European Aviation Safety Agency

European Technical Standard Order

Subject: STATIC ELECTRICAL POWER INVERTER

1 - Applicability

This ETSO gives the requirements which static electrical power inverters that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 - Procedures

2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

2.2 - Specific

None.

3 - Technical Conditions

3.1 - Basic

3.1.1 - Minimum Performance Standard

Standards set forth in the attached Federal Aviation Administration Standard, „Airborne Static Electrical Power Inverters"dated July 25, 1963.

3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

3.1.3 – Computer Software

None

3.2 - Specific

None

4 - Marking

4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2; in addition to the markings required by this paragraph, the instrument must be marked to indicate:

- rated terminal voltage, frequency and number of phases
- rated power in volts amperes
- output load power factor
- maximum operating altitude.

4.2 - Specific

None.

5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

FEDERAL AVIATION AGENCY
WASHINGTON, D.C.

MINIMUM PERFORMANCE STANDARDS FOR AIRBORNE STATIC ELECTRICAL POWER INVERTERS

JULY 25, 1963

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MINIMUM PERFORMANCE STANDARDS FOR

AIRBORNE STATIC ELECTRICAL POWER INVERTERS

1.0 GENERAL STANDARDS

1.1 *Purpose:* To specify the minimum requirements for airborne static electrical power inverters.

1.2 *Scope:* This standard provides the minimum performance criteria under environmental test conditions for static electrical power inverters intended to be used as a source of continuous or emergency alternating current power.

1.3 *Types of Inverters:* This standard applies to static electrical power inverters with a nominal input of 28 volts d.c. and an output of 115 volts, 400 cycles per second.

1.4 *Definitions:* The following are definitions of terms used throughout this standard:

a. Static electrical power inverter - An equipment made of solid state electrical components which produces an alternating current from a direct current source.

1.5 *Ratings of Components.* The equipment shall not incorporate in its design any components of such rating that when the equipment is operated throughout the range of the specified test, the ratings established by the manufacturer of the component are exceeded.

1.6 *Proof of Reliability.* The design of the equipment shall be such that the application of the specified test produces no condition which would be detrimental to the reliability of equipment manufactured in accordance with such design.

2.0 REQUIRED PERFORMANCE UNDER ENVIRONMENTAL TEST CONDITIONS

The environmental test procedures applicable to a determination of the performance of the airborne static electrical power inverter are set forth in Appendix A of this standard.

2.1 *Power Output:* With rated input voltage, the power output shall not be less than that specified in the manufacturer's rating. In specifying the equipment rating the manufacturer shall establish the following:

a. Minimum output load power factor.

b. Any special temperature control requirements.

c. Conditions of electrical loading including tolerance limits.

The inverter shall be capable of delivering at least 10 percent more output than the specified rating for a period of two hours without damage.

The inverter under the conditions of paragraph 2.2b. shall deliver 90 percent of the rated load for a period of 5 minutes.

2.2 *Voltage Input:* The rated input voltage, as measured at the inverter input terminals, shall be 28 volts d.c. The inverter shall:

a. Be capable of continuous operation under full load without degradation of performance over an input voltage range of ±2 volts.

b. Operate electrically at an input voltage of 20 volts.

c. Withstand, without damage, input voltage transients of 88 volts for a time period of 1 millisecond.

NOTE : For complex electrical systems the specified transient overvoltage can rise to much higher values over the time period of 1 millisecond or longer. For such applications conservative values of transient overvoltage are recommended.

2.3 *Frequency:* The frequency of the inverter under all conditions of load and test environment shall be 400 cycles per second ±1 percent at the input voltages specified in 2.2a. and 2.2b.

2.4 *Voltage Output:* The average phase output voltage, under the conditions of input specified in 2.2a. and 2.2b. and under all conditions of test environment, shall be 115 volts a.c. +5 percent -7 percent

2.5 *Waveform:* The output waveform shall be substantially sinusoidal and contain less than 7 percent harmonic distortion under all load conditions not exceeding 110 percent rated output

2.6 *Phase Balance:* Output phase voltages, for three phase units, shall not be unbalanced by more than ±5 percent when applied to balanced loads within a power factor range of 0.80. Displacement between phases shall be within the limits of 120° ±5°.

