

Specification for

Efglas type electric cables with copper conductors for aircraft

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Foreword

This British Standard, which has been prepared on the basis of Ministry of Aviation specification EL.1936 (Issue 4), relates to cables for use at operating temperatures higher than those for which Tersil cables complying with BS G 189 are suitable. At temperatures above 105 °C it is essential that the material and finish of any termination should be compatible with that of the conductor of the cable. Performance requirements for crimped terminations at all temperatures are given in BS G 178.

The relevant requirements of the standard are in agreement with those adopted as a basis for ISO Recommendations for the dimensions and conductor resistance of heat-resisting electric cables for aircraft, in course of preparation by the International Organization for Standardization.

The standard makes reference to the following British Standards:

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

BS 872, *Abrasive papers and cloths (technical products).*

BS 6360, *Copper conductors in insulated cables and cords.*

BS 6746, *PVC insulation and sheath of electric cables.*

BS 6746C, *Colour chart for PVC insulation and sheath of electric cables.*

NOTE The values in British units are to be regarded as the standard. Where metric equivalents are given they are approximate and for information only. In Table 1 to Table 5 such equivalents are shown only for the more essential features of the cables, i.e. the nominal conductor areas the overall diameters of the finished cables and the weights of the cables. Equivalents of other values in these tables and more accurate conversions of the metric values which are quoted should be based on the tables in BS 350, “*Conversion factors and tables*”.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18 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.

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1 Scope

a) This British Standard specifies requirements for “Efglas”¹⁾ type cables for aircraft wiring of circuits in which the potential between conductors, or between a conductor and metal braid or the aircraft structure, does not exceed 600 volts (r.m.s.) and the frequency does not exceed 1 600 c/s and where any combination of ambient temperature and conductor current for continuous service does not produce a stabilized conductor temperature in excess of 260 °C. The cables remain flexible at temperatures down to – 70 °C. The cables do not support combustion but do not comply with the requirements of BS 2G 100 in respect of fire resistance.

b) The generic name “Efglas” is applicable only to cables covered by this British Standard and complying with all its requirements.

c) The standard includes the following ranges of cables:

- i) *Efglas*. Cable with a copper conductor and composite insulation of glass and polytetrafluoroethylene (PTFE).
- ii) *Efglasmet*. Similar to the Efglas range but with the addition of a metal braid.
- iii) *Efglasmet sheath*. Similar to the Efglasmet range but with the addition of an external sheath of PTFE and glass braid.
- iv) *Efglaslarge*. Similar to the Efglas range but with a greater thickness of insulation and with a correspondingly greater resistance to abrasion. These cables have the same overall diameters as those specified for the equivalent American cables (in U.S. Specification MIL-W-7139), but are heavier than their Efglas counterparts.
- v) *Duefglas and Triefglas*. Two- or three-core cables consisting of two or three Efglas cables marked with coloured stripes for phase identification and twisted together.
- vi) *Duefglasmet sheath and Triefglasmet sheath*. Duefglas and Triefglas cable assemblies with an overall metal braid and with a PTFE sheath over the braid.

d) The cables are classified and identified, not by current ratings, but by a series of numbers indicative of the conductor cross-sectional area. These numbers correspond to those used for equivalent American cables.

An indication of the relationship between this system of identification and that provided by BS E 21, Electric cables for aircraft (Pren Type), is given in Appendix A for information.

A guide to the current ratings of Efglas cables is given in Appendix B.

Section 1. Requirements

2 Materials

a) *Copper conductors and wires*. Annealed copper wire shall be in accordance with BS 6360 as far as applicable. The wire for the conductors and metal braids shall be nickel coated and shall comply with the requirements of Clauses 26 and 27. The conductors only shall comply with the tensile and elongation requirements of Clause 25.

b) *Insulation*. The insulation shall be of such a quality that the finished cable complies with all the requirements of this British Standard.

3 Construction

a) *General*.

i) *Conductor*. The conductor shall be bunched, or multi-layer bunched. It shall consist of nickel-plated copper wires complying with the requirements of Subclause 2 a). Joints in single wires shall be brazed or hard soldered but the complete conductor shall not be joined. There shall be no kinks or other irregularities in the conductor.

