U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: ELECTRICAL EQUIPMENT AND INSTALLATIONS

Date: 10/22/07 **AC No:** 25.1353-1A

Initiated by: ANM-100

1. PURPOSE. This advisory circular (AC) provides guidance for demonstrating compliance with the transport category airplane certification requirements of § 25.1353 *Electrical equipment and installations*.

2. APPLICABILITY.

a. The guidance provided in this document is directed to airplane manufacturers, modifiers, foreign regulatory authorities, Federal Aviation Administration (FAA) transport airplane type certification engineers, and designees.

b. This material is neither mandatory nor regulatory in nature and does not constitute a regulation. It describes acceptable means, but not the only means, for demonstrating compliance with the applicable regulations. We will consider other methods of demonstrating compliance that an applicant may elect to present. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations. On the other hand, if we become aware of circumstances that convince us that following this AC would not result in compliance with the applicable regulations, we will not be bound by the terms of this AC, and we may require additional substantiation as a basis for finding compliance.

c. This material does not change or create any additional regulatory requirements nor does it authorize changes in or permit deviations from existing regulatory requirements.

d. Terms such as “shall” or “must” are used in this AC only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described herein is used.

3. CANCELLATION. This AC cancels AC 25.1353-1, *Electrical Equipment and Installations,* dated March 25, 2004.

4. DEFINITION.

Electrical Wiring Interconnection Systems (EWIS). In part, an EWIS is any wire, wiring device, or combination of these, including termination devices, installed in any area of the airplane for the purpose of transmitting electrical energy between two or more intended termination points. The complete regulatory definition of an EWIS is in § 25.1701, which is included in Appendix A of this AC.

5. COMPLIANCE GUIDANCE. Section 25.1353(a) requires in part that "Any electrical interference likely to be present in the airplane must not result in hazardous effects on the airplane or its systems." The term "hazardous" means the same here as it does in §§ 25.1309 and 25.1709. Those two rules, however, require assigning a numerical probability to an event that can cause a failure condition. In § 25.1353(a), however, as in § 25.1707, the applicant must perform a qualitative design assessment of the installed electrical equipment and controls to determine that the consequences of any electrical interference will not result in effects that would prevent the continued safe flight and landing of the airplane. The qualitative design assessment should be made using reasonable engineering and manufacturing judgment and relevant service history.

A numerical probability assessment of the installed electrical equipment and controls may still be necessary, but that would be accomplished under the requirements of § 25.1309 or other applicable safety assessment requirements. The requirements of § 25.1353(a) are not in lieu of those contained in other applicable safety assessment requirements.

a. Section 25.1353(a). The following sources of interference should be considered when demonstrating compliance to the requirements of § 25.1353(a):

(1) Conducted and radiated interference caused by electrical noise generation from apparatus connected to the busbars.

(2) Coupling between electrical wires or between cables and aircraft antenna cables.

(3) Malfunctioning of electrically-powered apparatus.

(4) Parasitic currents and voltages in the electrical distribution and grounding systems, including the effects of lightning currents or static discharge.

(5) Different frequencies between generating or other systems.

b. Section 25.1353(b). This paragraph requires that EWIS components meet the requirements of §§ 25.1357, 25.1703, 25.1707, 25.1711, and 25.1717. Section 25.1707(c) contains the separation requirements formerly located in § 25.1353(b) for wires and cables that carry heavy current. Refer to AC 25.1357-1A for compliance guidance related to the

requirements of § 25.1357 and to AC 25.1701-1 for compliance guidance related to the requirements of §§ 25.1703, 25.1707, 25.1711, and 25.1717.

c. Sections 25.1353(c)(6)(ii) and (iii). As discussed in paragraph 4d., where temperature sensing and over-temperature warning devices are installed to comply with §§ 25.1353(c)(6)(ii) or (iii), their correct operation should be verified at agreed maintenance intervals in addition to compliance with §§ 25.1309(a) and (b).

