U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: CIRCUIT PROTECTIVE DEVICES

Date: 10/22/07 **AC No:** 25.1357-1A

Initiated by: ANM-100

1. PURPOSE. This advisory circular (AC) provides guidance for demonstrating compliance with the transport category airplane certification requirements of § 25.1357 *Circuit protective devices (CPD).*

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 means 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 means of compliance when the acceptable means of compliance described herein is used.

3. CANCELLATION. This AC cancels AC 25.1357-1, *Circuit Protective Device Accessibility,* dated September 20, 1988.

4. DEFINITIONS.

a. Essential to Safety in Flight. For the purpose of compliance with § 25.1357(d), a CPD is considered to be essential to safety in flight if its disconnection would result in a major, hazardous, or catastrophic failure condition as defined below. These failure conditions are identical to those proposed by the Aviation Rulemaking Advisory Committee for the draft (Arsenal) version of AC 25.1309-1b, dated June 10, 2002, and match those contained in AC 25.1701-1, *Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes*, for § 25.1709.

Failure Condition	Explanation
Major	Failure conditions that would reduce the capability of the airplane or the ability of the flightcrew to cope with adverse operating conditions to the extent that there would be, for example: • a significant reduction in safety margins or functional capabilities; • a significant increase in flightcrew workload or in conditions impairing flightcrew efficiency; • discomfort to the flightcrew; or • physical distress to passengers or cabin crew, possibly including injuries.
Hazardous	Failure conditions that would reduce the capability of the airplane or the ability of the flightcrew to cope with adverse operating conditions to the extent that there would be, for example: • a large reduction in safety margins or functional capabilities; • physical distress or excessive workload such that the flightcrew cannot be relied upon to perform their tasks accurately or completely; or • serious or fatal injuries to a relatively small number of persons other than the flightcrew.
Catastrophic	Failure conditions that would result in multiple fatalities, usually with the loss of the airplane NOTE: A catastrophic failure condition was defined differently in previous versions of § 25.1309 and in accompanying advisory material as "a failure condition that would prevent continued safe flight and landing."

b. Accessible. For the purpose of compliance with § 25.1357(d), an accessible CPD is one that can be readily reset or replaced by a member of the flightcrew without their leaving their seat. Although § 25.1357(d) does not use the term "accessible" this is what § 25.1357(d) means when it says that the circuit breaker or fuse "...must be located and identified so that it can be readily reset or replaced in flight." A physically inaccessible but remotely controllable CPD is considered accessible if its control device is accessible to the flightcrew in accordance with this definition.

c. 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.

a. Protection Against Arc Faults. Protection against faults should be provided. Arc fault circuit breakers (AFCB) may provide one means to protect against arc faults. As of the publication date of this AC, AFCB technology is still being developed. However, as the technology matures and AFCBs become available, applicants should evaluate the merits of using AFCBs in their designs.

b. § 25.1357(a). It should be demonstrated that no hazard results from the effects of variations in ambient temperature on either the protective device or the equipment it protects when selecting and designing the installation of the automatic protective devices required by § 25.1357(a).

c. § 25.1357(d). This section requires that a CPD must be accessible if the ability to reset or replace it is essential to safety in flight. Single failures and combinations of failures, including automatic CPD disconnections, must be considered in defining a safe design. Any single CPD through which continued electrical power is conducted, including those used to protect buses or power sources, that is essential to safety in flight must be accessible to the flightcrew without their having to leave their seats.

d. Circuit Breaker Reset

(1) Service experience shows that attempts by the flightcrew to restore power by resetting or replacing a CPD after its automatic disconnection can sometimes create a fire hazard and will often be unsuccessful because the majority of such disconnections are caused by faults that must be corrected by maintenance action. Therefore, designs should not require resetting or replacing CPDs in flight to cope with any failure condition, except as part of an approved fault-clearing and isolation procedure in a situation where the flightcrew believes a catastrophic event could occur if the circuit breaker is not reset.

(2) Service experience also shows that attempts by the flightcrew to clear and isolate faults at the individual load level can sometimes create a fire hazard, especially if the flightcrew is unable to confidently identify the faulty circuit or component and the limits of the faults' effects. Few circuits or components are located where such confident determinations can be made. Therefore, designs should allow safe accomplishment of all necessary fault-clearing and isolation procedures at the bus or power source level by ensuring that disconnection of any bus or power source as part of any such procedure

does not cause any loss of function that would result in a major, hazardous, or catastrophic failure condition.

