

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 §§ 25.901(c) and  
25.981(a)(3) of Title 14, Code of Federal  
Regulations

**Regulatory Docket No. FAA-2015-3166**

**GRANT OF EXEMPTION**

By letter dated June 29, 2015, Mr. Tim Hendrix, Certification & Airworthiness Manager, The Boeing Company, 2401 E. Wardlow Road, Long Beach, California, 90807-5309, petitioned the Federal Aviation Administration (FAA) for an exemption from the requirements of §§ 25.901(c) and 25.981(a)(3) of Title 14, Code of Federal Regulations (14 CFR). This exemption, if granted would allow planned type-design changes to the Boeing Model 747-400 (freighters only) and 747-400BCF airplane center wing-tank (CWT) fuel-quantity indication system (FQIS) fuselage wiring installation.

**The petitioner requests relief from the following regulation(s):**

**Section 25.901(c)**, at Amendment 25-126, requires that for each powerplant and auxiliary power unit installation, it must be established that no single failure or malfunction or probable combination of failures will jeopardize the safe operation of the airplane except that the failure of structural elements need not be considered if the probability of such failure is extremely remote.

**Section 25.981(a)(3)**, at Amendment 25-125, requires 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-2015-3166.

**The Extent of Relief Sought and Reasons**

14 CFR 25.901(c) Amendment 25-126 Boeing relief is necessary because direct compliance would require excessive design changes and retrofit of in-service airplanes. Changes include the following: Further redesign of the Airplane Wiring System to ensure FQIS wire separation for numerous airplane configurations. Make new tank penetrations and procure new in-tank wiring harnesses. Modify the Fuel Quantity Processor Unit (FQPU) and associated connectors. The solution would require a FQIS architecture change to relocate the FQPU and consider Remote Data Connectors (RDCs). In-tank component changes (new brackets, potential need for shorter probes, revised in-tank wire harness and retention means). Software changes related to Fuel Tank Gauging Function (to account for capacitance changes if shorter in-tank probes are required).

14 CFR 25.981 (a)(3) Amendment 25-125 Boeing relief is necessary because: Same as above.

**Background**

The FAA is planning to issue a notice of proposed rulemaking (NPRM) for the 747, similar to the 757 NPRM No. 2011-NM-094-AD, which proposes to require modifying the FQIS wiring or fuel tank systems to prevent development of an ignition source inside the center fuel tank. Paragraph (h)(2) states, "Within 72 months after the effective date of this airworthiness directive (AD), modify the airplane by separating FQIS wiring that runs between the FQIS processor and the center fuel tank, including any circuits that might pass through a main fuel tank, from other airplane wiring that is not intrinsically safe."

Boeing is proposing to accomplish the FAA's planned AD requirements by separating the FQIS CWT wiring between the FQIS processor and the center fuel tank, as well as using the FQIS built in test equipment (BITE) check. The BITE service bulletin (SB) 747-28-2340, which includes the instructions to ensure tank circuit wiring integrity, is already approved by the FAA. The CWT FQIS wiring separation is being prepared with guidance from the FAA's approved standard for retrofit wire separation from FQIS wiring. But the combination of BITE and wire separation will not result in the FQIS system being compliant to § 25.901(c) at Amendment 25-126 and § 25.981(a)(3) at Amendment 25-125. Since the wiring changes are a change to type design, but will not be compliant, an exemption is being petitioned. Boeing states that the FAA's response to a 757 NPRM comment suggests that the FAA will accept petitions for exemption for the "latent-plus-one" requirements of §§ 25.901(c) and 25.981(a)(3), and there has also been FAA communication that this acceptance applies to the 747.

