LABELS AND LOCATION AIDS 6.0
LOCATION AIDS 6.6

GUIDELINE

GUIDELINE

6.6.1 DEMARCATION

a. CONTRAST—Lines of demarcation should be visually distinctive from the panel background.

b. PERMANENCE—Lines of demarcation should be permanently attached.

COMPLIANCE CHECKLIST

N/A	Yes	No	References/Comment
[redacted]			

GUIDELINE

6.6.2 COLOR

Color should be dedicated to specific functions or conditions throughout the control room in order for the code to elicit the expected operator response. The color coding scheme should be used consistently throughout the control room.

COMPLIANCE CHECKLIST

N/A	Yes	No	References/Comment

APPENDIX A

ALARM SYSTEMS 3.0
GENERAL SYSTEM CHARACTERISTICS 3.1

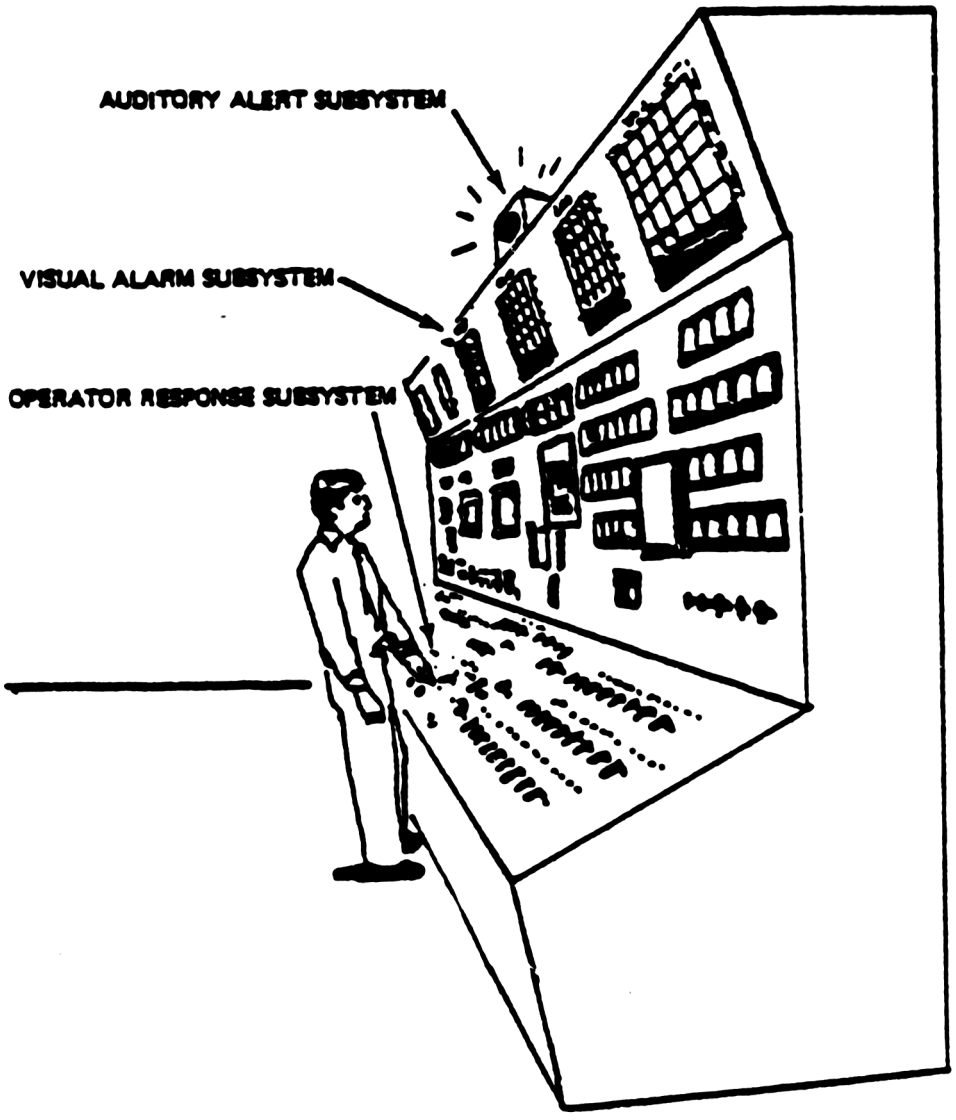

Exhibit 3-1. Alarm system

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

6.6.3 USE OF MIMICS (Cont'd)

c. SYMBOLS

(1) Graphic symbols should be readily understood and commonly used.

(2) Symbols should be used consistently.

GUIDELINE

2.2.7 RELIABILITY

a. FAILURE OF ALARM CIRCUITRY—Failure of auditory signal circuitry should not adversely affect plant equipment.

b. FALSE ALARMS—Auditory alarm systems should be designed so that false alarms are avoided.

c. SYSTEM TEST—Auditory signal system test capabilities should be provided.

COMPLIANCE CHECKLIST

N/A	Yes	No	References/Comment

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	References/Comment

7.1.2 OPERATOR/COMPUTER DIALOGUE

Users of computer systems interact most successfully with the system through the use of a "dialogue" which both the person and the computer can understand. This dialogue is usually called "command language." Selection of a command language can depend on many factors including the type of computer system, the expertise of the user, the frequency of interaction, the type of interaction, etc. The following guidelines should be considered.

a. LANGUAGE CHARACTERISTICS

(1) Dialogue should be based on the operator's point of view, not the programmer's.

(2) Dialogue should be logical.

(3) Dialogue should be used in a consistent manner.

(4) Dialogue should reflect the vocabulary and syntax of the expected user population.

(5) Input words (e.g., keywords) should approximate real words.

(6) Dialogue should require an explicit command in order to terminate an interaction.

b. ENTRY LENGTH—Individual input words which must be typed should not exceed 7 characters.

COMMUNICATIONS 2.0
AUDITORY SIGNAL SYSTEMS 2.2

GUIDELINE

2.2.4 PROPAGATION OF SIGNALS

a. DIRECTION OF SOUND – Sound sources (speakers, buzzers, etc.) should direct sound toward the center of the primary operating area.

b. AUDIBILITY – Auditory alert and warning signals should be audible in all parts of the control room.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment
			SEE PLANT COMMUNICATION TECH. SPECS.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.1.3 PROMPTING AND STRUCTURING

The ability of operators to interact successfully with the computer system can be aided significantly by attention to structuring of input and output information and by providing prompts to orient and guide the user.

a. OPERATOR REQUESTS—The computer system should contain prompting and structuring features by which an operator can request additional information.

b. CORRECTION OF DATA—The computer system should contain prompting and structuring features by which an operator can request corrected information when an error is detected.

c. MODE/FILE DISPLAY—Are the displays appropriately titled to allow operator recognition of the processing being performed?

d. SPECIFIC ERROR CORRECTION—The computer system should permit correction of individual errors without requiring re-entry of correctly entered data.

e. ENTRY FILE—The computer system should contain a sequential file of operator entries, available upon operator request.

GUIDELINE

2.2.3 AUDITORY CODING TECHNIQUES

Auditory signals may be coded. For example, coding can be used to prioritize signals or to direct operator attention to areas outside the primary operating area. If auditory coding is employed, the following principles should be applied:

a. DISTINCTIVE CODING—Coding methods should be distinct and unambiguous, and should not conflict with other auditory signals.

b. PULSE CODING—Auditory signals may be pulse coded by repetition rate, but the number of codes should be limited (2 or 3). Repetition rates should be sufficiently separated to ensure operator discrimination.

c. FREQUENCY CHANGE CODING—If modulation of the frequency (Hz) of a signal denotes information, center frequencies should be between 500 and 1000 Hz.

d. DISCRETE FREQUENCY CODING—Discrete-frequency codes may be used for audible signal coding. Frequencies should be broad band (±100 Hz) and widely spaced within the 200-5000 Hz range. No more than 5 separate frequencies should be used.

e. CODING BY INTENSITY – Coding by intensity is not recommended.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment
			SEE PLANT COMMUNICATION TECH. SPECS.

PROCESS COMPUTERS 7.0
COMPUTER ACCESS 7.1

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.1.4 DATA ENTRY—KEYBOARDS (Cont'd)

b. NUMERIC KEYBOARD ARRANGEMENT—The configuration of a keyboard used to enter solely numeric data are a 3x3+1 matrix, either "telephone" style or "calculator" style. See Exhibit · 7-2.

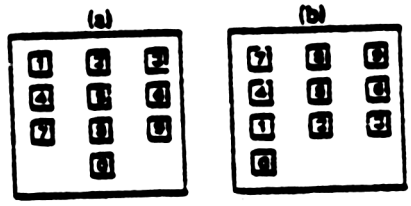

Exhibit · 7-2. Acceptable arrangements of keys in a numeric-only keyboard.

GUIDELINE

2.2.1 USE OF AUDITORY SIGNALS

Auditory signals are used to attract operator attention and to present information independent of operator position or head orientation. Auditory signals have some drawbacks, since they may interfere with speech communication and are limited in their capability to indicate what is wrong and what to do.

a. DEDICATED USE—Systems used to transmit non-verbal auditory signals should be used only for that purpose, unless priorities have been established for transmission of verbal and non-verbal information.

b. LOCALIZATION—Auditory signals should provide localization cues that direct operators to those control room work stations where operator attention is required.

c. SELECTION

(1) Auditory signals should be selected to avoid confusion with ambient control room noises.

(2) Auditory signals should be selected to avoid interference with other auditory sources, including verbal communication.

COMPLIANCE CHECKLIST

N/A	Yes	No	References/Comment

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.1.4 DATA ENTRY—KEYBOARDS (Cont'd)

e. KEY DISPLACEMENT AND RESISTANCE—To provide positive key movement feedback to the operator, and to reduce inadvertant activation of keys,

(1) Key displacement should be as shown in Exhibit 7-4.

(2) Key resistance should be as shown in Exhibit 7-4.

f. POSITIVE INDICATION—To provide positive key actuation feedback to the operator, a definite indication should be provided (e.g., snap, feel, audible click, release of resistance).

g. KEYBOARD SLOPE—Keyboards should have a slope between 15° and 25° from the horizontal (see Exhibit 7-5).

h. VISUAL FEEDBACK—Data being entered via keyboards should be displayed as it is keyed.

i. RELEVANT KEYS—The presence of non-relevant keys, such as might be used by programmer personnel, adds to keyboard complexity and induces operator errors. Control room keyboards should contain only those keys which are used by operators.

Displacement (inches)

	Numeric	Alpha-numeric
Minimum	0.03	0.08
Maximum	0.19	0.25

Resistance (ounces)

	Numeric	Alpha-numeric
Minimum	3.5	8.9
Maximum	14.0	8.3

Exhibit 7-4. Recommended key displacement and resistance.

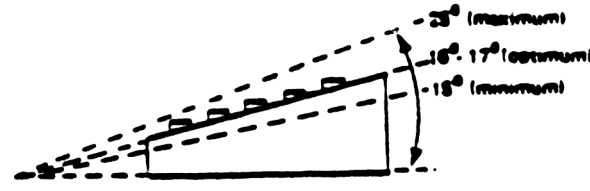

Exhibit 7-5. Keyboard slope limits.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

2.1.7 POINT-TO-POINT INTERCOM SYSTEMS

Such systems should be provided to interconnect the control room with important plant areas such as the Shift Supervisor's Office, Plant Security Office, operator's lounge, locker rooms, and possibly restrooms.

a. INTELLIGIBILITY – At a minimum, the intercom system should provide transmission of the voice spectrum to telephone standards (200 to 3300 Hz).

b. GAIN ADJUSTMENT – Gain should be adjustable at each intercom unit, but adjustability should be limited to preclude reducing volume below an audible level.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.1.8 COMPUTER FUNCTION CONTROLS (Cont'd)

d. FUNCTION CONTROLS (Cont'd)

(3) Each function control is clearly labeled to indicate its function to the operator.

