Exemption No. 17021

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
RENTON, WASHINGTON 98057-3356

In the matter of the petition of **The Boeing Company** for an exemption from § 25.981(a)(3) of Title 14, Code of Federal Regulations	**Regulatory Docket No. FAA-2014-1042**

GRANT OF EXEMPTION

By letter dated December 12, 2014, Mr. Douglas M. Lane, Director of Commercial Airplanes, The Boeing Company, P.O. Box 3707, MC 03-56, Seattle, Washington, 98124-2207, petitioned the Federal Aviation Administration (FAA) for an exemption from the requirements of § 25.981(a)(3) of Title 14, Code of Federal Regulations (14 CFR). This exemption, if granted, would allow Boeing to use the requirements of FAA Policy Statement PS-ANM-25.981-02, *Policy on Issuance of Special Conditions and Exemptions Related to Lightning Protection of Fuel Tank Structure and Systems*, for fuel tank structural lightning protection for the Model 737-7, 737-8, and 737-9 airplanes (737 MAX) as an alternative to full compliance to § 25.981(a)(3).

The petitioner requests relief from the following regulation:

> **Section 25.981(a)(3), at Amendment 25-125**, states that 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 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.

The petitioner supports its request with the following information:

This section quotes the relevant information from the petitioner's request, with minor edits for clarity. The complete petition is available at the Department of Transportation's Federal Docket Management System, on the Internet at http://regulations.gov, in Docket No. FAA-2014-1042.

Description of Issue

Boeing is petitioning for an exemption to 14 CFR 25.981(a)(3) for fuel tank structural lightning protection for the 737-8 (Project Number PS12-0038). The petition is also requested for the 737-7 (Project Number PS12-0037) and 737-9 (Project Number PS12-0039). The references to the 737 MAX in this document refer to the 737-7, 737-8, and 737-9 models. The subject regulation section is unchanged between Amendment level 102 and 125. The FAA Policy Statement PS-ANM-25.981-02 provides the following alternate requirements:

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.

Note: FAA Policy Statement PS-ANM-25.981-02 defines "Practicality" as a balance of available means, economic viability, and proportional benefit to safety.

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 critical design configuration control limitations (CDCCL), 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.

Discussion

Boeing has concluded that there are no practical means utilizing current technology to obtain triple redundant means of fuel tank structural fastener lightning protection in all locations. For example, one impractical option would be to apply an inspection interval which monitors the health of each fastener that penetrates the fuel tanks. With thousands of fasteners on the wing of the 737 MAX, and the inability to visually inspect most means of protection, this option is impractical. Increasing the number of in-tank inspection intervals could also have a potential unintended consequence of damaging the ignition protective features or other components inside the fuel tanks.

Examples of additional design considerations, found to be impractical, were:

- Conductive steel fasteners: Widespread use results in higher weight, fuel burn and associated emissions, and higher risk of corrosion. Design with all steel fasteners is still not dual fault tolerant.

- Additional sealant on bolt locations already sealed: Reduces structural inspectability for cracks and corrosion, potentially reducing overall fleet safety. Would result in additional weight, fuel burn and emissions.

- Composite skin protection methods: Not applicable to aluminum design. Note the majority of these methods are intended to increase conductivity of the outer tank surface in the area local to the fastener heads, which aluminum structure provides inherently.

- Fuel tank bladders or double walled fuel tanks: Would result in a new enclosed fuel vapor space, which would pose an additional vapor ignition threat during a lightning attachment and thus does not increase safety. This would also increase weight which increases fuel burn and emissions, plus reduces usable fuel tank volume which reduces range. The bladders also inhibit structural inspectability inside the tank.

- Spot bonds: Spot bond is a local bond in which the primer is removed at the internal fastener interface with structure. Removing primer increases corrosion risk, detracting from any benefit of increased conductivity offered by the spot

bond. The spot bonds would still be subject to faults and do not result in a dual fault tolerant design.

