BRITISH STANDARD

BS 2G 147-1: 1966
Incorporating Amendment No. 1

Specification for

A.C. motors for aircraft —

Part 1: Three-phase constant frequency squirrel-cage induction motors

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Contents

Foreword

This standard has been prepared as part of a programme of work to bring the aircraft series British Standard for rotating machines up to date in relation to present-day and probable future requirements, and to experience gained in working to earlier issues of the standards.

It is intended that the standard, when completed, shall cover the whole range of a.c. motors for aircraft applications in a series of separate Parts.

Part 1 is a revision of BS G 147:1955.

Reference is made in the standard to the following British Standards:

BS 2G 100, *General requirements for electrical equipment and indicating instruments for aircraft.*

BS G 102, *General requirements for rotating electrical machines for aircraft*[1)].

NOTE Where metric equivalents are 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 6 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.

[1)] In course of preparation.

1 Scope

This part of BS G 147 covers the general design and test procedure for three-phase constant frequency (400 c/s) a.c. squirrel-cage induction motors for use in aircraft, other than motors classed as engine starter motors.

2 Definitions

For the purposes of this part of BS G 147 the following definitions apply:

2.1
motor

the term "motor" includes gears supplied with the motor

2.2
type motor

a motor representative of others identical in design, construction and rating

2.3
rating

the operating limitations assigned to the motor by the manufacturer

2.4
rated speed and torque

the speed and torque declared by the manufacturer for nominal voltage and frequency

2.5
time rating

the time for which the motor can be operated at rated torque without exceeding the safe temperature

Section 1. General requirements

3 Design and construction

The design and construction of the motor shall comply with the relevant requirements of BS 2G 100 and BS G 102.

Section 2. Particular requirements

4 Supply voltage and frequency

The motor shall be suitable for use on constant frequency a.c. supplies having the characteristics specified in BS 2G 100-3.

5 Overhaul periods

Unless otherwise required by the individual specification, the motors shall be suitable for the following periods of unattended bench operation before requiring maintenance. The design aim should be to achieve 3 000 (aircraft) hours operation of the motor before requiring overhaul.

a) continuous duty	1 500 hours operation
b) frequent duty (e.g. with an inching actuator)	75 hours total running time in accordance with the relevant duty cycle
c) infrequent duty	
d) limited life (standby emergency duty)	not less than 5 per cent of the performance of a), b) or c), as appropriate.

6 Rotation

Motors shall be marked with an arrow to show the direction of rotation with a supply of phase sequence A, B, C, connected to terminals A, B, C respectively. For reversible motors the relationship between the direction of rotation and the supply connections shall be stated.

7 Rating

The manufacturer shall declare the rated torque(s) and speed(s) at the nominal terminal voltage and frequency, and the time rating(s) for the declared ambient temperature(s). The manufacturer shall declare any limitation of the frequency of operation and the ON and OFF time periods for continually repeated operation.

Any variation in rating due to the method of mounting shall be agreed between the manufacturer and the purchaser.

NOTE Short-time rated motors are generally required to be capable of performing at least three consecutive operations without rests for cooling. Therefore the time of one operation should not exceed one third of the time rating of the motor, i.e. the time for which the motor can be operated at rated torque without exceeding the safe temperature. For actuators this means six operations of the motor.

8 Cooling

a) The manufacturer and purchaser shall agree upon the cooling arrangements to be provided for the motor.

b) Cooling connections shall comply with the requirements of BS G 102.

9 Performance

a) There should preferably be no limitation in the performance of the motor in respect of the attitude in which it may be mounted. Any such limitations shall be declared.

b) Unless otherwise specified in the individual specification, at minimum voltage and maximum frequency the following relationships shall obtain:

Starting torque to rated torque:	not less than 1.25 for short-time rated motors, and not less than 1.1 for continuously rated motors
Pull-out torque to rated torque:	not less than 1.5
Run-up torque i.e. the minimum torque occurring between pull-out and starting torque, to rated torque:	not less than 1.1

On starting at maximum voltage and minimum frequency, the current shall not exceed six times the normal full load current.

10 Mounting and drive

The mounting and drive of the motor shall comply with the requirements of BS G 102.

