CORRECTED COPY

This is a correction to Partial Grant of Exemption No. 10268 issued on May 19, 2011. Changes to the *FAA's analysis* section in the final exemption draft were inadvertently left out of the issued exemption. These changes clarify the FAA's position regarding the equivalent level of safety finding to the requirements of § 25.997(d) and why an equivalent level of safety could not be found at this time for § 25.1305(c)(6). The FAA's decision and provisions remain the same. Please file this corrected copy with the signed original Partial Grant of Exemption. The changes in this corrected copy were incorporated on May 24, 2011.

Exemption No. 10268

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 § 25.1309(c) of Title 14, Code of Federal Regulations	**Regulatory Docket No. FAA-2010-1284**

PARTIAL GRANT OF EXEMPTION

By letter dated December 20, 2010 (BDCO-10-05416)), C. M. Thompson, Lead Project Administrator, Development Projects, The Boeing Company, P.O. Box 3707, Seattle, WA 98124-2207, petitioned for a time-limited exemption from the requirements of Title 14, Code of Federal Regulations (14 CFR) 25.1309(c). If granted, this exemption would provide relief from the requirement to provide indication of anticipated fuel system contamination to the flightcrew of Boeing Model 787-8 airplanes powered by General Electric GEnx-1B engines. The petitioner proposed that this exemption would expire June 30, 2014, for new airplane deliveries and December 31, 2018, for retrofitted airplanes.

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

> **Section 25.1309(c),** at Amendment 25-116, requires "Warning information must be provided to alert the crew to unsafe system operating conditions, and to enable them to take appropriate corrective action. Systems, controls, and associated monitoring and warning means must be designed to minimize crew errors which could create additional hazards."

The petitioner supports its request with the following information:

The following information summarizes the petition submitted by The Boeing Company. The complete petition is available on-line in the Federal Docket Management System at http://www.regulations.gov. The docket number is FAA-2010-1284.

> The General Electric GEnx-1B will be one of the first General Electric engines to incorporate a method to detect gross fuel system contamination. The FAA recently provided Boeing guidance regarding what is needed to show compliance with § 25.1309(c) for flightcrew alerting of impending bypass of a component upstream of the main fuel filter. Therefore, it would create a significant burden if Boeing were now required to incorporate this new gross fuel system contamination indication on the first production 787-8 airplanes prior to type certification.
>
> <u>Effect on Safety</u>
>
> The GEnx-1B fuel system design allows for the greatest possible tolerance to gross fuel contamination. Excessive fuel system component blockage of the GEnx-1B engine does not limit fuel flow to the engine due to multiple bypasses in the design.
>
> The main fuel filter is sized for compliance with § 33.67 and subsequently § 25.997(d). The fuel strainer at the low pressure pump exit provides additional filtering capability for the system. The fuel strainer is sized to protect the heat exchangers and high pressure fuel pump gear stage from extreme/maintenance induced contamination. The fuel strainer does not stop particles that are within the size range of expected contamination. This contamination is passed through the eductor pump and the heat exchangers to the filter. When the filter is exposed to contaminated fuel and debris accumulates to the point that it reaches impending blockage, an alert is provided to the flight deck via an advisory level message according to the requirements of § 25.1305(c)(6). The GEnx-1B fuel system indications provide flightcrew warning information that an unsafe operating condition may exist via the main fuel filter advisory-level messages. This alerting scheme provides an adequate level of safety for the airplanes affected by this exemption. This is the same fuel filter alerting on all Boeing production airplanes.
>
> The existing GEnx engine also incorporates a differential pressure sensor across the fuel strainer that under certain conditions provides engine indicating and crew alerting system

(EICAS) status messages and central maintenance computer (CMC) messages for additional awareness beyond any previous GE-powered airplane.