(4) Multiple computer consoles exist in the control room, the design and layout of the function controls is consistent for all consoles.

(5) When function keys are included with an alpha-numeric keyboard, the function keys should be physically separate from the alpha-numeric keys.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

2.1.6 ANNOUNCING SYSTEMS

These systems are made up of amplifiers, loudspeakers, and microphones. The microphone input is provided, in some installations, by a dialable connection to a transmitter of the powered telephone system.

a. INTELLIGIBILITY AND COVERAGE—These are the key factors in announcing system effectiveness. The system must provide rapidly intelligible messages to all areas where personnel subject to page may be located.

(1) Intelligibility requires the integration of carefully selected components (microphones, amplifiers, and loudspeakers) into an overall system providing good frequency response in the audio band which is critical for intelligibility. At a minimum, telephone quality is required (200 to 3300 Hz); higher intelligibility is achieved by a band of 200 to 6100 Hz.

(2) Coverage depends on loudspeaker location. Adequate coverage requires that speakers should be placed so that they are available in all necessary areas and that there are no "dead spots" within any area.

b. MICROPHONE CHARACTERISTICS

(1) Frequency response should be compatible with that of the rest of the system.

(2) 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.

(3) Microphones should have high sensitivity to speech signals.

GUIDELINE

7.1.7 COMPUTER RESPONSE TIME TO OPERATOR QUERIES

Timely response to operator inputs can be an important factor in reduction of operator errors, as well as for achievement of operator acceptance of the computer system. Undue delays in responding to operator inputs may lead the operator to assume that the input was not accepted, or that the input was made incorrectly, or that something is wrong with the computer. Responses to an input or request within 1 to 3 seconds will generally maintain the operator's attention and thus reduce operator error. The nature of the query, the complexity of the programmed response logic, and the speed of the computer are determinants of response time.

a. MAXIMUM RESPONSE TIMES—The computer system should provide the correct response to each type of query within the recommended response times listed in Exhibit 7-6.

b. RESPONSE DELAY MESSAGES—When response time for any query exceeds 3 seconds, a delay message should be presented to maintain the operator's attention and to confirm normal computer operation. (See also Guideline 7.2.6.)

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

2.1.4 PORTABLE RADIO TRANSCEIVERS (Cont'd)

c. PACKAGING

(1) To the extent permitted by design for effective electrical/RF function, portable transceivers should be small, light, and easy to carry.

(2) Their use should leave one hand available most of the time for other tasks.

(3) The microphone should be integrated into the transceiver package.

d. PARTY IDENTIFICATION—When there are more than two parties on a channel operating at separate locations, procedures must provide for unambiguous identification of the speaker.

e. BATTERY REPLENISHMENT

(1) A supply of fresh replacement batteries should be stowed in an accessible, well-marked space.

(2) The stock should be kept large enough to support long periods of continuous operation in case of emergency.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

GUIDELINE

COMPLIANCE CHECKLIST

	N/A	Yes	No	Reference/Comment

7.1.8 ACCESS AIDS

As a rule, control room operators lack the in-depth computer training and experience of computer system engineers and programmers. While some operators become very proficient users of the computer system, their expertise is usually focused on the portions of the system with which they interface most frequently over an extended period. In addition, their attention is more likely to be directed toward the characteristics and functioning of plant systems than to that of the computer. This guideline addresses provisions for bridging the gaps in the control room operator's knowledge and experience regarding the effective use of the computer.

a. COMPUTER SYSTEM PROCEDURES

(1) A complete set of computer system operating procedures and contingency procedures should be available in the control room.

(2) Procedures should be prepared from the point of view of the control room operator.

(3) Procedures should be in hard-copy form,

(4) Operating procedures should describe:

(a) The overall computer system.

(b) The computer system components with which the operator can interface.

(c) The specific procedures necessary to accomplish all of the operator-computer interface functions.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.1.3 ACCESS AIDS (Cont'd)

a. COMPUTER SYSTEM PROCEDURES (Cont'd)

(5) Contingency procedures should describe:

(a) Indications available to the operator which identify failure or malfunctioning of the computer system.

(b) Necessary actions to be performed by the operator if the computer fails or malfunctions.

b. DATA POINT INDICES

(1) The specific codes, or addresses, by which data displays can be called up by an operator should be cross-indexed by:

(a) Alpha-numeric or numeric code

(b) Program name

(c) System/subsystem identification

(d) Functional group identification.

(2) Cross-indices should be available in the control room in hard-copy form as a minimum.

PROCESS COMPUTERS 7.0
CATHODE RAY TUBE (CRT) DISPLAYS 7.2

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.2.1 CRT DISPLAY CHARACTERISTICS

In the majority of process computer systems, one or more CRT displays (video displays) comprise the principal interface between computer output and control room operators. (The other interface is the printed record; see Section 7.3.) It is, therefore, important that the characteristics of the display device promote transfer of computer output to the operator. The quality of the displayed image must be consistent with operator needs.

a. READABILITY—Alpha-numeric and graphic characters should be easily readable by the operator under all control room lighting conditions.

b. REFLECTED GLARE—CRT screens should be installed to minimize or eliminate reflected glare at normal operator viewing angles.

6.7.2.1 CRT DISPLAY CHARACTERISTICS (Cont'd)

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

c. **GEOMETRIC DISTORTION**—The cumulative effects of all geometric distortion should not displace any point within the viewable area of the screen from its correct position by more than 5% of picture height.

d. **RESOLUTION**—Discrimination of fine detail is a function of the number of scan lines or addressable points ("resolution elements") per unit length.

(1) CRTs for displaying simple alpha-numeric text should have a minimum of 20 resolution elements per inch.

(2) CRTs for displaying complex symbols and graphic detail should have a minimum of 100 resolution elements per inch.

(3) Complex symbols which must be distinguished from other complex shapes should have a minimum of 10 resolution elements for the longest dimension of the symbol.

e. **REGENERATION RATE**—The regeneration rate for a particular CRT display should be above the critical frequency at fusion so that the occurrence of disturbing flicker is not perceptible.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.2.1 CRT DISPLAY CHARACTERISTICS (Cont'd)

f. CRT DISPLAY CONTROLS

(1) Parameters such as luminance (brightness), contrast, and color should be adjustable by the control room operator.

(2) Adjustment controls should conform to the appropriate guidelines in Section 4.0 Controls, and Section 8.0 Control-Display Integration.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	References/Comment

7.2.2 SYMBOLS AND CHARACTERS

The dimensional factors of data displayed on a CRT take on greater significance because of the movement of operators from one benchboard position to another in a control room. Distance from the operator to the screen is, therefore, variable, and must be taken into account during control room layout (in general) and CRT design (in particular). As an operator's distance from the CRT increases, the perceived dimensions of CRT characters, symbols, spacing, etc. decreases proportionately because of a reduction of the "visual angle" (see Exhibit 7-7). This is the vertical angle subtended at the eye by a viewed object, symbol, or character, usually expressed in minutes of arc. For visual angles less than 600 minutes, this relationship is shown by:

$$\alpha = \frac{(57.3)\,(60)\,L}{D}$$

where "L" is measured perpendicular to the line of sight. Under optimum conditions (illumination, contrast, etc.) the human eye can identify characters of the alphabet at visual angles of 5 minutes of arc (defining 20:20 vision). Since presentations on CRT displays in an operational environment do not approach the optimum conditions of vision testing, this lower level must be increased.

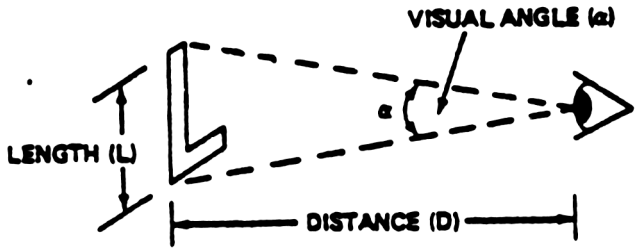

Exhibit 7-7. Visual angle as a function of distance and character size.

COMPLIANCE CHECKLIST

7.2.2 SYMBOLS AND CHARACTERS (Cont'd)

a. SYMBOL SIZE—When a displayed symbol of complex shape is to be distinguished from another symbol shape that is also complex, the visual angle of the symbol should subtend not less than 20 minutes of arc at the required viewing distance.

b. ALPHA-NUMERIC CHARACTER SIZE

(1) The height of alpha-numeric characters should have a visual angle of not less than 12 minutes of arc at the required viewing distance.

(2) Alpha-numeric characters should be upper-case letters.

c. CHARACTER WIDTH-TO-HEIGHT RATIO—The width-to-height, ratio for alpha-numerics should be between 3:5 and 1:1.

d. STROKE-WIDTH-TO-CHARACTER-HEIGHT RATIO—Stroke-width-to-character-height ratio should be between 1:5 and 1:10.

e. GRAPHICS—A graphic line will appear continuous if the separation between addressable points, or resolution elements, is less than one minute of arc. To provide the illusion of continuity, graphic lines should contain a minimum of 50 resolution elements per inch.

f. CHARACTER AND SYMBOL SEPARATION

(1) Horizontal separation between characters or symbols should be between 10% and 85% of character or symbol height.

(2) Separation should be not less than 25% of character or symbol height when any of the following degraded conditions exists:

(a) When character or symbol width is less than 85% of height;

(b) When character or symbol luminance is less than 12 ft-L;

(c) When luminance contrast is less than 88%;

N/A	Yes	No	Reference/Comment

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.2.2 SYMBOLS AND CHARACTERS (Cont'd)

f. CHARACTER AND SYMBOL SEPARATION (Cont'd)

(d) When CRT screen location is greater than 35° to the left or right of the operator's straight-ahead line of sight;

(e) When the visual angle subtended by symbol height is less than 15 minutes of arc;

(f) When the visual angle subtended by character height is less than 12 minutes of arc.

g. CHARACTER STYLE (FONT)

(1) Simple character fonts should be used, with no serifs, variable stroke widths, slanting, etc.

(2) When dot-matrix characters are used, 7x9 dot-matrix should be used in preference to 5x7 dot-matrix.

(3) Character styles such as Lincoln/Mitre or Leroy should be used.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment
[redacted]			

7.2.3 OPERATOR-DISPLAY RELATIONSHIPS

The use of CRT displays in power plant control rooms generally falls in three categories: (a) the CRT is mounted in a desk-type console at which the operator is seated; (b) the CRT is mounted in a vertical panel above a benchboard, with the operator having some lateral freedom of movement at the work station; (c) the CRT is mounted on a stand, or perhaps on a desktop, with some capability for rotating or moving it to suit the needs of a variety of users. The guidance in this subsection deals with those factors which should be considered regardless of type of installation, as well as the parameters which are dependent on the type of installation and the nature of the physical relationship between CRT and operator.

a. VIEWING DISTANCE – Viewing distance should be greater than 18 inches.

b. VIEWING ANGLE – The minimum angle between the operator's actual line-of-sight (LOS) as measured from the operator's normal work station, and the plane of the display screen should be 45° or greater in either the horizontal or vertical direction. See Exhibits 7-8 and 7-10.

c. SCREEN LOCATION, SEATED OPERATORS

(1) CRT displays which require frequent or continuous monitoring, or which may display important (e.g., alarm) information, should be located within the following limits as measured from the normal operator work station (see Exhibit 6.7-9):

(a) Horizontal limits—Not more than 35° to the left or right of the operator's straight-ahead LOS.

(b) Vertical limits—Not more than 20° above and 40° below the operator's horizontal LOS.

