

技術報告書

HF-010

Draft Revision of Human Factors Guideline HF-010

KAERI

2002

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2003. 5.

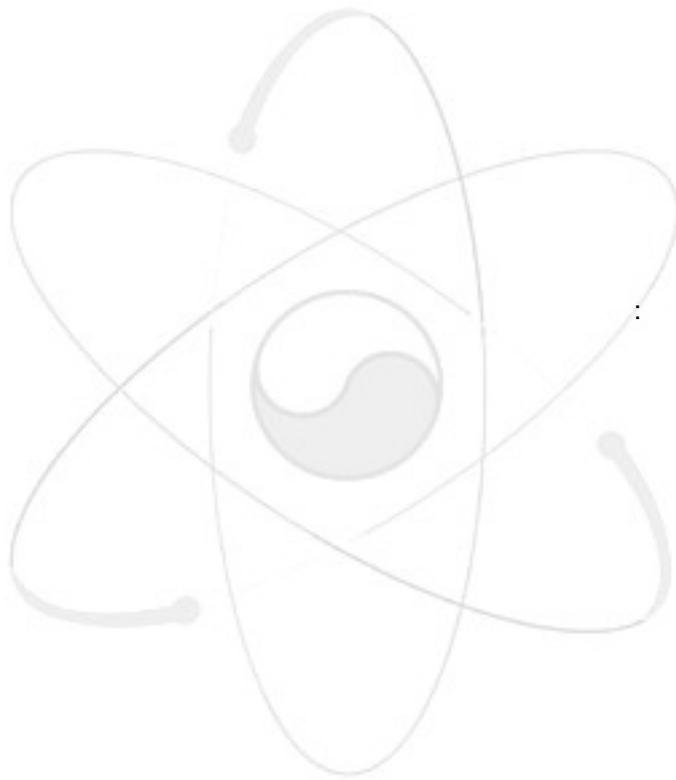
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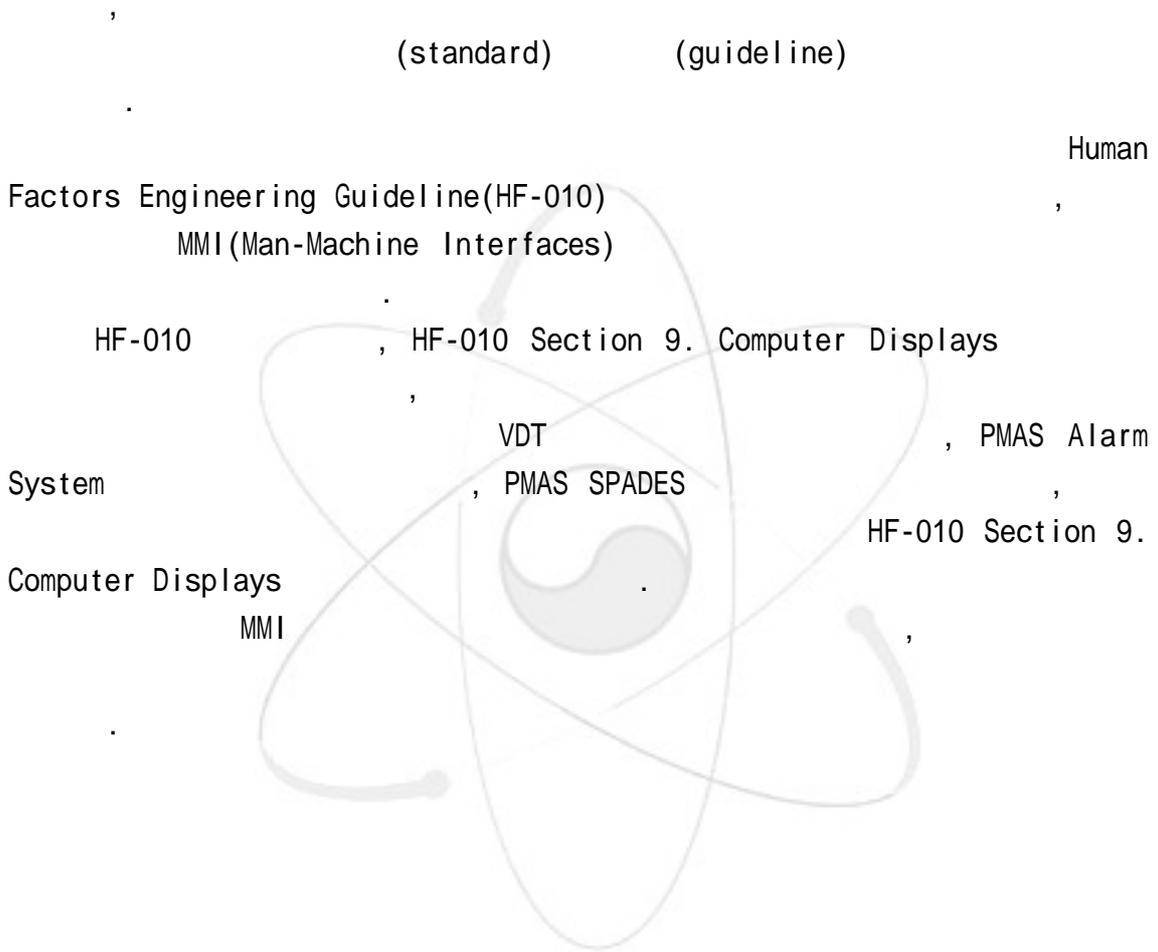
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(Man-Machine Interfaces System, MMIS)



SUMMARY

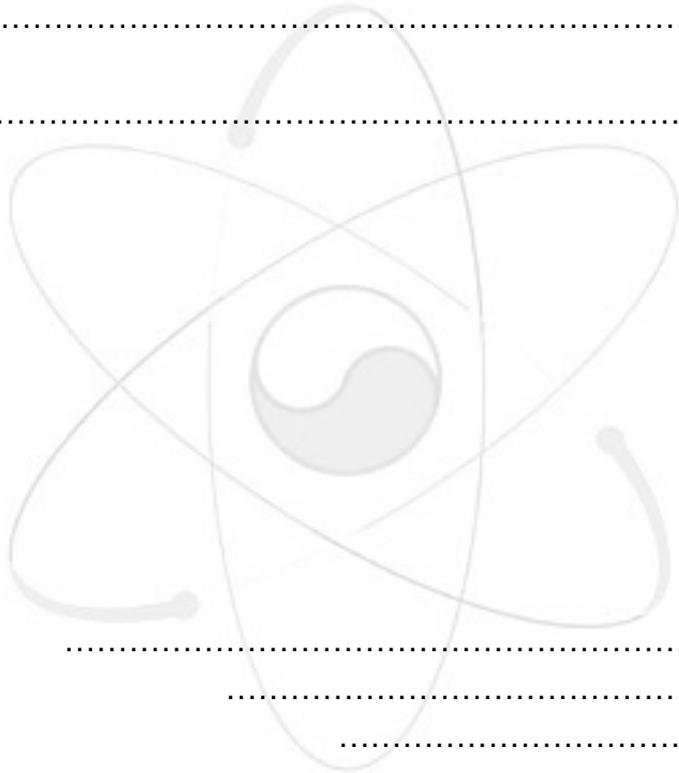
The Application of Human Factors to the design of Man-Machine Interfaces System(MMIS) in the nuclear power plant is essential to the safety and productivity of the nuclear power plants, human factors standards and guidelines as well as human factors analysis methods and experiments are weightily used to the design application.

