U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: Qualification Testing of Turbojet and Turbofan Engine Thrust Reversers

Date: July 7, 2015
Initiated By: ANE-111

AC No: 20-18B

1. Purpose. This advisory circular (AC) provides guidance for demonstrating compliance with Title 14 of the Code of Federal Regulations (14 CFR) 33.97, Thrust reversers, and for certifying a thrust reverser for use with a turbojet or turbofan engine. It does not address aircraft-level effects of the installation and use of a thrust reverser.

2. Applicability.

a. The guidance provided in this AC is directed to engine manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration (FAA) 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 will consider other methods an applicant may present to demonstrate compliance. We use terms such as “should,” “may,” and “must” only in the sense of ensuring applicability of this particular method of compliance when the method in this AC is used.

c. While these guidelines are not mandatory, we derived them from extensive FAA and industry experience in determining compliance with the relevant regulations. If we find that following this AC would not result in compliance with the applicable regulations, this AC will not bind us, and we may require additional proof as the basis for finding compliance.

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

3. Cancellation. AC 20-18A, Qualification Testing of Turbojet Engine Thrust Reversers, dated March 16, 1966, is cancelled.

4. Related Regulations.

a. 14 CFR 23.933, Reversing systems.

b. 14 CFR 23.934, Turbojet and turbofan engine thrust reverser systems tests.

c. 14 CFR 25.933, Reversing systems.

d. 14 CFR 25.934, Turbojet engine thrust reverser system tests.

e. 14 CFR 25, Appendix K to Part 25—Extended Operations (ETOPS).

f. 14 CFR 33.28, Engine control systems.

g. 14 CFR 33.63, Vibration.

h. 14 CFR 33.85, Calibration tests.

i. 14 CFR 33.87, Endurance test.

j. 14 CFR 33.89, Operation test.

k. 14 CFR 33.97, Thrust reversers.

l. 14 CFR 33.99, General conduct of block tests.

5. Background.

a. Experience has shown that guidance is required on the extent of thrust reverser system testing that applicants must do to show compliance to § 33.97. Experience has also shown that the purpose of including the thrust reverser in the tests listed in § 33.97(a) is not intuitively clear from reading the text of the regulation. In addition, guidance is required on the extent of the thrust reverser system needed to comply with the § 33.97(b) test. This AC provides that guidance.

b. Different applicants consider the thrust reverser to be part of the engine or part of the airplane. The regulations are set up to allow thrust reversers for turbojet and turbofan engines to be certified at the engine level under part 33, or at the airplane level under parts 23 or 25. Sections 23.934 and 25.934 both require that thrust reversers certified at the airplane level meet the requirements of § 33.97. Section 23.934 also allows for testing other than that specified in § 33.97(a) and (b) to be used, if engine operation and vibratory levels are not affected. The text of § 25.934 does not allow for alternate testing methods to replace the requirements of § 33.97(a) and (b). This AC provides guidance for complying with § 33.97.

c. Applicants have raised further questions as to how to account for variations from standard-rated severity levels when conducting thrust reverser testing under ground static conditions with non-standard and varying atmospheric conditions. The actual thrust levels and engine exhaust gas temperature (EGT) for thrust reversers using core or mixed flow are of particular importance in this respect for reverser cyclic testing. This AC provides guidance on how to account for non-standard and varying atmospheric conditions with fan-only and core/mixed-flow thrust reversers.

6. Guidance. The endurance, calibration, operation, vibration and cyclic testing conducted under § 33.97(a) and (b) must use a thrust reverser that is the same as the proposed type design to the extent defined in paragraphs 7 and 8 of this AC. The § 33.97(b) test must meet minimum severity levels as described in paragraph 9 of this AC. The objective of § 33.97(a) testing is to ensure that the thrust reverser installation and operation do not damage the engine or reduce its operability. The objective of § 33.97(b) testing is to demonstrate the durability of the thrust reverser assembly.

7. Engine Compatibility Testing. The reason for including the thrust reverser in the endurance, calibration, operation, and vibration tests, as prescribed by § 33.97(a), is to ensure

that the installation and use of the thrust reverser does not adversely impact the performance, durability, or operability of the engine. The tested thrust reverser must be representative of the type design to the extent described below.

a. Endurance test.

