



AEROSPACE RECOMMENDED PRACTICE

ARP5414™**REV. B**

Issued 1999-12
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Reaffirmed 2026-02

Superseding ARP5414A

(R) Aircraft Lightning Zone

RATIONALE

This revision incorporates changes throughout that are consistent with in-service reports on aircraft lightning attachments that were collected to support a review of coherence between the zoning established process and the likely and unlikely zones of lightning attachment observed in service. The contents, including the figures of the ARP, were revised to be consistent with the in-service lightning attachment data. An appendix with the in-service data used in support of the changes was added to the document.

Due to the extensive re-work and re-organization of this revision, the standard “change bar” indications for the changes are not shown; therefore, an “R” has been placed before the document title.

ARP5414B has been reaffirmed to comply with the SAE Five-Year Review policy.

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1. SCOPE

This SAE Aerospace Recommended Practice (ARP) defines lightning strike zones and provides guidelines for locating them on particular aircraft, together with examples. The zone definitions and location guidelines described herein are applicable to Parts 23, 25, 27, and 29 aircraft. The zone location guidelines and examples are representative of in-flight lightning exposures.

1.1 Purpose

This ARP provides information to determine aircraft lightning attachment zones. This lightning zoning ARP should be used with two other documents: ARP5412 and ARP5416. The relationship between the three documents and the equivalent EUROCAE documents is shown in Figure 1. These documents are used to define the aircraft lightning environment and tests required to support the aircraft lightning protection certification.

Lightning zoning is one step in demonstrating that the aircraft is adequately protected from both direct and indirect effects of lightning. Lightning zoning defines the surfaces of the aircraft that are likely to experience lightning channel attachment and the aircraft structures that conduct lightning current between attachment points.

Lightning zoning should be used with the aircraft lightning hazard assessment to determine the appropriate protection for a given aircraft part or location. The criticality of the systems or structure in the zone should be considered when defining the appropriate protection for parts and structure in a particular lightning zone.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP5412	Aircraft Lightning Environment and Related Test Waveforms
ARP5415	User's Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning
ARP5416	Aircraft Lightning Test Methods
ARP5577	Aircraft Lightning Direct Effects Certification

2.1.2 EUROCAE Publications

Available from EUROCAE Secretariat, 102 rue Etienne Dolet, 92240 Malakoff, France, Tel: +33 1 40 92 79 30, www.eurocae.net.

ED-14G	Environmental Conditions and Test Procedures for Airborne Equipment (technically equivalent to RTCA DO-160G)
ED-84A	Aircraft Lightning Environment and Related Test Waveforms (technically equivalent to ARP5412B)
ED-91B	Aircraft Lightning Zoning Standard (technically equivalent to this ARP)
ED-105A	Aircraft Lightning Test Methods (technically equivalent to ARP5416A)



