SAE Aerospace
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AEROSPACE STANDARD

AS 8020

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MINIMUM PERFORMANCE STANDARDS FOR ENGINE DRIVEN D.C. GENERATORS/STARTER-GENERATORS AND ASSOCIATED VOLTAGE REGULATORS

1. GENERAL STANDARDS

1.1 Scope: This Aerospace Standard (AS) covers the general minimum performance standards for generators/starter-generators and associated voltage regulators for use in direct current (DC) electric systems for civil aircraft.

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 Load Current
(3) Minimum Blast Cooling Requirement (If Blast Cooling is to be Used)
(4) Rated Speed Range
(5) Continuous Operating Speed
(6) Minimum Speed for Regulation
(7) Maximum Speed for Regulation
(8) Maximum Overspeed
(9) Minimum and Maximum External Field Resistance in Series With the Shunt Field
(10) Maximum Operating Altitude
(11) Allowable Brush and Commutator Wear (If Applicable)
(12) Maximum Static Torque (If Applicable)
(13) Equalizing Voltage (If Provided) at Rated Load Current
(14) Overhung Moment, With Respect to the Drive Pad
(15) Terminal Block Cover (If Provided)
(16) Type and Rating of Battery (If Required for Start-Up Excitation or Ripple Voltage Test)
(17) Maximum Allowable Starter Current and Voltage
(18) Rated Starter Locked Rotor Torque

1.2.2 Regulator:

(1) Rated Voltage
(2) Rated Maximum Controlled Field Current
(3) Minimum Blast Cooling Requirement (If Blast Cooling is to be Used)
(4) Minimum and Maximum Effective Regulator Resistance in Series With Generator Field
(5) Maximun Operating Altitude
(6) Range of Set Voltage Adjustment (If Adjustable)

1.3 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.

1.4 Test Samples: Tests under Sections (2) and (3) may performed in any sequence and using no more 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.

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1.5 System Description: Applicable performance tests described herein shall be met with a compatible generator and regulator. A battery shall not be included unless otherwise declared by the manufacturer.

2. MINIMUM PERFORMANCE UNDER STANDARD CONDITIONS

Tests under this section shall be performed under the Standard Test Conditions described in Addendum (A).

2.1 Generator Rating: The generator shall provide the continuous rated output current and voltage over the continuous operating speed range.

2.2 Overload Capacity: Unless otherwise declared by the manufacturer, the generator shall deliver 150% rated current for two (2) minutes and 200% rated current for five (5) seconds at the minimum speed. IN NO CASE SHALL THE GENERATOR OVERLOAD CAPACITY BE LESS THAN 120% OF RATED CURRENT.

2.3 Speed:

2.3.1 Speed Range: The continuous operating speed range shall be that range over which the generator provides continuous rated output current and voltage.

2.3.2 Minimum Speed for Regulation: When the generator is driven at minimum speed for regulation, it must deliver continuous rated current at rated voltage with not less than 0.5 ohm resistance connected in the external field circuit.

2.3.3 Overspeed: The generator shall be capable of being driven at an overspeed equal to 115% of the maximum rated speed for five (5) minutes without mechanical failure or impairment of electrical performance. This test shall be made with the generator control field circuit open and while the generator is hot from ANY prior test.

2.3.4 Maximum Speed for Regulation: When the generator is driven at the maximum speed for regulation, it must provide not more than rated voltage with 300 ohms or less resistance in the control field. Generators which do not have a control field shall be as specified by the manufacturer.

2.4 Output Voltage:

2.4.1 Steady State Voltage Regulation: When operating as a system, the Generator and Regulator shall have a voltage at the Point of Regulation that remains within ± 2.5% of the Regulator set voltage when operating at the minimum speed for regulation, maximum speed for regulation and at speed midway between these two speeds. At each test speed, the system shall be operated at no load, 25%, 50% and 100% rated current and the regulation values recorded. No Regulator adjustments are permitted during these tests. If the Regulator set voltage is adjustable, the adjustment range shall be declared by the manufacturer.

2.4.2 Transient Voltage: During the application and removal of loads, the transient voltage and recovery time shall not exceed the limits specified by Fig. 1.

2.4.3 Ripple Voltage: The generator peak ripple voltage shall not exceed ±7% of the nominal DC output voltage when operated at 120% minimum rated speed at 25% and 50% load. The field must be controlled by a manual rheostat when making this test. See Fig. 2.