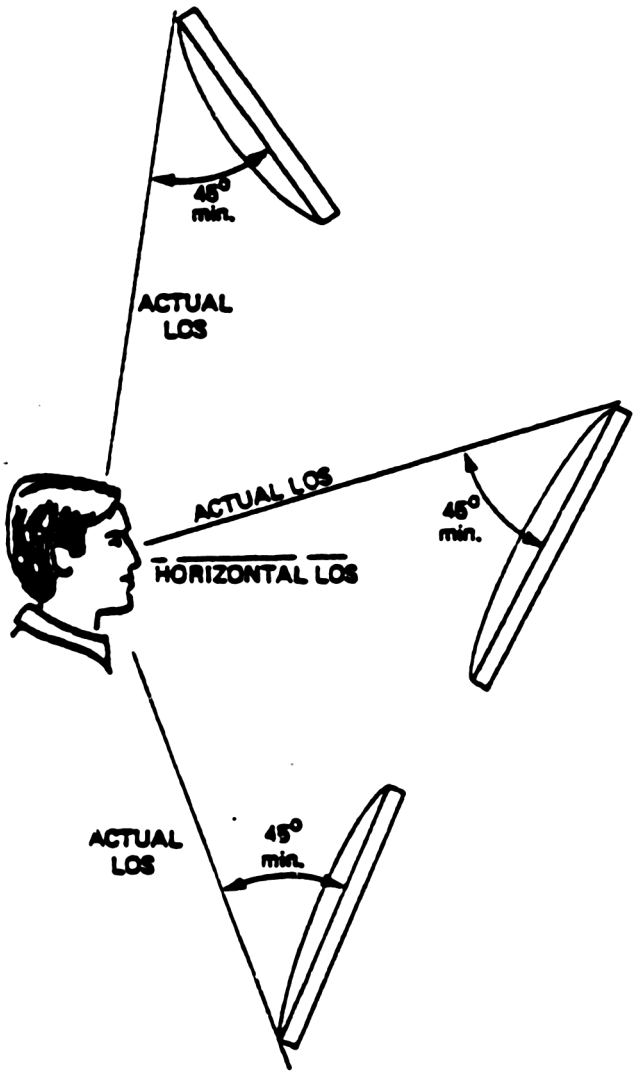

Exhibit 7-8. Minimum CRT viewing angle (shown only for vertical angles).

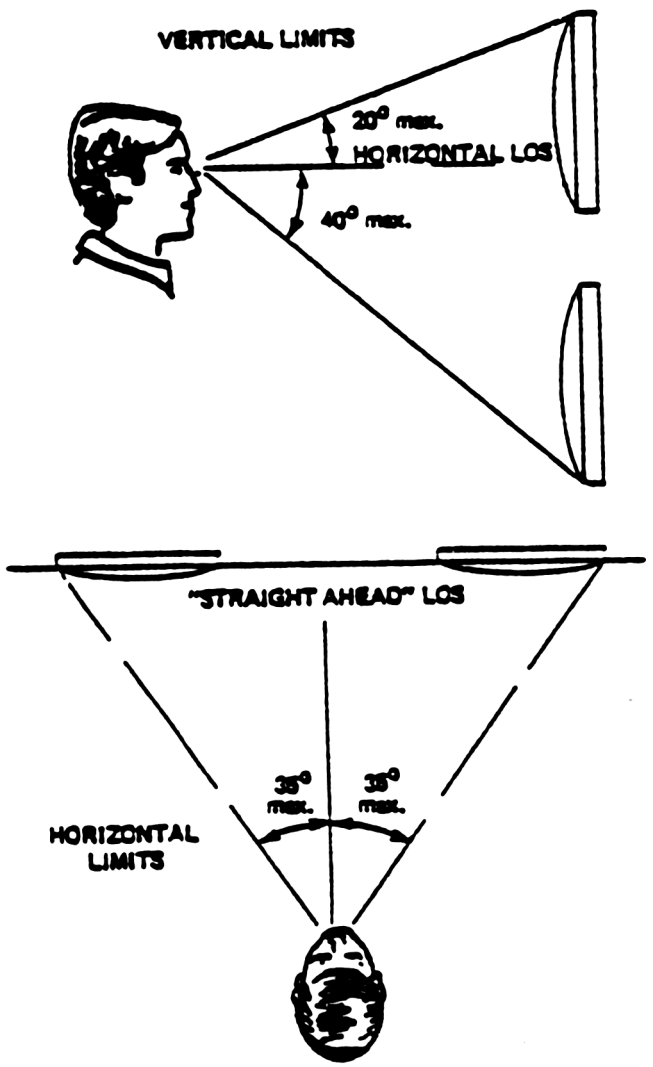

Exhibit 7-8. CRT screen location limits—seated operator, frequently monitored displays.

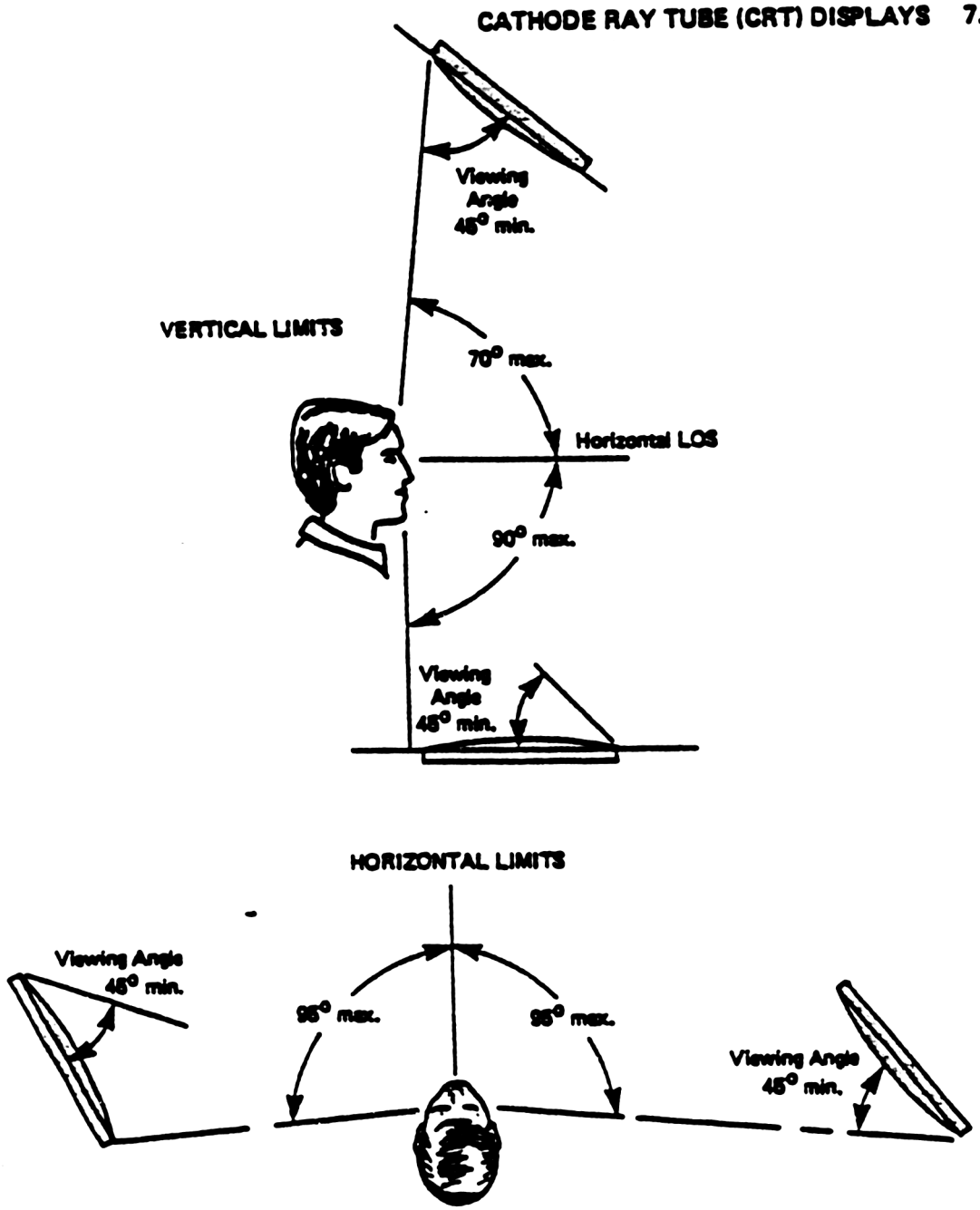

Exhibit 7-10. CRT screen location limits—seated operator, infrequently monitored displays.

COMPLIANCE CHECKLIST

	N/A	Yes	No	Reference/Comment
7.2.3 OPERATOR-DISPLAY RELATIONSHIPS (Cont'd) c. SCREEN LOCATION, SEATED OPERATORS (Cont'd) (2) CRT displays which do not require frequent or continuous monitoring, and which will not display important (e.g., alarm) information, should be located within the following limits (as measured from normal operator work stations which permit full operator head and eye rotation—see Exhibit 7-10): (a) Horizontal limits—Not more than 95° to the left or right of the operator's straight-ahead LOS. (b) Vertical limits—Not more than 70° above and 90° below the operator's horizontal LOS.				
d. SCREEN LOCATION, STANDING OPERATORS (1) CRT displays which require frequent or continuous monitoring, or which may display important (e.g., alarm) information, should be located within the following limits as measured from the normal operator work station: (a) Horizontal limits—Not more than 35° to the left or right of the operator's straight-ahead LOS. (b) Vertical limits—Not more than 35° above and 25° below the operator's horizontal LOS.				

7.2.3 OPERATOR-DISPLAY RELATIONSHIPS (Cont'd)

d. SCREEN LOCATION, STANDING OPERATORS (Cont'd)

(2) CRT displays which do not require frequent or continuous monitoring, and which will not display important (e.g., alarm) information, should be located within the following limits (as measured from normal operator work stations which permit full operator head and eye rotation):

(a) Horizontal limits—Not more than 95° to the left or right of the operator's straight-ahead LOS.

(b) Vertical limits—Not more than 85° above and 90° below the operator's horizontal LOS.

e. MOUNTING IN CONSOLES—When CRTs are permanently mounted in consoles, the console configuration, dimensions, and type of use (such as seated, sit-stand, or standing) affects the CRT/operator interface. Consoles in which CRTs are installed should conform to the guidelines of Section 1.2.

f. VISIBILITY OF DATA—All data and messages on the CRT screen should be within the unobstructed view of an operator at the normal work station.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.2.4 DATA PRESENTATION FORMAT

The format used in presenting data to operators is an important factor in preventing reading and selection errors, and reducing search time.

a. USABILITY OF DATA

(1) Data should be presented to the operator in a readily usable format. (There should be no requirement for transposing, computing, interpolating, or mentally translating displayed data into other units or numerical bases.)

b. ILLUSTRATIONS—Illustrations should be used whenever possible to supplement or explain text.

c. CHARACTER GROUPING

(1) When 5 or more digits and/or non-text alpha-nugnerics are displayed, and no natural (i.e., population stereotyped) organization exists, characters should be grouped in blocks of 3 to 4 characters each.

(2) Groups should be separated by a minimum of 1 blank character space.

d. MAINTENANCE OF ORDERING—Elements in a data field should be displayed in logical order (e.g., chronological).

e. PRESENTATIONS OF IDENTICAL DATA

(1) Within the limits of a.(1) above, identical data in different presentations should be displayed in a consistent, standardized manner.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.2.4 DATA PRESENTATION FORMAT (Cont'd)

f. MENU DESIGNATORS

(1) Numbers should be used as designators when listing selectable items.

(2) Numerical designators should start with the number "1" (not zero).

