U.S. Department
of Transportation

**Federal Aviation Administration**

# Advisory Circular

| **Subject:** Engine System and Component Tests | **Date:** 12/9/10 | **AC No:** 33.91-1 |
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| | **Initiated By:** ANE-111 | **Change:** |

**1. Purpose**. This advisory circular (AC) provides guidance and acceptable methods, but not the only methods, that may be used to demonstrate compliance with the engine component and systems test requirements under Title 14 of the Code of Federal Regulations (14 CFR), part 33, specifically § 33.91, paragraphs (a) and (b).

**2. Applicability**.

a. The guidance provided in this AC is directed to the engine manufacturer, modifier, or foreign regulatory authority.

b. This material is neither mandatory nor regulatory in nature and does not constitute a regulation. The FAA will consider other methods of demonstrating compliance that an applicant may elect to present. Terms such as "should," "shall," "may," and "must" are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance in this document is used. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations. On the other hand, if we become aware of circumstances that convince us that following this AC would not result in compliance with the applicable regulations, we will not be bound by the terms of this AC, and we may require additional substantiation as the basis for finding compliance.

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

**3. Applicable Regulation**. 14 CFR part 33.91, Engine System and Component Tests, paragraphs (a) and (b).

**4. Definitions**. For the purpose of this AC, the following definitions apply:

a. Component: Any individual device that is part of a specific engine system. Examples of engine components include, but are not limited to, fuel pump, oil pump, hydraulic pump, heat exchanger, hydromechanical fuel control, bleed air check valve, fuel shutoff valve, electronic

engine control device, ignitors, exciters, engine parameter sensors, accessory drive gearbox, etc. These components are generally mounted externally on the engine case, but some may be internally mounted, such as the temperature, pressure, speed, and torque sensors. Other types of components may also be affected.

b. System: A combination of inter-related components arranged to perform a specific function. Examples of engine systems are lubrication (e.g., main engine oil), hydraulic, air bleed (e.g., secondary/cooling/anti-ice), electrical, or similar engine type functions.

**5. General**. The intent of § 33.91, paragraphs (a) and (b) is to demonstrate by test that engine components and systems will perform satisfactorily in service, when operated at the limits of engine environmental and operating conditions. This requires that an individual component or complete system be tested under a variety of conditions. The applicable environmental conditions will vary with the type of component, engine model, intended aircraft installation, and corresponding operating conditions and limitations. Testing under § 33.91, paragraphs (a) and (b) is generally conducted when endurance testing under § 33.87 (or other part 33 requirements) is not sufficient to cover the extreme conditions that can be encountered in service. Successfully completing the applicable tests in accordance with the methods of compliance described in this AC, may be an acceptable showing of compliance to § 33.91, paragraphs (a) and (b). See Appendix 1 of this AC, reference 1, paragraphs 1-4 provide an additional perspective on general historical § 33.91 compliance.

**6. Test Categories**.

a. Table 1 below provides a summary of the testing we have found sufficient to meet the requirements of § 33.91, paragraphs (a) and (b). The identified test procedures cover many components and systems, however, not all test categories will apply to all types of components or systems, and other test categories that are not listed may apply. The identified tests are only required when the engine certification program content does not expose the component to the extreme conditions defined for that engine type design. Table 1 of reference 1 provides guidance on when a test category would generally apply to a particular component or system. Also, the latest revision of documents referenced in Table 1 should be applied unless otherwise identified in the approved test plan.

b. The references in Table 1 generally provide acceptable guidance for the noted test categories. However, the test parameter ranges specified in these documents must be verified to ensure they cover the component throughout the engine operating environment, including limits specified in the engine Installation Manual. Specific test procedures or limits should be developed when the test parameter ranges or procedures specified in the referenced documents are not sufficient to cover the engine operating environment.

