U.S. Department
of Transportation
**Federal Aviation
Administration**

Policy Statement

Subject: Policy on Issuance of Special Conditions and Exemptions Related to Lightning Protection of Fuel Tank Structure and Systems	**Date:** 06/24/14 **Initiated By:** ANM-100	**Policy No:** PS-ANM-25.981-02

Summary

This policy statement provides a means of applying special conditions, exemptions, or the changed product rule as alternatives to direct compliance to the provisions of Title 14, Code of Federal Regulations (14 CFR) 25.981(a)(3) at Amendment 25-102 or later for lightning protection of fuel tank structure and systems. The Federal Aviation Administration (FAA) developed this policy because we determined that compliance with current regulatory standards applicable to fuel tank lightning protection can be impractical in some cases for some areas of structural design. In addition, industry has requested that the FAA consider extension of such practicality considerations to the design of fuel tank systems.

The FAA has conducted research and issued standards for fuel tank flammability reduction that can be used to maintain an acceptable level of safety when full compliance with the current ignition prevention standards of § 25.981(a)(3) cannot be achieved. The FAA therefore plans further rulemaking to address the practicality issues with § 25.981(a)(3). Meanwhile, the FAA will consider alternatives to direct compliance with § 25.981(a)(3) through the use of special conditions, exemptions, or the changed product rule (14 CFR 21.101) to set a proper certification basis for new and changed type designs. This policy statement provides a standardized approach to applying these alternatives.

This policy statement supersedes FAA Memorandum ANM-112-08-002, *Policy on Issuance of Special Conditions and Exemptions Related to Lightning Protection of Fuel Tank Structure*, dated May 26, 2009. Memorandum ANM-112-08-002 is no longer effective.

This policy statement does not replace or predetermine the outcome of any future rulemaking project.

Definition of Key Terms

In this document, the terms “must,” “should,” and “recommend” have specific meanings that are explained in Attachment 1.

For this policy, definitions for the following terms apply:

- A “critical lightning strike” is one that attaches to the airplane in a location that affects a failed feature or structural failure, and the amplitude of the strike is sufficient to create an ignition source when combined with that failure.

- “Extremely improbable” failure conditions are those so unlikely that they are not anticipated to occur during the entire operational life of all airplanes of one type.

- “Extremely remote” failure conditions are those unlikely to occur on each airplane during its total life, but which may occur a few times when considering the total operational life of all airplanes of that type.

- “Fuel tank structure” includes structural members of the fuel tank such as airplane skins, joints, ribs, spars, stringers, and associated fasteners, brackets, coatings and sealant where a critical lightning strike could lead to ignition of fuel vapors.

- “Fuel tank systems,” or “systems,” in the context of this policy statement, include tubing, components, and wiring that are penetrating, located within, or connected to the fuel tanks in a way that a critical lightning strike could lead to ignition of fuel vapors.

- “Practicality” is a balance of available means, economic viability, and proportional benefit to safety.

- “Remote” failure conditions are those unlikely to occur to each airplane during its total life, but which may occur several times when considering the total operational life of a number of airplanes of that type.

Current Regulatory and Advisory Material

- Section 25.954, *Fuel system lightning protection*, Amendment 25-14, requires that the fuel system be designed to prevent the ignition of fuel vapor within the system due to direct lightning strikes, swept lightning strokes, and corona and streamering.
- Section 25.981, *Fuel tank ignition prevention*, Amendment 25-125, requires that the fuel tank and fuel tank system be designed so that no ignition sources are present where fuel vapors could ignite, and it limits flammability exposure.
- Advisory Circular 20-53B, *Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition Caused by Lightning*, dated June 5, 2006, describes one means to gain FAA approval for compliance with 14 CFR 23.954, 25.954, 27.954, and 29.954.
- Advisory Circular 20-107B, *Composite Aircraft Structure*, dated September 8, 2009, describes an acceptable means of compliance with 14 CFR parts 23, 25, 27, and 29 regarding airworthiness type certification requirements for composite aircraft structures involving fiber reinforced materials.
- Advisory Circular 20-155A, *Industry Documents to Support Aircraft Lightning Protection Certification*, dated July 16, 2013, recognized several SAE Aerospace Recommended Practices (ARPs) and European Organization for Civil Aviation

Equipment (EUROCAE) documents as acceptable methods for showing compliance with airworthiness regulations.

- Advisory Circular 25.981-1C, *Fuel Tank Ignition Source Prevention Guidelines*, dated September 19, 2008, provides guidance for demonstrating compliance with the certification requirements for prevention of ignition sources within the fuel tanks of transport category airplanes.
- Advisory Circular 25.1309-1A, *System Design and Analysis*, dated June 21, 1988, provides guidance for assessing the safety of airplanes and installed systems.
- Policy Memorandum PS-ANM100-00-113-1034, *Use of ARAC (Aviation Rulemaking Advisory Committee) Recommended Rulemaking not yet formally adopted by the FAA, as a basis for equivalent level of safety or exemption to Part 25.* This policy allows the use of Draft Advisory Circular 25.1309-Arsenal, *System Design and Analysis*, dated June 10, 2002.

