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

Advisory Circular

Subject: Turbine Engine Continued Rotation and Rotor Locking

Date: 06/23/2016
Initiated By: ANE-111

AC No: 33.74/92-1B
Change No.: N/A

This advisory circular (AC) provides guidance to demonstrate compliance with Title 14 of the Code of Federal Regulations (14 CFR), Section 33.74, Continued Rotation and Section 33.92, Rotor Locking Tests.

This document complies with the formatting requirements of FAA Advisory Circular System Order No. 1320.46D.

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CHAPTER 1. INTRODUCTION

1.1 Purpose.

This AC provides guidance to demonstrate compliance with Title 14 of the Code of Federal Regulations (14 CFR), Section 33.74, Continued Rotation and Section 33.92, Rotor Locking Tests.

1.2 Change or Cancellation Statement.

1.2.1 Change.

Not applicable.

1.2.2 Cancellation.

AC 33.74/92-1A, Turbine Engine Continued Rotation and Rotor Locking, dated July 23, 2003, is cancelled.

This revision (AC 33.74/92-1B) updates the previous AC to account for paragraph numbering imposed by 2007 rule modifications. It also imposes the reformatting requirements of FAA Order 1320.46D. Finally, we made nontechnical changes to improve clarity.

1.3 Applicability.

1.3.1 Audience.

This AC is directed to engine manufacturers, modifiers, and Federal Aviation Administration (FAA) engine type certification designees.

1.3.2 Compliance Methods.

This AC describes an acceptable means, but not the only means, to make a regulatory showing of compliance. If you (the applicant) use the means described in the AC, you must follow it in all respects. Terms such as “should,” “may,” and “must” are used only in the sense of ensuring applicability of this particular method of compliance when the method of compliance in this AC is used.

If you use a different means, we (the FAA) will evaluate what you provide to determine if you have demonstrated regulatory compliance. We will consider your proposed method(s) and what you present to show that your alternate method demonstrates compliance. If we determine you have demonstrated compliance to the regulation, we will accept your alternate method.

We are not bound by this AC if we find that following it will not result in compliance with the regulations. Also, we may require additional testing before we conclude you have shown compliance, even if you are using the means described in this AC.

1.3.3 Regulatory Impact.

This AC is not mandatory and it does not constitute a regulation. While not mandatory, the guidance it provides is derived from FAA and industry experience in determining compliance with the applicable regulations.

This AC does not change, authorize changes to, or permit deviations from, existing regulatory requirements. This AC also does not create any additional regulatory requirements.

1.4 Suggestions for Improvement.

Use the advisory circular feedback form in APPENDIX A of this AC to:

- Suggest improvements or changes.
- Request clarification.
- Report deficiencies.

1.5 Related Reference Material.

1.5.1 Regulations.

Table 1-1 lists regulations that apply to this AC.

Table 1-1. Relevant Regulations

Number	Title
14 CFR 33	Airworthiness Standards: Aircraft Engines
14 CFR 33.5	Instruction Manual for Installing and Operating the Engine
14 CFR 33.17	Fire Protection
14 CFR 33.74	Continued Rotation
14 CFR 33.75	Safety Analysis
14 CFR 33.92	Rotor Locking Tests
14 CFR 33.94	Blade Containment and Rotor Unbalance Tests
14 CFR 33.201	Design and Test Requirements for Early ETOPS Eligibility

CHAPTER 2. GUIDANCE

2.1 Continued Rotation (14 CFR 33.74).

2.1.1 General.

14 CFR 33.74 imposes a design requirement that basic continued rotation failure conditions or events do not develop into a hazardous event over a sustained continued rotation period. Continued rotation refers to a condition in which any main rotating system in an engine continues to rotate after the engine has been shut down. Continued rotation can be caused by windmilling or mechanical effects, or a combination of both. Windmilling is the rotation of a non-operating engine due to the airflow-induced forces on the blades caused by the forward motion of the aircraft. Mechanical effects include, for example, drive shaft clutch drag in some multiengine rotorcraft installations, which may result in continued rotation of the engine after it has been shut down.

14 CFR 33.74 applies to turbine engines installed in airplanes and rotorcrafts. Compliance to § 33.74 can be by test, analysis, or any method we determine to be acceptable.

2.1.2 Installation Assessment.

Test, analysis, or other data that you use to demonstrate compliance, should represent all planned or intended aircraft engine installations. When you conduct tests or analyses, ensure that the baseline certification assumptions address all intended aircraft applications.

Additional compliance data may be necessary if a future installation is more critical than those assumed in the original certification basis. For examples: two, rather than four, engine installation differences which may impact airflow-induced forces due to different aircraft speed; different mission profile; and implementation of extended operations (ETOPS).