A Korean engineering company has developed a human factors engineering guideline, so-call HF-010, and has used it for human factors design, however the revision of HF-010 is necessary owing to lack of the contents related to the advanced MMI(Man-Machine Interfaces).

As the results of the reviews of HF-010, it is found out that the revision of Section 9. Computer Displays of HF-010 is urgent, thus the revision was drafted on the basis of integrated human factors design guidelines for VDT, human factors design guidelines for PMAS SPADES display, human factors design guidelines for PMAS alarm display, and human factors design guidelines for electronic displays developed by the surveillance and operation support project of KNICS.

The draft revision of HF-010 Section 9 proposed in this report can be utilized for the human factors design of the advanced MMI, and the high practical usability of the draft can be kept up through the continuous revision according to the advancement of digital technology.

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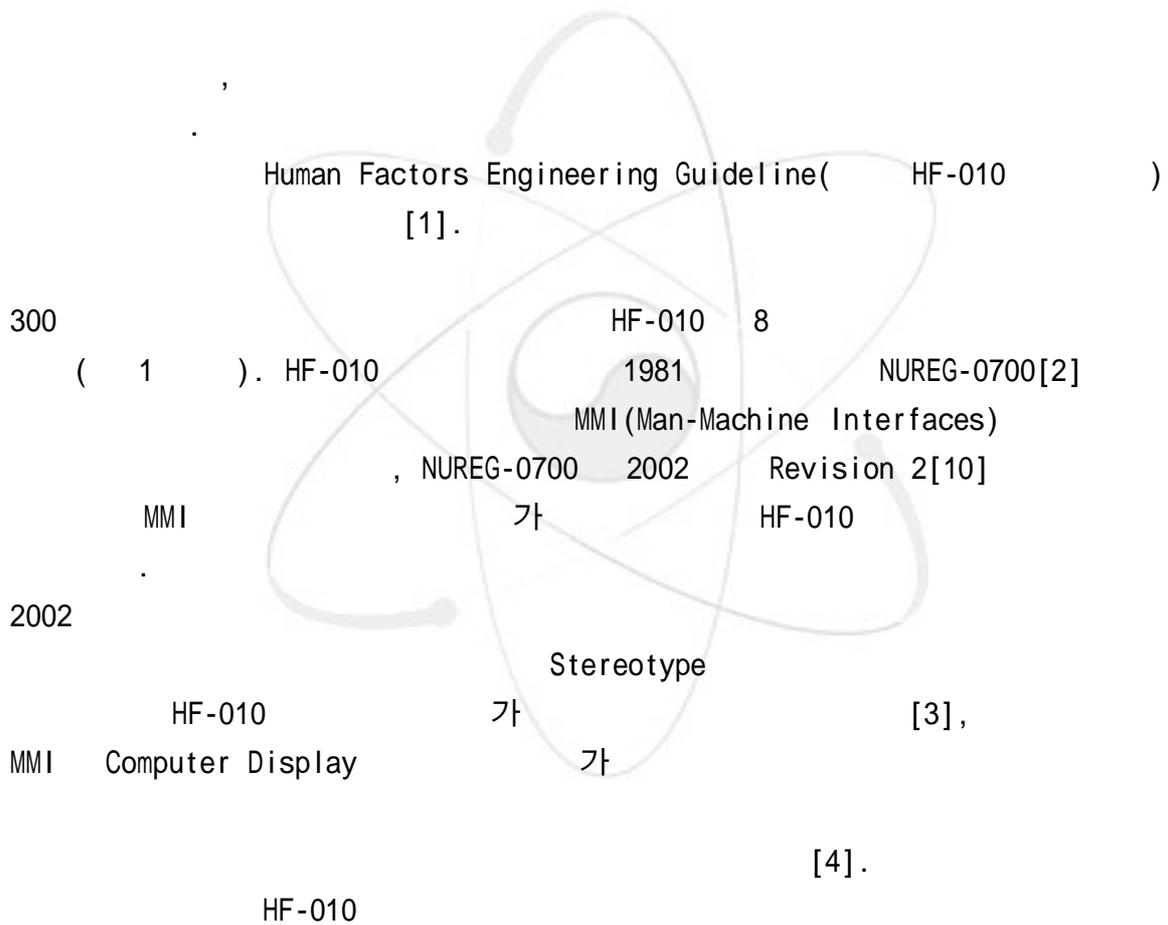


1.

(Man-Machine Interfaces System, MMIS)

(standard)

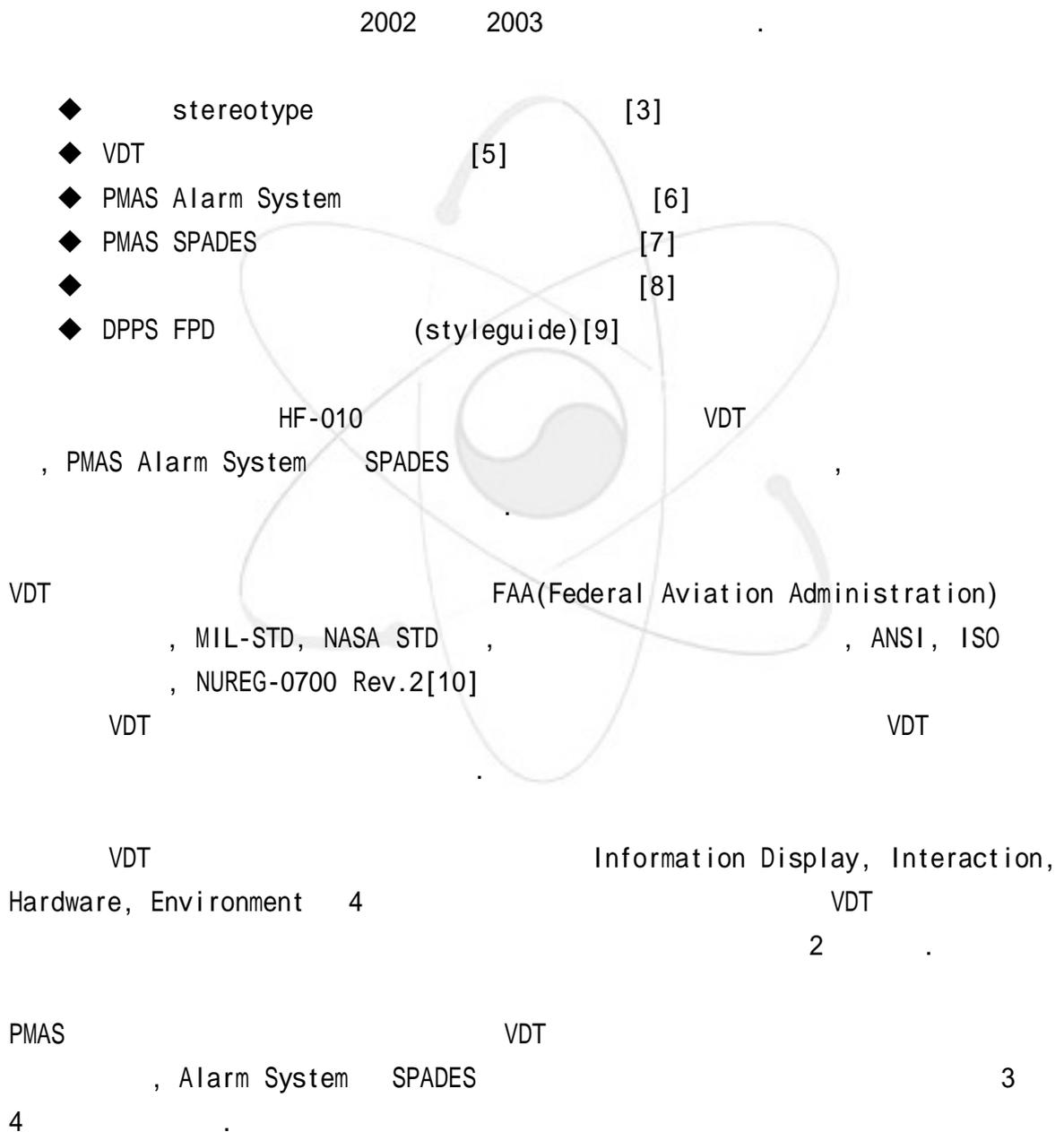
(guideline)