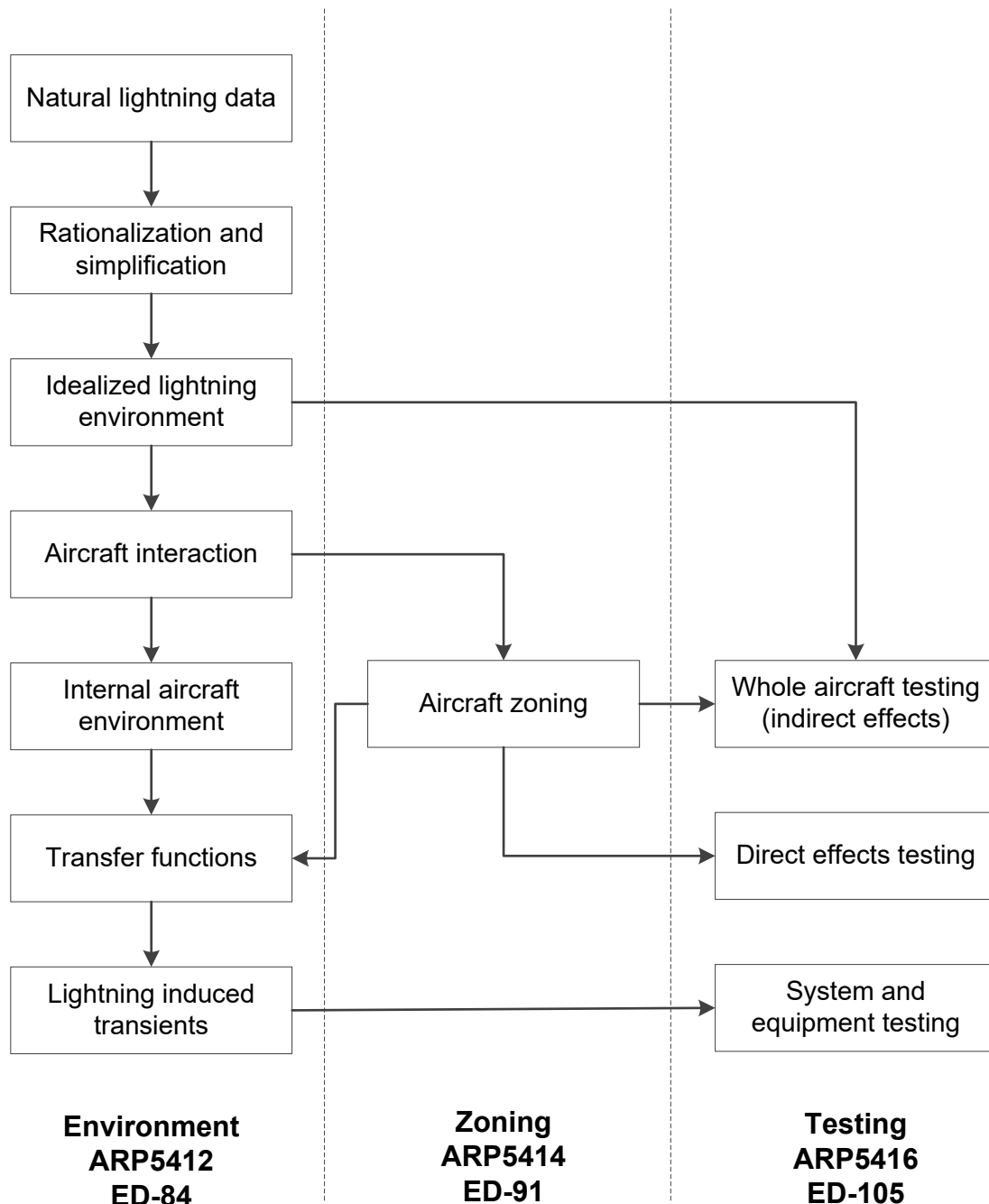


Figure 1 - Relationship between aircraft environment, zoning and testing

2.1.3 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

DO-160G

Environmental Conditions and Test Procedures for Airborne Equipment

2.2 Related Federal Aviation Administration Information

2.2.1 FAR Publications

Available from Federal Aviation Regulations, <https://www.faa.gov>.

Federal Aviation Regulations 14 CFR Parts 23.2335, 23.2430(a)(2), 23.2515, 25.581, 25.954, 25.1316, 27.610, 27.954, 27.1316, 29.610, 29.954, 29.1316 and 33.28(b)(2).

2.2.2 FAA Publications

The following Advisory Circulars (AC) may provide additional information. Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

AC 20-53B	Protection of Airplane Fuel Systems Against Fuel Vapor Ignition Due to Lightning, dated June 5, 2006
AC 20-136B	Aircraft Electrical and Electronic System Lightning Protection, dated September 7, 2011
AC 20-155A	Industry Documents to Support Aircraft Lightning Protection Certification, dated July 16, 2013
AC 21-16G	Radio Technical Commission for Aeronautics Document DO-160G, dated June 22, 2011
AC 23.1309-1E	System and Equipment Installations in Part 23 Airplanes, dated November 17, 2011
AC 25.1309-1A	System Design and Analysis, dated June 21, 1988
AC 27-1B	Certification of Normal Category Rotorcraft, dated February 4, 2016
AC 29-2C	Certification of Transport Category Rotorcraft, dated February 4, 2016

2.3 Related European Aviation Safety Agency Information

2.3.1 European Aviation Regulations

Available from European Aviation Safety Agency, Postfach 10 12 53, D-50452 Cologne, Germany, Tel: +49-221-8999-000, www.easa.eu.int.

