

**MINIMUM PERFORMANCE STANDARDS FOR
A-C GENERATORS AND ASSOCIATED REGULATORS**

REAFFIRMED

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1. GENERAL STANDARDS:

- 1.1 Scope:** This Aerospace Standard (AS) covers the general minimum performance standards of A-C generators and associated regulators for civil aircraft. The generator is a nominal 120/208-volt, 400-Hz, 3-phase, Y-connected system that provides the primary or backup power for electrical systems.

The machine can be a brush or brushless design and is normally air cooled.

- 1.2 Manufacturer's Declaration:** The manufacturer shall declare the following generator or regulator ratings and characteristics. These "declared" values shall be the same as those values termed "rated" under all sections of this AS.

1.2.1 Generator:

- (1) Rated Terminal Voltage
- (2) Rated KVA
- (3) Minimum Blast Cooling Requirement (If Blast Cooling Is to Be Used)
- (4) Rated Speed Range
- (5) Continuous Operating Speed (for 400 Hz)
- (6) Minimum Speed for Regulation
- (7) Maximum Speed for Regulation
- (8) Maximum Overspeed
- (9) Weight
- (10) Altitude Rating Chart (Including Brush Limitations)
- (11) Allowable Brush Wear (If Applicable)
- (12) Maximum Fault Torque
- (13) Mounting Configuration (Flange or Qad)
- (14) Overhung Moment, With Respect to the Drive Pad
- (15) Manufacturer's Part Number

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1.2.2 Regulator:

- (1) Rated Voltage (P.O.R.)
- (2) Manufacturer's Part Number Compatible with Generator
- (3) Cooling Requirement
- (4) Weight
- (5) Mounting Configuration
- (6) Range of Set Voltage Adjustment (If Adjustable)

1.3 Tests: The tests specified herein provide a laboratory means to determine the performance characteristics of A-C electric power generators under electrical and environmental conditions representative of those encountered in actual aeronautical operation.

Unless otherwise specified herein, the test procedures and the environmental test conditions and procedures shall be those defined in RTCA Document Number DO-160A for the applicable equipment and environmental categories declared by the manufacturer.

1.4 Test Samples: Tests under Sections (2) and (3) may be performed in any sequence and using no fewer than two (2) test generators or regulators. Section (4) tests may be performed in combination with Section (2) and (3) tests or performed separately on additional generators or regulators.

1.5 Effect of Tests: As a minimum performance requirement, the equipment shall complete all tests under Sections (2) and (3) without maintenance. There shall be no evidence of detrimental electrical or mechanical degradation.

1.5.1 Repair and Retest: If the equipment fails a test, the manufacturer may at his option repair and retest it or test a new unit in place of the failed unit. The manufacturer shall furnish a detailed report on the investigation of the failure and the corrective action. At the discretion of the inspecting authority, the repaired or replacement unit may be subjected to any applicable test herein in addition to those which the unit previously failed.

1.6 Nameplate Declarations: The manufacturer shall declare on the nameplate the (1) equipment category, and (2) the applicable environmental categories. Unless otherwise declared, the environmental conditions and the test conditions herein will apply.

1.7 Design and Construction: The design, construction, finish, marking shall be consistent with good aircraft practice. Terminals, connections, components and conductors shall be designed to preclude accidental shorting, contact with personnel or foreign conductive materials. Components shall not be stressed beyond their manufacturer's ratings.

1.8 Operation of Controls: The operation of controls, intended for use during flight, in all possible combinations and sequences, must not result in a condition hazardous to safety. Controls not normally adjusted in flight must not be readily accessible in flight.

2. MINIMUM PERFORMANCE UNDER STANDARD CONDITIONS: Tests under this section shall be performed under the Standard Test Conditions described in Appendix A.

2.1 Generator Rating: The generator shall provide the rated output current and voltage at the input speed.

2.1.1 Input Speed: For variable speed generators, all performance tests must be performed at minimum and maximum rated speeds. For constant speed generators (specified speed variation ± 5 percent or less), all performance tests must be run at average speed only.