(3) Spare fuses. If fuses are used, this section requires a number of spare fuses for use in flight equal to at least 50 percent of the number of fuses of each rating required for complete circuit protection. This section applies only to accessible fuses.

(4) Fault-clearing and isolation procedures. The airplane flight manual (AFM) or applicable AFM supplement should contain all fault-clearing and isolation procedures. These procedures should be approved by the cognizant Aircraft Certification Office or FAA designee.

e. § 25.1357(e). This section requires that "each circuit for essential loads must have individual circuit protection." Traditionally this would mean that each circuit for an airplane essential system would have its own dedicated circuit protective device, because each essential airplane system would have its own power source, equipment, and wiring. However, modern airplanes continue to increase their utilization of system architectures containing a high level of integration. That means, for example, that a single piece of avionics equipment may provide control of multiple airplane systems that are essential for safe operation. Typically these pieces of avionics are redundant, with two or three pieces of equipment providing for function redundancy. The traditional definition of a "circuit" cannot be applied in these cases. There is not a one-to-one correspondence of power source, control equipment, and wire for each airplane system controlled by the integrated circuit. Therefore, in the context of this paragraph, a circuit is defined as the circuit protective device, the equipment performing the integrated functions, and its associated wire. To demonstrate compliance with the requirements of § 25.1357(e) in the case of a piece of equipment that integrates multiple functionality, the applicant must demonstrate that the overall circuit has individual circuit protection. Note that other paragraphs, such as § 25.1357(a), may require that subsystems within the circuit also be provided circuit protection.

f. § 25.1357(f). This paragraph requires that circuit breakers not be used as the primary means to remove or reset system power for those airplane systems for which the ability to remove or reset power during normal operation is necessary, unless specifically designed as a switch.

(1) It is not the intent of the requirement that every electrically powered system in the airplane have a means to remove power other than a circuit breaker. We distinguish between airplane systems normally turned on and off during normal operations, such as passenger convenience systems, and those systems normally powered at all times, such as flight deck multi-function displays or the flight-management computer. But if, for example, the flight-management computer did require power cycling regularly, for whatever reason, this system would be required to have a means to do this other than using the circuit breakers, unless the circuit breaker is specifically designed as a switch.

(2) Systems requiring power removal during normal operations should be designed so that power is removed from the system as close as practical to the source of power instead of simply deactivating the outputs of the systems power supplies.

(3) A separate, or integrated, power switch may be used to show compliance with § 25.1357(f). If an integrated switch is used (that is, a switch that controls power to multiple airplane systems), then it must be shown that removing or resetting power for those multiple systems will not adversely affect safe flight.

(4) A switch-rated circuit breaker can be used if it is shown to be appropriately rated for the number of switch cycles expected to be executed during the service life of the system or of the circuit breaker.

g. § 25.1717 Circuit Protective Devices: EWIS. Section 25.1717 requires that electrical wires and cables be designed and installed so they are compatible with the circuit protection devices required by § 25.1357, so that a fire or smoke hazard cannot be created under temporary or continuous fault conditions.

h. Instructions for Continued Airworthiness. The Instructions for Continued Airworthiness (required by §§ 25.1529 and 25.1729) must include all maintenance actions necessary to maintain the CPD covered by § 25.1357.

i. Compliance Analysis and Testing. Compliance with the requirements of § 25.1357 may be shown by analysis and appropriate tests. You should consider automatic CPD disconnections, including disconnections of CPDs used to protect buses or power sources, in the same way as other failures are considered. You should apply this guidance to modifications to previously-certificated airplanes if –

- new inaccessible CPDs are used, or
- existing accessible CPDs are moved to new inaccessible locations.

/s/Ali Bahrami
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APPENDIX A

§§ 25.1357 and 25.1701

The text of §§ 25.1357 and 25.1701 is repeated here for the convenience of the reader.

§ 25.1357 Circuit protective devices.