2.5 Commutation (Brush Type Designs): During operation of the generator over the load and speed range there must be no more than fine pin point sparking of the brushes. For Starter-Generators, commutation during starter operation should not damage the commutator or degrade subsequent performance.

2.6 Dielectric Strength: The generator and/or regulator must withstand, without evidence of breakdown, a test voltage of 500 volts r.m.s. at 50 or 60 Hertz for one (1) minute or 600 volts r.m.s. for one (1) second. The test voltage shall be applied between electrical circuits and frame and between mutually insulated circuits. Where the electrical circuits are intentionally grounded to frame for RFI control, the grounding circuit may be disconnected for this test.

2.7 Equalizing Voltage: Where provided, the equalizing voltage must be within ± 10% of the specified equalizer voltage. Equalizer voltage shall be determined under stabilized conditions of 25° C ± 15% inlet air temperature, rated load current, rated continuous operating speed and with the recommended cooling.

2.8 Parallel Operation: With two or more generators feeding a common bus, load division over the rated generator speed range shall remain within 10% of the generator rated current from 25% to full rated load current. This test may be conducted with all generators at the same speed. There shall be no sustained oscillations of the load sharing in excess of 5% of the generator rated current.

2.9 Generator Compounding: For any speed within the specified speed range, the excitation current must increase with an increase in generator load up to the full load capacity.

2.10 No Load Speed (Starter-Generators Only): When operated at no load in the starter mode, with the maximum rated starter voltage applied and with the control field system specified by the manufacturer, the machine shall not achieve excessive speeds nor incur electrical or mechanical failure.

2.11 Starter-Generator Cranking Speed/Torque: When operated as a starter, the starter must be capable of delivering rated locked rotor torque at the rated maximum current and voltage.

2.12 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 (±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.

3. MINIMUM PERFORMANCE UNDER ENVIRONMENTAL CONDITIONS

All generators and regulators must meet the requirements of the following paragraphs by actual test, similarity proof or by analysis. Unless otherwise specified, the applicable Environmental and Test Procedures referenced are in accordance with RTCA Document DO-160.

3.1 Spike Susceptibility: While supplying full rated load, the generator and/or regulator shall be subjected to ten (10) minutes of negative and positive spike voltages. The spike voltage shall have an amplitude of 600 ± 50 volts and a duration of 10 ± 5 microseconds for both positive and negative polarities. Thirty (30) positive and thirty (30) negative spikes shall be applied at 10 ± 2 second intervals.

3.2 Radio Frequency Interference: The generator and/or regulator must meet the radiated and conducted emission limits of DO-160 when operated at the low and high end of the rated speed range. For each speed, 10% of rated load and full rated load shall be applied. Rated voltage is to be maintained throughout the test. In testing the generator, a manually controlled field rheostat may be used.

3.3 Operating Position: The generator and regulator must be designed to operate continuously in any attitude. For test purposes, unless otherwise specified, the normal continuous generator operating position shall be essentially horizontal.

3.4 Temperature-Altitude:

(1) 100 hours at rated continuous speed, rated terminal voltage, and rated load current at approximately sea level altitude at the maximum rated air inlet temperature.

For regulators only - The regulator shall control a generator operating at a speed which will cause the greatest variation in field current when full generator load is switched on and off. Once the variation in field current has been established, a simulator may be used for the generator, provided that the minimum and maximum values of field current are the same as those obtained with the generators. The load shall be switched on for five seconds and off for five seconds. Sufficient readings shall be taken to establish the variation. During the test, the voltage at the point of regulation shall remain within ±2.5% of the regulator set voltage. No voltage adjustment shall be permitted during the test.

3.4 (Continued)

(2) 100 hours at rated continuous speed, rated terminal voltage, and rated load current at maximum operating altitude. Test periods shall be not less than six hours continuous.

For regulators only - The regulator shall control the same generator or simulator used in the 100 hour sea level test, either of which may be located outside of the altitude test chamber. During the test, the voltage at the point of regulation shall remain within ±2.5% of the regulator set voltage. No voltage adjustment shall be permitted during the test.

(3) After completion of tests (1) and (2), generator brushes, if used, shall not have an accumulated wear exceeding 40% of allowable wear. Accumulated commutator wear shall not exceed 20% of allowable wear.

For regulators only - After completion of tests (1) and (2), the requirements of paragraphs 2.3.4 and 2.4.1 must be met.