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2.1	WRITTEN SIMILARITY	7.2	LETTERING AND WORDING
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4	CONTROL ROOM WORKSPACE	9.1	DISPLAY FORMAT
4.1	COMMUNICATIONS SYSTEM	9.2	USE OF GRAPHS
4.2	STORAGE SPACE	9.3	COLOR
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5	ANNUNCIATORS	9.5	HARDWARE
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5.10	ALARM PROCEDURES	10.3	LABEL MATERIAL
5.11	OUT-OF-SERVICE (OOS) AND BLANK WINDOWS	10.4	ATTACHMENT
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2.1



2. VDT

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1.2.	SPADES
1.3.	
1.4.	
2.	
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2.2	L2-
2.3	L3- P&ID
2.4	L3- P&ID
3.	
4.	Guideline

5.

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NUREG-0700 1981 Revision 1 Revision 2[10]
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, Hardware and Environment

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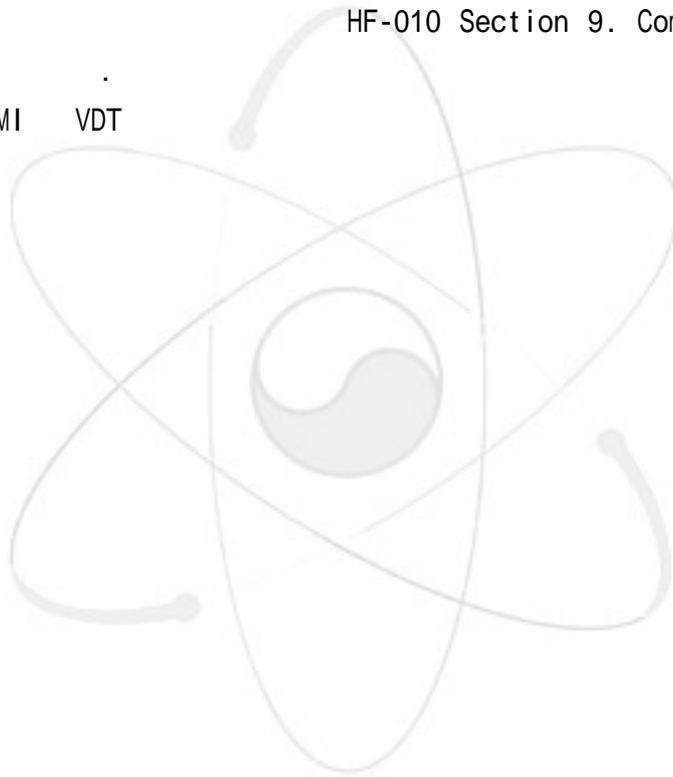
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MMI

VDT , PMAS Alarm System
, PMAS SPADES ,

HF-010 Section 9. Computer Displays

MMI VDT



- [1] KOPEC, Human Factors Engineering Guideline, HF-010.
- [2] NRC, Guidelines for Control Room Design Reviews, NUREG-0700, 1981.
- [3] KAERI, Stereotype, KAERI/TR-2388/2003, 2003.
- [4] KAERI, , 2003 3 .
- [5] KAERI, VDU , , 2003.
- [6] KAERI, PMAS , , 2003.
- [7] KAERI, PMAS SPADES , , 2003.
- [8] KAERI, , , 2003.
- [9] KAERI, DPPS FPD 가 , , 2003.
- [10] NRC, Human System Interface Design Review Guidelines, NUREG-0700 Rev.2, 2002.

A. VDT

HF-010 NUREG-0700 Rev.2

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[1. Information Display]

1.1.8 Unique Assignment of Color Codes

* HF-010 (1)

* NUREG0700 (1)

1.2.7.3 Area Coding

* HF-010 (1)

* NUREG0700 (1)

1.2.7.5 Display Range Coding

* HF-010 (1)

* NUREG0700 (1)

1.3.1.1 Between-Character Spacing

* HF-010 (1)

* NUREG0700 (1)

1.3.1.14 Character Height-to-Width Ratio

* HF-010 (1)

* NUREG0700 (1)

1.3.1.15 Character Stroke Width-to-Height Ratio

* HF-010 (1)

* NUREG0700 (1)

1.3.5 Numeric Data

* HF-010 (2)

* NUREG0700 (8)

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* HF-010 (2)

* NUREG0700 (4)

1.3.9.3 Lines and curves

* HF-010 (2)

* NUREG0700 (11)

1.3.9.6 Bar charts and histograms

* HF-010 (1)

* NUREG0700 (10)

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* HF-010 (1)

* NUREG0700 (2)

1.4.6 Numeric and date/time format

* HF-010 (1)

* NUREG0700 (8)

1.6.1.1 Title bar and title

* HF-010 (1)

* NUREG0700 (3)

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* HF-010 (1)

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- * NUREG0700 (3)

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- * NUREG0700 (27)

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- * HF-010 (4)
- * NUREG0700 (3)

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- * HF-010 (1)
- * NUREG0700 (4)

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- * HF-010 (1)
- * NUREG0700 (4)

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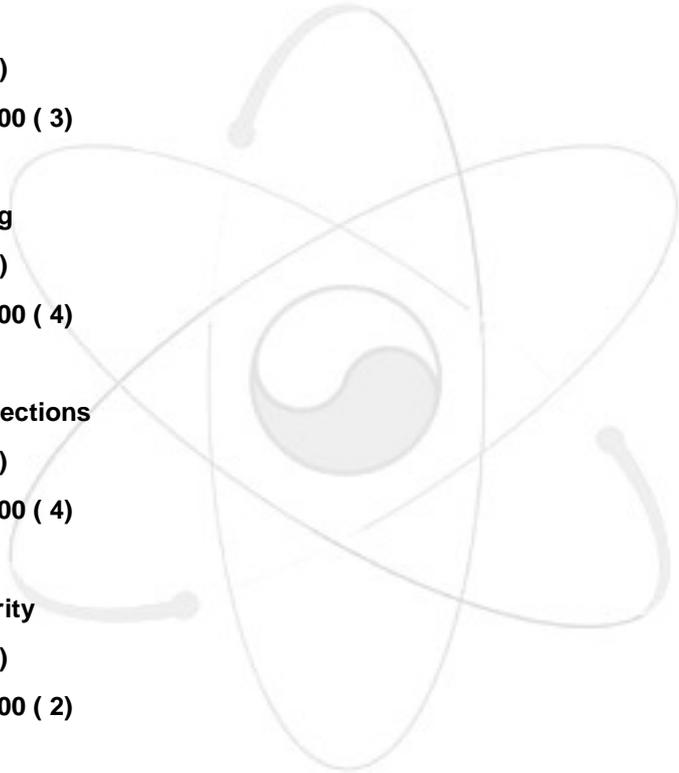
- * HF-010 (1)
- * NUREG0700 (2)