2.7 *Overload Capacity:* The inverter shall be capable of withstanding, without damage, a current overload of at least 150 percent for a time duration of 5 minutes.

2.8 *Input Overvoltage:* The inverter shall be capable of withstanding, without damage, input overvoltage up to 130 percent of the rated input voltage for a time period of 5 minutes while supplying full rated output power.

2.9 *Short Circuit Conditions:* The inverter shall be capable of withstanding, without damage, an output short circuit applied separately to each phase or simultaneously to all phases for a time period of one minute. Within 5 minutes after removal of the short circuit condition, the unit shall be energized and run continuously for a period of at least 20 hours. During this period the unit shall, without degradation of performance, deliver the specified output.

2.10 *Dielectric Strength:* The equipment shall withstand, without damage, the application of l,500 volts r.m.s. 60 cycles between windings and between each winding and frame for a time period of 1 minute.

NOTE : If this method of testing is not feasible, dielectric tests may be conducted on components prior to final assembly or with the critical components disconnected.

2.11 *Altitude:* The inverter shall provide continuous rated power, voltage, and frequency at the maximum declared operating altitude for a period of 24 hours. Inverters intended for locations in pressurized cabin areas also shall provide rated performance at an altitude of 40,000 ft. for a time period of two minutes without damage.

a. For inverters intended to be installed in pressurized areas, the minimum acceptable declared operating altitude is 10,000 feet.

b. For inverters intended to be installed in unpressurized areas, the minimum acceptable declared operating altitude is 30,000 feet.

2.12 *E mission of Spurious Radio Frequency Energy:* The levels of conducted and radiated spurious radio frequency energy emitted by the inverter shall not exceed those levels specified in Appendix A of RTCA Paper 120-61/DO-108-Environmental Test Procedures-Airborne Electronic Equipment dated July 13, 1961, for Category A equipment.[1]

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[1]Copies of this paper may be obtained from the RTCA Secretariat, 'Room 1072, T-5 Building 16th and Constitution Avenue, N.W., Washington, D.C., at a cost of 75 cents per copy.

APPENDIX a

ENVIRONMENTAL TEST PROCEDURES: ELECTRICAL EQUIPMENT
ELECTRICAL POWER INVERTERS

A. TEST EQUIPMENT STANDARDS

1. *Test Facilities:* The apparatus used in conducting the tests described in this Appendix should be capable of producing the specified environmental conditions. The equipment under test should not occupy more than 50 percent of the volume of the test chamber. Heat sources should be disposed so that radiant heat does not fall directly on the equipment under test.

2. *Measurement Tolerances:* Allowable tolerances on test condition measurements are as follows:

a. Temperature: Plus or minus 4° F.
b. Altitude: Plus or minus 5 percent.
c. Humidity: Plus or minus 5 percent relative.
d. Vibration Amplitude: Plus or minus 5 percent.
e. Vibration Frequency: Plus or minus 2 percent.

3. *Temperature stabilization:* Temperature stabilization may be checked by a temperature sensing device in good thermal contact with the largest centrally-located internal mass in the equipment under test.

4. *Deterioration:* Deterioration or corrosion of any internal or external components which could in any manner prevent the continued safe operation of the equipment during its service life will constitute failure to meet the environmental test to which the equipment was subjected.

B. TEST PROCEDURES

1. *High Temperature Test:* The equipment shall be placed within the test chamber and the internal temperature of the chamber raised to 160° F. with an internal relative humidity of not more than 5 percent. The item of equipment shall be maintained at 160° F. for a period of 50 hours. While still at this temperature, the equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10. The temperature shall then be reduced to prevailing room conditions and a visual examination conducted in accordance with paragraph A.4.

