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Standard Practice for Simplified Methods for Addressing High-Intensity Radiated Fields (HIRF) and Indirect Effects of Lightning on Aircraft [1]

This standard is issued under the fixed designation F3367; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers simplified methods for addressing High-Intensity Radiated Fields (HIRF) and the Indirect Effects of Lightning (IEL) on aircraft. The material was developed through open consensus of international experts in general aviation. This information was created by focusing on Aircraft Certification Level 1, Level 2, and Level 3 Normal Category aeroplanes. The content may be more broadly applicable. It is the responsibility of the applicant to substantiate broader applicability as a specific means of compliance. The topics covered within this practice are: Overview; Minimum Design Requirements; Aeroplane Assessment Level; HIRF and IEL Safety Analysis; HIRF Compliance; IEL Compliance.

1.2 An applicant intending to propose this information as Means of Compliance for a design approval must seek guidance from their respective oversight authority (for example, published guidance from applicable CAA) concerning the acceptable use and application thereof. For information on which oversight authorities have accepted this practice (in whole or in part) as an acceptable Means of Compliance to their regulatory requirements (hereinafter "the Rules"), refer to the ASTM Committee F44 web page (www.astm.org/COMMITTEE/F44.htm).

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

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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 Following is a list of external standards referenced throughout this practice; the earliest revision acceptable for use is indicated. In all cases, later document revisions are acceptable if shown to be equivalent to the listed revision, or if otherwise formally accepted by the governing civil aviation authority; earlier revisions are not acceptable.

2.2 *ASTM Standards:*[2]

F3060 Terminology for Aircraft

F3230 Practice for Safety Assessment of Systems and Equipment in Small Aircraft

F3309/F3309M Practice for Simplified Safety Assessment of Systems and Equipment in Small Aircraft

2.3 *EUROCAE Standards:*[3]

ED-14E Environmental Conditions and Test Procedures for Airborne Equipment

ED-107 Guide to Certification of Aircraft in a High-Intensity Radiated Field (HIRF) Environment

2.4 *European Aviation Safety Agency (EASA):*[4]

CS-23 Amdt 5 Certification Specifications for Normal-Category Aeroplanes

AMC 20-136 Aircraft Electrical And Electronic System Lightning Protection

AMC 20-158 Aircraft Electrical And Electronic System High-Intensity Radiated Fields (HIRF) Protection

2.5 *Federal Aviation Administration (FAA):*[5]

AC 20-136B Aircraft Electrical and Electronic System Lightning Protection

[1] This practice is under the jurisdiction of ASTM Committee F44 on General Aviation Aircraft and is the direct responsibility of Subcommittee F44.50 on Systems and Equipment.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from EUROCAE, 9-23 rue Paul Lafargue, "Le Triangle" building, 93200 Saint-Denis, France, https://eshop.eurocae.net/.

[4] Available from European Aviation Safety Agency (EASA), Postfach 10 12 53, D-50452 Cologne, Germany, https://www.easa.europa.eu.