(4) Low Temperature

For regulators only - The regulator shall be subjected to the Low Temperature Test as set forth in paragraph 4.4 of the Environmental Test Procedures. Compliance shall be demonstrated by meeting the requirements of paragraphs 2.3.4 and 2.4.1, herein.

(5) High Temperature

For regulators only - The regulator shall be subjected to the High Temperature Test as set forth in paragraph 4.5 of the Environmental Test Procedures except that the equipment shall be operated for six (6) hours in lieu of the two (2) hours noted. Compliance shall be demonstrated by meeting the requirements of paragraphs 2.3.4 and 2.4.1, herein.

3.5 Humidity: After being subjected to the humidity tests, as set forth in paragraph 6.0, category (A), of the Environmental Test Procedures, and:

(a) Within one (1) hour after completion of the humidity test, primary input power shall be applied. Within one (1) hour after applying primary input power, tests shall be initiated and consecutively performed without undue delay to demonstrate compliance to the requirements of paragraphs 2.3.2 (generator only), 2.3.4, 2.4.1 (regulator only), 2.5 (generator only), and 2.6.

3.6 Shock: Subject the equipment to the Operational Shock Tests as set forth in paragraph 7.0 of the Environmental Test Procedures. Following the application of the operational shocks:

(a) The requirements of paragraphs 2.3.2 (generator only), 2.3.4, and 2.4.1 (regulator only) must be met.

(b) All mechanical devices must operate satisfactorily.

3.7 Vibration:

(a) While the equipment is subjected to the vibration conditions as set forth in paragraph 8.0 of the Environmental Test Procedure, the requirements of paragraphs 2.3.2 (generator only), 2.3.4, and, if applicable, 2.5 (generator only) must be met for generators. Regulators must meet paragraph 2.4.1 (regulator only).

(b) After completion of vibration tests, the equipment must meet the dielectric tests of paragraph 2.6 of this standard.

3.8 Torsional Vibration: The generator, when operated under the following conditions, shall limit the torsional vibration to no greater than the specified limits. Generators equipped with torsional vibration dampers only suitable for use on gas turbine engine must reflect this restriction on the nameplate of the machine. Verification tests must be conducted with a torsional vibration source whose inertia is at least 20 times that of the generator being tested.

3.9 Low Temperature Storage: The generator must meet the requirements of paragraphs 2.3.2, 2.3.4, and, if applicable 2.10 after being stored at -65° C for 8 hours. The regulator must meet the requirements of paragraph 2.4.1 after being stored at -65° C for 8 hours.

4. OPTIONAL ENVIRONMENTAL REQUIREMENTS

If the manufacturer chooses to mark his equipment as approved for any or all of the following Environments, he must meet the applicable requirements as proved by test, similarity proof, or analysis. Equipment marking shall be in accordance with Appendix A of DO-160.

4.1 Fluid Resistance: The generator and/or regulator must be subjected to the test procedures of paragraph 11.0, "Hydraulic Fluid". In addition, this test must be performed using aviation gasoline, jet fuels, and MIL-L-23699 lubricating oil. The generator must meet the requirements of paragraphs 2.3.2 and 2.3.4 upon completion of the test. The regulator must meet the requirements of paragraph 2.4.1 upon completion of the test.

4.2 Waterproofness: After being subjected to the waterproofness test of paragraph 10.0 of the Environmental Test Procedures, the generator must meet the requirements of paragraphs 2.3.2, 2.3.4, and the regulator must meet the requirements of paragraph 2.4.1 of this standard.

4.3 Sand and Dust:

(a) Generator - The generator must be subjected to the Sand and Dust conditions as set forth in paragraph 12.0 of the Environmental Test Procedures. This test must be conducted with the generator air inlet in a horizontal position with the generator operating at a continuous speed in the mid point of the speed range and no load. Upon completion of the tests, the generator must meet the requirements of paragraphs 2.3.2 and 2.3.4. Overheating, bearing failures and/or other electrical or mechanical damage is not permitted.

Brush wear, if applicable, must not exceed the manufacturer's stated limit for such a time period and commutation must meet the requirements of paragraph 2.5 of this standard during the test interval.

(b) Regulators - The regulators must be subjected to the Sand and Dust conditions set forth on paragraph 12.0 of the Environmental Test Procedures. At the conclusion of this test the regulator must meet the requirements of paragraph 2.4.1.

4.4 Fungus Resistance: The generator and/or regulator must be subjected to the tests of paragraph 13.0 of the Environmental Test Procedures. At the end of the test period, after examination for evidence of deterioration, generators must meet the requirements of paragraphs 2.3.2 and 2.3.4. Regulators must meet the requirements of paragraph 2.4.1.