3.1.5.3 Display Information Consistent with User Conventions

- * HF-010 (4)
- * NUREG0700 (4)

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- * HF-010 (1)
- * NUREG0700 (7)



3.2.4.2.3 Legend Pushbuttons

- * HF-010 (5)
- * NUREG0700 (5)

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- * NUREG0700 (1)

4.1.1.2.2 Air Velocity

- * HF-010 (1)
- * NUREG0700 (1)

4.1.1.3.4 Task Area Luminance Ratios

- * HF-010 (1)
- * NUREG0700 (1)

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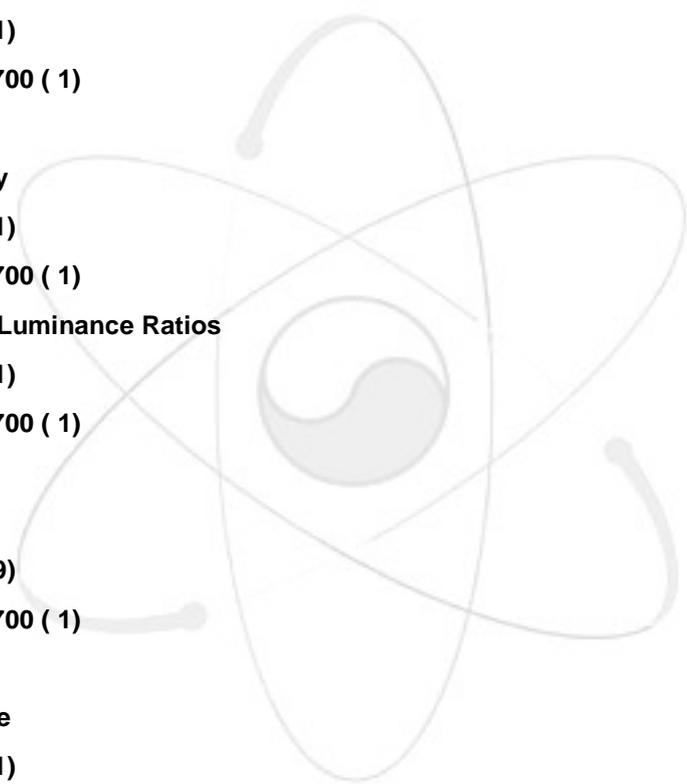
- * HF-010 (9)
- * NUREG0700 (1)

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- * HF-010 (1)
- * NUREG0700 (2)

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- * HF-010 (6)
- * NUREG0700 (1)



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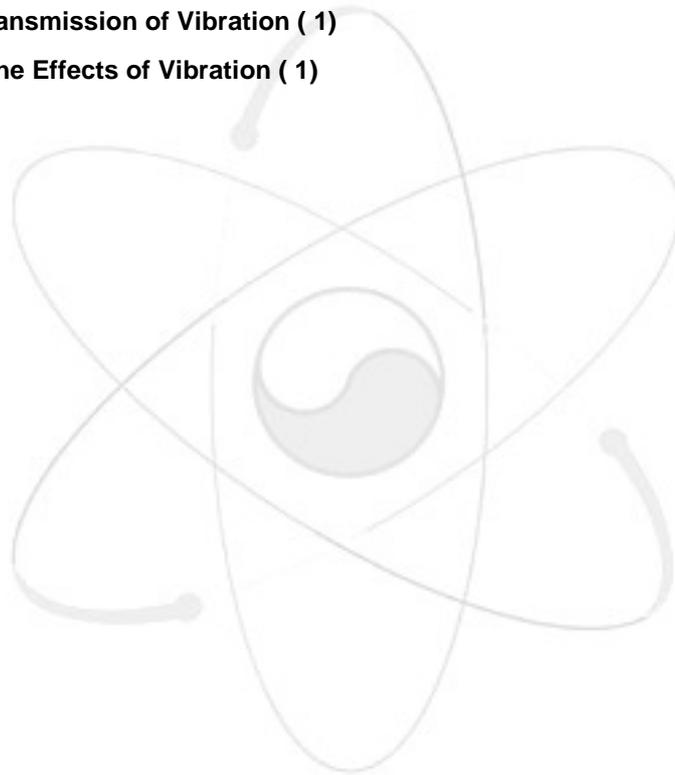
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B. HF-010

9. COMPUTER DISPLAYS

9.1 INFORMATION DISPLAY

General Principle - Computer displays shall be designed for clarity, rapid error-free interpretation, and accurate presentation of information. Computer displays which are designed to perform control functions should comply with the guidelines of section 9 as much as practical. Computer hardware shall be designed to support this principle.

9.1.1 Display Format

Date, time, and page number except MENU page should appear on all displays which are supported by vertical and horizontal paging. This information may be deleted from other displays where it would add undue clutter

All displays should contain a clear title in double-height characters, located centered at the top of each page or another prominent method of identifying the display should be used.

All CRT displays shall use format, units and limits (scale range) that correspond to control board instrumentation and control.

To avoid "BUSY" screens, data should not change more often than 1 time a second and rapidly oscillating data shall be smoothed out.

9.1.2 Color

9.1.2.1 Foreground/background

A uniform nondistracting background color should be used with a hue/contrast that allows the data (foreground) to be easily visible and

which does not distort or interfere with the coding aspects of the display.

9.1.2.2 Color selection

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

Dominant wavelengths above 650 nanometers in displays should be avoided.

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

9.1.3 Coding

9.1.3.1 Color Coding

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

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

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

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

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

The following CRT colors and associations are recommended. Other color schemes compatible with MCB indicator, annunciator and demarcation colors may be used provided it can be demonstrated by the supplier that the standards of NUREG-0700 are met.

Red : On - Energized - Use to indicate status of plant components in graphic displays.

Yellow : Caution Alarm - Good attention getter - Use for priority 2 CRT alarms
(Amber)

Green : An easily visible but non-attention getting color. Use for displaying bars on charts, scale numbers, normal parameters.

Off : Deenergized - Use to indicate status of plant components in graphic displays.

Black : Use as the background color. May be used as the character color when reverse video (negative imaging) is used.

White : Another easily visible but non-attention getting color. Use white for alphanumeric data, titles, normal analog values, and page numberings, as well as menus, scale tics and X-Y lines.

Cyan : (Light Blue) - Looks similar to white. Use cyan for demarcation lines, status message and error messages.

Blue : Poor contrast - Limit use to advisory messages, graph scale lines and demarcation (Dark) lines.

Magenta : Good attention getting color but harsh to the eye. Use for radiation displays and stand-out items such as interrupt messages and priority 1 alarms.

Orange : A good attention getting color - Use for paging messages,

titles, and interrupt messages.

