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# Part V

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## Federal Aviation Administration

**14 CFR Part 33**

**Airworthiness Standards; Continued Rotation and Rotor Locking Tests, and Vibration and Vibration Tests; Final Rule**

**DEPARTMENT OF TRANSPORTATION**

**Federal Aviation Administration**

**14 CFR Part 33**

**[Docket No. 28107; Amendment No. 33–17]**

**RIN 2120–AF57**

## Airworthiness Standards; Continued Rotation and Rotor Locking Tests, and Vibration and Vibration Tests

**AGENCY:** Federal Aviation Administration, DOT.

**ACTION:** Final rule.

**SUMMARY:** This amendment revises the Federal Aviation Administration's (FAA's) continued rotation and vibration certification standards for the issuance of original and amended type certificates for aircraft engines. This amendment is the result of an effort to harmonize the Federal Aviation Regulations (FAR's) with European requirements being drafted by the Joint Aviation Authorities (JAA). This amendment will provide nearly uniform requirements that will simplify international airworthiness approval, while maintaining a level of safety equivalent to that established by the current standards.

**DATES:** Effective July 5, 1996.

**FOR FURTHER INFORMATION CONTACT:** Marc Bouthillier, or Thomas Boudreau, Engine and Propeller Standards Staff, ANE–110, Engine and Propeller Directorate, Aircraft Certification Service, FAA, New England Region, 12 New England Executive Park, Burlington, MA 01803–5299; telephone (617) 238–7111; fax (617) 238–7199.

**SUPPLEMENTARY INFORMATION:**

### Background

Part 33 of title 14 of the Code of Federal Regulations (14 CFR part 33) prescribes certification standards for the issuance of original and amended type certificates for aircraft engines. Part E of the Joint Aviation Requirements (JAR–E) prescribes the corresponding certification standards of the JAA. While part 33 and JAR–E are similar, they differ in several respects. Non–uniform standards impose a regulatory burden on applicants seeking certification under both sets of standards in the form of additional costs and delays in the time required for certification.

As part of its commitment to promote harmonization of part 33 and JAR–E, the FAA, with the cooperation of the JAA, established the part 33/JAR–E Authorities Engine Group to compare part 33 and JAR–E. This group included regulatory representatives from France, Canada, Germany, the United Kingdom, and the United States. The basis for the comparison was part 33, as amended through Amendment 11, and JAR–E, as amended through Change 7. As its initial effort, the study group focused on gas turbine engines and concentrated on JAR–E items that appeared to be more stringent than part 33. The continued rotation and rotor locking test requirements, and vibration and vibration test requirements, were identified as differences sufficiently significant to cause the JAA to apply additional conditions to U.S. manufacturers seeking JAA certification. The FAA requested the ARAC to further evaluate these initiatives and ARAC assigned the task to the Propulsion Harmonization Working Group. The task resulted in an ARAC recommendation to the FAA to proceed with rulemaking. The FAA issued a Notice of Proposed Rulemaking (NPRM), No. 95–3, published in the Federal Register (60 FR 12360, dated March 6, 1995). The proposal reflected the ARAC recommendations.

### Discussion of Comments

All interested persons have been afforded an opportunity to participate in this rulemaking, and due consideration has been given to all comments received. The commenters represent domestic industry and foreign airworthiness authorities. Six commenters provided the FAA with comments to NPRM 95–3. Two of these six commenters expressed no objection to the proposals. The comments are grouped according to the applicable revised and new sections of part 33.

*Section 33.74 Continued Rotation*

Two commenters state that the term ''windmilling'' should be changed to ''continued rotation,'' to be consistent with the existing wording of part 23 and part 25, and to encompass mechanical as well as aerodynamic effects.

The FAA agrees. The FAA has changed the term ''windmilling'' to ''continued rotation,'' wherever it appears.

One commenter states that the wording of proposed 33.74 in the NPRM is awkward, and should be revised for clarity.