Table 1 and Table 5 state the number and diameter of individual wires to be used for the complete conductor. The resistance of the insulated conductor, measured as specified in Clause 19, shall be not greater than the values given in Table 1 and Table 5.

ii) *Insulation*. The insulation shall consist of a layer of PTFE adjacent to the conductor and of subsequent layers of PTFE and PTFE impregnated glass braids or tapes which are subsequently heated so that the PTFE and glass braids or tapes become a compact sintered mass. All fibrous glass yarns used in braiding shall be coated with PTFE to the extent of not less than 15 per cent by weight of the coated yarn.

All fibrous glass tapes used in insulation shall contain not less than 50 per cent of PTFE by weight of coated tape.

¹⁾ The various combinations of the word “Efglas” used to distinguish these cables were originated by the Royal Aircraft Establishment of the Ministry of Aviation.

The outer surface of the cable may present itself either as a lapped PTFE tape which shall be finally sintered, or as an extruded PTFE layer.

The cables shall be circular in cross section. The insulation shall not be loose on the conductor, but it shall be possible to strip the complete insulation, leaving the conductor in a condition sufficiently clean to permit satisfactory connection to termination.

iii) The exterior of the cable shall be coloured white. The cable size shall be identified by the method stated in Clause 5.

iv) *Metal braids.* Nickel-plated copper wires, as specified in Subclause 2 a), shall be used to form the overall metal braids of single core or multi-core cables. The braids shall be close fitting, but wherever a single core (Uniefglasmet) cable is cut it shall be possible to slide the metal braid back by hand a distance of 4 in (102 mm) in a length of 2 ft (60 cm) one end of the cable being clamped. The braid shall subsequently be capable of being returned to within 1 in (25.4 mm) of the free end of the cable.

Where breaks in the individual wires occur, the ends shall be brazed or tucked out of the braid and there shall not be more than one such break in any one-inch (25.4 mm) length of cable.

Where renewal of the spindles is necessary, the ends shall be tucked out of the braid, and there shall not be more than one spindle renewal in any twelve-inch (30 cm) length of cable.

There shall be no joints in the complete braid. The diameter of wire used shall be as stated in Table 2, Table 3 and Table 4. The number of spindles and ends per spindle shall be such as to ensure that the filling factor is not less than 0.70. The lay factor shall not exceed 3. The formulae to be used for the calculation of the above details are given in Appendix C.

v) *Sheath.* Where an outer sheath is called for it shall be of PTFE as defined in the third paragraph of Sub-clause 3 a) ii) and shall be coloured white.

b) *Uniefglas cables*

i) The cables shall consist of single cores complying with the requirements of Subclauses 2 a), 2 b) and 3 a), i), ii), and iii). The outside diameters of the cables shall be as shown in Table 1.

ii) When required by the purchaser, phase identification shall be provided on the cables by means of a helical stripe of left-hand lay, in the colours red, yellow or blue. The colours shall match reasonably those specified in BS 6746. Such cables shall be ordered by the addition to the cable nomenclature of the word "red", "yellow" or "blue" as appropriate.

The average width of the stripe shall be as follows:

Uniefglas 22 to 12 $\frac{1}{8} \pm \frac{1}{16}$ in
(3.2 $\pm$ 1.6 mm)

Uniefglas 10 to 0 000 $\frac{3}{16} \pm \frac{1}{16}$ in
(4.8 $\pm$ 1.6 mm)

The lay for all sizes shall be 1 in (25.4 mm) minimum and 1 ½ in (38.1 mm) maximum.

c) *Uniefglasmet cables.* The cables shall consist of Efglas cables to which has been added a metal braid complying with the requirements of Subclause 3 a) iv). The outside diameters of the cables shall be as shown in Table 2.

d) *Uniefglasmet sheath cables.* The cables shall consist of Efglas cables, with or without the size identification, to which have been added a metal braid complying with the requirements of Subclause 3 a) iv) and a PTFE outer sheath complying with the requirements of Subclause 3 a) v).

