

Committee Correspondence

Name of Committee: AE-2 Lightning Committee

Date: January 29, 2009

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Subject: Guidance material for 14 CFR 25.981 Policy Memo ANM-112-08-002

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Attention: Victor Wicklund
Propulsion/Mechanical Systems Branch, ANM-112

Dear Mr. Wicklund:

The SAE AE2 and EUROCAE WG-31 Lightning Committees strongly support the FAA efforts to address the issues involved with the current fuel tank lightning protection requirements. In addition, the Committees also strongly endorse the FAA efforts to define requirements that are practical to comply with and will be consistently and uniformly applied to airplane designs. As such, the committees, working together, have developed guidance material to be used in conjunction with the FAA's 14 CFR 25.981 Policy Memo ANM-112-08-002. Endorsement of this guidance material by the FAA will allow more uniform implementation of these high standards for fuel tank lightning protection.

The Committees are made up of global aircraft lightning protection specialists coming from North America, South America, Europe and Asia that are employed by government and regulatory authorities, research organizations and universities, aircraft and aircraft equipment manufacturers, independent lightning specialists and test laboratories. Committee members function as competent and authoritative individuals in the area of aircraft lightning protection, and not as representatives of any organization with which they may be associated. The Committees have worked with the FAA and other aviation regulatory authorities worldwide for over 30 years in the development of aircraft lightning protection standards. This working relationship has resulted in the constant improvement of aircraft lightning protection design and verification methods, resulting in an outstanding safety record in regards to all aspects of lightning protection.

The guidance material provides insight into the examination of the design in regard to fault tolerance, providing guidance on testing requirements as well as instructions on the numerical analysis, if fault tolerance is not possible.

In the development of this material, the two committees have utilized the expertise of the FAA's Chief Scientist and Technical Advisors in the area of Lightning (Mr. Dave Walen) and Propulsion Controls (Mr. Hals Larsen).

The committee has posted the material on the SAE website (<http://www.sae.org/servlets/works/committeeHome.do?comtID=TEAAE2>) which will be accessible, to the general public.

It is strongly recommended, by the two committees, that the FAA accept the usage of this material and reference it within the means of compliance Issue Papers associated with Special Conditions or Exemptions per the policy as being acceptable means of compliance.

As stated above, this guidance material has been coordinated with the EUROCAE Working Group 31 – Lightning Committee (**Eurocae report ER-002**) as well as other international specialists, is over whelming supported by the members of both committees, and was endorsed unanimously at the last SAE AE2 meeting in January.

As always, we greatly appreciate the opportunity to continue our legacy of over three decades of support to the FAA in the constant improvement of standards for aircraft lightning protection.

Regards,

Jack Schroeder
SAE AE-2 Committee Chairman

Billy M. Martin
SAE AE-2 Vice Committee Chairman

Jean Patrick Moreau
EUROCAE WG-31 Committee Chairman

Cc: GAMA, AIA, FAA rep on SAE Aerospace Council



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Equipement de l'Aviation Civile

ER-002

POLICY GUIDANCE FOR FUEL TANK STRUCTURAL LIGHTNING PROTECTION POLICY

TABLE OF CONTENTS

1	OVERVIEW.....	1
	1.1 Background.....	1
	1.2 Process Overview.....	1
	1.3 Assess Design for Applicability of Policy.....	2
	1.4 References	3
2	DETERMINE REGULATORY PATH	4
	2.1 Determine Practicality of Direct Compliance	4
	2.2 Determine Special Conditions or Exemption Path	6
3	ASSESS DESIGN FOR FAULT TOLERANCE.....	7
	3.1 Identify Potential Failure Modes	7
	3.2 Assess Failure Conditions	9
	3.3 Determine Fault Tolerance	13
	3.4 Determine Practicality of Providing Fault Tolerance	13
4	CONDUCT NUMERICAL PROBABILITY ASSESSMENT	14
	4.1 Determine Failure Rates and Distribution.....	15
	4.1.1 In-service failures	16
	4.1.2 Manufacturing Escapes.....	19
	4.2 Determine Ignition Source Threshold Factor.....	19
	4.3 Determine Rate of Critical Lightning Attachment	21
	4.4 Determine Flammability Exposure for Fuel Tanks	22
	4.5 Determine Probability of Fuel Vapor Ignition	23
5	VERIFY COMPLIANCE	26
6	INCORPORATE PRACTICAL MEASURES TO PREVENT, DETECT AND CORRECT FAILURES.....	28
	6.1 Practical Design Measures	28
	6.2 Practical Manufacturing Measures	28
	6.3 Practical Maintenance Measures	29

