SUBPART F - EQUIPMENT

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Section 25.1351 General

a. **Rule Text.**

(a) Electrical system capacity. The required generating capacity, and number and kinds of power sources must-

(1) Be determined by an electrical load analysis; and

(2) Meet the requirements of 25.1309.

(b) Generating system. The generating system includes electrical power sources, main power busses, transmission cables, and associated control, regulation, and protective devices. It must be designed so that --

(1) Power sources function properly when independent and when connected in combination;

(2) No failure or malfunction of any power source can create a hazard or impair the ability of remaining sources to supply essential loads;

(3) The system voltage and frequency(as applicable) at the terminals of all essential load equipment can be maintained within the limits for which the equipment is designed, during any probable operating condition; and

(4) System transients due to switching, fault clearing, or other causes do not make essential loads inoperative, and do not cause a smoke or fire hazard.

(5) There are means accessible, in flight, to appropriate crewmembers for the individual and collective disconnection of the electrical power sources from the system.

(6) There are means to indicate to appropriate crewmembers the generating system quantities essential for the safe operation of the system, such as the voltage and current supplied by each generator.

(c) External power. If provisions are made for connecting external power to the airplane, and that external power can be electrically connected to equipment other than that used for engine starting, means must be provided to ensure that no external power supply having a reverse polarity, or a reverse phase sequence, can supply power to the airplane's electrical system.

(d) Operation without normal electrical power. It must be shown by analysis, tests, or both, that the airplane can be operated safely in VFR conditions, for a period of not less than five minutes, with the normal electrical power(electrical power sources excluding the battery) inoperative, with critical

type fuel(from the standpoint of flameout and restart capability), and with the airplane initially at the maximum certificated altitude. Parts of the electrical system may remain on if --

(1) A single malfunction, including a wire bundle or junction box fire, cannot result in loss of both the part turned off and the part turned on; and

(2) The parts turned on are electrically and mechanically isolated from the parts turned off.

(Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-41, 42 FR 36970, July 18, 1977; Amdt. 25-72, 55 FR 29785, July 20, 1990)

b. **Intent of Rule.** The intent of paragraph (d) of this section, relating to the propulsion system, is to assure that loss of normal electrical power will not result in an unsafe condition due to possible affects on the propulsion system.

c. **Background.**

(1) The regulatory history shows that this requirement originated from sections 4b.620 through 4b.622 of the Civil Air Regulations (CAR) 4b, December 31, 1953. Amendment 25-AD (29 FR 18289, December 24, 1964) added Part 25 [New] to the Federal Aviation Regulations and replaced Part 4b of the CAR. It was part of the Agency recodification program announced in Draft Release 61-25, published in the Federal Register on November 15, 1961 (26 FR 10698). It was recodified from CAR 4b without any substantive changes.

(2) This section was modified by Amendment 25-41 (42 FR 36960, July 18, 1977), which followed two Notices of Proposed Rulemaking:

- Notice 75-10 (40 FR 10802, March 7, 1975); and
- Notice 75-23 (40 FR 23048, May 27, 1975).

The amendments based on Notice 75-10 were deferred to the series of amendments titled “Miscellaneous Amendments" so that they could be considered with the final disposition of certain proposals in Notice 75-23. The following excerpts are from the preamble to that Amendment and discuss the comments received to the Notices.

> One commenter suggests that the phrase “not used solely for starting engines" in proposed § 23.1351(f) could be misinterpreted. The explanation in the Notice stated that the proposal was intended to prevent damage to the aircraft's electrical system if reverse polarity or reverse phase sequence of the external power source occurred. Therefore, as suggested by the commenter, [*the FAA has clarified*] proposed §§ 23.1351(f), 25.1351(c), 27.1351(e), and 29.1351(d) [designated as § 29.1351(c)] . . . to require protection if “external power can be electrically connected to equipment other than that used for engine starting."
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> One commenter objects to proposed §§ 27.1351(e) and 29.1351(d) on the grounds that they do not provide a reasonable limit on the extent to which one has to go to ensure that a reverse polarity connection cannot be made. The FAA believes that the proposals are

clear and unambiguous as to their intent and as to what is required. The FAA believes that a more detailed requirement would be unnecessarily restrictive.

One commenter objects to proposed § 25.1351(c) on the grounds that it does not cover every external power condition that should be protected against, and that its objective is already covered by current regulations on electrical systems and equipment. [*The FAA does not agree*.] The purpose of the proposal is for protection against those hazardous conditions involving external power that have occurred in service. With respect to the current regulations on electrical systems and equipment, they are not sufficiently specific to adequately deal with the subject matter of these proposals.