The outside diameters of the cables shall be as shown in Table 3.

e) *Duefglas and Triefglas cables.* The cables shall consist of two or three Uniefglas cables of the same size, with phase identification in accordance with Subclause 3 b) ii) in the combinations stipulated by the purchaser, twisted together with a right-hand lay approximately 12½ times the pitch circle diameter for sizes 22 to 4 and approximately 16 times the pitch circle diameter for sizes 2 to 0 000. The assemblies shall be made from single-core cables for which the manufacturer holds type approval, except that only one of the cables in an assembly need bear the printed identification.

f) *Duefglasmetsheath and Triefglasmetsheath.*

The cables shall consist of Duefglas or Triefglas cables, with phase identification, but with or without size identification, to which have been added a protective layer of PTFE tape, an overall metal braid complying with the requirements of Subclause 3 a) iv) and an outer sheath complying with Subclause 3 a) v). The diameters over braid and over sheath shall be as shown in Table 4 and the sizes of these cables shall be restricted to those shown in the table. Glass yarn fillers may be used in the make-up of these cables in order to obtain a circular shape.

g) *Uniefglaslarge cables.* The cables shall consist of single cores complying with the requirements of Clauses 2 a), 2 b) and 3 a), i), ii) and iii). The dimensions of the cables shall be as shown in Table 5.

4 Fastness of colour cables

All colours shall be fast to light, heat and moisture. The materials used shall be capable of retaining their colours after storage for long periods in the tropics.

5 Cable size identification

Cable shall be identified by the word Efglas, Efglasmetsheath, Duefglasmetsheath, Triefglasmetsheath or Efglaslarge, as appropriate, with the numerals corresponding to its size permanently and legibly printed on the outer surface. Preferably the horizontal axis of the characters should be parallel to the axis of the cable. The printing, which shall be in black, shall be repeated with a spacing of 6 inches to 12 inches (152 mm to 304 mm). The height of the characters shall be approximately two thirds of the maximum overall diameter of the cable for sizes 22 to 10 inclusive; for sizes 8 to 0 000 inclusive and for Duefglasmetsheath and Triefglasmetsheath cables the height of character may be the same as for size 10. A longitudinal line in the spaces is not permissible.

If necessitated by the limited length of legend that the manufacturer is able to print with existing equipment, EFGLASMETSHEATH may be abbreviated to FGMETSH, DUEFGLASMETSHEATH and TRIEFGLASMETSHEATH to 2FG-METSH and 3FG-METSH respectively, and EFGLASLARGE to FGLARGE.

In single core Efglas, Efglasmetsheath and Efglaslarge cables the size number shall follow immediately after the name. In two- and three-core assemblies metal braided and sheathed overall the number shall appear in the space indicated above e.g. 2FG22METSH, 3FG20METSH.

6 Identification of manufacturer and year of manufacture

The manufacturer shall not mark the cable itself with his name and address, but with a code letter in accordance with the current British Standards Institution list²⁾ of manufacturers' identification marks for aircraft electric cables. The cable shall also be marked with a letter to indicate the year of manufacture. All manufacturers shall use the same letter for the current year, which shall be as stated in Table 7. The letter to be used shall be that for the year in which the PTFE insulation is finally sintered.

The identification letters shall be of the size specified in Clause 5, and shall be printed on the cable immediately following the cable size identification, e.g. EFGLAS22 XY. The manufacturer's code letter shall precede the letter indicating the year of manufacture.

7 Designation of cable

For the purposes of references on drawings and orders the cables shall be designated by the number of this British Standard, together with the individual cable name, and, if relevant, the phase colour or colours, e.g.

"BS G 192/Uniefglas 22"

"BS G 192/Uniefglasmet 10"

"BS G 192/Uniefglas 16/blue"

"BS G 192/Duefglas 12/red/yellow"

8 Packing and labelling

Unless otherwise agreed between the purchaser and manufacturer, the minimum length of cable shall be 100 yards (90 m) for sizes 22 to 10 and 50 yards (45 m) for sizes 8 to 0 000. Not more than one length of cable shall be supplied on one reel. Cables shall not be supplied in coils unless this is required by the contract.