1 - OVERVIEW

1.1 Background

The Federal Aviation Administration (FAA) recently released policy memo ANM-112-08-002 on the fuel tank safety provisions of Title 14, Code of Federal Regulations (14 CFR) 25.981(a)(3), as amended by Amendment 25-102, for lightning protection of fuel tank structure. The FAA developed this policy because they determined that compliance with current regulatory standards applicable to lightning protection of fuel tank structure may be impractical in some cases for some areas of structural design.

This document is intended to provide guidance to manufacturers who may apply this policy to their type design programs and to establish criteria to encourage a consistent approach be applied across industry. The content of this document has been developed by the SAE AE-2 and EUROCAE WG-31 lightning committees. Manufacturers should coordinate directly with their certifying authority to ensure that their proposed application of this policy is acceptable and the means of compliance and compliance data planned are sufficient for certification.

1.2 Process Overview

Application of the policy has been broken down into a number of process steps in this document. Figure 1.2-1 provides an overview of the high level process to apply the policy. This process consists of the following major steps:

- a) Section 1.3 describes the initial assessment required to determine eligibility to apply the policy.
- b) Figure 2.0-1 provides a process flowchart for determining the regulatory path based on the options described in the policy. The three main options are direct compliance with § 25.981(a)(3), special conditions as defined in the policy or petitioning for an exemption using the criteria defined in the policy. The latter two options are dependent upon the level of flammability exposure in the design. Detailed process steps are provided in Section 2.
- c) Figure 3.0-1 provides a process flowchart for how to assess the design for fault tolerance. Detailed process steps are provided in Section 3.
- d) For areas of the design where it is found to be impractical to provide fault tolerance, Figure 4.0-1 provides a process flowchart for how to conduct the required numerical probability assessment to ensure a fuel vapor ignition is extremely improbable. The detailed process steps associated with this are described in Section 4.
- e) Figure 5.0-1 provides a process flowchart for how to verify compliance of the protection design. This will typically include verification of fault tolerance by test. Detailed process steps are provided in Section 5.
- f) Section 6 describes a step that addresses the analysis required to demonstrate that all practical measures have been incorporated into the design, manufacturing processes and instructions for continued airworthiness to prevent, detect and correct failures of structural lightning protection features.

