

**DESIGN OBJECTIVES FOR CRT DISPLAYS
FOR PART 25 (TRANSPORT) AIRCRAFT**

1. INTRODUCTION:

This SAE Recommended Practice is intended as a guide toward standard practice and is subject to change to keep pace with experience and technical advances. This report provides additional information pertinent to AS8034.

2. PURPOSE:

This Aerospace Recommended Practice (ARP) recommends display system performance criteria for direct view cathode-ray-tube (CRT) instrumentation on the flight deck of all aircraft subject to Part 25 certification.

3. SCOPE:

This ARP covers CRT electronic display devices, both single color and multicolor, and is applicable to the following types of displays:

Type I: Flight and Navigation Displays
Type II: Engine, Systems and Warning Displays
Type III: Control Displays

3.1 Documents: The following documents are referenced for guidance: (See Appendix 1 - How to Order Documents).

3.1.1 Regulations:

FAR Part 25/JAR Part 25

3.1.2 Military Specifications:

MIL-D-87213 (USAF) - Displays, Airborne, Electronically/Optically Generated

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3.1.3 SAE Documents:

- ARP268G - Location and Actuation of Flight Deck Controls for Transport Aircraft
- AS425C - Nomenclature and Abbreviations for Use on the Flight Deck
- ARP450D - Flight Deck Visual, Audible, and Tactile Signals
- ARP571C - Flight Deck Controls and Displays for Communication and Navigation Equipment for Transport Aircraft
- ARP1068B - Flight Deck Instrumentation, Display Criteria and Associated Controls for Transport Aircraft
- AIR1093 - Numeral, Letter and Symbol Dimensions for Aircraft Instrument Displays
- ARP1161 - Crew Station Lighting - Commercial Aircraft
- ARP1782 - Photometric and Colormetric Measurement (when approved) Procedures for Direct View CRT Display Systems
- AMS 2521A - Reflection Reducing Coatings for Instrument Glasses
- ARP4032 - Human Engineering Considerations in the Application of Color to Electronic Aircraft Displays
- AS8034 - Minimum Performance Standard for Airborne Multipurpose Electronic Displays

3.1.4 Other:

- Supplement No. 2 to CIE Publication No. 15 - Recommendations on Uniform Color Spaces - Color Difference Equations - Psychometric Color Terms
- RTCA DO-160B/EUROCAE ED-14B - Environmental Conditions and Test Procedures for Airborne Equipment
- RTCA DO-178A/EUROCAE ED-12A - Software Considerations in Airborne Systems and Equipment Certification
- EIA RS-501 - Recommended Practice for Measurement of X-Radiation from Raster Scanned Direct View Display Cathode-Ray Tubes
- EIA RS-502 - Recommended Practice for Measurement of X-Radiation from Non-Raster-Scanned Direct View Cathode-Ray Tubes
- EIA RS-503 - Recommended Practice for Measurement of X-Radiation from Direct View Display Cathode Ray Tubes
- UL 1418 - Implosion Protected Cathode Ray Tubes for Television Type Appliances, Third Edition Revised October 3, 1983.
- Advisory Circular 25-11 - Transport Category Airplane Electronic Display July 16, 1987

4. GENERAL REQUIREMENTS:

- 4.1 Equipment Functions: The design objective for flight deck displays as set forth in ARP1068B are applicable to these CRT displays unless they are superseded by or conflict with the recommendations of this ARP.
- 4.2 Environmental Conditions: The detailed performance requirements specified in Section 5 shall apply for the applicable environmental conditions.
- 4.3 Implosion Protection: The display unit shall be designed and constructed so that no CRT implosion occurs when the unit is operated over the range of normal and abnormal conditions and that in the extremely abnormal event of a CRT implosion, no incapacitation of the flight crew or adjacent equipment results.



4.3 Implosion Protection: (Continued)

The display unit shall be tested for endurance for the most severe conditions of pressure and temperature levels and variations in both normal and abnormal operating conditions (including overpressure and decompression) specified by D0-160B.

To verify the display unit performance in the event of an implosion, the unit shall meet the requirements defined in UL-1418 15.1 and 15.1A when tested in accordance with UL-1418 15.4 (thermal-shock), 15.6 (high energy impact) and 15.7 (missile impact). The wetting of 15.4 shall be extended to include liquid nitrogen. Zone I shall be extended to surround the unit.

4.4 Smoke and Toxicity: All materials used shall not liberate gases or fumes that are detrimental to performance of the aircraft or to performance or health of personnel.

4.5 Malfunction Indication: Means must be provided to indicate malfunctions or failures to the appropriate crew member in a positive manner. (Reference ARP1068B, 5.2.)

4.6 Definitions: Definitions shall be in accordance with AS425C, Nomenclature and Abbreviations for Use on the Flight Deck, and as noted in the glossary of terms defined in Section 6.

5. DETAIL REQUIREMENTS:

5.1 Display Physical Characteristics:

5.1.1 Useful Screen: Equipment shall provide the maximum size active viewing area consistent with the limitations of unit outline and required features (controls, handles, etc.).

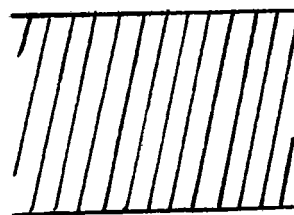
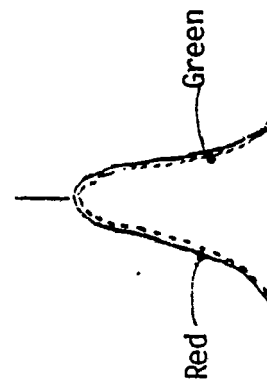
5.1.2 Viewing Characteristics: All indicating means (indicia, pointers, symbols, etc.) on the useful display surface shall be completely visible from any eye position within the instrument's viewing envelope as specified by the equipment manufacturer. Each installation should be examined to insure that the design eye position is within the instrument's viewing envelope. The examination may be a combination of test, analysis, simulation or flight test.

