INTERNATIONAL STANDARD 2156

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Aircraft — Fire-resisting electrical cables — Methods of test

Aéronefs — Câbles électriques résistant au feu — Méthodes d'essai

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up has the right to be represented on that Committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

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 2156 was drawn up by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, and circulated to the Member Bodies in February 1971.

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

Austria	Germany	South Africa, Rep. of
Belgium	Israel	Spain
Brazil	Italy	Thailand
Czechoslovakia	Japan	Turkey
Egypt, Arab Rep. of	Netherlands	United Kingdom
France	New Zealand	U.S.A.

No Member Body expressed disapproval of the document.

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Aircraft — Fire-resisting electrical cables — Methods of test

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the tests suitable for establishing the compliance of fire-resisting electrical cables for aircraft with the performance requirements stated in ISO 2155.

This International Standard is intended to serve as a basis for test specifications to be included in the relevant national standards when the Official Board of Inspection considers that existing tests are inadequate.

The tests are classified as follows :

I Type tests only

II Type tests and routine production tests

III Type tests and production quality tests

2 REFERENCES

ISO 1967, *Aircraft — Fire-resisting electrical cables — Dimensions, conductor resistance and mass.*

ISO 2155, *Aircraft — Fire-resisting electrical cables — Performance requirements.*

ISO ..., *Aircraft — Electrical cables — Fire resistance test.* [1)]

I TYPE TESTS ONLY

3 HOT CUTTING TEST

This test is designed to check that the cable, when in use, will withstand a certain compression force when placed against fixed metallic structures which are relatively sharp.

3.1 The apparatus to be used for this test is shown diagrammatically in annex C. It is installed in a temperature-controlled enclosure.

The beam is balanced by adjusting the counterweight so that the arm remains motionless when no weight is attached to it.

The edge of the square-shaped knife shall have a radius very close to 0,40 mm (1/64 in) which shall be checked regularly.

The test piece is arranged on the support of the apparatus in such a way that the knife blade is perpendicular to the axis of the cable.

3.2 The test shall be begun after the assembly of apparatus and test piece has been stabilized for at least 1 h at 260 ± 5 °C. Weights shall then be placed on the end of the beam at a minimum rate of 700 g/min (1.5 lb/min) until the core is perforated. This operation shall not last more than 1 min.

The test shall be carried out six times, and after each test the test piece shall be advanced 75 mm (3 in), always being turned in the same direction. The minimum force to be applied to the cable so that the knife reaches the core shall be specified in the relevant national standard.

4 AGEING TEST FOLLOWED BY AN INSULATION TEST WHILE IMMERSED IN WATER

4.1 Two samples of cable shall be bent into U-loops, each having a maximum diameter equal to ten times the diameter of the cables for sizes No. 22 to No. 10 and fifteen times the diameter of the cables for size No. 8 and larger. The samples shall then be placed in an oven, with hot air renewed by natural draught, for 168 h at a temperature of 280 ± 5 °C. When the samples are taken from the oven at the end of this period, they shall not show any signs of splitting or cracking. The marking shall remain legible but slight discoloration is not considered as a fault.

4.2 The samples shall then be immersed in water at a temperature of 20 ± 5 °C for 5 min with their ends protruding 100 mm (4 in) above the surface. While so immersed, they shall withstand without failure a current of 1 500 V (r.m.s) gradually applied and maintained for 1 min between the conductor and the water.

1) In preparation.

5 TEST FOR RESISTANCE TO AIRCRAFT FLUIDS

5.1 A number of samples of cable shall be bent into loops the diameter of which shall be approximately six times the outside diameter of the cable. A sample shall then be immersed in each of the following fluids, with the ends protruding 38 mm (1.5 in) above the surface, for not less than 8 h at a temperature such as is likely to be experienced in service by the particular fluid :

a) fuels;

b) lubricants (including ester-based lubricants);

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

d) de-icing fluids.

At the end of this period, each sample shall be removed from the fluid, allowed to cool to a temperature of 20 ± 5 °C and wiped twice with a clean cloth.

5.2 After this treatment, the samples shall comply with the following conditions :

a) no sign of splitting, cracking or other deterioration shall be discernible by the naked eye;

b) the cable marking and identification shall remain legible.

6 HUMIDITY CYCLING TEST

6.1 A chamber that can provide a temperature of 71 ± 2 °C and a relative humidity of 95 ± 5 % shall be used for this test. Humidity shall be maintained by hermetic sealing. Heat losses shall be such that the inside temperature can fall from + 71 °C to + 38 °C in less than 16 h from the time when the heat supply is turned off.