The FAA agrees. The FAA has rewritten this section to more clearly state the requirement. The phrase ''any of the engine main rotating systems'' replaces ''engine'', and the revised section now specifies that the standard does not apply when rotor locking systems are in place. In addition the phrase ''and in the flight conditions expected to occur'' replaces the phrase ''likely to occur''. The FAA has also made additional changes to revised § 33.74 as noted in response to other comments.

One commenter states that the term ''typical installation'' should be deleted, because the rule applies to all installations.

The FAA agrees. This term has been deleted from this section.

One commenter states that the term ''for any reason'' be either deleted or clarified, because this wording will require compliance for the case of a failed rotor locking devices, if installed.

The FAA agrees. The rule does not intend to consider a failed rotor locking device. The FAA has, therefore, added a clarifying statement to this effect. However, the term ''for any reason'' has been retained to cover all other reasons for an engine shutdown.

One commenter states that the term ''flight conditions expected to occur'' be included in the text of the rule.

The FAA agrees. The FAA has included this term in the rule.

Two commenters state that the term ''hazard to the aircraft'' should be deleted, and replaced by more definitive criteria.

The FAA agrees. The FAA has replaced this term with a more definitive criteria by referencing § 33.75. That criteria can be evaluated at the engine level, without the need for an aircraft installation assessment.

One commenter states that the proposed rule should also require determination of aircraft/engine interface loads associated with continued rotation with rotor unbalance, and submittal of these for engine certification.

The FAA disagrees. The FAA considers this comment to be beyond the scope of this rulemaking, because the proposal addresses only the continued rotation characteristics of the engine; it did not address aircraft structural requirements for various engine load conditions. Also, the commenter does not specify any criteria for evaluating aircraft/engine interface loads, which can only be evaluated when considering an entire airplane.

*Section 33.63 Vibration*

One commenter expressed concern with the apparent inference to structural assessments of the aircraft due to engine dynamic loads. The commenter suggests that this part of the proposal not be issued and that the appropriate ARAC Structures and Propulsion working groups be tasked to work the issue.

The FAA disagrees. The FAA considers this comment is beyond the scope of this rulemaking. The revision

to § 33.63 clarifies, but does not alter, the original intent of a requirement that was promulgated as a Civil Air Regulation on June 15, 1956. The practical application of this requirement is to demonstrate those peak vibratory stresses of engine components do not exceed the material endurance limit for all normal engine operation (i.e., does not consider engine failure conditions that would be evident to the crew). The requirement of parts 23.939, 25.939, 27.939, and 29.939 further ensures that the installation of the engine to the aircraft will not result in excessive vibratory stresses of engine components for all normal engine operation. Additionally, the combined requirements of paragraphs 33.63 and 33.29(b) require that an indication of excessive vibration (rotor unbalance) be provided to the installer. These indications are provided to the crew to alert them of conditions beyond what is considered normal engine operation so that immediate corrective actions can be taken. It has never been the intent of this requirement nor is it the intent of the revised requirement to establish the abnormal engine environment for designing aircraft structures. In a separate and unrelated task, the FAA has chartered the ARAC Loads and Dynamic Harmonization Working Group to assess whether the current aircraft structural requirements adequately address the engine dynamic loads resulting from turbine engine failures.

*Section 33.83 Vibration test*

Section 33.83(a)

One commenter states that additional clarification be provided on the intended means of measuring vibration stresses. The commenter states that the requirements infer direct measurements of vibratory stresses can only be measured using strain gauges.

The FAA disagrees. Typically, vibration stresses are measured directly. However, in certain instances, indirect measurements of blade deflections can supplement direct measurements of vibratory stresses. Further clarification of the intended measurements is not needed as the regulation retains language that is understood by engine manufacturers and is basically unchanged since its inception as a Civil Air Regulation on June 15, 1956.

Section 33.83(b)

One commenter suggested editorial changes to emphasize that the vibration surveys cover the ranges of physical and corrected rotation speeds.

The FAA agrees. The paragraph has been revised to better define the intent of the harmonized vibration requirements.

One commenter states the phrase ''throughout the declared flight envelope'' was used redundantly in proposed paragraphs 33.83(a) and 33.83(b).

