

Invertors for secondary electrical supplies for aircraft

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Foreword

In this British Standard the aim has been to provide not only for invertors for general use on aircraft, but also as far as practicable for those suitable for aircraft applications requiring a more closely controlled output. To this end the performance and test requirements are appropriately differentiated as being for general purposes and for special purpose machines. They are also differentiated according to the classification of an invertor by the altitude for which it is suited.

Owing to the wide variety of uses of aircraft invertors, and because of the need for taking account, in such a general specification, of the penalties of weight and size likely to be involved in achieving a very closely controlled output, some of the performance requirements for special purpose invertors are necessarily a compromise between the needs of applications requiring different degrees of accuracies.

The environmental performance requirements of the standard are related to the acceleration, climatic and vibration requirements of the 1952 edition of BS G 100. These are currently under review in the light of conditions obtaining on modern high-performance aircraft, but it is believed that the publication of this British Standard in its present form will nevertheless serve a useful purpose. Its requirements will be reviewed as soon as the impending changes in BS G 100 take place.

NOTE Where metric equivalents have been given, the figures in British units are to be regarded as the standard. The metric conversions are approximate. More accurate conversions should be based on the tables in BS 350 “Conversion factors and tables.”

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 19 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Amendments issued since publication

Amd. No.	Date	Comments

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1 Scope

This British Standard covers the general design and test procedure for apparatus for deriving alternating current at controlled voltage and frequency from an aircraft d.c. supply.

2 Definitions

For the purposes of this British Standard the definitions in BS 205, “*Glossary of electrical terms*”, shall apply, except those defined in the following list:

2.1

inverter

a dynamo electric machine and necessarily associated control apparatus for deriving alternating current at a sensibly constant voltage and frequency from a direct current supply

2.2

rating

the operating limitations assigned to the inverter by the manufacturer

2.3

rated output

the output at the nominal voltage and nominal frequency declared by the manufacturer. In the case of a three-phase output, the output voltage of the inverter is the average of the three line voltages

2.4

time rating

the declared operating time of the inverter at rated output

2.5

type inverter

an inverter which is representative of others identical in design, construction and rating

2.6

type tests

tests to which type inverters are subjected to establish the declared performance of inverters of the same type

2.7

production tests

tests to which an inverter identical with a type inverter is subjected in order to ascertain that it is electrically and mechanically sound and in working order

2.8

quality tests

tests to which sample inverters are subjected to ensure that the standard of reliability and workmanship is maintained

Section 1. General requirements

3 Classes of inverter

a) Two classes of inverter are dealt with in this British Standard:

Class 1 — Suitable for use up to an altitude of 20,000 ft (6,100 m) or at an equivalent air pressure,

Class 2 — Suitable for use up to whatever altitude is assigned to it by the manufacturer.

b) Each class is sub-divided into two groups:

Group A — Special purpose, for use where closely controlled output is necessary.

Group B — General purpose.

4 Supply voltage

Unless otherwise required by the individual specification, the inverter shall be capable of operating over an input voltage range of 25–29 volts on a nominal 28 V d.c. supply, or over a range of 100–116 volts on a nominal 112 V d.c. supply.

5 Output voltage and frequency

a) *Voltage*. The nominal output voltage, from the respective input voltages, shall be 115 V and 200 V r.m.s. line to line.

b) *Frequency*. The nominal output frequency shall be 400 c/s.

6 Voltage balance

For a three-phase inverter, on balanced linear non-reactive load, the maximum difference between individual line to line voltages shall not exceed the following values:

Group A — 2 per cent of nominal voltage.

Group B — 3 per cent of nominal voltage.

7 Wave form of output voltage

a) *Group A*. When the inverter is supplying the loads indicated in Table 1, the voltage wave at constant frequency shall be such that:

i) the mean value of the voltage lies between 88.6 per cent and 91.3 per cent of the measured r.m.s. voltage,

ii) the divergence of corresponding ordinates from those of the sine wave of the equivalent r.m.s. value does not exceed four per cent of the measured r.m.s. voltage, and

iii) the r.m.s. value of the total harmonic content does not exceed 4 per cent of the measured r.m.s. voltage.

b) *Group B*. At all balanced linear non-reactive loads between 15 per cent and 100 per cent of full load the ratio of peak to r.m.s. value of the voltage shall be within the limits 1.41 ± 10 per cent, and the individual and total harmonic content shall not exceed the following values:

three-phase invertors —
individual $3\frac{1}{2}$ per cent, total 5 per cent.

Single-phase invertors —
individual $3\frac{1}{2}$ per cent, total 7 per cent.