Dim White : A non-attention getting color. Use for non-essentials and demarcation lines.

When using other than these color screens described above colors must be readily discriminable. Some options for more colors are light and dark green, light brown, light and dark red, and pink.

9.1.3.2 Brightness/intensity coding

Coding by differences in brightness should be used for applications that require discrimination between only two categories of displayed items on a VDU and up to three on a transilluminated display.

The bright state should be at least 100 percent brighter than the normal state.

9.1.3.3 Symbol coding

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.

Symbol coding may be used to enhance information assimilation from data displays. Symbols shall be analogs of the event or system element they represent or be in general use and well known to the expected users. Where size difference between symbols is employed, the major dimensions of the larger shall be not less than 150% of the major dimension of the smaller. Not more than three size levels shall be used.

Graphic symbols should be readily understood, commonly used and should be consistent with or based upon standard P&ID symbols as much as is practical.

9.1.3.4 Spatial coding

Spatial coding should be used to give meaning to an item of information such as to identify it as a menu item, or to indicate title pages, information fields, alarms, and active and static display areas.

Standard information fields (such as the title, message area, location of labels for hard-wired multi-function keys, etc.) that are repeated on a set of displays should be placed in the same location on all of the displays.

9.1.3.5 Multidimensional coding

Coding dimensions may be combined when multiple meanings are appropriate. For example, a red object combined with blinking may combine the meanings “exceeds setpoint” and “attention urgently required.”

9.1.3.6 Format Coding

Line coding should be used consistently across graphs.

Lines can be used to aid in focusing the user's attention on related information or to separate unrelated groupings of information. Line borders delineate the boundaries of menu bars, display control options, and entire windows. Lines can be coded by such attributes as width or thickness, color, and pattern (e.g., solid, dashed, and dotted).

When the orientation of a line is used to code direction or value, contextual information should also be provided.

The maximum number of widths for linewidth coding should be three.

Major display sections (for data display) should use one or two pixel wide demarcation lines for separation, or other methods such as spacing

allowing easy discerning of separation of display sections.

9.1.3.7 Size and Pattern Coding

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

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

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.

9.1.3.8 Highlighting

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.

Blinking (flashing) displays can be used for transition to computer alarm state (and suppressed when acknowledged) and for graphic displays where plant parameters exceed the setpoint and are shown out of bounds. Blink rates for these should not detract from readability.

No more than two flash rates should be used.

When flash coding must be used on text, the flash rate should be 1/3 Hz to 1Hz with an on/off cycle of 70%.

9.1.3.9 Auditory Coding

Auditory signals should be provided to alert the user to situations that require attention, such as an incorrect input action or a failure of the HSI to process an input from the user.

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.

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

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

9.1.3.10 Text 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.

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.

Codes such as bold, italics, and underline should not be used to identify selection points if other conventional uses of these codes in the text, such as to emphasize certain words, is likely to confuse the user.

Paragraphs of text shall be separated by one blank line and be left justified.

9.1.4 Characters

Messages shall be concise but complete. Lettering shall be easily discriminable and readable.

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

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

For a given font, it should be possible to clearly distinguish between the following characters: X and K, T and Y, I and L, I and 1, 0 and Q, 0 and O, S and 5, and U and V.

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

Character height should subtend a visual angle of 15 minutes (viewing distance multiplied by 0.004) as a minimum; a visual angle of 20 minutes (viewing distance multiplied by 0.006) is preferred.

Characters used on labels should be sized to take into account viewing distances and illumination conditions.

Letter width-to-height ratio should be between 1:1 and 3:5. Numeral width-to-height ratio should be 3:5 except for the numeral "4," which should be one stroke width wider, and the numeral "1," which should be one stroke in width.

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

A minimum of two stroke widths or 15 percent of character height, whichever is greater, should be used for spacing between lines of text. Stroke width to character height ratio should be between 1:5 and 1:10.

9.1.5 Abbreviations and Acronyms

Abbreviations and acronyms should be used consistently and limited to those well known to the users.

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

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

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

Abbreviations and acronyms should not include punctuation.

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.

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

9.1.6 Labels

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

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

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.

Labels should be meaningful words or accepted technical terms.

Label formats should be consistent across and within displays.

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

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

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

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

9.1.7 Icons and Symbols

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

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

Icons should be accompanied by a text label.

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

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

Icons should be simple, closed figures when possible.

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

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

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

Icons and symbols should always be oriented 'upright.'

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

9.1.8 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.

Numeric values should ordinarily be displayed in the decimal number system.

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

9.1.9 Borders, Lines, and Arrows

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.

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.

Unnecessary borders should not be used in the display.

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

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

Graphic lines should have a minimum density of 40 pixels per inch.

9.1.10 Graphs

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

Scales and Units - Graphs on computer generated displays should use the same scales and units that operators are familiar with from MCR instrumentation and plant procedures.

The dependent variable should be on a consistent graph axis.

Bar charts should be used only when the operator can clearly and rapidly interpret them. All bars should be a minimum of 10 pixels wide to facilitate this. Color coding on bar charts should be used as delineated in the color section.

Wherever operationally feasible, small fluctuations shall be removed from limit lines and values for graphs and the limit lines made linear

(straight).

9.1.11 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.

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

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

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

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

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.

Subclassifications in hierarchical lists should be indented by three (3) spaces with each new level of nesting

9.1.12 Tables

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

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

Labels should include the unit of measure for the data in the table; units of measurement should be part of row or column labels.

Units should be included in column or row headings, not after every data entry (for tabular data).

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.

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.

9.1.13 Windows

Windows should be identified by a label consistently located at the top of the window's border.

The scroll motion rate should allow the user to scroll by line or by display unit.

ROLL and SCROLL commands should refer to the display window, not the text/data.

Additional Information: The display window should appear to the user to be an aperture moving over stationary text.

The user should have the ability to scroll through the contents of a window both horizontally and vertically.

Window types should be perceptually distinct.

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

The action that opens a window should automatically make that window active.

A temporary window object should not obscure critical control information and command entry interfaces of the active window.

Under normal operating conditions, active windows should be front most on the display.

User control of windows should operate consistently from one display to another for each type of window.

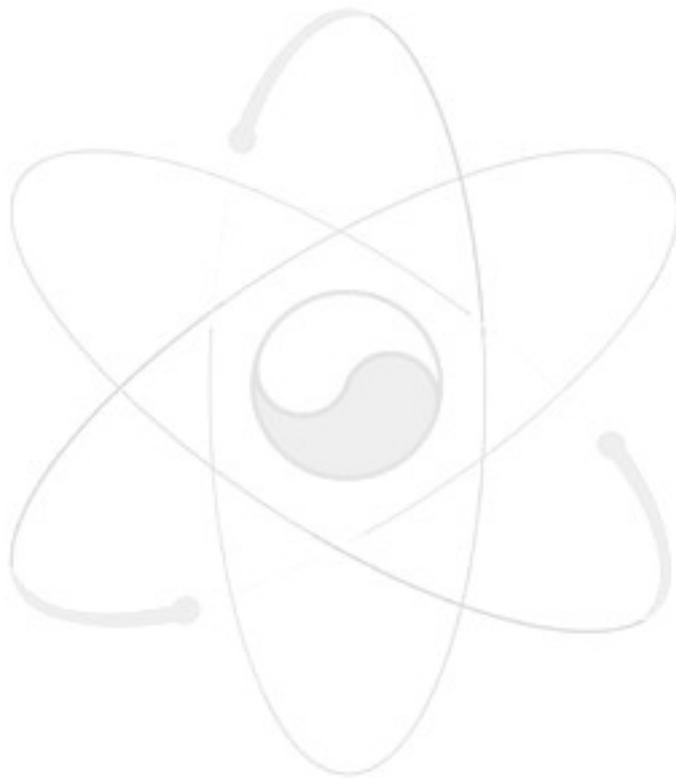
As appropriate to the user task, windows should be capable of the following operations: scrolling/panning, resizing, moving, hiding, activating, deactivating, copying to/from, zooming in/out, tabbing, and undo-last.