This petition for an exemption is being made because full compliance to these rules for the 747-400 freighters would require extensive system design/installation changes, but do not substantially improve the safety of the current airplane design, and are economically prohibitive given that the retrofit 747-400 freighter fleet is small, and so extensive system changes are not in the public's interest. The FQIS system was previously shown compliant to §§ 25.1309 and 25.901(c) for type certification (TC); however, both § 25.901(c) at Amendment 25-126 and § 25.981(a)(3) at Amendment 25-125 have additional failure combination requirements. For systems that may cause a catastrophic hazard, § 25.1309 requires no single failure and no combination of failures greater than extremely improbable; § 25.901(c) at Amendment 25-126 requires no single failure or probable combination of failures; and § 25.981(a)(3) at Amendment 25-125 requires no single failure, no single-plus-latent (greater than extremely remote), and no multiple combination greater than extremely improbable. This exemption is being sought for the no single-plus-latent (greater than extremely remote) as is stated in § 25.981(a)(3) and interpreted by the FAA for § 25.901(c). An exemption is also being sought for the non-environmental aspects of § 25.901(c) provided by FAA interpretation, and the explicit § 25.981(a)(3) requirements of manufacturing variability, aging, wear, corrosion, and likely damage, as these considerations are already covered by airline maintenance of the type design of the airplane.

### **Statement of Public Interest**

Without exemption relief for the FQIS CWT wiring changes, the intent of the NPRM and the FAA's previous communication of intent for airplane design improvement for the CWT FQIS to address those 747-400 freighters that do not have a nitrogen generating system (NGS) cannot be met. For compliance, airplane changes to the entire FQIS (all tanks) would be required for fleet retrofit such as:

- Extensive airplane wiring changes to ensure adequate wire separation throughout the fuel quantity indication system.
- In-tank component changes (new brackets] potential need for shorter probes] revised in-tank wire harness and retention means).
- Software changes related to Fuel Tank Gauging Function and Safety function if shorter probes are required.

The current FQIS system has been thoroughly evaluated for safety aspects as was required per Special Federal Aviation Regulation No. 88 (SFAR 88) for the FQIS; however, the FAA determined there were safety issues identified with FQIS wiring connected into a high flammability tank. For the 747-400, it is the CWT. The time needed to successfully design and implement system changes beyond the proposed CWT FQIS wiring separation design changes to comply with the rules would further impact the availability of the wiring change on this out-of-production fleet of 747 airplanes. These new complete FQIS design changes would not provide any economic benefit to the operators and do not provide any significant benefit or increased level of safety. The Boeing Company considers that the granting of this exemption would negate the need for

the FAA to evaluate the additional data required to support compliance with these regulations. Therefore, granting this exemption would reduce the burden on FAA resources and consequently public expenditure.

Granting this exemption is in the public interest for the aforementioned reasons and will:

1. Enhance the safety of the 747-400 freighter fleet (as has been determined by the FAA) for those airplanes not installing NGS by adding wiring changes for the CWT FQIS.
2. Enhance the safety of the 747-400 freighter fleet by also including FQIS BITE for the CWT circuit interval tests, so that when done in addition to the CWT FQIS wiring separation, the airplane addresses the single-plus-latent failure modes for the FQIS, which was the probable failure combination indicated by the National Transportation Safety Board (NTSB) Report AAR-00-03 for the Trans World Airlines (TWA) flight 800 accident.

### **Statement of No Adverse Effect on Safety**

The addition of the FQIS CWT wiring changes with a BITE interval check, in lieu of a fully compliant (all tanks) FQIS (which would have a hot short protector (HSP<sup>1</sup>) FQPU line replacement unit (LRU), wire separation for the tank (total of 7) circuit wiring (both outside and inside the tank), and a fault detecting BITE that is annunciated); does not have an adverse effect on safety.

In the proposed CWT FQIS wire separation design change, the ignition source threat from other airplane systems is reduced, since the wiring will have increased separation. There are also airworthiness limitations in the instructions for continued airworthiness (ICA) that ensure that any other system change will continue to maintain the separation provided by this proposed design change which will now clearly be visually identified as FQIS wiring. Together, this improves the wiring failure modes and improves the system probability relative to fuel tank ignition. With the addition of the FQIS BITE interval checks for the CWT, the probability is better since the exposure of wiring failures will be further reduced.

For the CWT FQIS, where the changes to the FQIS are being done instead of the installation of NGS as determined by the FAA to be an acceptable substitute safety improvement, the combination of the separation, the ICA, and the BITE/circuit test addresses no single failures in combination with latent failures with an acceptable level of safety by ensuring the continued integrity of protection features from threats to the tank circuit wiring.