The FAA disagrees. Revised paragraph 33.83(a) contains general vibration test requirements while revised paragraph 33.83(b) contains more specific test requirements. The defining term ''throughout the declared flight envelope'' is needed in both paragraphs.

One commenter states that alternative wording is needed to the speed extension requirements of proposed paragraph 33.83(b). The commenter further states that the surveys should be extended sufficiently to reveal the maximum stress value but limiting the rotational speed extension to no more than an additional 2 percentage points.

The FAA agrees. The FAA will incorporate the wording recommended by the commenter to better define the intent of the speed extension requirement.

Section 33.83(c)

One commenter states that the proposal eliminates those requirements specific to accessory drives and mounting attachments, and also asks whether the FAA is still concerned about accessory drives and mounting attachments.

The FAA disagrees. The FAA still has concerns on the integration requirements of accessory drives and mounting attachments and specific reference to accessory loading is retained in revised paragraph 33.83(c). New paragraph 33.83(f) provides for a more complete and thorough integration of the engine to the aircraft, including accessory drives and mounting attachments.

One commenter states that an additional subparagraph to paragraph 33.83(c) is needed to emphasize the requirement to evaluate factors that might induce or influence flutter vibration.

The FAA agrees. Flutter vibration was included in the discussion of proposed 33.83(b) in the NPRM. Revised 33.83(c) contains a new paragraph (c)(2) that defines the intent of the harmonized vibration requirements.

Section 33.83(d)

Two commenters state that proposed paragraphs 33.83 (d) and (e) need clarification to distinguish between the standard that applies to normal operation from that applicable to likely fault conditions. One suggests that the order of proposed paragraphs 33.83 (d) and (e) needs to be reversed.

The FAA agrees. The FAA has reversed order of new paragraphs 33.83 (d) and (e) and has added additional words to clarify which criterion applies in each condition.

One commenter suggested editorial changes to clarify that vibratory stresses are combined with steady stresses when comparing to the material's endurance limit.

The FAA agrees. The paragraph has been revised to better define the intent of the harmonized vibration requirements. The phrase ''when combined with the appropriate steady state stresses'' has been added to new paragraph 33.83(d).

One commenter states that proposed paragraph 33.83(e) appears to be a design not a performance requirement, and therefore, infers that this proposed paragraph is inappropriately included in the vibration test section.

The FAA disagrees. New paragraph 33.83(d) is the primary criterion for evaluating the results of tests and analyses conducted in accordance with revised paragraphs 33.83 (a), (b), and (c).

One commenter states that the standard requiring vibration stresses to be less than the endurance limits of the materials concerned should be relaxed to assess the vibration stresses against the endurance limits of the materials concerned.

The FAA does not agree. The commenter's suggestion allows for acceptance of vibration stresses greater than the endurance limits without any definitive limitation. All engines on an aircraft are subject to the same environmental and operating conditions. The standard requiring vibratory stresses of less than the endurance limit is necessary, therefore, to minimize the likelihood of having multiple engines on the same aircraft fail for the same root cause. The FAA recognizes that there may be instances where a particular vibration failure mode does not result in engine anomalies (such as, power loss, high vibrations sensed by the flight crew, limit exceeded) that could cascade into a hazardous condition. The FAA has determined that such instances are rare. The FAA can evaluate the merit of these instances on a case by case basis.

Section 33.83(e)

One commenter suggested editorial changes to clarify the assessment of fault conditions.

The FAA agrees. The paragraph has been revised to better define the intent of the harmonized vibration requirements. The phrase ''of likely

fault conditions'' has been replaced by the phrase ''of excitation forces caused by fault conditions'', and the phrase ''on vibration characteristics'' has been moved to the beginning of the paragraph.

One commenter states that the requirement to assess vibrations should not apply throughout the declared flight envelope for failure conditions. The commenter further states that it is excessive to require assessments throughout the declared flight envelope for failure conditions.

