

Minimum Performance Standards for Aerospace Electric Power Converters

RATIONALE

This standard has been superseded by DO-160 and MIL-PRF-7115 and is out of date.

CANCELLATION NOTICE

This document has been declared "CANCELLED" as of July 2011. By this action, this document will remain listed in the Numerical Section of the Aerospace Standards Index.

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## 1. SCOPE:

This SAE Aerospace Standard (AS) establishes the minimum performance standards for equipment used as secondary direct current (DC) electrical power sources in aerospace electric power systems.

### 1.1 Purpose:

The purpose of this document is to define the guidelines and minimum performance test standards to be met by static electric power converters designed to operate from primary electric power systems. The tests specified herein provide a laboratory means to determine the performance and reliability characteristics of electric power converters under electrical and environmental conditions representative of those encountered in actual aerospace applications.

### 1.2 Field of Application:

Electric power conversion equipment whose initial application is to provide secondary DC power for aerospace utilization systems and equipment, but not limited to aerospace use.

## 2. REFERENCES:

### 2.1 Applicable Documents:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other documents shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this specification and references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS1212 Electrical Power, Aircraft, Characteristics and Utilization of  
AS1831 Electrical Power, High Voltage Direct Current, Aircraft, Characteristics and  
Utilization of  
AS8023 Minimum Performance Standards for Aerospace Static Electric Power Inverters

2.1.2 U.S. Government Publications: Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-HDBK-217 Reliability Prediction of Electronic Equipment  
MIL-HDBK-263 Electrostatic Discharge Control Handbook for Protection of Electrical and  
Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated  
Explosive Devices) Metric

2.1.3 Radio Technical Commission for Aeronautics Publications: Available from Documents Order Desk, One McPherson Square, 1140 Connecticut Avenue, NW, Suite 1020, Washington, DC 20036-4001.

RTCA/DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

2.2 Definitions:

2.2.1 AEROSPACE ELECTRIC POWER CONVERTER: Equipment, or a combination of equipment, used to convert primary aircraft AC or DC electric power to a different DC voltage or voltages. For AC output applications refer to AS8023, Minimum Performance Standards for Aerospace Static Electric Power Inverters.

2.2.2 DEFINITION OF TERMS: Unless otherwise specified herein, the terms used are those defined in Radio Technical Commission for Aeronautics (RTCA) Document Number DO-160.

2.2.3 STATIC: Equipment that does not utilize mechanical devices as active components of the power conversion technology.

2.2.4 FAILURE: Any test condition where the equipment/unit under test is unable to meet minimum performance requirements or as is otherwise specified for each test and or equipment.

2.2.5 VARIABLE COMPONENT: Electrical or mechanically adjustable component.

2.2.6 SWITCHING FREQUENCY RANGE: Primary or central frequency range within which the active power switching devices operate.

2.2.7 TRIPLENS: The 3rd harmonic and every whole integer multiple of the 3rd harmonic.

### 3. TECHNICAL REQUIREMENTS:

#### 3.1 General:

- 3.1.1 Design and Construction: The design, construction, finishes, and marking shall be consistent with the standards of aerospace industry good aircraft practice. Terminals, connections, components and conductors shall be designed to preclude accidental shorting, polarity reversal, improper installation, and contact with personnel or foreign conductive materials.
- 3.1.2 Adjustments and Controls: Controls and/or variable components that are not normally adjusted in flight shall not be readily accessible to flight personnel.
- 3.1.3 Flammable Materials: Except for small parts (i.e., seals, grommets, fasteners) and other small electrical parts that would not contribute significantly to the propagation of a fire, all materials used in the equipment shall be non-burning or self-extinguishing and shall not release toxic gases.
- 3.1.4 Reliability: As a minimum requirement, reliability predictions shall be made available. The statistical analysis shall be based on field usage and/or reliability analysis that is completed and documented. Reference tools for this process include but may not be limited to MIL-HDBK-217.

#### 3.2 Minimum Performance Requirements Under Standard Test Conditions:

Unless otherwise stated herein, the conditions of test shall be those defined in Section 3.0 of RTCA Document Number DO-160 and, unless otherwise specified, after temperature stabilization of the equipment, reference DO-160 Section 2.

##### 3.2.1 Qualification Test Conditions and Procedures:

- 3.2.1.1 General: Unless otherwise specified herein, the test procedures and the environmental test conditions and procedures shall be those defined in RTCA Document Number DO-160 for the equipment and category as declared by the manufacturer.
- 3.2.1.2 Effects of Tests: As a minimum performance requirement, the equipment shall satisfactorily complete all tests herein without maintenance or failure.
- 3.2.1.3 Repair and Retest: If the equipment fails a test, the manufacturer may, with option, repair and retest the equipment 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 needed to return the equipment to specified condition. At the discretion of the inspecting authority, the repaired or replacement unit may be subjected to any or all-applicable tests herein in addition to those, which the unit previously failed.