(3) If the use of numbers as designators would create confusion because of other numbers which make up the item to be designated, alphabetic characters should be used.

(4) When used, alphabetic designators should start with the letter "A."

g. LISTS

(1) Lists should be vertically aligned and left-justified.

(2) Indentation should be used for sub-classifications.

h. TABLES AND GRAPHS—Quantitative data which must be scanned and compared should be presented in either tabular or graphic form.

i. HYPHENATION—The use of hyphenation should be minimized.

j. ALIGNMENT

(1) When presented in tabular form, alpha-numeric data should be left-justified.

(2) When presented in tabular form, numeric data should be right-justified with decimal points aligned.

k. PERIODS—Periods should be placed after item selection designators and at the end of a sentence.

	COMPLIANCE CHECKLIST			
	N/A	Yes	No	References/Comment
7.2.4 DATA PRESENTATION FORMAT (Cont'd)				
l. STANDARDIZED FIELDS—The following standardized fields should be used:				
(1) Telephone Number: (914)555-1212				
(2) Time: HH:MM:SS, HH:MM, MM:SS:(.S)				
(3) Date: MM:DD:YY.				
m. DATA GROUP LABELING				
(1) Each individual data group or message should have a descriptive title.				
n. LABEL PLACEMENT—Labels should be located in a consistent manner either above or to the left of the data group or message they describe.				
o. LABEL ORIENTATION—Labels should be oriented horizontally.				
p. LABEL HIGHLIGHTING				
(1) Labels should be highlighted or otherwise accentuated to facilitate operator scanning and recognition. (The technique used to highlight labels should be easily distinguished from that used to highlight emergency or critical messages.)				
q. OPTION LABELS—When presenting a list of operator options, the label should reflect the question or choices being posed to the operator.				

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.2.5 SCREEN LAYOUT AND STRUCTURING

Screen layouts and structuring of data presented on CRTs should minimize operator scanning and reading requirements, and minimize the probability of operator error.

a. ORGANIZATION OF DATA

(1) Displayed data should be organized in a logical, consistent manner.
Displayed data should reflect some obvious and inherent quality of the data groups (e.g., hierarchical, sequential, or mimic relationships).

b. LOCATION OF DATA GROUPS—Physical location of specific data groups (e.g., alarms, menus) on the screen should be consistent.

c. DEMARCATION OF DATA SUBGROUPS—Organization and separation of information subgroups should be made apparent to the operator through the use of blank spaces, lines, or some other form of visible demarcation.

d. USE FREQUENCY RANKING — Lists of options should be organized according to the probability of selection for each item, with high probability items presented first.

e. ALPHA-NUMERIC RANKING — Non-option lists of equal-probability options should be presented in alphabetical or numerical order.

f. SEPARATION OF PARAGRAPHS—Paragraphs in continuous text should be separated by at least one blank line.

g. SELECTION DESIGNATORS—Selection designators in menus should be separated from text descriptors by at least one blank space.

7.2.5 SCREEN LAYOUT AND STRUCTURING (Cont'd)

h. **PAGE DESIGNATION**—When data are contained on multiple pages, each page should display both page number and total number of pages.

i. **CONTINUOUS NUMBERING**—Items contained in a numbered list and described on "continue" pages should be numbered relative to the first number on the first page of the list.

j. **PLACEMENT OF INSTRUCTIONS**—When directions to the operator accompany a list of options, such directions should precede presentation of the list.

k. **URGENT MESSAGES**

(1) Urgent messages requiring immediate operator response should be highlighted to attract the operator's attention.

(2) Urgent messages should always be displayed in the same location.

l. **USE OF CURSOR**—In systems in which selection is made by use of a cursor, formats should be organized to minimize positioning movements of the cursor.

m. **SCREEN LOADING**—The amount of information-bearing activated screen area should not exceed 25% of the total screen area. This does not include demarcation lines used to separate groups of data.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.2.5 SCREEN LAYOUT AND STRUCTURING (Cont'd)

n. TREND PLOT SCALES—CRT displayed trend plot scales should be consistent with the intended functional use of the data. (For example, the monitoring of neutron flux at reactor trip may have a variable scale of 0% to 100% of the design value and a time scale resolution of seconds. However, post-trip monitoring may have a variable scale of 0% to 10% with a time scale resolution of minutes. Finally, operational log data of neutron flux may have a time scale resolution of hours.)

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.2.8 MESSAGES

Messages are of 3 types:

- Prompts. Used to provide directions to the operator for initiating and/or completing an action involving the computer system.
- Error messages. Used to inform the operator of invalid or incorrect inputs to the system.
- Feedback. Used to indicate to the operator the status of the computer system and/or the controlled/monitored system, following an operator input or action.

Messages should conform to the following guidelines:

a. MESSAGES, GENERAL

(1) Messages should be concise.

(2) Messages should provide the operator with the information necessary to complete a specific action or decision sequence.

b. MESSAGE CONTENT—Information contained in messages should be necessary, complete, and readily usable.

c. USE OF PROMPTS—Prompts should be displayed whenever the operator may need directions or guidance to initiate or complete an action or sequence of actions.

d. CONTENT OF PROMPTS—Prompts should contain clear and specific cues and instructions which are relevant to the action to be taken.

e. PROMPT INFORMATION SEQUENCE—Directions should be placed in the sequence to be used by the operator.

f. USE OF ERROR MESSAGES—Whenever an operator error or invalid input is detected, an error message should be displayed.

7.2.8 MESSAGES (Cont'd)

g. ERROR CORRECTION GUIDANCE—Error messages should contain instructions to the operator regarding required corrective action.

h. ERROR CORRECTION EASE—Capability should be provided for operator correction of individual errors without affecting adjacent valid entries.

i. SYSTEM STATUS FEEDBACK MESSAGES—Feedback messages should be provided to the operator to indicate changes in the status of system functioning.

j. SELECTION FEEDBACK—When a displayed message or datum is selected as an option or input to the system, the subject item should be highlighted, or otherwise positively identified, to indicate acknowledgement by the system.

k. DELAY FEEDBACK—When system functioning requires the operator to stand-by, such as when the computer is searching for requested data, periodic feedback should be provided the operator to indicate normal system operation and the reason for the delay.

l. ACTIVITY COMPLETION FEEDBACK—When a process or sequence is completed by the system, positive indication should be presented to the operator concerning the outcome of the process and requirements for subsequent operator actions.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.2.7 GRAPHIC CODING AND HIGHLIGHTING

The state of the technology associated with CRT displays is constantly changing, with new graphics and highlighting methods based on both software and hardware capabilities frequently being introduced. Process computer CRT displays which utilize these techniques can provide valuable enhancement of displayed information, and support improved observer recognition and understanding of displayed data. Misguided or unnecessary use of such techniques can distract the observer, create confusion, and induce errors. The principles that follow are purposely general in order to provide flexibility to control room designers and promote creative application of useful aspects of this technology.

a. USE OF HIGHLIGHTING—Highlighting should be used to attract the operator's attention to any displayed data item or message which is important to decisionmaking or action requirements.

b. CONSISTENT APPROACH

(1) Highlighting methods which have information value beyond their attention-getting quality should have the same meaning in all applications.

(2) Highlighting methods associated with emergency conditions should not also be used in association with normal conditions.

c. CONTRAST ENHANCEMENT—When contrast enhancement (i.e., increased illumination intensity level) is used for highlighting, not more than two (preferable) or three (maximum) brightness levels should be used in a single presentation.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.2.7 GRAPHIC CODING AND HIGHLIGHTING (Cont'd)

d. FLICKER OR BLINKING—Blinking of a symbol or message (e.g., ON-OFF or alternating high-low brightness) for purposes of highlighting should be reserved for emergency conditions or similar situations requiring immediate operator action.

e. BLINK RATES

(1) When blinking is used for highlighting, a maximum of 2 blink rates should be used.

(2) When a single blink rate is used, the rate should approximate 2-3 "blinks" per second with a minimum of 50 msec "on" time between blinks.

(3) When 2 blink rates are used, the fast blink should approximate 4 per second and the slow blink should approximate 1 per second.

(4) When 2 blink rates are used, the "on-off" ratio should approximate 50%.

(5) When 2 blink rates are used, the higher rate should apply to the most critical information.

f. INVERSE VIDEO—Image reversal (e.g., dark characters on a light background) should be used primarily for highlighting in dense data fields, such as a word or phrase in a paragraph of text, or a set of characters in a table of data.

g. USE OF GRAPHIC CODING—Graphic coding methods (e.g., symbols, boxes, underlines, colors) should be used to present standard qualitative information to the operator or to draw the operator's attention to a particular portion of the display.

COMPLIANCE CHECKLIST

	N/A	Yes	No	Reference/Comment
7.2.7 GRAPHIC CODING AND HIGHLIGHTING (Cont'd)				
h. GRAPHIC CODE CONSISTENCY – Graphic codes, used seperately or in combination, should have the same meaning in all applications.				
i. GEOMETRIC SHAPE CODING– Does the geometric shape coding conform to specific plant standard?				
j. NUMBER OF SYMBOLS				
(1) The number of basic symbols used for coding should be kept small.				
(2) The upper limit under optimum display conditions should be 20.				
(3) The upper limit under adverse display conditions should be 6.				
(4) When needed, other highlighting and graphic techniques (color, filled versus unfilled, and other "modifiers") should be used to display different states or qualities of a basic symbol.				
k. USE OF COLOR—The many hues (colors) and saturations (lightness and darkness) available in modern CRT displays are virtually limitless. Care must be taken to select the best colors and to specify their use such that they will be consistent with the use of all other colors in the control room.				
(1) Colors used on the CRT to convey information should be consistent in use and meaning with all other color codes in the control room.				
(2) Once colors are assigned a specific use or meaning, no other color should be used for the same purpose.				

APPENDIX A

PROCESS COMPUTERS 7.0
CATHODE RAY TUBE (CRT) DISPLAYS 7.2

"PAGE INTENTIONALLY LEFT BLANK."

COMPLIANCE CHECKLIST

	N/A	Yes	No	Reference/Comment
7.2.7 GRAPHIC CODING AND HIGHLIGHTING (Cont'd) l. COLOR MEANINGS—When color is used, the meaning of the colors should, where applicable, equate with the commonly understood meaning of those colors. The following specific meanings for selected colors should apply when these colors are used in CRT displays: (1) Does the color code used in the CRT displays conform to the CRT color standard for the specific plant?				
m. RED-GREEN COMBINATIONS (1) Whenever possible, red and green colors should not be used in combination. (Use of red symbols/characters on a green background should especially be avoided.)				

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.2.8 MULTIPLE-PAGE CONSIDERATIONS

When it is necessary for a presentation to encompass more than a single page, or when scrolling, panning, and zooming of a single page is anticipated, the following principles apply.

a. OPERATOR MEMORY

(1) Page design and content planning should minimize requirements for operator memory.

(2) All data relevant to a specific operator entry should be displayed on a single page.

b. AUDIT TRAIL—When pages are organized in a hierarchical fashion, containing a number of different paths through the series, a visual audit trail of the choices should be available upon operator request.

c. LOCATION REFERENCES

(1) When the operator is required to scroll or pan on a large logical frame, location references should be provided in the viewable portion of the frame. (For example, when scrolling a list, only part of which is visible at any one time, the present and maximum location should be shown.)