**TABLE 1**

| Test No. | Test Category | Acceptable Test Procedures | Comment |
|---|---|---|---|
| 1 | High Temperature | ARP5757 Sec 5.1 | See Note 1 |
| 2 | Low Temperature | ARP5757 Sec 5.2 | See Note 1 |
| 3 | Room Temperature | ARP5757 Sec 5.3 | See Note 1 |
| 4 | Contaminated Fluids | ARP5757, Section 5.4 | See Note 1 |
| 5 | Vibration | DO-160 Section 8 | See Notes 2 and 3 |
| 6 | Operational Shock & Crash Safety | DO-160 Section 7 | See Notes 2 and 3 |
| 7 | Sustained Acceleration | ARP5757, Section 5.7 | See Note 1 |
| 8 | Sand & Dust | DO-160 Section 12 | See Notes 2 and 3 |
| 9 | Fluids Susceptibility | DO-160 Section 11 | See Notes 2 and 3 |
| 10 | Salt Fog | DO-160 Section 14 | See Notes 2 and 3 |
| 11 | Fuel System Icing | ARP5757, Section 5.11 | Refer to § 33.67 for requirements. |
| 12 | Induction Icing | AC 20-147 | Refer to § 33.68 for requirements and AC 20-147 for guidance. |
| 13 | Fungus Resistance | DO-160 Section 13 | See Notes 2 and 3 |
| 14 | Temperature & Altitude | DO-160 Section 4 | See Notes 2 and 3 |
| 15 | Temperature Variation | DO-160 Section 5 | See Notes 2 and 3. (Also refer to § 33.28(b) and AC 33.28-1 (Chapter 7-3.a.(1) |
| 16 | Explosive Atmosphere | DO-160 Section 9 | See Notes 2 and 3 |
| 17 | Humidity | DO-160 Section 6 | See Notes 2 and 3 |
| 18 | Waterproofness | DO-160 Section 10 | See Notes 2 and 3 |
| 19 | Environmental Limits<br>• Lightning<br>• Electromagnetic Interference (EMI)<br>• High Intensity Radiated Fields (HIRF) | DO-160 Sections 15, 19, 20, 21 and 22 | Refer to § 33.28(b)(2) and AC 33.28 for additional information about environmental limits requirements for engine control system components (see Note 4). |
| 20 | Power Input & Voltage Spike | DO-160 Sections 16, 17 and 18 | See Notes 2 and 3 |
| 21 | Proof Pressure | ARP5757 Sec 5.21 | See Note 1 |
| 22 | Burst Pressure | ARP5757 Sec 5.22 | See Note 1 |

**TABLE 1** (continued)

| Test No. | Test Category | Acceptable Test Procedures | Comment |
|---|---|---|---|
| 23 | Pressure Cycling | ARP5757, Section 5.23 | See Note 1 |
| 24 | Fire Protection | AC 33.17-1 | Refer to § 33.17 for requirements and AC 33.17-1 for guidance |
| 25 | Specialized Tests<br>• Electronic Engine Control Overheat | AC 33.28-1 and AC 33.28-2 | Refer to § 33.28 for requirements. See AC 33.28-1 and AC 33.28-2 for guidance on FADEC overheat testing. |
| 26 | Containnment | ARP5757, Section 26 | See Note 1 |

**Note 1**: See reference 1 in Appendix 1 of this AC (SAE ARP5757).
**Note 2**: See reference 2 in Appendix 1 of this AC (RTCA DO-160).
**Note 3**: Reference 3 (AC 21-16) provides information concerning the use of reference 2 for type certification purposes.
**Note 4**: Section 33.28(b)(2) refers to § 33.91 with respect to certain environmental limits demonstration requirements.

c. Test Category Descriptions:

(1) High Temperature: To verify that the component can function as intended in its maximum temperature environment, and to identify any damage that could be caused by exposure to maximum temperatures that may lead to component malfunction or failure.

(2) Low Temperature: To verify that the component can function properly in its minimum temperature environment, and to identify any damage that could be caused by exposure to minimum temperatures that may lead to component malfunction or failure.

(3) Room Temperature: To identify any component damage caused by extended operation at room temperature, which could lead to component malfunction or failure.

(4) Fluid Contamination: To verify the component can function properly in a contaminated fluid environment.

(5) Vibration: To verify that exposure to the declared vibration environment does not cause structural failure, and that the component functions properly in that environment. The declared vibration environment is that environment utilized for compliance with § 33.63, Vibration (see AC 33.63-1, titled “Turbine Engine Vibration”); or other known engine vibration environment if more severe.

