



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

Intermediate Guidance Material for Compliance Demonstration Related to Lightning Protection of Fuel Tank Structure 25.981 Requirements

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TABLE OF CONTENTS

FOREWORD	I
TABLE OF CONTENTS	II
 CHAPTER 1 OVERVIEW	 1
1.1 BACKGROUND	1
1.2 APPLICATION OF THE POLICY	1
 CHAPTER 2 COMPLIANCE DEMONSTRATION PROCESS	 4
2.1 IDENTIFY THE FUEL SYSTEM DESIGN FEATURES AND ASSOCIATED LIGHTNING PROTECTION	5
2.2 DETERMINE THE LIGHTNING STRIKE ZONES FOR THE AIRCRAFT	5
2.3 ESTABLISH THE AIRCRAFT LIGHTNING ENVIRONMENT OF THE DESIGN.....	5
2.4 IDENTIFY POTENTIAL FAILURE MODES OF THE DESIGN FEATURES	7
2.5 IDENTIFY POTENTIAL IGNITION SOURCES ASSOCIATED WITH THE DESIGN FEATURES AND POTENTIAL FAILURE MODES.	8
2.6 PERFORM SAFETY ASSESSMENT TO DETERMINE FAULT TOLERANCE	9
2.6.1 FAULT TOLERANCE ASSESSMENT	9
2.6.2 DETERMINATION OF IMPRACTICALITY TO PROVIDE FAULT TOLERANCE	9
2.7 ASSESS THE COMBINED RISK OF ALL NON-FAULT TOLERANT CONDITIONS...	10
2.7.1 GENERAL	10
2.7.2 CONSIDER ROBUSTNESS OF THE DESIGN TO MINIMIZE FAULTS	12
2.7.3 CONSIDER HOW MANY LOCATIONS NON-FAULT TOLERANT CONDITIONS EXIST	12
2.7.4 CONSIDER ROBUSTNESS OF DESIGN WITH FAULTS PRESENT TO TOLERATE LIGHTNING THREAT LEVELS WITHOUT CREATING AN IGNITION SOURCE	12
2.7.5 CONSIDER MEASURES USED TO DETECT FAILURES AND LIMIT LATENCY WHERE PRACTICAL	13
2.7.6 ASSESS WHETHER THE COMBINATION OF ALL NON-FAULT-TOLERANT FAILURE CONDITIONS WHICH COULD RESULT IN AN IGNITION SOURCE IS REMOTE	13
2.8 DEVELOP SUPPORTING DATA FOR LIGHTNING PROTECTION PERFORMANCE	14
2.9 DEVELOP INSTRUCTIONS FOR CONTINUED AIRWORTHINESS, MAINTENANCE AND SURVEILLANCE PROGRAMS	18
2.10 INCORPORATE PRACTICAL MEASURES TO PREVENT, DETECT AND CORRECT FAILURES	19
2.10.1 PRACTICAL DESIGN MEASURES	19
2.10.2 PRACTICAL MANUFACTURING MEASURES	19
2.10.3 PRACTICAL MAINTENANCE MEASURES	20
2.10.4 PRACTICAL AIRWORTHINESS LIMITATIONS MEASURES	20
2.11 VERIFY COMPLIANCE TO THE REQUIREMENTS	20
 APPENDIX 1 RELATED DOCUMENTS	 22
 APPENDIX 2 DEFINITIONS.....	 23
 APPENDIX 3 WG-31 MEMBERSHIP.....	 24
 IMPROVEMENT SUGGESTION FORM	 26

CHAPTER 1

OVERVIEW

1.1 BACKGROUND

On May 26, 2009, the Federal Aviation Administration (FAA) released ANM-112-08-002, *Policy on Issuance of Special Conditions and Exemptions Related to 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.

In the 2009 Policy Memo, the FAA also stated a plan to develop changes to the regulations to eliminate the need for Exemptions or Special Conditions for certification of fuel tank lightning protection.

Subsequently, the FAA chartered an Aviation Rulemaking Committee (ARC) to provide recommendations regarding fuel tank lightning protection regulations. The ARC provided their recommendations in a report to the FAA in May 2011.

On June 24, 2014, the FAA released PS-ANM-25.981-02, *Policy on Issuance of Special Conditions and Exemptions Related to Lightning Protection of Fuel Tank Structure and Systems*, which superseded the 2009 Policy Memo and incorporated the following recommendations of the ARC committee:

- Revision of the definition of practicality
- Replacement of the numerical assessment requirements with qualitative assessments when fault tolerance is impractical
- Expansion of applicability to include systems
- Modifications to the requirements for maintenance and continued airworthiness

This report is intended to provide guidance to applicants who seek to apply this 2014 Policy Statement to their type design programs and to establish criteria to encourage a consistent approach be applied across industry. The content of this report has been developed by EUROCAE WG-31 and SAE AE-2. Applicants should coordinate directly with their airplane certification 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 APPLICATION OF THE POLICY

The 2014 Policy Statement says,

“This policy may be applied to the design of lightning protection features in fuel tank structure and systems for which compliance with § 25.981(a)(3) is shown by the applicant and determined by the FAA to be impractical. However, all other potential fuel tank ignition sources must still be compliant with § 25.981(a)(3).”

