INTERNATIONAL STANDARD 2032

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Heat-resisting equipment wires for aircraft

First edition — 1973-04-01

UDC 629.7.064.5 : 621.315.2 **Ref. No. ISO 2032-1973 (E)**

Descriptors : aircraft, aircraft equipment, wires, electric wires, thermal resistance, specifications, materials specifications, tests, marking.

Price based on 4 pages

ISO 2032-1973 (E)

FOREWORD

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Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2032 was drawn up by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, and circulated to the Member Bodies in July 1970.

It has been approved by the Member Bodies of the following countries :

Brazil	India	South Africa, Rep. of
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Belgium
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Heat-resisting equipment wires for aircraft

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the requirements for a range of equipment wires (hook-up wires) designed for the internal wiring of meters, panels and electrical and electronic equipment for use on aircraft. Three classes of equipment wire are specified as follows :

- Type A : for use at voltages up to 250 V r.m.s.
- Type B : for use at voltages up to 600 V r.m.s.
- Type C : for use at voltages up to 1 000 V r.m.s.

The wires are suitable for use where, in continuous service, no combination of ambient temperature and conductor current produces a stabilized conductor temperature in excess of 200 °C.

The wires are suitable for fixed wiring at temperatures down to − 75 °C but are not suitable for severe flexing below − 50 °C. These wires do not support combustion but they should not be regarded as complying with the requirements of ISO . . .[1] in regard to fire resistance.

This International Standard includes the requirements for wires with copper conductors, including those with an outer covering in the form of a metal braid.

2 TERMINOLOGY

2.1 conductor : Conducting portion of an equipment wire.

2.2 wire : Cylindrical metallic wire of uniform cross-sectional area, used to form the conductor or braid.

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 insulation : Part of an equipment wire which serves to insulate the conductor.

2.6 metal braid : A number of wires applied spirally over the insulation and interwoven to form a uniform and substantially continuous covering.

2.7 equipment wire : Complete assembly of conductor, insulation and metallic braid if any.

2.8 sample : Amount of equipment wire of one and the same dimension and type, taken from a batch.

3 MATERIALS

3.1 Copper wires shall 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 shall be coated with silver or other suitable metal which will satisfy the requirements of the relevant national specification.

3.2 The tensile strength and elongation of wires taken from conductors shall conform to the appropriate values shown in Table 1 which are based on a gauge length of 254 mm (10 in) held in clamps separated at a rate exceeding 127 mm (5 in) per minute, the tensile strength being calculated on the original cross-sectional area of the wire.

TABLE 1

Diameter		Maximum tensile strength		Minimum elongation
mm	in	MPa*	lbf/in²	%
0,08 to 0,125	0.003 15 to 0.004 92	325	47 000	5,5
0,15 to 0,20	0.005 9 to 0.007 87	303	44 000	9,0
0,25 to 0,45	0.009 84 to 0,017 7	296	43 000	13,5
0,60 to 0,90	0.023 6 to 0.035 4	290	42 000	18,0

* 1 MPa = 1 MN/m².

3.3 The material used for the insulation shall be polytetrafluoroethylene or other material giving an equivalent performance. It shall be applied in such a way that the equipment wire meets all the requirements of this International Standard.

1) In preparation.

4 CONSTRUCTION

4.1 Conductor

4.1.1 The conductor shall consist of a number of wires bunched or stranded. The wires shall be annealed copper coated with silver or other suitable metal as specified in 3.1.

4.1.2 The complete conductor shall not be joined. Individual wires may be joined, preferably by brazing or soldering, but no joint shall be within 300 mm (12 in) of any other joint in the same layer.

4.2 Complete equipment wire

4.2.1 The insulation shall be of uniform circular cross-section throughout the length of the equipment wire and the conductor shall be evenly centred in the insulation.

4.2.2 The insulation shall not be loose but it shall 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 When specified by the purchaser, the equipment wire shall be coded for circuit identification by colouring, printing or other suitable method.

4.2.4 When specified by the purchaser, the equipment wire shall bear means of identification in accordance with section 11.

4.3 Metal-braided equipment wire

4.3.1 Annealed copper wire coated with silver or other suitable metal and complying with the requirements of 3.1 shall be used to form the overall outer cover of metal-braided equipment wires.

4.3.2 The metal braids shall be close fitting but wherever the equipment wire is cut it shall be possible to slide the metal braid back by hand a distance of 100 mm (4 in) in a length of 600 mm (24 in), one end of the equipment wire being clamped. The braid shall subsequently be capable of being returned to within 12,5 mm (0.5 in) of its original position.

4.3.3 Where breaks in the individual wires occur, the ends shall be brazed, hard soldered or tucked out of the braid and there shall not be more than one such break in any 25 mm (1 in) length of equipment wire.

