alarms are presented in no fixed location and according to some logic, such as time or priority. Usually, the same display device can be used to present many different alarms (in contrast with SDCV display where a given location presents only one alarm). A scrolling message list is an example of this type of display.

Spatially Dedicated, Continuously Visible (SDCV) Alarm Display – An alarm display that is in a spatially dedicated position and is always visible whether in an alarmed or cleared state. Conventional alarm tiles are an example of an SDCV alarm display.

Speech Display – Speech messages (either computer-generated or a recorded human voice) presented through audio devices, such as speakers and headsets.

Split Bar – The divider placed across the middle of the window that separates the panes.

Split Box – A rectangular indicator located inside the scroll-bar of a split window or immediately above the scroll-bar of a split-able window.

String – A linear sequence of entities such as characters or physical elements.

Stroke Width – The width of a line comprising a character.

Symbol – A representation of something by reason of relationship, association, or convention.

Table – A rows and columns structure consisting of functional areas that contain data and that may or may not require input. Tables may be used to present a variety of types of information. A collection of data in a form suitable for ready reference.

Tear-off Menu – A menu that can be removed from the menu bar and moved to another location on the screen where it can remain on display. Tear-off menu are also called “tracked” or “pushpin” menus.

Text – The primary display for word processing consists of alphanumeric character strings in linear arrays, making up words, sentences, and paragraphs. The main body of printed or written matter on a page or in a message.

Text Box – Edit controls into which the user types information. Most text boxes are one line tall, but message.

Text Entry – Initial entry and subsequent editing of textual data.

Tile – A type of spatially dedicated, continuously visible alarm-display that changes state (i.e., brightness, color, and/or flash rate) to indicate the presence or absence of an alarm condition, and includes text to identify the nature of the alarm state.

Transaction – An action by a user followed by a response from the computer. Transaction is used here to represent the smallest functional unit of user-system interaction.

Variable – A quantity that can assume any of the given set of values.

Video Display Unit – An electronic device for the display of visual information in the form of text and/or graphics. Typically abbreviated VDU.

Vigilance – The degree to which an operator is alert.

Visual Angle – A measure, in degrees, of the size of the retinal image subtended by a viewed object. It represents the apparent size of an object based on the relationship between an object's distance from the viewer and its size (perpendicular to the viewer's line of sight). An object of constant size will subtend a smaller visual angle as it is moved farther from the viewer. Visual angle is typically defined in terms of minutes of visual arc.

Warning Signal – A signal that alerts the operator to a condition requiring immediate action (see caution signal).

Word – A character string or a bit string considered as an entity.