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Flexible steel wire rope for aircraft controls — Technical specification

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FOREWORD

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It was approved in February 1971 by the Member Bodies of the following countries :

Australia	Israel	Spain
Brazil	Italy	Thailand
Canada	Japan	United Kingdom
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Flexible steel wire rope for aircraft controls — Technical specification

1 SCOPE AND FIELD OF APPLICATION

This International Standard defines the technical requirements which must be satisfied by flexible wire ropes of the "preformed" type made either of carbon steel wire or of corrosion-resisting steel wire, for aircraft controls.

2 DEFINITIONS[1)]

2.1 wire : Each cylindrical steel element.

2.2 strand : An element of rope consisting of an assembly of several wires of appropriate shape and dimensions spun helically in one or more layers.

2.3 wire rope : A construction of several strands wound helically in one or more layers.

2.4 preformed wire rope : A wire rope in which the wires in the strand and the strands in the rope are formed during rope manufacture into the shape that they will assume in the finished rope.

2.5 diameter

2.5.1 *nominal diameter* : The value by which the diameter of the wire, strand or rope is designated.

2.5.2 *measured (or actual) diameter* : That diameter which is obtained by measuring in accordance with a prescribed method (see 5.2.2).

2.6 length of lay : The pitch of the helix of the axis of the strand (or wire) in the longitudinal axis of the rope (or strand).

2.7 core wire (king wire) : The centre wire of each strand.

2.8 centre or core strand (of a wire rope) : A straight strand composed of wire as for the other strands.

2.9 elongation : For the purpose of this International Standard only, that length by which the rope extends between defined upper and lower limits of load (i.e. between 1st and 2nd reading), expressed as a percentage of the gauge length measured at the lower limit (see 5.4).

3 WIRE FOR ROPES

3.1 General

The cold drawn wire shall be produced from steel manufactured by any process other than the Bessemer process. It shall be free from defects detrimental to the performance of the rope and shall satisfy the requirements listed in the following clauses.

3.2 Chemical composition of the steel

3.2.1 *Carbon steel (cast analysis limitations)*

The cast analysis of the steel shall be such that the performance requirements and physical tests on the wire and wire rope are satisfied, but with the following limitations :

Elements	Maximum percentage
Sulphur	0.040
Phosphorus	0.040
Sulphur and phosphorus	0.065

3.2.2 *Corrosion-resisting steel (cast analysis limitation)*

The cast analysis shall conform to the following limits :

Element	Percentage	
	minimum	maximum
Carbon	–	0.12
Silicon	0,2	1.0
Manganese	0.5	2.0
Nickel	8.0	11.0
Chromium	16.5	19.0
Sulphur	–	0.030
Phosphorus	–	0.045

1) The definitions given relate only to this International Standard but, where appropriate, are in accordance with ISO 2532, *Steel wire ropes — Vocabulary*. (At present at the stage of draft.)

3.3 Mechanical properties of the wire

3.3.1 *Carbon steel wire*

The tensile strength of any wire shall not fall outside the limits of the range given below for the appropriate tensile grade and nominal wire diameter.

Nominal wire diameter		Tensile grade number	Tensile strength range
mm		N/mm²	N/mm²
from	up to and including		
0.20	0.30	1 950	1 950 to 2 350
0.30	0.40	1 950	1 950 to 2 300
0.40	0.50	1 950	1 950 to 2 250
0.50	0.76	1 850	1 850 to 2 100

3.3.2 *Corrosion-resisting steel wire*

The wire used for the wire rope, except for core or king wires, shall have a tensile strength of not less than that given in the following table.

Nominal wire diameter		Minimum tensile strength
mm		N/mm²
from	up to but not including	
0.10	0.20	2 060
0.20	0.25	1 960
0.25	0.30	1 865
0.30	0.40	1 815
0.40	0.50	1 765
0.50	0.60	1 715

The variation in tensile strength of all the wires in any one layer of the rope shall not be greater than 295 N/mm².

3.4 Protection of carbon steel wire

Carbon steel wire shall be subjected to one of the two treatments given below, as stipulated by the user, in conformity with the indicated conditions.

3.4.1 *Zinc coating*

The minimum mass of zinc deposited shall be as follows :[1)]

For wires of 0.25 mm and smaller : 20 g/m²
0.26 to 0.40 mm : 30 g/m²
0.41 to 0.50 mm : 40 g/m²
0.51 to 0.60 mm : 50 g/m²

NOTE — If the hot-dip process is used, the purity of the zinc should not be less than 98.5 %.

1) This corresponds to Class B of ISO/R 2232.

3.4.2 *Tinning*

The minimum mass of tin deposited shall be as follows :

For wires of 0.25 mm and smaller : 0.9 g/m²
0.26 to 0.38 mm : 1.5 g/m²
0.39 mm and larger : 3.0 g/m²

4 MANUFACTURE OF WIRE ROPE

4.1 Types of construction

Wire ropes covered by this specification may be of two types :

4.1.1 *7 X 7 Construction*

This shall be composed of six outer strands each of seven wires spun in a right hand direction around a centre strand of seven wires, with a length of lay of between 6 and 8 times the diameter of the rope.

a) The centre strand shall be composed of a layer of six wires spun in a right hand direction around a core or king wire. It shall be of sufficient diameter to give full support to the outer strands, and shall have a length of lay not exceeding 60 % of the length of lay of the complete rope.

b) The six outer strands shall be composed of a layer of six wires spun in a left hand direction around a core or king wire; they shall have a length of lay not exceeding 60 % of the length of lay of the complete rope.