Several commenters state that proposed §§ 25.1351(d) and 29.1351(c) do not conform to the special condition on which they were based, since they would require the aircraft to operate safely for 5 minutes without normal generator or battery power; whereas the special condition allowed the use of battery power. The FAA agrees that proposed §§ 25.1351(d) and 29.1351(c) should be revised for consistency with recently issued Special Conditions. The proposals are therefore revised by adding the parenthetical phrase “(electrical power sources excluding the battery)" after the word “power" in the first sentence.

One commenter states that §§ 25.1351(d) and 29.1351(c) are unreasonable in that they would require compliance at the maximum certificated altitude, with critical type fuel, and after loss of electrical power, which is a combination that has not occurred in service. The FAA believes that this set of conditions could exist in service, and that it must be considered in the interests of safety.

One commenter suggests that the phrase “including a wire bundle or junction box fire" in proposed §§ 25.1351(d)(1) and 29.1351(c)(1) should be deleted since these are not “single" malfunctions. The FAA does not agree that they should be deleted. The FAA believes that the occurrence of a fire in a wire bundle or in a junction box should be considered in this context as a single event or malfunction, even though it may result in several circuit failures.

One commenter suggests that proposed §§ 25.1351(d) and 28.1351(c) should provide for continued flight after the specified 5 minute interval. [*The FAA does not agree.*] The recommended change is beyond the scope of the Notice. In addition, the FAA does not have sufficient information at the present time to justify such a requirement.

Another commenter questions whether engine thrust reduction and descent, or engine(s) flameout, descent, and subsequent engine restart at a reasonable altitude, would meet the requirements of the proposed rule. The FAA believes that proposed § 25.1351(d) provides for the situation described by the commenter, as long as the airplane can be operated safely.

One commenter objects to proposed § 29.1351(c), contending that the requirement is unnecessary for rotorcraft and would result in the introduction of electrical systems of unnecessary complexity and increased likelihood of mismanagement. The FAA does not agree. The loss of normal generator power is potentially hazardous in all transport category aircraft and must be considered in electrical system design. As to the effect on electrical system complexity and the probability of mismanagement, the FAA has not observed a significant increase in complexity or cases of mismanagement on aircraft that have already been required to comply under a [related] Special Condition.

(3) This section was further modified by Amendment 25-72 (55 FR 29756, July 20, 1990), which followed Notice of Proposed Rulemaking 84-21 (49 FR 47358,

December 3, 1984. The Notice was based on a review of Part 25 that was originally initiated to ensure that the type certification standards contained in that Part remain appropriate and practicable for the smaller transport category airplanes. After the review was begun, the scope was expanded to include relieving the regulatory burden wherever possible without compromising the existing standards, and updating Part 25 for clarity and accuracy. As stated in the Notice, relatively few changes were found to be warranted with respect to type certification of the smaller transport category airplanes or relieving the regulatory burden.

d. **Policy/Compliance Methods.**

(1) Guidance for showing compliance with the electrical systems aspects of this section can be found in Advisory Circular 25-XX, "Certification of Transport Airplane Electrical Equipment Installations" ("Electrical Systems Mega AC"). Guidance for compliance with § 25.1351(d) of this section, relating to the effects of electrical system power loss on the propulsion system, is provided below:

> Compliance with § 25.1351(d) requires "that the airplane can be operated safely in VFR conditions, for a period of not less than 5 minutes, with the normal electrical power (electrical power sources excluding the battery) inoperative, with critical type fuel (from the standpoint of flameout and restart capability), and with *the airplane initially at the maximum certificated altitude."* This requirement is intended to ensure that loss of normal electrical power will not result in an unsafe condition due to possible affects on the propulsion system. When the regulation was promulgated, the critical condition that was of concern was loss of all AC power during high altitude operation where suction feed operation with higher vapor pressure fuels could result in flame out of the engines and/or the inability to restart the engines due to vapor lock of the fuel system. For airplanes equipped with AC powered fuel pumps, where flame out of the engines occurs following loss of AC power, this requirement has historically required demonstration of the capability to windmill-restart the engines on suction feed, using battery power for ignition and other critical functions necessary for continued operation.
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> The airplane design and engine fuel performance should be evaluated following loss of the normal power source. Testing should be accomplished to demonstrate that loss of power would not result in an unsafe condition. Historically, two critical flight conditions have been identified:
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> 1. The first is loss of power at the maximum certificated altitude as defined in the regulation.
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> 2. The second is loss of power during climb conditions.
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> The fuel systems on some newer engine models are configured with fuel/oil heat exchangers that may allow significant heating of the fuel in the engine fuel feed system following shutdown or flame out of the engine. In several instances, this characteristic has resulted in vapor lock of the engine fuel system following loss of all electrical power at altitudes well below the maximum service ceiling. Restart of the engines has not been possible prior to reaching 15,000 feet. The FAA has concluded that this is an unsafe feature and has required the consideration of this condition in showing that no unsafe condition will result following loss of normal electrical power. In several instances, manufacturers have provided alternate power sources for the fuel pumps (ram air turbine or battery powered electrical bus), to demonstrate no unsafe condition would result .

