# DESIGN DIRECTIVE FOR CATHODE RAY TUBE SELECTION

| PREPARED BY: | REVIEWED BY: | APPROVED BY: |
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| 12/6/83 | | |

FOREWORD: Cathode Ray Tubes (CRTs) providing interface between the computer output and operating personnel shall be selected for maximum readability. While software generation, CRT location and room lighting conditions are important considerations in determining readability, the factors given in this Design Directive shall be applied in the FSV Control Room. Where given factors are contingent upon software, location, and room lighting conditions, the associated Design Directives are to be evaluated in conjunction with this directive prior to selecting or specifying CRTs.

## SELECTION CONSIDERATIONS

I. SCREEN LUMINANCE - The following screen background considerations for ambient light environments are preferred; however, where conformity to existing installations is a consideration, only the contrast ration must be met.

A. For low to medium ambient illumination environments (typically 5 to 20 footcandles), utilize light characters on a dark background, with a screen luminance of 23 foot lambert (ft-L) minimum and 45 ft-L preferred.

Contract between light characters and a dark screen background shall be 15:1 minimum and 20:1 preferred, in 20 ft-L of ambient light.

B. For medium to high ambient illumination environments (typically 20 and above footcandles), utilize dark characters on a light background, with a screen background luminance of 23 foot-Lamberts (ft-L) minimum and 46 ft-L preferred.

Contrast between dark characters and a light screen background shall be 1:15 ft-L minimum and 1:20 preferred, in 20 ft-L of ambient light.

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

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

Section III (Resolution) Subject to Revision

A. CRTs for displaying simple alpha-numeric text shall have a minimum of 20 resolution elements per inch.

B. CRTs for displaying complex symbols and graphic detail shall have a minimum of 100 resolution elements per inch.

C. Complex symbols which must be distinguished from other complex shapes shall have a minimum of 10 resolution elements for the longest dimension of the symbol.

D. Alpha-numeric characters shall have a minimum of 10 resolution elements per character height.

IV. REGENERATION RATE - The regeneration rate for a particular CRT display shall be above the critical frequency at fusion so that the occurrence of disturbing flicker is not perceptible.

V. 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 or other operating area. Distance from the operator to the screen is, therefore, variable, and must be taken into account during CRT selection. 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 figure 1). This is the vertical angle subtented 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:

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

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.

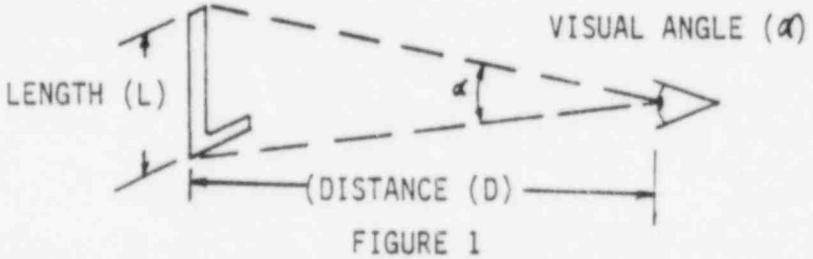


FIGURE 1
Visual angle as a function of distance and character size.

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 shall subtend not less than 20 minutes of arc at the required viewing distance.

B. ALPHA-NUMERIC CHARACTER SIZE

1. The height of alpha-numberic characters shall have a visual angle of not less than 12 minutes of arc at the required viewing distance.

2. Alpha-numberic characters should be uppercase letters.

C. CHARACTER WIDTH-TO-HEIGHT RATIO - The width-to-height ration for alpha-numerics shall be between 3:5 and 1:1.

D. LINE (or dot) WIDTH-TO-CHARACTER-HEIGHT RATIO - line (or dot) width-to-character-height ratio shall 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 shall contain a minimum of 50 resolution elements per inch.

F. CHARACTER AND SYMBOL SEPARATION

1. Horizontal separation between characters or symbols shall be between 10% and 65% of character or symbol height.

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

- When character or symbol width is less than 85% of height;
- When character or symbol luminance is less than 12 ft-L;
- When luminance contrast is less than 88%;
- When CRT screen location is greater than 35° to the left or right of the operator's straight-ahead line of sight;
- When the visual angle subtended by symbol height is less than 15 minutes of arc;
- When the visual angle subtended by character height is less than 12 minutes of arc.

G. CHARACTER SYTLE (FONT)

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

2. When dot-matrix characters are used, a 5x7 dot matrix is considered a minimum with a 7x9 matrix preferred.

3. Character styles such as Lincoln/Mitre or Leroy shall be used.

VI. CRT DISPLAY CONTROLS

A. Luminance (brightness), and contrast controls shall be visible and accessible from the operator's position. (control location behind hinged panels is acceptable, provided the panel when open, does not restrict operator access or vision.)

B. A deguassing control shall be visible and accessible from the operator's position, if manually actuated deguassing is required as a part of routine operation.

C. Operator controls shall conform to the following guidelines:

1. The minimum distance between the outermost gripping surface of any rotary control and any other control or panel structure shall be one (1) inch.

2. The minimum distance between the outermost circumferential edge of any pushbutton and other control or panel structure shall be one-half (1/2) inch.

3. Rotary knob length shall be a minimum of five-eighths (5/8) inch in length.

4. Rotary knob mean diameter shall be minimum of one-half (1/2) inch.

## ASSOCIATED DIRECTIVES

DD-DD-1 - Requirements and Guidance for Preparing Design Directives
DD-CRL-1 - Cathode Ray Tube Location
DD-SLS-1 - Screen Layout and Structuring

## SOURCE MATERIALS AND REFERENCES

NUREG-0700
Human Factors in Engineering,
McCormick, 1976