d. Instructions for Continued Airworthiness. Instructions for Continued Airworthiness (ICA) (required by §§ 25.1529 and 25.1729) must include all maintenance actions necessary to ensure that electrical system components maintain their compliance with the requirements of § 25.1353 throughout the expected service life of the airplane.

e. Lithium-Ion Batteries. Lithium-ion (Li-ion) batteries have certain failure and operational characteristics and maintenance requirements that differ from that of nickel cadmium (Ni-Cd) and lead acid rechargeable batteries. The following discussion provides some background information and design and installation considerations for these unique characteristics. It should not be considered as guidance for complying with § 25.1353(c), however, because that rule does not apply to Li-ion batteries and use of such batteries may require Special Conditions, per the requirements of § 21.16. The following information is provided to help the applicant develop the design and installation of the Li-ion battery and may help the applicant in complying with any Special Conditions that may be issued in lieu of § 25.1353(c) for Li-ion battery installations.

(1) Background.

(a) Overcharging. Li-ion batteries in general are significantly more susceptible to internal failures that can result in self-sustaining increases in temperature and pressure (i.e., thermal runaway) than Ni-Cd and lead-acid batteries. This is especially true for overcharging, which causes heating and destabilization of the components of the cell and can thus cause the formation, by plating, of highly unstable metallic lithium. Metallic lithium can ignite, resulting in a self-sustaining fire or explosion. Certain types of Li-ion batteries pose a potential safety problem because of the instability and flammability of the organic electrolyte employed by the cells of those batteries. The severity of thermal runaway increases with increasing battery capacity because of the higher amount of electrolyte in large batteries.

(b) Over discharging. Discharge of some versions of the Li-ion cell beyond a certain voltage (typically 2.4 volts) can cause corrosion of the electrodes of the cell, resulting in loss of battery capacity that cannot be reversed by recharging. This loss of capacity may not be detected by the simple voltage measurements commonly available to flightcrews as a means of checking battery status, a problem shared with Ni-Cd batteries.

(c) Flammability of Cell Components. Unlike Ni-Cd and lead-acid cells, some types of Li-ion cells employ, in a liquid state, electrolytes that are known to be flammable. This material can serve as a source of fuel for an external fire in the event of a breach of the cell container.

(2) Li-ion design and installation considerations.

(a) Safe cell temperatures and pressures should be maintained during any probable charging or discharging condition, or during any failure of the charging or battery monitoring system. The Li-ion battery installation should be designed to preclude explosion in the event of those failures.

(b) Li-ion batteries should be designed to preclude the occurrence of self-sustaining, uncontrolled increases in temperature or pressure.

(c) The battery installation should prevent accumulation of hazardous quantities of toxic gases that may be emitted by the Li-ion battery during normal operation or as the result of any failure of the battery charging or monitoring system.

(d) The battery installation should prevent accumulation of hazardous quantities of flammable fluids that may escape from the Li-ion battery.

(e) Corrosive fluids or gases that may escape from any Li-ion battery should not damage surrounding airplane structure or adjacent essential equipment.

(f) Each Li-ion battery installation should have provisions to prevent any hazardous effect on structure or essential systems that may be caused by the maximum amount of heat the battery can generate during a short circuit of the battery or of its individual cells.

(g) Li-ion battery installations should have a system to automatically control the charging rate of the battery to prevent battery overheating or overcharging, and,

1 A battery temperature-sensing and over-temperature-warning system with a means for automatically disconnecting the battery from its charging source in the event of an over-temperature condition or,

2 A battery-failure sensing and warning system with a means for automatically disconnecting the battery from its charging source in the event of battery failure.

(h) If the failure of a Li-ion battery installation would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions, or prevent continued safe flight and landing, a monitoring and warning feature providing appropriate flightcrew indication should be provided to alert the crew

whenever the capacity and state of charge (SOC) of the batteries have fallen below levels considered acceptable for airplane dispatch.