The FAA does not agree. The FAA does not intend that the requirements apply to all failure conditions. No assessments are required, for example, where the condition will quickly result in an engine shutdown or result in immediate symptoms that will necessitate flight crew actions. The FAA does intend, however, that assessments be made of typical fault conditions (such as, turbine nozzle guide vane burn-throughs, fuel nozzle blockage, minor foreign object damage) that may not be immediately detectable by the flight crew and that could cascade into a hazardous condition. Requiring assessments of typical fault conditions throughout the declared flight envelope is not considered excessive. The assessment criterion for fault conditions is to show only that no hazardous condition is created, where the stricter assessment criterion for normal operation requires that assessed vibratory stresses do not exceed the material's endurance limit.

Section 33.83(f)

One commenter suggested changing ''installation documents'' to read ''installation instructions'' to be consistent with § 33.5.

The FAA agrees. The noted editorial change has been incorporated.

Paperwork Reduction Act

In accordance with the Paperwork Reduction Act on 1990 (44 U.S.C. 3501 et seq.), there are no requirements for information collection associated with this rule.

Regulatory Evaluation, Regulatory Flexibility Determination, and Trade Impact Assessment

Proposed changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic effect of regulatory changes on small entities. Third, the Office of Management and Budget directs agencies to assess the effect of regulatory changes on international trade. In conducting these analyses, the FAA has determined that this rule: (1) will generate benefits outweighing its costs; (2) is not a ''significant regulatory action'' as defined in the Executive Order; (3) is not ''significant'' as defined by DOT's policies and procedures; (4) will not have a significant impact on a substantial number of small entities; and (5) will not constitute a barrier to international trade. These analyses, available in the docket, are summarized below.

Regulatory Evaluation Summary

Of the several amendments, only one might result in additional cost. The FAA has identified the requirements in revised § 33.83(b) as the only amendment that could require minor additional engine testing and engineering analysis, resulting in minor additional compliance costs. The revised engine continued rotation requirements of new § 33.74 and the amendments to § 33.92(a) could potentially result in cost savings to engine and transport airplane manufacturers.

The primary benefits of the rule will be harmonization of airworthiness standards with the European Joint Aviation Requirements and clarification of existing standards. The resulting increased uniformity of standards will simplify airworthiness approval for import and export purposes and will avoid some of the costs that can result when manufacturers seek type certification under both sets of standards. While not readily quantifiable, the cost economies of harmonization will far exceed the minor incremental cost of the rule.

Regulatory Flexibility Determination

The Regulatory Flexibility Act (RFA) of 1980 was enacted by Congress to ensure that small entities are not unnecessarily or disproportionately burdened by Federal Regulations. The RFA requires a Regulatory Flexibility Analysis if a proposed rule will have a significant economic impact, either detrimental or beneficial, on a substantial number of small entities. Based on FAA Order 2100.14A (Regulatory Flexibility Criteria and Guidance), which outlines procedures and criteria for implementing the RFA, the FAA has determined that the rule will not have a significant economic impact on a substantial number of small entities.

International Trade Impact Assessment

The rule will not constitute a barrier to international trade, including the export of U.S. aircraft engines to foreign countries and the import of foreign aircraft engines into the U.S. Instead, the revised standards will harmonize with existing and proposed standards of foreign aviation authorities, thereby lessening restraints on trade.

Paperwork Reduction Act

In accordance with the Paperwork Reduction Act of 1990 (44 U.S.C. 3501 et Seq.), there are no requirements for information collection associated with this rule.

International Compatibility

The FAA has reviewed corresponding International Civil Aviation Organization international standards and recommended practices and Joint Aviation Authorities requirements and has identified no difference in these amendments and the foreign regulations.

Federalism Implications

The regulations adopted herein will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this regulation will not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

For the reasons discussed above, the FAA has determined that this regulation (1) is not a ''significant regulatory action'' under Executive Order 12866; (2) is not a ''significant rule'' under DOT Regulatory Policies and Procedures (44 FR 11034, February 26, 1979); (3) will not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the RFA; and (4) will not substantially impact on international trade. A final regulatory evaluation of the regulation, including a final Regulatory Flexibility Determination and International Trade Impact Assessment, has been placed in the docket. A copy may be obtained by contacting the person identified under **FOR FURTHER INFORMATION CONTACT.**

List of Subjects in 14 CFR Part 33

Aircraft, Aviation safety, Safety.