4.5 Salt Spray: The generator and/or regulator must be subjected to the tests of paragraph 14.0 of the Environmental Test Procedures. At the end of the test period, generators must meet the requirements of paragraph 2.3.2 and 2.3.4. Regulators must meet the test requirements of paragraph 2.4.1.

4.6 Explosion: The generator and/or regulator must not be cause for explosion when subjected to the test conditions of paragraph 9.0 of the Environmental Test Procedures.

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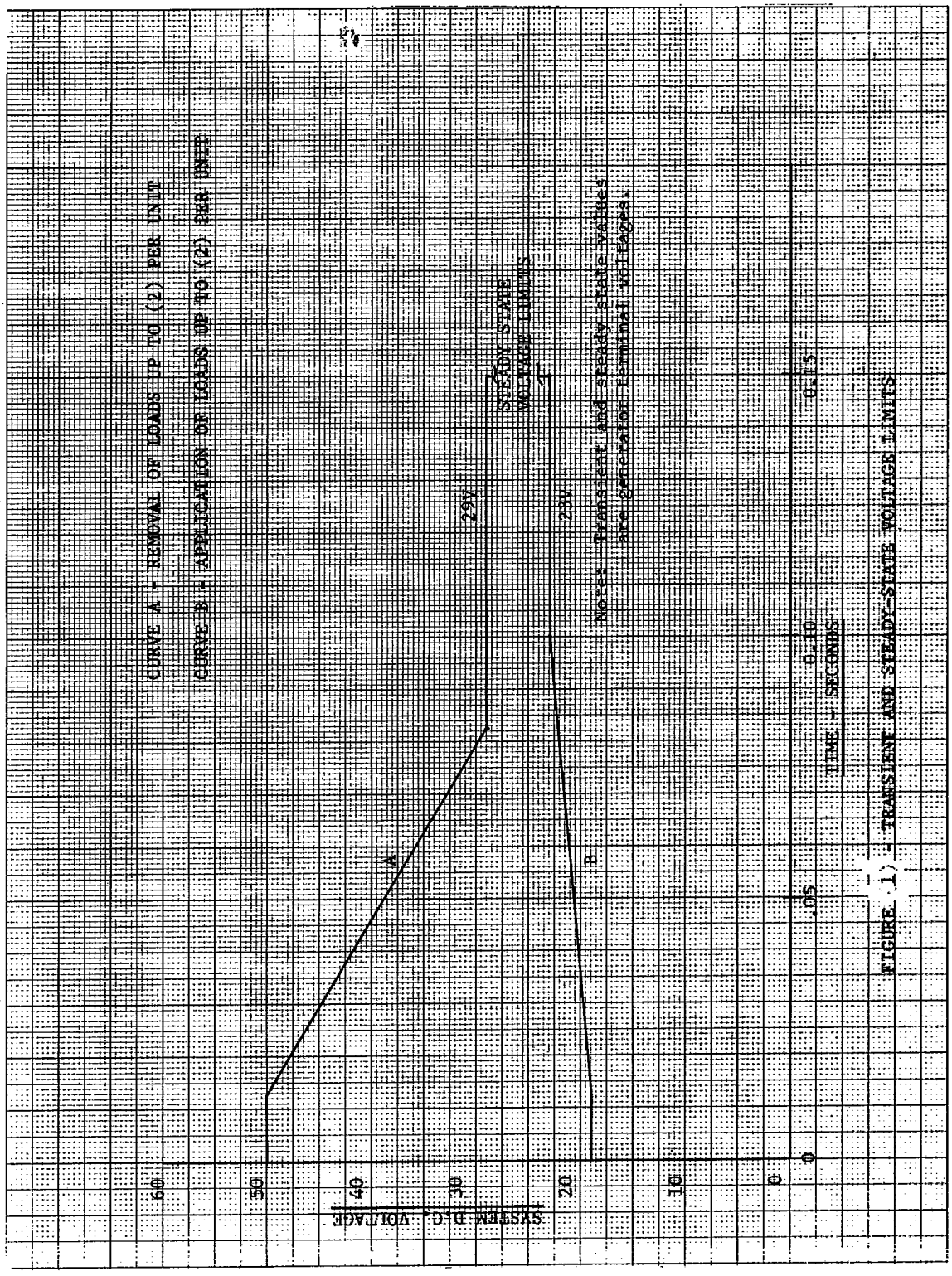

Notes: Transient and steady-state values are generator terminal voltages.