(1) The endurance test, as prescribed by § 33.87, does not require actuation of the thrust reverser. If the thrust reverser does not use core or mixed flow gasses, then actuating it under the conditions of the endurance test is not necessary to meet the requirements of § 33.97. For thrust reversers that use core or mixed gas flows, see the guidance on thrust reverser cyclic test severity in paragraph 9 of this AC.

(2) While the reverser may remain in the stowed position, the entire thrust reverser assembly, including any related supporting parts, must be included in the test. The reason for incorporating the type design thrust reverser in the endurance test, even if the thrust reverser is not actuated, is to ensure that the mechanical and aerodynamic loads from the stowed thrust reverser are applied to the engine. Any deviations between the type design thrust reverser and the thrust reverser used during the test must not affect the mechanical or aerodynamic loads on the engine.

(3) The thrust reverser control system does not need to be operational for the endurance test prescribed by § 33.87. Note that under § 33.97, cyclic testing may be, but does not have to be, conducted at the same time, or on the same engine as the § 33.87 endurance test. If the thrust reverser cyclic testing is combined with the § 33.87 endurance test, refer to the discussion on the control system in paragraph 8 of this AC.

(4) The initial maintenance inspection test requires consideration of the reverse thrust portion of the flight cycle, and the AC on Initial Maintenance Inspection (IMI), encourages incorporation of the thrust reverser during the test. Under part 25, appendix K, § K.25.2.2(d) for extended operations (ETOPS), the thrust reverser must be included in the IMI test. See §§ 33.90 and 33.201, and their associated ACs for further guidance.

b. Calibration test. The calibration test, as prescribed by § 33.85, does not require actuation of the thrust reverser. This is because the calibration test does not measure reverse thrust, which is not a rating under § 33.7. The reverser may remain in the stowed position. The thrust reverser assembly, including any parts that might affect the performance of the engine, must be included in the test. Any deviations between the type design thrust reverser and the thrust reverser used during the test must not affect the performance of the engine. The thrust reverser control system does not need to be operational for the calibration test prescribed in § 33.85. The reason for not measuring reverse thrust performance under part 33 is that it is highly dependent on the installation of the engine/reverser combination on the airplane.

c. Operation test.

(1) During the operation test, as prescribed by § 33.89, the applicant must actuate the thrust reverser to ensure its use in service will not adversely affect the operating characteristics of the engine. The applicant must demonstrate that use of the thrust reverser will not cause a surge or a stall to the extent that a flameout, structural failure, over-temperature, or failure of the engine to recover power or thrust would result.

(2) The applicant must install the entire thrust reverser assembly on the engine to demonstrate that the operability of the engine is not adversely affected. Any deviations between the type design thrust reverser and the thrust reverser used during the test must not affect the operating characteristics of the engine.

(3) The operation test must demonstrate that at all positions throughout its normal range of travel, the thrust reverser will not adversely affect the operating characteristics of the engine. The thrust reverser control system does not need to be used to actuate the thrust reverser if the applicant can show that any transient effects that occur during actuation are less severe than the effects demonstrated during the test.

(4) If part or all of the operation test is combined with another test, sufficient data must be captured to meet the requirement of § 33.89 to demonstrate that the engine has safe operating characteristics throughout its specified operating envelope. In the case of the thrust reverser, the specified operating envelope must include any adverse engine operating and environmental conditions, e.g., airspeeds, altitude, temperature, where the thrust reverser is intended to be used.

d. Vibration test.

(1) The applicant must actuate the thrust reverser during the vibration test. Actuation of the thrust reverser, as prescribed by § 33.83, is required to ensure its use in service will not adversely affect the engine.

(2) The applicant must show that the vibration test demonstrates that the vibration characteristics of those components that may be subject to mechanically or aerodynamically induced vibratory excitations are acceptable during thrust reverser actuation. The applicant must show that thrust reverser actuation will not cause subsequent damage. In addition, the test must show that the thrust reverser meets the requirements of § 33.63, i.e., the engine should not induce excessive stress in any part of the thrust reverser because of vibration.

(3) For the same reason as with the operation test, the entire thrust reverser assembly must be installed on the engine. Additionally, the vibration test must demonstrate that at all positions throughout its normal range of travel, the thrust reverser will not induce excessive stress on any engine part.