Adoption of the Amendment

Accordingly, the Federal Aviation Administration (FAA) amends 14 CFR part 33 as follows.

## PART 33—AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES

1. The authority citation for part 33 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701, 44702, 44704.

2. Section 33.63 is revised to read as follows:

### § 33.63 Vibration.

Each engine must be designed and constructed to function throughout its declared flight envelope and operating range of rotational speeds and power/thrust, without inducing excessive stress in any engine part because of vibration and without imparting excessive vibration forces to the aircraft structure.

3. A new section 33.74 is added to read as follows:

### § 33.74 Continued rotation.

If any of the engine main rotating systems will continue to rotate after the engine is shutdown for any reason while in flight, and where means to prevent that continued rotation are not provided; then any continued rotation during the maximum period of flight, and in the flight conditions expected to occur with that engine inoperative, must not result in any condition described in § 33.75 (a) through (c).

4. Section 33.83 is revised to read as follows:

### § 33.83 Vibration test.

(a) Each engine must undergo vibration surveys to establish that the vibration characteristics of those components that may be subject to mechanically or aerodynamically induced vibratory excitations are acceptable throughout the declared flight envelope. The engine surveys shall be based upon an appropriate combination of experience, analysis, and component test and shall address, as a minimum, blades, vanes, rotor discs, spacers, and rotor shafts.

(b) The surveys shall cover the ranges of power or thrust, and both the physical and corrected rotational speeds for each rotor system, corresponding to operations throughout the range of ambient conditions in the declared flight envelope, from the minimum rotational speed up to 103 percent of the maximum physical and corrected rotational speed permitted for rating periods of two minutes or longer, and up to 100 percent of all other permitted physical and corrected rotational speeds, including those that are overspeeds. If there is any indication of a stress peak arising at the highest of those required physical or corrected rotational speeds, the surveys shall be extended sufficiently to reveal the maximum stress values present, except that the extension need not cover more than a further 2 percentage points increase beyond those speeds.

(c) Evaluations shall be made of the following:

(1) The effects on vibration characteristics of operating with scheduled changes (including tolerances) to variable vane angles, compressor bleeds, accessory loading, the most adverse inlet air flow distortion pattern declared by the manufacturer, and the most adverse conditions in the exhaust duct(s); and

(2) The aerodynamic and aeromechanical factors which might induce or influence flutter in those systems susceptible to that form of vibration.

(d) 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.

(e) The effects on vibration characteristics of excitation forces caused by fault conditions (such as, but not limited to, out-of balance, local blockage or enlargement of stator vane passages, fuel nozzle blockage, incorrectly schedule compressor variables, etc.) shall be evaluated by test or analysis, or by reference to previous experience and shall be shown not to create a hazardous condition.

(f) Compliance with this section shall be substantiated for each specific installation configuration that can affect the vibration characteristics of the engine. If these vibration effects cannot be fully investigated during engine certification, the methods by which they can be evaluated and methods by which compliance can be shown shall be substantiated and defined in the installation instructions required by § 33.5.

5. Section 33.92 is revised to read as follows:

### § 33.92 Rotor locking tests.

If continued rotation is prevented by a means to lock the rotor(s), the engine must be subjected to a test that includes 25 operations of this means under the following conditions:

(a) The engine must be shut down from rated maximum continuous thrust or power; and

(b) The means for stopping and locking the rotor(s) must be operated as specified in the engine operating instructions while being subjected to the maximum torque that could result from continued flight in this condition; and

(c) Following rotor locking, the rotor(s) must be held stationary under these conditions for five minutes for each of the 25 operations.

Issued in Washington, DC, on May 29, 1996.

David R. Hinson,

*Administrator.*

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