FIGURE 1) - TRANSIENT AND STEADY-STATE VOLTAGE LIMITS

ADDENDUM A

This addendum sets forth definitions and test conditions for determining performance of the equipment representative of its operational environment, but is limited to those tests not already defined in the RTCA Environmental Test Document, DO-160, or MIL-STD-704.

1. DEFINITION OF TERMS

1.1 Generator: Any mechanically driven device which supplies D.C. power including, but not limited to, those with commutators, conductors, homopolar and flux switch types, alternators with rectified output (D.C. alternator) with or without slip rings and also generators used as starters. Where the term "generator" is used, the applicant for approval should test his equipment in view of the foregoing statement.

1.2 Regulator: The device(s) necessary to provide voltage regulation and/or to control the excitation of a generator. Associated protective functions (overvoltage, undervoltage, feeder fault, etc.) may be incorporated within the regulator as a common panel.

1.3 Transient: A changing condition of a voltage characteristic which goes above or below the steady-state limit within a finite time period.

2. CONDITIONS OF TEST

The conditions of test are to be as set forth in paragraph 3.0 of the Environmental Test Procedures of RTCA Document DO-160, except as follows:

2.1 Mounting: The generator must be mounted on the test drive stand with its longitudinal axis horizontal.

2.2 Cooling: For sea level tests, if blast cooling is required at the generator air inlet, its temperature must be measured inside the cooling duct and must be within ± 10° C of ambient air temperature in the test area. Ambient temperature shall be 25° C ± 15.

2.3 Location of Load: The load must be so located that it will not appreciably affect the ambient temperature of the test chamber.

2.4 Warm-up: Prior to testing, unless otherwise stated, the generator must be operated within its rated continuous speed range, and with rated load and terminal voltage, for sufficient time to reach a stabilized operating temperature. This is the condition where the rate of rise of the field temperature with respect to ambient does not exceed 2° C in five minutes.

3. TEST PROCEDURES

The following test procedures, including those referenced in the Environmental Test Procedures, must be used.

3.1 Ripple Voltage: Ripple voltage must be determined by means of a peak reading VTVM in series with a 4.0 microfared capacitor as shown in Fig. 2. Peak readings must be taken with the voltmeter successively connected for each of the two polarities.

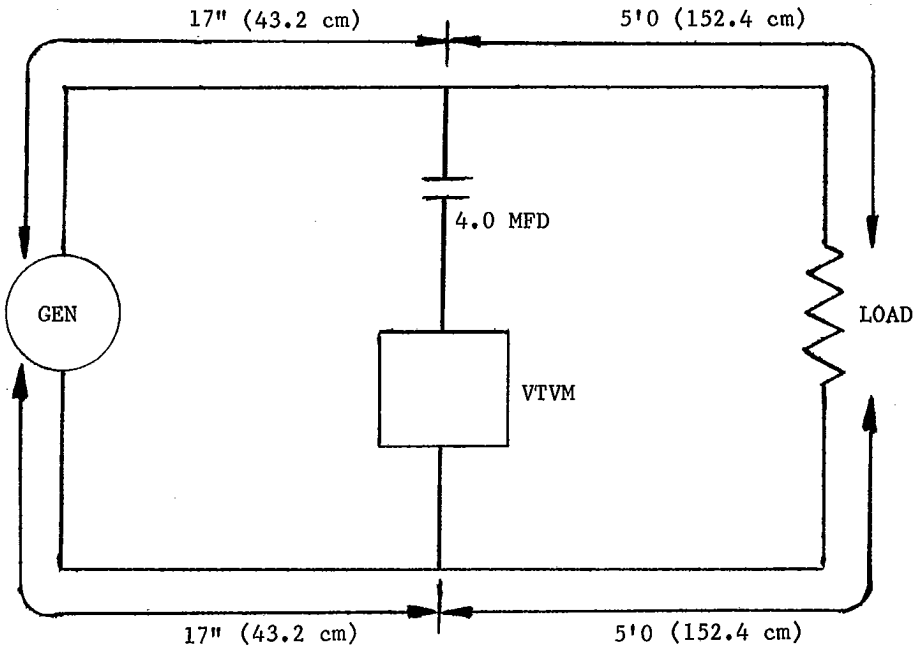

Figure 2 RIPPLE VOLTAGE TEST SET-UP