

DESIGN OBJECTIVES FOR CRT DISPLAYS FOR PART 23 AIRCRAFT

1. SCOPE:

- 1.1 This SAE Aerospace Recommended Practice (ARP) 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 quantitative information pertinent to AS8034.
- 1.2 This ARP recommends display system performance criteria for direct view cathode-ray-tube (CRT) instrumentation on the flight deck of all aircraft subject to Part 23 certification.
- 1.3 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

2. REFERENCES:

The following documents are referenced for guidance: (See Appendix I – How to Order Documents).

2.1 Regulations:

FAR Part 23/BCAR Part 23

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2.2 SAE Documents:

ARP268G	Location and Actuation of Flight Deck Controls for Transport Aircraft
AS425C	Nomenclature and Abbreviations, Flight Deck Area
ARP450D	Flight Deck Visual, Audible and Tactile Signal
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	Numerical, Letter and Symbol Dimensions for Aircraft Instrument Displays
ARP1161	Crew Station Lighting - Commercial Aircraft
ARP1782	Photometric and Colorimetric Measurement Procedures for Direct View CRT Display Systems
ARP1874	Design Objectives for CRT Displays for Part 25 (Transport) Aircraft
AMS 2521A	Reflection Reducing Coatings for Instrument Glasses
ARP4032	Human Engineering Considerations in the Application of Color Electronic Aircraft Displays
AS8034	Minimum Performance Standard for Airborne Multipurpose Electronic Displays

2.3 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
UL1418	Implosion Protected Cathode Ray Tubes for Television Type Appliances, Third Edition Revised October 3, 1983

3. GENERAL REQUIREMENTS:

- 3.1 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.
- 3.2 Environmental Conditions: The detailed performance requirements specified in Section 4 shall apply for the applicable environmental conditions.
- 3.3 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.
- The display unit shall be tested for endurance under conditions of pressure and temperature levels and variations in both normal and abnormal operating conditions (including overpressure and decompression) specified by the appropriate categories of DO-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.
- 3.4 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.
- 3.5 Malfunction Indication: Means must be provided to indicate malfunctions or failures to the appropriate crew member in a positive manner (ARP1068B 5.2).
- 3.6 Definitions: Definitions shall be in accordance with AS425C and as noted in the glossary of terms defined in Section 5.

4. DETAIL REQUIREMENTS:

4.1 Display Physical Characteristics:

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

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

- 4.1.3 Symbol Alignment: Symbols that are interpreted relative to each other (i.e., 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 instruments viewing envelope. See Table I for conversion to linear dimensions.
- 4.1.4 Linearity: Within the central 80% of the useful screen, a symbol (preferably a square box) randomly placed should remain uniform in each dimension within $\pm 15\%$ of that dimension. Outside of this 80% region, the tolerance is $\pm 20\%$. Verification should typically be made on symbols with dimensions between 5 and 10% of screen diagonal.
- 4.1.5 Jitter: For a static display it is desirable that there be no discernible display jitter viewed from any point within the instruments viewing envelope. In no case shall a display element jitter more than 0.5 mr peak-to-peak as viewed from any point within the instruments viewing envelope.
- 4.1.6 Convergence: The desired color of a line or symbol should always be obvious and not cause misinterpretation, i.e., 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 0.65 mr within the central 80% of the screen and 0.85 mr over the entire screen, from any point within the instruments viewing envelope. Fig. 1 illustrates this requirement.
- 4.1.7 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 phosphor colors at any intensity setting where the contrast ratio is greater than 10 should not exceed 1.5 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 (i.e., 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.

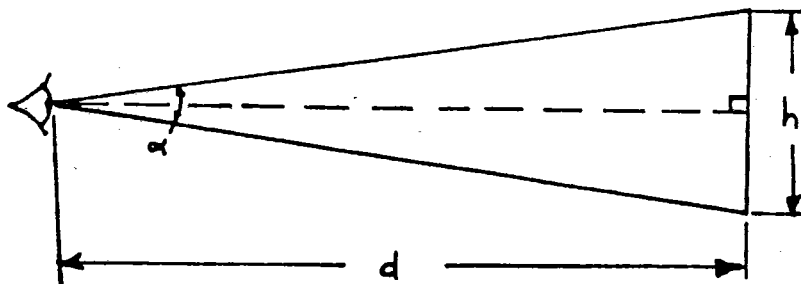
TABLE I - Conversion Table

NOTE: Milliradians (mr) to inches (in) or to millimeters (mm) at a design eye distance, d , of 762 mm (30 in) which is a typical design eye distance.

α		h		α		h	
mr	deg min	in	mm	mr	deg min	in	mm
0.10	0.3'	0.0030	0.08	5.5	18.9'	0.165	4.19
0.15	0.5'	0.0045	0.11	6.0	20.6'	0.180	4.57
0.20	0.7'	0.0060	0.15	6.5	22.3'	0.195	4.95
0.25	0.9'	0.0075	0.19	7.0	24.1'	0.210	5.33
0.30	1.0'	0.0090	0.23	7.5	25.8'	0.225	5.72
0.35	1.2'	0.0105	0.27	8.0	27.5'	0.240	6.10
0.40	1.4'	0.0120	0.30	8.5	29.2'	0.255	6.48
0.45	1.5'	0.0135	0.34	9.0	30.9'	0.270	6.86
0.50	1.7'	0.0150	0.38	9.5	32.7'	0.285	7.24
0.55	1.9'	0.0165	0.42	10	34.4'	0.30	7.6
0.60	2.1'	0.0180	0.46	15	51.6'	0.45	11.4
0.65	2.2'	0.0195	0.50	20	1° 9'	0.60	15.2
0.70	2.4'	0.0210	0.53	25	1° 26'	0.75	19.1
0.75	2.6'	0.0225	0.57	30	1° 43'	0.90	22.9
0.80	2.8'	0.0240	0.61	35	2° 1'	1.05	26.7
0.85	2.9'	0.0255	0.65	40	2° 17'	1.20	30.5
0.90	3.1'	0.0270	0.69	45	2° 35'	1.35	34.3
0.95	3.3'	0.0285	0.72	50	2° 52'	1.50	38.1
1.0	3.4'	0.0300	0.76	55	3° 9'	1.65	41.9
1.5	5.2'	0.0450	1.14	60	3° 26'	1.80	45.7
2.0	6.9'	0.0600	1.52	65	3° 43'	1.95	49.5
2.5	8.6'	0.0750	1.91	70	4° 1'	2.10	53.3
3.0	10.3'	0.0900	2.29	75	4° 18'	2.25	57.2
3.5	12.0'	0.1050	2.67	80	4° 35'	2.40	61.0
4.0	13.8'	0.1200	3.05	85	4° 52'	2.55	64.8
4.5	15.5'	0.1350	3.43	90	5° 10'	2.70	68.6
5.0	17.2'	0.1500	3.81	100	5° 44'	3.00	76.0

Notes: 1. $h \approx \alpha d$,
 h = Character height (distance unit)
 α = Angle (radians)
 d = Viewing distance (distance unit)

Design
Eye



2. This conversion table is for reference only. No performance criteria are implied.