



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

Aviation Safety

1200 District Avenue
Burlington, MA 01803

In the matter of the petition of

**Rolls-Royce Deutschland Ltd &
Co KG (Type Certificate
Previously Held by Rolls-Royce
plc)**

For an exemption from §§ 33.14 and
33.83(d)
of Title 14, Code of Federal
Regulations

Exemption No **18082A**
Regulatory Docket No. FAA-2018-0880

GRANT OF TIME-LIMITED EXEMPTION

By letter dated December 3, 2020, Warren Pell, Airworthiness Specialist Engineer, Rolls-Royce plc, P.O. Box 31, Derby, DE24 8BJ, England, petitioned the Federal Aviation Administration (FAA) on behalf of Rolls-Royce Deutschland Ltd & Co KG (RRD) for an exemption from §§ 33.14 and 33.83(d) of Title 14, Code of Federal Regulations (14 CFR). The petition requests to extend the time for compliance of Condition and Limitation No. 3 in the Time-Limited Exemption, granted on December 13, 2018. This exemption extension would temporarily exclude the intermediate pressure compression (IPC) system on certain Trent 1000 and Trent7000 series engine models from requirements relating to vibration stress combined with steady stresses, exceeding the endurance limits of the materials concerned. The proposed 18 months exemption extension, if granted, would allow RRD additional time to complete the installation of new IPC stage 1 and 2 rotor blades on specific Trent 1000 and Trent7000 series engine models currently in service. After which time, full compliance with the regulatory requirements will be restored. Due to the aircraft utilization rate and the restrictions of operating in a pandemic environment, RRD has requested to extend the December 31, 2021, compliance date to June 30, 2023.

RRD requests an extension for the temporary relief applicable to the Trent 1000 and Trent7000 series engine models listed in the Table of Affected Engines, produced before December 31, 2019. From December 31, 2019, all-new production engines have a revised standard of IPC stages 1 and 2 rotor blades fitted, thus restoring compliance with 14 CFR § 34.14 and § 33.83 (d). However, for engines produced before this date, an extension to the time for compliance of Condition and Limitation No. 3 in the Time-Limited Exemption granted on December 13, 2018, exemption is requested from December 31, 2021, to June 30, 2023.

Table of Affected Engines.

Engine Model	Rating: (x 1000 lbs.)
Trent 1000-AE3	69
Trent 1000-CE3	75
Trent 1000-D3	75
Trent 1000-G3	72
Trent 1000-H3	64
Trent 1000-J3	78
Trent 1000-K3	78
Trent 1000-L3	75
Trent 1000-M3	80
Trent 1000-N3	80
Trent 1000-P3	75
Trent 1000-Q3	78
Trent 1000-R3	81
Trent7000-72	72
Trent7000-72C	72

The petitioner requests relief from the following regulations:

Section 33.14, amendment 33-10, prescribes that –

By a procedure approved by the FAA, operating limitations must be established which specify the maximum allowable number of start-stop stress cycles for each rotor structural part (such as discs, spacers, hubs, and shafts of the compressors and turbines), the failure of which could produce a hazard to the aircraft. A start-stop stress cycle consists of a flight cycle profile or an equivalent representation of engine usage. It includes starting the engine, accelerating to maximum rated power or thrust, decelerating, and stopping. For each cycle, the rotor structural parts must reach stabilized temperature during engine operation at maximum rated power or thrust and after engine shutdown, unless it is shown that the parts undergo the same stress range without temperature stabilization.

Section 33.83(d), amendment 33-17, prescribes that –

Except as provided by paragraph (e) of this section, the vibration stresses associated with the vibration characteristics determined under this section, when combined with the appropriate steady stresses, must be less than the endurance limits of the materials concerned, after making due allowances for operating conditions for the permitted variations in properties of the materials. The suitability of these stress margins must be justified for each part evaluated. If it is determined that certain operating conditions, or ranges, need to be limited, operating and installation limitations shall be established.

The petitioner supports its request with the following information:

The following paragraphs quote the relevant information from the petitioner’s request with minor edits for clarity. The FAA has included the specific engine models from the previous exemption for clarity. The complete petition is available at the Department of Transportation’s Federal Docket Management System, on the Internet at <https://www.regulations.gov>, in Docket No. FAA-2018-0880.