Flight test demonstration.

Aircraft with AC-powered fuel pumps typically require two flight tests. The first consists of a test with the AC pumps off and the airplane configured as described in Advisory Circular 25-7A, "Flight Test Guide for Certification of Transport Category Airplanes," chapter 5, section 2 ("Fuel System Hot Weather Operation, §25.961"). [That AC describes considerations for conducting a hot fuel climb demonstration. The test is conducted utilizing the critical fuel (from an engine flame out standpoint (usually JP-4 or Jet B)) at the critical temperature (required to be a minimum of 110°F per § 25.961 (a)(5).] This test establishes the altitude at which AC power loss would result in all engine power loss. Once the engine power loss altitude has been established, power to the fuel pumps is restored and the climb is continued to maximum service ceiling. The pumps are then turned off, allowing the test engine to flame out. This test typically results in fuel vapor within the fuel lines and priming of the line up to the engine driven fuel pump may not occur until the altitude has reached as low as 16,000 ft. Suction feed engine restart attempts are initiated (once the airplane has reached the restart envelope) during a simulated all engine out descent until engine restart is achieved. This test establishes the suction feed relight recovery altitude from service ceiling altitude.

Results from the initial flight test may show other conditions are more critical. Suction feed climb performance previously demonstrated on some engine types indicates that flameout could occur at altitudes as low as 25,000 ft. Restart of engines with long restart times from lower altitude attained during the climb may be more critical than restart from maximum service ceiling. Therefore, testing at the critical condition is required. The FAA has determined that an unsafe condition would exist if restart and altitude stabilization did not occur prior to reaching 15,000 ft.

(2) The following excerpts are from an FAA letter in response to an airplane manufacturer's request to use a Special Condition in lieu of FAR 25.1351 requirements and provide additional compliance guidance. This letter provides additional background into development of the requirements of § 25.1351.

We have reviewed your subject proposal to substitute § 25.1351, added by Amendment 25-41, for a Special Condition that would set the requirements for operation without electrical power. We do not concur with this change, unless the requirements of § 25.1309(b) and (c) are applied to the electrical generation and distribution system. We offer the following explanation for this finding:

a. The original Special Condition from which § 25.1351(d) was developed was a requirement to determine if continued safe flight was possible for a five-minute period following loss of all generators (but not the battery). Although flight testing of this condition was conducted in VFR conditions, the requirement was applicable for all probable flight conditions. Therefore, sufficient instruments for the flight crew to achieve and maintain straight and level flight in IFR conditions had to be available to the flight crew with all generators off. However, the primary purpose of this Special Condition was to demonstrate the continued safe operation of the engines for five minutes and, if necessary, the safety of procedures to compensate for the loss of one or more engines due to the loss of the generators. Battery operation was normal for this evaluation. Special Conditions of this type were applied and demonstrated on previous model airplanes.

b. On later airplanes, this requirement was changed to require safe operation in VFR conditions without electrical power from either the generators or the batteries for five minutes. This was to assure that emergency procedures for electrical fire and smoke

could be accomplished satisfactorily, and to show that electrical power could be restored after this time period. Five minutes was assumed to be the time necessary to accomplish the AFM emergency procedures for electrical fire or smoke. This Special Condition is not the same as that discussed in paragraph (a). above.

c. The same Special Condition described in paragraph b. above was used for a previous model airplane. However, after lengthy discussions, consideration of the simultaneous loss of all generators and the battery was not required due to the physical and electrical separation of the generators and the battery electrical supply systems installed on the subject model airplanes. This interpretation and the Special Conditions which were later applied to other model airplanes are basically the same as the NPRM for § 25.1351(d), which was published in the Federal Register on May 27, 1975 (40 FR 23053), as a part of Notice 75-23. However, a further interpretation was applied to this wording which caused the airplane to be demonstrated with only the generators turned off and the battery turned on because the battery was isolated from the generators.

We believe that application of § 25.1351(d) requirements alone does not provide sufficient protection for either the loss of all generators in IFR conditions or for an electrical fire. However, the requirements of § 25.1309(b) and (c) do provide a minimum level of safety for these events. Current generator reliability does not permit a twin-engine airplane with two generators to show that loss of both generators is extremely improbable. Therefore, an airplane of this type must be shown to be capable of continued safe flight and landing after loss of both generators. If the airplane is approved for some. conditions, then these conditions must be assumed to exist at the time of the failure.

e. **References.**

(1) Civil Air Regulations 4b, December 31, 1953.

(2) Amendment 25-AD (29 FR 18289, December 24, 1964).

(3) Amendment 25-41 (42 FR 36970, July 18, 1977).

(4) Amendment 25-72 (55 FR 29785, July 20, 1990).