Service history studies conducted showed that the fuel strainer/filter architecture used on GE90, GE90-115B, CF6-6, CF6-50, CF6-80A, CF6-80C2, and CF6-80E engines (similar architecture of the GEnx-1B engine) have had no known in-flight shutdown or power interruption events attributed to fuel strainer clogging.

The proven service history of similar engine models, the maintenance actions defined to preclude the introduction of solid contamination into the fuel tanks and the existing flight deck messages and crew procedures from associated checklists provide an adequate level of safety for the airplanes affected by this exemption.

The petitioner's statement of public interest:

Granting this petition is in the public interest because it would allow adequate time for Boeing and its supplier to develop an effective design solution for the requirement to add a flight deck indication of gross fuel system contamination that became applicable to the Model 787-8 after the airplane development program completed firm configuration of the 787-8. Conversely, if the requested relief is not granted, the addition of the subject flight deck indication at this late stage of the airplane development program would lead to delays in the deliveries of Model 787-8 airplanes.

Availability of 787-8 airplanes with the GEnx-1B engines will reduce fuel burn and hence reduce emissions of carbon dioxide, reduce global emissions of NOx, and reduce operating costs of airlines.

In addition, without adequate time to develop a robust solution, nuisance flight deck alerts in-service have the potential to reduce operational safety when flightcrews are tasked to respond to false indications potentially resulting in unnecessary flight diversions, landing at airports that they are not familiar with, and conceivably, shutting down an engine unnecessarily.

The public interest will be advanced by the grant of exemption as it is in the best economic interest of the United States. Many 787-8 customers are overseas. Further delivery delays of the 787-8 are not in the interest of the public due to the potential negative impact to export sales, the balance-of-trade, the gross domestic product, and economic health of the United States.

Federal Register publication

A summary notice of the petition was published in the *Federal Register* on January 21, 2011 (76 FR 3933). No comments were received.

The FAA's analysis

Title 14, Code of Federal Regulation (14 CFR), part 25, § 25.997(d) and part 33, § 33.67, require that the engine fuel feed system have a filter located upstream of the positive displacement pump on the engine with a capacity that meets the engine endurance requirements of 14 CFR part 33. Section 25.1305(c)(6) requires that the filter used to show compliance with § 25.997 must provide indication to the flightcrew of impending bypass of the fuel filter. Compliance with the part 33 requirement includes demonstrating that the fuel filter has adequate capacity to complete a maximum length flight with fuel containing a standardized concentration of contaminants. Section 25.1305(c)(6) requires indication to the flightcrew if the filter is approaching its capacity that could lead to bypassing of contaminants to downstream engine components. This requirement is intended to address possible contamination that exceeds the standardized level addressed by the part 33 fuel filter capacity test. This will allow the flightcrew to take appropriate action, such as landing at the nearest airport to minimize the potential for loss of engine thrust. Service history as well as evidence from the 787 flight test program has shown that highly contaminated fuel tanks may result from debris generated by manufacturing and maintenance actions. Identified contaminants include cotton lint and fibers, metal shavings, fasteners, paper towels, respirators, rolls of tape, and cleaning rags.

The Boeing Model 787-8 airplane is equipped with General Electric GEnx-1B engines. These engines include a fuel strainer located upstream of an ejector pump, the fuel cooled oil coolers (FCOC) for the electrical generator oil and engine oil, and the gear stage of the engine driven fuel pump. The main fuel filter is located downstream of the gear stage of the engine driven fuel pump and protects critical components of the engine, including the fuel nozzles and engine fuel control components. The design includes advisory alerts from each engine to the flightcrew in the event the fuel filter has collected contaminants that could cause the filter to bypass debris to critical downstream engine components. The purpose of these advisory alerts is to make the flightcrew aware that there is a problem with the fuel system so that appropriate action, such as landing at the nearest suitable airport, can be taken.