(2) Sectional coordinates should be used when large schematics must be panned or magnified.

d. OPERATOR CONTROL—The operator should have some capability for controlling the amount, format, and complexity of information (e.g., core dumps, program outputs, error messages) being displayed by the system.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.2.8 MULTIPLE-PAGE CONSIDERATIONS (Cont'd)

e. LOCATION CONSISTENCY—If the message is a variable option list, common elements should maintain their physical relationship to other recurring elements.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.3.1 PRINTER CHARACTERISTICS

In most process computer systems, printers comprise a principal interface between the computer and the operator. Printers are used to provide an historical record of all parameters monitored by the computer, as well as a real-time "display," whether or not the data are presented on CRTs. As such, the printers and the data displayed on them must receive the same level of consideration as all other operator-computer interfaces.

a. PRINTER APPLICATIONS

(1) Control room printers should provide the capability to record alarm data, trend data, and plant status data.

b. DISPLAY COPIES

(1) The system should be designed to provide hard copy of any page appearing on the CRT at the request of the operator.

(2) If the copy will be printed remote to the operator, a print confirmation or denial message should be displayed.

(3) Printer operation should not alter screen content.

c. FORM OF PRINTED INFORMATION—Printed information should be presented in a directly usable form with minimal requirements for decoding, transposing, and interpolating.

d. PRINTER SPEED—Printers used for recording trend data, computer alarms, and critical status information should have a high-speed printing capability of at least 300 lines a minute to permit printer output to keep up with computer output.

COMPLIANCE CHECKLIST

7.3.1 PRINTER CHARACTERISTICS (Cont'd)	N/A	Yes	No	Reference/Comment
e. PRINTER OPERATION—Paper, ribbons, and ink (if used) should be consistent with the following:				
(1) Hard-finish matte paper should be used to avoid smudged copy and glare.				
(2) There should be a positive indication of the remaining supply of recording materials.				
(3) Instructions for reloading paper, ribbon, ink, etc. should appear on an instruction plate attached to the printer.				
(4) When the printer is down during reloading, data and information which would normally be printed must not be lost.				
(5) A takeup device for printed materials should be provided which requires little or no operator attention and which has a capacity at least equal to the feed supply.				
f. PRINT COPY ACCESSIBILITY—The following features should be provided to enhance operator accessibility of printed material:				
(1) Provisions should be made so that the operator can always read the most recently printed line.				
(2) Printed material should have an adequate contrast ratio to ensure easy operator reading.				
(3) It should be possible to annotate the print copy while it is still in the machine.				
(4) The recorded matter should not be obscured, masked, or otherwise hidden in a manner which prevents direct reading of the material.				

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

7.3.2 ALARM MESSAGES

Alarm messages are quantitative descriptions of those out of tolerance conditions which have been displayed to the operator in abbreviated form by way of illuminated annunciator tiles.

a. ALARM RECORDS

(1) A printer should be provided for recording alarm messages.

(2) All annunciator alarms should be recorded.

b. ALARM SEQUENCE—Alarm messages should be recorded in the sequence of their occurrence.

c. OPERATOR-REQUESTED PRINTOUT—Provisions should be included to provide, upon operator request, printouts by alarm group (e.g., system, subsystem, component).

d. ALARM IDENTIFICATION—Alarm messages should be readily distinguishable from other messages.

e. ALARM DISCRIMINATION—Alarm messages should provide rapid identification of the nature of the alarm.

f. CONSISTENT TERMINOLOGY—Wording in alarm messages should:

(1) Clearly relate to the specific annunciator tile that is illuminated.

(2) Contain at least that information (i.e., wording) presented in the illuminated annunciator tile.

(3) Provide additional specific data.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	References/Comments

7.3.3 GRAPH AND TABLE REQUIREMENTS

When printers are used to record/present tabular data, or graphic information, factors similar to those applicable to CRT displays should apply.

a. SHAPE OF FUNCTION—If the general shape of the function is important in making decisions, a graph should be used.

b. INTERPOLATION—If interpolation is necessary, line graphs are preferable to bar graphs and tables.

c. GRIDS

(1) Graphs should be constructed so that numbered grids are bolder than unnumbered grids.

(2) If 10-grid intervals are used, the fifth intermediate grid should be less bold than the numbered grid, but bolder than the unnumbered grids.

d. TABLES

(1) Tables should be simple, concise, and readable.

(2) When table columns are long, numbers should be separated into groups by providing a space between groups of five.

(3) When columns are not separated by vertical lines, the columns should be separated by at least 2 character widths.

8.0 CONTROL-DISPLAY INTEGRATION

NOTE TO CRDR REVIEWER: REFER TO THE MAIN CONTROL ROOM PANEL PHOTOGRAPHS AND PLANT SPECIFIC PANEL DRAWINGS PRIOR TO THE SURVEY.

CONTROL-DISPLAY INTEGRATION 8.0

BASIC CONTROL-DISPLAY POSITION RELATIONSHIPS 8.1

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

8.1.1 SINGLE CONTROL AND DISPLAY PAIRS

Controls and displays which are normally used together should be located in close proximity to each other, but positioned and separated sufficiently so that the display is not obstructed during operation.

a. PROXIMITY—A visual display that will be monitored during control manipulation should be located sufficiently close that an operator can read it clearly and without parallax from a normal operating posture.

b. OBSCURATION—Controls and displays should be located so that displays are not obscured during control operation (see Exhibit 8-1).

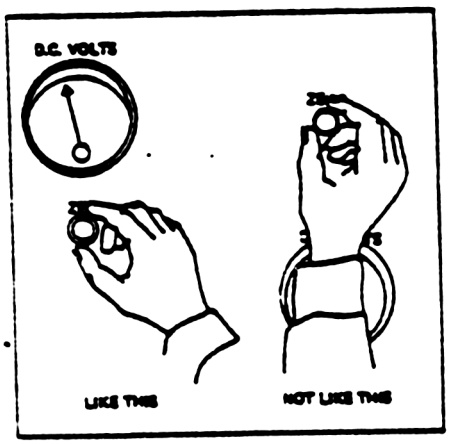

Exhibit 8-1 Manipulation of a control should not obscure the related display.

8.1.1 SINGLE CONTROL AND DISPLAY PAIRS (Cont'd)

c. ASSOCIATION—Related controls and displays should be easily identified as being associated. This association can be established (or enhanced) by (1) location, (2) labeling, (3) coding, (4) demarcation, and (5) consistency with operator expectations. The following relationships should be immediately apparent to the operator:

(1) Association of displays with controls.

(2) The direction of movement of control and display.

(3) The rate and limits of movement of the control and display.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

CONTROL-DISPLAY INTEGRATION 8.0

BASIC CONTROL-DISPLAY POSITION RELATIONSHIPS 8.1

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

8.1.2 MULTIPLE CONTROLS OR DISPLAYS

The control and monitoring of nuclear power plant systems will occasionally require either multiple controls or multiple displays. Control display relationships in multiple arrays should be apparent to the operator and consistent with human expectations.

a. MULTIPLE CONTROLS, SINGLE DISPLAY—When several interacting controls are associated with a single display, the array should conform to the following conditions:

(1) Controls should be mounted below the display.

(2) Controls should be centered on the display.

(3) Controls should be grouped in a line or matrix.

(4) If not feasible to mount controls directly below the display, controls should be mounted to the right of the display.

(5) Where there is a normal order of use, controls should be arranged for use in left-to-right, top-to-bottom, or other natural sequence.

(6) Where the above techniques cannot apply, or where for other reasons the relationships are not readily apparent, layout enhancement techniques should be employed—spacing, demarcation, color shading, insert panels, panel relief, and the use of mimics.

8.1.2 MULTIPLE CONTROLS OR DISPLAYS (Cont'd)

b. SINGLE CONTROL, MULTIPLE DISPLAYS— When more than one display is affected by a single control, the array should conform to the following conditions:

(1) Displays should be located above the control.

(2) The control should be placed as near as possible to the display, and preferably underneath the center of the display array.

(3) Displays should be arranged horizontally or in a matrix.

(4) If it is not feasible to mount displays above the control, they should be mounted to the left of the control.

(5) Where there is a normal order of use, displays should read from left-to-right, top-to-bottom, or in other natural sequence.

(6) Where the above techniques cannot apply, or where for other reasons the control-display relationship is not clearly apparent, layout enhancement techniques should be employed.

(7) Displays should not be obscured during control manipulation.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

8.1.2 MULTIPLE CONTROLS OR DISPLAYS (Cont'd)

c. DISPLAY SELECTORS—Where displays are selected for viewing using a rotary selector switch, the following should apply:

(1) The control should move clockwise from OFF (if appropriate) through settings 1, 2, 3...n.

(2) The control position sequence should conform to the display sequence.

(3) Control position indications should correspond with display labels.

(4) Displays should read off-scale, not zero, when not selected, especially if zero is a possible parameter displayed (see Exhibit 8-2).

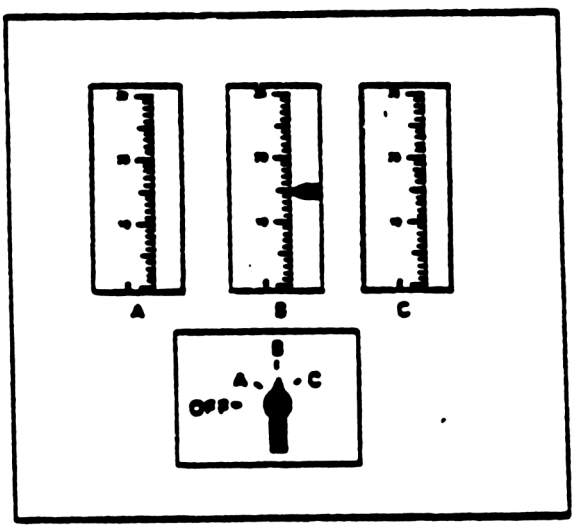

Exhibit 8-2. Displays sequenced by a rotary selector switch. Displays not operating should read off scale—not zero.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

8.2.1 LOCATION AND ARRANGEMENT OF CONTROL-DISPLAY GROUPS

a. FUNCTIONAL INTEGRITY – Multiple controls or displays related to the same function (e.g., power, status, test) should be grouped together.

b. SEQUENCE OF USE – Sequence of use should be as follows:

(1) Left to right.

(2) Top to bottom.

(3) The above combined (normal reading order).

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

8.2.2 SINGLE PANEL ARRANGEMENTS

Appropriate arrangements for control-display relationship, in order of preference, are (a) display above each control, (b) displays and controls in matched rows, and (c) multi-row displays with a single row of controls. Practice should be consistent, so that operator expectations are not confused.

a. DISPLAY ABOVE EACH CONTROL—The preferred configuration is as shown by Exhibit 8-3, with the display above each control. If this configuration is used, the following should apply:

(1) Each display should be located directly above its associated control.

(2) The display/control pairs should be arranged in rows.

b. CONTROLS AND DISPLAYS IN ROWS—As an alternative, displays may be arrayed in rows as the upper portion of a panel, matched to controls arrayed in similar rows below, as shown in Exhibit 8-4.

(1) Each control should occupy the same relative position as the display to which it is associated.

(2) Controls and displays should have corresponding labels.

c. MULTI-ROW DISPLAYS WITH SINGLE-ROW CONTROLS—A less desired arrangement is that of Exhibit 8-5, in which two or more rows of displays are arrayed above a single row of controls.

(1) Displays should be ordered left to right and top to bottom (in normal reading order), and matched to controls ordered left to right.

(2) Controls and displays should have corresponding labels.