2.1.3 Failure Conditions.

2.1.3.1 General.

You should address any failure condition that results in continued rotation after the engine is shutdown, and show that it will not result in a hazardous condition. Refer to the following subparagraphs (subparagraph 2.1.3.2 through subparagraph 2.1.3.6).

2.1.3.2 Applicable Failure Conditions.

The following conditions may result in continued rotation after the engine is shutdown (other conditions may also apply): loss of rotor centerline support (for example, main bearing failure, bearing support failure, fusing of frangible main bearing designs, etc.); engine rotor airfoil loss and resulting unbalance effects, including § 33.94 fan and turbine blade-out conditions; complete loss of engine oil supply, oil quantity, or oil pressure; and any basic nonhazardous, in-flight shutdown (IFSD) cause, such as fuel starvation.

2.1.3.3 Inherently Hazardous Basic Engine Failures.

Section 33.74 generally does not consider certain inherently hazardous basic engine failures, such as main rotor structure failures (disks, spacers, seals, and shafts. etc.), unless those failures are considered initially nonhazardous; or would likely result in sustained continued rotation of the engine.

Failure of such components usually results in a limited period of rotation after the initial event.

2.1.3.4 Rotor Locking Device Failure.

Section 33.74 generally does not consider rotor locking device failure scenarios, since the rotor locking device is expected to perform its intended function per the requirements of § 33.92. Refer to paragraph 2.2 for guidance.

2.1.3.5 Failed Airframe Structure or Airframe Foreign Object Source Ingestion.

Section 33.74 does not consider ingestion of failed airframe structures (for example, slat/flap or radome parts); or significant airframe foreign object sources (for example, lavatory ice), if beyond the scope of part 33 type certification.

2.1.3.6 Effect of Continued Rotation on Other Aircraft Structures, Systems, or Flight Crew.

Section 33.74 does not apply to the effects of engine continued rotation on other aircraft structures; other aircraft systems; and the flight crew.

2.1.4 Operating Conditions.

2.1.4.1 General.

You should determine the flight conditions that could occur during continued rotation operations. This determination should include, but is not limited to, the criteria described in the following subparagraphs (subparagraph 2.1.4.2 through subparagraph 2.1.4.5).

2.1.4.2 Maximum Exposure Time for Continued Rotation for Individual Event.

Determination of the maximum exposure time for continued rotation must consider all exposure time scenarios regardless of expected probability, and therefore: must not be based on the probability of occurrence as a function of flight phase; should consider special operations, such as ETOPS, and must cover the maximum diversion time of the airplane during such operations; must address the maximum diversion time approved for the engine, if the engine is approved for Early ETOPS eligibility in accordance with § 33.201; and should assume a minimum diversion time of one hour for all non-ETOPS aircraft applications.

2.1.4.3 Turbine Rotor(s) Rotational Speeds within One-Engine Inoperative Flight Envelope.

Determination of turbine rotor(s) rotational speeds within the one-engine inoperative flight envelope should take into account significant flight phases (takeoff, climb, cruise, descent, approach, and landing). It should also consider the effect of engine damage on continued rotation rotor speeds.

2.1.4.4 Unbalance Levels.

Determination of unbalance levels must consider the initial event and subsequent damage, as they apply to the failure condition that you are evaluating.

2.1.4.5 Engines Certificated for Use on Supersonic Aircraft.

You must show compliance for the expected duration at supersonic and supersonic-to-subsonic transition flight conditions. This is in addition to duration of continued rotation for the remainder of flight at subsonic speeds.

2.1.5 Pass/Fail Criteria.

Section 33.74 defines the pass/fail criteria. The compliance determination should consider both the initial event and the duration of the continued rotation.

2.1.6 Compliance Considerations.

2.1.6.1 General.

You should take into consideration the criteria in the following subparagraphs (subparagraph 2.1.6.2 through subparagraph 2.1.6.7) when you develop your analysis technique.

2.1.6.2 Fire Hazards.

Protection against fire is especially important during extended continued rotation periods. Continued rotation of the main rotors, coupled with high unbalance levels, could produce high stress levels in flammable-fluid-conveying parts at sub-idle natural frequencies. Failure of such parts could result in leakage of hazardous quantities of flammable fluids and increased fire hazard. For example, in some engine designs, continued rotation will result in continued main engine oil flow (no shutoff means) with the potential for leakage if certain oil system parts fail. Continued rotation could also result in “rubbing” of titanium rotor and stator components with the potential for a titanium fire and increased fire hazard.

You should assess the applicable continued rotation conditions against the fire protection requirements of § 33.17 and § 33.75. The fire protection assessment should consider both the initial event and the duration of the continued rotation.

2.1.6.3 Fatigue Assessment.

You should perform a fatigue assessment for an installed engine over the assumed diversion profile. This assessment should account for transient exposure to peak vibrations, such as the initial event. This assessment should also account for sustained exposure to vibration loads over the maximum continued rotation period. Average material properties may be used.