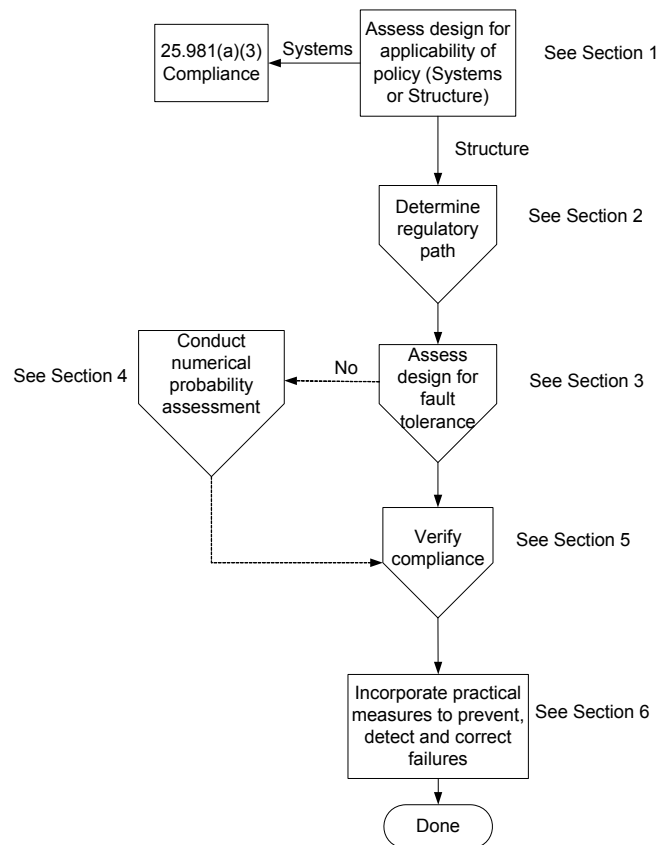


FIGURE 1.2-1: OVERVIEW OF COMPLIANCE PROCESS

1.3 Assess Design for Applicability of Policy

The initial assessment for determining if the policy applies is to determine if the area of lightning protection design in question fits the criteria for fuel tank structure. The policy only applies to areas of fuel tank structure, and does not apply to lightning protection of systems components. Per the policy, “fuel tank structure” includes structural members, such as airplane skins, joints, ribs, spars, stringers, and associated fasteners, brackets, coatings and sealant. In addition, system supporting structure that is intended and expected to remain undisturbed for the life of the airplane uses many of the same construction techniques and presents some of the same impracticality issues, and is therefore eligible for consideration as an “area of fuel tank structure.” System components and system supporting structure that are likely to be disturbed if maintenance is required on a system (even if that system would not normally require maintenance) is not eligible under this policy and should be required to comply with § 25.981(a)(3). For these design areas, disassembly and reassembly of electrical bonding elements is considered to present a significant additional risk that a bond will be compromised during the life of an airplane, which generally does not exist for structure that is intended to be permanent.

Some examples of designs that may be considered fuel tank structure for purpose of this policy in addition to those listed above are:

- External or internal access doors – these are structural in nature despite not being “permanent” installations. Because of the likelihood of removal for inspections, they may require unique controls to ensure that any electrical bonding or other protection features are installed correctly after removal.
- Fuel pump housings where the housing itself is considered to be a permanent installation and where the fuel pump can be removed for maintenance without disturbing the housing installation.
- Fuel drain or vent installations where the installation is permanent and any maintenance can be accomplished without disturbing their installation.
- Brackets that mount system installations, such as transport elements, to structure. Typically these brackets are permanent installations whereas clamps attached to these brackets would potentially be removed for maintenance and therefore would not fall within the scope of this policy.

Some examples of designs that would not likely be considered fuel tank structure for purpose of this policy are:

- Fuel system components that may need to be removed or replaced.
- Transport elements such as tubing or wiring that may need to be disturbed in order to perform maintenance.
- Clamps holding transport elements to brackets or structure as noted above.

1.4

References

- ANM-112-08-002, “Policy on Issuance of Special Conditions and Exemptions Related to Lightning Protection of Fuel Tank Structure”, 26 May 2009
- § 25.981, “Fuel Tank Ignition Prevention”
- § 25.954, “Fuel System Lightning Protection”
- AC 20-53B, “Protection Of Aircraft Fuel Systems Against Fuel Vapor Ignition Caused By Lightning”, 5 June 2006
- AC 20-155, “SAE Documents To Support Aircraft Lightning Protection Certification”, 28 April 2006
- AC 25.981-1C, “Fuel Tank Ignition Source Prevention Guidelines”, 19 September 2008
- AC 25.1309-1A, “System Design and Analysis”, 21 June 1988
- ARP5412A, “Aircraft Lightning Environment and Related Test Waveforms”, February 2005
- ARP5414A, “Aircraft Lightning Zoning”, February 2005
- ARP5416, “Aircraft Lightning Test Methods”, March 2005
- ARP4761, “Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment”, December 1996
- ARP5150, “Safety Assessment of Transport Airplanes in Commercial Service”, November 2003
- DOT/FAA/AR-05/8, “Fuel Tank Flammability Assessment Method User’s Manual”, May 2008

2 - DETERMINE REGULATORY PATH

Figure 2.0-1 defines a process for determining the regulatory path based on the options described in the policy. The main steps in this process are defined in this section.