After testing, the cable shall have the ends sealed to prevent the ingress of moisture. Each length shall bear a durable label giving the following particulars:

- a) Name of manufacturer.
- b) Name of cable, e.g. Uniefglas 22.

²⁾ Obtainable from BSI, 2 Park Street, London, W.1.

- c) Size of conductor, e.g. 19/0.006 in.
- d) British Standard number and year of issue.
- e) Date of manufacture (month and year).
- f) Release reference number or contract number, or both.
- g) Actual length in yards.

When the cable is being bought directly by a British Government department, the label shall also carry the Government property mark (broad arrow).

Section 2. Tests

9 General

Tests shall be made to prove compliance with all requirements of this British Standard. It is not intended or recommended that complete tests shall be made on every cable length supplied.

Efglasmet and Efglasmetsheath cables shall be made from Efglas cable that complies with all the following relevant tests.

In addition, Efglasmet cable shall comply with Clauses 10, 12, 17, 18, 19, 20, 26 and 27 and Efglasmetsheath cable shall comply with Clauses 10, 11, 12, 14, 15, 17, 18, 19, 20, 26 and 27.

For ease of reference these requirements are set out in Table 13.

The manufacturer shall produce evidence to the satisfaction of the approving authority³⁾ that cable of the type to be supplied to the specification fulfils its requirements.

The manufacturer shall disclose to the purchaser and approving authority any proposal to introduce constructions or processes differing from those used for the cable submitted to type tests, and shall obtain the approving authority's written approval before applying the change to production.

Three kinds of test are specified as follows:

- a) *Type tests.* Type tests (Clauses 10 to 28) shall each be made on separate specimens from a sample selected by the manufacturer from each of the following groups of cables, a sample being regarded as representative of all the sizes of cable in its group provided that they are made by the same process and with the same materials.

Efglas cables.

Group 1: Uniefglas 22 to 16

Group 2: Uniefglas 14 and 12

Group 3: Uniefglas 10 to 2

Group 4: Uniefglas 1 to 0 000.

In Group 1 the cable to be tested shall be the smallest size it is proposed to manufacture.

Efglasmet cables.

Group 1: Uniefglasmet 22 to 8.

In this group the cable to be tested shall be the smallest size it is proposed to manufacture.

Efglasmetsheath cables.

Group 1: Uniefglasmetsheath 22 to 16

Group 2: Du-and Triefglasmetsheath 22 to 16.

In this group the cable to be tested shall be the smallest size it is proposed to manufacture.

Efglaslarge cables.

Group 1: Uniefglaslarge 22 to 16

Group 2: Uniefglaslarge 14 and 12

Group 3: Uniefglaslarge 10 to 2

Group 4: Uniefglaslarge 1 to 0 000.

In Group 1 the cables to be tested shall be the smallest size it is proposed to manufacture.

b) *Production routine tests.* Production routine tests (Clauses 17 to 20) shall be made on every length of cable.

c) *Production quality tests.* Production quality tests (Clauses 21 to 26 and 28) shall be made on each batch of 10 000 yards or 10 000 metres of cable, or at least once on each two months' production, whichever is the less. A batch of cable may consist of different sizes and types but, wherever possible, the sample should be representative of the sizes and types being produced.

Tests on the nickel plating of the copper wires used for the conductors and for the braids (Clause 27) shall normally be made on the wires before manufacture of the cable, and shall be applied with the frequency stated above. The inspecting authority may, however, require these tests to be applied to wires taken from the finished cable.

Two samples of cable shall be selected from the production batch, one sample being of the smallest size produced. Specimens from each of these samples shall each be subjected to the tests in Clauses 21 to 26. Should either of the samples fail on any one of the tests, the test shall be repeated on specimens from four further samples taken at random but including two samples of the smallest size produced. Should any one of these samples fail, the batch shall be deemed not to comply with this specification.

³⁾ For cables for aircraft subject to British civil or military air-worthiness requirements, the approving authorities are the Air Registration Board (through a design authority approved by the Board) and the Ministry of Aviation, respectively.