2.1.2 Overload: No critical temperature as defined by the generator manufacturer shall be exceeded during the following overload conditions and duration. The test shall be conducted at ground level with the generator stabilized while operating at rated load and minimum speed while cooled with maximum rated coolant temperature. 150% of rated current at minimum rated lagging power factor for 2 minutes. 200% of rated current at minimum rated lagging power factor for 5 seconds.

2.2 Voltage Regulation:

2.2.1 Steady State Characteristics (Balanced Load Conditions): For any combination of rated loads and speeds, the voltage shall remain within the limits of $\pm 3\%$ of nominal. See Fig. 1. Note: The voltage regulators shall not be physically disturbed in any way during the tests to prove compliance with this requirement.

2.2.2 Response Characteristics: The generator output terminal voltage must stabilize to nominal $\pm 3\%$ within 200 milliseconds after the loading is either varied abruptly from zero to full rated or from full rated to zero load.

2.2.3 Transient Voltage: The generator must be tested to prove that it does not produce over-voltage transients in excess of those shown in Fig. 1 when tested under any of the load variations defined in 2.1.1 and 2.1.2.

2.3 Excitation: The generator in conjunction with its associated regulator must build up and be self-excited (without external power) under all conditions of load and faults within the rated speed range.

2.4 Slip Rings: Where applicable, there must be no more than fine, pin-point sparking of the brushes over the rated speed range for no load, half-load, and rated load. This test must be conducted after the generator temperature has stabilized during continuous operation at rated load and speed.

2.5 Phase Voltage and Angular Displacement: These standards must be met with unity power factor loads and measured at generator terminals.

2.5.1 Balanced Loads: For balanced load conditions of no load and full load per phase, the individual phase voltage must not deviate from the average by more than 0.5 percent, and the angular displacement between phases must be $120^\circ \pm 0.6^\circ$.

2.5.2 Unbalanced Loads: For combinations of unbalanced load conditions of 1/6, 1/3, and 2/3 of rated load per phase (on one phase and no load on the other two phases), the individual phase voltages must not deviate from the average by more than 1, 2, and 4 percent respectively, and the angular displacement between phases must be $120^\circ \pm 1^\circ$, $120^\circ \pm 2^\circ$, and $120^\circ \pm 4^\circ$, respectively.

2.6 Voltage Modulation:

2.6.1 Magnitude: The output modulation, with regulator in operation, must not exceed 3.5 volts when the generator is operated at no-load and at rated load. The voltage is to be measured as the peak-to-valley difference between the minimum and maximum voltages reached on the modulation envelope, over a period of at least one second.

2.6.2 Frequency Characteristics: The frequency components of the voltage modulation envelope must not exceed the limits of Fig. 2 of Appendix A.

2.7 Waveform: The line-to-neutral crest factor must be $1.414 \pm 10\%$, and the value of any harmonic must not exceed 3% of the fundamental and a total RMS harmonic content of 4% of the fundamental when tested under the following conditions:

2.7.1 At unity power factor loads of 100% rated current, 50% and no-load.

2.7.2 Condition 2.7.1 repeated at minimum rated power factor.

2.7.3 The observed change in the line-to-neutral crest factor, from no load to rated load, must not exceed 10%.

2.8 Dielectric Strength: The generator must withstand the following test voltages at 60 Hertz, applied between windings and between windings and frame, for the time specified. Electromechanical regulator/excitors must be tested from each terminal to case; however, similar units containing semi-conductors, capacitors and other sensitive electric components need not meet this test.

2.8.1 Circuits of 50 volts or less must be tested at 500 volts RMS for 1 minute or 600 volts RMS for 1 second.

2.8.2 Circuits of over 50 volts must be tested at twice the rated voltage plus 1000 volts RMS for 1 minute or 120% of the 1-minute voltage for 1 second.

