Petition for Exemption from §25.671(c)(1), §25.671(c)(2), §25.1309(b)(1), 25App-K25.1.1, and 25App-K25.1.2 of Title 14, Code of Federal Regulations

Petition for Exemption from 14 Code of Federal Regulations (CFR) §25.671(c)(1), §25.671(c)(2), §25.1309(b)(1), 25App-K25.1.1 and 25App-K25.1.2 for Boeing Model 757-200, 757-200CB, 757-200PF, 757-300 Airplanes.

Name and Address of the Petitioner

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Section(s) of the Regulations from which Relief is Sought:

Boeing is requesting relief from the design and performance requirements of 14 CFR §25.671(c)(1) §25.671 (c)(2), §25.1309(b)(1), 25App-K25.1.1, and 25App-K25.1.2 for the 757 flight controls aileron electric trim actuator and mechanical installation to address an existing unsafe condition resulting from a component failure.

14 CFR §25.671(c) Amendment 25-23 requires:
(c) The airplane must be shown by analysis, tests, or both, to be capable of continued safe flight and landing after any of the following failures or jamming in the flight control system and surfaces (including trim, lift, drag, and feel systems), within the normal flight envelope, without requiring exceptional piloting skill or strength. Probable malfunctions must have only minor effects on control system operation and must be capable of being readily counteracted by the pilot.

(1) Any single failure, excluding jamming (for example, disconnection or failure of mechanical elements, or structural failure of hydraulic components, such as actuators, control spool housing, and valves).
(2) Any combination of failures not shown to be extremely improbable, excluding jamming (for example, dual electrical or hydraulic system failures, or any single failure in combination with any probable hydraulic or electrical failure).

14 CFR §25.1309(b) Amendment 25-41 requires:
(b) The airplane systems and associated components, considered separately and in relation to other systems, must be designed so that—

(1) The occurrence of any failure condition which would prevent the continued safe flight and landing of the airplane is extremely improbable, and

25App-K25.1.1 Amendment 25-120, a step-up from original type certification basis per AC 21.101-1B, requires:
The airplane-engine combination must comply with the requirements of part 25 considering the maximum flight time and the longest diversion time for which the applicant seeks approval.

25App-K25.1.2 Amendment 25-120, a step-up from original type certification basis per AC 21.101-1B, requires:
An applicant must consider crew workload, operational implications, and the crew's and passengers' physiological needs during continued operation with failure effects for the longest diversion time for which it seeks approval.

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The Extent of Relief Sought and Reason(s)

Regulation	Requires:	Relief is Necessary because:
14 CFR §25.671(c)(1) Amendment 25-23 & 14 CFR §25.671(c)(2) Amendment 25-23 & 14 CFR §25.1309(b)(1) Amendment 25-41	Systems and equipment must be designed so that Catastrophic effects and single point failures are extremely improbable.	The requirements state no single points of failure can lead to a Catastrophic event and an extremely improbable failure risk on the order of 1.00E-09 per flight hour (FH) or less. A failure condition was found as a result of a safety investigation of a failed cast bracket. The safety investigation re-assessed the highest hazard effect class of the trim actuator linkage disconnect from Major to Catastrophic. The Catastrophic condition due to trim linkage disconnect which may lead to loss of control, cannot be shown to be "extremely improbable." The current Boeing fleet history has insufficient flight hour data to satisfy on the order of 1.00E-09 per FH or less probability. The mitigating design trim system current service history shows no trim system single-point disconnects and an updated failure probability risk of 3.52E-09 per FH. Full compliance would require extensive redesign. The additional complexity and risk of an extensive redesign of a 38-year old aircraft aileron trim system to add redundancy and integrate the redesign across the history of design changes, including service bulletins and STC integration, will not increase safety and reliability beyond this simpler mitigating design for the current fleet of 761 aircraft. Boeing petitions for relief from §25.671(c)(1), §25.671 (c)(2), §25.1309(b)(1), and 25App-K25.1.1 for the mitigating redesign from the single point disconnect and extremely improbable failure criteria with consideration of ETOPS.
25App-K25.1.1 Amendment 25-145	Maximum flight time and the longest diversion time need to be considered when assessing the requirements of §25.671(c)(1), §25.671(c)(2), and §25.1309(b)(1).	
25App-K25.1.2 Amendment 25-145	Flight crew workload and operational implications failure effects need to be considered for the longest diversion time.	The original electric trim actuator system was certified using FAA Advisory Circular (AC) 120-42 or AC120-42A for ETOPS. Increased crew workload and operational implications for all failure modes of the system were not previously considered. There are failure modes of the unchanged portions of the system that may result in a diversion or increase crew workload, not previously considered to be Major for ETOPS.