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

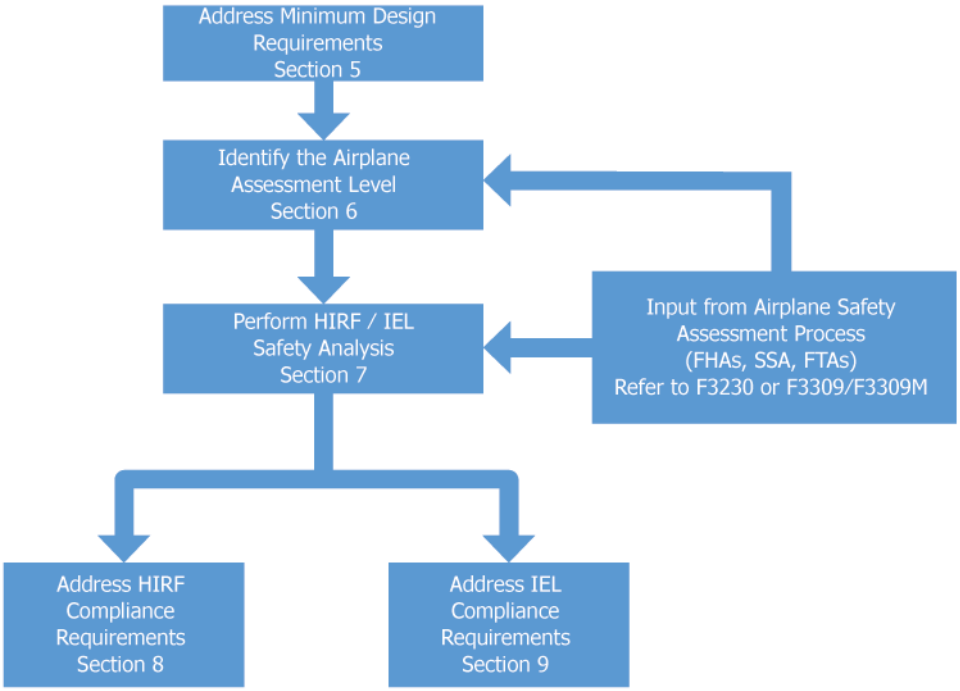

FIG. 1 Overview Flowchart

AC 20-158A The Certification of Aircraft Electrical and Electronic Systems for Operation in the High-Intensity Radiated Fields (HIRF) Environment

AC 23.1309-1E System Safety Analysis and Assessment for Part 23 Airplanes

AC 25.1309-1A System Design and Analysis

Part 25 Amdt 25-122 Airworthiness Standards: Transport Category Airplanes

Part 23 Amdt 23-64 Airworthiness Standards: Normal Category Aircraft

2.6 *RTCA:*[6]

DO-160E (or later when not specified) Environmental Conditions and Test Procedures for Airborne Equipment

2.7 *SAE Recommended Practice:*[7]

SAE ARP 5412B Aircraft Lightning Environment and Related Test Waveforms

3. Terminology

3.1 *Definitions*—Terminology specific to the system safety assessment process is contained in Practice F3230. Terminology specific to this practice is provided in 3.2. For general terminology, refer to Terminology F3060.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *dB*—A measure of signal or field strength attenuation in decibels.

3.2.2 *function*—intended behavior of a product based on a set of defined requirements regardless of implementation. The specific action of a system, equipment, and flight crew performance aboard the aircraft that, by itself, provides a completely recognizable operational capability.

3.2.2.1 *Discussion*—For example, "display aircraft attitude to the pilot" is a function. One or more systems may perform a specific function or one system may perform multiple functions, or both.

3.2.3 *primary system*—a system that is the primary means of providing the function.

3.2.3.1 *Discussion*—For example, a primary flight display would have the primary display of attitude information to the pilot.

3.2.4 *redundant system*—a system that provides an identical function to one performed by another system.

3.2.5 *secondary system*—an independent system that can be used to accomplish the same function in addition to the primary system.

3.2.5.1 *Discussion*—For example, a standby attitude indicator provides a secondary means of presenting attitude information to the pilot in addition to the primary attitude indicator.

3.2.6 *system*—a combination of inter-related items arranged to accomplish a given function.

3.2.7 *V/m*—A measure of electrical field strength in volts per meter.

3.3 *Abbreviation:*

3.3.1 *IEL*—Indirect Effects of Lightning

4. Overview Flowchart

4.1 The flowchart in Fig. 1 provides an overview of the methods outlined in this practice.

[6] Available from RTCA, 1150 18th NW, Suite 910, Washington DC 20036, http://www.rtca.org.

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

5. Minimum Design Requirements

5.1 In order to utilize the methods described in this practice, the following minimum design considerations should be addressed. If deviations from these minimum design considerations are desired, the acceptability of the methods described must be agreed to by the applicable Civil Aviation Authority.

5.1.1 Systems that are part of the Type Certificated Engine must be installed in accordance with the engine manufacturer's requirements. The minimum HIRF and lightning qualification in accordance with Sections 8 and 9 of this ASTM practice should be met at the aircraft level.

5.1.2 The recommended test levels for a higher Certification Level aeroplane are acceptable in all cases for a lower Certification Level aeroplane. For example, the HIRF requirements specified for a Level 2 or 3 aeroplane may be used on a Level 1 aeroplane in any frequency band.

5.1.3 The airframe should incorporate low impedance electrical conductors for lightning current to flow through the aeroplane. The low impedance conductors should be incorporated into the basic structure of the aeroplane.

5.1.3.1 For aeroplanes with primarily aluminum structure, the aluminum skin provides a low impedance electrical conductor. Standard rivets and bolts provide adequate electrical bonding between permanent structural joints. Electrical bonding straps or jumpers should be installed on moving parts or for removable panels or parts.

5.1.3.2 For aeroplanes with primarily carbon fiber or fiberglass structure, metal mesh, metal foil, or expanded metal foil should be incorporated onto the external surfaces of the aeroplane composite structure. This mesh or foil must be joined together electrically and provide a continuous electrical conductor between the extremities of the aeroplane. Use of metallic components internal to the structure of the aeroplane may also be used to provide similar shielding for equipment and its wiring.