For each component you evaluate, you should show the accumulated fatigue damage to be less than or equal to the fatigue damage to failure of the component, so that the conditions of § 33.75(g)(2)(i) through (vi) do not occur over the continued rotation period. The fatigue assessment should consider both the initial event and the duration of the continued rotation.

2.1.6.4 Loads.

You should determine loads on the engine structure by test, validated analysis, or both. You should determine the steady and vibratory loads for the significant operating conditions noted in paragraph 2.1.4 of this AC, and take into consideration: the range of continued rotation frequencies for the various failure events; continued rotation periods; aircraft accelerations; and ambient temperature variation.

Load determination should consider both the initial event and the duration of the continued rotation.

2.1.6.5 Electrical Discharge.

You should consider the potential hazard of electrical discharge from ignition exciters that, by design, continue to build a charge during continued rotation. The objective is to prevent ignition sources within the engine nacelle that may affect maintenance personnel after flight completion.

2.1.6.6 Analysis Methodologies.

Your analysis techniques must be able to provide sufficient detail to determine the continued rotation loads on the installed engine. You must adequately validate these techniques by demonstrating the capability to predict dynamic results for the identified continued rotation conditions.

Before you use an analysis to produce new certification compliance data to represent new design features or new operating environments or operating characteristics, it must be calibrated and validated using data from one of, or a combination of, the following: prior certification test; field data; component tests; and/or acceptable component test or laboratory test.

You must examine any component or laboratory test or tests used to produce new data for quality, applicability to the new product being certified, and adherence to your established engineering and testing standards, or to accepted industry standards.

You may need to use conservative assumptions regarding installation to cover multiple installations.

2.1.6.7 Engine Modeling.

Any models you use should be validated; contain sufficient detail to accurately conduct transient and steady state analyses; include all major engine static and rotating components; and provide for representative connections at the engine-aircraft interfaces.

2.2 Rotor Locking Device (14 CFR 33.92).

2.2.1 General.

A rotor locking device is defined as any flight crew-actuated, engine type design component or system that prohibits engine rotor rotation after engine shutdown. Activation of the rotor locking device stops and prevents continued rotation of the engine rotor(s) during flight, when the engine is not operating. You may incorporate a rotor locking device into the engine type design, or as an aircraft installation requirement.

Incorporation of a rotor locking device complies with the safety objective of § 33.74 (refer to paragraph 2.1). Incorporation of a rotor locking device must satisfy the operational and endurance test requirements identified in § 33.92, when the engine is subjected to the environmental conditions that result in the maximum torque. The assessment of the maximum torque should consider both damaged and undamaged engine rotors.

14 CFR 33.92 applies to turbine engines installed in airplanes and rotorcrafts that incorporate a means to stop and lock the rotor(s) to prevent continued rotation. Compliance to § 33.92 must be demonstrated by test, the means to stop and lock the rotor if continued rotation is prevented.

2.2.2 Reliability.

Because the rotor locking device is not expected to be used frequently, you should show that under normal engine operating conditions, the device will not deteriorate beyond serviceable limits or fail to perform the intended function.

Overall reliability, as related to continued rotation related failure modes, should be consistent with § 33.75(a)(3) requirements for protection against hazardous effects.

2.2.3 Design Criteria.

You should ensure that the rotor locking device is designed so that the flight crew may lock (to stop rotation) and unlock (to initiate engine restart attempts) the device in flight, as required. You should also evaluate the effect an uncommanded activation of the rotor locking device in flight can have on continued safe flight and landing of the aircraft. Significant effects should be explained in the Installation and Operating Instructions required by § 33.5. Finally, you should evaluate the various environmental threat effects (for example, rain, hail, icing, and bird ingestion) on rotor locking device performance over the engine operating envelope. Significant effects should be explained in the Installation and Operating Instructions required by § 33.5.

APPENDIX A. ADVISORY CIRCULAR FEEDBACK FORM

If you find an error in this document, or have recommendations to improve it or to add new subjects, you may complete this form and submit it as follows:

(1) Email: 9-AWA-AVS-AIR500-Coord@faa.gov

(2) Fax: 202-267-3983
Attention: AIR Directives Management Officer

Subject: ____
(document number, subject)

Date: ____________
(mm/dd/yyyy)

Please check all appropriate line items:

☐ Error noted in paragraph ________ on page ________.
(Check all that apply and provide brief description, below)
☐ Editorial
☐ Procedural
☐ Conceptual

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☐ Recommend paragraph ________ on page ________ be changed as follows:
(Provide brief description)

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☐ Recommend the following subject be addressed in a future change to this AC:
(Provide brief description)

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☐ Other comments:
(Provide brief description)

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☐ I would like to discuss the above. Please contact me.

Submitted by: ____ Date: ____________

Organization: ____

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