		Boeing petitions for relief from 25App-K25.1.2 for 757 flight controls aileron electric trim actuator system, where the hazard effect class of failures may be impacted due to consideration of flight crew workload that are not affected by this change.

Description of Issue

The Boeing Company is developing a mitigation action for the 2017 part failure identified in AD 2019-12-13, where the cast actuator ground bracket completely separated from the primary casting. This is the first reported complete separation failure in the 38-year service history of the 757 Series aircraft (first delivery in 1983).

In the original 757 design▲, the three Aileron Systems components – the Aileron Load-Feel /Centering Mechanism, the Aileron Trim Actuator, and the Aileron Trim Actuator Ground Bracket – were all aligned/oriented in the same plane. Operationally, when the Load Feel / Centering Mechanism functions, it follows a circular path. The rod-end of the Trim Actuator is attached to the Load Feel/Centering Mechanism, and follows that same circular arc while its opposite end pivots at the Ground Bracket. With all components oriented in the same plane, the Trim Actuator / Ground Bracket arrangement acted as a free hinge, thereby applying no out-of-plane load to the Ground Bracket.

In 1982, a design change was implemented that rotated the Aileron Trim Actuator and the Ground Bracket by 90-degrees to better orient the drainage provision in the Trim Actuator. With this re-orientation, however, as the Aileron Trim Actuator followed the arc from Load Feel / Centering Mechanism operation, it was possible for the Trim Actuator to apply an out-of-plane prying load to the Ground Bracket. In 2017, an Operator reported a failure of a Ground Bracket. Analysis of the failed component indicated that an out-of-plane prying load caused the bracket failure. That Ground Bracket failure resulted in disabling all load-feel, centering and aileron trim functions.

The 757 has a history of pilot induced oscillation (PIO) concerns and multiple service bulletins to mitigate the PIO affects at the critical landing phase of flight have been issued. The disconnection of the aileron trim linkage was reevaluated resulting in an increased highest hazard classification from Major hazard to a Catastrophic hazard. The re-evaluation has driven the need to create redundancy in the aileron trim linkage system to comply with 14CFR §25.671(c) and §25.1309(b).

Boeing's mitigating design for the aileron trim linkage focuses on eliminating the single point failure of the subject in-service event by incorporating redundancy into the structural attachment bracket and reorienting the Aileron Trim Actuator bracket with in-plane mechanism connections that are common on the 747-400, 747-8, 767, and 777 and also eliminates the possibility of prying load failures.

Designing in redundancy has some advantages for dual load-path designs. However, redundancy increases complexity and forces interaction between the other redundant functions. During the re-design phase of the aileron trim system many variations were evaluated over a two year period. The successful designs that complied with all the CFR requirements for redundancy and integrated into the existing support structure with all fleet historical design variations, were considered high risk for increased complexity and potential for adding new and unanticipated failures with other redundant systems, thus reducing predicted reliability. Additionally, a more complex design adds additional maintenance and reliability error possibilities related to human factors for in-service modifications and support.

▲ See attachment for Boeing proprietary supporting data.

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Boeing's finalized approach to mitigating the failed bracket is to replace the single load-path bracket with a stronger bracket that will increase safety over the prior design by using stronger materials and the addition of a secondary load-path at the affected bracket location. The simplified design conforms to a time tested actuator orientation installation method that has a proven fleet wide performance with no single point disconnect failures. Additionally, the trim system inspection frequency of the final design will increase to satisfy the updated safety assessment.