When control actions such as command entry may be taken by a user working within a window, those control actions should be consistent from one window to another.

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

When multiple windows are open simultaneously, the user should have the capability to easily tile, layer, or sequentially view the windows.

Automatically updated windows should have display freeze capability.



9.2 INTERACTION

9.2.1 Controls

Screen control locations and control options shall be clearly and appropriately indicated.

Icons may be used to represent operations, processes, and data structures graphically, and they may be used as a means of exercising control over system functions, components, and data structures.

Input and control devices provided for interacting with the HCI should be appropriate for the user's task requirements.

Designers should display fewer than 20 icons simultaneously on the same screen.

A push button shall have either a text or graphic label.

To ensure that the user knows that a pushbutton has been pressed far enough for activation, a positive indication should be provided.

Radio buttons shall be used if it is required that one and only one of a set of mutually exclusive options be selected.

Check boxes shall be provided if a user must be able to select any number including none of a set of options.

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.

A graphic control allows for a simple interpretation of what the control represents and how it works. Specially designed graphics maintain this idea with each graphic being unique in appearance and function.

A specialized graphic clearly represents an actual physical object and is only used when it is less complicated than other options offered by the application.

Sliders are appropriate and should be used when users must set a value within a fixed range and the precise value is less important than relative position.

9.2.2 Dialogue

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

9.2.3 Direct manipulation

Direct manipulation should be used primarily in tasks with actions and objects that lend themselves to pictographic representation, and in which the actions and objects need not be modified for the successful interpretation of the command by the system.

When direct manipulation interaction is used, the system or application should use a pointing device as the primary means of manipulation.

9.2.4 Form-filling

Form filling should be provided as an aid for composing complex command entries.

9.2.5 Menu

All displayed information about a menu item shall be on a single page when feasible.

Broad and shallow menu structures, rather than narrow and deep menu structures should be used.

Menus should have a limited number of items in breadth and in depth.

Hierarchic menus should be organized and labeled to guide users within the hierarchic structure.

If meaningful categories cannot be developed for menu options then visual groups should be created for long menus.

9.2.6 User guidance

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

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.

When processing in response to an entry is lengthy, the user should be given some positive indication of subsequent completion.

Prompt messages should provide direction to the operator and shall display required action or options.

Error messages will be used when invalid (out of range) input is detected. They should specify corrective actions when appropriate.

Feedback messages should inform the operator of changes in system status.

9.2.7 Navigation

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

Short navigation paths should be provided between display pages that will

be used one after the other.

Navigation targets should be easily detectable.

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

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

Navigational links to cross-referenced information and to notes, cautions, warnings, reference material, and communication and help facilities should be provided.

9.2.8 Cursors

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

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

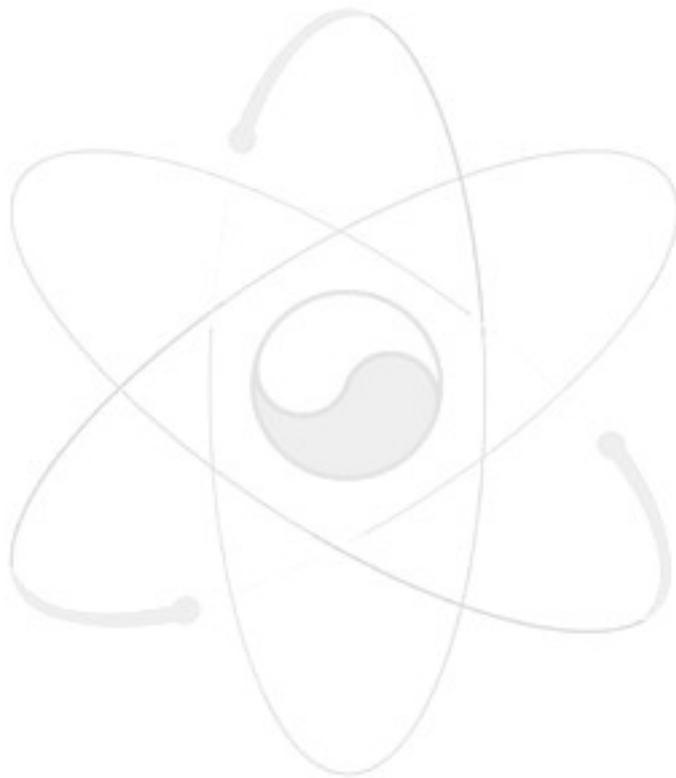
The cursor should not be so distracting as to impair the searching of the display for information unrelated to the cursor.

The displayed cursor should be stable.

On the initial appearance of a data entry display, the cursor should appear automatically at some consistent and useful location.

When there is a predefined HOME position for the cursor, that position should be consistently defined on all displays of a given type.

When the user must repeatedly return the cursor to the origin or other specific screen location, automatic return or repositioning of the cursor should be provided.



9.3 HARDWARE AND ENVIRONMENT

Note - Hardware shall be supplied by NSSS, Turbine/Generator, and other vendors as part of plant package. However, the following criteria still apply.

9.3.1 Glare

All MCR CRTs should be fitted with glare shields or anti-glare screens or mounted at an angle empirically determined to minimize glare.

9.3.2 Resolution

CRTs should be capable of high resolution graphics.

Resolution shall exceed to a level so that all the elements on the screen can be seen naturally.

9.3.3 Contrast

Luminance contrast between display and background should be 15:1 minimum and 20:1 preferred.

9.3.4 Regeneration

Screen regeneration rate should be high enough to prevent perceptible flicker.

9.3.5 Refresh rate

Data refresh rates should not exceed once per second as this would be meaningless to the operator.

Refresh rates for data should, in general, be determined by task analysis and ability of plant detectors, both as determined by the supplier.

9.3.6 Luminance

Character luminance and screen luminance shall be 23 foot-lamberts

minimum and 46 foot-lamberts preferred. Less than 25% shall be through diffuse reflection of ambient illumination.

9.3.7 Response time

Computer response times shall correspond to NRC guidelines (Appendix D) or be empirically determined not to impact operator performance.

9.3.8 Input device

Keyboards shall support convenient display page access. Vertical and horizontal access keys shall permit quick maneuvers within a display hierarchy. Immediate access to crucial displays shall be provided.

9.3.9. Viewing Distance

A nominal viewing distance of 510 mm (20 in.) for VDT use shall be provided.

9.3.10. Viewing Angle

All areas of the display surface shall be legible from within at least 30 degrees of the axis centered on, and normal to, the screen.

9.3.11 Image formation time

Flat panel displays should have an image formation time less than 55ms.