The required humidity shall be obtained by using distilled water or rainwater.

6.2 A sample 15 m (50 ft) long shall be placed in the chamber and the temperature and humidity raised to 71 ± 2 °C and 95 ± 5 % respectively.

The temperature shall be maintained for 6 h. The heating shall then be cut off for 16 h to allow the temperature to fall to below 38 °C. At the end of this time, the heating shall be turned on again so that the temperature may rise to 71 ± 2 °C within 2 h.

This 24 h cycle shall be repeated fifteen times in succession. The sample shall then be removed from the chamber.

6.3 The cable shall be immersed in water at 20 ± 5 °C, with an additive of 5 % sodium chloride, in such a way that its ends are approximately 50 mm (2 in) from the surface of the liquid; the liquid shall be connected to earth.

After being immersed for 15 min, the cable shall be connected to a 500 V d.c. electrical supply. After 1 min, the insulation resistance of the insulator shall be measured; it shall not be less than 2 000 MΩ for the 15 m (50 ft) of cable.

7 CAPILLARY TEST

A test piece 100 mm (4 in) long shall be taken from a cable of each of the various sizes to be subjected to the test and weighed to the nearest 0,1 mg . A 50 mm (2 in) length of the test piece shall be vertically immersed in a test tube filled with distilled water for 24 h in a draught-free room. It shall then be removed from the distilled water and excess water on the surface shall be wiped off immediately with a clean dry cloth. The test piece shall be weighed to the nearest 0,1 mg and its variation in mass shall be calculated as a percentage of its original mass. This weighing shall be carried out within 5 min of the removal of the test piece from the distilled water.

8 ABRASION TEST (see annex A)

8.1 The abrasive belt used for this test is of the greatest importance as comparable test results can only be obtained with new belts having identical characteristics. It is accordingly recommended that the abrasive belts and the weights to be used for the test be specified in the relevant national standard.

8.2 A sample of the cable shall be set up on the machine described in annex A and the appropriate weight applied to the carriage. The test shall be started with a graphite belt located beneath the cable and the belt shall be slid under the cable. When the next belt passes under the cable, the indicator lamp shall not light. The test shall be repeated four times, and the test piece shall be moved 75 mm (3 in) towards one of the clamps and rotated through 90° in the same direction after each test.

II TYPE TESTS AND ROUTINE PRODUCTION TESTS

9 SPARK TEST No. 1

9.1 Choice of fault detector

Fault detectors supplied by manufacturers with dry testing equipment are of various types and sizes : metal wires spirally wound to form tubes, metal tubes, small chains, etc.

Fault detectors must be chosen that are compatible in size with the diameters of the cables to be tested. If the detector is tubular in shape, its diameter shall be as near as possible to that of the cable being tested.

9.2 Test voltages

The test voltages shall be in accordance with those indicated in 9.1 of ISO 2155.

9.3 Duration of passage of the cable

The detector shall be long enough for each portion of the cable to remain in it for at least 0,2 s.

9.4 Sensitivity of the equipment

The indicating instrument shall be sufficiently sensitive to be able to function when a device constituting an "artificial fault" is connected in place of the detector.

This "artificial fault" consists of a spark gap in series with a condenser. The electrode voltage is 6 kV r.m.s. The capacity of the condenser shall be capable of adjustment to correspond to currents of 5, 10, 15, 20, 25 and 30 mA, which are the operating currents of the various types of machine used. The capacity chosen shall be such that the current is that of the machine in normal operation.

The spark gap consists of a point which moves across the front of a metal plate in 0,02 s. The distance between the plate and the circle described by the point is 5 mm (0.200 in).

10 SPARK TEST No. 2

A length of cable equal to 10 % of the cable supplied shall be immersed for 1 h in water at a temperature between 15 and 25 °C in such a way that the ends of the cable, when bent back outside the container, are at least 50 mm (2 in) from the surface of the liquid.

At the end of this time, an a.c. voltage of 1 500 V r.m.s. at a frequency of 50 to 60 Hz shall be applied between the core of the cable and the water.

The voltage shall be maintained for 1 min during which there shall be no sign of any perforation of the insulation.

11 TEST FOR RESISTANCE PER UNIT LENGTH OF THE CONDUCTOR

The maximum values for the resistance per unit length shall be in accordance with those of ISO 1967.

III TYPE TESTS AND PRODUCTION QUALITY TESTS

12 TESTS FOR ELONGATION AND BREAKAGE OF WIRES

Individual wires taken from the conductor shall withstand a load of 200 Pa before breaking. The pull should be applied at a maximum speed of 5 mm/s (0.200 in/s). The machine used to measure the elongation shall be sufficiently accurate to indicate the tractive effort to the nearest 1 %.

