US Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: General Type Certification Guidelines for Turbine Engines

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Change:

1. Purpose. This advisory circular (AC) provides general guidance concerning type certification projects for aircraft turbine engines. This AC applies to certain sections of Title 14 of the Code of Federal Regulations (14 CFR) parts 21, 33, and 45, and describes or references methods of compliance that may be acceptable for engine type certification work. This guidance is general in nature, and where necessary, further reference is made to other documents, which may be the primary source for information on a particular subject.

2. Applicability.

a. The guidance provided in this document is directed to engine manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration (FAA) engine type certification designees.

b. This material is neither mandatory nor regulatory in nature and does not constitute a regulation. It describes acceptable means, but not the only means, for demonstrating compliance with the applicable regulations. We ("the FAA") will still consider other methods an applicant may present to demonstrate compliance. 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 in this document is used. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with relevant regulations. If we find that following this AC would not result in compliance with the applicable regulations, we will not be bound by this AC, and we may require additional substantiation as the basis for finding compliance.

c. This material does not change, create any additional, authorize changes in, or permit deviations from existing regulatory requirements.

3. Cancellation. AC 33-2B, "Aircraft Engine Type Certification Handbook," dated June 30, 1993, is cancelled.

4. Related Documents. Please check the GPO Access website at http://ecfr.gpoaccess.gov for parts 21, 33, and 45 of 14 CFR.

5. Related Reading Material. Please check the FAA's website at http://www.faa.gov/regulations_policies/ for the latest revision of the following documents:

a. Order 8110.4 et seq., "Type Certification."

b. Order 8110.52 et seq., "Type Validation and Post-Type Validation Procedures."

6. General Type Certification Process. This AC provides guidance to the public about several subjects that can be encountered during the engine certification program. In addition, this AC provides intent and method of compliance guidance for selected part 33 regulations that do not have an independent AC. It should be noted that, beyond this AC, a number of documents exist which provide guidelines for type certification. Order 8110.4 et seq., "Type Certification," contains details of the type certification process and is used by the FAA for U.S. domestic programs. Order 8110.52 et seq., "Type Validation and Post-Type Validation Procedures," contains details of the process that we use for non-U.S. applicants seeking an FAA type certificate (TC) or when U.S. applicants seek a foreign TC. Lastly, "The FAA and Industry Guide to Product Certification," has useful information about conducting type certification programs. The certificate managing Aircraft Certification Office (ACO) can provide information on how to obtain a copy of these orders or the guide.

7. Surplus Military Aircraft Engines and Parts. This section provides guidance for the type certification and airworthiness approval of military-surplus engines and parts. Regulations governing this process are §§ 21.25 and 21.27.

a. Surplus Military Engines for Restricted Category Aircraft.

(1) Section 21.25(a)(2) permits type certification of surplus military aircraft from an Armed Force of the United States (U.S. military), for the special purpose operations defined in § 21.25(b). The engine model supplied with the aircraft does not receive a separate TC; it is included in the aircraft TC. Therefore, the supplied engines are not required to directly comply with part 33 requirements. For engine design changes proposed after the § 21.25 TC is issued, see Order 8110.56 et seq. for instructions.

(2) The applicant must identify in the airworthiness limitations section of the aircraft instructions for continued airworthiness (ICA), the life limits and inspection intervals applicable to the engine life limited parts. If the overall engine load and fatigue spectrum for the special purpose operation is more severe than the U.S. military operation, applicants must determine if the existing life limit and inspection interval values are still applicable, or if revised values are necessary. Applicants may need to develop a fatigue life methodology to accomplish the above actions. See Order 8110.56 et seq. for instructions on determining life limits and preparing the ICA.

(3) The following references provide guidance for the activity of engine military surplus and restricted category aircraft:

(a) Order 8110.4 et seq., "Type Certification."

(b) AC 20-142, "Eligibility and Evaluation of U.S. Military Surplus Flight Safety Critical Aircraft Parts, Engines, and Propellers."

(c) AC 20-62E, "Eligibility, Quality, and Identification of Aeronautical Replacement Parts."

(d) Order 8110.56 et seq., "Restricted Category Type Certification."