3.2.1.4 Manufacturer Declaration: Unless otherwise stated in the customer's detailed requirements document, the manufacturer prior to testing shall declare the applicable environmental categories per DO-160. The manufacturer shall also declare as a minimum the following:

- a. Rated Input Voltage.
- b. Rated Input Current.
- c. Rated Input Frequency (AC Input Applications).
- d. Rated Output Voltage(s).
- e. Rated Output Current(s).
- f. Maximum Output Ripple Voltage for rated input and load.
- g. Minimum Efficiency.
- h. Minimum Rated Load Current(s).
- i. Power Factor (AC Input Applications).
- j. Switching Frequency.
- k. Output Voltage Regulation (with tolerance values).
- l. Line and Load Regulation.
- m. Type and Limits of Input/Output Overload Protection.
- n. Cooling Method (User requirements when applicable).
- o. Dimensions (Maximum).
- p. Weight (Maximum).

3.2.1.5 Line and Load Regulation Tests: Unless otherwise specified by the procurement organization, the converter output voltages shall remain within the manufacturer's declared tolerances, when each of the following input voltage conditions of Table 1 are tested for a minimum of 5 minutes. For each input voltage condition the converter shall be operated at all load and frequency combinations of minimum rated load, half the rated load, full rated load, minimum rated frequency, nominal rated frequency, and maximum rated frequency.

The values within Table 1 are typical, specific applications may require modification of these typical test conditions and shall be declared.

Other specified or custom input frequency ranges for AC systems may require modification of these typical test conditions and shall be declared.

TABLE 1 - Line and Load Regulation Test Voltages and Frequencies

AC Input Phase Voltage (VRMS)	AC Input Frequency (Hz)	DC Input Voltage (VDC) (28 nom. // 270 nom.)
108	380	22 // 250
115	400	28 // 270
118	420	29 // 280

- 3.2.1.6 Output Voltage Transients: Output transient voltages shall be measured during specified worst case load changes. Voltage excursions shall not deviate by more than  $\pm 10\%$  of the specified voltage regulation limits and shall return to steady state in less than 5 milliseconds.
- 3.2.2 Efficiency: Efficiency will be measured at nominal input voltage and at full rated load and nominal environmental conditions.
- 3.2.3 Low Voltage Input Operation: Unless otherwise declared, the converter shall demonstrate its ability to start and to operate continuously for 30 minutes at minimum input voltage per 3.2.1.5 under full load as applicable. The output voltage shall remain within specified limits. The converter shall continue to operate within normal regulation limits when the input voltage is increased to nominal.
- 3.2.4 High Voltage Input Operation: The converter shall demonstrate its ability to start and operate for 30 minutes at minimum load output with maximum input voltage per 3.2.1.5 as applicable. The converter output shall remain within normal limits. The converter shall operate within normal regulation limits when the input voltage is reduced to nominal.
- 3.2.5 Momentary Low Voltage Inputs: The converter shall not be damaged, while operating at full load and minimum input voltage, when the input voltage is rapidly reduced to 0 volts for 5 milliseconds and then increased back to minimum input voltage. The converter shall operate within rated output voltage regulation limits upon reaching minimum input voltage. Each test condition shall be repeated five times, within a 5-minute period, using 0 voltage interruption periods of 5, 10, 25, 50, 100 and 150 milliseconds for each interruption.
- 3.2.6 Short/Overload Circuit Protection: Unless otherwise declared, with an initial minimum load and nominal input voltage applied, the converter shall not be damaged or exhibit failure when a short circuit is applied across each output or when operated at 120% of nominal load for a duration agreed upon between the manufacturer and procuring organization. The output voltage shall return to within normal limits after the short or overload is removed and equipment is operated as specified.
- 3.2.7 Surge Voltage: Unless otherwise declared, the converter shall be tested in accordance with section 16 of DO-160. Upon test completion, the converter shall meet the requirements of 5.3 and 5.5 herein.
- 3.2.8 Conducted Voltage Spike Test: Unless otherwise declared, the converter shall be tested in accordance with section 17 of DO-160.
- 3.2.9 Reverse Polarity: For DC Input Voltage, a means shall be provided for protecting the converter from the application of reverse polarity input voltage. This may be done in conjunction with an input circuit breaker. The protection means may be provided mechanically, which requires visual verification, or electronically, which requires testing.

