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Standard Specification for Design and Installation of an Infrared (IR) Searchlight System (USA)[1]

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INTRODUCTION

This specification establishes the exposure limits and safe operating guidelines for infrared (IR) radiating devices to be mounted on N registered aircraft or any aircraft which is flown or operated in the United States or its territories. This specification applies to devices such as searchlights and landing lights or other IR radiating devices that emit incoherent IR energy. For IR systems that emit coherent IR radiation, refer to FAA AC 20-183. This specification does not establish the requirements for mounting to a specific aircraft and does not authorize the installation onto an aircraft. Specific installation requirements for each airframe type shall comply with Federal Aviation Administration (FAA) regulations and guidelines and are in addition to the requirements set forth in this specification.

The American Conference of Governmental Industrial Hygienists (ACGIH) has established threshold limit values (TLVs) for IR radiation exposure.[2] The TLVs represent a safe exposure limit without physical harm, even with daily exposure. In general terms, the components of the TLV are a function of the intensity of the IR radiation (within a specified band), the distance to (or from) the radiating source, over a period of time (exposure).

For this specification, the safe exposure time has been set at 100 seconds to reach the TLV. Therefore, the safe operating distance is established by determining the maximum output radiation of the device such that 100 seconds of exposure does not exceed one TLV as established by ACGIH.

1. Scope

1.1 This specification establishes the manufacturing design, manufacturing quality system and installation requirements for airborne infrared (IR) searchlight equipment, systems, and devices. This specification applies only to IR devices that produce incoherent IR radiation and affixed to an aircraft which is N registered or operated and flown within the United States and its territories.

1.2 This specification establishes the minimum and maximum system performance and provides guidelines for an operator to develop functional operation requirements to ensure IR safety.

1.3 This specification covers IR device emissions in support of night vision goggles or other devices such as electro-optical/infrared (EO/IR) sensors capable of detecting IR radiation.

1.4 This specification covers IR device emissions that may pose a hazard to the flight crew, aircraft, and bystanders.

1.5 This specification covers IR device emissions and related safety controls such as duration, beam width, radiant intensity, and wavelength.

1.6 This specification encourages an Original Equipment Manufacturer (OEM) to maintain a robust quality assurance program and a well-documented configuration control process at the component level and continued through installation at the system level.

1.7 The OEM shall include the warnings, exposure limitations and corresponding data, and installation instructions described within this specification in their operation and installation manuals. These manuals shall be provided with the product or device.

[1] This specification is under the jurisdiction of ASTM Committee F39 on Aircraft Systems and is the direct responsibility of Subcommittee F39.04 on Aircraft Systems.

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[2] *Light and Near-Infrared Radiation: TLV(R) Physical Agents*, 7th ed., American Conference of Governmental Industrial Hygienists, 2015, www.acgih.org.

1.8 *Units*—The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.10 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *FAA Standards:*[3]

FAA AC 21-16(G) RTCA Document DO–160 Versions D, E, F, and G Environmental Conditions and Test Procedures for Airborne Equipment, or latest versions available

FAA AC 20-115C Airborne Software Assurance

FAA AC 20-183 Laser Airworthiness Installation Guidance

FAA 8110.4C Type Certification

2.2 *IEC Standard:*[4]

IEC 61508 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems

2.3 *RTCA Standards:*[5]

RTCA/DO-160 Versions D, E, F, G, or latest Environmental Conditions and Test Procedures for Airborne Equipment

RTCA/DO-178 Software Considerations in Airborne Systems and Equipment Certification

RTCA/DO-254 Design Assurance Guidance for Airborne Electronic Hardware

2.4 *SAE Standard:*[6]

SAE/ARP4761 Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment

2.5 *Federal Standards:*[7]

14 CFR Part 27 Airworthiness Standards: Normal Category Rotorcraft

14 CFR Part 29 Airworthiness Standards: Transport Category Rotorcraft

14 CFR Part 21 Section 21.307 and 21.308 Certification Procedures for Products and Articles, Quality System and Quality Manual

MIL-STD 3009 Lighting, Aircraft, Night Vision Imaging System (NVIS) Compatible

NOTE 1—For all referenced documents, the latest version of the released document shall be used.

3. Terminology

3.1 *Definitions:*

3.1.1 *beam width, n*—beam diameter or beam width of an electromagnetic beam is the diameter along any specified line that is perpendicular to the beam axis and intersects it.

3.1.1.1 *Discussion*—The beam diameter or beam width is measured at 10 % of the peak intensity.