2.9 Flexible Drive: If the generator is equipped with a torsional vibration damper, it must be demonstrated that, when operated under the following conditions, the torsional vibrations are limited within the following specified limits. Limits for turbine aircraft generators are in parentheses. These tests must be conducted with a torsional vibration source whose torsional inertia is at least 20 times that of the rotor of the generator being tested. The manufacturer shall provide under the Data Requirements of this TSO, any limitations, restrictions, or other conditions pertinent to generator drive.

- 2.9.1 100 Hours with ± 1 degree (± 0.5 degree) torsional input to the drive shaft at critical torsional frequencies (mechanical resonance). The flexible drive must limit the rotor amplitude within ± 5 degrees (± 4 degrees).
- 2.9.2 50 hours with ± 2 degrees (± 1 degree) torsional amplitude input to the drive shaft at torsional frequencies of 2 to 40 c.p.s. The flexible drive must limit the rotor amplitude within ± 7 degrees (± 5 degrees).
- 2.9.3 15 minutes with ± 2 degrees (± 1 degree) torsional amplitude input to the drive shaft at critical torsional frequencies. The flexible drive must limit the armature amplitude within ± 7 degrees (± 5 degrees).
- 2.9.4 If "dead band" or "clearance" is embodied in the drive elements, the amplitudes given above shall be increased by one-half the amount of total clearance.
- 2.10 Shear Section: A shear section or device shall be provided at the generator input that mates with the engine accessory drive (spline or gear type). This section shall shear at rated static shear torque ($\pm 10\%$). The shear section shall be so designed that its shearing action will not result in loose pieces which could damage adjacent or associated components. Belt driven generators need not meet the shear section requirements.
- 2.11 Short Circuit Capacity: Generators and associated voltage regulators shall be capable of delivering 300 percent rated current into a three-phase short circuit at average rated speed for constant speed generators and 115% minimum rated speed for variable speed generators for a minimum of 5 seconds. The short circuit current capability of the equipment for the line-to-neutral and line-to-line short circuits applied to and between any phase must be at least equal to 300 percent rated current. Tests shall be conducted to determine that the equipment combination can meet these requirements with the equipment temperatures stabilized at rated load operation. For this test, the point of regulation and load application must be at the terminals of the generator.
- 2.12 Bearing Failure: In the event of bearing failure, the generator shall not be a fire hazard when operated at rated load for 4 hours. This can be demonstrated using the following procedure.
- Following disassembly and inspection, the generator shall be reassembled with the original parts except that the lubricant, cage, and seals in the bearings shall not be installed. The generator shall be operated for 4 hours regardless of electrical failure. Only intermittent sparks that emanate from within shall be permitted, and any tendency to flame shall be cause for rejection.
- 2.13 Overspeed: The generator must be test driven at an overspeed equal to 115% of its maximum speed for regulation for 5 minutes without mechanical failure or impairment of electrical performance. This test may be made with the generator control field circuit open. The equipment must be at stabilized temperature as a result of testing or delivering rated load.

2.13 (Continued):

At the conclusion of the overspeed operation, the generator shall be operated under rated operating conditions to verify its integrity and compliance with 2.2.

2.14 Operating Position: Any operating attitude constraints shall be defined by the manufacturer.3. MINIMUM PERFORMANCE UNDER ENVIRONMENTAL CONDITIONS: Unless otherwise specified, the test procedures applicable to a determination of the performance of aircraft A-C generators under environmental conditions are contained in the RTCA Document DO-160A, Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and instruments.3.1 Fluid Resistance: The generator and regulator must be subjected to the test procedures of paragraph 11.0 for the fluids specified by the manufacturer. The generator and regulator shall be marked in accordance with Appendix A of DO-160A and detailed information included with the manufacturer's installation instructions.3.2 Low Temperature Storage: The generator and its regulator/ exciter must meet the requirements of paragraph 2.2 after having been stored at a temperature of -65°F (-53.9°C) for 8 hours, and with no warm-up time preceding the test.3.3 Radio Frequency Interference: The generator and its regulator/ exciter equipment must not be a source of broadband or pulsed CW interference, either radiated or conducted, in excess of the levels specified in paragraph 21.0 of DO-160A. This test must be conducted under conditions of no-load and full load at both minimum and maximum operating speeds.3.4 Temperature Altitude: The generator and regulator shall be tested at the maximum temperature-altitude condition for the equipment category declared by the manufacturer. The tests shall be in accordance with paragraph 4.0 of DO-160A.

