# SUBPART C - STRUCTURES
## (Propulsion Considerations)

## Section 1. Lightning Protection

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### Section 25. 581 Lightning protection.

a. **Rule text.**

*(a) The airplane must be protected against catastrophic effects from lightning.*

*(b) For metallic components, compliance with paragraph (a) of this section may be shown by --*

*(1) Bonding the components properly to the airframe; or*

*(2) Designing the components so that a strike will not endanger the airplane.*

*(c) For nonmetallic components, compliance with paragraph (a) of this section may be shown by-*

*(1) Designing the components to minimize the effects of a strike; or*

*(2) Incorporating acceptable means of diverting the resulting electrical current so as not to endanger the airplane.*

*[Amdt. 25-23, April 8, 1970]*

b. **Intent of Rule:** The basic intent of this rule is self-explanatory. However, the level of "protection" required is not clearly spelled out in either of the two related notices, nor in any directly applicable published policy. In practice the level of protection required has been similar to that for § 25.954 compliance (i.e., protection against "likely" lightning encounters). Furthermore, the compliance option in section (c)(1) of the rule would appear to indicate that this was not intended to be an absolute prohibition against any catastrophic effects from all possible lightning encounters but rather that everything "practical" should be done to protect the aircraft.

c. **Background.**

(1) The regulatory history shows that this rule originated in Section 628 of the Civil Air Regulations (CAR) 4b, September 1962. 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). This rule was recodified from CAR 4b.628 without any substantive changes.

(2) Notice of Proposed Rulemaking 68-18 (33 FR 11913. August 22, 1968) proposed that the lightning protection requirements of § 25.1369 be adopted into a new regulation, § 25.581. Amendment 25-23 (35 FR 5665, April 8, 1970) followed Notice 68-18, and adopted the proposed change. The following excerpt from the preamble to Amendment 25-23 provides additional insight into the intent of this rule.

> The Notice proposed to add a new § 25.581 to require lightning protection of the airplane structures.
>
> The suggestion of one commenter that the rule should require compliance with both subparagraphs (b)(1) and (b)(2) in all cases cannot be adopted since, for some purposes, it is necessary to electrically isolate some exposed parts to enable them to function.
>
> One commenter expresses concern as to the adequacy of the proposed protection against high induced current from a lightning strike causing arcing within the airplane which could result in loss of essential systems; and also suggests the word “catastrophic” be changed to “hazardous.” On the other hand, another commenter suggests that the proposal is strict in that it did not take into account lesser protection requirements for components located in areas with low probability of strike attachment, such as classification zone three in Advisory Circular 20-53 [“Protection of Aircraft fuel Systems Against Fuel Vapor Ignition Due to Lightning”]. Advisory Circular 20-53 is concerned with fuel system lightning protection and the zone classifications in that Advisory Circular are not considered generally applicable to airframe components when the hazard may be due to a high current flow in a zone even though the point of stroke attachment may be in another zone. The FAA believes that the proposed rule will provide the desired protection insofar as it is possible within the present state-of-the-art.
>
> The rule is adopted as proposed, except that the title has been changed to read “Lightning Protection,” since the requirement covers more than structures.

It is important to note that, while this rule is located within “Subpart C - Structures,” it is clear from the preamble that “the requirement covers more than structures.” Consequently this rule applies to the powerplant and associated systems in conjunction with other more specific rules such as § 25.954 (“Fuel system lightning protection”) and § 25.1316 (“System lightning protection”).

d. **Policy/Compliance Methods.**

(1) Advisory Circular 20-53A, "Protection Of Aircraft Fuel Systems Against Fuel Vapor Ignition Due To Lightning," and the associated Users Manual, Report Number DOT/FAA/CT-83/3 are primarily associated with § 25.954 compliance. However, this policy has generally served as the standard for establishing what external lightning environment is "likely" to be incident at each aircraft surface, as well as providing guidance as to what may constitute adequate protection from the "direct effects" of a lightning strike.

FAA Advisory Circular 20-136, "Protection of Aircraft Electrical/Electronic Systems against the Indirect Effects of Lightning," is primarily associated with § 25.1316 compliance. However, this guidance can also be used to assess compliance with § 25.581 for the indirect effects of lightning on aircraft systems and structures, which are potentially susceptible to the "indirect effects" of lightning.