3.1.2 *effective spectral radiance, n*—integrated radiance of an IR device per unit wavelength weighted by the hazard function and the measurement is expressed in units of (W/cm^2·sr) and used to establish the threshold limit values (TLVs).

3.1.3 *exposure duration, n*—time the infrared (IR) source is directly viewed or directed toward a human target.

3.1.3.1 *Discussion*—The exposure duration is a function of the intensity and wavelength of radiation over time. The American Conference of Governmental Industrial Hygienists (ACGIH) has established safe exposure limits (TLVs) that define exposure to an IR source without permanent physical damage.

3.1.4 *eye safe distance, n*—distance and duration of unobstructed exposure to the direct IR beam at effective spectral radiances.

3.1.5 *intended function, n*—through the emission of IR, facilitates the utilization of night vision equipment (cameras or goggles, or both).

3.1.6 *wavelength, n*—for an electromagnetic wave, the distance in the direction of propagation between nearest points at which the electric vector has the same phase.

3.1.6.1 *Discussion*—The wavelength unit generally used in spectrophotometry related to colorimetry is the nanometer (nm). Unless otherwise stated, values of wavelength are generally those in air.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *infrared light, IR, n*—in this specification, refers to the nonvisible portion of the light spectrum that may be either filtered or direct emission, adjacent to the red end of the visible spectrum, with wavelengths from 700 to 3000 nm.

4. Performance Requirements

4.1 The minimum safe operating distance is established by analyzing the total radiated IR energy such that the TLV is not exceeded during 100 seconds of exposure.

4.2 The IR emitting device shall be tested to quantify the IR emissions. The testing laboratory (or Original Equipment Manufacturer (OEM)) shall be capable of documenting that results obtained which represent the maximum values that the equipment is capable of emitting throughout its life cycle and under worst-case conditions. Test equipment and standards should be traceable to an accredited authority such as National Institute of Standards and Technology (NIST). Worst-case conditions are those in which the device may produce more energy than the intended or anticipated levels because of component failure or any other operating or failure mode.

[3] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov.

[4] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, 1st Floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, http://www.iec.ch.

[5] Available from RTCA, Inc., 1150 18th St. NW, Suite 910, Washington, DC 20036.

[6] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

[7] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, http://www.access.gpo.gov.

4.2.1 After initial testing and product verification, OEMs are required to test subsequent production units under the guidelines of their respective Quality System as described in Section 5.

4.2.2 Changes or modifications to the device or end product require a new test unless the OEM establishes that such product or device revisions represent no change to the IR emission values or monitoring and control functions. New test data or the manufacturer's statement of similarity and compliance to previous testing shall be sent to each supplemental type certificate (STC) and PMA holder for the device. The data shall be made available within 30 days of a revision change and before release for installation on an aircraft.

4.2.3 For serial production, the test results for each device shall accompany the product when it is shipped or leaves the OEM's facility, along with other pertinent data and certifications required for safe installation and continued airworthiness.

5. OEM / Manufacturing – Serial Production Quality System

5.1 For serial production of IR emitting devices, the OEM shall have a Quality System which meets the requirements of CFR Part 21 Section 21.307 and 21.308, or,

5.1.1 An approved ASTM Quality System, or,

5.1.2 ISO 9000 or AS 9000 Certification.

6. Installation Requirements

6.1 The installer shall ensure that safe operating requirements for the IR device are met such that there are no hazards for the flight crew, ground/maintenance personnel, or bystanders.

6.1.1 A keyed lockout switch shall be installed which disables the IR function of the IR device such that the IR function may only be activated by authorized personnel. Authorized personnel will include only those specifically trained in the safe operation of the IR function. This switch shall be placarded as such during the installation of the IR searchlight or device. This switch is only to be used by trained and authorized maintenance personnel using established operating guidelines as established by the aircraft operator.

NOTE 2—This specification does not establish safe ground operating procedures for maintenance personnel. These procedures shall be developed and implemented by the air operations unit or facility.

6.1.1.1 Safe operation training guidelines shall include the following topics at a minimum:

(1) Potential hazards involved with the use of IR devices,

(2) IR exposure limits and safe operating distances for each IR device installed or operated,

(3) How to protect the flight crew and bystanders from hazardous IR exposure, and

(4) Processes and procedures for periodic maintenance and repairs of the IR device.