Upon completion of the tests, the generator and regulator shall show compliance with paragraphs 2.2, 2.5 as applicable.

3.5 Endurance: The generator and regulator shall be subjected to an endurance test consisting of a total operation of 360 hours in which a 6-hour load cycle is used to produce the following load conditions:

Full load	- 2 hours
No load	- 5 minutes
Full load	- 2 hours
No load	- 5 minutes
Full load	- 1 hour 50 minutes
3-phase short circuit	- 5 seconds (6 times/120 hours)

3.5 (Continued):

While load cycling, the generator and regulator shall be operated at ambient pressure in the stabilized low operating temperature, the stabilized short-time operating temperature, and the normal operating temperature as defined in paragraphs 4.3 and 3.4, respectively, of D0-160A for their respective categories. A minimum of 120 hours shall be accumulated at each temperature.

The temperature transitions shall be accomplished at no load. The duration of the temperature transitions and the stabilization times shall not be included in the determination of total test time.

3.6 Humidity: The generator and regulator shall be tested in accordance with paragraph 6.3.1, Category A, of D0-160A. Upon completion of test, the generator and regulator shall show compliance with paragraph 2.2.1.

3.7 Shock: Subject the equipment to the Shock Tests as set forth in paragraph 7 of D0-160A,

(a) Operational Shock: Following the application of the operational shocks:

(1) The requirements of paragraphs 2.2.1 and 2.5 herein must be met.

(2) All mechanical devices must operate satisfactorily.

(b) Crash Safety Shocks: Following the application of this test, the equipment must have remained in its mounting and no external parts of the equipment or its mounting must have become detached from the remainder of the equipment or from the shock table. It need not operate after this test.

3.8 Vibration:

(a) The regulator shall be subjected to vibration level declared by the manufacturer per paragraph 8 of D0-160A; the requirements of paragraph 2.2.1 herein must be met.

(b) After completion of the vibration tests, the regulator must meet the dielectric tests of 2.9 of this standard.

(c) The generator shall be subjected to vibration level declared by the manufacturer per paragraph 8.0 of D0-160A. During this test, the generator shall be electrically inactive and rotating at a speed that will preclude brinelling of the bearings.

4. SPECIAL PURPOSE ENVIRONMENTAL TEST CONDITIONS AND PROCEDURES: Where any of the following requirements apply, the applicable portions of RTCA Document D0-160A shall be met.

- 4.1 Waterproofness Test: The equipment shall be subjected to the waterproofness test of paragraph 10 of DO-160A, and the equipment must meet the requirements of paragraphs 2.2.1 and 2.5 herein.
- 4.2 Sand and Dust: The generator and regulator must be subjected to the sand and dust conditions as specified in paragraph 12 of DO-160A, but, in addition, the generator must be operating at its nominal speed and at no load. At the end of the two 6-hour test runs, the equipment must not have overheated nor suffered bearing damage. Brush wear must not exceed the manufacturer's stated limits for such a time period. Upon completion of the test, the equipment shall meet the requirements of paragraph 2.2.1 herein.
- 4.3 Fungus Resistance: The equipment may be subjected to the tests of paragraph 13 of DO-160A. At the end of the 28-day test period, the equipment must have no physical deterioration that would impair its performance or seriously affect its expected service life, and it must meet the requirements of paragraphs 2.2.1 and 2.5 herein. Alternatively, the manufacturer can certify that the equipment does not provide an environment conducive to fungus growth.
- 4.4 Salt Spray: The equipment must be subjected to the tests of paragraph 14 of DO-160A. At the end of the test period, it must also meet the requirements of paragraphs 2.2.1 and 2.5 herein.
- 4.5 Explosion: The equipment must not cause an explosion when subjected to the conditions of test of paragraph 9 of DO-160A. The test procedure will be that declared by the manufacturer.

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