

Optical Measurement Procedures for
Airborne Head Up Display (HUD)

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1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) contains methods used to measure the optical performance of airborne binocular Head Up Displays (HUDs). This document covers methods for conformal and non-conformal HUD systems that are intended for use in the cockpit by the pilot or copilot. The focus of this document is on displays that generate the HUD information using a cathode ray tube (CRT), however, the majority of the methods can be applied to other display technologies. These measurement methods are provided for testing to the requirements of AS8055.

This document does not address measurement methods for sensor imaging systems, or displays worn by the pilot (goggles, helmet mounted displays).

2. REFERENCES:

The documents listed in 2.1 are referenced for guidance in this document. The documents listed in 2.2 are provided for information purposes only and do not form a part of the requirements of this document.

2.1 Applicable Documents:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, 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.

J1330	Photometric Lab Accuracy Guidelines
ARP4260	Photometric and Colorimetric Measurement Procedures for Airborne Flat Panel Displays
AS8055	Minimum Performance Standard for Airborne Head Up Display (HUD)

2.1.2 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
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2.1.3 CIE (Commission Internationale de l'Eclairage) 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, Radiometric Physics Division, National Bureau of Standards, Washington, DC 20234.

Pub. S001	Colorimetric Illuminants
Pub. S002	Colorimetric Observers
Pub. 15.2	Colorimetry, 2nd Edition
Pub. 17.4	International Lighting Vocabulary, 4th Edition
Pub. 18.2	The Basis of Physical Photometry
Pub. 53	Methods of Characterizing the Performance of Radiometers and Photometers
Pub. 63	The Spectroradiometric Measurement of Light Sources
Pub. 64	Determination of the Spectral Responsivity of Optical Radiation Detectors
Pub. 69	Methods of Characterizing Illuminance Meters and Luminance Meters

2.1.4 Electronic Industry Association (EIA) Publications: Available from Electronic Industries Association, 2500 Wilson Boulevard, Arlington, VA 22201.

EIA-503-A	Recommended Practice for the Measurement of X-Radiation from Direct-View Television Tubes.
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2.2 Related Publications:

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

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

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
ARP4102/8	Flight Deck, Head Up Displays
ARP4103	Flight Deck Lighting and Visual Interface
ARP4155	Human Interface Design Methodology for Integrated Display Technology. (Note: Revision A is in process.)
ARP4256	Design Objectives for Liquid Crystal Displays for Part 25 (Transport) Aircraft
ARP4260	Photometric and Colorimetric Measurement Procedures for Airborne Direct View Flat Panel Displays (When Approved)
ARP4654	HUD Symbolology Review
ARP4742	Display Characteristics of HUDs Used in Civil Transport Aircraft (DRAFT)
AS8034	Minimum Performance Standard for Airborne Multipurpose Electronic Displays

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2.2.2 Regulatory Publications:

“FAA AC-()” documents are available from the U.S. Department of Transportation, Utilization and Storage Section, M-443.2, Washington, DC 20590.

“FAR” documents may be purchased from the Government Printing Office, Washington, DC 20402.

“TSO” documents are available from Aircraft Engineering Division (AIR-100), Aircraft Certification Service, Federal Aviation Administration, 800 Independence Avenue SW, Washington, DC 20591.

“JAR” documents may be purchased from Westward Digital Ltd., 37 Windsor Street, Cheltenham, GL52 2DG, England.

FAA AC 20-57A	Automatic Landing Systems
FAA AC 20-110H	Index of Aviation Technical Standard Orders
FAR 23.1311	Electronic Display Instrument Systems
JAR-HUDS-901	Category 3 Operations with a Head Up Display
JAR-HUDS-902	Category 2 Operations with a Head Up Display
JAR-HUDS-903	Head Up Displays
TSO-C113	Airborne Multipurpose Electronic Displays

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

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

2.2.4 CIE (Commission Internationale de l'Eclairage) 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, Radiometric Physics Division, National Bureau of Standards, Washington, DC 20234.

Pub. No. 15, Supplement No. 2 Recommendations on Uniform Color Spaces Color Difference Equations - Psychometric Color Terms.

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2.2.5 U.S. Government Publications: "MIL" documents may be ordered by FAX to: (215) 697-1462, with credit card for payment. Check or money order must be mailed to DODSSP, Customer Service, 700 Robbins Avenue, Building 4B, Philadelphia, PA 19111-5094. Include payment with order.

MIL-HDBK-87213	Air Force Guide Specification: Military Handbook; Electronically/Optically Generated Airborne Displays.
MIL-STD-810E	Military Standard: Environmental Test Methods and Engineering Guidelines
MIL-STD-1241A	Military Standard: Optical Terms and Definitions.
MIL-STD-1295A	Military Standard: Human Factors Engineering Design Criteria for Helicopter Cockpit Electro-Optical Display Symbology (Cancelled)
MIL-STD-1787B	Military Standard: Aircraft Display Symbology

2.2.6 Other Publications:

SOAR CSERIAC 92-2 May 1992, Human Factors Issues in Head-Up Display Design: "The Book of HUD"

2.3 Definitions:

Definitions used in this document are as noted in the Glossary of Terms defined in AS8055. The word "shall" is used to express an essential (mandatory) requirement. Conformance with the specific recommendation requires that there be no deviation. The word "should" is used to express a recommendation. Deviation from the specified recommendation may require justification.

3. GENERAL REQUIREMENTS:

3.1 Laboratory Standard Measurement Conditions:

Unless otherwise specified, equipment shall be tested under the conditions specified in Section 3 of RTCA DO-160D/EUROCAE ED-14D and/or sections of this document.

3.2 Laboratory Standards:

The use of industry traceable (e.g., National Institute of Standards and Technology) radiometric and photometric standards for the calibration of test equipment will help ensure inter-instrument correlation. Some standards are required to be recalibrated on a regular cycle or when an elapsed time of usage has expired. Strict adherence to calibration and recalibration and maintaining calibration records is prerequisite to good laboratory procedure and is highly recommended.

3.3 Measurement Equipment:

The photometric measurement equipment should meet the requirements specified in ARP4260 paragraph 3.4.

The minimum requirements for the angular measurement equipment are given in 4.1.