(e) Policy No. PS-AIR-100-2003-09-12-03-ResMIl, "Restricted Category/Military Surplus Program Management," dated September 12, 2003.

b. Surplus Military Engines for Normal Category Aircraft. Section 21.27 allows type certification of surplus aircraft from the U.S. military, including the installed engine(s), under normal category. The engine does not receive its own TC, but it must be shown to have substantially the same level of airworthiness as would be provided by part 33 (see § 21.27(c)). The references listed below discuss general requirements for airworthiness certification and provide guidance in making the required determination of engine airworthiness:

(1) Order 8110.4 et seq., "Type Certification."

(2) AC 20-62E, "Eligibility, Quality, and Identification of Aeronautical Replacement Parts."

(3) AC 20-142, "Eligibility and Evaluation of U.S. Military Surplus Flight Safety Critical Aircraft Parts, Engines, and Propellers."

c. Surplus Military Engine Parts for Civil Engines. Certain U.S. military engine parts may have potential for civil use. Parts from dual-use engines may be installed in both restricted and normal category aircraft. Parts unique to the U.S. military may also be installed in restricted category aircraft. The references below outline methods by which military-surplus parts might be installed in civil engines:

(1) AC 20-142, "Eligibility and Evaluation of U.S. Military Surplus Flight Safety Critical Aircraft Parts, Engines, and Propellers."

(2) AC 20-62E, "Eligibility, Quality, and Identification of Aeronautical Replacement Parts."

d. Engine Conversion from Military to Civil Model. Surplus U.S. military engines with an FAA TC may be eligible for conversion from their military model to a civilian counterpart model that also has an FAA TC. These conversions are typically accomplished using approved data found in manufacturer service documents. Those documents also provide the instructions necessary to make the conversion. However, other conversion methods may be possible.

e. New Engine Certification and Production Using Military Surplus Parts. U.S. military surplus parts (new or used), which were originally produced under an FAA-approved quality system (for example, production certificate), may be used for new engine production under a TC and a production certificate (PC). This is not a maintenance activity; it is new production.

f. Importing Surplus Foreign Military Engines and Parts. Used foreign military engines may also be eligible for restricted category under § 21.25(a)(2) if:

(1) The U.S. military procured and accepted the engine for their operational use, and

(2) The U.S. military excessed the engine for public sale.

Imported surplus or foreign military engines that do not meet these requirements are not eligible for restricted category under § 21.25.

g. Engine Parts (New or Used) From Non-Aviation Sources. Derivatives of civil aircraft engines are sometimes used in marine and industrial applications. Parts for these derivative engines may carry the same engine TC holder part numbers as aircraft engines. It is recommended that spare parts be procured from commercial aviation sources, as parts procured from non-aviation sources may not be eligible for installation in aircraft engines.

8. Data Plates. The applicant must comply with part 45, part and product marking and identification requirements. For engines, a fireproof data or identification plate is required per § 45.11. The data plate must contain, at a minimum, the information noted in § 45.13. For example, it must include the exact model name as specified in the TC and TCDS [refer to § 45.13(a)(2)].

a. Optional Information. Optional information may be inscribed on the data plate at the discretion of the applicant. However, optional information should only be added if the information does not conflict with § 45.13 requirements, and if it's placed in a field separate from the engine model designation. For example, a TC holder may wish to specify an engine configuration or aircraft installation for a certain engine model/serial number combination. This could be useful for managing certain type design requirements (e.g., aircraft-specific data entry plug) or fleet-management issues (e.g., life limited part tracking). The designator may be inscribed on the data plate, appearing in a separate field from the model designation.

b. Fireproof Requirement. Part 45 requires that a data plate be fireproof. An acceptable method of compliance is to apply a 2000° Fahrenheit flame over the entirety of the test piece for 15 minutes. The data plate must be readable after the test. See § 33.17 and AC 33.17-1 for related information concerning fire testing of engine components.

c. Mounting the Data Plate. The data plate must be located in an accessible place on the engine where it is easily viewed, will not likely be defaced or dislodged during normal operation or maintenance, and will not be lost or destroyed in an accident. Additional information about compliance with part 45 is contained in AC 43-17, "Methods, Techniques and Practices

Acceptable to the Administrator Governing the Installation, Removal or Change of Identification Data and Identification Plates."

