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METHODS OF TEST FOR GENERAL PURPOSE ELECTRICAL CABLES WITH COPPER CONDUCTORS FOR AIRCRAFT

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BRIEF HISTORY

The ISO Recommendation R 634, *Methods of Test 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 1960 and led, in 1962, to the adoption of a Draft ISO Recommendation.

In May 1965, this Draft ISO Recommendation (No. 807) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies:

Argentina	Israel	Switzerland
Belgium	Italy	U.A.R.
Brazil	Japan	United Kingdom
Canada	Netherlands	Yugoslavia
Chile	Portugal	
Czechoslovakia	Republic of South Africa	
France		
Germany	Spain	

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 November 1967, to accept it as an ISO RECOMMENDATION.

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METHODS OF TEST FOR GENERAL PURPOSE ELECTRICAL CABLES WITH COPPER CONDUCTORS FOR AIRCRAFT

1. SCOPE

This ISO Recommendation describes the tests suitable for establishing the compliance of general purpose electrical cables with copper conductors for aircraft with the performance requirements stated in ISO Recommendation R 474, *Performance Requirements for General Purpose Electrical Cables with Copper Conductors for Aircraft*. They are intended for use as a basis for specifying tests in the relevant national specifications where the national type approving authorities consider that existing tests are inadequate.

The tests are classified as follows:

I. Type tests only,

II. Type and production routine tests,

III. Type and production quality tests.

I. TYPE TESTS ONLY

2. RESISTANCE TO TYPICAL AIRCRAFT FLUIDS

2.1 The object of this test is to check that the cable will not be affected in such a way as to cause failure in service or undue difficulties in servicing by any of the fluids with which it is likely to come into contact on modern aircraft.

2.2 Separate cable samples should be bent into a loop of a diameter approximately fourteen times the overall diameter of the cable and immersed each in one of the following fluids, with the ends clear of the fluid, for not less than 20 hours, at a temperature such as is likely to be experienced in service for the particular fluid:

(*a*) Aviation fuels;

(*b*) Lubricating oils (including ester-based oils);

(*c*) Hydraulic fluids (including ester-based hydraulic fluids);

(*d*) De-icing fluids.

2.3 After immersion, the samples should be wiped, straightened and cooled to a temperature of 20 ± 5 °C, and then subjected to a bend of 360° round a mandrel having a diameter of not more than fourteen times the overall diameter of the cable. After this treatment, the diameter of the cable should not have increased by more than 5 %. There should be no cracking, splitting or other deterioration of the outer coverings and the samples should withstand a voltage test of 1500 V r.m.s. and a frequency at any value from 25 to 100 Hz inclusive, for at least 1 minute without breakdown in water.

3. AGEING IN AIR AT HIGH TEMPERATURE, FOLLOWED BY A BEND TEST AT ROOM TEMPERATURE AND AN INSULATION TEST WHILE IMMERSED IN WATER

3.1 The object of this test is to check that there is no cracking of the outer coverings of the cable during bending after heating and that the cable will not break down electrically due to displacement of the conductor resulting from deformation of the insulation at high temperature with the conductor under a tensile load. In addition, the test is designed to check that there is no deterioration of the conductor surface as a result of the insulation having been aged at a high temperature.

3.2 Air oven

A test piece of cable at least 24 in (61 cm) long, having the insulation removed for 1 in (25 mm) at each end, should be bent at least 180° round a cylindrical mandrel of diameter as specified in Table 1. The conductor should be loaded in such a manner that the portion of the insulation compound between the conductor and the mandrel is under compression while the conductor has attached at each end the load specified in Table 1. These conditions should be maintained for a period of 120 hours in an air oven at a constant temperature of 120 ± 2 °C. On removal from the air oven, the test piece should be cooled to between 20 and 25 °C within a period of 1 hour. When cooled, the cable should be freed from the load, removed from the mandrel and straightened. The test piece should then be subjected successively to the tests mentioned in clauses 3.3 and 3.4, and subsequently the insulation should be removed from the test piece and the conductor examined. It should show no signs of corrosion.