11 Vibration, acceleration, climatic proofing and compass safe distance

The motor shall meet the requirements of BS 2G 100-2 in respect of:

a) vibration
b) acceleration
c) climatic test
d) compass safe distance

} to the performance grading declared by the manufacturer

12 Explosion-proofness

If required by the individual specification the motor shall meet the requirements of BS 2G 100-2 for explosion-proof equipment. Motors ventilated other than by clean air shall comply with these requirements whilst running.

13 Fire resistance

A motor which to be installed within a potential fire zone, and which must function during or after a fire, shall meet the appropriate test of fire resistance specified in BS 2G 100-2 as declared by the manufacturer.

14 Waterproofing

If required by the individual specification, the motor shall meet the requirements of the Grade A or Grade B water-proofness tests described in BS 2G 100-2, as declared by the manufacturer.

15 Declaration of performance

In addition to the declarations required by BS 2G 100, the following information shall be provided by the manufacturer in regard to the motor:

a) Rated torque(s), speed(s), direction of rotation, current and power factor.

b) Time rating(s).

c) Cooling requirements.

d) Starting, run-up and pull-out torque at minimum voltage and maximum frequency.

e) Starting current and power factor for maximum voltage and minimum frequency.

16 Nameplate

a) A nameplate and, where possible, a modification plate shall be mounted on the body of the motor.

b) The following information shall be marked on the nameplate:

Manufacturer's name or identification

Serial number

Type (or part) number.

Stores reference number, when applicable.

c) If possible, the following information should also be marked on the nameplate:

Voltage and frequency

Number of phases

Speed

Output in watts

Time rating

d) The modification plate shall provide for ten modification references. If the motor is too small to accommodate a modification plate, another form of indentifying modification shall be agreed with the Approving Authority.

Section 3. Tests

17 General

a) Tests shall be made to prove compliance with all requirements of this British Standard. The tests required are as follows: the results obtained shall be recorded.

Type tests. (Clauses **18** to **31**) to be made on each design of motor.

Production routine tests. (Clauses **32** to **36**) to be made on every motor manufactured to this British Standard.

Production quality tests. (Clauses **37** to **42**) to be made on batch sample or samples.

b) The tests prescribed in Clauses **18** to **27** inclusive shall be performed in that order on the same motor. Similarly, tests in Clause **28** shall be made on one motor, but not necessarily on the motor used for the tests referred to above, which shall previously have been subjected to the test in Subclause **19** a). Other type tests may be made on another motor or motors. Every motor used for type test purpose shall previously have passed tests equivalent to the production routine tests.

Tests shall be made at the maximum or minimum voltages specified in BS 2G 100-3 or in the individual specification. Unless otherwise specified, the tests shall be made at a temperature of 20 ± 5 °C, any departure from this temperature being recorded.

Type tests

18 Resistance test

The resistance of the windings shall be measured and the values corrected to 20 °C.

19 Load tests

a) The current, input power and speed shall be recorded over a range of output torques from zero to pull-out torque for nominal voltage and frequency and for minimum voltage and maximum frequency.

At rated load and balanced terminal voltage, the maximum difference between line currents shall not be greater than 10 per cent of the average of the three currents.

b) On motors supplied complete with gears, the test in a) shall be repeated with the gearing removed. The efficiency of the gearing at the various torques shall be derived and plotted.

20 Starting test

With the rotor just turning, measurements of current, input power and torque shall be recorded and the values plotted over a range of applied voltage from zero to nominal at maximum frequency. Care should be taken that the motor does not overheat during this test.

21 Run-up torque test

The run-up torque shall be recorded at minimum voltage and maximum frequency.

22 Temperature test

Continuously running motors shall be tested under the worst conditions of temperature and altitude. They shall be run at rated torque and at minimum voltage and maximum frequency until steady temperature conditions are reached.

Short-time rated motors shall be run at normal ambient temperature at rated torque and at minimum voltage and maximum frequency for a period equal to 110 per cent of the time rating of the motor.