4.3.4 When 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 300 mm (12 in) length of equipment wire.

4.3.5 There shall be no joints in the complete braid.

4.3.6 The metal braid shall not increase the maximum diameters of the specified type of equipment wire by more than 0,76 mm (0.030 in).

5 DIMENSIONS AND CONDUCTOR RESISTANCE

The dimensions and conductor resistance of the finished equipment wires shall comply with Tables 2 and 3.

6 RESISTANCE TO ADVERSE ENVIRONMENTAL CONDITIONS

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

7 TESTS

7.1 The tests listed below shall be in accordance with the relevant national standard for equipment wires for aircraft suitable for operation at stabilized conductor temperatures up to $200\ ^{\circ}C$.

7.2 Preferred methods of test are stated in ISO 2436. Evidence shall be available to the purchaser that the equipment wire covered by the present International Standard has satisfactorily passed type tests conducted in accordance with sections 8, 9 and 10. It is not necessarily intended that a type test shall be made on every size of equipment wire. 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 equipment wires in the group.

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

8 TYPE TESTS ONLY

Samples of equipment wire shall have passed the tests listed in sections 9 and 10 before submission to the following type tests :

1) ageing in air at high temperature, followed by an insulation test while immersed in water;

2) ageing in air at high temperature, followed by an insulation test at the ageing temperature;

3) bend test at low temperature;

4) flammability test.

TABLE 2 – Unscreened equipment wire

Nominal area of conductor		Size No.	Minimum number of wires	Maximum resistance of finished equipment wire at 20 °C		Nominal diameter of conductor		Maximum diameter over insulation					
								Type A		Type B		Type C	
mm^2	in^2			Ω/km	Ω/1 000 yd	mm	in	mm	in	mm	in	mm	in
0,035 2	0,000 054 6	32	7	570,7	521.3	0,24	0.009 5	0,59	0.023	0,84	0.033	1,16	0.046
0,055 0	0.000 085 3	30	7	365,3	334.0	0,30	0.012	0,65	0.026	0,90	0.035	1,22	0.048
0,085 9	0.000 133	28	7	223,3	204.2	0,38	0.015	0,73	0.029	0,98	0.039	1,30	0.051
0,124	0.000 192	26	7	155,1	141.8	0,45	0.018	0,80	0.032	1,05	0.041	1,37	0.054
0,220	0.000 341	24	7	87,2	79.74	0,60	0.024	0,95	0.037	1,20	0.047	1,52	0.060
0,336	0.000 521	22	7	57,1	52.22	0,75	0.030	1,10	0.043	1,35	0.053	1,67	0.066
0,597	0.000 925	20	7	32,14	29.39	1,00	0.039	1,35	0.053	1,60	0.063	1,92	0.076
0,933	0.001 45	18	7	20,57	18.81	1,25	0.049	–	–	1,85	0.073	2,17	0.085
1,34	0.002 08	16	19	14,28	13.06	1,50	0.059	–	–	2,10	0.083	2,46	0.097
1,68	0.002 61	14	19	11,13	10.18	1,68	0.066	–	–	2,28	0.090	2,74	0.108
3,02	0,004 68	12	19	6,17	5.64	2,25	0.089	–	–	2,85	0.112	3,31	0.130
4,65	0.007 21	10	37	4,01	3.66	2,80	0.110	–	–	3,40	0.134	3,86	0.152

TABLE 3 – Screened equipment wires

Nominal area of conductor		Size No.	Minimum number of wires	Maximum resistance of finished equipment wire at 20 °C		Nominal diameter of conductor		Maximum diameter over insulation					
								Type A		Type B		Type C	
mm^2	in^2			Ω/km	Ω/1 000 yd	mm	in	mm	in	mm	in	mm	in
0,035 2	0,000 054 6	32	7	570,7	521.3	0,24	0.009 5	0,59	0.023	0,84	0.033	1,16	0.046
0,055 0	0.000 085 3	30	7	365,3	334.0	0,30	0.012	0,65	0.026	0,90	0.035	1,22	0.048
0,085 9	0.000 133	28	7	223,3	204.2	0,38	0.015	0,73	0.029	0,98	0.039	1,30	0.051
0,124	0.000 192	26	7	155,1	141.8	0,45	0.018	0,80	0.032	1,05	0.041	1,37	0.054
0,220	0.000 341	24	7	87,2	79.74	0,60	0.024	0,95	0.037	1,20	0.047	1,52	0.060
0,336	0.000 521	22	7	57,1	52.22	0,75	0.030	1,10	0.043	1,35	0.053	1,67	0.066
0,597	0.000 925	20	7	32,14	29.39	1,00	0.039	1,35	0.053	1,60	0.063	1,92	0.076
0,933	0.001 45	18	7	20,57	18.81	1,25	0.049	–	–	1,85	0.073	2,17	0.085
1,34	0.002 08	16	19	14,28	13.06	1,50	0.059	–	–	2,10	0.083	2,46	0.097
1,68	0.002 61	14	19	11,13	10.18	1,68	0.066	–	–	2,28	0.090	2,74	0.108
3,02	0,004 68	12	19	6,17	5.64	2,25	0.089	–	–	2,85	0.112	3,31	0.130
4,65	0.007 21	10	37	4,01	3.66	2,80	0.110	–	–	3,40	0.134	3,86	0.152

