

# ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

## ISO RECOMMENDATION

### R 474

#### PERFORMANCE REQUIREMENTS FOR GENERAL PURPOSE ELECTRICAL CABLES WITH COPPER CONDUCTORS FOR AIRCRAFT

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## BRIEF HISTORY

The ISO Recommendation R 474, *Performance Requirements for General Purpose Electrical Cables with Copper Conductors for Aircraft*, was drawn up by Technical Committee ISO/TC 20, *Aircraft*, the Secretariat of which is held by the British Standards Institution (BSI).

Work on this question by the Technical Committee began in 1958 and led, in 1960, to the adoption of a Draft ISO Recommendation.

In March 1961, this Draft ISO Recommendation (No. 421) was circulated to all the ISO Member Bodies for enquiry. It was approved by the following Member Bodies:

Australia	France	Portugal
Belgium	Germany	Spain
Canada	Iran	Sweden
Chile	Israel	United Kingdom
Colombia	Italy	U.S.S.R.
Czechoslovakia	Netherlands	Yugoslavia
Finland	New Zealand	

No Member Body opposed the approval of the Draft.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in February 1966, to accept it as an ISO RECOMMENDATION.

**PERFORMANCE REQUIREMENTS  
FOR GENERAL PURPOSE ELECTRICAL CABLES  
WITH COPPER CONDUCTORS FOR AIRCRAFT**

**1. SCOPE**

- 1.1 This ISO Recommendation states the requirements for cables for general purpose wiring of aircraft circuits in which the voltage between conductors, or between a conductor and metal braid or the aircraft structure, does not exceed 600 volts (r.m.s.) and in which the frequency does not exceed 1600 Hz. The cables are suitable for use where, in continuous service, no combination of ambient temperature and conductor current produces a stabilized conductor temperature in excess of 105 °C. These cables are suitable for fixed wiring in aircraft at a temperature down to — 75 °C, but are not suitable for severe flexing at temperatures below — 30 °C. These cables do not support combustion, but they should not be regarded as complying with the requirements of ISO Recommendation R . . . \* in regard to fire resistance.
- 1.2 This ISO Recommendation includes the requirements for cables with copper conductors or composite conductors, including those with an outer covering in the form of a metal braid.

**2. TERMINOLOGY**

- 2.1 *Conductor*. Conducting portion of a cable.
- 2.2 *Wire*. Cylindrical metallic wire of uniform cross-sectional area, used to form the conductor.
- 2.3 *Stranded conductor*. Conductor composed of a number of wires twisted together. When the conductor consists of more than one layer, alternate layers are twisted in opposite directions.
- 2.4 *Bunched conductor*. Conductor composed of a number of wires in which all wires are twisted together in the same direction.
- 2.5 *Rope lay conductor*. Conductor in which a number of groups of wires are assembled in concentric layers. Each group may consist of wires assembled in stranded or bunched formation.
- 2.6 *Composite conductor*. Conductor composed of copper wires and/or wires of a metal of greater strength.
- 2.7 *Insulation*. Part of a cable which serves to insulate the conductor.
- 2.8 *Core*. Conductor and insulation of a cable, excluding all additional coverings.

\* ISO Recommendation R . . . , *Environmental and operational conditions of aircraft electrical equipment. Part 5: Fire resistance*, at present Draft ISO Recommendation No. 766.

- 2.9 *Protective covering.* Outside covering of a cable, protecting the insulation against deterioration caused by abrasion or injurious fluids.
- 2.10 *Metal braid.* A number of wires applied spirally over the insulation or protective covering and interwoven to form a uniform and substantially continuous covering.
- 2.11 *Cable.* Complete assembly of conductor, insulation and protective covering.
- 2.12 *Sample.* Amount of cable of one and the same dimension and type, taken from a batch.
- 2.13 *Test piece.* Continuous length of cable taken from a sample.

### 3. MATERIALS

- 3.1 Copper wires should be of annealed high conductivity copper having a resistivity not greater than the value fixed by the International Electrotechnical Commission (IEC) for "Standard annealed copper".\* Each wire should be uniformly coated with pure tin.
- 3.2 The tensile strength and elongation of wires taken from conductors should conform to the appropriate values shown in Table 1, which are based on a gauge length of 10 in (254 mm) held in clamps separated at a rate not exceeding 12 in (300 mm) per minute, the tensile strength being calculated on the original cross-sectional area of the wire.

TABLE 1. - Tensile tests on wires

Material	Diameter		Tensile strength		Minimum elongation
	in	mm	lbf/in <sup>2</sup>	kgf/cm <sup>2</sup>	per cent
Copper	0.020 to 0.012	0.508 to 0.305	43 000 max.	3023 max.	13.5
	0.011 to 0.003	0.279 to 0.076	44 000 max.	3094 max.	9.0

- 3.3 The conductors of Size 20 and Size 22 cables may be composed of copper wires and of wires of a stronger metal with an equivalent conductivity and a tensile strength as given in Table 2, below.

TABLE 2.