Reason for the exemption being sought

The IPC system of the Trent 1000 and Trent7000 series engine models listed in the Table of Affected Engines will comply with 14 CFR Part 33, subject to granting the exemption extension requested herein.

Before the FAA granted Time-Limited Exemption No. 18082, RRD reported service occurrences in the Trent 1000 Package C fleet where a combination of low cycle fatigue (LCF) and high cycle fatigue (HCF) led to IPC stages 1 and 2 rotor blades cracking and, in a small number of instances, blade release. Furthermore, several service occurrences of cracks in the compressor drum stage 2 disc-post were reported; but with no propagation to failure. To ensure continued safe operation for the Trent 1000 and Trent7000 series engine models listed in the Table of Affected Engines, reduced life limitations were initially imposed on the IPC stages 1 and 2 rotor blades and stage 2 IPC drum within the Airworthiness Limitations Section (ALS) of the Time Limits Manual (TLM).

Under the relief provided by Time-Limited Exemption No. 18082 Condition and Limitation No. 1, RRD increased the IPC drum life by showing that any related drum crack present would not propagate to failure. For the IPC stages 1 and 2 rotor blades, a conservative inspection program was also introduced to prevent any blade cracks from propagating to failure in service. RRD’s compliance with Condition and Limitation No. 1 is discussed in the FAA’s Analysis of this Grant of Time-Limited Exemption.

Since the granting of Time-Limited Exemption No. 18082, to date, and following over 1,300 service inspections of IPC stages 1 and 2 of the engine models listed in the Table of Affected Engines, there have been no crack findings.

Condition and Limitation No. 3 in the FAA’s Grant of Time-Limited Exemption, granted on December 13, 2018, states, “On or before December 31, 2021, RRD must have

completed modification of in-service engines so that the Trent 1000 and 7000 engines fully comply with the provisions of § 33.14 at amendment 33-10; and 33.83(d) at amendment 33-17.” Before the coronavirus disease 2019 (COVID-19) pandemic, all affected in-service engines were scheduled for modification before December 31, 2021, pursuant to Condition and Limitation No. 3. However, the fleet usage profile and overhaul capacity during 2020 has changed significantly because of the pandemic. Without re-planned engine removals and consequent airline and customer disruption, the December 31, 2021, date can no longer be met.

RRD Public Interest Statement

The following paragraphs are quoted directly from the petitioner’s request with minor edits for clarity.

Granting this extension to Time-Limited Exemption No. 18082 will promote and serve the public interest because:

- (a) The state-of-the-art engine models at issue in this petition represent the latest generation of engines and engine technology from the Trent engine family. The RB211/Trent family of engines has established an outstanding track record of performance and safety over 46 years and more than 281 million service flight hours. Thus, the engine models at issue in this petition are based on proven expertise and in-service verified design styles and practices—this experience and track record help ensure the product’s reliability and safety. As explained further in the points immediately below, these engine model’s continued operation in service will generate valuable public benefits.
- (b) These state-of-the-art engine models reduce fuel burn, thereby reducing harmful emissions such as carbon dioxide (CO₂) and oxides of nitrogen (NO_x) from levels experienced with other older engine types currently in service on other aircraft.
- (c) These state-of-the-art engine models make additional aircraft models available for purchase by U.S. airlines. Such choices are in the economic interest of the U.S. through the promotion of a more competitive market for large commercial transport aircraft.
- (d) Maintaining approval of these Trent 1000 engine models in the U.S. promotes the regulatory standards of the U.S. as a global benchmark for airworthiness. The promotion of the U.S. regulatory standards is in the public interest. This promotion increases the number of goods and services available to U.S. citizens compliant with the U.S. regulatory standards. Since many countries voluntarily adopt U.S. standards, this process does not increase the burden on the U.S. government.
- (e) Trent 1000 engine models are installed on Boeing 787 and Airbus A330-neo aircraft, which are operated by airlines both within and outside the U.S. Granting this extension to the time-limited exemption will minimize disruption to the revenue service of these aircraft until modifications can be scheduled; maintaining the mobility of the U.S. flying public.