6.1.2 A discrete visual annunciator is required when the device is in the IR operating mode. This is required since the IR energy is invisible to the naked eye. The discrete annunciator should be located on the hand control that operates the IR emitting device and near the pilot instruments and shall be night vision imaging system (NVIS) compliant (MIL-STD-3009). The operator and pilot should have visual annunciation of the IR device.

NOTE 3—The intent of this provision is to ensure that the pilot and flight crew are aware that the device is operating in the IR mode.

6.1.3 *Recommended*—The preferred method of lockout for the IR device is via a link to the radar altimeter. Activation of the system should not be possible when the altimeter altitude lockout is active (below the minimum safe altitude or target distance). If the radar altimeter is not available or impractical for the installation, the alternate means of compliance is by installation of an arm/disarm switch. The arm/disarm switch shall be accessible to the flight crew and secured with a keyed lockout.

6.1.4 The IR mode may not be selectable exclusively via software unless the software is developed using RTCA/DO-178 with Design Assurance Level B or higher. If in normal operation the device has an IR mode select or IR activation that is operated exclusively via software and is not RTCA/DO-178B compliant, the device shall also be controllable by an analog method that overrides this functionality in the event of an in-flight emergency or device malfunction (hazard).

6.1.5 This specification does not establish the requirements for mounting to a specific aircraft and does not authorize the installation onto an aircraft. Specific installation requirements for each airframe type shall comply with FAA regulations in addition to the requirements set forth in this specification.

6.1.6 *Environmental Qualification*—Ensure the environmental qualification of the installed equipment is appropriate for the intended aircraft installation environment. FAA guidance may be found in FAA AC 21-16(G), RTCA/DO-160 Versions D, E, F and G, or latest.

6.1.7 The installer and operator shall ensure that any repairs or replacement spare parts are only performed by authorized repair facilities and that the use of spare parts meets the OEM specifications.

7. Hazard, Malfunction, and Failure Assessment

7.1 This specification is to be used as a means to show compliance with requirements for certification of IR emitting devices. The hazard, malfunction, and failure assessment for an IR radiating device is in addition to those required for a normal TC, STC, or other approved installation under FAA regulations.

7.2 *Equipment Malfunction*—IR device malfunction resulting in an aircraft crewmember's or passenger's eye or skin being exposed to invisible IR energy exceeding the TLV is considered no less than a hazardous functional failure condition and could be catastrophic if continued safe flight is not possible because of the severity of the damage to a pilot's eye or skin. The system safety assessment of the system or device being installed on the aircraft shall assess and document the rationale for a hazardous functional failure condition classification. If there is no direct or reflected path into the cockpit or cabin because of the location of the IR searchlight system and physical shielding provided by the aircraft structure, this failure condition does not apply.

7.3 *System Safety Considerations*—In assessing and documenting the failure conditions, the installer shall consider direct and reflected IR beam energy; the location of the IR source, IR device's steering mechanism (if equipped), and circuitry; the use of mechanical, software, or airborne electronic hardware (AEH) stops that prevent the beam from being steered in a direction that could result in the aircraft occupants' eyes being exposed to direct or reflected IR energy; device arming and firing circuitry; and other design features whose malfunction could contribute to an inadvertent exposure or an exposure that exceeds the TLV. If the IR device's steering stops are implemented in software or AEH, their assurance level should be commensurate with the functional failure condition associated with the stops. Reflections off any part of the aircraft (such as the structure, blades, skids, or landing gear) should be considered specular. Mechanical stops may be required to prevent irradiation of aircraft structure, crew, or passengers. Stops implemented using a software or complex hardware control function should be developed using RTCA/DO-178 or RTCA/DO-254 and should exhibit a design assurance level commensurate with the hazard associated with failure of that function.

7.3.1 *Aircraft Structure*—Any malfunction capable of resulting in damage to aircraft structure because of IR energy exposure shall be assessed and documented to determine the extent of aircraft damage and the associated functional failure condition classification.

7.3.2 *Equipment Interfaces*—Any potential malfunction of the IR device interfaces with other aircraft system shall be assessed and documented to determine the effect on the aircraft system and IR device as well as the associated functional failure condition classifications.

7.3.3 *Loss of Function*—Because the IR device is non-required equipment, the functional failure condition for loss of the function is "no effect."

7.3.4 *Installation Design*—The installation design shall include all requirements applicable to the installation (such as the key control, emissions, indicator, labels, and remote interlock connector) and the technical controls (such as the aircraft interface safety interlock).

7.3.5 *Software*—If the IR device includes software that can contribute to malfunctions otherwise described within this specification, the software development shall follow the guidance in FAA AC 20-115C to a software level commensurate with the functional failure condition classifications determined from 7.2.