Size No.	Diameter of metal braiding wires						Maximum diameter over metal braid					
	Type A		Type B		Type C		Type A		Type B		Type C	
	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
32	0,08	0.003 2	0,10	0.003 9	0,10	0.003 9	0,99	0.039	1,34	0.053	1,66	0.066
30	0,08	0.003 2	0,10	0.003 9	0,10	0.003 9	1,05	0.042	1,40	0.055	1,72	0.068
28	0,08	0.003 2	0,10	0.003 9	0,10	0.003 9	1,13	0.045	1,48	0.059	1,80	0.071
26	0,08	0.003 2	0,10	0.003 9	0,10	0.003 9	1,20	0.048	1,55	0.061	1,87	0.074
24	0,10	0.003 9	0,10	0.003 9	0,10	0.003 9	1,45	0.057	1,70	0.067	2,02	0.080
22	0,10	0.003 9	0,10	0.003 9	0,10	0.003 9	1,60	0.063	1,85	0.073	2,17	0.086
20	0,10	0.003 9	0,10	0.003 9	0,10	0.003 9	1,85	0.073	2,10	0.083	2,42	0.096
18	–	–	0,10	0.003 9	0,10	0.003 9	–	–	2,35	0.093	2,67	0,105
16	–	–	0,10	0.003 9	0,10	0.003 9	–	–	2,60	0.103	2,96	0.117
14	–	–	0,10	0.003 9	0,10	0.003 9	–	–	2,78	0.110	3,24	0.128
12	–	–	0,10	0.003 9	0,12	0.004 7	–	–	3,35	0.132	3,91	0.154
10	–	–	0,12	0.004 7	0,12	0.004 7	–	–	4,00	0.158	4,46	0.176

9 TYPE AND PRODUCTION ROUTINE TESTS

Each length of equipment wire produced shall be submitted to the following tests :

1) conductor resistance tests;

2) spark test in the dry state (except metal-braided equipment wires). The spark test shall be made by means of a suitable chain-electrode device that will subject the insulation to an impressed a.c. voltage not less than the value shown in Table 4;

3) voltage test (metal-braided equipment wires). The voltage specified in Table 4 at a frequency of 25 to 100 Hz shall be applied for 1 min between conductor and braid in the dry state.

TABLE 4

Type of equipment wire	Spark test V r.m.s.	Voltage test V r.m.s.
A	2 000	750
B	3 000	1 000
C	6 000	2 000

10 TYPE AND PRODUCTION QUALITY TESTS

10.1 The following tests shall be made periodically during the manufacture of a batch of equipment wire in order to establish that certain important physical qualities are being maintained. It is recommended that such tests be made on each 100 000 m of equipment wire or at least once during each period of 2 months' production, whichever is the less.

10.2 Two samples taken at random, one sample being of the smallest size produced, shall be subjected to the tests listed below. Should either of the samples fail any one of the tests, the tests shall be repeated on four further samples taken at random. Should any one of these samples fail, the batch shall be deemed not to comply with this International Standard.

1) Voltage and insulation tests

a) Voltage test followed by an insulation resistance test applied after immersion in water at room temperature for not less than 12 consecutive hours.

b) In the voltage test, a voltage as specified in Table 4 at a frequency of 25 to 100 Hz shall be applied gradually between conductor and water and maintained at the specified value for 1 min.

c) The insulation resistance shall be measured after 1 minute's electrification at 500 V d.c. and the value shall not be less than the equivalent of 1 000 MΩ for 1 000 m of equipment wire.

2) Tensile and elongation tests on conductor wires.

3) Coating tests on conductor wires and braid wires.

4) Solderability test.

5) Stability (non-retraction) test of insulation.

11 MARKING AND IDENTIFICATION

11.1 Identification of type, size and manufacturer

When required by the purchaser, equipment wires Type B and C of size 24 and larger shall be indelibly marked with the type and size and a means of identification of the manufacturer provided throughout their length.

11.2 Labelling

Each length of equipment wire after testing shall bear a label giving the following particulars :

a) name of manufacturer;

b) national specification number;

c) designation of equipment wire and colour;

d) conductor size and stranding;

e) date (month and year) and place of manufacture;

f) inspector's reference;

g) actual length of equipment wire.