BRITISH STANDARD

BS 2G 146: 1966

Specification for

D.C. Motors for aircraft

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Contents

Foreword

This standard is a revision of BS G 146:1955 and has been prepared as part of a programme of work to bring the aircraft series British Standards 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.

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 British Standard covers the general design and test procedure for d.c. motors for use in aircraft, other than engine starter motors.

2 Definitions

For the purposes of this British Standard the following definitions apply:

NOTE The term "motor" includes gears supplied with the motor.

2.1
type motor

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

2.2
rating

the operating limitations assigned to the motor by the manufacturer

2.3
rated speed and torque

the speed and torque declared by the manufacturer for nominal voltage

2.4
time rating

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

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.

4 Supply voltage

The motor shall be suitable for use on direct current 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.

1) continuous duty	1 000 hours operation.
2) frequent duty (e.g. with an inching actuator). 3) infrequent duty	75 hours total running time in accordance with the relevant duty cycle.
4) limited life (stand-by emergency duty).	not less than 5 % of the performance of 1, 2, or 3, as appropriate.

6 Rotation

Motors shall be marked with an arrow to show the direction of rotation. For reversible motors the relationship between the direction of rotation and the supply connections shall be stated.

7 Rating

7.1 The manufacturer shall declare the rated torque(s) and speed(s) at the nominal terminal voltage, 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 continuously repeated operation.

7.2 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 6 operations of the motor.

8 Cooling

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

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

9 Mounting and drive

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

9.2 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.

10 Vibration, acceleration and climatic proofing

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

1) vibration 2) acceleration 3) climatic test	to the performance grading declared by the manufacturer.

11 Compass safe distance

The motor shall comply with the requirements of BS 2G 100-2 in respect of compass safe distance.

12 Radio interference

If required by the individual specification, the motor shall comply with the requirements of BS 2G 100-2 for freedom from radio noise.

13 Explosion-proofness

If required by the individual specification, the motor shall comply with 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.

14 Fire-resistance

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

15 Waterproofing

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

16 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:

1) Rated torque(s), speed(s), direction of rotation and current.
2) Time rating(s).
3) Cooling requirements.

17 Nameplate

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

17.2 The following information shall be marked on the nameplate:

1) Manufacturer's name or identification.
2) Serial number.
3) Type (or part) number.
4) Stores reference number, when applicable.

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

1) Voltage.
2) Speed.
3) Output in watts.
4) Time rating.

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

18 Tests: general

18.1 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. **19.1** to **19.17**, to be made on each design of motor.

Production routine tests. **20.1** to **20.5**, to be made on every motor manufactured to this British Standard.

Production quality tests. **21.1** to **21.5**, to be made on batch sample or samples.

18.2 The tests prescribed in **19.2** to **19.11** inclusive shall be performed in that order on the same motor. Similarly, tests in **19.12** shall be made on one motor, but not necessarily on the motor used for the test referred to above, which shall previously have been subjected to the test in **19.3.1**. Other type tests may be made on another motor or motors. Every motor used for type test purposes shall previously have passed tests equivalent to the production routine tests.

18.3 Tests shall be made at the maximum and 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.

19 Type tests

19.1 Preliminary inspection and preparation for test. The principal components shall be dimensionally checked against the relevant drawings, a record made of the parts liable to wear, and a check made that the brushes are bedded over the full arc for at least 80 % of their axial width. Any running required to condition the commutator surface shall be done prior to the commencement of the tests.

19.2 Resistance test. The resistances of the windings shall be measured and the values corrected to 20 °C.

19.3 Load test

19.3.1 For a range of output torques from zero to 150 % of the rated torque the current and speed shall be measured at the maximum and minimum terminal voltages specified in BS 2G 100-3, or in the individual specification.

If the motor is reversible these tests shall be made for both directions of rotation. The currents and speeds shall be plotted on a torque base and the values at rated torque thus derived for each direction of rotation shall be within five per cent of their respective average values.

In addition, the efficiency and shaft output power shall be calculated from the observed data and plotted on a torque base.

19.3.2 On motors supplied complete with gears, the test in **19.3.1** shall be repeated with the gearing removed. The efficiency of the gearing at various torques shall be derived and plotted.

19.4 Stall test. With the armature locked against rotation, measurements of current and torque shall be recorded and the values plotted over a range of applied voltage from zero to maximum or as high as is practicable without overheating. The test shall be repeated with the armature locked in several other positions.

19.5 Temperature test

19.5.1 For the purpose of the test continuously rated motors shall be run without stopping at rated torque and maximum test voltage for a time sufficient to allow them to attain steady temperature conditions. Short time rated motors shall be run continuously at rated torque and maximum test voltage for a period equal to 110 per cent. of their time rating.

Motors up to 1.8 in frame diameter shall be tested on the appropriate standard mounting plate which shall be 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		Side 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.

19.5.2 Before commencing the test, and while the motor is cold, the resistance and temperature of all the field windings shall be measured and these results shall be used in calculating the final field winding temperatures.

Where practicable the temperature rise of the following parts of the motor shall be measured by the change of resistance or thermocouple method:

1) windings (except armature);
2) brush;
3) commutator.

Any additional measurement that may be considered necessary, together with the method to be used, will be indicated in the individual specification.

19.5.3 At the conclusion of the test the temperature rise of the parts of the motor already indicated shall be such that under the worst combination of climatic and altitude conditions, the internal temperature at any point does not exceed the safe limits for the material employed.

NOTE No arbitrary temperature limits are specified for the various materials. In every case the situation and manner of application of the material must be considered, as well as the effect of wide variations of temperature and mechanical vibration which are inherent in the operating conditions.

For solder, the softening point and not the melting point is the criterion.