(6) Operational Shock & Crash Safety: The operational shock test is to verify the component can function properly when exposed to the shock/impact load conditions experienced during normal aircraft operations. The crash safety test is to verify that certain equipment will not detach from its mountings during an emergency maneuver in a manner that results in a hazardous engine effect.

(7) Sustained Acceleration: To verify the component can function properly when exposed to the expected acceleration forces associated with aircraft operations, and to identify any damage caused by exposure to those forces.

(8) Sand & Dust: To verify the component can function properly after exposure to a sand and dust environment, and to identify any damage caused by that exposure which could lead to a malfunction or failure.

(9) Fluid Susceptibility: To verify the component can function properly after exposure to common aviation fluids, and to identify any damage caused by that exposure which could lead to a malfunction or failure.

(10) Salt Spray: To verify the component can function properly after exposure to a salt spray environment, and to identify any damage caused by that exposure that could lead to a malfunction or failure.

(11) Fuel System Icing: To verify the fuel system components operate properly when exposed to fuel icing conditions. Refer to § 33.67 for test conditions.

(12) Induction Icing: To verify the component can function properly when the engine inlet is exposed to icing conditions. Refer to § 33.68 and AC 20-147, titled “Turbojet, Turboprob, and Turbofan Engine Induction System Icing and Ice Ingestion” for more information about icing requirements and methods of compliance.

(13) Fungus: To verify the component materials of construction do not support the growth of fungi.

(14) Temperature & Altitude: To verify that the component operates properly throughout the engine operating envelope.

(15) Thermal Cycle: To verify the component operates properly when exposed to temperature variations between the high and low extremes during flight operations.

(16) Explosion Proof: To verify the component cannot be the source of ignition for an explosion of flammable fluids or vapors in the surrounding atmosphere.

(17) Humidity: To verify the component operates properly when exposed to a high humidity atmosphere.

(18) Waterproofness: To verify the component operates properly after exposure to water spray or condensation, and to identify any damage caused by the exposure that could lead to malfunction or failure.

(19) Lightning/EMI/HIRF: To verify the component can adequately withstand the effects of prescribed lightning, EMI and HIRF effects.

(20) Power Input/Voltage Spike: To verify the component can function properly over the full range of declared electrical power inputs.

(21) Proof Pressure: To verify that the component can withstand the maximum working pressure (with margin) without damage or leakage, and remains in a serviceable condition.

(22) Burst Pressure: To verify the component can withstand the maximum possible pressure (with margin), without fracture or burst.

(23) Pressure Cycling: To verify the component can withstand the expected operational internal operational fluid pressure cycles without structural failure during the expected life of the component.

(24) Fire Protection: To demonstrate that the design and construction methods used minimize the occurrence and spread of fire. Refer to § 33.17 and AC 33.17-1, titled "Fire Prevention" for more information about fire protection requirements and methods of compliance.

(25) Specialized Tests (Electronic Engine Control Overheat): To verify the electronic elements of the engine control system do not cause an unsafe condition when exposed to operating temperatures exceeding specified limits.

**7. Conduct of Tests**.

a. Connection and Orientation of Components under Test: Generally, the test article should be connected and oriented (mechanically and electrically) in a similar manner (or functional equivalent) as it would be if installed on the engine.

b. Order of Tests: Tests may be conducted in any order and on any test article, except as noted in reference 2, section 3.2.

c. Combining Tests: Test procedures may be combined if you can demonstrate that the severity of all applicable conditions specified in the individual procedures, are equaled or exceeded in a combined test procedure (also see reference 2, section 3.3).

d. Test Equipment Calibration: All equipment used in these tests should be identified by make, model, serial number, software version, calibration expiration date, and must be within calibration. As applicable, all calibrations should be traceable to recognized standards. This information should be included in the test plan and final report.

e. Test Parameter Tolerance: Unless otherwise specified in your approved test plan, required test parameter values are either a minimum for high limits (for example, high temperature endurance test), or a maximum for low limits (for example, low temperature endurance test). You may need to adjust the selected parameter values based on test equipment accuracy, to assure that the required limit values are actually attained during the test.

f. Pass/Fail Criteria: The pass/fail criteria for most § 33.91, paragraphs (a) and (b) tests are summarized below:

(1) The component meets its design specification performance standards during operational testing and at the conclusion of the test.