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<sup>1</sup> A HSP is an LRU that is also designed to have the function to protect the tank circuit wiring from Electrical Power Source threats that could affect the airplane circuit wiring of the LRU (FQPU).

- A - The fault modes of the in-tank wiring have reduced exposure to 750 hours due to the BITE check and FLSS circuit test. Wiring inside the tank is well protected and has a very low failure probability which is improved by the lower exposure.
- B1 - The FQPU is an HSP up to 115VAC. If a low-probability higher voltage power source short were to occur on the airplane side of the FQPU, it most likely would, but for very high voltage power sources may not stop it from propagating through to the tank circuits, but the failure would at the least be detectable when the BITE interval check was done, and in most cases sooner, as it would most likely affect indication.
- B2 - The wiring from the FQPU to the tank will have separation provided by the AD-mandated SB. This wiring has low probability failure modes which also have reduced exposure provided by the 750-hour interval BITE check.

Whether the failure is A, or B1, or B2, there is no single failure. For the combination of failures, A and B1, or A and B2, the BITE has reduced the exposure and the latency interval for each protection design feature (wiring has less than extremely remote failure rates) and so the probability for each failure mode is better than remote. This also addresses the single-plus-latent failure requirement with an acceptable level of safety as the probability of either failure on the flight before the next interval check would both be better than remote.

The 747-400 FQIS was found to be compliant to § 25.901(c) during airplane type certification in 1989. Since then, Boeing has completed the SFAR 88 safety assessment and has increased the airplane fuel system safety with installation of an HSP LRU for the densitometer. For the 747-8 project, the FQPU, which has the same architecture as the 747-400 FQPU, was also shown to be an HSP LRU and so the fuel level sensing probes/compensator have that same protection. Following the SFAR 88 system safety assessments, Boeing's assessment was that the risks for the 747-400 FQIS installation were extremely improbable, which is the typical industry and § 25.1309 standard for an acceptable safety system. The Boeing approach to incorporate design changes to add CWT FQIS wire separation with visual identification, a CWT FQIS 750 hour BITE check, along with ICA that ensures that added systems wiring will maintain the separation for the life of the airplane, the HSP FQPU LRU, and the densitometer tank circuit HSP provided by Boeing SB 747-28A2266, will provide for an enhanced safety margin over the existing approved FQIS on the in-service fleet.

**Request to Waive Publication and Comment:**

Since the reference a) NPRM for the 757 is closely related to this change as the 747- 400 issue is the same, and the NPRM makes mention of a 757 petition for exemption, and has already gone through public commenting process, Boeing respectfully requests that the FAA waive the “publication and comment” step in the process for making a final decision on this exemption.

In addition to the timeliness concern, it is the Boeing position that the safety-associated aspects related to this system have been fully vetted in the public forum as part of the SFAR 88 project.

### **Privileges of the Exemption Outside of the United States**

Per 14 CFR 11.81(h), Boeing requests that the privileges of this exemption be extended outside of 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.

### **Justification for Exemption**

In accordance with the requirements of § 11.81(e), The Boeing Company has provided a means of compliance to the FAA to establish an acceptable level of safety to that provided by §§ 25.901(c) and 25.981(a)(3) by separating the FQIS wiring from other airplane power wires that will meet the minimum separation requirements for most of the wire runs. For the areas that minimum separation is not achievable due to space limitation, other positive separation means such as clamps, spacers, and sleeving will be used for the CWT FQIS which also includes FQIS BITE interval checks for the CWT. These design changes address the single-plus-latent failure modes for the FQIS which was the probable failure combination indicated by the NTSB TWA flight 800 accident report. Therefore, granting this exemption would, in turn, reduce the burden on FAA resources and consequently public expenditure.

### **Conclusion:**

Boeing is petitioning for an exemption from the provisions of 14 CFR 25.901(c)[25-126] and 14 CFR 25.981 (a)(3)[25-125] at the system level as they apply to the FQIS installed on the 747-400 (Freighters Only) and 747-400 BCF airplanes for the FQIS wiring changes described above.

