

**Design Objectives for Liquid Crystal Displays
for Part 25 (Transport) Aircraft**

FOREWORD

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 document provides additional information pertinent to AS8034.

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1. SCOPE:

This document covers monochrome and color LCDs (transmissive, transreflective, and reflective), both matrixed and segmented in format, and is applicable to the following types of displays:

- a. Flight and navigation displays
- b. Engine, systems, and warning devices
- c. Control displays

In this document the terms "LCD", "LCD Display", "Display", and "Instrument" are synonymous and encompass the display system (e.g., LCD device, drivers, backlight, display processor, etc.), not just the device.

1.1 Purpose:

This document recommends design and performance criteria for liquid crystal displays (LCDs) on the flight deck of aircraft subject to Part 25 certification. It is intended as guidance for the certifying authority. A secondary purpose is to share information about the unique characteristics of LCDs and how they relate to the flight deck.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this specification to the extent specified herein. In the event of conflict between the text of this specification and references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

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
ARP4102	Core Document, Flight Deck Panels, Controls and Displays
ARP4102/7	Electronic Displays
ARP4103	Flight Deck Lighting and Visual Interface
ARP4105	Nomenclature and Abbreviations for Use on the Flight Deck
AS8034	Minimum Performance Standard for Airborne Multipurpose Electronic Displays
AMS 2521B	Reflection Reducing Coatings for Instrument Glasses

SAE ARP4256 Revision A

2.1.2 FAA Publications: Available from the Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591.

FAR Part 25/JAR 25
TSO-C113 Airborne Multipurpose Electronic Displays

2.2 Related Publications:

The following publications are provided for information purposes only and are not a required part of this SAE Aerospace Recommended Practice.

2.2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP1161	Crew Station Lighting - Commercial Aircraft
ARP1782	Photometric and Colorimetric Measurement Procedures for Direct View CRT Displays
ARP1874	Design Objectives for CRT Displays for Part 25 (Transport) Aircraft
ARP4032	Human Engineering Considerations in the Application of Color to Electronic Aircraft Displays
ARP4101	Core Document, Flight Deck Layout and Facilities
ARP4260	Photometric and Colorimetric Measurement Procedures for Airborne Direct View Flat Panel Displays
ARP4067	Design Objectives for CRT Displays for Part 23 Aircraft

2.2.2 FAA Publications: Available from the Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591.

Advisory Circular 25-11, Transport Category Airplane Electronic Display Systems
Advisory Circular 23.1311-1A, Installation of Electronic Displays in Part 23 Airplanes

2.2.3 U.S. Military Publications: Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

AFGS-87213B (USAF) Displays, Airborne, Electronically/Optically Generated

2.2.4 CIE Publications: Available outside of the U.S. from Bureau Centrale De La CIE, 52, Boulevard Malesherbes, 75008 Paris, France and inside the U.S. from United States National Committee of the Commission Internationale De L'Eclairage, c/o Thomas Lemons, TLA-Lighting Consultants, Inc., 7 Pond Street, Salem, MA 01970-4893.

Supplement No. 2 to CIE Publication No. 15 Recommendations on Uniform Color Spaces Color Difference Equations - Psychometric Color Terms

2.2.5 RTCA/EUROCAE Publications: Available from RTCA, Inc., 1140 Connecticut Avenue, Suite 1020, Washington, DC 20036.

RTCA DO-160D/EUROCAE ED-14D Environmental Conditions and Test Procedures for Airborne Equipment

RTCA DO-178B/EUROCAE ED-12B Software Considerations in Airborne Systems and Equipment Certification

2.3 Definitions:

Definitions used in this document shall be as noted in the Glossary of Terms defined in Section 5.

The word “shall” is used to express an essential (mandatory) requirement. Conformance requires that there be no deviation. The word “should” is used to express a recommended requirement. Deviation from the specified recommendation may require justification.

3. GENERAL REQUIREMENTS:

3.1 Equipment Functions:

The design objectives for flight deck displays as set forth in ARP4102/7 are applicable to LCD displays unless they are superseded by or conflict with the recommendations of this document.

3.2 Environmental Conditions:

Except as detailed in appropriate sections of this document, the performance requirements specified in Section 4 apply over the applicable environmental conditions and test procedures set forward in RTCA document DO-160C and over the useful life of the equipment. In no case shall performance be degraded so as to lead to erroneous interpretation or loss of displayed data.