NOTE: Cross cockpit viewing to the other pilot's displays should be provided to achieve the capability dictated by certain failure conditions of critical functions. The off-axis angle is installation dependent and may exceed 50 deg from a normal to the display. Displays mounted on a center panel or center pedestal should be visible to both pilots.

a, c = Width of misconverged portion as seen from normal viewing distance
 b = Width of desired color as seen from normal viewing distance
 d = Center-to-center spacing of contributing beams (misconvergence)

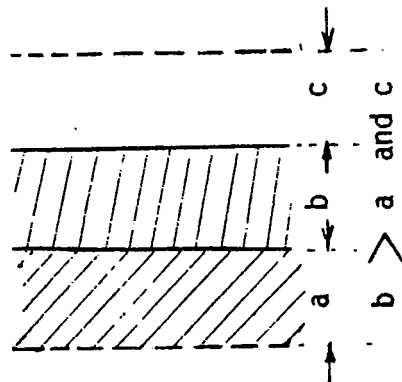
ACCEPTABLE (PERFECT)

Yellow

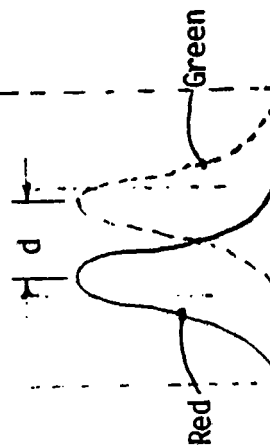
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ACCEPTABLE

Red Yellow Green

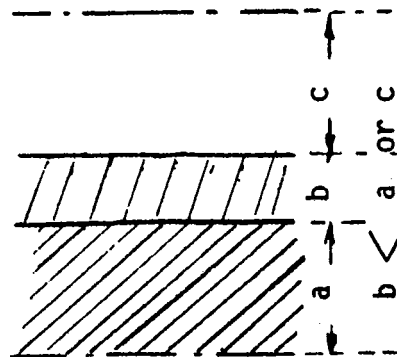


d - don't care

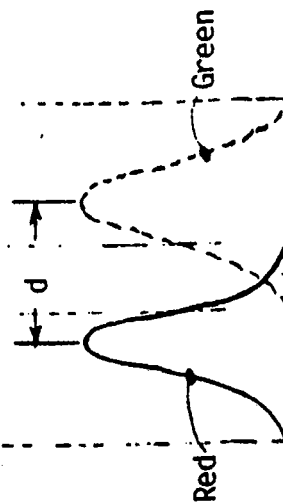


UNACCEPTABLE

Red Yellow Green



d - don't care



ALTERNATE CRITERIA: Use $|d|$ if the primary method is not decisive.

FIGURE 1 - CONVERGENCE CRITERIA (EXAMPLES)

- 5.1.3 Symbol Alignment: Symbols which are interpreted relative to each other (that is, cursors on scales, command bars against reference points, etc.) shall be aligned at their midpoints to within 0.7 mr from any point within the instrument's viewing envelope. (See Table 1 for conversion to linear dimensions.)
- 5.1.4 Linearity: Within the central 80% of the useful screen, a symbol (preferably a square box) randomly placed shall remain uniform in each dimension within +10% of that dimension. Beyond the 80% region, the tolerance is +15%. Verification should typically be made on symbols whose dimensions are between 5 and 10% of screen diagonal.
- 5.1.5 Jitter: For a static display, it is desirable that there be no discernible display jitter viewed from the design eye position. In no case shall a display element jitter more than 0.3 mr peak-to-peak from any point within the instrument's viewing envelope.
- 5.1.6 Convergence: The desired color of a line or symbol should always be obvious and not cause misinterpretation; that is, the width of any misconverged portion shall be no larger than the width of the desired color. Typically the convergence of the beam centers for each of the primary colors should be within 0.55 mr within the central 80% of the screen and 0.7 mr over the entire screen from any point within the instrument's viewing envelope. Fig. 1 illustrates this requirement.
- 5.1.7 Line Width: The CRT line width should be compatible with an adequate readability of the data displayed. The line width may be increased to improve readability. Line widths of the primary colors at any intensity setting where the contrast ratio is greater than 10 should not exceed 1.0 mr over the entire screen. At high ambient light levels where the contrast ratio may be below 10, the "visual line width" of the primary colors should not exceed 3.0 mr over the entire screen. Line widths should be sufficiently wide to preclude distracting visual effects when symbols move (that is, rotate or translate) across the screen. Where shadowmask CRTs are used, the minimum line width shall be no less than 80% of the phosphor dot pitch for any intensity setting. A line width of 1.4 times the pitch of a stripe patterned screen or 1.2 times the pitch of a dot patterned screen is typically required to avoid distractions at higher luminance settings.
- 5.1.8 Line Width Uniformity: Symbol lines of a specified color and luminance shall be uniform in width to ± 0.35 mr over the useful screen.
- 5.1.9 Focus: Display focus should be sharp and clear at all display luminance levels. This does not preclude defocussing at lower luminance levels to accommodate the minimum line width requirements of 5.1.7 or defocussing large areas to merge widely spaced lines; the defocussing technique should not degrade the edge gradient.
- 5.1.10 Symbol Quality: Symbols should have a high quality painted-on appearance with no bright spots, tails, squiggles, skews or gaps; the distorted dimension should not exceed one half the local line width.