The elongation of the metal shall not be less than 5 %. It shall be measured by means of an instrument giving immediate and accurate indication of the load applied. The accuracy of this instrument shall not be less than 1 %.

The length of the specimen held between jaws shall be 250 ± 5 mm (10 ± 0.200 in).

13 TEST ON THE DIAMETER, COMPOSITION AND LAY OF CONDUCTORS

The diameter shall be checked by inserting the conductor into the gauge specified in annex B. The composition shall be checked by counting the number of elementary wires constituting the conductor. The diameter and composition of the conductor shall be in accordance with the values in ISO 1967.

14 WEIGHING TEST ON THE FINISHED CABLE

The finished cables shall be weighed; their mass per unit length, expressed in grams per metre (lb/1 000 ft), shall not be greater than that specified in ISO 1967.

15 CHECKING THE THICKNESS OF THE INSULATION ON THE FINISHED CABLE

The radial thickness of the insulation surrounding the conductor is deduced from the formula $\frac{D-d}{2}$. The values of D and d shall be in accordance with those given in table 1.

TABLE 1

Maximum diameter of conductor d		Outside diameter of finished cable			
		D_{min}		D_{max}	
mm	in	mm	in	mm	in
0,84	0.033	2,30	0.905	2,95	0.116
1,04	0.041	2,60	0.102	3,18	0.125
1,32	0.052	3,02	0.119	3,43	0.135
1,55	0.061	3,23	0.127	3,73	0.147
1,88	0.074	3,81	0.150	4,32	0.170
2,36	0.093	4,19	0.165	4,70	0.185
3,25	0.128	5,10	0.205	5,84	0.230
4,47	0.176	6,50	0.256	7,11	0.280
5,54	0.218	7,90	0.311	8,69	0.342
6,91	0.272	9,40	0.370	10,34	0.407
8,76	0.345	11,30	0.445	12,29	0.484
9,75	0.384	12,62	0.497	13,54	0.533
10,97	0.432	13,64	0.537	14,55	0.573
12,45	0.490	15,11	0.595	16,13	0.635
13,92	0.548	16,76	0.660	17,78	0.700
15,62	0.615	18,54	0.730	19,56	0.770

16 CHECKING THE OUTSIDE DIAMETER OF THE FINISHED CABLE

This operation shall be carried out with an optical micrometer, a measuring microscope or any equivalent instrument. The diameter shall not be greater than that specified in ISO 1967.

17 COLD COILING TEST

A new sample, of adequate length, shall be attached to a mandrel by one of its ends. A weight shall be attached to the other end; the value of the weight and the diameter of the mandrel are given in table 2.

TABLE 2

Nominal section mm²	Corresponding cable No.	Mandrel diameter		Test load	
		mm	in	daN	lbf
0,38	22	150	6	0,90	2
0,60	20				
0,93	18				
1,22	16	200	8	1,40	3
1,94	14				
3,08	12				
5,29	10	250	10	2,30	5
8,55	8	300	12		
13,6	6	350	14	4,50	10
21,6	4	400	16		
33,9	2	500	20	6,80	15
41,5	1	550	22		
52,8	0	600	24	9,00	20
68	00			11,30	25
85	000			13,60	30
107	0000				

The assembly shall be placed in a chamber in which the temperature is brought to -55 ± 2 °C at a rate of not more than 50 °C/min.

This temperature shall be maintained in the chamber for 1 h. At the end of this time, the mandrel shall be rotated through 180° at a constant speed that the operation carried out in the chamber does not take more than 30 s.

After settling for 1 min at ambient temperature, the cable insulation or covering shall show no sign of splitting or cracking.

The sample shall successfully withstand the spark test specified in 4.2.

18 FIRE-RESISTANCE TEST

The cable samples shall be subjected to the fire-resistance test specified in ISO ...

19 ACCELERATED AGEING TEST (Production quality test only)

19.1 The samples shall be kept in a hot-air oven in which the air is renewed by natural draught and the temperature maintained at 350 ± 5 °C for 6 h.

19.2 The sample shall then successfully withstand the spark test specified in 4.2.

ANNEX A

MACHINE FOR THE ABRASION TEST

A.1 A diagram of this machine is given in figure 1. A sample of cable C, approximately 1,2 m (50 in) long, is clamped at points A and B without being stretched. The cable is held at X between a grooved carriage S with a mass of 56 g (20 oz), carrying a weight W, and a "garnet" belt T, 25,4 mm (1 in) wide, with the rough side uppermost. The belt is drawn beneath the cable at a constant speed of 1 520 ± 80 mm/min (60 ± 3 in/min) and passes between the driving roller D and the free roller drum E from F to drum G. It is an advantage if the rollers D and E are faced with rubber. The drums F and G are connected by a belt such that the diameter of the pulley at F is roughly twice that of the pulley at G. The belt shall have a slight slip to compensate for the different rotational speeds of the two drums. Each drum shall be capable of accommodating 45 m (50 yd) of abrasive belt.