(i) The ICA should contain maintenance procedures for Li-ion batteries in spares storage to prevent replacement of batteries whose function is required for safe operation of the airplane with batteries that have experienced degraded charge retention ability or other damage due to prolonged storage at low SOC.

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APPENDIX A

§§ 25.1353 and 25.1701

The text of §§ 25.1353 and 25.1701 is repeated here for the convenience of the reader.

§ 25.1353 Electrical equipment and installations.

(a) Electrical equipment and controls must be installed so that operation of any one unit or system of units will not adversely affect the simultaneous operation of any other electrical unit or system essential to safe operation. Any electrical interference likely to be present in the airplane must not result in hazardous effects on the airplane or its systems.

(b) Storage batteries must be designed and installed as follows:

(1) Safe cell temperatures and pressures must be maintained during any probable charging or discharging condition. No uncontrolled increase in cell temperature may result when the battery is recharged (after previous complete discharge)—

(i) At maximum regulated voltage or power;
(ii) During a flight of maximum duration; and
(iii) Under the most adverse cooling condition likely to occur in service.

(2) Compliance with paragraph (b)(1) of this section must be shown by test unless experience with similar batteries and installations has shown that maintaining safe cell temperatures and pressures presents no problem.

(3) No explosive or toxic gases emitted by any battery in normal operation, or as the result of any probable malfunction in the charging system or battery installation, may accumulate in hazardous quantities within the airplane.

(4) No corrosive fluids or gases that may escape from the battery may damage surrounding airplane structures or adjacent essential equipment.

(5) Each nickel cadmium battery installation must have provisions to prevent any hazardous effect on structure or essential systems that may be caused by the maximum amount of heat the battery can generate during a short circuit of the battery or of individual cells.

(6) Nickel cadmium battery installations must have—

(i) A system to control the charging rate of the battery automatically so as to prevent battery overheating; or

(ii) A battery temperature sensing and over-temperature warning system with a means for disconnecting the battery from its charging source in the event of an over-temperature condition; or

(iii) A battery failure sensing and warning system with a means for disconnecting the battery from its charging source in the event of battery failure.

(c) Electrical bonding must provide an adequate electrical return path under both normal and fault conditions, on airplanes having grounded electrical systems.

§ 25.1701 Definition.

(a) As used in this chapter, electrical wiring interconnection system (EWIS) means any wire, wiring device, or combination of these, including termination devices, installed in any area of the airplane for the purpose of transmitting electrical energy, including data and signals, between two or more intended termination points. This includes:

(1) Wires and cables.

(2) Bus bars.

(3) The termination point on electrical devices, including those on relays, interrupters, switches, contactors, terminal blocks and circuit breakers, and other circuit protection devices.

(4) Connectors, including feed-through connectors.

(5) Connector accessories.

(6) Electrical grounding and bonding devices and their associated connections.

(7) Electrical splices.

(8) Materials used to provide additional protection for wires, including wire insulation, wire sleeving, and conduits that have electrical termination for the purpose of bonding.

(9) Shields or braids.

(10) Clamps and other devices used to route and support the wire bundle.

(11) Cable tie devices.

(12) Labels or other means of identification.

(13) Pressure seals.

(14) EWIS components inside shelves, panels, racks, junction boxes, distribution panels, and back-planes of equipment racks, including, but not limited to, circuit board back-planes, wire integration units, and external wiring equipment.

(c) Except for the equipment indicated in paragraph (a)(14) of this section, EWIS components inside the following equipment, and the external connectors that are part of that equipment, are excluded from the definition in paragraph (a) of this section:

(1) Electrical equipment or avionics that are qualified to environmental conditions and testing procedures when those conditions and procedures are—

(i) appropriate for the intended function and operating environment, and

(ii) acceptable to the FAA.

(2) Portable electrical devices that are not part of the type design of the airplane. This includes personal entertainment devices and laptop computers.

(3) Fiber optics.