Certification Specifications 23.2335, 23.2430(a)(2), 23.2515, 25.581, 25.899, 25.954, 25.1316, 25.1705(b), 27.610, 27.865(b)(3), 27.954, 27.1316, 29.610, 29.865(b)(3), 29.954, 29.1316, E.50(a), and E.170

2.3.2 European Aviation Safety Agency Acceptable Means of Compliance

AMC 20-1	Certification of Aircraft Propulsion Systems Equipped with Electronic Controls
AMC 20-3	Certification of Engines Equipped with Electronic Engine Control Systems
AMC 20-29	Composite Aircraft Structure
AMC 20-136	Aircraft Electrical and Electronic System Lightning Protection
AMC 25.581	Lightning Protection
AMC 25.899	Electrical Bonding and Protection Against Lightning and Static Electricity
AMC to CS-E 170	Engine Systems and Component Verification

2.4 Definitions

ATTACHMENT POINT: A point of contact of the lightning flash with the aircraft.

BREAKDOWN: The production of a conductive ionized channel in a dielectric medium resulting in the collapse of a high electric field.

DWELL POINT: A lightning attachment point.

DWELL TIME: The time that the lightning channel remains attached to a single spot on the aircraft.

EXTERNAL ENVIRONMENT: Characterization of the natural lightning environment for design and certification purposes.

FIRST RETURN STROKE: The high current surge that occurs when the leader completes the connection between the two charge centers.

FLASHOVER: This term is used when the arc produced by a gap breakdown passes over or close to a dielectric surface without puncture.

LEADER: The low luminosity, low current precursor of a lightning return stroke, accompanied by an intense electric field.

LIGHTNING CHANNEL: The ionized path through the air along which the lightning current pulse passes.

LIGHTNING FLASH: The total lightning event. It may occur within a cloud, between clouds, or between a cloud and ground. It can consist of one or more return strokes, plus intermediate or continuing currents.

LIGHTNING STRIKE: Any attachment of the lightning flash to the aircraft.

LIGHTNING STRIKE ZONES: Aircraft surface areas and structures classified according to the possibility of lightning attachment, hang-on, and current conduction.

REATTACHMENT: The establishment of new attachment points on the surface of an aircraft due to the sweeping of the flash across the surface of the aircraft by the motion of the aircraft.

RESTRIKE: A subsequent high current surge attachment. This normally follows the same path as the first return stroke, but may reattach to a new location further aft on the aircraft.

SWEPT LEADER: A lightning leader that has moved its position relative to an aircraft, subsequent to initial leader attachment, and prior to the first return stroke arrival, by virtue of aircraft movement during leader propagation.

SWEPT CHANNEL: The lightning channel relative to the aircraft, which results in a series of successive attachments due to sweeping of the flash across the aircraft by the motion of the aircraft.

2.5 Abbreviations

A	Amperes
AC	Advisory Circular
AMJ	Advisory Material Joint
C	Charge Transfer (coulombs or ampere - seconds)
d	Distance (meters)
h	Altitude Above Ground (meters)
kA	Kiloamperes

kV	Kilovolts
kV/m	Kilovolts per Meter
m/s	Meters per Second
ms	Milliseconds
t	Time
TAS	True Air Speed
v	Velocity (meters/second)

3. BACKGROUND

Lightning zoning is a fundamental step in determining appropriate lightning protection for aircraft. Lightning tends to attach to and sweep across specific locations on aircraft. This document provides definitions for regions of aircraft where lightning attachments are likely and where lightning attachments are expected to sweep. These lightning attachment regions or zones can be used to define appropriate lightning protection for structure systems, along with certain aspects of the fuel system. These zones can be used to define appropriate tests to demonstrate that the lightning protection is effective.