Motors up to 1.8 in frame diameter shall be tested on the appropriate standard mounting plate which shall be held vertically on a base of heat-insulating material. The motor shall be held on the plate by the normal mounting means. The plate shall be polished aluminium alloy and shall have the following dimensions:

Nominal frame size		Hole at centre of plate		Sides of plate		Thickness of plate	
in	mm	in + 0.001 − 0	mm	in	mm	in	mm
0.7	17.8	0.501	12.7	1.875	47.6	0.1250	3.2
0.8	20.3	0.501	12.7	2.250	57.2	0.1250	3.2
0.9	22.9	0.501	12.7	2.700	68.6	0.1250	3.2
1.1	27.9	1.001	25.4	3.200	81.3	0.1250	3.2
1.3	33.0	1.157	29.4	3.750	95.3	0.1875	4.8
1.5	38.1	1.313	33.4	4.300	109.2	0.1875	4.8
1.8	45.7	1.563	39.7	5.250	133.4	0.1875	4.8

Where applicable, coolant flow shall be maintained at the agreed rate and maximum temperature uninfluenced by the method of loading, and the pressure drop shall be recorded.

23 Cold test

The motor shall be brought to the declared minimum ambient operating temperature throughout. While at this temperature the motor shall be placed in a humidity chamber controlled at not less than 95 per cent humidity at any temperature between 15 °C and 25 °C until the hoar frost formed on the motor has liquefied. As soon as this has occurred the motor shall be returned to the cold chamber and brought again to the declared minimum ambient temperature. It shall then be started and operated at rated torque and minimum voltage and maximum frequency until it reaches constant speed. The approximate time taken to reach constant speed shall be noted.

24 Hot test

The motor shall be brought to the declared maximum ambient operating temperature throughout and then run at minimum voltage and maximum frequency and rated torque for its time rating, or for 30 minutes if it is continuously rated. During the test the current and input power of the motor shall be recorded.

25 Overspeed test

Continuously running motors shall be run at rated torque and nominal voltage and frequency for half an hour followed immediately by a period of three minutes at 125 per cent of the nominal synchronous speed at no load, without excessive noise or vibration. For short-time rated motors the three-minute run shall be commenced with the motor cold.

The motor shall be subjected to the test in Clause **26** and shall then be stripped and examined and there shall be no signs of movement of the rotor parts or of damage to the stator or rotor.

26 Insulation resistance tests

While the windings are still hot from the tests in Clause **25** the motor shall be subjected to insulation resistance tests in accordance with BS 2G 100-2, except that the resistance between live parts and the frame shall not be less than 10 meghoms.

27 Endurance tests

a) The principal components shall be dimensionally checked against the relevant drawings and a record made of the dimensions of parts liable to wear.

b) During the tests specified below no adjustments or maintenance of any kind shall be made and normal cooling shall be allowed.

During the tests the motor shall be run at rated torque and at nominal voltage and frequency. Motors with built-in gear boxes, if reversible, shall be run in each direction of rotation for 50 per cent of the test period.

c) The test periods for motors of various grades of duty shall be:

i) *Continuous duty*: a total running period of 1 500 hours in cycles of 10 hours running and 2 hours shut down: in addition the motor shall be stopped and immediately re-started at hourly intervals.

ii) *Frequent duty and infrequent duty*: a minimum running time of 75 hours with not less than 25 one-hour cooling intervals.

iii) *Limited life*: running for 5 per cent of the total running periods specified in i) or ii) as appropriate.

d) At the conclusion of the endurance test, the motor shall be run under no-load and rated load conditions.

The input power and current during the test shall be recorded.

e) If at the conclusion of the endurance test whilst the windings are still hot the insulation resistance is less than 5 megohms, the motor shall be cleaned, without replacement of any parts, after which the insulation resistance should not be less than 5 megohms. Failure to attain this value shall be investigated and a record made of any action necessary to achieve it.

f) At the completion of the endurance test the motor shall be stripped, and the dimensions of parts liable to wear checked against those obtained as a result of the check specified in a).

28 Acceleration, vibration and climatic tests

a) The motor shall be subjected to acceleration and vibration tests appropriate to the performance grading of BS 2G 100-2 declared by the manufacturer, and to the cycles of temperature, pressure and humidity specified for the Grade 1 or Grade 2 climatic test of BS 2G 100-2, as appropriate to the performance grading declared by the manufacturer.

b) The performance of the motor at no-load, rated voltage and frequency, when measured after the tropical exposure test shall be within 5 per cent of that measured in Clause **19** a).

c) The functioning tests specified in the vibration, acceleration and climatic tests in BS 2G 100-2 shall each consist of running the motor on no-load.

d) Insulation resistance shall be measured before the humidity, temperature and pressure tests and tropical exposure tests, immediately on removal from the chamber after these tests, and at suitable intervals of time to enable the recovery under normal ambient conditions to be plotted until a constant value is obtained.

e) The motor shall be dismantled and visually examined for signs of deterioration.