The design of the GEnx-1B engine does not directly comply with the requirements of § 25.997(d). This is because the filter that is provided at the location required by § 25.997(d) does not meet the capacity and indication requirements of that regulation. Boeing requested an equivalent safety finding for this design. The request was based on compensating design features. These design features showed that the upstream strainer would protect the gear stage of the engine driven fuel pump from hard body damage (such as from a bolt, nut, or washer) and that smaller contaminants would pass through the strainer and gear stage and be collected in the main filter, resulting in annunciation to the flightcrew. Locating the main filter downstream of the engine driven pump provided additional safety benefits since there have been cases of fuel pump failures that generate debris that clogs the fuel metering unit or the fuel nozzles. When this unsafe condition occurred on previous engine models, an airworthiness directive was issued that required the installation of a strainer in the fuel system upstream of the fuel nozzles and the fuel metering unit. The installation of the strainer corrected the unsafe condition of the debris clogging fuel nozzles and causing an engine case burn through. Therefore, we agree with Boeing that this design provides an equivalent level of safety to the requirements of § 25.997(d).

Boeing also requested an equivalent safety finding for § 25.1305(c)(6) because the filter required by § 25.997 did not provide the indications required by § 25.1305(c)(6). While it was first thought this initial equivalent safety finding could be applied to § 25.1305(c)(6), it was later determined that contaminants that bypass the upstream screen may collect in components such as the engine FCOC that are upstream of the main fuel filter and its bypass indication. This could result in delay of flight crew response to gross fuel contamination. There were extensive discussions regarding the features needed to provide equivalent safety. Through these discussions the FAA and Boeing agreed upon the indication features needed to provide compensating features to support an equivalent safety finding. This agreement was arrived at late in the program and these design features cannot be incorporated prior to initial certification. In reviewing Boeing's petition for exemption the FAA determined they also need a time limited exemption from § 25.1305(c)(6), but they did not petition for an exemption from this regulation. The FAA has determined it is in the public interest to include a time limited exemption to § 25.1305(c)(6) as part of this rulemaking.

In addition recent experience from the 787 flight test program, as well as in-service events on other airplane models, shows that severe fuel contamination can lead to fuel filter bypass, engine power loss, and diversions. Most importantly, fuel contamination is a common cause threat that may affect multiple engines due to general fuel contamination across the entire fuel system or because a single contaminated fuel tank may be feeding multiple engines. There is no specific requirement to alert the flightcrew of impending bypass on multiple engine fuel filters, upstream strainers, or fuel oil coolers. Historically, pilot skill was relied on to interpret impending fuel bypass indications from each engine to make the determination that contamination may be affecting more than one engine. However, § 25.1309(c) contains a general requirement to provide indication to the flightcrew under certain conditions.

Similar to other Boeing airplane models, the 787 has a flightcrew advisory alert for a single engine fuel filter impending bypass condition. For the 787, Boeing will also include a collector message that presents both visual and aural alerts for dual engine fuel filter impending bypass conditions. Boeing will also provide flightcrew procedures for responding to these alerts. This is a significant improvement from previously approved designs.

The General Electric GEnx-1B engine used on the Boeing 787-8 airplanes also incorporates fuel bypass features intended to prevent a temporary interruption of fuel supply to the engines resulting from ice build up on any upstream components, including the upstream strainer and engine and generator FCOC. These features would prevent temporary fuel flow interruption due to ice that caused the loss of thrust on the Boeing 777 at Heathrow airport. However, the FAA has determined that the lack of any flightcrew indication for impending bypass of the engine FCOCs and main engine fuel filters on both engines, and the associated flightcrew procedures, is non-compliant with the requirements of § 25.1309. In addition to ice, contaminants could also cause unannunciated blockages in the upstream strainer and possible bypass of debris to the engine and generator fuel/oil coolers. Analysis conducted by Boeing and General Electric indicates that under certain operating conditions blockage of the engine FCOC could cause the engine oil to overheat, which could lead to subsequent shutdown of the engines. Review of the 787 airplane with General Electric GEnx-1B series engines showed this blockage of the engine

FCOC would not be indicated to the flightcrew by any flight deck annunciations or maintenance messages.