Background

Before Amendment 25-102 to part 25, § 25.954 was the regulation applied to lightning protection of fuel tanks. As it was normally applied, that regulation only required prevention of ignition of vapors in the tank with no consideration of expected design failures, aging, wear, or maintenance errors for airplane structure. After a 1996 transport airplane accident caused by a catastrophic fuel tank explosion, the FAA pursued a layered approach to precluding fuel tank explosions by (1) preventing ignition sources from occurring in the fuel tanks, and (2) reducing the flammability of the fuel tanks.

Amendment 25-102. At the time we developed Amendment 25-102 (i.e., 1998-2001), the FAA and industry were still exploring the dynamics of tank flammability and the fleet average flammability exposure for transport airplane fuel tanks. Evaluation of the technical and economic viability of fuel tank inerting systems for commercial transport airplanes was also in its early stages at that time. The FAA adopted changes to § 25.981(a) that applied the existing safety analysis principles of §§ 25.901(c) and 25.1309(b) to fuel tank system ignition sources.

Amendment 25-102 also introduced § 25.981(b) requirements to identify critical design configuration control limitations (CDCCL) to prevent development of ignition sources within the fuel tank systems.

Amendment 25-102 added § 25.981(c), which required that fuel tank flammability be minimized, or that effects of an explosion be mitigated such that any damage from a fire or explosion would not prevent continued safe flight and landing. We intended this requirement to be separate from, and in addition to, the requirement to prevent ignition sources.

While Amendment 25-102 added § 25.981(c) to require minimization of flammability or mitigation of damage from vapor ignition events, Amendment 25-102 primarily focused on the prevention of ignition sources since significantly reducing the level of fuel tank flammability was believed to be impractical at that time. The amended ignition prevention requirements in § 25.981(a)(3) require consideration of factors such as aging, wear, and maintenance errors as well as the existence of single failures, combinations of failures not shown to be extremely improbable, and single failures in combination with latent failures to account for the cause of many ignition sources in fuel tanks and deficiencies in the existing regulations. This amendment to § 25.981, which applies to the fuel tank system, requires the designs be protected from lightning, through the use of failure tolerant features.

The policy for showing compliance with the ignition prevention requirements of § 25.981 was based on the long-standing practice that fuel tank vapor should be assumed to be flammable at any time (probability of flammability = 1). However, in the preamble to Amendment 25-102, the FAA also suggested we might consider fuel tank flammability exposure in the future in meeting the requirements of § 25.981(a)(3) for ignition prevention. The preamble stated –

> However, if technological changes are developed, such as full-time fuel tank inerting, and prove to be a superior method of eliminating the risk of fuel tank ignition, the FAA could consider a change in this philosophy in future rulemaking.

Amendment 25-102 introduced § 25.981(a)(3) –

> *25.981(a): "No ignition source may be present at each point in the fuel tank or fuel tank system where catastrophic failure could occur due to ignition of fuel or vapors. This must be shown by:*
>
> *(3) Demonstrating that an ignition source could not result from each single failure, from each single failure in combination with each latent failure condition not shown to be extremely remote, and from all combinations of failures not shown to be extremely improbable. The effects of manufacturing variability, aging, wear, corrosion, and likely damage must be considered."*

This specific requirement affecting fuel systems is based on the combined requirements of §§ 25.901(c) and 25.1309(b). As stated in Advisory Circular (AC) 25.981-1C, "in order to eliminate any ambiguity as to the restrictions on latent failures, § 25.981(a)(3) explicitly requires that any anticipated latent failure condition not result in the airplane being one failure away from a catastrophic fuel tank ignition."

AC 25.981-1C also states that applicants should assume that a lightning attachment could occur at any time (probability of lightning = 1). In addition, industry and FAA practice had been to assume that a defined set of severe lightning current components would be associated with every lightning strike to the aircraft.

After promulgation of Amendment 25-102, the FAA and industry continued research and discussion of the measurement and modeling of fuel tank flammability and development of practical means to reduce or eliminate flammability in transport airplane fuel tanks. This eventually led to the certification of practical retrofit designs for center wing fuel tank nitrogen generation systems on two existing transport airplane models. Those systems use nitrogen enriched air that is generated onboard the airplane to displace oxygen in the fuel tank. This results in inerting the fuel tank throughout most of the flight and ground operations. Some applicants for new type certificates involving composite wing structure have included flammability reduction means, such as an ullage inerting system, for all fuel tanks, including the main fuel tanks located in the wing.

Amendment 25-125. Amendment 25-125, which was part of the fuel tank flammability reduction (FTFR) rule issued in 2008, revised § 25.981(b) and (c) to introduce specific performance-based standards for the maximum flammability allowed in various fuel tanks. Amendment 25-125 maintained the alternative adopted by Amendment 25-102 allowing ignition mitigation means. Amendment 25-125 established a new fleet average flammability exposure limit of 3 percent for all fuel tanks, or that of an equivalent conventional unheated aluminum fuel tank. Fuel tanks that are not main fuel tanks and that have any portion located within the fuselage contour must be limited to 3 percent fleet average exposure and 3 percent warm day exposure. As an alternative, an applicant may install a means to mitigate the effects of a fuel tank vapor ignition event in fuel tanks such that no damage caused will prevent continued safe flight and landing. Amendment 25-125 did not change the ignition prevention standards of § 25.981(a).

Amendment 25-125 also moved the CDCCL requirements created by Amendment 25-102 to § 25.981(d).