- 3.2.10 Starting: Unless otherwise defined, the converter shall be capable of starting under all specified conditions. During starting, the output voltage shall not exceed the nominal value by more than 5%.
- 3.2.11 Harmonic Currents: In order to minimize the influence on the input power source, equipment designs shall limit input current harmonics. Equipment whose rated capability is 500 VA or greater will meet one of the following categories as specified:
- Category A: Current harmonics shall be less than 30% of the full rated fundamental current divided by the order of the harmonic, up to the 32nd harmonic.
  - Category B: Current harmonics shall be less than 30% of the full rated fundamental current divided by the order of the harmonic, up to the 32nd harmonic, except for triplens whose limits shall be 10% of the full rated fundamental current divided by the order of the harmonic.
- 3.2.11.1 Even Harmonics: Even harmonics for category A and B equipment shall not exceed 1% of the full rated fundamental current divided by the order of the harmonic, up to the 32nd harmonic or 100 mA rms divided by the order of the harmonic, whichever is less.
- 3.2.11.2 Multiple Unit Installations: Input harmonic current limits for multiple unit installations whose aggregate load exceeds 500 VA, or equipment whose rated capability is less than 500 VA, shall be specified by the end user.

Additional reference on this matter may be referenced in RTCA DO-160.

- 3.2.12 Insulation Resistance: Insulation resistance testing shall be performed as follows:
- between the 28(270)VDC inputs and frame with the DC outputs connected to frame and a test voltage of 50(500)VDC.
  - between the 28(270)VDC output and frame with the AC or DC inputs connected to the frame and a test voltage of 50(500)VDC.
  - between the AC inputs (if applicable) and frame with the DC outputs connected to frame and a test voltage of 200VDC.

At the maximum rated operating temperature, the measured insulation resistance shall not be less than 10M ohms.

NOTE: Frame connected filters may be disconnected for this test.

### 3.3 Minimum Performance Under Environmental Test Conditions:

The converter shall meet the requirements of the following paragraphs by actual test, similarity, and/or analysis. Unless otherwise specified, the applicable terms, environmental and test conditions and procedures referenced are in accordance with RTCA Document DO-160.

- 3.3.1 Temperature Test: The converter shall be tested in accordance with the applicable low temperature test in section 4 of DO-160. Upon completion of the test, the converter shall meet the requirements of 5.3 and 5.5 herein.

The converter shall be tested in accordance with the applicable high temperature test in section 4 of DO-160. The unit shall be tested in a condition, which simulates its specified operating environment. If a fan is used in the temperature chamber, the moving air shall not impinge directly on the converter. Upon completion of the test, the converter shall meet the requirements of 5.3 and 5.5 herein.

- 3.3.2 Temperature/Altitude Test: The converter shall be tested at the maximum temperature/altitude condition for the equipment category declared by the manufacturer in accordance with section 4 of DO-160. Upon completion of the test, the converter shall meet the requirements of 5.3 and 5.5 herein.
- 3.3.3 Humidity Test: The converter shall be tested in accordance with the applicable humidity test in section 6 of DO-160. Upon completion of the test, the converter shall meet the requirements of 5.3 and 5.5 herein.
- 3.3.4 Shock Test: The converter shall be tested in accordance with the applicable shock test in section 7 of DO-160. Upon completion of the test, the converter shall meet the requirements of 5.3 and 5.5 herein.
- 3.3.5 Vibration: The converter shall be tested in accordance with the applicable vibration test in section 8 of DO-160. The converter shall be operated at the nominal input voltage and at full load and meet the minimum performance requirements of 5.3 and 5.5 during and after the test. Unless otherwise declared, the converter output shall be in accordance with the manufacturer's declared tolerances.
- 3.3.6 Audio Frequency Conducted Susceptibility: The converter shall be tested in accordance with the applicable audio frequency conducted susceptibility test in section 18 of DO-160, for the category as declared by the manufacturer. Unless otherwise declared, the converter output shall be in accordance with the manufacturer's declared tolerances when tested at nominal input voltage and at full load. Input voltage modulation should be monitored during this test and shall not exceed the limits as defined in section 16 of DO-160.
- 3.3.7 Induced Signal Susceptibility: Unless otherwise declared, the converter shall be tested in accordance with the applicable induced signal susceptibility test in section 19 of DO-160 for the equipment category as declared by the manufacturer. The converter shall be operated at the nominal input voltage and at full load and meet the minimum performance requirements of 5.5 herein during and after the test.