Boeing is working with General Electric to develop changes to the airplane indication system. These changes will provide specific annunciation of impending fuel filter bypass conditions if present on both engines and annunciation of an impending bypass condition of the engine FCOCs if present on both engines. These hardware and software changes will take significant time to develop and incorporate into the engine and airplane design. The need for these indications was identified late in the certification program, during flight testing, when manufacturing debris partially clogged the Fuel Oil Heat Exchangers (FOHE) on the Rolls-Royce Trent 1000 engines. Therefore, it is impractical to make significant modifications to the airplane and engine prior to the scheduled 787-8 certification date. In its petition, Boeing stated that service history studies showed that the fuel strainer/filter architecture used on GE90, GE90-115B, CF6-6, CF6-50, CF6-80A, CF6-80C2, and CF6-80E engines (similar architecture of the GEnx-1B engine) have not had any known in-flight shutdown or power interruption events attributed to fuel strainer clogging.

We agree with Boeing that the GEnx-1B engine includes design improvements when compared to earlier FAA-approved General Electric engine designs. These improvements include a differential pressure sensor across the fuel strainer that, under certain conditions, provides engine indicating and crew alerting system (EICAS) status messages and maintenance messages.

While Boeing has recommended retrofitting the airplanes delivered under the provisions of this exemption to full compliance by December 31, 2018, it has not provided a reason why retrofit should take 4 years to complete if the service information is provided in 2014. Without information indicating otherwise, we believe that bringing the airplane into full compliance sooner is in the public interest and that a 2-year retrofit program is reasonable. We are limiting operation of airplanes delivered under the provisions of this exemption to December 31, 2016, unless they have been retrofitted with a design that has been found to be to fully compliant.

The 787-8 is designed to limit maintenance actions that require entry into the fuel tanks. The reduced number of fuel tank entries minimizes the potential for maintenance errors resulting in debris inside the fuel tanks. This exemption is time limited for 5-6 years after the first 787-8 enters service, so few out-of-sequence maintenance actions are expected that would increase the exposure for large quantities of fuel contaminants inside the fuel tanks. The exemption also includes a provision that requires special inspections of the fuel tank and fuel strainer prior to initial airplane delivery, and after any out-of-sequence maintenance actions that result in entry into the center wing fuel tank after the airplane enters service.

The FAA considers the petitioner's request to be in the public interest because the Boeing Model 787-8 airplane design with GEnx engines provides improved flightcrew awareness of gross fuel contamination of the fuel strainers, and adequate fuel bypass features for critical engine components to prevent loss of thrust due to ice accumulation. To minimize the potential for contamination in the fuel tanks, we have included special maintenance requirements as one of the conditions in this exemption. These compensating features provide an acceptable level of safety and due to the late discovery of this deficiency, full compliance to § 25.1309(c) prior to

delivery is impractical. Full compliance would require significant modifications to the airplane and engine and delay the airplane's delivery. When compared to the airplane fleet it is replacing, the 787-8 meets later safety standards that provide improved safety and reduced costs and emissions. In addition, the 787-8 has significant improvements in fuel efficiency and will typically be replacing older, less-fuel-efficient models. Introduction of the 787-8 will reduce the public expense for fuel consumed in air travel and freight delivery as well as reduce greenhouse gas emissions. In addition, the 787-8 type-certification program is near completion. Without this exemption, Boeing would not receive design approval for the airplane in a timely manner, delaying the fleet safety and efficiency improvements. Delay would also cause disruption to several major domestic and international corporations that are anticipating the imminent delivery of the 787-8 airplane to meet their business needs. Finally, the time limited exemption requires both production incorporation and retrofit of the design modifications. Therefore, the exposure of the 787-8 airplane to fuel contamination will be limited.

The FAA has considered the information provided by the petitioner and has determined that it has sufficient merit to warrant a partial grant of exemption.