9.3.12 Electromagnetic Compatibility

The magnitude of environmental magnetic fields should not exceed the susceptibility of the computer workstation display.

9.1.13 Static Electricity

The computer workstation should be free of electrostatic potentials in excess of ± 500 volts. It should be cleaned of tactically precipitated dust periodically.

9.4 ALARM SYSTEM

9.4.1 Alarm Display Functions

The alarm display should support the user's ability to rapidly discern :

- Priority (e.g., urgency for action and importance to plant safety);
- Distinct alarm states: new, acknowledged, and cleared;
- The first-out alarms for reactor trip;
- The need to access other displays to verify or clarify the alarm state; and
- The difference between alarms which can be cleared through ongoing corrective actions (i.e., by operations personnel) and alarms that require significant maintenance intervention.

To satisfy all alarm information needs, multiple alarm display formats, such as dedicated tile-like display and message lists may be necessary.

9.4.2 Alarm Information Content

The alarm should provide the following information:

- Alarm title or legend;
- Alarm source, i.e., the particular sensor or group of sensors supplying the signal;
- Alarm priority;
- Set-point and parameter values;
- Required immediate operator actions; and
- Reference to procedure for more detailed follow-up actions.

However, this information should be presented whenever possible, so long as it does not result in a confusing display or overload the operator with information. The system should not provide excessive information in a single display and should not employ excessive levels and/or dimensions for coding information

9.4.3 Use of Spatially Dedicated, Continuously Visible Displays

Spatially dedicated, continuously visible (SDCV) alarm displays should be considered for:

- Regulatory Guide 1.97 Category 1 parameters,
- Alarms that require short-term response,
- The most important alarms used in diagnosing and responding to plant upsets, and
- The most important alarms used to maintain an overview of plant and system status.

Spatial dedication means that the alarm messages always appear in the same position. Continuously visible means a parallel presentation method is used, i.e., the alarm information is always available to the operator, as opposed to serial presentation methods in which the operator must select the information to be seen..

9.4.4 Alarm Coding Consistency

Coding(e.g., flash-rate, intensity, and color coding) conventions should be consistently applied throughout alarm displays.

9.4.4.1 Redundant Coding Dimensions

Redundant codes (e.g., fast flashing or bright) should be used for alarms that require rapid operator action.

9.4.4.2 Coding of Alarm Priority

A method of coding the visual signals for the various priority levels should be employed.

Acceptable methods for priority coding include color, position, shape, and symbolic coding. Color and position (top to bottom) are especially effective visual coding methods. However, coding priority by alarm element position can disrupt the functional grouping of elements and

should not be used when the loss of functional grouping may affect the operator's ability to effectively use alarm information. In this case, another dimension, such as color, should be used for priority coding.

9.4.4.3 Spatial Coding

Spatial coding may be used to indicate alarm importance.

Spatial coding can be effective especially in VDU types of alarm presentation. In an otherwise variable alarm display, having a dedicated or consistent location for presentation of important alarms will enhance operators' ability to detect them

9.4.5 Functional Grouping of Alarms

Alarms within a display should be grouped by function, system, or other logical organization.

9.4.5.1 Visual Distinctness of Functional Groups

Alarm functional groups should be visually distinct from one another.

Although the concept of functional grouping is typically applied in the context of spatially dedicated, continuously visible displays, it can be applied to alarm lists as well.

9.4.5.2 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).

Grouping alternatives should not interfere with the operator's detection of high-priority alarms

9.4.5.3 Simultaneous Display of High-Priority Alarms

For non-spatially dedicated alarm presentations such as VDU message lists, sufficient display area should be provided for the simultaneous viewing of all high-priority alarms.

If non-spatially dedicated alarm displays are used, they should have sufficient display space available for simultaneous presentation of all high-priority alarms under the worst credible conditions. Operators should never have to page or scroll a display to view high-priority alarms

9.4.5.4 Listing by Priority

Lists of alarm messages should be segregated by alarm priority with highest priority alarms being listed first

9.4.6 Alarm Text/Legend

Alarm text should be clearly understandable, use standard terminology, and address conditions specifically.

9.4.6.1 Alarm Source Identification

The content of each message should provide information that identifies the alarm source.

9.4.6.2 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 a VDU or is printed.

9.4.6.3 Parameter Values

Deviant parameter values should be included in the alarm message where alarm information is presented on VDU or printer displays.

9.4.7 Blank Lines for the Alarm Lists

Alphanumeric alarm lists should have a separation (blank row) between every four or five alphanumeric messages.

9.4.8 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.

9.4.9 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 (e.g., new and acknowledged) of the alarm condition.

9.4.10 Separation of Status Indication

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.

If the presentation in the alarm display of status indications is justified on the basis of the unique aspects of the design, such status messages should be designed so that operators may readily distinguish them from true alarm messages.

9.4.11 Alarm Graphics

The graphics related to alarm presentation should be designed such that the display is fully contained in one VDU screen.

For example, the operators should not have to scroll the graphic of the

overall reactor system, a major subsystem such as the primary system, or a portion of the subsystems, such as the pressurizer, to access a complete set of related alarm messages.

9.4.12 Indication of Alarm Status

New, acknowledged, and cleared alarm states should have unique presentations to support the operators' ability to rapidly distinguish them

9.4.12.1 New Alarms

New alarms should be indicated both by visual (e.g., flashing) and audible means

9.4.12.2 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.

9.4.12.3 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.

Reverse video (or dark letters on light background) can be used to highlight acknowledged but uncleared alarms and for urgent messages.

9.4.12.4 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.

9.4.13 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.

To meet the general alarm system principle of guiding the operator's response to an alarm, the immediate actions should be provided to the operator. For conventional alarm systems, the immediate operator actions should be available in Alarm Response Procedures that are clearly and simply keyed to an alarm tile and located nearby for easy and quick reference.

9.4.14 Format for Tile Displays

The format of messages on alarm tiles or tile-like displays should be consistent for all alarms. Information on a tile might be organized as follows: top line, name of alarmed parameter; middle line, alarm setpoint value; bottom line, indication of severity.

9.4.15 User-Defined Alarms/Setpoints

The alarm system may provide temporary, user-defined alarms and user-defined set points for specific conditions where such alarms are determined to be of assistance in selected evolutions (e.g., temporary alarms to support increased monitoring of a problem component, or at other times when the user wants to know of a parameter trend that is approaching a limit).

9.4.15.1 Interference of User-Defined Alarms/Setpoints with Existing Alarms

User-defined alarms and setpoints should not override or interfere with the existing alarms and setpoints.

9.4.15.2 Indication of User-Defined Alarms/Setpoints

The alarm system should provide clear indication of user-defined alarms and setpoints as distinct from the alarm/setpoints designed into the system.

9.4.16 Message Overflow

Alphanumeric alarm messages that overflow the first page of alarm messages should be kept on subsequent alarm pages.

9.4.17 Preclude of Message Scrolling

The method of adding alarm messages to the list should preclude message scrolling.

Scrolling makes it difficult to read alarm messages, especially when many alarms are coming in. An alternative method of viewing alarm lists, such as paging, is preferred.

9.4.18 Paging in One or Multiple Page Increments

Users should be able to page in one page or multiple page increments.

The user might page multiple pages directly by moving the page icon on the scroll bar, at which time the display might move to the location in the file that corresponds to the page number on the page icon.