- (f) The Trent 1000 engine models at issue are built with U.S. supplied parts that constitute approximately 30 percent of the engine value. RRD employs 6,000 people in over 27 states in the U.S. and sales of the engine support U.S. jobs, contribute to the U.S. economy, and enhances the U.S. balance of trade and gross domestic product, all of which promote the U.S. public interest.

RRD Statement of No Adverse Effect on Safety

The following paragraphs are quoted directly from the petitioner's request with minor edits for clarity and correction.

The FAA's grant of this requested temporary exemption extension will have no adverse effect on safety. Compliance with § 33.14 and § 33.83 is significant for safety purposes because it demonstrates that an engine's rotors will not fail under a varying range of potential operating conditions.

The primary safety objective of 14 CFR § 33.83 is to avoid HCF-initiated failures, which implies not allowing HCF crack initiation and crack growth, mainly because propagation to failure of an HCF crack typically occurs very rapidly. However, RRD has demonstrated that IPC stages 1 and 2 rotor blade cracks and stage 2 IPC drum cracks cannot grow to failure in service under all certified operational conditions when managed in accordance with an inspection program defined in the ALS section of the TLM. This result, therefore, provides the intent of the protections afforded by 14 CFR § 33.14 and § 33.83, i.e., precluding LCF and HCF-initiated failures.

Furthermore, there has been no crack finding in over 1,300 IPC stage 1 and 2 rotor blades inspections.

Full compliance with 14 CFR § 33.14 and § 33.83 will eventually be re-established for the IPC. In the interim, RRD proposes that justifying the absence of crack propagation to failure in service in the IPC stages 1 and 2 rotor blades and stage 2 IPC drum will temporarily provide an acceptable level of safety, provided all compensating factors defined in temporary Exemption No. 18082 are addressed to the satisfaction of the FAA.

Summary

RRD seeks an extension to the time for compliance of Condition and Limitation No. 3 in the Time-Limited Exemption, granted on December 13, 2018, from December 31, 2021, to June 30, 2023. RRD seeks relief from 14 CFR 33.14 at amendment 33-10 and 14 CFR 33.83(d) at amendment 33-17 for the IPC system of the Trent 1000 and Trent7000 series engine models. This exemption will provide adequate time to re-establish full compliance with §§ 33.14 and 33.83(d) for the remaining in-service engines that RRD cannot modify in accordance with Condition and Limitation No. 3 of Exemption No. 18082. The schedule for in-service fleet modification was significantly affected by the effects of the COVID-19 pandemic on fleet usage and overhaul capacity. For the duration of this time-limited exemption, RRD proposes to continue the inspection program in the ALS section of the TLM for IPC stages 1 and 2

rotor blades and stage 2 IPC drum and remove from service any cracked parts found during inspection. In addition, RRD will continue modification of in-service engines to re-establish full compliance with §§ 33.14 and 33.83(d) in accordance with Condition and Limitation No. 3, set forth in Exemption No. 18082. RRD seeks to extend the time for compliance of Condition and Limitation No. 3 in the Time-Limited Exemption, granted on December 13, 2018, from December 31, 2021, to June 30, 2023, to permit continuing modification of in-service engines produced before December 31, 2019.

Federal Register publication

A summary of the petition was published in the Federal Register on March 12, 2021 (86 FR 14177). The FAA received no comments.

The FAA's analysis is as follows:

FAA Analysis – Introduction

FAA Time-Limited Exemption No. 18082, dated December 13, 2018, provided temporary relief from the requirements of §§ 33.14 and 33.83(d) for the IPC stages 1 and 2 rotor blades and stage 2 IPC drum subject to specific conditions and limitations.

For the Trent 1000 and Trent7000 series engine models listed in the Table of Affected Engines, RRD complied with Condition and Limitation No. 1 in Time-Limited Exemption No. 18082 before the March 31, 2019, compliance date. Condition and Limitation No. 1 required RRD to demonstrate the absence of crack propagation to failure and provide data to the FAA. Additionally, this condition and limitation required RRD to provide information for FAA approval, including service management actions established under 14 CFR 33.4. The service management actions were required to be established by RRD so that any inspections or life limit necessary to ensure non-propagation to failure must be included in the ALS of the TLM. Further, this condition and limitation required RRD to establish an inspection program, evaluate any crack findings in the IPC drum or stage 1 and 2 rotor blades. As a result, the FAA approved RRD's compliance under a change in type design for the Trent 1000 series engines on January 31, 2019, and for the Trent7000 series engine models on May 15, 2019.