19.6 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 % 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 until it reaches constant speed. The approximate time taken to reach constant speed shall be noted.

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

19.8 Overspeed test. Continuously rated motors shall be run at rated torque and nominal voltage for half an hour followed immediately by a period of three minutes no load at 125 % of the maximum operating speed in order to check that the noise and vibration are not abnormal. 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 **19.9** and shall then be stripped and examined. There shall be no signs of relative movement or of damage to the field system or armature/commutator assembly.

19.9 Insulation resistance tests. While the windings are still hot from the tests in **19.8** the motor shall be subjected to an insulation resistance test in accordance with BS 2G 100-2, except that the resistance between live parts and the frame shall not be less than 2 megohms when measured at 250 V d.c.

19.10 Altitude tests

19.10.1 The motor shall be suitably instrumented to enable the temperature of the bearings, field windings and any other parts likely to run hot to be determined. Under conditions of air temperature, pressure, humidity and cooling applicable to its duty, it shall be run at maximum voltage at rated torque. Continuously rated motors shall be run for 100 hours in ten cycles of ten hours nominal duration each cycle to be preceded by a two-hour sea level run. Intermittently rated motors shall be run under the relevant load conditions and duty cycle specified for the endurance test, except that the duration shall be ten per cent of the period specified for that test. During the test the temperatures of the parts selected for instrumentation shall be recorded periodically. They shall be within the safe limits for the materials employed.

19.10.2 For air-cooled machines records shall be made of the following measurements, and equivalent measurements shall be made for machines with other forms of cooling:

1) Terminal voltage

2) Input current

3) Air-pressure drop across machine

4) Inlet air pressure

5) Inlet air temperature

6) Mass flow of air

7) Inlet dew point

8) Temperature of a brush remote from the air inlet, taken at intervals of not more than one hour, measured by a thermocouple embedded in the brush.

9) Initial length of each brush

10) Length of each brush at end of each run.

11) Air temperature near the commutator taken at intervals of not more than one hour.

19.11 Endurance tests

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

19.11.2 During the test specified below no adjustments or maintenance of any kind shall be made and normal cooling shall be allowed.

During the test the motor shall be run at rated torque and at nominal voltage. Reversible motors shall be run in each direction of rotation for 50 % of the test period.

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

1) *Continuous duty*. A total running period of 1 000 hours in cycles of ten hours running and 2 hours shut down: in addition the motor shall be stopped and immediately re-started at hourly intervals.

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

3) *Limited life*. Running for 5 % of the total running periods specified in (1) or (2), as appropriate.

19.11.4 At the conclusion of the endurance test, the motor shall be run under no-load and rated load conditions. The input current and speed shall be recorded.

19.11.5 At the conclusion of the endurance test whilst the windings are still hot the insulation resistance measured at 250 V d.c. shall not be less than 50 000 ohms. If the insulation resistance is less than one megohm the motor shall be cleaned, without replacement of any parts, after which the insulation resistance should not be less than 1 megohm. Failure to attain these values shall be investigated and a record made of any action necessary to achieve them.

19.11.6 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 **19.11.1**.

19.12 Acceleration, vibration and climatic tests

19.12.1 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.

19.12.2 The performance of the motor at no-load and rated voltage, when measured after the tropical exposure test shall be within 5 % of that measured in **19.3.1**.

19.12.3 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.

19.12.4 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.

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

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

19.14 Compass interference test. The motor shall be subjected to the tests for compass safe distance detailed in BS 2G 100-2.

19.15 Radio interference test. If required by the individual specification, the motor shall be tested for freedom from radio noise in accordance with the requirements of BS 2G 100-2.

19.16 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: otherwise it shall be run at nominal voltage during the test.

19.17 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.

20 Production routine tests

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

20.2 Preliminary run. Before commencing tests, the motor shall be run at a suitable speed for a period sufficient to ensure that the brushes are bedded over the full arc for at least 80 % of their axial width. Any running required to condition the commutator surface shall also be done prior to the commencement of the test.

20.3 Overspeed test. With the motor hot, it shall be run for a period of one minute at 125 % of the maximum operating speed on no load to check that the noise and vibration are not abnormal.

20.4 Load test. The motor shall be tested at rated torque and nominal voltage.

The values of current consumption and speed obtained from these tests shall not deviate from those obtained in the type test **19.3** by more than:

Irreversible motors		Reversible motors	
1) current:	10 %	1) mean current:	10 %
2) speed:	10 %	2) mean speed:	10 %
		3) speed in either direction:	within 5 % of the mean speed

20.5 Insulation tests. Immediately after the tests in **20.4**, the motor shall be subjected to insulation tests in accordance with BS 2G 100-2, except that

1) a high voltage test shall be made at 500 volts 50 c/s a.c., applied between the live parts and the frame; and

2) the insulation resistance between live parts and the frame shall not be less than 2 megohms when measured at 250 V d.c.

The high voltage test shall be applied once only.

21 Production quality tests

21.1 Selection of samples. Unless otherwise agreed with the purchaser or Inspecting Authority, as appropriate, sample motors for quality tests shall be selected on the following basis:

1) At the commencement of production, or when production recommences after a lapse of 6 months or more, quality tests shall be made on one of the first motors produced from each source of manufacture.

2) 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**.

3) Quality tests shall be applied to one motor in every 100 produced, or one test shall be made in every 6 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 recommenced 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.

21.2 Load tests. The motor shall be tested in accordance with the requirements of **19.3**.

21.3 Temperature test. The motor shall be tested in accordance with the requirements of **19.5** and the results shall be recorded.

21.4 Endurance tests. The motor shall be tested in accordance with the requirements of **19.11**

21.5 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 **19.11.1**.

An abridged report on the tests and conditions 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 **20.5**.

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