The FAA's decision

In consideration of the foregoing, I find that a time-limited grant of exemption is in the public interest regarding 14 CFR 25.1305(c)(6) and 25.1309(c), at Amendment 25-116. Therefore, pursuant to the authority contained in 49 U.S.C. §§ 40113 and 44701, delegated to me by the Administrator, The Boeing Company is granted an exemption until December 31, 2016, from the requirements of §§ 25.1305(c)(6) and 25.1309(c), at Amendment 25-116, as they pertain to indication of impending bypass of the engine oil fuel cooled oil coolers and indication of impending bypass on the main fuel filters of multiple engines, for the Boeing Model 787-8 airplanes powered by General Electric GEnx-1B, or subsequent variants of the engine, with the following provisions:

1. For Model 787-8 airplanes granted a certificate of airworthiness before June 30, 2014, the Airworthiness Limitations section of the Instructions for Continued Airworthiness must include a limitation that requires operators to verify contaminants have not accumulated on the fuel strainer located upstream of the engine driven fuel pump. The procedures must be accomplished after the first flight following any maintenance actions that result in personnel entry into the center wing fuel tank and before the next flight. The limitation must also require an inspection of the fuel cooled oil cooler if the fuel strainer has bypassed fuel.

2. Boeing must develop and implement procedures that include appropriate pass/fail criteria acceptable to the FAA for determining if contamination is present on the fuel strainer located upstream of the engine driven fuel pump. If the upstream strainer has bypassed fuel, inspection of the face of the fuel cooled oil cooler and removal of any unacceptable contaminants is required. This inspection must be accomplished following completion of production flight tests, and prior to issuance of the standard certificate of airworthiness or export certificate of airworthiness (as applicable in support of customer delivery),

3. Prior to June 30, 2014, Boeing must complete the design and show compliance to §§ 25.1305(c)(6) and 25.1309(c), at Amendment 25-116, for design improvements and flightcrew procedures to allow timely flightcrew awareness and response to hazardous fuel contamination.

4. Prior to July 31, 2014, Boeing must develop and submit for FAA approval service information to incorporate any design changes and/or operating and maintenance limitations developed to meet the provision of §§ 25.1305(c)(6) and 25.1309(c), as identified in provision 3 (above).

5. By July 1, 2011, Boeing must present to the FAA a comprehensive compliance plan and schedule, supporting the deliverables outlined in conditions 3 and 4 (above). Thereafter, Boeing must submit a status report every three months to the Seattle Aircraft Certification Office identifying all actions completed to date as well as those that remain outstanding. The report must demonstrate Boeing's progressive performance and accomplishments indicating its projected success in meeting the schedule and conditions of the exemption. Boeing must also submit drafts of the service information required by condition 4 (above) to the FAA by April 30, 2014.

6. For Model 787-8 airplanes granted a certificate of airworthiness prior to June 30, 2014, that do not have the design changes incorporated as identified by provision 3 (above), the "Airworthiness Limitation" section of the Model 787-8 airplane "Instructions for Continued Airworthiness" must state that delivered airplanes cannot be operated after December 31, 2016, unless the design changes submitted in accordance with provision 4 (above) are incorporated by the owner or operator.

7. If an application for an airworthiness certificate is made on or after June 30, 2014, the affected airplanes must incorporate the indication of impending bypass of the fuel cooled oil cooler in compliance with §§ 25.1305(c)(6) and 25.1309(c).

8. The FAA will not issue original airworthiness certificate approvals for any Boeing Model 787-8 airplane on or after June 30, 2014, unless that airplane has incorporated the design changes that Boeing has shown to be fully compliant with §§ 25.1305(c)(6) and 25.1309 and the provisions of this exemption have been met.

Issued in Renton, Washington, on May 19, 2011.

Signed by Ali Bahrami

Ali Bahrami
Manager, Transport Airplane Directorate
Aircraft Certification Service