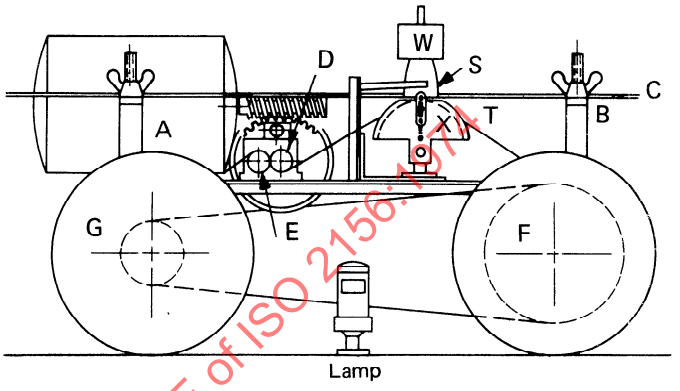


FIGURE 1 — **View of the complete machine for the cable abrasion test**

A.2 Figure 2 is an enlarged view of the part marked X in figure 1, showing the details of that part of the machine at which abrasion occurs. The cable C is held in place by the weight W (see figure 1) while the belt T passes underneath it. Bands of colloidal graphite are painted across the rough side of the belt with a spacing of 914 ± 12,7 mm (36 ± 0.5 in) between the centres of adjacent bands. Each band is 9,5 mm (0.375 in) wide. These bands ensure that electrical contact is made with the conductor when the insulation has been worn away by abrasion. The roller R and the wire L are isolated from the frame of the machine. An electrical circuit is arranged as shown in this figure.

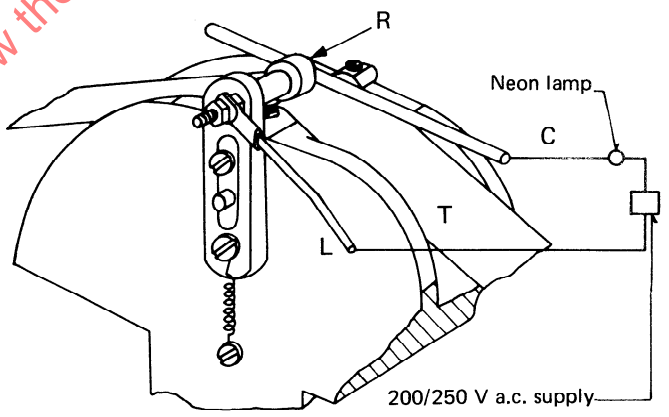


FIGURE 2 — **Enlarged view of indicating roller and electric circuit**

A.3 Figure 3 shows the angle made by the belt at the point of contact with the cable. The graphite bands can be applied with a paint brush, using diluted colloidal graphite. The graphite should preferably be applied in several thin coats to avoid flaking as it dries. The abrasive belt can only be used once.

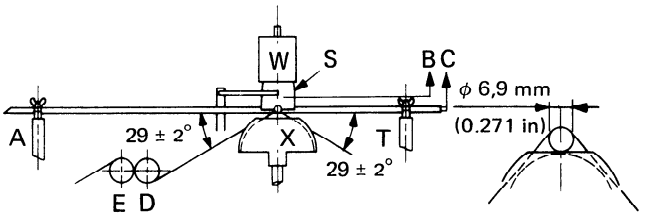
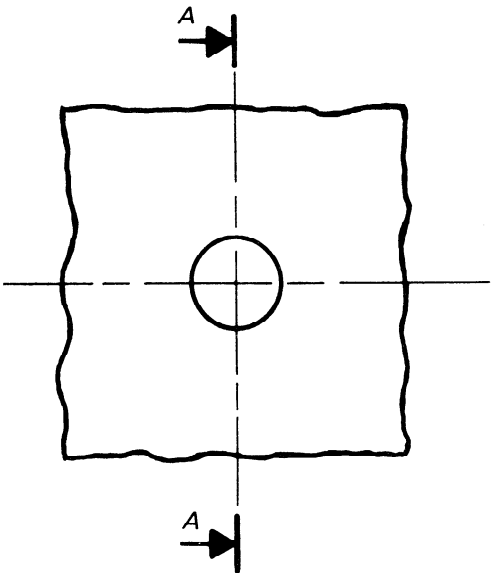
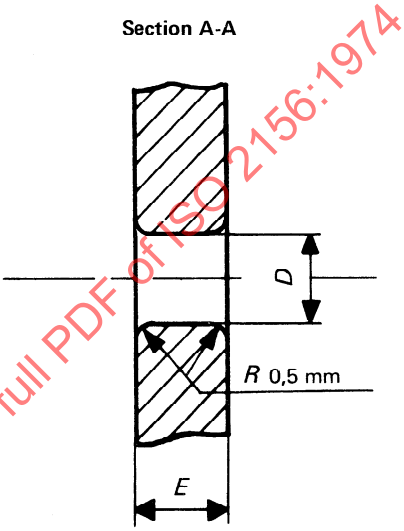