Cable size	Minimum equivalent conductivity in reference to copper	Minimum tensile strength
22	50 per cent	31 lbf (14 kgf)
20	66 per cent	44 lbf (20 kgf)

\* IEC Publication No. 28, *International Standard of Resistance for Copper.*

- 3.4 Primary insulation and protective covering.** The materials used for the primary insulation and protective covering of the cables should be such that the finished cable will comply with all the requirements of this ISO Recommendation. The materials should be free from ingredients likely to cause staining or discolouration of the cable.

#### 4. CONSTRUCTION

##### 4.1 Conductor

Conductors should consist of a number of wires, bunched, stranded, or in rope lay formation. The wires should be tinned annealed copper complying with the relevant requirements of section 3. Alternatively, and subject to the agreement of the airworthiness authority, the conductor may consist of a mixture of tinned annealed copper wires and wires of a stronger metal.

The complete conductor should not be joined. Individual wires may be joined, preferably by brazing or soldering. Alternatively, in the case of wires of a diameter less than 0.012 in (0.3 mm) the joint may be made by twisting the ends together. Not more than one joint should occur in each 50 m of wire.

##### 4.2 Complete cable

- 4.2.1** The insulation should be of uniform circular cross section throughout the length of the cable and the conductor should be evenly centred in the insulation.
- 4.2.2** The insulation should not be loose, but it should be possible to strip the complete insulation, leaving the conductor in a condition sufficiently clean to permit satisfactory connections being made to terminations without further cleaning.
- 4.2.3** The protective coverings over the primary insulation should be so treated and applied that there is no wrinkling back of the exterior protective sheath.
- 4.2.4** The cables should bear means of identification in accordance with section 11.

##### 4.3 Metal-braided cables

Tinned copper wires complying with the requirement of clause 3.1 should be used to form the overall outer cover of metal-braided cables.

The metal braids should be close fitting, but wherever the cable is cut it should be possible to slide the metal braid back by hand a distance of 4 in (100 mm) in a length of 2 ft (600 mm), one end of the cable being clamped. The metal braid should subsequently be capable of being returned to within one inch (25 mm) of its original position.

Where breaks in the individual wires occur, the ends should be soldered or tucked out of the metal braid, and there should not be more than one such break in any one-inch (25 mm) length of cable and in each 10 m of individual wire.

#### 5. DIMENSIONS AND CONDUCTOR RESISTANCE

The dimensions and conductor resistance of the finished cables should comply with ISO Recommendation R 469\* and with the requirements of the relevant specification.

#### 6. RESISTANCE TO ADVERSE ENVIRONMENTAL CONDITIONS

The finished cables should be suitable for fixed wiring at temperatures down to  $-75^{\circ}\text{C}$ . They should be non-hygroscopic and resistant to fluids likely to be encountered on aircraft; they should not support mould growth. All colours should be fast to light and moisture, even after storage for long periods in the tropics.

\* ISO Recommendation R 469, *Dimensions and conductor resistance of general purpose electrical cables with copper conductors for aircraft.*

## 7. TESTS

The tests listed below should be in accordance with the relevant national standard for general purpose electrical cables for aircraft suitable for operation at stabilized conductor temperatures up to 105 °C.

Preferred methods of test are stated in ISO Recommendation R...\*. Evidence should be available to the purchaser that cable covered by this ISO Recommendation has satisfactorily passed type tests conducted in accordance with sections 8, 9 and 10. It is not necessarily intended that a type test should be made on every size of cable. The national standard may, subject to the agreement of the national airworthiness authority, permit the division of the range of sizes into groups, tests on one sample being accepted as representative of all the cables in the group.

In order that a consistent standard of quality be maintained, the manufacturer should conduct production routine tests (see section 9) and production quality tests (see section 10).

## 8. TYPE TESTS ONLY

Samples of cable should have passed the tests listed in sections 9 and 10 before submission to the following type tests:

- (a) Resistance to typical aircraft fluids (fuel, hydraulic fluid, lubricating oil, including synthetic ester-based oils, and de-icing fluids).
- (b) Ageing in air at high temperature, followed by a bend test at room temperature, and an insulation test while immersed in water.
- (c) Flexibility test at room temperature.
- (d) Bend test at low temperature.
- (e) Surface creepage test while immersed in salt water.
- (f) Heat test (to check that adjacent cables do not adhere at elevated temperatures).
- (g) Test of physical properties of insulation material (e.g. 60 days at 113 °C).
- (h) Abrasion test.

## 9. TYPE AND PRODUCTION ROUTINE TESTS

Each length of cable produced should be submitted to the following tests:

- (a) Conductor resistance tests.
- (b) Insulation tests.
  - (i) Insulation tests on the core should consist of a voltage test followed by an insulation resistance test, applied after immersion in water for not less than twelve consecutive hours.

Alternatively, five per cent of the core length may be tested in this manner, provided all the core made is submitted to a spark test in the dry state.

\* ISO Recommendation R... , *Methods of test for general purpose electrical cables with copper conductors for aircraft*, at present Draft ISO Recommendation No. 807.