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READABILITY OF ELECTRONIC DISPLAYS

by

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## INTRODUCTION

The technological advances in the field of electro-optics over the past twenty years has led to the expanded use of electronic displays for the presentation of a wide variety of information. Cathode Ray Tubes (CRT), Light Emitting Diodes (LED), Liquid Crystals (LCD), Gas Discharge Panels, and other types of light emitting displays are being used for information displays varying from single character displays to those with 40 or more lines of data to maps and pictures.

For any display to be useful, the information that it displays must be readable. This paper discusses the more important human factor parameters affecting the readability of electronic displays. The dominant parameters are divided into categories of display design, man-machine interface, and the environmental factors. The last section of this paper briefly discusses the advantages and disadvantages of the different types of displays.

It will be emphasized that the parameters are not independent of one another. Altering one parameter may have an effect on one or more other parameters (i.e., decreasing character size may decrease resolution also). Conversely, if one parameter cannot be changed, one or more of the others may be altered to get the same resultant readability (i.e., if character size is fixed, increasing resolution or decreasing viewing distance will improve readability).

Since the bulk of displayed information is alphanumeric, the discussion will be restricted to alphanumeric displays.

## DISPLAY DESIGN CHARACTERISTICS

Many of the factors which can affect readability of a display are

intrinsic to the display machinery. Factors such as character size, resolution, and font are designed into the display; once the equipment is installed, these factors generally cannot be altered. The best time to consider these very important human factors is while designing the display or when shopping for a display.

### Symbol size

The size of the displayed character is probably the most important readability factor. Symbol size may be measured by subtended angle ( $\alpha$ ). Subtended angle allows for differences in viewing distance<sup>1</sup> by measuring character height (H) relative to viewing distance (D).

$$\tan \alpha, \text{ min of arc} = \frac{H}{D}$$

By knowing the viewing distance and the appropriate subtended angle, the appropriate character size may be selected.

Considerable research has been conducted to determine the optimum subtended angle. Results vary, but there is a general consistency. See Table 1 for values of subtended angle for "near error free" reading.

These findings agree generally with the current design standards of 10-15 min. of arc.<sup>2</sup> Note that the more recent research has emphasized the effects of other parameters such as illumination, blur, resolution, and glare on the optimum subtended angle. Under good conditions 15 minutes of arc will be readable, but as the conditions worsen, the subtended angle must increase upwards to as much as 35 minutes.

### Resolution

Resolution is the number of dots per character height (for dot matrix displays) or the number of lines per character height (for raster type CRT's). For CRT's the minimum recommended resolution is 10

Table 1

## Some Recommendations of Displayed Alphanumeric Characters\*

<u>Reference</u>	<u>Subtended Angle, minutes of arc</u>
Minimum Normal acuity (Snellen E Chart)	5
"Reasonable" size (Murrell, 1965; Fletcher, 1972)	10
Electronic Displays (Shurtleff, 1967; Gould, 1968)	12-15
"Image size" (H.E.G.; 1972)	12-20
"Preferred" size (Duncan and Konz; 1974)	17
MIL-STD-1742 (1974)	
General Labels, good viewing	16+
Non-critical Data	6-24
Critical Data	
high luminance	12-25
low luminance	25-37
"Minimum recommended" (Buckler, 1977)	
Good Conditions	15
Degraded Conditions	21-25

\*(Portions of this Table adapted from Smith, 1978)<sup>2</sup>