8 Modulation of output voltage

a) At all balanced linear non-reactive loads between 15 per cent and 100 per cent of full load the percentage modulation of the output voltage shall not exceed the values given below when calculated from

$$\frac{a_1 - a_2}{a_1 + a_2} \times 100$$

where a_1 and a_2 are the maximum and minimum amplitudes of the modulated wave.

These maximum values are:

Group A — 0.15

Group B — 0.5

b) For Group B machines the manufacturer shall declare the amplitude and frequency of any modulation below 100 cycles per second.

9 Control of voltage and frequency

a) *Voltage*. At all balanced loads between 15 per cent and 100 per cent and at power factors between 0.8 lag and 0.95 lead, each line to line r.m.s. voltage shall be within the following limits:

Group A — ± 2 per cent of nominal.

Group B — ± 3 per cent of nominal.

For three-phase invertors the manufacturer shall declare the departure from this tolerance when the load is unbalanced to the extent that any one line current differs from the average by 1 amp or 15 per cent of the average, whichever is the greater.

b) *Frequency*. At all loads between 15 per cent and 100 per cent and at power factors between 0.8 lag and 0.95 lead, the frequency shall be within the following limits:

Group A — ± 2 per cent of nominal.

Group B — ± 5 per cent of nominal.

10 Adjustment of voltage and frequency

Trimmers shall be provided to allow adjustment of terminal voltage between 105 per cent and 98 per cent of nominal, in addition to providing for the correction of voltage and frequency drift throughout the life of the inverter.

Table 1 — Load conditions

Number of phases	Basic load	Auxiliary load				Volts
		Rectifier	Resistance	Capacitance	Inductance	
3	Balanced three-phase load at 0.8 power factor (lagging) 0.375W kilowatts	Three-phase full wave	$\frac{195}{W}$ ohms	7W μ F	$\frac{1.5}{W}$ henry with a d.c. resistance of 33 ohms/henry.	115
			$\frac{580}{W}$ ohms	7W μ F	$\frac{1.5}{W}$ henry with a d.c. resistance of 100 ohms/henry.	200
1	Unity power factor load 0.375W kilowatts	Full wave	$\frac{80}{W}$ ohms	7W μ F	$\frac{1.5}{W}$ henry with a d.c. resistance of 13 ohms/henry.	115
			$\frac{260}{W}$ ohms	7W μ F	$\frac{1.5}{W}$ henry with a d.c. resistance of 43 ohms/henry.	200

NOTE

a) W = rated output of inverter in kilowatts.

b) The three components of the auxiliary load are connected in parallel across the output of the rectifier.

c) The auxiliary load component values should be within five per cent of the figures quoted.

11 Regulation response

- a) When resistive load is switched from 100 per cent to 15 per cent, or vice versa, the voltage and frequency shall be restored to within their normal tolerances within 0.1 and 0.5 seconds respectively.
- b) For Group A machines only, during the first two cycles after such switching, or during starting, the peak value of the voltage shall not exceed 225 per cent of the nominal r.m.s. value, and during the remainder of the surge period it shall be between 165 per cent and 115 per cent of the nominal r.m.s. value.
- c) For Group B machines during such switching, or during starting, the peak value of the voltage shall not exceed 300 per cent of the nominal r.m.s. value.

12 Synchronous impedance

The synchronous impedance shall not exceed 200 per cent.

13 Protection

Unless otherwise required by the individual specification, means shall be provided for automatic shut-down of the inverter if the output voltage or frequency exceeds 125 per cent of the nominal values; inherent protection against low voltage or low frequency shall not in general be provided.

14 Vibration, acceleration and climatic proofing

The design and construction of the inverter shall be such as to meet the requirements of BS G 100¹⁾ in respect of:

- a) vibration, to the performance grading declared by the manufacturer;
- b) acceleration, Grade I;
- c) climatic test, Grade I or Grade II, as declared by the manufacturer.

15 Flameproofness

Where the inverter or any part of it is specified to be flame-proof, it shall comply under any operating conditions with the requirements of BS G 100 for flame-proof equipment.

16 General construction

The inverter shall be sound, suitable for its purpose, and its design and construction shall comply with the relevant requirements of BS G 100¹⁾.