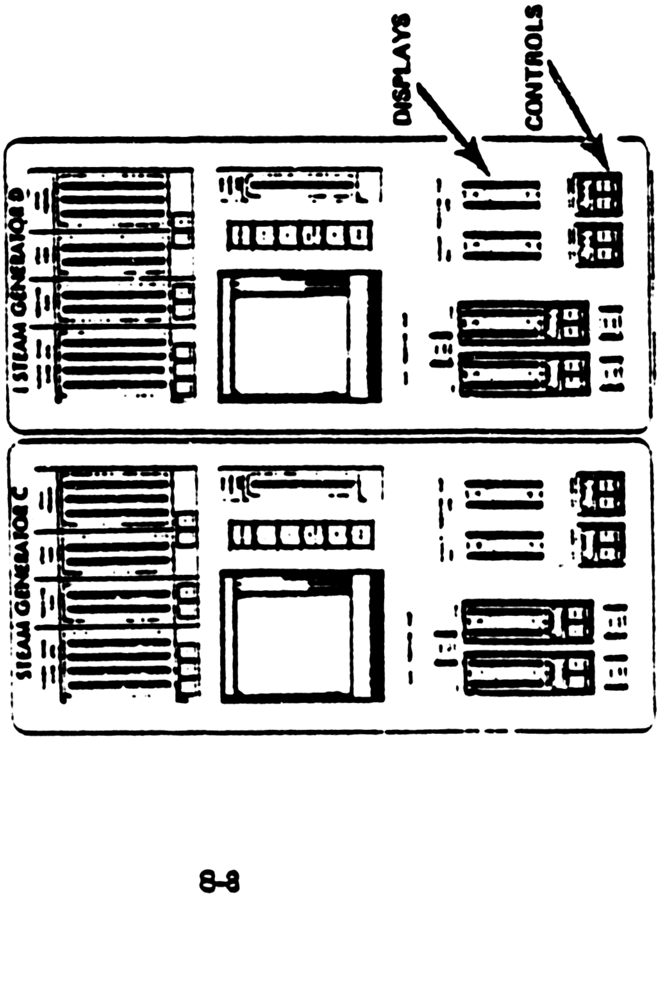

Exhibit 8-3. Control-display pairs arranged in a matrix. Displays above controls (arrows) is the preferred arrangement.

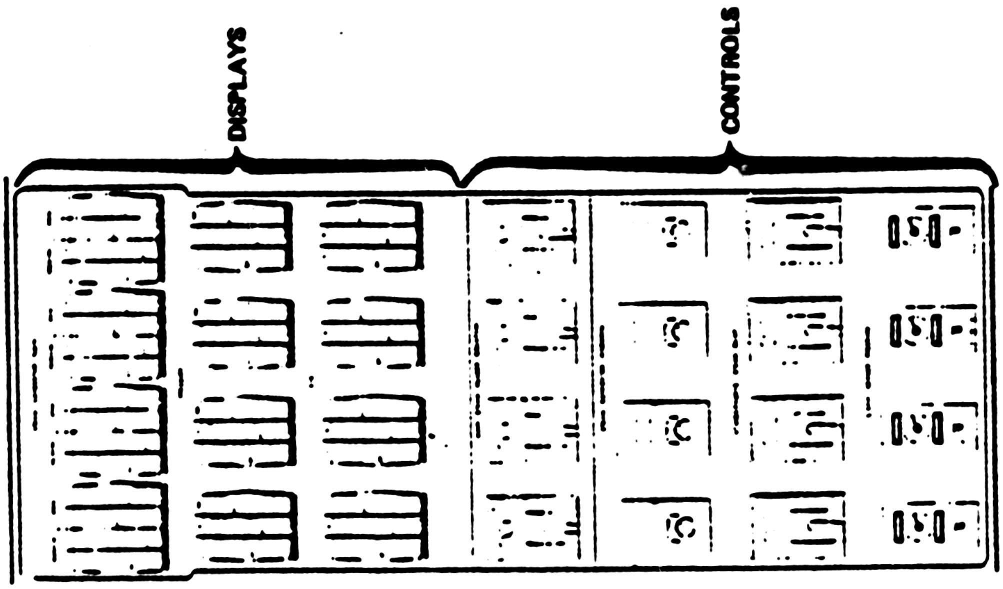

Exhibit 8-4. Rows of displays located in the same relative positions as their associated controls on the lower panel. (from Seminara et al., 1979)

CONTROL-DISPLAY INTEGRATION 8.0
GROUPS OF CONTROLS AND DISPLAYS 8.2

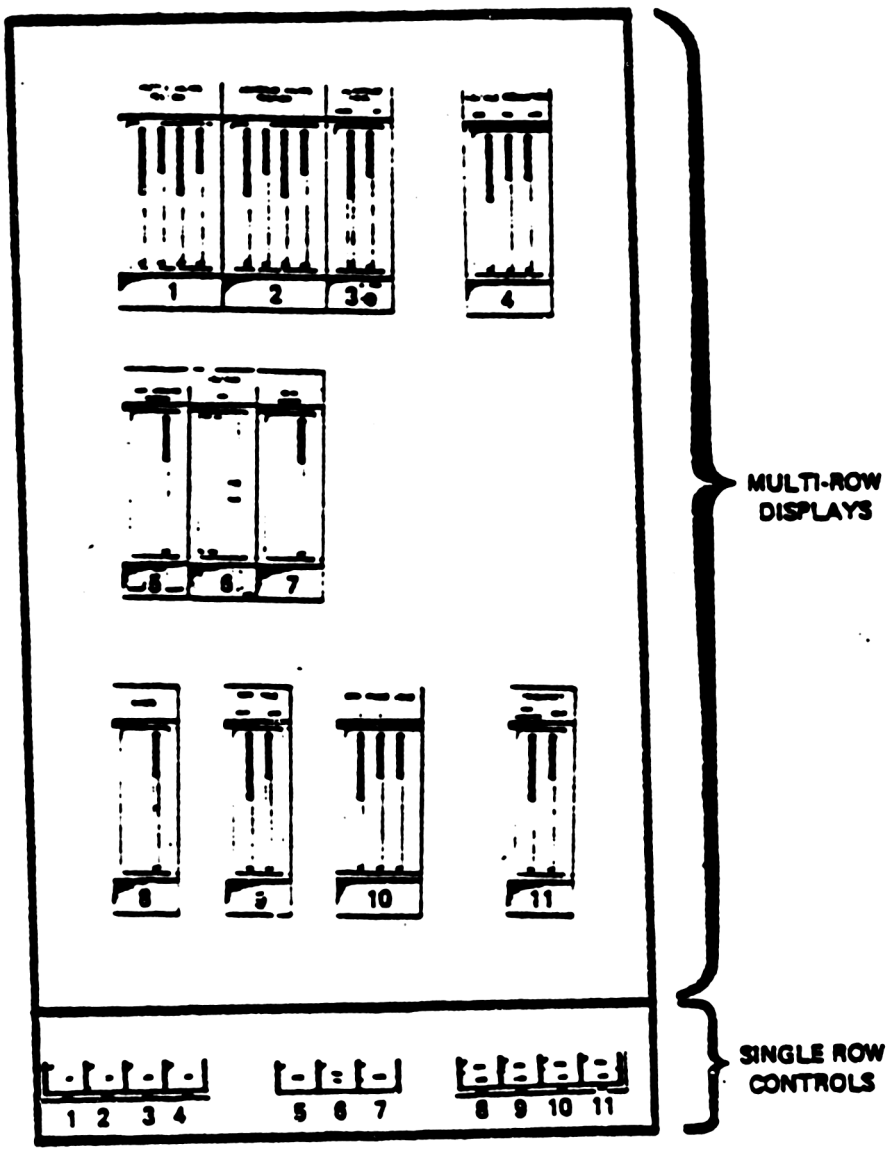

Exhibit 8-5. Multi-row displays with a single row of controls (controls and displays coded by number).

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

8.2.2 SINGLE PANEL ARRANGEMENTS (Cont'd)

d. CONSISTENT PRACTICE—Arrangements of functionally similar controls and displays should conform to the same convention throughout the control room.

e. CONTROL/DISPLAY PACKAGES—When controls and related displays are assembled using modular packaged units, the design of the packages will limit the location and arrangement which can be achieved. In this case, modules should be selected and arranged to achieve maximum conformity with the principles described above.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	References/Comment

8.2.3 CONTROLS AND DISPLAYS IN SEPARATE PLANES

a. SEPARATED CONTROLS AND DISPLAYS—Where displays are on separated panels, they should be on the adjacent upper panel from their associated controls. See Exhibit 8-6.

b. FACING PANELS—In no case should related controls and displays be located on separate panels that face each other.

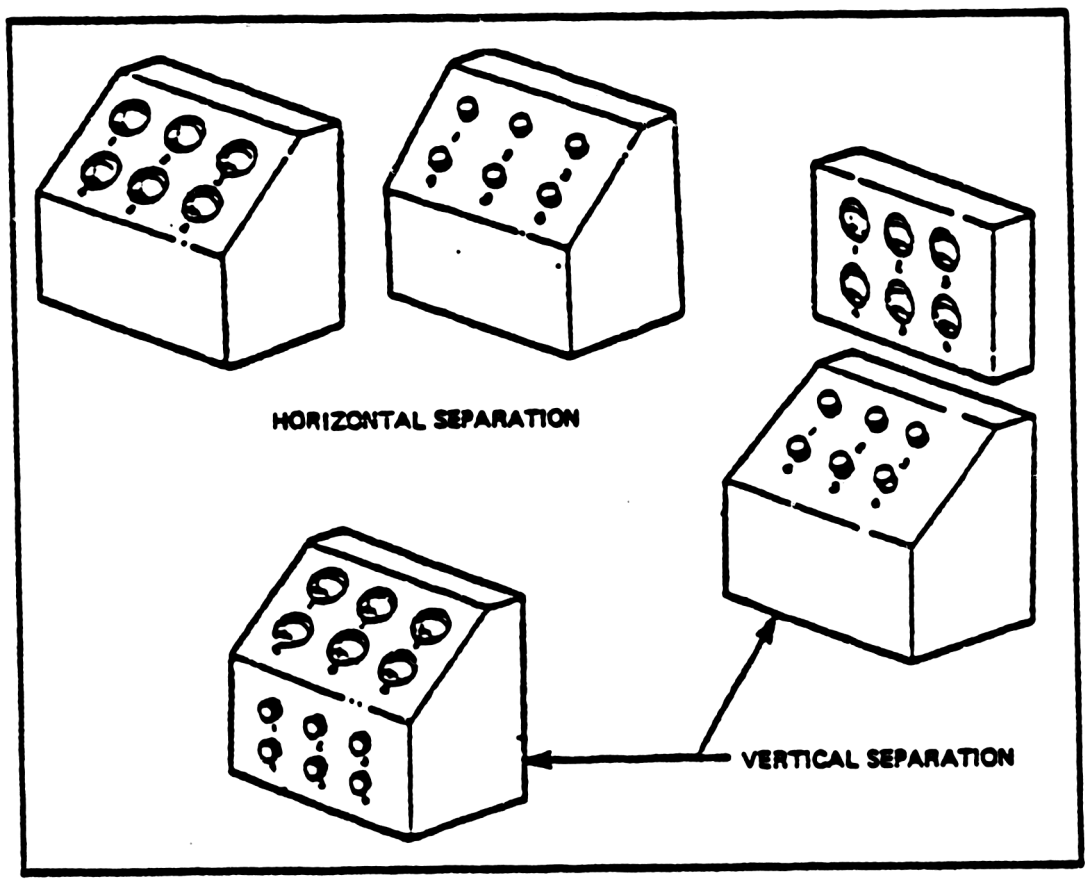

Exhibit 8-6. Acceptable arrangements for displays and controls on separate panels.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

8.3.1 GENERAL MOVEMENT RELATIONSHIPS

The response of a display to control movements should be consistent, predictable, and compatible with the operator's expectations. The following principles apply to general movement relationships.

a. ROTARY CONTROLS—Rotary controls should turn clockwise to cause an increase in parameter value. The associated display movements should be as follows:

(1) Linear scales, up or to the right.

(2) Digital displays, increasing in value.

(3) Strings of indicator lights, bottom-to-top or left-to-right.