4. AIRCRAFT LIGHTNING INTERACTION

4.1 Initial Lightning Attachment

Aircraft in flight are exposed to both naturally occurring and aircraft initiated (triggered) lightning strikes. A naturally occurring strike begins when a lightning leader which originates at a cloud charge center happens to approach an aircraft. When this happens, the electric field associated with charge in the leader intensifies about the aircraft extremities, and discharges, called junction leaders, emanate from major extremities, and, propelled by the electric field, propagate in the general direction of the lightning leader. One and sometimes more of these junction leaders may connect with one or more branches of the lightning leader. The aircraft surfaces where these junction leaders originated from thus become the initial lightning attachment points. At the same time additional junction leaders, originating at other extremities, are propagating away from the aircraft, in the general direction of a region of opposite polarity charge. This may be the earth, or it may be a cloud charge region of opposite polarity. The location(s) of these leader(s) constitute other initial lightning attachment points.

An aircraft-initiated strike may result when the aircraft is in an electric field associated with charged cloud regions and the field intensity about the aircraft's extremities is sufficient to initiate and propel bi-directional leaders, from these extremities. These leaders propagate between regions of opposite polarity charge, and conduct lightning currents through the airplane, as occurs with naturally occurring lightning. The places from which the bi-directional leaders originate are also called initial attachment points. Examples of the two lightning strike mechanisms described above are shown in Figure 2.

The same aircraft locations may be initial attachment points for either type of lightning strike. Lightning attachment locations exist typically at aircraft extremities such as nose, wing and empennage tips, tail cones, propellers and rotor blades, and some engine nacelles.