(4) The thrust reverser control system does not need to be used to actuate the thrust reverser if the applicant can show that any transient effects that occur during actuation are less severe than the effects demonstrated during the test. Any deviations between the type design thrust reverser and the thrust reverser used during the test must not affect the mechanical or aerodynamic loads on the engine.

(5) The vibration test of the engine with the thrust reverser installed may be combined with the operation test of § 33.89 if the applicant can show that the other requirements of §§ 33.83 and 33.89 are complied with.

8. Thrust Reverser Cyclic Testing.

a. The purpose of the cyclic testing, as prescribed by § 33.97(b), is to demonstrate thrust reverser durability. Therefore, the entire type design thrust reverser assembly must be installed on the engine.

b. To ensure the cyclic testing actuates the thrust reverser in the same way it will be operated in service, the applicant must incorporate the thrust reverser control system up to the point where the engine meets the aircraft or aircraft pylon.

c. Because this is a test of the thrust reverser and not the airplane wiring/control system, the portion of the thrust reverser system installed on the airplane does not need to be included in the test set-up. For example, it is not necessary to include the wires or linkages from the engine pylon to the cockpit. Any slave control hardware or software used, however, must cause the thrust reverser to actuate in the same way as the type design control system. Other than minor repairs or service during the test as allowed by § 33.99(b), the thrust reverser must be serviceable according to the Instructions for Continued Airworthiness (ICA) after completion of the test.

9. Thrust Reverser Cyclic Test Conditions.

a. Section 33.97(b) requires 175 reversals from flight-idle thrust to maximum reverse thrust, and 25 reversals from rated takeoff thrust to maximum reverse thrust. Whether maximum EGT is required depends on the design of the thrust reverser. If the thrust reverser only uses bypass air and is not exposed to core exhaust gases, then the EGT at maximum rated thrust is not critical.

b. Some thrust reversers use core exhaust gas, for example, when a clam-shell design is used, or mixed flow, combined fan and core cascade designs. In those designs, the thrust reverser will be exposed to core-exhaust temperatures, which are much higher than fan-exit temperatures and depend on the EGT at the start of the actuation cycle. The worst core temperatures are defined under § 33.87. For such designs, the applicant must show that the thrust reverser assembly is capable of withstanding the temperatures it would be exposed to under the conditions of the endurance test under § 33.87 during the 25 reversals from rated takeoff thrust to maximum reverse thrust. Nonetheless, the intent of § 33.97(b) is for the thrust reverser endurance cycles to represent in-service operation.

c. As discussed above, the endurance test of § 33.87 does not require thrust reverser actuation. For convenience, however, the applicant may decide to conduct the reversals required by § 33.97(b) during the endurance test under § 33.87, or in a separate test. If the tests under §§ 33.87 and 33.97(b) are combined, consider the impact of the § 33.97(b) cycles on the demonstration of compliance with § 33.87.

10. Relationship to Other Regulations.

a. The airworthiness regulations are structured to allow the applicant to certify thrust reversers either at the airplane level under parts 23 and 25, or at the engine level under part 33. When certifying the thrust reverser as part of the airplane, both §§ 23.934 and 25.934 specifically call out compliance with § 33.97. Section 23.934 allows testing, other than that specified in § 33.97(a) and (b), to be used if engine operation and vibratory levels are not affected. The text of § 25.934 does not allow for alternate testing methods to replace the requirements of § 33.97(a) and (b).

b. If the engine control system (e.g., full authority digital engine control software) controls the deployment of or is involved in the deployment and operation of the thrust reverser, then the applicant must address the safety of the related software and control hardware in the control-system system safety assessment. The applicant should include the thrust reverser in the safety

assessment to ensure that the thrust reverser control system does not cause unacceptable thrust changes or oscillations (refer to § 33.28(e)). In addition, §§ 23.933(a) and 25.933(a) incorporate requirements on the effects of potential inadvertent thrust reverser deployment.

c. When planning to certify a thrust reverser at the part 33 level, the applicant may wish to coordinate with the airplane manufacturer to determine whether any of the requirements in §§ 23.933 and 25.933 could be met coincidentally with the engine-level testing under § 33.97.

If you have any suggestions for improvements or changes, you may use the template provided at the end of this AC.

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An error has been noted:

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Recommend paragraph _____ on page _____ be changed as follows:
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In a future change to this advisory circular, please include coverage on the following subject:
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