TABLE 1. — **Diameters of mandrels and test loads for bend tests**

Cable		Cable size	Maximum diameter of mandrel				Test load			
Nominal conductor area			Bend test*		Bend test at low temperature**		Bend test*		Bend test at low temperature**	
in²	mm²		in	mm	in	mm	lbf	daN	lbf	daN
0.000 598	0.38	22	4.5	115	3	76	0.75	0.3	2	0.9
0.000 93	0.60	20	4.5	115	3	76	0.75	0.3	2	0.9
0.001 47	0.95	18	4.5	115	3	76	1.0	0.4	2	0.9
0.001 89	1.22	16	6.5	165	3	76	1.0	0.4	3	1.4
0.003 01	1.94	14	6.5	165	6	152	1.0	0.4	3	1.4
0.004 77	3.08	12	6.5	165	6	152	3.0	1.4	3	1.4
0.008 2	5.29	10	10	254	6	152	3.0	1.4	5	2.3
0.013 3	8.55	8	10	254	6	152	3.0	1.4	5	2.3
0.021 1	13.6	6	10	254	10	254	6.0	2.7	10	4.5
0.033 5	21.6	4	10	254	10	254	6.0	2.7	10	4.5
0.052 6	33.9	2	10	254	18	457	6.0	2.7	15	6.8
0.064 3	41.5	1	10	254	18	457	6.0	2.7	15	6.8
0.081 8	52.8	0	10	254	18	457	10.0	4.5	20	9.0
0.105	68	00	10	254	18	457	10.0	4.5	25	11.3
0.132	85	000	10	254	18	457	10.0	4.5	30	13.6
0.166	107	0000	10	254	18	457	10.0	4.5	30	13.6

3.3 Bend test at room temperature

At a temperature maintained between 20 and 25 °C one end of the test piece should be secured to the mandrel and the other end to the load specified in Table 1. The mandrel should be rotated until the full length of the test piece is wrapped round the mandrel and is under the specified tensile load with adjoining turns in contact with each other. The mandrel should then be rotated in the reverse direction until the full length of the surface of the cable which was outside during the first wrapping is now next to the mandrel. This procedure should be repeated until two bends in each direction have been formed in the same section of the cable. There should be no cracking or puckering of the outer coverings of the finished cable as a result of this test.

3.4 Insulation test in water

The uninsulated ends of the test piece should be fastened in metallic contact to a metal bar. Care should be taken to avoid fraying the ends of the insulation and protective covering. The distance between the two uninsulated ends of the cable should be equal to the diameter of the mandrel specified in Table 1. The test piece should be immersed in a 5% aqueous sodium chloride solution at a temperature of 20 to 25 °C so that the insulation and protective covering protrudes 1½ in (38 mm) from the surface of the liquid. After immersion for

* See clauses 3.2 and 3.3.
** See clause 5.3, method B.

5 hours, a potential with a voltage of 1500 V r.m.s. and a frequency at any value from 25 to 100 Hz inclusive should be applied between the conductor and an electrode in contact with the liquid. This voltage should be increased at a uniform rate from 0 to 1500 V within 30 seconds and maintained at 1500 V for a period of 5 minutes without breakdown.

4. FLEXIBILITY TEST AT ROOM TEMPERATURE

4.1 The purpose of this test is to check that none of the constituent parts of the cable will crack during the flexing which is likely to be experienced during installation or service.

4.2 Before submission to the following test the cable should be maintained for a period in air at a temperature of 20 ± 5 °C and a relative humidity of 75 %.

4.3 The test piece of the complete cable should be wound on a mandrel into a close helix of at least three complete turns at a temperature of 20 ± 5 °C under a tensile load of such a value as to ensure that the cable conforms to the mandrel. The mandrel diameter should not be more than three times the maximum specified overall diameter of the cable for cables having overall diameters up to 0.48 in (12.2 mm) and six times the maximum specified overall diameter of cable for larger cables.

4.4 The complete test should comprise five test cycles, each cycle consisting of the winding of the cable on the mandrel, unwinding and rewinding in the reverse direction so that the surface of the cable inside the helix during the first winding is on the outside of the helix on rewinding.