Amendment 26-2. Amendment 26-2 (also part of the FTFR rule issued in 2008) added regulations requiring compliance with the flammability standards in the new version of § 25.981(b) for certain existing type designs, for certain type design change programs, for pending new type certificate programs, and for future new production of existing type design airplanes after September 20, 2010 (Amendment 26-3 corrected an inadvertent error in the compliance date). At the same time, Amendments 121-340, 125-55 and 129-46 added operational requirements for installation and operation of flammability reduction means on certain airplanes manufactured after 1991. As stated in the FTFR rule preamble, the FAA made these changes because we recognized that measures in Amendment 25-102 aimed at ignition source prevention would not alone be enough to prevent future fuel tank explosions on transport airplanes. That preamble stated –

> Predicting the effectiveness of ignition prevention actions is challenging, since many ignition sources are the result of human error, which cannot be precisely predicted or quantitatively evaluated. Despite extensive efforts by the FAA and industry to prevent ignition sources, we continue to learn of new ignition sources. Some of these ignition sources are attributable to failures by engineering organizations to identify potential ignition sources and provide design changes to prevent them. Others are attributable to actions by production, maintenance, and other operational personnel, who inadvertently compromise wiring and equipment producing ignition sources. Regardless of the causes, we believe that ignition prevention actions, while necessary, are insufficient to eliminate ignition sources.

The FAA now has a better understanding of the flammability exposure level of unheated aluminum wing tanks and the performance and availability of systems providing flammability reduction means. As shown by the issuance of the FTFR rule and as discussed in the preamble for that rule, the FAA has now determined that there are practical methods available to significantly reduce risk because of fuel tank flammability. In addition, the FAA realized in 2008 that application of § 25.981(a)(3) to fuel tank structural lightning protection can be impractical in some cases.

Relevant Past Practice

Existing composite and aluminum structural technology can generally provide the ability to withstand single faults and still prevent ignition sources in the event of an airplane lightning strike for most areas of the design. However, systems with potentially catastrophic failure modes typically meet requirements such as §§ 25.901 and 25.1309 through a design architecture that can withstand multiple independent failures without a catastrophic effect. As it applies to fuel tank lightning protection for basic airplane structure, compliance with § 25.981(a)(3) would typically need a design with three reliable, independent, and redundant protective features to prevent ignition sources. However, for certain certification programs conducted since Amendment 25-102 became effective, applicants have shown that it was impractical to provide multiple redundant protective features for some aspects of aircraft structural lightning protection using state-of-the-art technology for both composite and traditional aluminum fuel tank structure.

A design architecture that can withstand single failures, but not multiple failures, that could result in an ignition source, could potentially comply with § 25.981(a)(3) when combined with either regular inspections at sufficiently short intervals, or when combined with a monitoring device to verify the functionality of the protective features. However, inspections and monitoring features for the various structural design features may not be practical. Confirming the continued functionality of structural lightning protection features can be difficult because of the significant challenges of providing continual monitoring of the health of the features. It can also be difficult because of the limited capability to inspect the features without significantly impacting aircraft performance, efficiency, or other protective features critical to safety. While some concepts involving monitoring aids attached externally to the wings have been considered, the protective features are often integral to the fuel tank structure or internal to the fuel tanks. Inspection of features inside fuel tanks requires access to the fuel tanks, which is usually only scheduled a few times during the life of the airplane. Increasing the frequency of internal fuel tank inspections would have the undesirable effect of increasing the possibility of damaging the lightning protection features or other design features during the inspection process.

Applicants have also argued that it is not practical to provide effective fault-tolerance for certain design areas of fuel tank structure. Certain known single failure conditions can create an ignition source in the event of a critical lightning attachment. These areas include cracking of structural elements, complete fracture of a bolt with high tension loading that causes gapping or departure of one or both ends of the bolt from the bolt hole and simultaneously compromises sealant over the bolt, and failures of sealant where the sealant is the primary feature needed to prevent an ignition source. Design changes to provide fault tolerance for these design areas to prevent ignition sources have in some instances been found to be impractical.

In 2008, after examining some of these design areas with applicants, the FAA agreed to consider granting exemptions (or exceptions under § 21.101, when applicable) to § 25.981(a)(3) for fuel tank structure lightning protection designs. Multiple applicants with airplanes using conventional aluminum structure have requested and received full or partial exemptions from § 25.981(a)(3) for structural lightning protection. For other applicants for winglet installation design changes, the FAA has granted exceptions under § 21.101, allowing application of an earlier amendment of § 25.981(a) for fuel tank structure and/or systems. In addition, the FAA has approved special conditions in lieu of § 25.981(a)(3) for proposed designs that included features to reduce flammability significantly below the level required by § 25.981(b) at Amendment 25-125. The FAA also approved special conditions for a design using composite wing structure with a flammability reduction system for all fuel tanks.

In 2009, the FAA chartered the Large Airplane Fuel System Lightning Protection Aviation Rulemaking Committee (Lightning ARC) to re-examine §§ 25.954 and 25.981 to address issues such as these that have surfaced during application of the requirements of Amendment 25-102 to the design of lightning protection of fuel tank structure and systems. The charter-defined intent of the Lightning ARC was to establish a balanced approach to ensure that airplane designs provide an acceptable level of safety, while allowing manufacturers to use designs that are economically viable in terms of design, manufacture, and operation. The Lightning ARC completed its work and provided recommendations in a report published in May 2011.