- Fastener Free Wing Structure: Structure that does not have any fasteners would not be susceptible to lightning protection faults associated with fasteners but is not necessarily dual fault tolerant. It is not possible to produce raw materials large enough to create monolithic wing panels or spars in dimensions that the 737 MAX requires. Also, monolithic designs would reduce structural crack tolerance. Using adhesives instead of fasteners to bond major components represents a radical departure from established metallic wing primary structure experience.

These types of designs were determined to be impractical because some are not possible within the current state of the art; others introduce more risk than mitigated, and because the design is safe without them.

In addition, adding sealant over ¼ inch and larger rivets was determined to be impractical due to lack of proportional safety benefit, increased weight, increased fuel burn, increased emissions, and reduced inspectability during maintenance. Boeing has assessed the likelihood of lightning attachment to a faulted rivet during flammable tank conditions, and concluded this combination is not expected to occur in the life of the fleet. Regardless of this probabilistic conclusion, Boeing has performed development testing (will repeat for compliance) of rivet installations representative of the 737 design and demonstrated that even with faults present, the installations will not cause an ignition source during severe direct lightning attachments. Since the design is already safe during this combination of conditions that are unlikely to occur in the life of the fleet, Boeing concluded that further mitigation (i.e., covering ¼ inch and larger rivets with sealant) would not provide a commensurate safety benefit to the public considering the significant weight and associated fuel costs, plus carbon emissions, aircraft production costs, and operator maintenance cost impacts. Additional detailed proprietary information has been provided to the FAA via Boeing letter RA-14-05275.

The only faults currently identified for which the design is not fault tolerant are:

1. The potential for a crack in structure, or

2. A bolt failure that also causes the fastener nut (or collar) to release with sufficient force to tear free the associated cap seal.

Both of these failure modes are identified in the FAA Policy Statement as typical situations where applicants have been unable to identify practical means for fault tolerance. In each of these cases, sparking due to these failures would only occur if there was a direct attachment to the local area of the failure. An assessment will be provided demonstrating that the risk of a fuel vapor ignition due to the sum of these failures is not anticipated in the life of the fleet.

Proposed Risk Mitigation

As discussed in FAA Policy Statement PS-ANM-25.981-02, Boeing will submit detailed proprietary information to the FAA about the measures taken in the 737 MAX design to provide practical structural lightning protection. In general, the 737 MAX lightning protection features are based on state of the art industry design practices for aluminum wing structure including inherent current paths that have been used in existing in-service designs. Further, Boeing proposes to enhance the lightning protection by incorporating fault tolerant protection means where practical, thereby increasing the level of fuel tank safety.

Boeing will comply with 14 CFR 25.981(b) at Amendment 25-125. A flammability exposure assessment will be provided showing that the 737 MAX main tanks are low flammability exposure tanks equivalent to a conventional unheated aluminum main wing. In addition, the center wing tank of the 737 MAX will utilize an inerting system designed to meet the flammability exposure criteria of appendix M to part 25. The aspects of NGS [nitrogen generation system] performance with respect to compliance to 14 CFR 25.981 are covered in the 737 MAX Fuel System Installation Certification Plan.

Boeing will provide the following with respect to each of the five policy requirements:

Policy Requirement 1 - Prevent catastrophic fuel vapor ignition due to lightning:

In summary, Boeing will implement in the design all practical measures for fault tolerant structural lightning protection. Boeing will utilize manufacturing processes to minimize the risk of errors in aircraft manufacturing which could affect the lightning protection features. Structural repair manual procedures will be provided to retain the lightning protection features throughout the life of the airplane. Instructions for Continued Airworthiness, including CDCCLs, will be developed and included in the certification documentation. A complete analysis of the manufacturing process and repair procedure will be part of the Fuel System Lightning Protection System Safety Assessment.

Policy Requirement 2 - Provide fault tolerant lightning protection:

Boeing will show that where practical the structural fastener and joint designs for the Model 737 MAX wing will provide fault tolerant lightning protection. A detailed failure mode and effects analysis (FMEA), including a qualitative assessment of all known and hypothetical failure modes, will be provided as part of the compliance documentation. Analysis, design review, and use of existing test data will be the primary means to demonstrate fault tolerance for both direct and conducted current lightning threats. Where analysis is insufficient or test data is not available, additional testing will be performed. The systems supporting structure will also be analyzed as part of the safety assessment to ensure that they meet the requirement of the policy statement.