4.5 After this treatment no part of the cable should show signs of damage likely to affect the performance of the cable in service. The test pieces should then be subjected to a voltage test of 1500 V r.m.s. and a frequency at any value from 25 to 100 Hz inclusive, for at least 1 minute without breakdown in water.

5. BEND TEST AT LOW TEMPERATURE

5.1 The purpose of this test is to check that no constituent parts of the cable will crack under conditions of severe flexing at temperatures down to –30 °C. The test is not necessarily applicable to cables having an overall diameter of 0.345 in (8.8 mm) or larger.

5.2 Before submission to the test, the cable should be maintained for a period in air at a temperature of 20 ± 5 °C and a relative humidity of 75 %. The mandrels used in the test should be of metal and should be allowed to cool to the specified temperature with the cable.

5.3 Acceptable alternative methods of test are as follows:

Method A

(*a*) A test piece of the cable at least 12 in (30 cm) long should be stored in air at a temperature of –30 ± 2 °C for a period of 6 hours, immediately after which it should be wound on a mandrel. The diameter of the mandrel should be ten times the maximum specified diameter of the cable. The rate of bending should be uniform at one complete turn each second. A revolving mandrel should be used.

(*b*) After 1 minute and with the cable still on the mandrel there should be no signs of cracking of the constituent parts to normal vision and the sample should withstand without breakdown a voltage test of 1500 V r.m.s. and a frequency at any value from 25 to 100 Hz inclusive for at least 1 minute in water.

Method B

(*a*) One end of a test piece of the cable of suitable length should be secured to a mandrel and the other end to a load weight, using a mandrel diameter and weight appropriate to the size of cable, as shown in Table 1. The temperature of the test piece should be lowered to –55 ± 1 °C at a rate not exceeding 50 °C per minute. After being maintained at this temperature for 1 hour, and while still at –55 ± 1 °C, the cable should be wrapped round the mandrel for 180°. The rate of bending should be uniform, and the time to complete the bend of 180 ° should be 30 seconds. A revolving mandrel should be used.

(*b*) The insulation should be removed for a distance of 1 in (25 mm) from each end of the test piece which should then be subjected to the insulation test described in clause 3.4 with the bent portion submerged.

6. SURFACE CREEPAGE TEST WHILST IMMERSED IN SALT WATER

A 30 in (76 cm) length of cable should have the insulation removed 1 in (25.4 mm) at each end, care being taken not to fray the end of the insulation. The cable should then be immersed in a 5% aqueous sodium chloride solution at a temperature of 50 ± 2 °C for twenty-four hours with the ends of the insulation and protective covering protruding 1½ in (38 mm) above the surface of the solution and with a current-limiting resistance of 75 000 Ω inserted in the circuit. At the end of that period, while the cable is still immersed and at a temperature of 20 ± 5 °C, a voltage of 1400 V d.c. should be applied between the conductor and the solution for 1 minute. The leakage current flowing should not exceed 0.2 milliampere.

7. HEAT TEST

7.1 The purpose of this test is to check that adjacent cables do not adhere when heated to the maximum temperature likely to be experienced in service.

7.2 For this test, six samples of cable, each approximately 6 in (150 mm) long, should be laid about a central cable and laced together and maintained at a temperature of 115 °C for a period of 1 hour. At the end of that period and after being allowed to cool to a temperature of 20 ± 5 °C the cables should be unlaced and it should then be possible to separate them without sticking occurring between adjacent cables.

8. TEST FOR EMISSION OF SMOKE

8.1 The purpose of this test is to check that the finished cable will not give off visible smoke at any temperature up to 110 °C.

8.2 The test should be conducted in still air at an ambient temperature of 25 °C. A test piece of cable approximately 15 feet (4.5 m) long should be so suspended that at least the central 10 foot (3 m) section is horizontal and unsupported. One end of the test piece should be suitably weighted so that no sagging will occur during the test. An electric current should be applied to the cable and the voltage drop measured over the central 10 foot (3 m) portion.
The resistance of the cable should be calculated from the current and voltage values, and the temperature of the conductor determined from the change in resistance. The current should be so adjusted that the conductor temperature stabilizes at 110 ± 2 °C. This conductor temperature should be maintained for 1 hour, during which there should be no emission of visible smoke from the test piece when viewed against a matt black background.