The Lightning ARC report identified two additional areas where application of § 25.981 to lightning protection was problematic. First, the report stated that applying a third layer of lightning protection to fuel tank systems, as normally required to comply with § 25.981(a)(3), was possible but it added design complexity, was not necessary to provide a level of safety consistent with what is required by other regulations for other aspects of airplane design, and could potentially introduce unforeseen negative safety consequences. To address this effectively, the ARC report recommended that fuel tank systems lightning protection should be addressed in a similar manner as fuel tank structural lightning protection. Second, the report stated that likely damage was found to be a contributor to failures that could affect lightning protection and would usually occur during maintenance activity. The Lightning ARC report recommended that caution information associated with critical lightning protection features be incorporated directly into maintenance documentation used by maintenance personnel in addition to CDCCLs as currently required by § 25.981(d).

Policy

Until related rulemaking is completed, the FAA will propose special conditions or grant exemptions with conditions to define appropriate airworthiness requirements for new fuel tank structure and systems, as well as design changes and supplemental type certificates (STCs) affecting fuel tank structure and systems. For design changes and STCs where we determine exceptions appropriate under § 21.101, the FAA will apply § 25.981(a) at an earlier amendment level. Specific policy on the application of § 21.101 for type design changes is discussed below.

1. Eligibility for consideration under this policy

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).

2. Guidance for alternatives to complying with § 25.981(a)(3)

The applicant’s design goal should be to provide fault tolerance wherever practical. In the definitions section of this policy statement, practicality is defined as a balance of available means, economic viability, and proportional benefit to safety. A means to provide fault tolerance against potential ignition sources that is possible with little economic impact is practical even if the probability of the potential ignition source conditions would be remote without them. However, if the means would have a significant economic impact on production, operational, or maintenance costs, it is not necessary to use these means if it can be determined that the probability of a potential ignition source, combined with a critical lightning strike and flammable fuel tank conditions, is such that catastrophic ignition is extremely improbable, i.e., it is not anticipated to occur during the entire operational life of all airplanes of one type.

Critical lightning protection features are those features that are designed and installed in a manner such that their physical, functional, and installation integrity is necessary to prevent ignition sources in the event of a lightning strike. These features may be required to achieve a compliant design or may be included as a condition of special conditions or exemption. If required by special conditions or exemption, the applicant must develop cautions, and include them as CDCCL, identifying the presence of critical lightning protection features to avoid inadvertent modification or damage of these features during maintenance. Additionally, these cautions must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness and in the maintenance documentation. Instructions for restoration and repair methods that are necessary to maintain design of the fuel tank structure and systems should be included in the FAA-approved structural repair manual.

Effectiveness of designs to provide fault tolerance to failures should be demonstrated using industry testing practices in SAE ARP5416 and should be evaluated in combination with normal design variability (e.g., drawing tolerances). It should not be necessary to assume that all tolerances will be at worst case concurrently (that is, stacking of drawing tolerances is not required). Drawing and process limits, and conditions within those limits, are considered part of the basic design and are not failure conditions.

The following two sections provide guidance regarding the determination of practicality and impracticality in providing fault tolerance and list assessment tasks to show compliance to § 25.981 for both fault-tolerant and non-fault-tolerant designs.

a. Examples of determinations of practicality and impracticality in providing fault tolerance:

(1) Design changes or features that will typically be determined to be practical:

(a) Installation of rivets and bolts in aluminum structure that are well bonded through strict control of fastener/hole fit, fastener and hole quality, and installation practices to prevent the creation of arcs, sparks, or hot gas ejection in the event of a critical lightning strike.

(b) Installation of bolts in composite structure that are well bonded through strict control of fastener/hole fit, fastener and hole quality, and installation practices, and with additional design features to distribute current such as foil or mesh at the material surface, to prevent the creation of arcs, sparks or hot gas ejection in the event of a critical lightning strike.

(c) Installation of lightning protective sealant or cap seals over fastener heads/ends located inside fuel tanks to provide fault tolerance.

(2) Preventive installation features and design areas that will typically be determined to be impractical:

(a) Preventing fatigue cracking within structural elements such as spars, skins, stringers, and ribs.

(b) Preventing failure of fasteners highly loaded in tension that leads to separation of the fastener or part of the fastener from the hole, or gapping of the fastener head or nut, and consequent failure of a cap seal.

(c) Preventing Category 1 damage for composite structure (reference AC 20-107B).

b. Examples of design, manufacturing, and maintenance processes that will typically be determined to be practical:

Note: Although these practices themselves are not considered to be "independent features" for providing fault tolerance, they can be considered as measures to minimize the likelihood of failures or measures necessary to support assumptions about failure modes or rates in a safety analysis.

(1) A structured design review process to ensure that all relevant design features are reviewed to identify critical design areas, critical processes, and associated testing and analysis requirements.

(2) Engineering review (and approval for repairs and alterations) of the proposed design to identify failure modes that may occur because of manufacturing variability (including errors or escapes), maintenance errors, repairs or alterations, aging, wear, corrosion, or likely damage.

(3) Engineering review of manufacturing processes to identify failure modes that may occur because of manufacturing variability (including errors or escapes).