Testing will show that the fastener installations will not produce any sparks inside the fuel tanks during exposure to threats for the applicable lightning zone requirements. For example, during previous programs Boeing has shown by test that most structural joints and some fasteners provide inherent fault tolerant protection. In addition, Boeing has shown by test that a cap seal, as a second layer of protection, will contain sparking where a fastener or joint cannot demonstrate inherent fault tolerant protection.

Policy Requirement 3 - Demonstrate safety of limited non fault tolerant conditions:

For the limited areas in which a single or cascading failure could result in a loss of all protection features, a safety assessment will be done to show that the summed risk on all non-fault-tolerant lightning related fuel tank ignition threats is not anticipated to occur during the entire operational life of all 737 MAX airplanes. Service experience on the existing Boeing aircraft commercial fleet (including the 737 fleet) shows each of these failures to be rare. This assessment is similar to the assessment for the 747-8 aircraft (reference Exemption 10174), where analysis demonstrated that the probability of a lightning related fuel tank ignition is extremely improbable (and thus unlikely to occur in the life of the fleet). The 737 MAX wing is a conventional aluminum wing, much smaller in size relative to 747-8/8F and uses the fastener types and installation procedures and design standards common to Boeing airplanes. A failure rate based on in-service data for fasteners on Boeing airplanes will be used. The expected rate of occurrence of structural cracking will be conservatively based on Boeing's structural fatigue methodology. This methodology is based on test and service experience, and ensures that the presence of fatigue cracks is minimized during the life of the airplane.

Currently, Boeing has identified two non-fault-tolerant failure modes (broken bolts and structural cracks); however, analysis and/or testing is not complete thus additional non-fault-tolerant installations may be identified which may also be impractical to preclude. All areas where fault tolerance is impractical will be identified in the Fuel System Lightning Protection System Safety Assessment.

Policy Requirement 4 - Provide lightning protection maintenance information:

Non-fault-tolerant features: No ALI [airworthiness limitation item] or mandatory inspections for structural lightning protection related to non-fault-tolerant features (e.g., broken bolts and cracks) are anticipated. However, assessment is not complete; they will be included if necessary. Existing mandatory structural inspections are adequate to ensure related failures will not exceed failure rates used in risk analyses.

Fault tolerant features: As recently added to the 737 AWLs [airworthiness limitations], a CDCCL will require an inspection of sealant per an airplane maintenance manual fuel tank closure procedure any time the tank area is exited after maintenance or alteration. No additional maintenance or inspections for structural lightning protection are anticipated. However, assessment is not complete; additional maintenance requirements will be included if necessary.

Repairs: The structural repair manual (SRM) will include instructions to minimize the risk that alterations (repairs) will affect lightning protection. The SRM will include CDCCL references (equivalent to cautions). Also note that as discussed above, CDCCL will identify an airplane maintenance manual procedure to perform a visual sealant inspection before exiting any tank area where maintenance, inspection, or repair has been performed.

Policy Requirement 5 - Analysis of design, manufacturing, and maintenance procedures:

Boeing has implemented in the design all practical measures for structural lightning protection. The manufacturing processes will include practical means to minimize the risk that lightning protection features are not implemented as intended on the drawings. As noted for requirement 4, the continued airworthiness program will include appropriate CDCCL and the SRM repair procedures will be established to retain the lightning protection features throughout the life of the airplane. A complete analysis of the manufacturing process and repair procedure will be part of the fuel system lightning protection system safety assessment. Additional detailed proprietary information has been provided to the FAA via Boeing letter RA-14-05275.

Statement of Public Interest

Boeing states that it is working to improve the efficiency of the 737 model by a redesign. The 737 MAX has an all new engine for improved fuel burn and reduced community noise over the 737-800 model. For lightning protection, the 737 MAX has additional features to enhance safety and protect the fuel tanks from potential ignition sources due to a lightning event. All practical measures have been utilized. All features to directly meet the rule are impractical and would potentially add significant cost, weight, increased emissions, and maintenance to the airplane without a proportional safety benefit. Further, additional lightning protection features could inhibit the ability to inspect the structure (reducing safety).