5.1.3.3 For aeroplanes constructed of tube and fabric, the tube skeleton can be considered as the low impedance electrical path through the aeroplane. The bonding also may be achieved by the use of bonding straps or jumpers where required to electrically bond other metallic sub-structure that might be relied upon to provide bonding for equipment.

5.1.4 Electrical bonding specifications and verifications should be developed and implemented on the production drawings and instructions for continued airworthiness.

6. Aeroplane Assessment Level Assignment

6.1 Determine the Aeroplane Assessment Level using Table 1. This Aeroplane Assessment Level assignment of I, II or III will be used to determine the applicable IEL and HIRF requirements for each aeroplane.

TABLE 1 Aeroplane Assessment Level Matrix

Aeroplane Certification Level	Aeroplane Assessment Level			
	Reciprocating Engine(s)		Turbine Engine(s)	
	1	>1	1	>1
Level 1	I	II	II	II
Level 2	I	II	II	II
Level 3	III	III	III	III

7. HIRF and IEL System Safety Analysis

7.1 *Perform HIRF and IEL System Safety Analysis:*

7.1.1 Obtain the assessment of system failure conditions that was performed as part of the system safety assessment process in accordance with Practices F3230 or F3309/F3309M. This will typically take the form of a Functional Hazard Assessment but simpler methods may have been employed depending on the complexity of the system.

7.1.2 Identify those failure conditions where exposure to HIRF or IEL could result in a failure condition that:

7.1.2.1 Would prevent continued safe flight and landing. These failure conditions would be classified as Catastrophic in the assessment discussed in 7.1.1.

7.1.2.2 Would significantly reduce the capability of the aeroplane or the ability of the flight crew to respond to an adverse operating condition. These failure conditions would be classified as Hazardous in the assessment discussed in 7.1.1.

7.1.2.3 Would reduce the capability of the aircraft or the ability of the flight crew to cope with adverse operating conditions. These failure conditions would be classified as Major in the assessment discussed in 7.1.1.

NOTE 1—Compliance with 7.1.2.3 is only required when the cognizant CAA requires major failure conditions to be addressed for HIRF or indirect effects of lightning, or both.

7.1.2.4 In addressing the requirements of 7.1.2, the nature of HIRF and IEL should be considered.

(1) The potential for common mode failures across multiple systems performing the same or different functions due to the simultaneous exposure to the HIRF and IEL threat must be considered. Simultaneous and common mode failures due to HIRF or lightning does not have to be assumed for multiple systems that contribute to a hazardous failure condition when consisting of federated equipment installations that are not identical in design.

(2) The inherent immunity of mechanical systems with no electrical circuitry should also be considered.

7.1.2.5 In addressing the requirements of 7.1.2, the effects of HIRF and IEL should not be combined with random failures that are not the result of the HIRF and Lightning threat. Additionally, the effects of HIRF and Lightning do not need to be considered in combination.

7.1.3 Identify what systems and equipment are required to prevent the failure conditions identified in 7.1.2.

7.1.4 The minimum HIRF and lightning qualification in accordance with Sections 8 and 9 of this ASTM practice should be met at the aircraft level. A minimum of one system must meet availability requirements, or, specifically for HIRF, multiple systems may be used to show availability requirements across the entire frequency band. If multiple systems are used to show availability for HIRF, then each of those systems should automatically recover the function after the threat is removed. For example, the Primary system meets requirements for a certain frequency range while the STBY system meets the requirements at frequencies the Primary was not able to. In this example, both the Primary and STBY should automatically recover the function after the threat is removed.

8. HIRF Compliance

8.1 HIRF compliance may be shown using the methods described in this section.

8.2 For the systems and equipment identified in 7.1.3, establish appropriate pass/fail criteria that ensures the following requirements are met:

8.2.1 For failure conditions where the loss of a function is Catastrophic:

8.2.1.1 The function at the aeroplane level is not adversely affected during and after the time the aeroplane is exposed at the HIRF environment. It is not necessary for all redundant systems to pass this requirement provided at least one system maintains the function in the presence of HIRF, in the entire frequency band.

NOTE 2—At a minimum, the other redundant systems must still be tested to the HIRF levels corresponding to the hazard classification associated directly with the loss of, or erroneous operation of, the redundant system.

8.2.1.2 When the requirements of 8.2.1.1 are met, recovery of normal operation of that function in redundant systems for Level 1, 2, and 3 aeroplanes can be accomplished by pilot action.