9. Part 33 Guidance Material. This paragraph contains guidance for selected sections of part 33.

a. Section 33.19, Durability. Section 33.19(a) requires that the engine be designed and constructed to minimize the development of an unsafe condition between overhaul periods, and that the compressor and turbine rotor containment case structures be designed to contain the damage from a rotor blade failure. The containment structures must retain this capability throughout their service lives, as maintained in accordance with the ICA. So, § 33.19 provides a general safety standard for engines between "overhaul" periods, and for rotor blade containment and propeller pitch controls.

(1) References:

(a) AC 33-4, "Design Considerations Concerning the Use of Titanium in Aircraft Turbine Engines."

(b) AC 33-5, "Turbine Engine Rotor Blade Containment/Durability."

b. Section 33.21, Engine Cooling. This section addresses operating fluid, external engine surface, component operating temperature, secondary bleed air system, as well as other related cooling considerations, such as internal flow-path cooling of turbochargers, rotors, spacers, nozzles, combustors, cases, etc. The safe operation of all critical structural components is of utmost importance. Applicants should ensure that a stable engine operating environment is maintained, thereby safeguarding engine component's integrity throughout their design life and/or time to inspection, as appropriate.

(1) References: None.

c. Section 33.23, Engine Mounting Attachments and Structure. This section requires the applicant to specify the maximum allowable limit and ultimate loads for engine mounting attachments and related engine structure. Methods for determining and substantiating these values are described below.

(1) Limit loads are the maximum static and dynamic operational loads expected to occur in service. There are several sources of mount loading that need to be considered when calculating the overall limit loads imposed upon the engine attachment mount structure. These include static loads, operating engine maximum reactive torque loads, gyroscopic loads, maximum ground and flight maneuver loads, and gust loads. Ultimate load capability is specified by the applicant, and is generally related to certain engine failure cases (e.g., fan blade or main rotor support failure) or emergency aircraft maneuvers. The engine applicant should coordinate with the installer to determine expected loads on the engine mount structure.

(2) Rig and component level testing and validated analysis are acceptable methods for

demonstrating load capability under § 33.23.

(3) Engine mounting attachments and structure designs should consider low cycle fatigue (e.g., the applicability of § 33.70), corrosion, and other deterioration effects expected during the design life of the engine.

(4) References: None.

d. Section 33.25, Accessory Attachments. This section requires that engine accessory drives and their mount pads permit proper engine operation at maximum loads; prevent contamination and excessive loss of oil; and permit inspection, adjustment, and removal of accessories. Some engine accessory drives are protected from potential failure conditions (such as accessory seizure) by drive shaft shear features. In this case, applicants must show that the shear feature will not fail under all normal operating load conditions. Applicants should also show that the shear section will not otherwise result in damage or hazard to the engine or aircraft installation.

(1) References: None.

e. Section 33.29, Instrument Connection. This section describes instrumentation requirements. In § 33.29(b), "turbojet" includes both turbofan and open rotor engine types. The installation instructions required by § 33.5 should contain all instrumentation information needed by the installer.

(1) References:

(a) AC 33-7A, "Guidance for 30-Second and 2-Minute One-Engine-Inoperative (OEI) Ratings for Rotorcraft Turbine Engines."

(b) AC 33.28-1, "Compliance Criteria for 14 CFR § 33.28, Aircraft Engines, Electrical and Electronic Engine Control Systems."

f. Section 33.66, Bleed Air System. The need to restrict bleed airflow should either be incorporated in the engine type design, such as by an orifice, or otherwise specified in the engine installation instructions and engine TCDS.

(1) References: None.

g. Section 33.67, Fuel System. This section requires that the engine fuel system be designed and constructed to operate satisfactorily under all applicable operating conditions. For § 33.67(b)(5) compliance, one-half the average predicted mission flight time has been considered acceptable for the demonstration time period. Test demonstrations should be conducted at fuel flows most critical to the mission. We recommend Table X of Military Specification MIL-E-5007E (AS), "Engines, Aircraft, Turbojet and Turbofan, General Specification For, Table X, Typical Fuel Contaminants," dated September 1, 1983, for examples of typical fuel contaminants, particle sizes, and quantities to be considered.