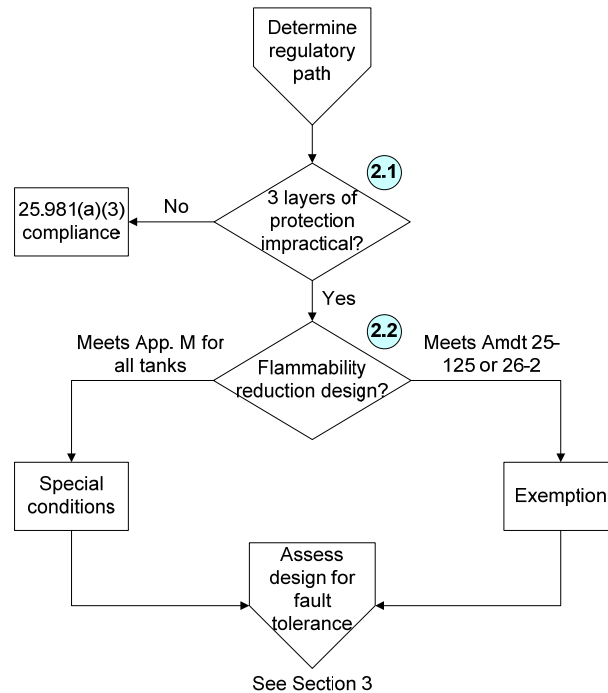


FIGURE 2.0-1: DETERMINE REGULATORY PATH

2.1 Determine Practicality of Direct Compliance

Direct compliance with § 25.981(a)(3) typically implies that three independent, effective, and reliable protection features (or sets of features) be provided to prevent ignition sources for design areas that are addressed by this subparagraph. General guidance for compliance with § 25.981 is provided in AC 25.981-1C. The ANM-112-08-002 policy requires that direct compliance be demonstrated where it is practical. If direct compliance cannot be demonstrated, then either the Special Condition or Exemption routes to compliance may be considered in all or parts of the fuel tank structure.

The following are guidelines for establishing independent, reliable and effective protection features, or design features. For lightning, the threat conditions to assess for this include lightning direct attachment in Zones 1 and 2 and the associated conducted currents in the traditional Zone 3 definition that flow between attachment points. Lightning zones are defined in AC 20-155 via reference to ARP5414A. The fuel tank areas of concern with regards to potential lightning related ignition sources are joints that include fasteners penetrating to the exterior of the tank to lightning strike Zone 1 and 2 surfaces, and other mechanical joints in tank structures in Zone 3 which must conduct lightning currents between potential attachment points.

Note that external fasteners and skin in surface Zone 3 need not show direct compliance or apply the policy regarding multiple features of lightning protection for direct lightning attachment since the likelihood of lightning attachment to these surfaces has already been determined to be very low. In Zone 3, only one protection feature is required for direct lightning attachment.

Independent Features are those that are not subject to common cause failures that could also compromise the other protection feature (or features) relied upon to provide the fault tolerance.

Examples are:

- Sealant or other barrier covering a potential ignition source such as an external fastener, with sufficient robustness that failure of an underlying protection feature, such as an isolating washer does not allow voltage or thermal spark products to reach the flammable vapor space.
- An exterior fastener coating intended to prohibit direct lightning channel contact with the fastener, which, remains effective at preventing lightning channel contact with the fastener regardless of failure modes introduced by other aspects of the joint design
- A fastener sleeve intended to provide good electrical bonding to the surrounding hole, which if omitted or damaged, does not impair the protection effectiveness of other protection features such as sealants, or exterior fastener coatings.
- When one feature is misinstalled or not installed by mistake, the other feature(s) remain effective in preventing ignition sources.