All 757 aircraft will be retrofitted with the dual load-path bracket. The existing single point failure locations of the trim actuator and installation bolts, previously described, will remain and have no history of failure. Compliance for the acceptability of retaining the single point failures is satisfied by the qualitative service history assessment.

The Aileron Trim Actuator root P/N is used in the same orientation on the 747-400, 747-8, 767, and 777 as in the new design for the 757. A search using the Airplane Safety Information System (ASIS) and Airplane Reliability and Maintainability Systems/ In-Service Data Program (ARMS/ISDP) databases found no known events of bracket fracture / disconnection on the 747-400, 747-8, 767, or 777 and no known events of other aileron trim linkage disconnect on the 747-400, 747-8, 757, 767, or 777. The 737CL, 737NG, 737MAX Aileron Trim Actuator (similar design, different specification) is in the same orientation as the new design for the 757. A search using ASIS and ARMS/ISDP databases found no known events of bracket fracture and no known events of other aileron trim linkage disconnect on the 737CL, 737NG, 737MAX. Neither search was limited by date.

As of February 2021 records, the service history data analysis▲ of the Aileron Trim Actuator root P/N demonstrates ZERO disconnect failures in 284,492,675 FH. Assuming one failure, the failure rate per flight hour is 3.52E-09. The service history of the aileron trim linkage orientation configuration for 737CL, 737NG, 737MAX, 747-400, 747-8, 767, or 777 is ZERO disconnect failures in 605,745,193 FH. Assuming one failure, the failure rate per flight hour is 1.65E-09. For all the other models listed above, the disconnection of the aileron trim linkage does not result in a Catastrophic consequence.

Statement of Public Interest
The existing aircraft configuration has failed due to overload and material properties inconsistency. Addressing the known failure mode will maintain the certified level of safety, although the design cannot be shown compliant to all CFRs. Designing the system to satisfy all CFRs would result in a more complex system that would be difficult to modify in-service and add unintended risk to the system. The public interest is served by redesigning the known, unreliable ground bracket and increasing the inspection frequency of the final design as soon as possible. The design change will elevate safety levels across operating fleets. An overall elevation of safety is in the public interest.

Statement of No Adverse Effect on Safety
The proposed relief to regulations outlined in this petition would not adversely affect the public safety. Granting of the exemption would allow the addition of a redundant load-path at the original point of failure. Returning the actuator installation orientation to the common fleet method (the 757 original certified orientation) and increasing the inspection frequency of the final design further mitigates the original "overload failure mode" identified in AD 2019-12-13.

Request to 'Waive Publication and Comment'
Not Requested

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 in countries having bilateral

▲ See attachment for Boeing proprietary supporting data.

agreements with the United States accepting FAA 14 CFR part 25 as their airworthiness standards for transport category aircraft. The 757 series aircraft is intended for the global market place.

Conclusion

Boeing petitions the FAA to grant relief from 14 CFR §25.671(c)(1), §25.671(c)(2), §25.1309(b)(1), 25App-K25.1.1, and 25App-K25.1.2 as they relate to the mitigating action resulting from the failed 757 aileron trim actuator ground bracket, AD 2019-12-13. Such a grant would allow for the noted design change to be certified for use by the 757 fleet to introduce a secondary load path bracket, which will increase reliability and address a known safety concern, feasible for operators to implement, and reduce risk to the change for potential unexpected failure modes due to integration with other redundant systems.

Summary to be Published in the Federal Register

DESCRIPTION OF RELIEF SOUGHT: Exemption for the 757 Aileron Trim Mitigating Design change for AD 2019-12-13 to allow for the earliest possible incorporation of these safety-related fleet modifications.

PETITIONER: Boeing Commercial Airplanes

SECTION OF 14 CFR AFFECTED: 14 CFR §25.671(c)(1), §25.671(c)(2), §25.1309(b)(1), 25App-K25.1.1, and 25App-L25.1.2

DESCRIPTION OF RELIEF SOUGHT: Exemption for the 757 series aircraft redesign of the aileron trim linkage to eliminate root cause of prior failure and return of the trim actuator to a more common design orientation.