(1) Reference: Military Specification MIL-E-5007E(AS), "Engines, Aircraft, Turbojet and Turbofan, General Specification For, Table X, Typical Fuel Contaminants," dated September 1, 1983.

h. Section 33.69, Ignition System. The engine installation instructions should define the characteristics and interface requirements for all sources of electrical power required by the engine ignition system for reliable operation.

(1) Reference: Policy No. PS-ANE100-2001-1998-33.69-R1, "Policy for Evaluating Ignitions System Requirements, 14 CFR 33.69," dated February 26, 2001.

i. Section 33.84, Engine Overtorque Test. This section applies to turboshaft and turbopropeller type engines, which incorporate a free power turbine. This requirement allows the applicant to establish a maximum overtorque operating limit as follows:

(1) The maximum overtorque limit is approved for use for up to 20 seconds maximum duration, and for all conditions except operation at the 30-second/2-minute OEI rating (see reference below for limit definition).

(2) This limit addresses a main rotor droop condition primarily affecting turboshaft engines with free power turbines; however, certain turbo propeller installations may exhibit the same phenomena. An overtorque condition may also occur following an in-flight loss of power. For example, an engine failure on a multi-engine rotorcraft might reduce available power by half, resulting in an instantaneous decrease in scheduled main rotor speed. As the main rotor control system corrects this droop by commanding a speed increase, and with additional collective normally applied by the pilot to maintain flight path, power demand at the main rotor increases sharply. It is due to this increased power demand that an overtorque condition may occur. Torque produced while the operating engine accelerates the main rotor back to its normal operating speed can cause high stress in the engine power transmission components.

(3) The power or torque-transmitting components in a free turbine engine are typically the turbine blades, disks, shafts, and gears (if configured with a gearbox). Torque has varying effects on the stress levels of these components. The following situations generally apply when analyzing these power transmission components:

(a) Turbine blades and disks are dominated by centrifugal loads, with overall strength being affected by core gas temperature. The torque produced by core gas loads has only a minor effect with regard to the total stress on turbines and blades.

(b) The stress levels of shafts and gears are typically dominated by the amount of torque they are transmitting. Shafts and gears are minimally affected by core gas temperatures.

(4) Typically, the time spent at maximum steady-state speed and temperature limits during the endurance test required by § 33.87, results in a more severe demonstration of stress and durability than would occur during a maximum overtorque event. This data can sometimes be

used to support compliance with § 33.84(b)(4). Therefore, the requirement to run the overtorque test at maximum steady-state temperature may be adjusted if you obtain FAA approval.

(5) Reference: 14 CFR part 1, § 1.1, General Definitions *(Maximum engine overtorque).*

j. Section 33.88, Engine Overtemperature Test. This test demonstrates a minimum overtemperature capability for the engine model.

(1) This rule requires a test demonstration on a complete engine. The test vehicle and facility should be set up to minimize any mismatch of internal flow capacities of components and systems.

(2) For § 33.88(a) compliance, the maximum permissible rpm and indicated turbine gas temperature refer to the highest approved steady-state values, which are specified in the engine TCDS. This includes limits associated with all ratings, including OEI ratings of 2 ½-minute duration or greater.

(3) Section 33.88(b) contains additional test requirements for engines with a 30-second OEI and 2-minute OEI rating.

(4) The test overlimit values (e.g., 75 °F / 35 °F) must be applied at the turbine inlet station (typically called T4), not the type design operating limit measurement station (e.g., EGT or ITT). It remains, however, that the overtemperature test value is a function of the maximum steady-state operating temperature limit (at the type design measurement location). To determine the proper overtemperature test value, determine the turbine inlet (T4) temperature associated with the maximum steady-state limit value (at the type design measurement location). Add the overlimit value to this turbine inlet temperature (T4) to obtain the overtemperature test value for indicated turbine gas value.