Requiring the 737 MAX to attempt to directly comply with this rule would significantly inhibit Boeing's ability to design and certify the airplane on a competitive schedule. It would also render the 737 MAX to be of lesser value to the public interest with no commensurate increase in safety. Many Boeing customers are depending on the 737 MAX to meet their business needs. The new 737 MAX airplane will typically replace older, less fuel efficient models, reducing the public expense for fuel consumed in air

travel and freight delivery. Therefore, Boeing believes that it is in the public interest for the FAA to grant this exemption.

Statement of No Adverse Effect on Safety

With current design practices for lightning protection, Boeing aircraft designs have accumulated in excess of 800 million revenue service flight hours with no lightning related events. Prior to these designs and service hours, there were two commercial jet transport hull loss events which are believed to have been caused by lightning strikes (reference Aviation Rulemaking Advisory Committee (ARAC) Report: 1998 ARAC Fuel Tank Harmonization Working Group report, Task Group 1 Service History / Fuel Tank Safety Level Assessment). The first was in 1963, which led to the development of lightning protection standards for fuel tanks. The second and last event was in 1976 and also resulted in improvements in fuel tank lightning protection. The hours accumulated since the last event represent over eight times the hours accumulated with earlier designs through 1976. The accident-free fleet history since 1976 shows current Boeing wing designs have sufficient protection against lightning induced fuel tank ignition events.

This safety record for the fuel system designs upon which the enhanced Boeing 737 MAX design is based, indicates that the proposed fuel tank lightning protection design of the model 737 MAX will be safe.

Request to Waive Publication and Comment

Boeing requests to waive the requirement for publication and comment. Boeing believes there is good cause to be granted a waiver due to the fact that the FAA previously found a grant of exemption was in the public interest for the same fuel tank lightning protection compliance to 14 CFR 25.981(a)(3) issue on the 747-8/8F (BDCO Project No. PS05-0212 and PS05-0211) (Exemption No. 10174 was granted).

Privileges of the Exemption Outside the United States

Per 14 CFR 11.81(h), Boeing requests that the privileges of this exemption be extended outside the United States. This extension of privileges is necessary for operations based within foreign countries having bilateral agreements with the United States accepting FAA 14 CFR part 25 as their airworthiness standards for transport category aircraft. The 737 MAX is intended for the global market place.

Federal Register publication

Although the petitioner requested that action on its petition not be delayed for publication in the Federal Register, the FAA found that the petition, if granted, would set a precedent. Therefore, to allow an opportunity for the public to comment on the petition, a summary of it was published in the Federal Register on July 6, 2015 (80 FR 38505). No comments were received.

The FAA's Analysis

Fuel Tank Structure

In May 2001, the FAA issued the "Transport Airplane Fuel Tank System Design Review, Flammability Reduction, and Maintenance & Inspection Requirements" final rule (Docket No. FAA-1999-6411, effective June 6, 2001) that was adopted as Amendment 25-102. This amendment added specific ignition-prevention requirements and a new flammability-minimization requirement to § 25.981.

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, and latent failures that may be the cause of ignition sources in fuel tanks. Although Boeing is requesting relief from § 25.981(a)(3) at Amendment 25-125, that section is unchanged from Amendment 25-102.

Section 25.981, as amended by Amendment 25-102, requires that the structural aspects of airplane designs be protected from the effects of lightning with features that are failure tolerant. Prior to this amendment, only § 25.954 had been applied to lightning protection of fuel tanks. That provision requires only that the airplane design prevents ignition of vapors in the tank with no consideration for anticipated design failures, aging, wear, or maintenance errors.

Systems aspects of the fuel tank system with potentially catastrophic failure modes would typically meet the requirements of § 25.981(a)(3) by providing at least triple redundancy in their protective features with periodic inspections, or dual-redundant features with continuous system monitoring to reduce the latency period. Dual-redundant design schemes could only comply with § 25.981(a)(3) when combined with either regular inspections at very short intervals or a monitoring device to verify the functionality of the protective features. Inspection of the various design features may be difficult or impossible if the feature is internal to the fuel tank and part of the wing structure.