(4) Engineering review of service history records to identify failure modes that may occur because of manufacturing variability (including errors or escapes), maintenance errors, repairs or alterations, aging, wear, corrosion, or likely damage.

(5) Implementation of practical manufacturing and quality control processes to address the issues identified through the required engineering reviews.

(6) Manufacturing and quality control processes that include measures typically used for other critical features of the airplane.

(7) Quality control processes that require inspection of critical features by a person other than the person that performed the manufacturing work.

(8) Provisions in Instructions for Continued Airworthiness to identify cautions in maintenance documents regarding lightning protection features, as well as life limits or repetitive inspections for non-fault-tolerant features. For any penetration into the fuel tank, or any structural damage within the fuel tank, the structural repair manual (SRM) should specify repair methods that maintain lightning protection features.

(9) Mandatory maintenance actions necessary to ensure maintained compliance with the lightning protection requirements should be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness as required by appendix H25.4. CDCCL identifying the presence of lightning protection features and requiring any repairs or restorations be done in accordance with the FAA-approved SRM would also be included in the Airworthiness Limitations section. Instructions for restoration and repair methods, when applicable, that are necessary to maintain the lightning protection features of the design should be included in the FAA-approved SRM.

An optimized design and certification can be achieved when the potential non-fault-tolerant design features are identified and developed early.

3. Evaluating non-fault tolerance of airplane fuel tank structure

The goal of these alternatives is to provide a means of demonstrating that the occurrence of a lightning strike generating an electrical current of sufficient density (to cause ignition) at a non-fault-tolerant structural detail located within a flammable fuel tank environment will not be anticipated over the life of the airplane fleet. To achieve this, the following three assessments should be performed and evaluated collectively:

- Probability of the occurrence of a flammable condition within a fuel tank (specify flammable zones).

- Probability of the occurrence of a lightning strike of sufficient amplitude to create an ignition source at a failed feature or structure within a fuel tank flammability zone (i.e., a critical lightning strike).

- Potential for the presence of a structural discrepancy resulting in a non-fault-tolerant feature within a flammable fuel tank zone.

Once the flammable fuel tank zones are defined (with probability of occurrence) along with the determination of the probability of a critical lightning strike occurring within the flammability zones, an evaluation of the potential for the occurrence of a structural discrepancy (non-fault-tolerant feature) within the flammable fuel tank zones can be performed. By determining the probable occurrence of a critical lightning strike, the structure can then be evaluated against the predicted rate of occurrence. For example, if it is shown that the probability of such a lightning strike may occur every x flight hours, the specified structural discrepancies can then be evaluated against that. For example, will inspections be able to reliably detect cracks (at or exceeding gap size required to create arcing) before the probability of occurrence is exceeded?

To achieve the goal of the subject alternatives, the applicant should demonstrate that the exposure time of each specified structural discrepancy (non-fault-tolerant feature) that can occur within the flammable zones, when combined with the probability of a flammable fuel tank condition and the probability of a critical lightning strike, will be such that catastrophic failure from ignition due to lightning will not be anticipated over the life of the fleet. The following paragraphs identify those areas that should be addressed to support a determination of the exposure time of a structural discrepancy within a flammable fuel tank zone.

For traditional metallic airplanes, structural cracks or broken fasteners due to overstress, fatigue, or accidental and environmental damage are probable conditions. Historically these conditions have not resulted in known ignition sources because electrical current densities in aluminum airplanes are low except at or very near the lightning attachment point on the airplane skins. Therefore, few structural cracks or failures will become ignition sources given the amount of available energy. Lightning would have to attach in the specific vicinity of the structural crack or broken fastener, be of sufficient amplitude to cause sparking, and occur in a flammable environment in order to cause ignition. For airplanes using composite structure for fuel tanks, the electrical current densities may be much higher than a conventional metallic structural design, resulting in a higher risk of a structural failure or discrepancy becoming an ignition source in the event of a lightning strike.

Evaluation of fault tolerance should include consideration of structural discrepancies resulting from overstress, aging, fatigue, wear, manufacturing defects, accidental and environmental damage, and likely damage. Likely damage includes conditions that could be reasonably anticipated to occur in the life of an individual airplane due to operation, scheduled and unscheduled maintenance. In addition, probable escapes in the production design process should be considered as probable failures.

If required by special conditions or exemption, a determination of the potential for a non-fault-tolerant condition resulting in a lightning-related ignition source must be based upon appropriate assessments. The objective of these assessments is to demonstrate that, for a discrepant structural condition in a fuel tank vapor zone, the exposure time of the non-fault-tolerant feature to a lightning induced electrical current density of sufficient magnitude to become an ignition source will be minimized to such a degree that catastrophic failure due to a lightning strike is not anticipated during the entire operational life of all airplanes of that type. In performing the assessments to determine the potential for non-fault-tolerant condition to result in a lightning-related fuel vapor ignition, the following factors should be collectively considered, addressed, and documented:

a. Identification and evaluation of all conditions necessary for a fuel tank structural discrepancy to result in an ignition source due to a lightning strike;

b. Analysis of the electrical current densities within the fuel tank structure considering its material properties and configuration;

c. Appropriate analysis and test data to support any conclusion that the occurrence of a critical lightning strike at a particular location on the airplane where a discrepancy exists, combined with fuel tank flammability causing fuel tank ignition, is extremely improbable;

d. Necessary analysis and test data to support any conclusion that the electrical current density generated by a lightning strike in the specific vicinity of a structural crack or broken fastener in the fuel tank will not be of sufficient amplitude to cause sparking; and

e. Evaluation of fuel tank structure in areas of the fuel tank that may be susceptible to a fuel vapor condition and electrical current densities that can result in a lightning-related ignition. This should include assessing the structure's:

(1) Susceptibility to failure (such as cracking, delamination, fastener failure, failed fastener cap seals, failed sealant, etc.);

(2) Inspectability (determining if discrepant structure could be reliably inspected such that the exposure time of the failure to a critical lightning strike will be reduced to a level that supports the safety objective);

(3) Service data (reports of failed structure, such as cracks, delamination, failed fasteners, failed fastener cap seals, sealant, that could become an ignition source);

(4) Maintenance inspection programs (determining if inspections will reliably detect failures and discrepancies such that their exposure time will be reduced to a level that supports the safety objective). This includes mandated (e.g., Airworthiness Limitations section of the Instructions for Continued Airworthiness as required by appendix H25.4 and § 25.1529) and non-mandated programs; and

(5) Fatigue and damage tolerance evaluation of crack initiation/propagation rate, crack characteristics (e.g., crack width versus crack length), detectable crack size, probability of detection, inspection threshold, interval.

f. An example of an assessment process addressing potential for fuel tank structural cracking:

(1) After determining, for a given fuel tank zone, the probability of the simultaneous occurrence of a fuel vapor condition and lightning strike that would induce an electrical charge of sufficient energy in this zone to cause ignition, the following should be accomplished:

(a) For each fuel vapor zone where it is determined that the simultaneous occurrence of a fuel vapor condition and lightning strike of sufficient electrical charge that could cause ignition could occur during the operational life of an airplane:

- Determine if the structure in this zone is susceptible to fatigue cracking. If it is susceptible to fatigue cracking, determine the minimum size of crack that could be a source for arcing. This crack length should then be compared to the inspection methods available, to determine the probability of detecting a crack of this size.

- As part of the damage tolerance evaluation, an analysis should be performed to determine the duration of time (in flight cycles) it will take for a crack of minimum arcing size to grow to the minimum detectable length. This crack propagation rate should then be used along with the probability of detection for the specified inspection method to determine the exposure time. That is, the number of flight cycles an airplane may be exposed to have an ignition source due to a structural failure (crack, failed fastener, etc.)

(b) The goal of this effort is to minimize the exposure time. The applicant should evaluate this exposure time against the probability of the simultaneous occurrence of a fuel vapor condition and lightning strike than would induce an electrical charge of sufficient energy in this zone to cause ignition. A low probability combined with low exposure time will be necessary to demonstrate that catastrophic ignition is extremely improbable, i.e., it is not anticipated to occur during the entire operational life of all airplanes of one type.

(2) If for a given fatigue crack it is shown that the exposure time is too great such that it cannot be demonstrated that catastrophic ignition to be extremely improbable, then a fault tolerant design for the subject fuel vapor zone being analyzed must be provided in order to demonstrate compliance with § 25-981(a)(3) at Amendment 25-102.

g. It may be possible to demonstrate that a new or changed design or design feature will perform similarly to a previously certificated design or design feature under foreseeable lightning threats. If applicable, the applicant may provide a comparative analysis of similar design features and details on a previously certificated airplane. The comparative analysis would include a detailed assessment of the design features and details that affect susceptibility to failure, exposure time to lightning hazard, service experience, and any applicable analyses and test data.

If the assessment shows failures in any particular area of an airplane that can result in fuel tank ignition sources, then appropriate compensating features should be provided. For any compensating feature (or maintenance action) developed, in compliance with special conditions or exemption, the applicant must demonstrate that the feature/action will contribute to minimizing a failed structure’s exposure time to a critical lightning strike to such a degree that an ignition event of the fuel tank would be classified as extremely improbable.

In an effort to determine the probability of non-fault-tolerant conditions resulting in a lightning-related fuel tank explosion, the results from the assessment of the factors listed above should be considered and presented in a collective manner.

Note: Additional guidance on lightning protection considerations for airplanes with fuel tanks fabricated using composite materials is provided in AC 20-107B, *Composite Aircraft Structure*.

4. Evaluating non-fault tolerance of airplane fuel tank systems

Fuel tank systems have been able to comply with § 25.981(a)(3) at Amendment 25-102, through careful application of fault-tolerant design principles. In general, compliance with the requirement of § 25.981(a)(3) to consider single failures plus extremely remote latent failures has required fuel tank system designs that provide three layers of protection against ignition sources. However, in some cases we have found that such compliant system designs exceed the level of safety required for other aspects of airplane systems design, and exceed what is required to ensure protection against catastrophic fuel tank ignition events. The FAA therefore acknowledges that the concepts of impracticality discussed above with respect to structures can, in principle, be extended to systems as well.

The successful history of fuel tank system compliance with § 25.981(a)(3), and thus the absence of specific impracticality examples regarding fuel tank systems, places the burden on the applicant to demonstrate that it is impractical to provide redundant system-protective features. In practice this means that the FAA will not accept fuel tank system designs where a catastrophic failure condition can result from a single failure, including potential latent failures, in combination with lightning and flammability exposure. This is consistent with the systems requirements of § 25.1309.