NOTE 3—It is accepted that a system upset by the exposure to HIRF will recover their normal operation after a system reset is performed. The use of a circuit breaker is an acceptable form of resetting the equipment, given how infrequently this is likely to occur. No HIRF testing is required to demonstrate that the affected redundant systems will recover after removal of the HIRF threat and a system reset is performed.

8.2.2 When erroneous (Note 4) behavior of a function is considered Catastrophic:

8.2.2.1 The function shall not be adversely affected during and after the time the aeroplane is exposed at the HIRF environment, if the adverse effect is considered Catastrophic.

8.2.2.2 If the availability of the function is not considered Catastrophic, then the function does not need to recover normal operation. It is acceptable for the function to be lost at the Catastrophic test level in lieu of presenting erroneous or misleading information.

NOTE 4—Erroneous behavior may be Hazardously Misleading Information (HMI) presented to the pilot as well as erroneous information that is an input to a system (for example, AP, FADEC, De-Ice, etc.), either of which may result in a Catastrophic condition for the aircraft.

8.2.3 For Major/Hazardous failure conditions:

8.2.3.1 Electrical/electronic systems must recover normal operation of that function in a timely manner after the aeroplane is exposed to the HIRF environment, if the availability of the function is considered to be Major/Hazardous.

NOTE 5—Major failure conditions are only required to be addressed if required by the cognizant CAA.

NOTE 6—Some CAA regulations currently state that requirement only applies to IFR operations. Aircraft approved for VFR operation fly in the same HIRF environment as IFR approved aircraft. At the time the rule was made, it did not consider certain technologies that have emerged since then (for example, EVTOL, Unmanned aircraft with fly-by-wire capability, etc.) for aircraft that are approved for VFR operations. The operations of these new technologies may lead to Major/Hazardous failure conditions that were not previously considered. Therefore, this paragraph is also considered applicable to aircraft that have been approved for VFR operations.

8.2.3.2 When the requirements of 8.2.3.1 are met, recovery of normal operation of that function in redundant systems is not necessary. It is acceptable for the function to be lost in lieu of presenting erroneous or misleading information.

8.2.3.3 If erroneous (Note 7) operation of the function is considered to be Hazardous, then the function shall not be adversely affected. The function does not need to recover if the availability is not considered Major/Hazardous.

NOTE 7—Erroneous behavior may be Hazardously Misleading Information (HMI) presented to the pilot as well as erroneous information that is an input to a system (for example, AP, FADEC, De-Ice, etc.), either of which may result in a Major/Hazardous condition for the aircraft.

8.3 Demonstrate that the systems and equipment successfully meet the pass criteria established in 8.2 when subjected to the required HIRF Levels specified in Table 2. The demonstration of meeting HIRF levels may be performed via test or analysis, or both.

9. Indirect Effects of Lightning Compliance

9.1 Indirect Effects of Lightning compliance may be shown using the methods described in this section.

9.2 Compliance with the requirements of this section are required for those aircraft whose operations are likely to be struck by lightning.

9.2.1 Compliance with this section must be addressed for aircraft that are approved for IFR operations.

9.2.2 Applicants must coordinate with their CAA to determine if any other operations must be considered.

9.2.3 No additional IEL compliance is required for aeroplanes limited to VFR only.

9.2.4 For failure conditions where the loss of a function is Catastrophic:

9.2.4.1 The function at the aeroplane level is not adversely affected during and after the time the aeroplane is exposed to lightning. It is not necessary for all redundant systems to pass this requirement provided at least one system maintains the function.

NOTE 8—At a minimum, the other redundant systems must still be tested to the IEL levels corresponding to the hazard classification associated directly with the loss of, or erroneous operation of, the redundant system.

9.2.4.2 When the requirements of 9.2.4.1 are met, recovery of normal operation of that function in redundant systems for Level 1, 2, and 3 aeroplanes is not necessary. There must be a means for the pilot to attempt to reset the affected redundant systems.

NOTE 9—The use of a circuit breaker is an acceptable form of resetting the equipment, given how infrequently this is likely to occur. No IEL testing is required to demonstrate that the affected redundant systems will recover.

9.2.5 When erroneous (Note 4) behavior of a function is considered Catastrophic:

9.2.5.1 The function shall not be adversely affected during and after the time the aeroplane is exposed to lightning if the adverse effect is considered Catastrophic.

9.2.5.2 If the availability of the function is not considered Catastrophic, then the function does not need to recover normal operation. It is acceptable for the function to be lost at the