(2) No functional changes occur during the test resulting in significant engine events affecting safety or operability of the engine.

(3) Successful post-test completion of the applicable Production Acceptance Test (PAT) sections to serviceable or ultimate limits, as appropriate, for that particular test category.

(4) Post-test inspection or disassembly (if required by the test plan), reveals no impending failures or damage which could impair the components' ability to function in a safe manner.

> **Note**: The provisions above are applicable for most components. Your approved test plan for each component under test must specify the required post-test actions and detailed pass/fail criteria.

**8. Other Considerations**.

a. Conformity Requirements: The cognizant engine and/or aircraft certification office will determine the conformity requirements for test articles. You should develop a comprehensive conformity plan for engine type certification projects that require § 33.91 tests.

b. Compliance by Similarity: Each category in this AC is defined as a test to be passed. However, in some cases you may be able to show § 33.91 compliance by similarity; by using test data from a previous engine type certification program. You may use it to the extent that similarity exists between the component previously tested and your new component. Similarity is normally shown through a relatively simple and direct comparison of the design features, and the operating characteristics and environment of the new component relative to the previously approved component. Some guidelines are:

(1) The new design must be within the scope of the previously approved design in all significant aspects, such as geometry, stress levels, limiting stress locations, operating characteristics, function, manufacturing processes, material properties, etc.

(2) The engine and installation operating conditions and environment are similar or within the original design scope demonstrated by the original test.

(3) The data from the original compliance finding is adequate to show compliance, so that no significant new data or analysis is required to show similarity.

(4) We will not generally conclude that you have shown § 33.91 compliance through similarity if your claim is based solely on the use of previously successful design practices or field service histories on similar engine models or components.

(5) You cannot show § 33.91 compliance through showing similarity to a previously approved similarity finding. Similarity must be shown to the original test data that demonstrated direct compliance.

(6) Compliance may be based on test data collected using earlier version of the industry standard documents referred to in this AC (e.g., DO-160), if that test data shows compliance to the current guidance.

c. Aircraft Installation: Testing under § 33.19, paragraphs (a) and (b) should consider aircraft interfaces where appropriate. For example, lightning and EMI testing for electronic control components generally require that representive aircraft harnessing be installed to have a valid test. Other components or systems may have other aircraft interface considerations. Similarly, the expected installed environment (e.g., temperatures/pressures/flows) should be considered in test plan development.

d. Test Set Up: Normally tests associated with § 33.91 compliance are conducted as bench or rig tests. However, certain components or systems may best be tested on an engine, provided that the requirements for that test category can be achieved.

**9. Test Plans**.

a. Certification test plans should include the following information:

(1) Applicable regulation(s) and purpose of test;
(2) Component name(s) and operational description;
(3) Part and serial number(s);
(4) Part detail drawing(s) or sketches (for example, to denote features of interest);
(5) Installation drawing(s) or sketches (for example, to describe installation in an engine);
(6) Conformity requirements;
(7) Definition and range of component operating and environmental parameters;
(8) Test equipment requirements (calibration and set-up);
(9) Test methods and procedures;
(10) Test pass/fail criteria;
(11) Data recording methods; and
(12) Deliverable test data.

b. The certification test plan should contain, as a minimum, the information noted above, and should be FAA approved before conducting the test. A copy of the approved test plan should be available at the test facility at the time of test.

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## REFERENCES

1. SAE Aerospace, Aerospace Recommended Practice, Document No. ARP5757, *Guidelines for Engine Component Tests*.

2. RTCA Inc., Document No. DO-160, *Environmental Conditions and Test Procedures for Airborne Equipment*.

3. FAA AC 21-16, *RTCA, Inc. Document RTCA/DO-160, Environmental Conditions and Test Procedures for Airborne Equipment*.