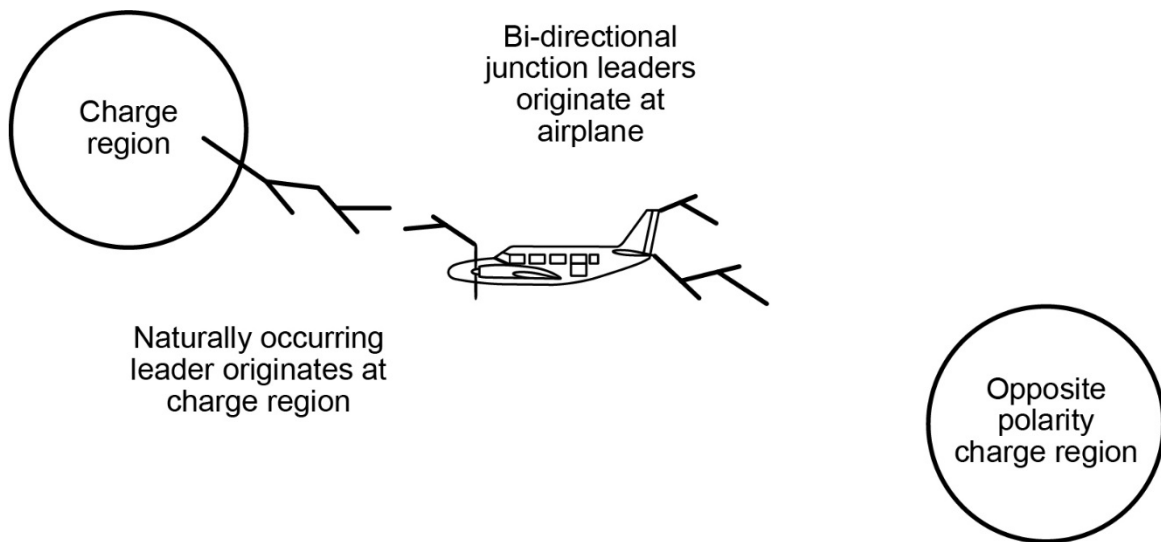
4.2 Swept Channel Process

When an aircraft is struck by lightning, currents in the channel flow through the aircraft. However, due to the speed of the aircraft and the length of time that the lightning channel exists, the aircraft can move a significant distance relative to the lightning channel. When a forward extremity, such as a nose or wing mounted engine nacelle, is an initial leader attachment point, the movement of the aircraft through the lightning channel usually causes the channel to sweep back over the surface as illustrated in Figure 3, allowing the channel to reattach to airplane surfaces aft of the initial attachment point. This is known as the swept-channel process. The characteristics of the surface can cause the lightning channel to reattach to and dwell at various surface locations for different periods of time, resulting in a series of successive lightning attachment points along the sweeping path. These subsequent attachment points have been referred to as dwell points.

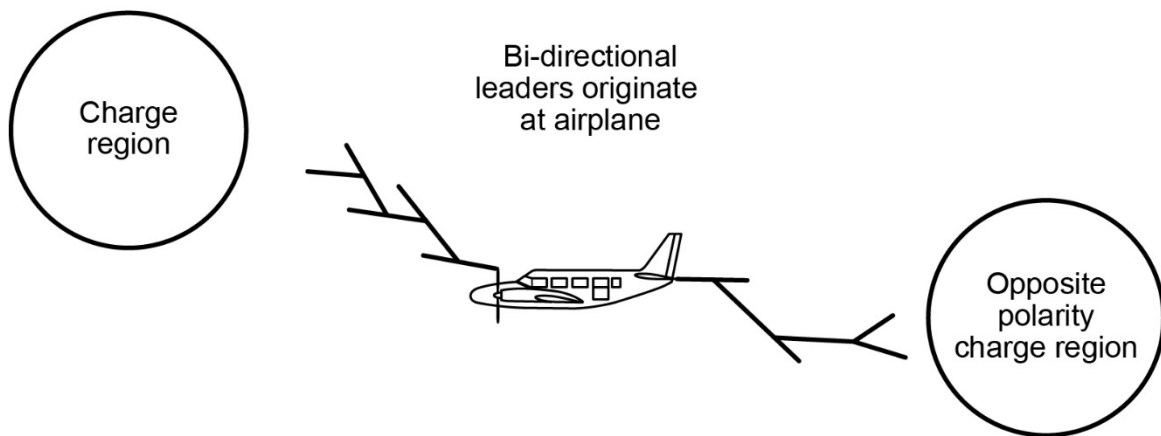
The amount of damage produced at any dwell point on the aircraft by a swept channel depends upon the type of the aircraft skin material and finish, the dwell time at that point, and the lightning currents which flow during the attachment. Stroke currents as well as intermediate currents and small portions of continuing currents may occur at any attachment point. Subsequent strokes flowing in the channel sometimes cause it to reattach to new dwell points.

When the lightning channel has been swept back to a trailing edge, it may remain attached at such an edge for the remaining duration of the lightning flash. An initial leader attachment location at an aircraft trailing edge, of course, could not be subjected to any swept-channel action; therefore, all components of the lightning flash currents would be present at this location.

The significance of the swept-channel phenomenon is that surfaces of the vehicle that would not be susceptible to initial lightning attachment may also be involved in the lightning strike process as the lightning channel is swept backwards, although the channel may not remain attached at any single point for very long. On the other hand, strikes that reach trailing edges should be expected to remain attached and hang on there for the balance of their natural duration.