9.4.19 Provisions for Control Functions

Separate controls should be provided for silence, acknowledgment, reset (acknowledging an alarm that has cleared and returning it to normal), and testing.

9.4.20 Distinct Coding of Control Functions

Alarm system controls should be distinctively coded for easy recognition..

9.5 SPDS

General

SPDS should have functions to aid control room personnel during abnormal and normal operating conditions in determining the safety status of the plant.

SPDS should provide a concise display of critical plant variables to the expected users to aid in rapid and reliable assessment of the safety status of the plant.

SPDS should serve as an aid to evaluate the current status of and/or the challenges to the plant safety, in executing function-oriented procedures and monitoring the impact to the safety during anticipated transients and the initial phase of accident as well as the emergencies.

SPDS should adhere to all guidelines in Section 9 of this document.

9.5.1 Readily perceived and comprehended information

SPDS displays should be designed to be readily perceived and comprehended by the expected users.

Display conventions should be consistent throughout all SPDS displays.

SPDS display should be readable from the emergency station of control room operators responsible for evaluating the safety status of the plant.

The displayed contents should be readable by satisfying the human factors criteria for viewing angle, viewing distance, flicker, glare, noise, contrast, and location for standing and seated positions of the designated operating crew members.

9.5.2 Sufficient, minimum and critical information

SPDS should display critical information enough to aid the expected users in assessing, evaluating and mitigating the plant safety status.

SPDS should display a specific minimum set of parameters and the safety functions pre-determined by human factors and other technical analyses.

The minimum information to be provided by SPDS should be sufficient to provide information to plant operators about the pre-determined critical safety functions.

To monitor the process and the safety status of the plant, the operators must be able to evaluate each of the pre-determined critical safety functions or their equivalents.

A pre-determined minimum set of critical plant variables will help the expected users evaluate plant safety. The variables selected for SPDS should be ensured by the supporting analyses. The design of the display should have single primary display format for each mode of plant operation.

For each operating mode, display formats may either be automatically displayed or manually selected.

9.5.3 Concise display

SPDS displays should be concise for the expected users to figure out the meaning of the information.

A concise display of critical plant variables will help the expected users compare data from related plant functions and assess the safety status of the plant.

9.5.4 Rapid and reliable determination of safety status

In order for the expected users to rapidly and reliably determine the safety status of the plant, the displayed data represent the current and correct status of critical plant variables.

In order to keep the expected users current on the safety status of the plant, the display should be responsive to transient and accident sequences.

To prevent misleading the expected users, displayed data should be validated on a real-time basis where practical.

To instill the expected users' confidence in the use of displayed data, members of operating crew should be provided with the information and criteria they need to perform an operability evaluation of the SPDS. In addition, the crew must be able to easily recognize a failed SPDS.

9.5.5 Aid to control room personnel

To aid the control room personnel in evaluating the safety status of the plant during conditions that could have safety significance, the display should be capable of presenting magnitudes and trends of critical plant variables or derived variables.

To help control room operators detect abnormal conditions which warrant corrective actions, the SPDS, where feasible, should include perceptual cues to alert the personnel to the abnormal operating condition.

9.5.6 Convenient location

To be convenient to the expected users, the SPDS may be located on the control board. If the SPDS is a part of control boards, it must be easily recognized and readable.

To be convenient to the expected users, the display system should not interfere with the users' normal movement. The display system should not interfere with full visual access to other operating systems and with displays important for safe operation.

9.5.7 Continuous display

SPDS should continuously display information from which the safety status of the plant can be readily and reliably assessed by the expected users, especially control room personnel responsible for the avoidance of degraded and damaged core events.

A continuous single-format primary display is not necessary. The primary display may be a continuous indication of individual plant variables. The main concern is that the expected users are made aware of important changes in critical safety-related variables when they occur and that the users can readily obtain information from the SPDS to help them determine the safety status of the plant.

9.5.8 VDT syndrome

SPDS should avoid the possible negative VDT syndrome due to the psycho-physiological and visual-auditory characteristics of the provided hardwares.

9.5.9 Procedure and training

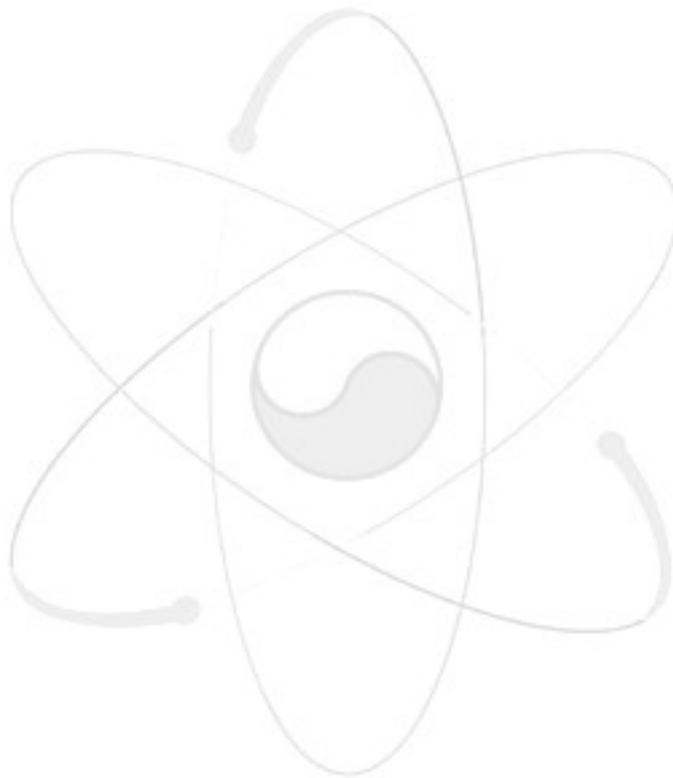
Control room personnel should be trained to respond to accident conditions both with and without the SPDS available.

Procedures will be developed in parallel with the development of SPDS. Procedures should describe the timely and correct safety status assessment when the SPDS is and is not available.

As the SPDS is not a Class 1E qualified display, compensatory measures

should be provided for control room operators when the SPDS is inoperable.

No additional operating staff other than the normal control room operating crew should be needed to operate the display during normal and abnormal plant operation and during display outages.



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<p>The Application of Human Factors to the design of Man-Machine Interfaces System(MMIS) in the nuclear power plant is essential to the safety and productivity of the nuclear power plants, human factors standards and guidelines as well as human factors analysis methods and experiments are weightily used to the design application.</p> <p>A Korean engineering company has developed a human factors engineering guideline, so-call HF-010, and has used it for human factors design, however the revision of HF-010 is necessary owing to lack of the contents related to the advanced MMI(Man-Machine Interfaces).</p> <p>As the results of the reviews of HF-010, it is found out that the revision of Section 9. Computer Displays of HF-010 is urgent, thus the revision was drafted on the basis of integrated human factors design guidelines for VDT, human factors design guidelines for PMAS SPADES display, human factors design guidelines for PMAS alarm display, and human factors design guidelines for electronic displays developed by the surveillance and operation support project of KNICS.</p> <p>The draft revision of HF-010 Section 9 proposed in this report can be utilized for the human factors design of the advanced MMI, and the high practical usability of the draft can be kept up through the continuous revision according to the advancement of digital technology.</p>							
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