2. *Low Temperature Tests:*

a. *Method I* - The item of equipment shall be placed within the test chamber and the chamber cooled to and maintained at a temperature of -65° F. until temperature stabilization (See paragraph A.3) or the equipment is reached. While at this temperature, the equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10.

b. *Method II (alternate to Method I)* - The equipment shall be placed within the test chamber and the chamber cooled to and maintained at a temperature of -80° F. for a period of 48 hours, at which time the equipment shall be examined in accordance with paragraph A.4. The temperature of the chamber shall then be raised to 65° F. and maintained for an additional 24-hour period, or until temperature stabilization is reached (See paragraph A.3), whichever is the longer. At the conclusion of this exposure period, while at this temperature, the equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10 and visually examined in accordance with paragraph A.4.

3. *Temperature shock Tests -*

a. *Method I-* The equipment shall be placed within a test chamber wherein a temperature of 185° F. is maintained. The equipment shall be subjected to this temperature for a period of 4 hours, at the conclusion of which, and within 5 minutes, the equipment shall be transferred to a chamber having an internal temperature of -40° F. The equipment shall be subjected to this temperature for a period of 4 hours. This completes one cycle. The equipment may be restored to room temperature before starting the next cycle. The number of complete cycles shall be three. At the conclusion of the third cycle, the equipment shall be removed from the test chamber and a within a period of one hour shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10. A visual examination shall then be completed in accordance with paragraph A.4.

b. *Method II (alternate to Method I)*-The equipment shall be placed within the test chamber and maintained for a period of at least one hour or until the equipment performance stabilizes at a temperature of 77° ±27° F. The chamber temperature shall then be reduced to -67° F. and maintained at this condition for at least one hour or until the equipment performance stabilizes. The internal temperature of the chamber shall then be increased to l60° F. and maintained at this condition for at least one hour or until the equipment performance stabilizes. The internal temperature shall then be returned to 77° ± 27° F. The equipment shall then be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10.

4. *Humidity Tests-*

a. *Method I* - The equipment shall be placed in the test chamber and set up to simulate installed conditions. The chamber temperature shall be between 68° F. and 100° F. with uncontrolled humidity. During the first 2-hour period the temperature shall be gradually raised to 160° F. The 160° F. temperature shall be maintained during the next 6-hour period. During the following l6-hour period, the temperature in the chamber shall be gradually reduced to between 68° F. and 100° F, which constitutes one cycle. The relative humidity throughout the cycle shall be not less than 95 percent. The cycle shall be repeated a sufficient number of times to extend the total time of the test to 240 hours (10 cycles). At the conclusion of the 240-hour period, the equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10 and a visual examination made in accordance with paragraph A.4. Distilled or demineralized water having a pH value of between 6.5 and 7.5 at 77° F. shall be used to obtain the desired humidity. The velocity of the air throughout the test area shall not exceed 150 feet per minute.

b. *Method II (alternate to Method I)* - The equipment shall be placed in the test chamber and set up to simulate installed conditions. The temperature in the chamber shall be 120° F. and the relative humidity not less than 95 percent. The test conditions shall be maintained for 360 hours. At the conclusion of this period, the equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10. An examination in accordance with paragraph A.4 shall then be made.

5. *Altitude Test:* The equipment shall be placed within the test chamber and the internal pressure reduced to the manufacturer's declared operated altitude. The ambient temperature in the chamber (irrespective of the test altitude) shall be -65° F. The equipment shall be maintained at this condition until the temperature stabilizes (See paragraph A.3). while at this condition, the equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10.