When § 25.981 became applicable to the structural lightning protection aspects of new airplane designs (Amendment 25-102), applicants found that it was impractical to meet the standard and to incorporate the additional protective features. The FAA agreed that it can be impractical to meet the specific requirements of § 25.981(a)(3) for certain areas of structural design. As a result, the FAA issued two exemptions and developed a new policy related to lightning protection of fuel tank structure. One exemption was for the Dassault Falcon 7X (Exemption No. 9148, issued April 20, 2007) and the other was for the Hawker Beechcraft Model 4000 (Exemption No. 8761A, issued August 28, 2008). On May 26, 2009, following a public-comment period, the FAA issued a policy (ANM-112-08-002) that defined criteria for the granting of exemptions and issuance of special conditions for structural lightning protection. The FAA issued additional special conditions and exemptions based upon that policy from 2009.

In 2014, the FAA superseded Policy No. ANM-112-08-002 with Policy No. PS-ANM-25.981-02, *Policy on Issuance of Special Conditions and Exemptions Related to Lightning Protection of Fuel Tank Structure and Systems* (issued June 24, 2014). This new policy provides a standard

approach to applying alternatives to direct compliance with § 25.981(a)(3). It contains the criteria the FAA will consider when applicants need to request an exemption to § 25.981(a)(3) because they find it impractical to directly comply with the ignition-prevention requirements relating to lightning protection of structure and systems. The primary differences between the latest policy statement and the previous one are:

(1) The additional applicability of the policy to fuel tank systems in addition to structure for areas of systems design where the applicant shows that compliance with § 25.981(a)(3) is impractical;

(2) Additional criteria for evaluating the practicality of direct compliance to § 25.981(a)(3);

(3) Additional criteria for establishing inspection requirements for structural failures that could result in an ignition source.

As it applies to fuel tank lightning protection for basic airframe structure (airplane skins, joints, ribs, spars, stringers, and associated fasteners, brackets, and coatings), Boeing contends that both the addition of a third, independent, ignition-source protective feature, and providing sufficient monitoring to detect latent failures in a dual-protective feature, are impractical for certain areas of metallic airplane-wing structure. Boeing evaluated possible means of providing additional protective features as a condition of this exemption, as discussed in the policy statement, and found it was impractical to incorporate those features into the Boeing 737 MAX. Boeing also identified two features through lightning tests and analyses that are not fault tolerant. They are 1) the potential for a latent crack in structure and 2) a bolt failure that also causes the fastener nut (or collar) to release with significant force to tear the associated cap seal away from the surrounding structure. Boeing will show that the probability of fuel-vapor ignition, due to these non-fault-tolerant features, is extremely improbable, which satisfies the criteria in the policy statement.

The FAA agrees with Boeing that compliance with § 25.981(a)(3) for fuel tank structure would require a combination of redundant protective features, and a high level of reliability of those features, that are excessively expensive to produce and maintain using available technology. Lightning energy can be transferred to fuel tanks installed in wings through the many fasteners and other structural elements. It is impractical to provide either continuous monitoring of the "health" of the protective features for these structures or to inspect them frequently enough to detect latent failures. These features are typically integral to the fuel tank structure or internal to the fuel tank, requiring access into the tank to verify the integrity of the feature. Inspections of airplane structure requiring fuel tank entry may be scheduled only once or twice during the life of the airplane.

As discussed in the preamble to Amendment 25-102, conventional, unheated, aluminum wing tanks minimize fuel tank flammability exposure, as required by § 25.981(c). Even if a latent failure of a protective feature occurred for such a tank, the risk of lightning-induced fuel tank explosions is relatively low when the tank is fueled with low-volatility fuels such as Jet A, as demonstrated by the service experience of these tanks. Due to the impracticality of full compliance with § 25.981(a)(3) for lightning protection and the reduced flammability exposure

of these tanks, the FAA believes granting an exemption is in the public interest if applicants can show that their design provides practical dual-protective features for fuel tank structural lightning protection that are both independent and robust, and show the probability of fuel tank ignition to be extremely improbable for any non-fault-tolerant features.