Condition and Limitation No. 1.a. required RRD to use a combination of testing, analytical modeling, and service experience to demonstrate full understanding of the sequence of potential multiple failure modes, including crack initiation and propagation mechanisms, subsequent effects on the assembly integrity, failure, and outcomes. Accordingly, RRD addressed Condition and Limitation No. 1.a. by demonstrating a full understanding of the sequence of potential multiple failure modes, including crack initiation and propagation mechanisms, subsequent effects on the assembly integrity, failure, and outcomes; and in particular, accounting for the Conditions and Limitations in subparagraphs 1.a.(i) through (viii).

Condition and Limitation No. 1.b. required RRD to show compliance with all other 14 CFR part 33 requirements with the largest possible crack present that is predicted to be encountered in-service. This includes demonstrating compliance with 14 CFR 33.201. RRD was required

to show the capability to perform three diversion cycles defined as the most severe with respect to crack propagation with the largest possible crack size present that is predicted to be encountered in-service, including consideration for a missed inspection finding. In addition, RRD was required to provide adequate data from service experience and representative engine testing covering the geometrical and operational variables affecting the rate of inflight shutdowns. RRD addressed Condition and Limitation No. 1.b. by showing compliance with all 14 CFR part 33 requirements (including § 33.201) with the largest possible crack present that was predicted to be encountered in service. RRD showed the capability to perform three diversion cycles defined as the most severe with respect to crack propagation with the largest possible crack size present. The largest crack size was as predicted to be encountered in service, including consideration for a missed inspection finding. In addition, RRD provided adequate data from service experience and representative engine testing covering the geometrical and operational variables affecting the rate of in-flight shutdowns.

Condition and Limitation No. 1.c. required RRD to establish service management actions under 14 CFR 33.4. RRD addressed Conditions and Limitation No. 1.c. including subparagraphs 1.c.(i) through (v) by establishing service management actions under § 33.4. The service management actions were incorporated in the ALS section of the TLM.

Condition and Limitation No. 2. required RRD to introduce redesigned IPC stage 1 and 2 rotor blades into new production engines so that new production engines fully comply with the provisions of § 33.14 at amendment 33-10; and § 33.83(d) at amendment 33-17. RRD addressed Conditions and Limitation No. 2 by introducing the redesigned IPC stages 1 and 2 rotor blades and restoring full compliance with 14 CFR 33.14 at amendment 33-10; and 33.83(d) at amendment 33-17, for all-new production engines produced after December 31, 2019.

Condition and Limitation No. 3 required RRD to have completed modification of in-service engines on or before December 31, 2021, so that the Trent 1000 and 7000 engines fully comply with the provisions of § 33.14 at amendment 33-10; and 33.83(d) at amendment 33-17. Condition and Limitation No. 3 is the subject of RRD's petition for an extension to Exemption No. 18082.

RRD requested an extension to the time for compliance of Condition and Limitation No. 3 from December 31, 2021, to June 30, 2023. The extension is sought to modify the in-service engines so that the Trent 1000 and Trent7000 series¹ engine models fully comply with the provisions of § 33.14 at amendment 33-10, and 33.83(d) at amendment 33-17. Before the COVID-19 pandemic, all affected engines were scheduled for modification before December 31, 2021. However, the fleet usage profile and overhaul capacity during the 2020 calendar year has changed significantly. The extended time allowance permits RRD's reduced maintenance shop capacity to modify the in-service engines. Following over 1,300 service

¹ The FAA requested, and RRD provided, clarification that the scope of RRD's petition to extend the previously granted Time-Limited Exemption No. 18082 is for all Trent 1000 and Trent7000 series engine models defined in section C and section H of RRD's December 3, 2020, petition. Although not explicitly stated in section G of RRD's petition, the request for relief is for all engine models listed in the Table of Affected Engines.

inspections of IPC stages 1 and 2 rotor blades and stage 2 IPC drum installed in the engine models listed in the Table of Affected Engines, there have been no crack findings.