6. *Vibration Tests:*

a. *Method I* - (Applies to equipment which mounts directly on the structure of aircraft powered by reciprocating, turbo-jet or turbo-propeller engines and to equipment which mounts directly on gas turbine engines) - The test specimen shall be mounted on the apparatus in a manner which is dynamically similar to the most severe condition likely to be encountered in service. The test specimen shall be performing its function during the entire test period whenever practicable. At the end of the test period, the test specimen shall be inspected thoroughly for damage or defects resulting from the vibration tests. The amplitude or acceleration for the frequency cycling test shall be within ±10 percent of the specified values. Vibration tests shall be conducted under both resonant and cycling conditions according to the following vibration test schedule (Table I):

TABLE 1 - VIBRATION TEST SCHEDULE

	Vibration at		
Types	Room Temp. (Minutes)	160° F (Minutes)	-65° F (Minutes)
Resonance	60	15	15
Cycling	60	15	15

(i) *Resonance* - Resonant frequencies of the test specimen shall be determined by varying the frequency of applied vibration slowly through the specified range of frequencies at vibratory accelerations not exceeding those shown in Figure I. Individual resonant frequency surveys shall be conducted with vibration applied along each of any set of three mutually perpendicular axes of the test specimen.

Whenever practicable, functioning of the test specimen should be checked against the requirements of paragraphs 2.1 through 2.10 concurrently with the operation of scanning the frequency range for resonant frequencies. The test specimen shall be vibrated at the indicated resonant conditions for the periods shown in the vibrations test schedule (Table I) and with the applied double amplitude or vibratory acceleration specified in Figure I. These periods of vibration shall be accomplished with vibration applied along each of three mutually perpendicular axes of vibrations. When more than one resonant frequency is encountered with vibration applied along any one axis, the test period may be accomplished at the most severe resonance or the period may be divided among the resonant frequencies, whichever is considered most likely to produce failure. However, in no instance shall the specimen be vibrated on any resonant mode for periods less than half as long as those shown for resonance in the vibration test schedule. When resonant frequencies are not apparent within the specified frequency range, the specimen shall be vibrated for periods twice as long as those shown for resonance in the vibration test schedule (Table I) at a frequency of 55 c.p.s. and an applied double amplitude of 0.060 inch.

(ii) *Cycling* - For test specimens mounted on vibration isolators, a vibration test shall be conducted with a constant applied double amplitude of 0.060 inch and the frequency cycling between 10 and 55 c.p.s. in one-minute cycles. Vibration shall be applied along each of three mutually perpendicular axes according to the vibration test schedule (Table I). For specimens which are to be installed in aircraft without vibration isolators, a vibration test shall be conducted with the frequency cycling between 10 and 500 c.p.s. in l5-minute cycles at an applied double amplitude of 0.036 inch or an applied acceleration of ± 10 g, whichever is the limiting value. Vibration shall be applied along each of three mutually perpendicular axes according to the vibration test schedule (Table I).

b *Method II* - (Apply to equipment which mounts directly to reciprocating engines) - The test specimen shall be mounted on the apparatus in a position dynamically similar to the most severe mounting likely to be used in service. Resonant frequencies of the test specimen shall be determined by varying the frequency of applied vibration slowly through the specified frequency range at vibratory accelerations not exceeding those shown in Figure I. Individual resonant frequency surveys shall be conducted with vibration applied along each of any set of three perpendicular axes of the test specimen. Whenever practicable, the functioning of the test specimen should be checked against the requirements of paragraphs 2.1 through 2.10 concurrent with the operation of scanning the frequency range resonant frequencies. If resonant frequencies are encountered, the test specimen shall be vibrated successively along each of three mutually perpendicular axes for four hours at the resonant conditions with the applied double amplitude or vibratory acceleration shown in Figure I. When more than one resonant frequency is encountered with vibration applied along any one axis, the test period may be carried out at the most likely severe resonance, or the period may be divided uniformly among the resonant frequencies, whichever procedure is considered most likely to produce failure. When clearly defined resonant frequencies are not encountered with the specified frequency range, the test specimen shall be vibrated for 12 hours along each of its mutually perpendicular axes at an applied double amplitude or 0.018 inch and a frequency of 150 cycles per second.