(a) Automatic protective devices must be used to minimize distress to the electrical system and hazard to the airplane in the event of wiring faults or serious malfunction of the system or connected equipment.

(b) The protective and control devices in the generating system must be designed to de-energize and disconnect faulty power sources and power transmission equipment from their associated busses with sufficient rapidity to provide protection from hazardous over-voltage and other malfunctioning.

(c) Each resettable circuit protective device must be designed so that, when an overload or circuit fault exists, it will open the circuit irrespective of the position of the operating control.

(d) If the ability to reset a circuit breaker or replace a fuse is essential to safety in flight, that circuit breaker or fuse must be located and identified so that it can be readily reset or replaced in flight. Where fuses are used, there must be spare fuses for use in flight equal to at least 50% of the number of fuses of each rating required for complete circuit protection.

(e) Each circuit for essential loads must have individual circuit protection. However, individual protection for each circuit in an essential load system (such as each position light circuit in a system) is not required.

(f) For airplane systems for which the ability to remove or reset power during normal operations is necessary, the system must be designed so that circuit breakers are not the primary means to remove or reset system power unless specifically designed for use as a switch.

(g) Automatic reset circuit breakers may be used as integral protectors for electrical equipment (such as thermal cut-outs) if there is circuit protection to protect the cable to the equipment.

§ 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 of equipment.

(b) 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
- § 25.1307 Miscellaneous equipment
- § 25.1309 Equipment, systems, and installations
- § 25.1351 General
- § 25.1353 Electrical equipment and installations
- § 25.1360 Precautions against injury
- § 25.1365 Electrical appliance, motors, and transformers
- § 25.1529 Instructions for Continued Airworthiness
- § 25.1701 Definition (of 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.

- 25-10 Guidance for Installation of Miscellaneous, Nonrequired Electrical Equipment, dated March 6, 1987
- 25-16 Electrical Fault and Fire Protection and Prevention, dated September 25, 1987
- 25.1309-1A System Design and Analysis, dated June 21, 1988
- 25.1353-1 Electrical Requirement and Installations
- 25-1360-1 Protection Against Injury
- 25.1365-1 Electrical Appliances, Motors, and Transformers
- 25.1701-1 Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes

Policy Memoranda. You can download an electronic copy of the following policy memorandums from the FAA Internet at http://rgl.faa.gov.

- PS-ANM100-1999-0021

Requirements of FAR 25.1357(e), issued April 20, 1999

- PS-ANM100-2000-00105 (also numbered 00-111-160)
  Interim Policy Guidance for Certification of In-Flight Entertainment Systems on Title 14 CFR Part 25 Aircraft, issued September 18, 2000

- PS-ANM100-2001-00113 (also numbered 00-111-196)
  Interim Summary of Policy and Advisory Material Available for Use in the Certification of Cabin Mounted Video Camera Systems with flight Deck Displays on Title 14 CFR Part 25 Aircraft, issued October 5, 2001

- ANM-01-111-165
  Policy Statement on Certification of Power Supply systems for Portable Electronic Devices on Part 25 Airplanes, issued March 28, 2005

Reports. You can download an electronic copy of the following report from the "Final Reports" section of the ATSRAC website: www.mitrecaasd.org/atsrac.

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

APPENDIX C

Following are the discussions of § 25.1357 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.

Section 25.1357 Circuit protective devices.

Section 25.1357 specifies standards for use, functional requirements, and installation requirements for electrical circuit protective devices. These standards protect the airplane's wiring from electrical faults or malfunctions.

JAR paragraph 25.1357(d) contains a requirement to provide sufficient spare fuses, formerly located in paragraph (f). The reason the JAA moved this text from paragraph (f) to (d) was to make it clear that the spare fuse requirement does not apply to fuses that are inaccessible in flight. We propose to revise § 25.1357 to move the spare fuse requirement of paragraph (f) to paragraph (d) to harmonize with the JAR requirement.

The proposed standard continues to address the underlying safety issue by providing protection for the airplane's electrical system from wiring faults or malfunctions, and by ensuring that there is no confusion about use of spare fuses in flight. It would maintain the same level of safety relative to the current regulations and is in line with current industry practice.

Manufacturers and operators of transport category airplanes could be affected by the proposed change. But since it is in line with current industry practice and does not result in any practical changes in requirements or practice, such effects would not be significant.