An example of a protection feature that is not independent is a layer of sealant that if the fastener fails, will through that failure, remove or damage the sealant in a manner which eliminates its ability to prevent arc products resulting from failure of the fastener.

Another example of a non-independent protection feature is an external protection feature, such as a fastener coating, which if failed or missing, allows a lightning strike to that fastener to overcome the effectiveness of internal protection features that are intended to contain arc products and prevent them from reaching the fuel vapor space.

Effective Features are those that are shown to adequately prevent ignition sources when exposed to the expected lightning current threat at that location. Effectiveness is typically determined as the result of testing. In some cases, single features alone can be demonstrated to be effective. In other cases, multiple features may be required to be combined to be effective so would be considered effective as a set. In the latter case, failures that affect any features in the set may be sufficient to compromise the overall effectiveness of that set.

An example of a protection feature that is not effective is a layer of sealant that is insufficiently robust to contain the arc products resulting from failure of a second protection feature such as an interference fastener.

Reliable Features are those features whose failure modes and failure rates are such that they are not normally expected to fail during the life of an airplane or the life limit of the feature, when installed correctly per design. Some failures may be expected over a fleet life of airplanes but are not expected on the typical airplane.

Most structural features can be found to be reliable as long as they are designed with adequate margin, to ensure durability and robustness, and are installed with sufficient controls.

To determine practicality of direct compliance requires an assessment of each area of design along with an initial review of fault tolerant capability of the design. In general, where the design shows dual fault tolerance [i.e. two of three (or more) features have failed but the design remains effective against ignition sources,] direct compliance may be achieved. Where the design can only tolerate a single failure (or no failure) before there is an ignition source risk, additional design options should be considered to determine if dual fault tolerance can be achieved. If so, then this design feature (or features) should be added as long as it is practical to do so. If not, then the design cannot achieve direct compliance and the policy may be applied as long as the design area in question is within the policy definition of fuel tank structure. Examples of what may be considered practical or impractical along with some general criteria for how practicality is determined are provided in the policy. Determination of impracticality for a given design should be reviewed for concurrence with the appropriate regulatory authority.

2.2 Determine Special Conditions or Exemption Path

If the applicant demonstrates that direct compliance is impractical, an alternative approach for lightning protection of fuel tank structure may be used in accordance with the policy. Special Conditions or a partial exemption are options that are described per the policy.

In order to select the most appropriate compliance path amongst the alternate approaches, it is necessary to consider the structural and fuel system configurations, as well as coordinate closely with regulators.

Per the policy, the following factors would be considered by the FAA in the determination of the appropriate compliance path:

1. Fuel system architecture
 - a. If the fuel system employs a Flammability Reduction Means (FRM) for all tanks, Special Conditions could be pursued
 - b. If the fuel system relies upon conventional unheated aluminum wing or equivalent design, an Exemption could be pursued
2. Impact of compliance path selection
 - a. Selection of an Exemption for a new type design applicant presupposes that compliance with § 25.981(b) will be established
 - i. $\leq 3\%$ fleet average flammability exposure, or that of a fuel tank within the wing of the airplane model being evaluated, whichever is greater
 - b. Selection of a Special Condition for a new type design applicant requires additional demonstration of compliance with 14 CFR Part 25 Appendix M for all tanks
 - i. $\leq 3\%$ fleet average flammability exposure
 1. $\leq 1.8\%$ of this total may be when FRM is operational but tanks are still flammable
 2. $\leq 1.8\%$ of this total may be when FRM is not operational and tanks are flammable
 - ii. $\leq 3\%$ fleet average flammability exposure during ground and takeoff/climb flight phases on warm days ($\geq 80^{\circ}\text{F}$)

It should be noted that an exemption may be requested in lieu of applying the special conditions, even if the flammability exposure meets the special conditions requirements. However, only an exemption path is possible if flammability cannot be shown to meet the enhanced criteria required by the special conditions.