7.3.6 *AEH*—If the IR device includes custom AEH (such as an application-specific integrated circuit, field-programmable logic device, or programmable logic device) that can contribute to the malfunctions described in 7.2, develop the AEH using RTCA/DO-254 to a design assurance level commensurate with the functional failure condition classifications determined from 7.2. For custom AEH classified as simple, Paragraph 1.6 of RTCA/DO-254 applies. The use of industry recognized system safety standards (such as SAE/ARP 4761 and IEC 61508) and development assurance standards (such as RTCA/DO-178C, RTCA/DO-254, and IEC 61508) for the equipment is encouraged when its malfunction could result in an exposure that could exceed the TLV.

7.4 *Other Functional Failure Conditions*—Other malfunctions not described in this specification should be identified and assessed to determine their functional failure conditions.

8. AFMS/RFMS and Configuration Control

8.1 Once installed and certified as an airborne system, changes to the IR device or the installation should not be made because they could affect the airworthiness (for example, electromagnetic and environmental compatibility or new failure modes) of the equipment installation and may invalidate the IR device's certification. Any changes shall be evaluated for their impact on airworthiness. The applicant should provide a plan for maintaining configuration control throughout the product life cycle. Alterations should not result in a modification to the equipment as certified by the equipment manufacturer without recertification by the FAA.

8.2 An approved airplane/rotorcraft flight manual supplement (AFMS/RFMS) is required for IR device installation in which airframe limitations, operational procedures, or the flight characteristics of the basic airframe limitations, operational procedures, or the flight characteristics of the basic aircraft change because of the proposed modification. It should include any special procedures required for safe operation of the IR device. It shall also include any changes to the limitations of the aircraft caused by the installation, particularly for externally mounted systems.

9. Operational Guidelines

9.1 For the IR device equipment installation, the AFMS/RFMS shall include the following limitations:

9.1.1 The IR device shall not be used to intentionally radiate other flying aircraft;

9.1.2 The key control shall be in the off position on the ground and during taxi, takeoff, and landing except for ground maintenance being performed by personnel properly trained in the use of the device, or as allowed in the AFMS/RFMS described in 8.2;

9.1.3 The IR device shall not be used to radiate people when the distance between the IR device and the people is less than the TLV. The TLV distance should be specified in the AFMS/RFMS or on a placard within view of the operator and flight crew;

9.1.4 The atmospheric conditions when the IR device shall not be used (such as rain or snow);

9.1.5 The flight conditions when the IR device shall not be used (such as angle of bank, flying in close proximity to terrain, or hoist operations);

9.1.6 The IR device shall not be used if any of the IR device safety interlocks that require an interface to an aircraft system are inoperable. The AFMS/RFMS should identify the aircraft interface safety interlocks;

9.1.7 The aircraft configurations when the IR device shall not be used (such as when cargo mirrors are installed since they may provide a reflected path into the cockpit);

9.1.8 Adequate instruction for operation, including warnings and cautions concerning precautions to avoid possible exposure to IR energy above acceptable limits;

9.1.9 Legible reproductions of all labels and hazard warnings should be affixed to the IR device; and

9.1.10 A listing of all controls, adjustments, and normal, abnormal, and emergency procedures for operation including the following statement: "Caution—Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure."

9.2 An approved AFMS/RFMS is required for an IR device equipment installation in which airframe limitations, operational procedures, or the flight characteristics of the basic aircraft change because of the proposed modification. It should include any special procedures required for safe operation of the IR device. It shall also include any changes to the limitations of the aircraft caused by the installation, particularly for externally mounted systems.

10. Inspection

10.1 Before installation, the device shall be inspected by the installer to ensure that it has been certified by the OEM and tested per Section 4.

10.2 The installer shall verify the part number, hardware revision level, and software revision level before installation. If the part number or revision level or both do not match the certificate for installation, the device may not be installed.

11. Certification

11.1 *FAR Part 23/27/29 1301 and 1309:*

11.1.1 Suitability for installation is obtained per this specification. The OEM will hold the certificate and provide a copy for each device to be installed on an aircraft.

11.1.2 This specification does not establish the requirements for mounting or installing an IR device to a specific aircraft and does not authorize the installation onto an aircraft. Specific installation requirements for each airframe type shall be established during installation and are in addition to the requirements set forth in this specification.

12. Keywords

12.1 design; infrared; installation; rotorcraft; search lights