a. Naturally occurring strike



b. Aircraft initiated strike

Figure 2 - Lightning strike mechanisms

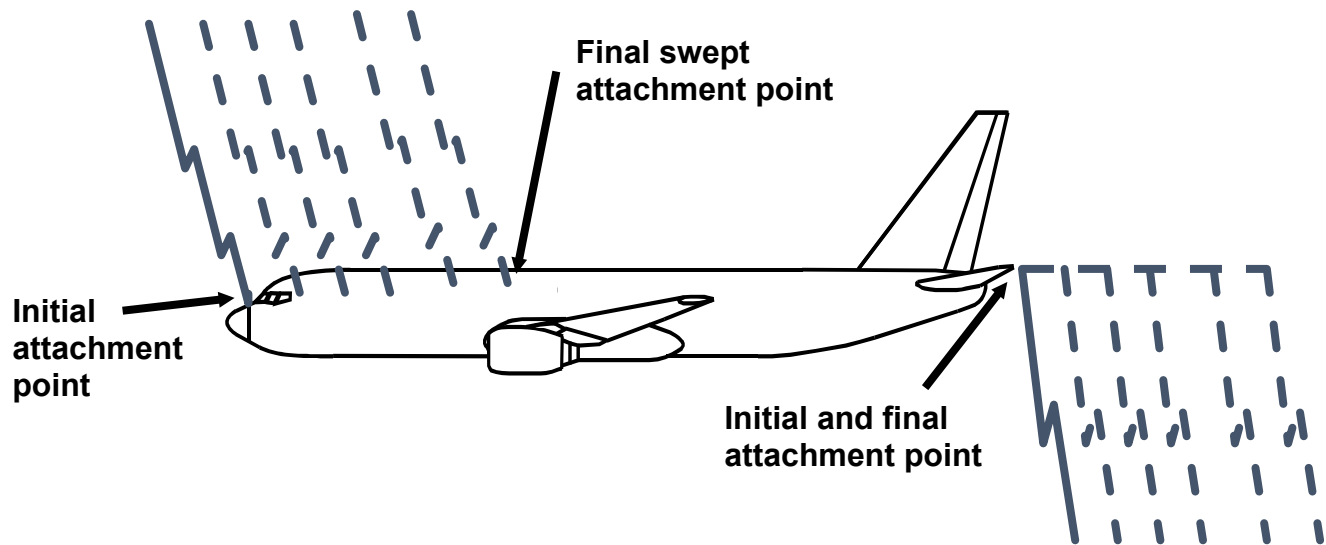


Figure 3 - Typical path of swept-channel attachment points

4.3 Conduction

During the time that the lightning channel is attached to any of the aircraft initial attachment or swept channel dwell points, currents will be flowing in the aircraft. The points of attachment on the aircraft can change as the airplane flies through the lightning channel, as described in 4.2.

The lightning current will distribute among all electrically conductive skins and structural elements between attachment locations. Some lightning current may also flow in non-structural components, such as push rods, hydraulic lines, plumbing, and electrical cables.

The magnitudes of currents that flow in various structural elements depend upon a variety of factors including geometry, material properties, and the characteristics of the lightning currents.

5. ZONE DEFINITIONS

The surface of an aircraft can be divided into a set of regions called lightning strike zones. These zones represent the areas likely to experience the various types of lightning currents and, consequently, the various components of the lightning environment defined in ARP5412/ED-84. There are three major divisions representing:

1. Regions likely to experience initial lightning attachment and first return strokes.
2. Regions which are unlikely to experience first return strokes, but which are likely to experience subsequent return strokes. This will happen where the aircraft is in motion relative to a lightning channel causing sweeping of the channel backwards from a forward initial attachment point.
3. Regions which are unlikely to experience initial or sweeping attachment, but which will have to conduct lightning current between attachment points.

Regions 1 and 2 are subdivided into specific lightning attachment zones as follows:

Zones 1A and 2A, where long hang-on of a lightning channel is unlikely because the motion of the aircraft with respect to the channel causes the attachment point to move across the surface of the aircraft in the opposite direction from the direction of motion.

Zones 1B and 2B, where the lightning channel attachment point is unlikely to move during the remainder of the flash because the location is a trailing edge or a large promontory from which the relative motion of the aircraft and channel causes the attachment point further.