5. Application of Policy

a. New Type Certificates - Exemptions

For new type certificate programs, the FAA will consider granting exemptions from § 25.981(a)(3) for lightning protection of fuel tank structure and systems, on airplanes that do comply with the applicable fuel tank flammability performance standards of § 25.981 as amended by the applicable amendment level. To grant such an exemption, the FAA must find that the approval of the proposed design would provide an acceptable level of safety and would be in the public interest.

Note: Section 26.37 addresses pending type certification projects as of the effective date of the rule. That section states, for new type certificates for airplanes with 30 passengers or more or payload of 7500 pounds or more for which application was made prior to the effective date of the rule, and for which the certificate was not issued by that same date, § 25.981 as of the effective date of the rule (Amendment 25-125) applies. For pending type certificate projects as of the effective date of the rule that do not exceed either the passenger or payload threshold, the requirement of § 25.981 at Amendment 25-102 to “minimize” flammability would apply.

The FAA does not expect to be able to make the findings required for an exemption from § 25.981(a)(3) for a new aircraft type if it cannot be shown to meet the applicable flammability requirements of § 25.981. Therefore, it is not envisioned that the FAA would grant exemptions to both § 25.981(a)(3) and the flammability requirements of § 25.981 for a new type certificate program.

Title 14 CFR § 11.81 lists the information that must be included in a petition for exemption. A petitioner seeking an exemption must include in their petition all of the information required by that regulation. In providing that information, petitioners seeking an exemption using the means provided by this policy statement should address the following:

- In responding to § 11.81(c), petitioners seeking an exemption under this policy should refer to this policy statement. The petitioner should identify the specific design features for which an exemption is sought. The petitioner should show that all practical measures have been taken to meet the requirements of § 25.981(a)(3) for the fuel tank structure and systems. For the design features for which an exemption is sought, the petitioner should show what potentially compliant design changes were examined, and what design changes were ruled out based on impracticality.

- In responding to § 11.81(e), a petitioner seeking an exemption under this policy should address each of the safety requirements listed below and reference this policy statement. In addition, the petitioner should include any other information they believe supports a finding that an acceptable level of safety will be provided.

If the FAA determines that it is in the public interest to grant an exemption under this policy, the FAA will typically apply the following ignition source prevention conditions to ensure that an acceptable level of safety is provided. The FAA has determined that these alternatives to full compliance would be applicable and sufficient for most designs.

(1) The fuel tank structure and systems must be designed and installed to prevent catastrophic fuel vapor ignition due to lightning.

(2) The fuel tank structure and systems lightning protection design must be fault tolerant for failures that result in lightning-related ignition sources.

(3) Fault tolerance is not required for any specific design feature if:

  (a) Fault tolerance is shown to be impractical for that feature, and

  (b) Fuel tank vapor ignition because of that feature and all other non-fault-tolerant features, when their fuel tank vapor ignition event probabilities are combined, is shown to be extremely improbable.

(4) Inspections or other procedures must be established to prevent development of lightning-related ignition sources within the fuel tank structure and systems, for example:

  (a) Identifying as airworthiness limitations, mandatory maintenance actions (i.e., inspections), or CDCCLs, necessary to preclude the development of unsafe conditions due to non-fault-tolerant lightning protection features;

(b) Including sampling programs, maintenance, and/or inspections for fault-tolerant lightning protection features in the manufacturer's recommended airplane maintenance program;

Note: If inspections from non-mandatory programs such as Baseline Zonal inspection program, Corrosion Prevention and Control Program (CPCP), etc., are going to be used to support the robustness of the overall inspection program, these programs must become mandatory and must be included in the Airworthiness Limitations section of the airplane's Instructions for Continued Airworthiness.

(c) Incorporating into applicable airplane maintenance documents, including the manufacturer's structural repair manual, caution information that identifies the lightning protection features of the fuel system design to minimize the potential for inadvertent damage or disruption of these features.

(5) An analysis must be performed to show that the airplane's design, its manufacturing processes, and the Airworthiness Limitations section of its Instructions for Continued Airworthiness include all practical measures to prevent, and detect and correct, failures of fuel tank structure and systems lightning protection features because of manufacturing variability, aging, wear, corrosion, and likely damage.

b. New Type Certificates – Special Conditions

The FAA may propose special conditions under § 21.16 to address lightning protection of fuel tank structure and systems for fuel tank systems with flammability reduction means that meet or exceed the performance standards set in appendix M to part 25 at Amendment 25-125 for all fuel tanks on the airplane. Since compliance with § 25.981(b) at Amendment 25-125 only requires compliance with the performance requirements of appendix M for normally-emptied fuel tanks within the fuselage contour, a flammability reduction system that complies with the appendix M requirements for all fuel tanks is considered to be a novel or unusual design feature.

In addition, the FAA may consider the requirements in § 25.981(a)(3) inappropriate for fuel tank structure and systems lightning protection features where applicants show that application of those requirements is impractical. The FAA may also find that an acceptable level of safety can be achieved with less stringent ignition source prevention requirements. Specifically, meeting the appendix M standard for all fuel tanks would reduce fuel tank flammability significantly below the maximum level that would otherwise apply to the main tanks on airplane designs that are required to meet Amendment 25-125. This additional risk reduction would be considered a compensating feature that offsets some relaxation of the requirements contained in § 25.981(a)(3).