APPENDIX B

RELATED REGULATIONS AND DOCUMENTS

Regulations. You can download an electronic copy of 14 CFR from the Internet at http://www.gpoaccess.gov/cfr/. A paper copy can be ordered by sending a request to the U.S. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402-0001, or by calling telephone number (202) 512-1800; or by sending a request by facsimile to (202) 512-2250.

- § 25.1301 Function and installation
- § 25.1309 Equipment, systems, and installations
- § 25.1353 Electrical equipment and installations
- § 25.1357 Circuit protective devices
- § 25.1529 Instructions for continued airworthiness
- § 25.1701 Definition
- § 25.1707 System separation: EWIS
- § 25.1711 Component Identification: EWIS
- § 25.1717 Circuit protective devices: EWIS
- § 25.1729 Instructions for continued airworthiness: EWIS

Advisory Circulars. You can download an electronic copy of the latest version of the following ACs from the FAA Internet at http://rgl.faa.gov.

- 25.1309-1A System Design and Analysis
- 25.1357-1A Circuit Protective Devices
- 25.1701-1 Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes

Reports. You can download an electronic copy of the following report from the "Final Reports" section of the Aging Transport Systems Rulemaking Advisory Committee (ATSRAC) website: www.mitrecaasd.org/atsrac.

"Task 6 Final Report," dated October 29, 2002, Aging Transport Systems Rulemaking Advisory Committee.

APPENDIX C

Following is the discussion of § 25.1353 published in the *Federal Register* on October 6, 2005 (70 FR 58508), in Notice of Proposed Rulemaking No. 05-08, Enhanced Airworthiness Program for Airplane Systems/Fuel Tank Safety (EAPAS/FTS), at the time this rule was proposed.

Paragraphs (a), (b), (c), and (d) of proposed § 25.1709 contain EWIS-related requirements derived from the existing regulations applying to electrical power generation systems and electrical equipment and installations (§§ 25.1351 and 25.1353). Section 25.1351 does not need any revision to support the proposed § 25.1709, but § 25.1353 is amended to reference § 25.1709.

The proposed requirements of § 25.1709(a) were derived from existing § 25.1353(a). While the requirements of § 25.1353(a) are retained, the portion of that requirement applicable to wiring has been moved to the proposed § 25.1709(a). Further clarification of the requirement is also included in the proposal. Section 25.1353(a) states " … wiring must be installed so that *operation* of any one unit or system of units…." Proposed section 25.1709(a) expands on the term "operation" to state that it means "operation under normal and failure conditions as defined by § 25.1309."

Proposed section 25.1709(b) would require that each EWIS be designed and installed so that any electrical interference likely to be present in the airplane will not result in hazardous effects on the airplane or its systems. This proposed requirement is based on new text recently added to § 25.1353(a) to harmonize part 25 with the existing text of the JAA JAR 25.1353(a)[i]. The text of JAR 25.1353(a) requires that any electrical interference likely to be present in the airplane must not result in hazardous effects on the airplane or its systems except under extremely remote conditions. The proposed § 25.1709(b) is recognition of the fact that electrical interference can be introduced into airplane systems and wiring by coupling between electrical cables or between cables and

[i] The JAA is the Joint Aviation Authority of Europe and the JAR is its Joint Aviation Requirements, the equivalent of our Federal Aviation Regulations. In the time since these proposals were developed, in 2003, the European Aviation Safety Agency (EASA) was formed. EASA is now the principal aviation regulatory agency in Europe, and we intend to continue to work with them to ensure our proposal is also harmonized with its Certification Specifications (CS). But since the harmonization efforts involved in developing this proposal occurred before EASA was formed, it was the JAA that was involved with them. So while the JAR and CS are essentially equivalent, and in the future we will be focusing on the CS, it is the JAR that will be referred to in the historical background discussions in this proposal.

coaxial lines, as well as by the other equipment that is the subject of § 25.1353(a).