(4) Circular meter pointers, clockwise.

b. LINEAR CONTROLS—Linear controls should move up or to the right to cause an increase in parameter value. The associated display relationships should be:

(1) Linear scales, up or to the right.

(2) Digital displays, increasing in value.

(3) Strings of indicator lights, bottom-to-top or left-to-right.

c. DISPLAY RESPONSE TIME LAG—In some cases there will be a time lag between the actuation of a control and the resulting change in system condition. That condition should be reflected by displays in real time.

(1) There should be no time lag between system condition change and display indication.

(2) When there is a time lag between control actuation and ultimate system state, there should be an immediate feedback indication of the process and direction of parameter change.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

8.3.2 CONTROL-DISPLAY RATIO

Control-display ratio should not be a consideration in evaluating control-display relationships. Control-display ratio will be determined by the separate requirements for precision of controls and displays.

a. CONTROLS—Controls should provide a capability to affect the parameter controlled easily, with the required level of precision. They should be effective in sufficient time, under expected dynamic conditions, and within the limits of manual dexterity, coordination, and reaction time.

b. DISPLAYS—Displays should provide a capability to distinguish significant levels of the system parameter controlled.

c. EXCESS PRECISION — Both displays and controls should have a precision which does not greatly exceed that required.

d. FEEDBACK — Feedback from the display should be apparent for any deliberate movement of a control.

9.0 PANEL LAYOUT

PANEL LAYOUT 9.0
GENERAL PANEL LAYOUT 9.1

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

9.1.1 ASSIGNING PANEL CONTENTS

Controls and displays should be placed within the control room at locations which promote efficient procedures, safe operation, and maximum operator awareness of the current system condition. There are three general methods for achieving this condition. They are: (a) grouping by task sequence, (b) grouping by system function, and (c) grouping by importance and frequency of use.

a. GROUPING BY TASK SEQUENCE—Controls and displays should be assigned to work stations so as to minimize operator movement. To the extent practical, this assignment should consider both normal and emergency procedures. It should be practical to perform all frequently occurring routine tasks, and time-sensitive emergency tasks, with a minimum of human movement from panel to panel.

b. GROUPING BY SYSTEM FUNCTION—Within the constraints of grouping by task sequence, controls and displays should be assigned to panels in functional groups related to system structure. This grouping should promote easy understanding of the relationship between controls and system, and should assist graphic or pictorial display of system relationships.

c. GROUPING BY IMPORTANCE AND FREQUENCY OF USE—Within the constraints of grouping by task sequence and by system function, controls and displays should be assigned to panels depending on their importance and frequency of use. Controls or displays which are neither important to plant safety nor frequently used should be installed in secondary panel locations.

PANEL LAYOUT 9.0
GENERAL PANEL LAYOUT 9.1

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

9.1.2 EFFECTIVE PANEL LAYOUT

The location of controls and displays within a single panel should make the most effective use of the viewing and manual manipulative areas. The allocation of panel positions should first ensure the integrity of arrangement or grouping by system function and task sequence. Within those constraints, consideration should be given to the following factors: (a) the frequency with which controls and displays are used; (b) the significance of controls and displays in terms of their possible use during an emergency; (c) the importance of controls and displays to overall system performance; and (d) special requirements in using a control device or display instrument, such as the need for accuracy, speed, application of force, or a particular type of movement.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

9.1.3 ENHANCING RECOGNITION AND IDENTIFICATION

Several enhancement techniques are available for setting apart groups of controls and displays. Three preferred techniques for enhancement are spacing, demarcation, and color shading. Other acceptable techniques for setting apart groups of controls include the use of insert panels and added panel relief.

a. SPACING – Spacing consists of physically separating groups of components on a panel with enough space between groups so that the boundaries of each group are obvious. Spacing between groups should be at least the width of a typical control or display in the group (see Exhibit 9-1).

b. DEMARCATION – Demarcation consists of circumscribing functional or selected groups of controls and displays with a contrasting line.

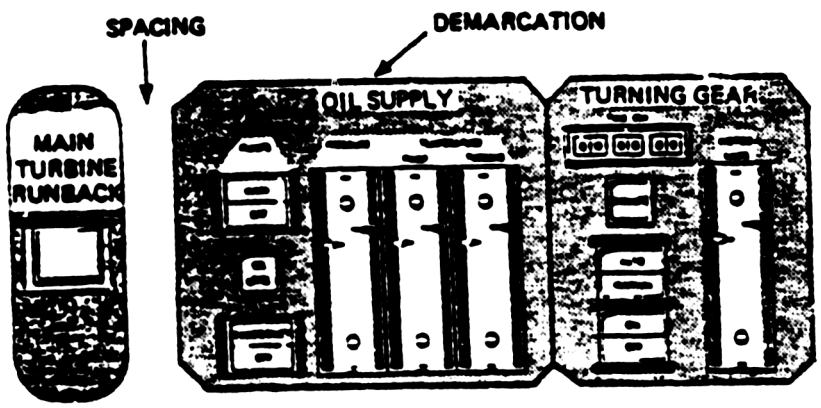

Exhibit 9-1. Separation of functional groups by spacing and demarcation.

9.1.3 ENHANCING RECOGNITION AND IDENTIFICATION (Cont'd)

c. **COLOR SHADING** – Color shading may be used to enhance recognition of controls, displays, or functional groups. When color shading is used, colors should provide adequate contrast, and should be consistent with other color coding in the control room.

d. **EMERGENCY CONTROLS** – Distinctive enhancement techniques should be used for emergency controls.

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

9.2.1 SEQUENCE, FREQUENCY OF USE, AND FUNCTIONAL CONSIDERATIONS

The layout of panels is a compromise among a number of considerations. In some instances, various human factors principles will conflict, not only with each other but also with other design requirements. Because it is difficult to rate the conflicting considerations for importance, final decisions must be based on careful evaluation and sound judgment. This subsection deals with the analysis of the factors of task sequence, frequency of use, and function.

a. SEQUENCE—Controls and displays which are used together during a normal task sequence should be grouped together.

(1) Displays which are observed in a specified sequence, as during hot-leg temperature check for all reactor coolant loops, should be grouped together. It is desirable that they be positioned so that they are normally used in a left-to-right, top-to-bottom, or other natural sequence.

(2) Controls which are operated in sequence, as in energizing a system or aligning a series of valves for a particular function, should be grouped together. It is desirable that they be positioned so that they are normally used in a left-to-right, top-to-bottom, or other natural sequence.

(3) When there is a set of related controls and displays, the layout of displays should be symmetrical with the controls they represent.

COMPLIANCE CHECKLIST

9.2.1 SEQUENCE, FREQUENCY OF USE, AND FUNCTIONAL CONSIDERATIONS (Cont'd)	N/A	Yes	No	Reference/Comment
[redacted]				
b. FREQUENCY OF USE—Frequently used controls and displays should be arranged to reduce search time and minimize the potential for error during use.				
(1) They should be near the center of the preferred visual and manual areas.				
(2) They should be positioned so as to be easily identified.				
c. FUNCTIONAL CONSIDERATIONS—Functionally related controls and displays should be grouped together when they are:				
(1) Used together to perform tasks related to a specific function (e.g., operation of the residual heat removal system).				
(2) Identical in purpose (e.g., reactor coolant pumps).				

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

9.2.2 LOGICAL ARRANGEMENT AND LAYOUT

The arrangement of controls and displays should be logical, but should not compromise sequence of operations or functional integrity. Logical arrangements are generally based on operator expectations. In general, operator expectations will be met when components have a left-to-right or top-to-bottom arrangement and are identified in alphabetic or numeric sequence. For example, four related displays in a row should be designated A, B, C, D, or 1, 2, 3, 4; correspondingly, any controls related to these displays should also be designated A, B, C, D, and 1, 2, 3, 4. Well-designed system mimics will help to direct and satisfy operator expectations.

a. ORDER AND LABELING – Components should be arranged left-to-right and/or top-to-bottom, and be identified in alphabetic or numeric sequence.

b. OTHER EXPECTATIONS – Where other operator expectations can be identified, components should be arranged to match these expectations.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

9.2.3 LAYOUT CONSISTENCY

The location and arrangement of recurring functional groups and of individual components of those groups should be similar from panel to panel or within a panel.

a. REPEATED FUNCTIONS – The layout of identical control or display sets should be consistent at all locations.

b. MIRROR-IMAGING – Layouts of repeated functions should not be mirror-imaged.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

9.2.4 STANDARDIZATION

When a precedent has been established in the arrangement and location of controls and displays, that standard practice should be followed unless other crucial considerations necessitate a change.

a. PANEL TO PANEL STANDARDIZATION—Standardization should be maintained where similar functions or panels are located at several work stations or units and must be used by the same personnel.

b. SIMULATOR-TO-CONTROL ROOM STANDARDIZATION—Standardization should be maintained where simulators or procedure trainers are used that simulate the actual operational equipment.

PANEL LAYOUT 9.0
SPECIFIC PANEL LAYOUT DESIGN 9.3

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

9.3.1 SEPARATION OF CONTROLS

Recommended minimum control separation distances are shown in Exhibits 9-2 and 9-3. In most cases, control room operations will require greater separation. The functional requirements that should be considered are:

a. ACCESS – Control access should not be impeded by any position of an adjacent control.

b. INADVERTENT ACTUATION – Control actuation should not result in inadvertent actuation of an adjacent control.

c. SIMULTANEOUS ACTUATION – Simultaneous actuation of adjacent controls (where required) should be possible.

Control	Minimum Separation (Inches)										
	Key-Operated Controls	Push-buttons Not in an Array	Push-button Arrays	Legend Switches, Legend Switch Array	Slide Switches, Rocker Switches	Toggle Switches	Thumb-wheels, Thumb-wheel Arrays	Rotary Selector Switches	Continuous Rotary Controls	J-Handles (Large)	J-Handles (Small)
Key Operated Controls	1.0	0.5	1.5	1.0	0.75	0.75	0.5	0.75	0.75	5.0	2.0
Pushbuttons Not in an Array	0.5	0.5	2.0	2.0	0.5	0.5	0.5	0.5	0.5	6.0	3.0
Pushbutton Arrays[1]	1.5	2.0	2.0	2.0	1.5	1.5	1.5	2.0	2.0	6.0	3.0
Legend Switches, Legend Switch Arrays[2]	1.0	2.0	2.0	2.0	1.5	1.5	1.5	2.0	2.0	6.0	3.0
Slide Switches, Rocker Switches	0.75	0.5	1.5	1.5	0.5	0.75	0.5	0.5	0.5	5.0	2.0
Toggle Switches[3]	0.75	0.5	1.5	1.5	0.75	0.75	0.5	0.75	0.75	6.0	3.0
Thumbwheels, Thumbwheel Arrays	0.5	0.5	1.5	1.5	0.5	0.5	0.5	0.75	0.75	6.0	2.0
Rotary Selector Switches	0.75	0.5	2.0	2.0	0.5	0.75	0.75	1.0	1.0	6.0	2.0
Continuous Rotary Controls	0.75	0.5	2.0	2.0	0.5	0.75	0.75	1.0	1.0	6.0	2.0
J-Handles (Large)	5.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	3.0	6.0
J-Handles (Small)	2.0	3.0	3.0	3.0	2.0	3.0	2.0	2.0	2.0	6.0	1.0

[1] Pushbuttons within an array, 0.75 inches center-to-center.

[2] Legend switches within an array, no minimum distance, but should be separated by a barrier. Barrier should be at least 0.125 inches wide, 0.183 inches high, with rounded edges. Legend switches manufactured as elements of a module or modular array may be mounted as closely as engineering considerations permit.

[3] Toggle switches arrayed in a horizontal line, 0.75 inches center-to-center.