When the FAA determines that special conditions are appropriate instead of § 25.981(a)(3), the special conditions will typically include the same conditions as described above for the exemption option.

c. Changes to Type Certificates, including STCs

(1) Exemptions for type design change programs and STCs on Amendment 25-102 airplanes.

For type design change programs on Amendment 25-102 airplanes, the FAA will consider granting exemptions from § 25.981(a)(3) as described above for new type certificates. The same ignition source prevention conditions described in paragraph 5b will be applied. For pre-Amendment 25-125 airplanes subject to part 26, the fuel tank flammability standards for the design change will be those required under §§ 26.33 and 26.35 as adopted in Amendment 26-2.

(2) Exemptions for type design change programs and STCs on pre-Amendment 25-102 airplanes.

For type design change programs that include § 25.981(a)(3) and (b) at Amendment 25-102 as a result of application of the certification basis upgrade provisions of § 21.101, and for which an exception under § 21.101 is not appropriate, the FAA will consider granting exemptions from § 25.981(a)(3) and (b) at Amendment 25-102 as described above for new type certificates. For example, for a design change that adds wing reserve tanks to an airplane, or that redesigns a significant portion of the wing structure, compliance with § 25.981(a)(3), as amended by Amendment 25-102, would have a material impact on fuel system safety. In such cases, the exemption conditions described above will be applied to set appropriate standards for that potential additional risk. For pre-Amendment 25-125 airplanes, the fuel tank flammability standards for the design change will be those required under the applicable provisions of §§ 26.33 and 26.35 at Amendment 26-2.

(3) Exceptions under § 21.101 for type design change programs and STCs on pre-Amendment 25-102 airplanes.

For type design changes on pre-Amendment 25-102 airplanes that are classified as "significant product level changes" under § 21.101, the FAA will consider allowing applicants to show compliance with an earlier amendment level of § 25.981(a) for lightning protection of fuel tank structure and systems under the provisions of § 21.101. The FAA determination will be based on the potential impact on fuel system safety that would result from application of Amendment 25-102. If the change would not result in a significant reduction in the risk of a lightning related fuel tank vapor ignition event were it required to comply with § 25.981(a)(3) at Amendment 25-102, then the exception provision of § 21.101(b)(3), "would not materially contribute to the level of safety of the changed product," will be used to allow application of an earlier amendment of § 25.981(a). For example, the FAA has found that compliance with an earlier amendment was acceptable for projects involving the installation of winglets. In these installations, a limited number of stringers and fasteners were added within the fuel tank and for which all new fasteners were cap-sealed to provide fault tolerance. Any exception would be limited to aspects of lightning protection of fuel tank structure where no material benefit from compliance is shown.

6. Methods of Compliance

Specific requirements and methods of compliance to address the design features covered under this Policy will be developed for each specific design by the applicable special conditions or exemption and by the issue paper process until the rulemaking discussed above is completed.

7. Applicability of § 25.954

Applicants should note that the airplane design must comply with the provisions of § 25.954. This policy statement is not intended to affect or eliminate the requirement to comply with that regulation.

Effect of Policy

The general policy stated in this document does not constitute a new regulation or create what the courts refer to as a "binding norm." The office implementing this policy should follow this policy when it is applicable to a specific project. If the implementing office becomes aware of reasons an applicant's use of this policy should not be approved, the office must coordinate its response with the policy issuing office.

Applicants should expect that certificating officials would consider this information when developing certification options relevant to new certificate actions.

Implementation

This policy discusses administrative design approval options available to applicants for type certificate, amended type certificate, supplemental type certificate, and amended supplemental type certification programs. These administrative compliance options are currently available and will continue to be available until regulatory changes preclude the need for these administrative design approval options.

Conclusion

The FAA has determined that compliance with current regulatory standards applicable to fuel tank lightning protection can be impractical in some cases for some areas of structural design. In addition, industry, through the Lightning ARC, has requested that the FAA consider extension of such practicality considerations to the design of fuel tank systems. Until related rulemaking is completed, the FAA will consider special conditions or grant exemptions with conditions to define appropriate airworthiness requirements for new fuel tank structure and systems, as well as design changes and supplemental type certificates affecting fuel tank structure and systems. This policy statement provides a standardized approach to applying those alternatives.

Contact

For information or questions regarding this policy, please contact Massoud Sadeghi, FAA, Transport Airplane Directorate, Airplane and Flight Crew Interface Branch, ANM-111 at 425-227-2117 or massoud.sadeghi@faa.gov.

/s/

Jeffrey E. Duven
Manager, Transport Airplane Directorate
Aircraft Certification Service

Attachment

Attachment 1

Terms

Table A-1 defines the use of key terms in this policy statement. The table describes the intended functional impact.

Table A-1 Definition of Key Terms

	Regulatory Requirements	**Acceptable Methods of Compliance (MOC)**	**Recommendations**
Language	Must	Should	Recommend
Meaning	Refers to a regulatory requirement that is mandatory for design approval.	Refers to instructions for a particular MOC.	Refers to a recommended practice that is optional.
Functional Impact	No Design Approval if not met.	Alternative MOC has to be approved by issue paper.	None, because it is optional.