3.3 Smoke and Toxicity:

No material used shall liberate gases or fumes that are detrimental to performance of the aircraft or to performance or to health of personnel.

3.4 Malfunction Indication:

Means must be provided to indicate malfunctions or failures to the appropriate crew member in a positive manner (reference ARP4102, 6.2). It is not practical to use built-in-self-test procedures to monitor the functionality of all the addressable elements in liquid crystal display devices. One manual means to detect addressable element malfunctions is to provide a “push-to-test” procedure which activates all display elements in “on” and “off” states. Displayed fonts, symbols, indicia, etc. should be designed to be tolerant of addressable element defects and failures whenever practical.

Particular emphasis should be given to precluding or mitigating failures which could result in hazardously misleading information. Inconspicuous and undetected loss of information could contribute to hazardously misleading information. Consideration should be given to drive and addressing techniques to avoid the loss of information resulting from the failure of rows, columns, and/or elements.

3.5 Glass Breakage:

Front glass strength shall be sufficient to withstand normal impacts that can be expected in the flight deck environment without cracking, breaking, or loss of LCD edge seal.

4. DETAIL REQUIREMENTS:

4.1 Display Visual Characteristics:

- 4.1.1 Viewing Characteristics: All indicating means displayed (indicia, pointers, symbols, etc.) shall be completely visible from any eye position within the viewing envelope(s) as specified by the equipment manufacturer. Each installation shall be examined to verify that the design eye position(s) and allowable head motion envelope(s) (reference 2.2.1, 4.1.1.1, and 6.1.5 of ARP4102) are within each viewing envelope.

Cross-cockpit viewing to the other pilot's displays should be provided to achieve the capability recommended by ARP4102. The cross-cockpit viewing angle is installation dependent and is usually a compound angle.

NOTE: The cockpit viewing angle requirements may far exceed 45 degrees.

- 4.1.2 Symbol Alignment: Symbols which are interpreted relative to each other (i.e., cursors on scales, command bars against reference points, etc.) shall be aligned to preclude misinterpretation of information.

- 4.1.3 Matrix Anomalies: Since the display is an array of discrete elements, displayed information may have visible spatial and color anomalies. Stair stepping, line width variation, and moire are examples of spatial anomalies; color banding and color fringing are examples of color anomalies. Anomalies are especially visible in dynamic images and may not be visible in static images. The extent of the anomaly is dependent on many factors including the size, shape, and arrangement of the display elements, construction of the symbol, rate, direction, and increment of motion and luminance control of the elements. The display shall have no matrix anomalies which cause distraction or erroneous interpretation. This shall be assessed with both static and dynamic formats.
- 4.1.4 Crosstalk: Crosstalk should not be readily apparent or distracting.
- 4.1.5 Jitter: There should be no discernible display jitter when viewed within the viewing envelope. Jitter of 0.3 mrad peak-to-peak from any point within the viewing envelope is a suggested upper limit, but that may not be acceptable in some instances.
- 4.1.6 Line Width Uniformity: When viewed from the design eye position (DEP), lines of a specified color and luminance should appear uniform in width at all rotational or translational orientations of the line. Line width variation should not be readily apparent or cause distracting visual effects. Lines with a minimum line width less than 70% of the maximum line width may produce an undesirable visual “roping” effect.
- 4.1.7 Symbol Quality: Symbols should not have distracting gaps or geometric distortions. Symbol quality characteristics shall not cause erroneous interpretations; any distorted dimension should not exceed one half the local line width.
- 4.1.8 Flicker: Flicker should not be readily discernible or distracting under day, twilight, or night conditions, considering both foveal and full peripheral vision, and using an operational format most susceptible to producing flicker. This is intended to include stroboscopic flicker induced by vibration and/or pilot motion.
- 4.1.9 Symbol Motion: Display symbology that is in motion (translation and/or rotation) should not have distracting jitter, jerkiness, or ratcheting effects. Dynamic symbols should maintain luminance (per 4.1.10), contrast, color, line width, and symbol quality characteristics independent of their rate of motion. Pointers and bar graphs should be designed with built in hysteresis or smoothing of the displayed value such that when a constant or near constant value of a parameter is to be displayed, objectionable motion is eliminated.