The Boeing petition states that the company will comply with § 25.981(b) at Amendment 25-125 and that it will provide a flammability exposure assessment showing that the 737 MAX main tanks are low flammability exposure tanks equivalent to a conventional unheated aluminum main wing. In addition, the center wing tank of the 737 MAX will utilize an inerting system designed to meet the flammability exposure criteria of appendix M to part 25. The aspects of the inerting system performance with respect to compliance with § 25.981 are covered in the Boeing 737 MAX Fuel System Installation Certification Plan. Therefore, the 737 MAX will satisfy the flammability criteria defined in § 25.981(b) and the policy statement.

The Model 737 MAX design does not have any fuel tanks or vent system features in lightning strike Zone 1. For the wing-skin fasteners of the tanks in Zone 2 (as illustrated in Advisory Circular 20-53B, *Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition Caused by Lightning*), Boeing must demonstrate that at least two independent and effective means of lightning protection are provided and reliably maintained. Boeing proposes lightning-protection features for the 737 MAX based on state-of-the-art, industry-design practices for aluminum wing structures including inherently conductive, low-resistance current paths that have been used in existing in-service designs. Boeing is enhancing lightning-protection features of the previous 737 design by incorporating additional fault-tolerant protection for fasteners in certain locations. To substantiate the effectiveness of lightning-protection features, Boeing must provide analysis and test data. Boeing has agreed to this as part of its petition request.

In addition to validating independent and effective design means of lightning protection for certification on new production airplanes, § 25.981(b) requires establishing critical design configuration control limitations (CDCCLs), inspections, and other procedures to prevent the development of ignition sources within the fuel tank system as the airplanes progress through their service life. These limitations, inspections, and procedures must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by § 25.1529. Boeing states that it will provide maintenance information, which will be included in the Instructions for Continued Airworthiness.

Boeing will identify maintenance-inspection tasks with appropriate inspection intervals to ensure the needed reliability of proper wing-fastener installation and sealant coverage. These actions should maintain the lightning-protection characteristics of these two independent protective features. Boeing has identified maintenance manual procedures that restore the protective features to the same level and with the same products and techniques as the original design specifications.

Fuel Tank Systems

With regard to fuel tank systems on the 737 MAX, Boeing did not request relief from the requirements of § 25.981(a)(3) for lightning protection of systems elements in its petition for

exemption. However, the FAA became aware that Boeing intends to include consideration of the probability of a lightning strike when assessing compliance for fuel tank systems and this approach is not consistent with the requirements of § 25.981 and previously published means of compliance. Advisory Circular (AC) 25.981-1C, *Fuel Tank Ignition Source Prevention Guidelines,* dated September 19, 2008, states:

> The severity of the external environmental conditions that should be considered when demonstrating compliance with § 25.981 are those established by certification regulations and advisory material (e.g., HIRF, lightning) regardless of the associated probability of exposure to any external environment. For example, the probability of lightning encounter should be assumed to be [equal to] one.

Including the probability of lightning in a numerical probability analysis when assessing compliance of the 737 MAX fuel tank systems is not acceptable under the means of compliance described in the AC. Furthermore, the FAA's intent to require the probability of environmental conditions (including lightning) to be equal to one was also stated in the preamble to the notice of proposed rulemaking for Amendment 25-102 to § 25.981 as follows:

> The severity of the external environmental conditions that should be considered when demonstrating compliance with this proposed rule are those established by certification regulations and special conditions (e.g., HIRF), regardless of the associated probability.

The above statement means that environmental conditions in which the airplane is approved to operate should be assumed to exist at all times when performing numerical system safety analyses for the purpose of showing compliance with § 25.981(a)(3).