The test specimen shall be performing its function during the entire test period whenever practicable. At the end of the test period the test specimen shall be inspected thoroughly for damage or defects resulting from the vibration tests.

7. *Shock Test:* The equipment shall be subjected to the shock conditions as normally used in service, including any shock mount assembly. A Shock Testing Machine conforming to Military Specification MIL-S-4456 is suitable for this test.

The test specimen should be subjected to 18 impact shocks of 10 g, each shock impulse having a time duration of 11 ± 1 milliseconds. The intensity should be within ±10 percent when measured with a filter having a band width of 5 to 100 cycles per second. The maximum g should be reached in approximately 5 1/2 milliseconds. The shock should be applied in the following directions:

a. Vertically, 3 shocks in each direction.

b. Parallel to the major horizontal axis, 3 shocks in each direction.

c. Parallel to the minor horizontal axis, 3 shocks in each direction.

The test specimen should not suffer damage.

The equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10.

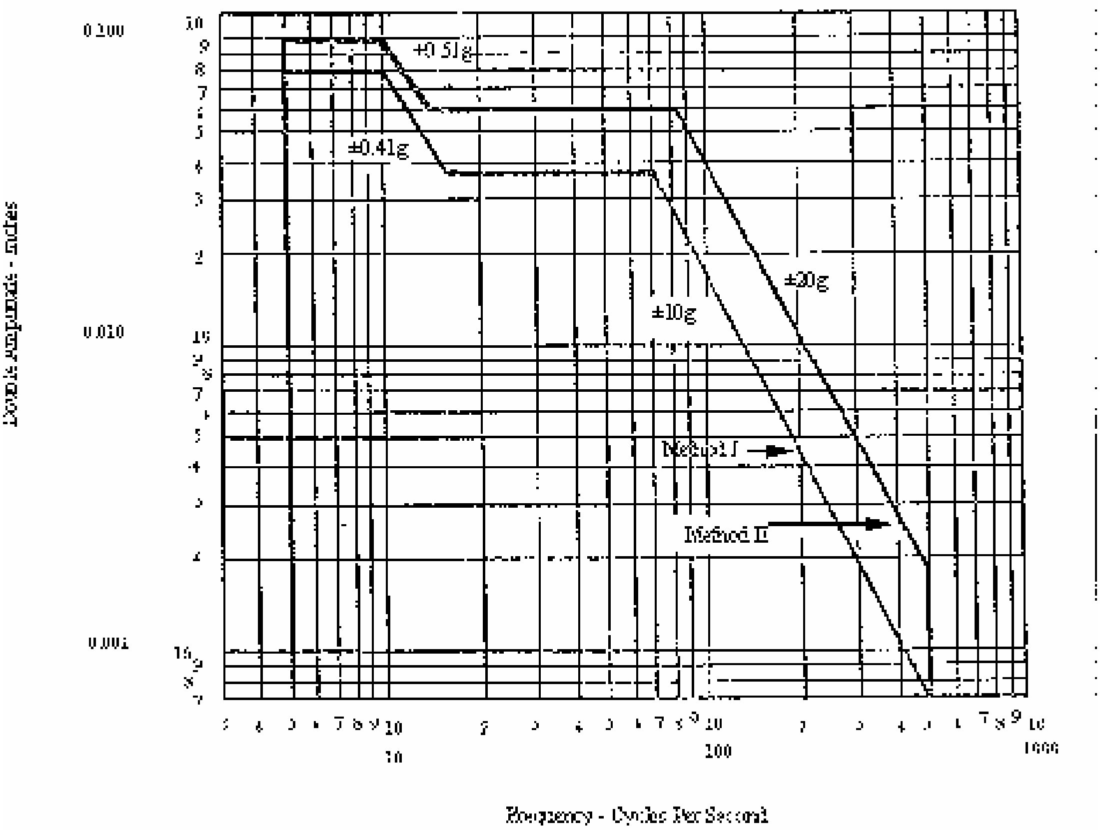

Figure I – Range Curves for Vibration Tests