Until RRD completes the modification of the remaining in-service engines, RRD's extension of the time for compliance of Condition and Limitation No. 3 in the Time-Limited Exemption would provide for the ongoing inspection program of the IPC stages 1 and 2 rotor blades and stage 2 IPC drum as required by the ALS section of the TLM approved by the FAA.

FAA Analysis – Public Interest

Granting this exemption is a net benefit to the U.S. public because it would not adversely affect safety and minimize disruption to the traveling public.

The level of safety provided by 14 CFR 33.14 at amendment 33-10 and 33.83(d) at amendment 33-17 would be preserved for the duration of the time-limited exemption by an inspection program to ensure that IPC stages 1 and 2 rotor blades and stage 2 IPC drums are crack free and meet serviceability requirements before these parts are returned to service. The FAA approved the design change in accordance with RRD complying with Condition and Limitation No. 1 in Time-Limited Exemption No. 18082, as discussed in the FAA Analysis section. Specifically: (1) RRD provided the data and justification that the inspection program will prevent cracked rotor blades from propagating to failure in service; and (2) RRD provided sufficient technical information justifying the increased life of the IPC drum, which shows that any crack in the IPC drum cannot propagate to failure within the proposed cyclic life.

The FAA's analysis determined that the inspection programs in the ALS section of the TLM provide an adequate level of safety. Also, due to the possibility of IPC stages 1 and 2 rotor blade cracks, the FAA included an extended operations (ETOPS) restriction for the affected Trent 1000 and Trent7000 series engine models on the type certificate data sheet to reduce the diversion time permitted from 330 minutes to 180 minutes when the life of the IPC stages 1 and 2 rotor blades exceed specified limits.

Denial of RRD's petition to extend the time for compliance of Condition and Limitation No. 3 in the Time-Limited Exemption, granted on December 13, 2018, from December 31, 2021, to June 30, 2023, would result in the grounding of currently operational aircraft. Therefore, the benefit of this time-limited exemption extension is to minimize the effects of grounding aircraft upon the U.S. flying public.

FAA Analysis – TLE 18 Month Extension Grant

RRD's petition requested an extension of 18 months for compliance with Condition and Limitation No. 3 in the Time-Limited Exemption, granted on December 13, 2018. RRD provided information to support their proposal of an 18 month extension and justified their extension request with information on the fleet's best schedule for overhaul capacity while maintaining continued operational safety. The FAA agrees that an extension of 18 months is appropriate to allow RRD the necessary time to modify the in-service Trent 1000 and Trent7000 series engine models.

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. §§ 106(f), 40113, and 44701 delegated to me by the Administrator, RRD is granted a time-limited exemption from 14 CFR 33.14 amendment 33-10 and 33.83(d) amendment 33-17. This time-limited exemption is granted to permit RRD to exclude temporarily the IPC system on the Trent 1000-AE3, Trent 1000-CE3, Trent 1000-D3, Trent 1000-G3, Trent 1000-H3, Trent 1000-J3, Trent 1000-K3, Trent 1000-L3, Trent 1000-M3, Trent 1000-N3, Trent 1000-P3, Trent 1000-Q3, Trent 1000-R3, Trent7000-72, and Trent7000-72C engine models (Trent 1000 and Trent7000) from the endurance limit requirements of §§ 33.14 and 33.83(d), subject to the conditions and limitations listed below.

Conditions and Limitations

1. RRD must continue to inspect the IPC stages 1 and 2 rotor blades and the IPC stage 2 drum in accordance with the ALS section of the TLM. RRD must evaluate any crack findings in the IPC stage 2 drum or stages 1 and 2 rotor blades and any changes to operator usage profiles for consistency with the certified assumptions and technical understanding. Findings inconsistent with the assumptions will be communicated to the European Union Aviation Safety Agency (EASA), the Certifying Authority; and
2. On or before June 30, 2023, RRD must have completed modification of in-service engines with redesigned IPC stages 1 and 2 rotor blades so that the Trent 1000 and Trent7000 series engine models fully comply with the provisions of § 33.14 at amendment 33-10; and 33.83(d) at amendment 33-17.

This exemption expires on June 30, 2023. Trent 1000 and Trent7000 series engine models that have not been modified with redesigned IPC stages 1 and 2 rotor blades to comply with 14 CFR part 33 requirements by that date may not be returned to service.

Issued in Des Moines, Washington, on June 11, 2021.

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