9. TEST OF PHYSICAL PROPERTIES OF INSULATION MATERIAL

9.1 Eight test pieces of insulation, taken from the finished cable and prepared as described in Annex A, should be aged by placing them in an oven at 113 ± 2 °C and maintaining them at that temperature for a period of 1440 hours. The ventilation rate should be between 3 and 10 air changes per hour. At the conclusion of this period the test pieces should be stored at 23 ± 1 °C for of least 16 hours immediately before being tested for elongation at break. The test should be made at 23 ± 2 °C and the testing machine should have loading grips of the self-tightening type. For a test piece of insulation consisting of a portion of the complete insulation, the rate of traverse of the loading grip should be such that the portion between the gauge marks on the sample is stretched at a rate not exceeding 600% per minute. For a dumb-bell test piece, the rate of traverse of the loading grip should not exceed 20 in (50 cm) per minute.

On eight tests, the highest and lowest values of elongation at break should be discarded and the average taken of the other six.

9.2 Eight tests for elongation at break should also be made on unaged insulation test pieces taken from an adjacent length of the same cable and tested under the conditions given above.

9.3 The insulation after ageing should retain at least 70% of its original elongation measured on the unaged test pieces.

10. ABRASION TEST

10.1 The abrasive tape used in the test is of the greatest importance as the test results can only be compared if the tapes used are new and of essentially the same characteristics. For this

reason it is recommended that the tapes and weights used in the test should be as specified in the relevant national specification.

10.2 The test piece should be clamped in the abrasion test apparatus described in Annex B and the appropriate weight applied to the saddle. Starting with a graphite band under the cable, the tape should be drawn across the cable. When the next band passes the cable, the indicator lamp should not light. The test should be made four times and after each test the test piece should be moved 3 in (76 mm) towards one of the clamps and rotated through 90° in the same direction.

II. TYPE AND PRODUCTION ROUTINE TESTS

11. CONDUCTOR RESISTANCE TESTS

The maximum values should be in accordance with ISO Recommendation R 469, *Dimensions and Conductor Resistance of General Purpose Electrical Cables with Copper Conductors, for Aircraft.*

12. INSULATION TESTS

The cable should be subjected to insulation tests in accordance with section 9, paragraph (b) of ISO Recommendation R 474.

III. TYPE AND PRODUCTION QUALITY TESTS

13. FLAMMABILITY TESTS*

The number of test pieces to be tested is stated in Table 2 below. All test pieces should be cut consecutively from the same coil. They should be freely exposed in an atmosphere of 75 % relative humidity at a temperature of 20 ± 5 °C for a period of 16 hours before testing.

Each test piece should be supported at an angle of 45° in a draught-free chamber. The hottest part of a vertical 3 in (76 mm) non-luminous flame** with a blue cone 1 in (25 mm) high should be arranged to impinge on the central portion of the test piece for the time specified in Table 2. During the test no flaming particles should fall from the cable. After the source of the flame has been removed, the cable should meet the following requirements:

(*a*) The cable should cease to burn within 5 seconds;

(*b*) The total length burned or charred should not exceed 3 in (76 mm).

TABLE 2. — **Flammability tests**

Nominal conductor area	Cable size	Time of flame application	Test pieces tested
mm²		seconds	
0.38 to 1.22 inclusive	22 to 16	5	10
1.94 to 85 inclusive	14 to 000	15	1

14. TENSILE AND ELONGATION TESTS ON CONDUCTORS

The conductors of the cables should comply with clauses 3.2 and 3.3 of ISO Recommendation R 474.

15. TINNING TESTS ON CONDUCTORS

Compliance with requirements for the tin coating of the conductors should be checked by inspection as required by the relevant national specifications.

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* Because of the importance of the cable extinguishing quickly after removal of the flame, this test is preferable to the form of test in which the main criterion is the rate of travel of the flame along the cable and which could lead to the rejection of a cable which, although burning rapidly, extinguishes quickly.

** 3/8 in (9.5 mm) Bunsen burner.