FIGURE 3 — **Details of the abrasive mechanism**

ANNEX B

GAUGE FOR CHECKING THE CONDUCTOR DIAMETER





Nominal cross-section of conductor	Corresponding cable No.	Maximum diameter of conductor		D H10		E_{min}	
mm^2		mm	in	mm	in	mm	in
0,38	22	0,84	0.033	0,91	0.036	5	0.197
0,60	20	1,04	0.041	1,12	0.044		
0,95	18	1,32	0.052	1,41	0.056		
1,22	16	1,55	0.061	1,65	0.065		
1,94	14	1,88	0.074	2,00	0.079		
3,08	12	2,36	0.093	2,50	0.098		
5,29	10	3,25	0.128	3,42	0.135		
8,55	8	4,47	0.176	4,67	0.184		
13,6	6	5,54	0.218	5,76	0.227	10	0.394
21,6	4	6,91	0.272	7,17	0.282		
33,9	2	8,76	0.345	9,03	0.355		
41,5	1	9,75	0.384	10,03	0.395		
52,8	0	10,97	0.432	11,25	0.443		
68	00	12,45	0.490	12,75	0.502		
85	000	13,92	0.548	14,25	0.561		
107	0000	15,62	0.615	15,95	0.628		

ANNEX C

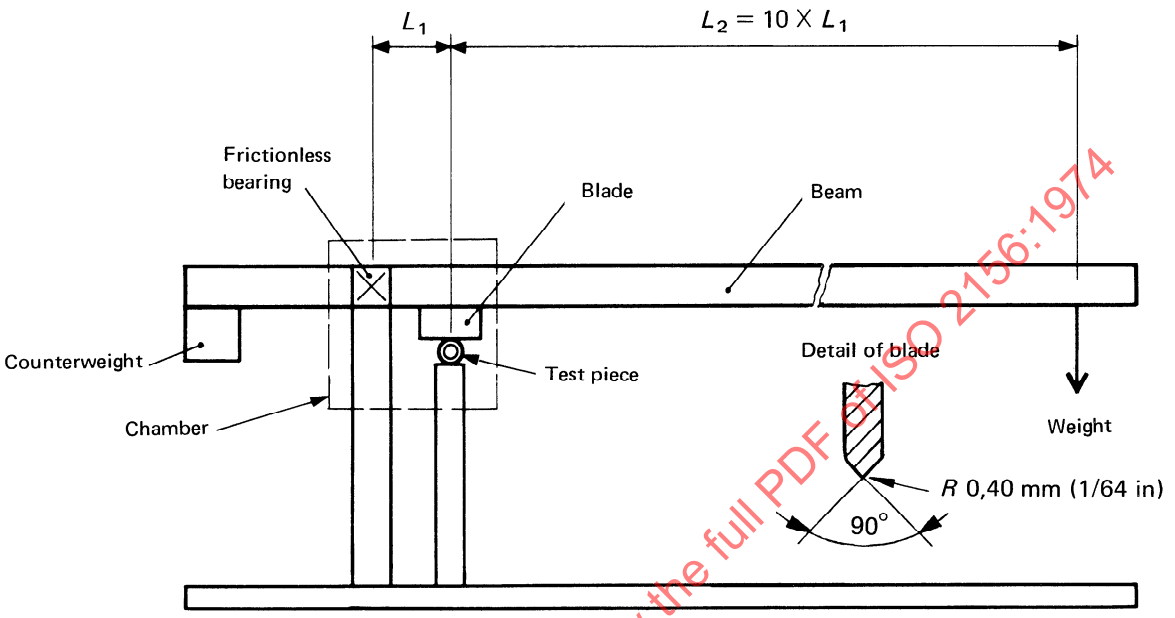


FIGURE 4 — **Apparatus for the hot cutting test**