The JAR paragraph 25.1357(a) references advisory material, ACJ 25.1357(a), which states that the effects of variations in ambient temperatures on either the protective device or the equipment it protects must not result in hazards. We intend to revise our current AC 25-1357 to include this ACJ material.

Section 25.1357(f) System power removal.

ATSRAC has proposed adding a requirement that airplane systems normally requiring power removal have a power switch to accomplish this, instead of relying on using the circuit breaker. The FAA has decided that this requirement belongs in § 25.1357.

It is not the intent of the proposal to require that every electrically powered system in the airplane have a means to remove power from them other than a circuit breaker. ATSRAC used the phrase "normally requiring power removal" to distinguish between airplane systems normally turned on and off during normal operations, such as passenger convenience systems, and those systems normally powered at all times, such as the flightdeck multi-function displays or the flight management computer. But if, for example, the flight-management computer did require power cycling regularly, for whatever reason,

this system would then be required to have a means to do this other than using the circuit breakers.

For systems requiring this power removal design feature, power should be removed from the system as closely as practical to the source of power instead of simply deactivating the outputs of the systems power supplies.

The ability to quickly remove power from an airplane system not required for the airplane's safe operation is important if an emergency situation demands isolation of a known or unknown source of fire or smoke. One of the first things flightcrews are instructed to do when faced with a fire or smoke emergency is to remove power from the known source or from all unnecessary systems if the source is unknown. This is to stop the fire or smoke from spreading. Currently, part 25 regulations do not require systems to have a separate shutoff feature. But the need for the flightcrew to be able to shut off unnecessary systems was tragically illustrated during the investigation of the fatal accident on September 3, 1998, of a Swissair Model MD-11, discussed earlier in this document.

After that accident, the FAA conducted a special certification review (SCR) on the IFE system installed on the airplane, and published its report ("Federal Aviation Administration Special Certification Review Team Report on: Santa Barbara Aerospace, STC ST00236LA-D, Swissair Model MD-11 Airplane, In-flight Entertainment System," June 9, 2000. A copy of this report is contained in the docket). One of the team's findings was that the design of the IFE system did not allow the flightcrew or cabin crew to completely remove electrical power in any other way than by pulling the system's circuit breakers. The FAA decided that this was an unsafe condition, and we issued an airworthiness directive prohibiting operation of MD-11 airplanes with that particular IFE system installed. The FAA expanded its investigation and reviewed previously issued STCs that had approved installation of IFE systems on transport category airplanes. That investigation identified over 20 STC IFE installations that had the same design characteristics as the one on the accident MD-11 airplane (no means to remove power other than by pulling the circuit breaker). We issued ADs to correct those inadequate IFE system designs. As more IFE systems with the same design characteristic are identified, ADs will be issued to correct the identified unsafe condition.

On September 18, 2000, the FAA issued a policy memorandum stating that a newly certified IFE system should have a way for the flightcrew or cabin crew to disconnect it from its source of power other than by using circuit breakers. A copy of this memorandum, titled "Interim Policy Guidance for Certification of In-Flight Entertainment Systems on Title 14 CFR Part 25 Aircraft (Policy Number 00-111-160)," is in the docket. Most airplane manufacturers are now equipping IFE systems on their newly delivered airplanes with a power source disconnection means. Subsequent policy covering cabin video surveillance systems also contains the same guidance (Policy Number 01-111-196, "Interim Summary of Policy and Advisory Material Available for Use in the Certification of Cabin Mounted Video Cameras Systems with Flight Deck Displays on Title 14 CFR Part 25 Aircraft," included in the docket). ATSRAC (as recommended by the ATSRAC Wire Systems Harmonization Working Group

and the ARAC Electrical Systems Harmonization Working Group) believes that this philosophy should be applied to any airplane system that requires having its power removed or reset during normal operations. The FAA agrees with this recommendation.

The proposed § 25.1357(f) would require that airplane systems needing a capability for having their power removed or reset during normal operations must be designed so that circuit breakers are not the primary means to do that. This is a new regulation whose requirements have not previously existed within part 25 and is a recognition that any airplane system, including an IFE system, that requires regular power removal or resetting needs to have a means to do so.