Therefore the applicant must substantiate that it is impractical to comply with § 25.981(a)(3) for lightning protection of fuel tank structure and systems in order to apply the policy criteria to their design. Per the policy, “practicality” is defined as “a balance of available means, economic viability, and proportional benefit to safety.” If there is no means of providing direct compliance or if the only means of providing direct compliance would have a significant economic impact on production, operational or maintenance costs without providing a proportional benefit to safety, it is acceptable to utilize the alternate requirements of the policy.

The rationale and justification associated with it being impractical to directly comply with § 25.981(a)(3) should be outlined in the Exemption Request or Special Condition Issue Paper. Details and proprietary information would be included in the appropriate compliance documentation. This rationale would typically identify where there are no design options available that will achieve direct compliance and/or specific design options that were considered but dismissed as being “impractical” per the policy definition. This rationale should consider both fuel tank structure and systems.

The FAA is expected to propose Special Conditions based on being appropriate in lieu of the existing regulations, as well as assuring an equivalent level of safety (for the public). Granting an Exemption is based upon providing an acceptable level of safety and being in the “public interest.” Therefore it is anticipated that the emphasis of the rationale for impracticality should be the public impact of additional design features, such as the fuel burn (and associated emissions) associated with higher design weights, operational and maintenance costs. Production costs are also a factor to the public travel costs, but may be a secondary factor when judging proportional benefit to public safety.

Regarding proportional benefit to safety, it is accepted that reducing risks to the level of Extremely Improbable at a system level will ensure an event is unlikely to occur in the life of a fleet. Once the airplane level risk of a catastrophic fuel tank vapour ignition event due to lightning is determined to be Extremely Improbable, any safety benefit from further reducing risk is negligible.

Under the new 2014 Policy Statement, the applicant has the opportunity to demonstrate that direct compliance to §25.981(a)(3) for *systems*, typically by providing three means of protection, is impractical based on a comparison of the associated safety benefits. The FAA has emphasized that the applicant must provide a clear justification to support the position that compliance is impractical, since recent certifications have been able to provide technical means for *systems* to comply. One approach to do this would be to demonstrate that two protection features (i.e. fault tolerant) each with an individual Remote failure rate, will ensure that the combined system level risk is less than Extremely Improbable (unlikely to occur in the life of a fleet). Considered together with all pertinent factors such as the likelihood of a lightning strike, lightning current amplitude, and flammability exposure, this would typically combine to far less probable than $1e-9$ per flight hour. A risk that is already far less probable than the accepted standard for unlikely to occur in the life of a fleet does not justify any additional complexity, weight and cost to further reduce the risk. The same approach can be done qualitatively, based on combination of three Remote conditions (Remote likelihood of each of the two means of protection failing, together with the Remote combination of lightning and flammability). It would also be appropriate to identify that added complexity may have potential negative implications to overall airplane safety, because of the increased chance for errors (installation or maintenance) and additional failure modes. For example:

- Installing multiple bond straps in parallel may provide additional redundancy, but it also doubles the likelihood of a failed jumper being present that may be a hazard. Or if slack in the installation allowed two jumpers to touch, the potential for sparking between them during a lightning event is a new hazard to address.
- Additional clamping may provide redundancy in ensuring wire separation from structure, but it also doubles the likelihood of support failures that may have unforeseen consequences.
- Additional sealant may contain potential sparking if both protection features in a fault tolerant design failed, but it also inhibits the ability to inspect for structural cracks. Having to remove sealant for structural inspections increases the potential for scratching or gouging the structure, which if not detected and corrected may lead to accelerated cracking after the inspection was just completed.
- Additional work inside the confined spaces of a fuel tank increases the risk for unidentified damage to other systems or structure inside the tank.
- Additional work and features increases the potential for foreign object debris (FOD) being left in the tank and causing engine feed issues or fuel transfers (clogged check valves or orifices).

It is difficult to quantify each of these risks that a more complex design causes, but they qualitatively support that adding complexity does not have a proportional benefit to safety when the risk with a less complex fault tolerant design is already Extremely Improbable (unlikely to occur in the life of the fleet).

The policy includes alternate requirements for Special Conditions and Exemptions. Special Conditions may be proposed by the FAA where there is a flammability reduction means that enables the proposed design to meet the Appendix M criteria for all fuel tanks. Alternatively, applicants may petition for an Exemption following the process defined in §11.81 and include the rationale and justification above for why it is impractical to directly comply, as well as how they plan to apply the alternate safety requirements of the policy to enable the FAA to find that it provides an acceptable level of safety.

CHAPTER 2

COMPLIANCE DEMONSTRATION PROCESS

If the applicant demonstrates that direct compliance with §25.981 (a)(3) at amendment 25-102 or 25-125 is impractical, an alternative approach for lightning protection of the fuel structure and systems may be used in accordance with the Policy Statement PS-ANM-25.981-02.