Section 2. Particular requirements

17 Arrangement and construction

- a) There should preferably be no limitation in the performance of the inverter in respect of the attitude in which it may be mounted. Equipment for control of voltage, frequency and wave form may be housed separately and connected to the machine by screened cables. It is preferable that any components for the suppression of radio noise and any requisite starting equipment should be capable of being mounted on the machine. Any separate control apparatus shall be capable of use with any appropriate dynamo electric machine and vice versa. For Group A machines, after initial build-up the output side of the machine shall provide its own excitation.
- b) The design and construction of the inverter shall be such that it is capable of 1,000 hours operation before requiring maintenance.
- c) The inverter shall be capable of operating from a fully insulated system, but provision shall be made by means of an internal and easily accessible link for earthing the negative terminal on the input side. A gland suitable for screened cable shall be provided for use where a negative lead is an installational requirement. The output winding shall be insulated from the frame of the inverter.
- d) The input and output windings shall be on separate armatures and insulated from each other. Where the star point is required to be brought out, it shall be stated in the individual specification.
- e) Any limitations of the requirements of a) to d) shall be declared.
- f) Input terminals shall be marked positive and negative as appropriate (red and blue where colours are used). Output terminals shall be marked A, B, C or 1, 2, 3 (red, white and blue where colours are used). If a star point is provided it shall be marked "N".

18 Phase sequence

The phase sequence shall be such that the terminal voltages measured from an artificial star point shall reach their maxima in the order A, B, C (red, white and blue respectively).

¹⁾ BS G 100 "General requirements for electrical equipment and indicating instruments for aircraft".

19 Suppression of radio interference

Provision shall be made in the inverter to limit interference with radio to the level prescribed in Appendix B. No special provision by extra chokes is required in the inverter for suppression of radio interference on the negative input side.

20 Brushgear

In addition to the relevant requirements of BS G 100:

- a) Provision should be made for adjustment of the position of brushgear, and brushes should be set for the best commutating position. Exception to this provision may be made if the same results are achieved through the relative location of commutator segments, armature slots and brushgear, etc.
- b) The design and finish of the brush boxes shall be such that the brushes will slide easily, and it shall be ensured that the springs and triggers shall not jam or foul the brush boxes as a result of wear of the brush. The current conducting brush pigtails shall be of suitable length to ensure that they do not restrict the travel of the brushes within the box and do not foul the coils of the springs.

21 Starting

- a) Starting shall be effected by single initiation; switching-off shall also result in the immediate re-setting of any starting device. Where starting equipment is not supplied with the inverter, the manufacturer shall provide the necessary particulars.
- b) The peak starting current, with any necessary starting device, shall not exceed 100 amp at 28 volts and 50 amp at 112 volts, or six times the nominal full load current at nominal input voltage, whichever is the greater. This current is to be based on nominal input voltage, equivalent brush drop and the starting resistance of the machine at 20 °C. The inverter shall reach nominal voltage and frequency within twice the declared tolerance in 45 seconds and shall achieve full control in four minutes.

- c) Class 1 invertors shall be capable of starting at – 40 °C and Class 2 at – 65 °C at minimum supply voltage with impedance equivalent to full load connected to the output terminals. The inverter, together with any requisite starting equipment, when connected to its full load, shall be capable of withstanding three consecutive starts to full speed at an ambient temperature of + 50 °C and at both maximum and minimum voltage. No fire risk shall result from a resistance being kept in circuit during a delayed start.

22 Cooling

- a) All invertors shall be capable of operating at ground level self-cooled, with appropriate cooling air pipes attached.
- b) Class 1 invertors shall be capable of operating self-cooled up to 20,000 ft (6,100 m) in an ambient temperature of + 35 °C:
- c) Class 2 invertors shall be suitable for the altitude conditions declared by the manufacturer. For blast-cooled machines the internal pressure drop in the machine on full load and with the appropriate cooling air pipe connectors attached, shall not exceed 6 in. w.g. (0.015 kg/cm²) at any altitude up to 60,000 ft (18,300 m) unless otherwise agreed between the manufacturer and the aircraft designer.
- d) Limits of atmospheric conditions are given in Figure 1.

23 Arrangement and construction of control panels

- a) Control equipment shall be laid out as far as practicable in units of approved²⁾ standard types and sizes.
- b) Detachability of sub-units, including hinging, where appropriate, should be arranged to afford maximum ease of access for servicing or inspection.
- c) Wiring is preferably underneath the chassis or deck plates with components above deck with their terminals projecting downwards when in the working position.
- d) Components shall be selected wherever practicable from approved²⁾ standard ranges.
- e) Equipment wires shall be selected wherever practicable from approved²⁾ standard ranges, and be arranged in looms laced and secured with tropicalized binding. All connections shall be made by an approved²⁾ method (see BS G 100).

²⁾ For equipment for aircraft subject to British civil or military airworthiness requirements, the approving authorities are the Air Registration Board (through a design authority approved by the Board), and the Ministry of Supply, respectively.