(5) Post-test acceptance criteria for § 33.88(a) testing requires that the engine turbine assembly and support structure be within serviceable limits. Applicable components include, but are not limited to, blades, discs, drums, spacers, shafts, seals, stators, nozzles, and support structure. Serviceable limits are as specified in the ICA, as required by § 33.4. Post-test acceptance criteria for § 33.88(b) testing requires the turbine assembly to maintain its integrity at the end of the test. Maintaining integrity means that no imminent failure conditions are evident, and that the engine can continue to operate for continued safe flight and landing after the event.

(6) References:

(a) AC 33-3, "Turbine and Compressor Rotors Type Certification Substantiation Procedures."

(b) Policy No. PS-ANE100-1988-00007, "Clarification Guidance on Implementation of FAR Section 33.88 Overtemperature Test," dated December 22, 1988.

(c) Policy No. PS-ANE100-1997-00004, "Engine Overtemperature Test; Governing

Temperature Location," dated October 7, 1997.

k. Section 33.89, Operation Test. The operations test must include all testing found necessary by the FAA to demonstrate safe operating characteristics throughout the specified operating envelope. Engine and component testing required for other part 33 sections may be used to show compliance to this section. The operations test should include tests to:

(1) Demonstrate start characteristics throughout the starting envelope.

(2) Demonstrate engine operation throughout the temperature and altitude envelopes.

(3) Demonstrate the ability of the engine to operate without damaging surge or stall (see § 33.65).

(4) Show adequate operational margins for variations in fuel schedule, variable geometry schedules, and installation/environmental effects.

(5) Demonstrate the ignition system design duty cycle.

(6) Demonstrate operation of the propeller parking brake (if equipped).

(7) References: None.

l. Section 33.95, Engine-Propeller Systems Tests. This test exercises the complete engine relative to propeller pitch and speed control, feathering, negative torque sensing, and decouplers.

(1) Compliance with this section is achieved by successfully completing the applicable tests and test cycles listed in § 33.95, paragraphs (a), (b), (c), and (d). Tests may be performed on an engine test stand, a test rig (such as a modified dynamometer rig or a propeller gearbox component test rig), or during flight test.

(2) Paragraphs (a) and (d) of this section address the feathering and reversing cycle tests. They are typically conducted with a propeller on an engine test stand in conjunction with other tests, such as the engine endurance test. Alternately they may be conducted on an aircraft in conjunction with flight tests.

(3) Paragraphs (b) and (c) of this section address the negative torque and thrust tests. The decoupling tests required by paragraph (c) are typically run on an aircraft during flight or on a test rig. The reason for this is the engine system requires a negative torque or thrust-load input from the propeller. Negative torque is achieved in-flight with a windmilling propeller. On a test rig, a device drives the propeller shaft to achieve negative torque.

(4) When testing on a rig, the propeller should be represented in a manner that directly matches its polar moment of inertia. A flywheel or similar device is appropriate to this purpose.

Failure to properly match the design of the "representative propeller" to the propeller may cause inadvertent decoupling or torque sensing to occur during undesired operating conditions, such as during engine shutdown or other transients.

(5) When conducting any of these tests, specialized instrumentation will generally be needed to detect and record the operation of the systems being tested.

(6) Successful completion of the tests means that the engine-actuated propeller control functions as intended, without detrimental effect on either the engine or the propeller.

(7) References: None.

m. Section 33.96, Engine Tests In Auxiliary Power Unit (APU) Mode. This test demonstrates engine operability and durability when operating in APU mode.

(1) These tests assess steady-state and dynamic operations including:

(a) Hot section tolerance for locked rotor operations, including effects on combustor stability/coking, turbine nozzle integrity, turbine blade integrity, and vibration.

(b) Engine drive system stability/response, including the power turbine rotors, shafting, bearings and supports, the reduction and accessory gear trains, and rotor brake components.

(2) These propeller brake tests may be conducted in conjunction with the required tests of § 33.87, where applicable, and as approved by the FAA. The rotor brake system features, including operating instructions and limitations, should be described in the installation and operating manual as required under § 33.5.

(3) References: None.

n. Section 33.97, Thrust Reversers. This section requires demonstration of thrust reverser operation and durability. Section 33.97(a) states that the thrust reverser must be installed for the endurance, calibration, operation, and vibration tests required under subpart F of part 33.

(1) Reference: AC 20-18A, "Qualification Testing of Turbo-jet Engine Thrust Reversers."

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