All of the general lightning protection guidance material currently is being revised. In the interim, these current policy standards, in conjunction with some specific policies discussed below, can be used.

(a) Protection of aircraft fuel systems against fuel vapor ignition due to lightning as covered by compliance with § 25.954.

(b) Protection of aircraft electrical/electronic systems against the indirect effects of lightning as covered by compliance with § 25.1316.

(c) Residual strength of load bearing structure following exposure to lightning where a structure that has been subjected to a "severe strike" should be able to support limit loads. Metallic structures are typically certified based on past design practices that have proven to provide satisfactory protection. Tests are normally required for composite primary structure.

(d) First return stroke location, extension in the direction of flight due to swept leader. In this case, the leader channel will tend to attach initially to regions of the aircraft where high electrical stress has caused streamers to form; the regions are determined by methods described in Advisory Circular 20-53A. For a cloud to ground strike, during the time the leader has traveled to ground and the return stroke has traveled back to the aircraft, the leader channel may have been swept back along the aircraft. Consequently, the initial high current return stroke attachment could be aft of the initial leader attachment. The extent of the swept distance will depend on the aircraft height above the ground and airspeed, as well as the leader and return speeds.

One method for taking account of this leader sweeping distance is known as the "d-method," where the formulae used are:

$$d = V_{ac} \times t$$

$$t = h/V_1$$

$$d = V_{ac} \times h/V_1$$

where:

**$V_{ac}$ = aircraft speed (m/s)**

**h = aircraft altitude ( m )**

**$V_1$ = leader speed ( m/s )**

**d = distance of swept leader extension ( m )**

**t = time of leader propagation from aircraft to ground ( s )**

The above formulae, assume that the leader speed (~$10^5$ m/s) is much slower than the return stroke speed (~$10^8$ m/s).

In response to this concern, an internal FAA Policy Memo was distributed on July 29, 1990. A copy of this policy memo is included within the "Policy/Compliance" portion at § 25.1316 of this Mega AC. Since that time, a draft advisory circular on "Zoning" has been in work within the Society of Aeronautical Engineers (SAE) AE4L and EUROCAE WG31 Committees. This general issue is specifically addressed in that draft AC by creating a new "Transition Zone" (Zone 1C) between the traditional Zones 1A and 2A. The d extension is due to the sweeping of the leader, which is a function of both the aircraft altitude and speed. The distinction between Zone 1A and Zone 1C is based on the fact that the peak current amplitude of waveform A decreases with altitude.

The step-by-step procedure is described below:

- In the first step a model $I = I_o \times e^{-h}$ has to be selected. This will allow one to determine two values $h_1$ and $h_2$ of the aircraft altitude above ground:

  **for $h < h_1$ --**
  **the peak current value of Waveform A is 200 KA> I > 150 KA**

  **for $h_1 < h < h_2$ --**
  **the peak current value of Waveform A is 150 KA> I >100 KA**

  **for $h_2 < h$ --**
  **the peak current value of Waveform A is 100 KA> I**

  Altitude $h_1$ and $h_2$ can then either be calculated with the formulae or extrapolated directly from the curves provided in the draft AC.

- In the second step, the zones 1A and 1C extensions $d_1$ and $d_2$ are calculated by using $h_1$ and $h_2$ in the formula

$$\mathbf{d = V_{ac} \times h/V_1}$$

The zones on the aircraft are then determined through:

**Zone 1A for $d<d_1$**

**Zone 1C for $d_1<d<d_2$**

**Zone 2A for $d_2<d$**

e. **References:**

(1) Civil Air Regulations 4b, September 1962.

(2) Notice of Proposed Rulemaking 68-18 (33 FR 11913. August 22, 1968).

(3) Amendment 25-23 (35 FR 5665, April 8, 1970).

(4) Advisory Circular 20-53A, “Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition Due to Lightning,” April 12, 1985.

(5) Advisory Circular 25-8, “Auxiliary Fuel System Installation,” May 2, 1986[Incorporated in total in this Propulsion Mega AC at Section 25.952].

(6) Report DOT/FAA/CT-83/3, “User’s Manual for AC-20-53A Protection of Airplane Fuel Systems Against Fuel Vapor Ignition Due to Lightning,” October 1984.