### **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 September 2, 2015 (80 FR 53223). No comments were received.

### **The FAA's analysis**

We agree with the petitioner's justification that granting the petition is in the public interest, with two exceptions.

For clarity, we do not agree with the petitioner's public-interest statements that "The time needed to successfully design and implement system changes beyond the proposed CWT FQIS wiring separation design changes, to comply with the rules, would further impact the availability

of the wiring change on this out-of-production fleet of 747 aircraft.” The AD worksheet for correcting this unsafe condition was issued in 2004. Boeing has not provided service instructions since that time. The time needed to develop a compliant design is minimal when compared to the petitioner’s delay in providing the service instructions. We did not consider this argument in our determination that granting the exemption is in the public interest.

We also do not agree with the petitioner’s public interest statement that “... the granting of this exemption would negate the need for [the] FAA to evaluate the additional data required to support compliance with these regulations. Therefore, granting this exemption would reduce the burden on FAA resources and consequently public expenditure.” FAA resources needed to review design changes that are needed for full compliance would be minimal, and these resources are available to address unsafe conditions. There would be no savings in public expenditure and no public interest by not providing a compliant design, and we did not consider this argument in our determination that granting the exemption is in the public interest.

We agree with the petitioner’s justification that granting the petition is in the public interest. Modification of existing in-service 747 airplanes to provide a compliant design would be costly because changing the fuel-quantity processor, separating airplane wiring from other high-power wiring, or providing electrical isolating devices to prevent electrical energy from entering the fuel tanks for the small number of cargo airplanes is cost prohibitive. This exemption will allow approval of service instructions needed to address an unsafe condition on the center wing-tank FQIS wiring.

The FAA has determined that the proposed modifications represent a reasonable, cost-effective method to achieve a meaningful reduction in the risk due to potential FQIS fuel-tank-ignition sources. The FAA’s current fuel-tank-safety airworthiness standards rely upon a balanced approach of limiting fuel-tank-flammability exposure time and precluding ignition sources that could form in the fuel tanks. For this reason, § 25.981 includes separate and distinct requirements for limiting fuel-tank flammability and preventing ignition sources in the fuel tanks. The wing and center wing-tank safety are addressed by considering flammability and ignition source mitigations. The wing tanks are exposed to outside air, are unheated, naturally cooled, and are considered low flammability. We do not consider it to be an unsafe condition for the FQIS wiring entering these wing tanks to be co-routed in wire bundles with wires carrying high electrical energies. Because the center wing tank is heated and is considered a high-flammability tank, additional ignition-source mitigations are provided. The modifications to separate a portion of the wiring for the center wing-tank FQIS significantly reduces the likelihood of a failure that could introduce high power onto the FQIS wiring. In addition, mandatory maintenance checks for the center tank FQIS wiring will be required as part of the petitioner’s design approval. This will significantly reduce the likelihood of a latent failure in the FQIS wiring resulting in an ignition source in the fuel tanks. Granting this exemption will allow FAA approval of service instructions needed to address the unsafe condition and therefore result in a safety improvement that is in the public interest.

SFAR 88 requires the type-design-approval holder to develop all design changes to the fuel-tank system that are necessary to meet the requirements of §§ 25.901 and 25.981. The petitioner did not specifically request exemption from this requirement. However, it did request an exemption

from §§ 25.901 and 25.981. Granting the exemption to these sections results in granting an exemption to the same ignition-source prevention requirements of SFAR 88. Therefore, we have added clarification in the exemption that states that exemption from SFAR 88 for the service instruction is also included in this exemption.

**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, The Boeing Company, is hereby granted an exemption from SFAR 88, and §§ 25.901(c) and 25.981(a)(3), as they pertain to fuel-tank-ignition prevention associated with the center wing-tank FQIS wiring installation, to allow for FAA-approval of Boeing Service Bulletins to address the unsafe condition in the FQIS that was identified through the SFAR 88 safety analysis. The applicability of any service bulletin approved using this exemption must be limited to airplanes with an all-cargo configuration.

Issued in Renton Washington, on March 29, 2016.

/s/

Victor Wicklund  
Acting Manager, Transport Airplane Directorate  
Aircraft Certification Service