Policy Statement PS-ANM-25.981-02 states that direct compliance for systems has been found to be practical in previously approved designs. However, it acknowledges that some of the resulting multiple-redundant system design details, particularly in the area of systems mounting features and electrical bonding features, were excessively complex and costly with little additional safety benefit when the expected failure modes of those features are considered. Considering the cost-versus-benefit for those features, it is arguable that many such features should be considered impractical. The policy statement therefore allows for exemption conditions providing relief from the requirements of § 25.981(a)(3) for systems elements where the applicant can show that direct compliance for those elements is impractical. The FAA determined that it is more appropriate to also grant relief from the requirements of § 25.981(a)(3) for fuel tank systems on the 737 MAX, in addition to fuel tank structure, rather than allow Boeing to consider the probability of lightning in a compliance analysis that conflicts with the means of compliance policy contained in AC 25.981-1C. The FAA has therefore included in its decision, a provision and conditions for exemption from § 25.981(a)(3) for systems elements where Boeing shows direct compliance to be impractical.

Conclusion

The FAA considers Boeing's request to be in the public interest because the Boeing Model 737 MAX design provides an acceptable level of safety, and full compliance to § 25.981(a)(3) is

impractical. Full compliance would require significant modifications to the fuel tank design; introduce additional complexity into the manufacturing and quality process, as well as into maintenance procedures that have not been shown to be completely effective; and add significant cost and schedule impact to the Boeing Model 737 MAX airplane program. The 737 MAX meets later safety standards, providing improved safety over that of airplanes it is replacing in the fleet. In addition, new 737 MAX airplanes typically will replace older, less fuel efficient models, reducing the public expense for fuel consumed in air travel and freight delivery.

Boeing states in its petition that the company will follow the current policy related to lightning protection of fuel tank structure and systems (PS-ANM-25.981-02) for the certification of the 737 MAX. The company will provide fault tolerant structural lightning protection features for the fuel tank structure, except for two identified failure modes and any subsequently-identified failure modes where Boeing can show that compliance is impractical. Boeing will also show that systems-related lightning protection features are compliant with § 25.981(a)(3) except in areas where Boeing can show compliance is impractical. In those areas, it will meet the conditions stated in the grant of exemption. The outcome of the conditions associated with the granting of this exemption may affect the regulatory compliance of the 737 MAX if analysis, test data, and maintenance information is not provided to the FAA as assured by Boeing.

Condition 4 of this Exemption requires that Boeing prevent development of lightning-related ignition sources within the fuel tank structure and systems, by establishing inspections or other procedures. Such prevention may necessitate one or more of the following actions, or others:

a) The identification of 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) The inclusion of sampling programs, maintenance, or inspections for fault-tolerant lightning protection features in Boeing'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 be included in the Airworthiness Limitations section of the airplane's Instructions for Continued Airworthiness.

c) The incorporation into applicable airplane maintenance documents, including the structural repair manual, of 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.

The FAA's decision

In consideration of the foregoing, I find that a grant of exemption is in the public interest. Therefore, pursuant to the authority contained in 49 U.S.C. 40113 and 44701 delegated to me by the Administrator, I grant The Boeing Company an exemption from 14 CFR 25.981(a)(3) as it

relates to the 737-7, 737-8, 737-9 (737 MAX) fuel tank structural lightning protection, and as it relates to systems lightning protection features where Boeing shows that compliance with § 25.981(a)(3) is impractical for that feature. This grant of exemption and the following conditions are consistent with the alternatives to direct compliance as set forth in Policy Statement PS-ANM-25.981-02.

This exemption is subject to the following conditions:

(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) Boeing provides substantiating documentation showing fault-tolerance is impractical for that feature; and

b) Boeing shows that fuel tank vapor ignition is extremely improbable (i.e., so unlikely that it is not anticipated to occur during the entire operational life of all 737 MAX airplanes) when the airplane's fuel tank vapor ignition event probabilities are combined with that feature and other non-fault-tolerant features.

(4) Boeing must establish inspections or other procedures to prevent development of lightning-related ignition sources within the fuel tank structure and systems.

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

Issued in Renton, Washington, on JUL 07 2016

Michael Kaszycki
Assistant Manager, Transport Airplane Directorate
Aircraft Certification Service