In general this approach will consist of an assessment of each lightning protection design and/or design feature for fault tolerance and, where designs are not fault tolerant, that they must be shown to be impractical to make fault tolerant along with an assessment confirming the likelihood of lightning related fuel tank vaporvapour ignition due to the combination of these non-fault tolerant designs being Extremely Improbable. The following eleven steps describe the basic process for demonstrating compliance to the relevant requirements determined by the selected compliance path:

- STEP 2.1: IDENTIFY THE FUEL SYSTEM DESIGN FEATURES AND ASSOCIATED LIGHTNING PROTECTION**
- STEP 2.2: DETERMINE THE LIGHTNING STRIKE ZONES FOR THE AIRCRAFT**
- STEP 2.3: ESTABLISH THE AIRCRAFT LIGHTNING ENVIRONMENT OF THE DESIGN**
- STEP 2.4: IDENTIFY POTENTIAL FAILURE MODES OF THE DESIGN FEATURES**
- STEP 2.5: IDENTIFY POTENTIAL IGNITION SOURCES ASSOCIATED WITH THE DESIGN FEATURES AND POTENTIAL FAILURE MODES**
- STEP 2.6: PERFORM SAFETY ASSESSMENT TO DETERMINE FAULT TOLERANCE**
- STEP 2.7: ASSESS THE COMBINED RISK OF ALL NON-FAULT TOLERANT CONDITIONS**
- STEP 2.8: DEVELOP SUPPORTING DATA FOR LIGHTNING PROTECTION PERFORMANCE**
- STEP 2.9: DEVELOP INSTRUCTIONS FOR CONTINUED AIRWORTHINESS, MAINTENANCE AND SURVEILLANCE PROGRAMS**
- STEP 2.10: INCORPORATE PRACTICAL MEASURES TO PREVENT, DETECT AND CORRECT FAILURES**
- STEP 2.11: VERIFY COMPLIANCE TO THE REQUIREMENTS**

Further explanation of each of the eleven steps as applied to Special Conditions or Exemptions is provided below.

2.1 IDENTIFY THE FUEL SYSTEM DESIGN FEATURES AND ASSOCIATED LIGHTNING PROTECTION

The fuel system requiring lightning assessment should be identified along with the means of lightning protection. The following are examples of the type of detailed documentation that should be provided:

- Details of each structural member or categories of members and fasteners exposed to direct attachment including the pertinent information needed to assess the ability to prevent fuel tank vapour ignition sources during attachment.
- Details of each structural joint or categories of joint and fasteners exposed to conducted currents resulting from lightning attachment including the pertinent information needed to assess the ability to prevent fuel tank vapour ignition sources.
- Details of each systems installation exposed to direct attachment or conducted current including the pertinent information needed to assess the ability to prevent fuel systems ignition sources.

Pertinent information can include, but is not limited to: material properties, thicknesses, and finishes (metallization, non-conductive coatings), fastener sizes, fit, and quantities, manufacturing tolerances, bonding or isolation, wire routing and shielding, etc. Typically this information is synthesized into a set of design groups or families that share similar characteristics relative to lightning protection performance. For each of the designs the lightning protection design features can also be identified and documented. This categorization organizes the designs and/or lightning protection design features into groups to aid with the evaluations identified below.

2.2 DETERMINE THE LIGHTNING STRIKE ZONES FOR THE AIRCRAFT

Determine the lightning zoning for the aircraft and particularly the fuel tank and fuel system regions using the zoning process defined in ED-91/ARP5414 document.

2.3 ESTABLISH THE AIRCRAFT LIGHTNING ENVIRONMENT OF THE DESIGN

The way the local lightning environment of the design is defined must be consistent with the principles that are used to verify the lightning protection performance of the design. Indeed, the definition of the threat determined at this step of the process must enable a direct correlation with the threat that is developed during a lightning test on a test sample and should be aimed at verifying the performance of the design.

The correlation can be done at different levels of aircraft design e.g. large object (wing), assembled joint/interface, group of fasteners or even at the fastener level itself. In the case where the protection principle is evaluated at the fastener level, for example, then the local lightning environment has to be established at the same scale for enabling correlation.

External surfaces of the aircraft are exposed to the external lightning environment, as defined in ED-91/ARP5414 and ED-84/ARP5412. All internal structural and system elements are exposed to the conducted currents resulting from lightning attachments in Zone 1 or Zone 2 regions.

Regardless of whether an area is exposed to a direct attachment, the lightning environment must also consider the worst case localized conduction current at the location of each and every component and interface inside the fuel tanks due to any lightning attachments to the aircraft. Historically similar design and manufacturing methods have been used in Zone 3 areas as in Zone 2, hence the design will generally provide effective lightning protection at most locations in the event of an unlikely attachment.

Determination of these threat levels requires an assessment of the worst case external attachment scenarios based on an appropriate combination of Analysis, Tests and Similarity: