



U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: Circuit Protective Devices **Date: 9/12/05**

**AC No:
25.1357-1X**

Initiated By: ANM-100

Change: DRAFT

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. 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 10th 2002 and match those contained in AC 25.17XX, Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes, for §25.1705.

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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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, reproduced in Appendix A of this AC.

3. COMPLIANCE GUIDANCE.

a. Arc Fault Circuit Breakers. Arc fault circuit breakers should be considered for use as they become available for the various types of circuits found in airplanes (28 VDC or 3 phase 115 VAC, for example).

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 §25.1353(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.

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 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.

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 essential airplane 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 closely 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. § 25.1721 Circuit Protective Devices: EWIS. Section 25.1721 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 25.1739) must include all maintenance actions necessary to maintain the CPD covered by § 25.1357 so that circuit protection is ensured throughout the expected service life of the airplane or of the CPD.

i. Compliance Analysis and Testing. Compliance with the requirements of § 25.1357 may be shown by analysis and appropriate tests. For new airplanes, such analysis and tests should show compliance regardless of whether CPDs are accessible. 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.

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) 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 between two or more intended termination points. Except as provided for in paragraph (c) of this section, this includes:

- (1) Wires and cables.
- (2) Bus bars.
- (3) The termination point on electrical devices, including 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.

(b) The definition in paragraph (a) of this section covers 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 and wire integration units.

(c) Except for the equipment indicated in paragraph (b) 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 Sections of 14 CFR part 25 that prescribe requirements for the design, substantiation, and certification relating to circuit protective devices in transport category airplanes include:

- § 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)
- § 25.1721 Circuit protective devices: EWIS
- § 25.1739 Instructions for Continued Airworthiness: EWIS.

Advisory Circulars.

- 25-10 Guidance for Installation of Miscellaneous, Nonrequired Electrical Equipment
- 25-16 Electrical Fault and Fire Protection and Prevention
- 25.1309-1A System Design and Analysis
- 25.1353-1 Electrical Requirement and Installations
- 25-1360-1 Protection Against Injury
- 25.1365-1 Electrical Appliances, Motors, and Transformers
- 25.17XX Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes

Policy Memoranda

- PS-ANM100-1999-0021 Requirements of FAR 25.1357(e)
- PS-ANM100-2000-00105 Interim Policy Guidance for Certification of In-Flight Entertainment Systems on Title 14 CFR Part 25 Aircraft
- PS-ANM100-2001-00113 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

- ANM-01-111-165

Policy Statement on Certification of Power Supply
systems for Portable Electronic Devices on Part 25
Airplanes

Reports

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