Exhibit 9-2. Minimum separation distances for controls. Distances are measured from edge-to-edge of the control rotation envelopes (see exhibit 9-5 which follows). Distances shown are industry-wide minimums, and are less than the desirable minimum separation for nuclear power plant control rooms.

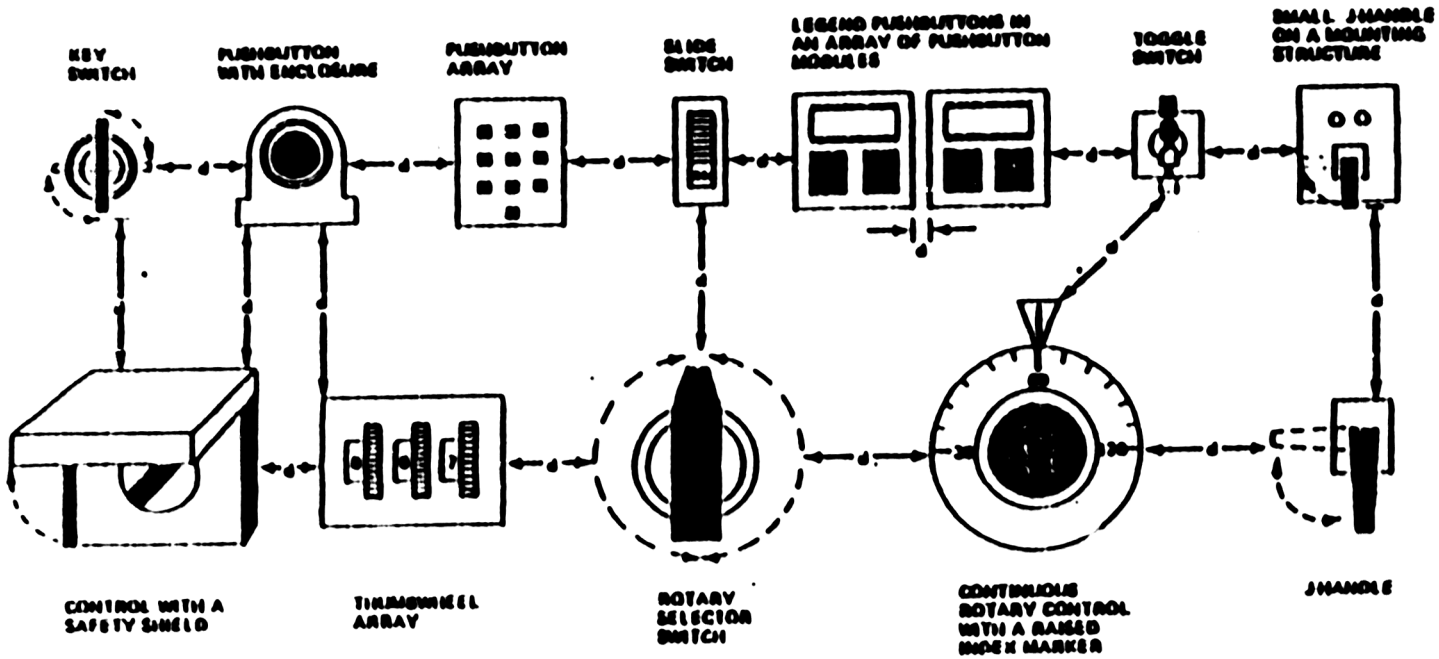

Exhibit 9-3. Measurement of minimum separation distance between controls. Distances (d) shown on Exhibit 9-4 (preceding) are measured from edge-to-edge of the maximum rotation (or movement) envelope of the control. This is the outside dimension of the control in all possible positions, including the body of the control, its supporting structure, and any housing or shield in all positions of the shield.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

9.3.2 STRINGS OR CLUSTERS OF SIMILAR COMPONENTS

On occasion it may be necessary to have a large group of similar components arranged together in strings, matrices, or other clusters. Those human factors principles presented in Section 9.2, Layout Arrangement Factors, should not be compromised where large clusters of components are concerned. However, considerations such as search time, discriminability of components, and avoidance of selection errors will often make a string or matrix the preferred arrangement. The following criteria should apply:

a. ORIENTATION—Horizontal rows of displays should be used rather than vertical columns (see Exhibit 9-4).

b. STRING LENGTH—Strings of small displays should not exceed about 20 inches on the control board.

c. NUMBER OF COMPONENTS

(1) No more than 5 similar components should be laid out in an unbroken row or column.

(2) If more than 5 similar components must be laid out together, the string or cluster should be broken up by techniques such as physical spacing or demarcation (see Exhibit 9-5).

d. LARGE MATRICES

(1) Large matrices of similar components should have the coordinate axes labeled for identification of any single component within the grid. The left and top sides of the matrix should be used for labeling (see Exhibit 9-6).

(2) Large matrices should be subdivided by appropriate demarcation.

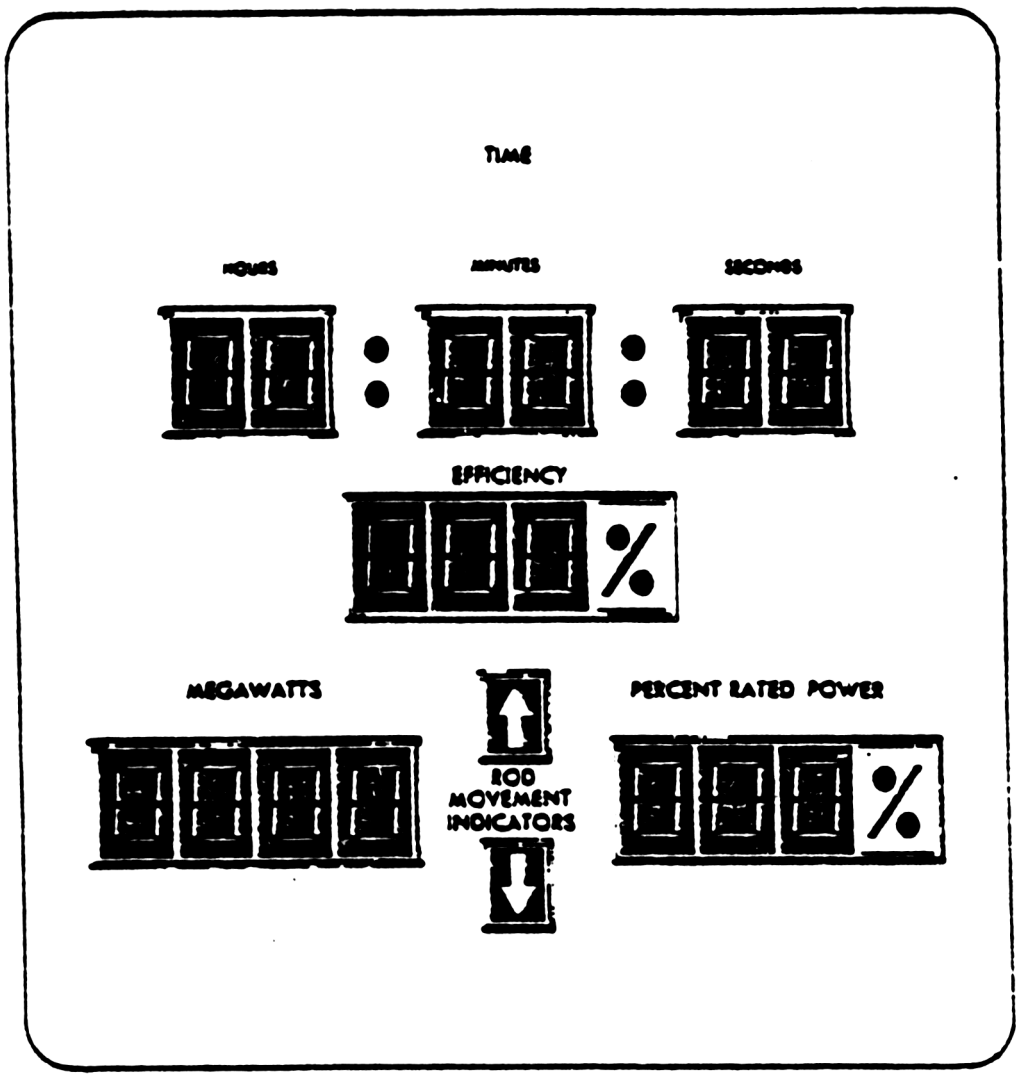

Exhibit 9-4. Horizontal orientation is preferred over vertical orientation.

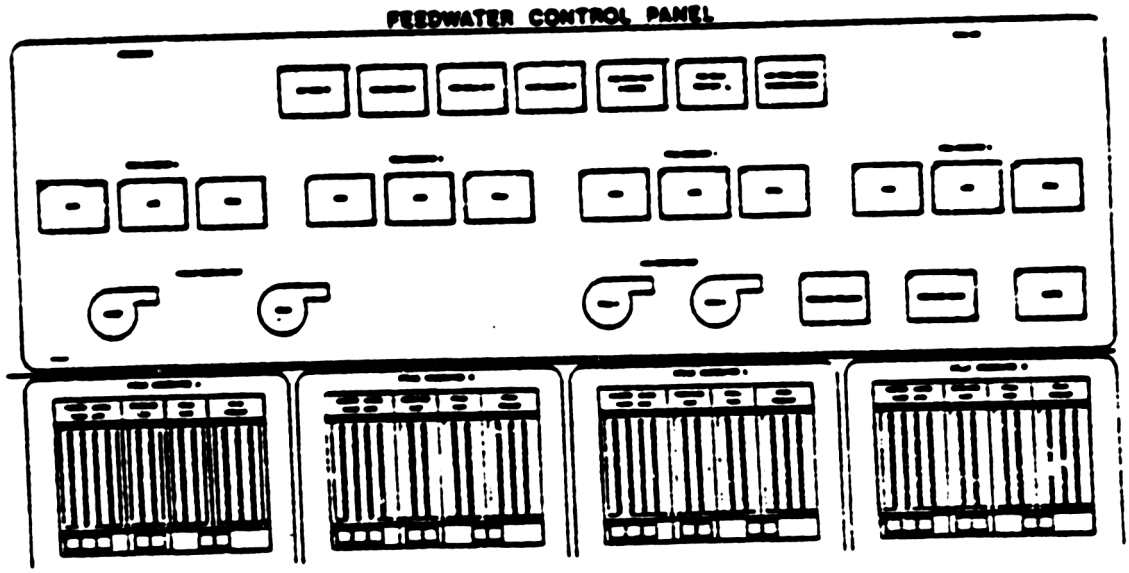

Exhibit 9-5. Long strings of components should be broken by spacing or demarcation.

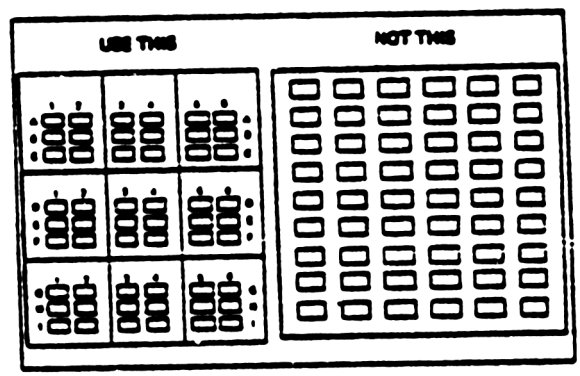

Exhibit 9-6. Coordinate axes of grid should be labeled, and appropriate delineation used to subdivide the matrix.

GUIDELINE

COMPLIANCE CHECKLIST

N/A	Yes	No	Reference/Comment

9.3.3 MIRROR-IMAGING

Mirror-imaging is an arrangement in which two functional groups are laid out symmetrically so that one is a complete, or almost complete, reversal of the other. Mirror-imaging should not be used, and any recurring functional groups should be replicated.