29 Waterproofing tests

If required by the individual specification, the motor shall be subjected to the Grade A or Grade B waterproofness test specified in BS 2G 100-2, as appropriate to the performance grading declared by the manufacturer.

30 Explosion-proofness test

If required by the individual specification, the motor shall be subjected to the test specified in BS 2G 100-2 for explosion-proof equipment. If it is totally enclosed or through-ventilated by clean air, the motor shall not be run during the test, otherwise it shall be run at nominal voltage and frequency.

31 Fire resistance test

If required by the individual specification, the motor shall be subjected to the test for fire resistance specified in BS 2G 100-2, for the grade declared by the manufacturer.

Production routine tests

32 Component check

All the components and sub-assemblies of the motor shall have been checked in accordance with the approved drawings.

33 Overspeed test

The motor shall be run for a period of one minute at 125 per cent of the maximum synchronous speed without excessive noise or vibration.

34 Load test

a) The motor, complete with any gearing normally supplied, shall be run at nominal voltage and frequency, at the rated value(s) of torque and at no load.

The values of current consumption, watts and speed obtained from these tests shall not deviate from those obtained in the type test (Clause **19**) by more than:

i)	mean current and watts:	10 per cent
ii)	no individual line current to deviate from the mean by more than:	10 per cent
iii)	speed:	5 per cent

b) For motors supplied without gearing, the test in a) may be replaced by a light running test and locked rotor test (at various angular positions), in which case the voltage, current and input power shall be within the limits specified in the production specification.

35 Starting torque test

With the rotor just turning, the starting torque at nominal voltage and frequency shall be checked and shall be not less than the declared value.

36 Insulation tests

While the windings are still hot from the tests in Clause **35** the motor shall be subjected to insulation tests in accordance with BS 2G 100-2, except that

a) for the high voltage test a test pressure of not less than 1 000 volts r.m.s. 50 c/s a.c. shall be applied between the live parts and the frame; and

b) for the insulation resistance test, the resistance between live parts and the frame shall not be less than 10 megohms.

The high voltage test shall be applied once only.

Production quality tests

37 Selection of samples

a) Unless otherwise agreed with the purchaser or Inspecting Authority, as appropriate, sample motors for quality tests shall be selected on the following basis:

i) At the commencement of production, or when production recommences after a lapse of six months or more, quality tests shall be made on one of the first motors produced from each source of manufacture.

ii) When the quantity scheduled for production is less than 100, one motor shall be selected for testing, except that the test may be omitted at the discretion of the Inspecting Authority when the quantity does not exceed 10.

iii) Quality tests shall be applied to one motor in every 100 produced, or one test shall be made in every six months, whichever provides the greater frequency of testing.

The samples shall be selected from current production and shall have previously passed the production routine tests.

During the quality tests the motor shall not be serviced in any way.

The sampling sequence shall be recommended upon the introduction of a major modification.

If a sample motor fails during any portion of the quality tests, it shall be dismantled for examination and a report on the cause of failure shall be made to the Approving Authority. Two further samples shall be selected in general from the same production batch, and the tests repeated. Only if these two further samples are satisfactory shall the batch be deemed to comply with the requirements of this British Standard.

38 Load tests

The motor shall be tested in accordance with the requirements of Clause **19**.

39 Starting test

The motor shall be tested in accordance with the requirements of Clause **20**.

40 Run-up torque test

The motor shall be tested in accordance with the requirements of Clause **21**.

41 Endurance tests

The motor shall be tested in accordance with the requirements of Clause **27**.

42 Dimensional check for wear

At the completion of the endurance test the motor shall be stripped and the dimensions of parts liable to wear checked against those obtained as a result of the check specified in Subclause **27** a).

An abridged report on the tests and condition of the motor after dismantling shall be prepared and submitted to the Approving Authority.

If the motor is to be reassembled after reconditioning, it shall be submitted to the normal production tests before re-acceptance for delivery, omitting the high voltage test in Subclause **36** a).

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