4.1.2 *7 X 19 Construction*

This shall be composed of six strands of nineteen wires spun in a right hand direction around a centre strand of nineteen wires.

a) The centre strand shall be composed of a first layer of six wires spun in a left or right hand direction around a core or king wire, and a second layer of twelve wires spun in a right hand direction. It shall be of sufficient diameter to give full support to the outer strands.

b) The six outer strands shall be composed of a first layer of six wires and a second layer of twelve wires spun in a left hand direction around a core or king wire.

4.1.3 *Length of lay*

In the case of 7 X 19 construction the length of lay of the centre strand and of the outer strands shall be as follows :

a) the inner layer of six wires shall have a length of lay of less than 60 % of the length of lay of the outer layer;

b) the outer layer of twelve wires shall have a length of lay of less than 50 % of the length of lay of the rope;

c) the six outer strands shall be closed around the centre strand in a right hand direction with a length of lay between six and eight times the diameter of the rope.

4.2 Joints

Twisted joints may be made in wires of diameter equal to or less than 0.20 mm. For wires of greater diameter than 0.20 mm the joints shall be made by electric welding or brazing. In the same strand, joints shall be not less than 6 m apart.

4.3 Lubrication

During manufacture of the rope a suitable anti-friction compound, which shall retain its properties between the temperatures of −55 °C and +70 °C and which shall have anti-corrosive properties, shall be applied to the wires and strands. Care shall be taken to ensure that for the purpose of application, the anti-friction compound is not heated above the upper temperature limits.

4.4 Rope lengths

Ropes shall be delivered in minimum lengths of 300 m, except that up to 20 % of the rope ordered may be furnished in lengths between 150 and 300 m.

5 INSPECTION OF WIRE ROPE

5.1 General procedure requirements

5.1.1 Throughout the following tests the temperature and humidity shall be normal and constant.

5.1.2 Before every inspection operation the inspector shall be satisfied that the measuring instruments are correctly calibrated.

5.2 Inspection of production lengths

5.2.1 *Visual examination*

All ropes shall be examined visually in order to check the quality of manufacture and finish. The distance between any two broken wires other than wires joined in accordance with 4.2 shall be at least 300 m.

5.2.2 *Measurement of diameter*

The actual diameter of the rope shall be measured after production with a measuring device with jaws broad enough to cover not less than two adjacent strands. At each of two points spaced at least 1 m apart, two measurements shall be taken at right angles to each other. The average of these four measurements must fall within the maximum and minimum diameters indicated in Table 1, columns 4 and 5. Each end of each manufactured length of wire rope shall be measured in this manner. These measurements shall be made on a straight portion of the rope under no tension.

5.2.3 *Cutting test*

The increase in the diameter of the wire rope after cutting shall not exceed the value indicated in Table 1. The measurement shall be made as near as possible to the end of the rope on both pieces. (This test may be carried out at the time of sampling for the various mechanical tests.)

5.3 Breaking strength of rope

5.3.1 *Test length*

The test length/distance between grips shall be not less than :

— 300 mm for ropes having a diameter of 6 mm of less;

— 600 mm for ropes having a diameter of more than 6 mm.

5.3.2 *Test piece*

The minimum length of test piece is made up of the test length plus an allowance for gripping. The test piece shall be representative of the rope as a whole and free from defects. Prior to selection the end of the test piece shall be secured to prevent turn being put into or taken out of the test piece. In the same way the rope from which the test piece is taken shall be secured. When cutting the test piece from the rope neither the rope nor the test piece shall be damaged. When testing a rope to destruction it is useful to provide it with conical sockets. Care has to be taken to ensure that the casting material penetrates well into untwisted wires.

5.3.3 *Testing*

Not more than 80 % of the minimum breaking load may be applied quickly; the remaining load shall be applied slowly, at a rate of approximately 10 N/mm^2 per second. The breaking load is reached when no further increase in load is possible.

5.3.4 *Evaluation of test*

Tests in which breakage occurs in or adjacent to the grips may be discarded at the option of the manufacturer in cases where the minimum breaking load is not reached.

5.4 Elongation test

5.4.1 *Definition*

For the purpose of this International Standard, elongation of a rope is as defined in 2.9.

5.4.2 *Preliminary procedure*

From each production length of wire rope a sufficient length shall be selected to provide an unobstructed test length of 250 mm minimum between the jaws of the test machine. This selected length shall be pre-stretched to remove constructional stretch and to bring the test length approximately into the elastic condition by the application of a load equal to 63 % of the minimum breaking load. This load shall be maintained for a period of at least 2 min and then released to not more than 5 % of the minimum breaking load.

5.4.3 *Test procedure*

On the test length thus prepared, and immediately following the preliminary procedure, the minimum gauge length of 250 mm shall be accurately measured, marked and recorded under an initial load equal to 5 % of the minimum breaking load of the rope. The load shall then be progressively increased until a load equal to 60 % of the minimum breaking load is reached and maintained for a period of 1 min minimum. The length between the gauge points shall again be measured. The difference between the two measurements is the elongation and shall be expressed as a percentage of the original gauge length. This percentage must be in accordance with that given in Table 2.

5.4.4 *Proof test*

Using the same test length as for the preceding elongation test, the load shall be progressively increased until a value of 80 % of the minimum breaking load is reached and maintained for a minimum period of 5 s.

This load shall then be released and the test length completely separated into its constituent wires and each wire shall be examined.

Any broken wires shall be cause for rejection of the production length represented by the test length.

5.5 Endurance test

An endurance test shall be carried out in accordance with ... (Addendum to ISO 2020 under preparation).[1)]

6 ACCEPTANCE CONDITIONS FOR ROPE : REJECTION AND RE-TEST

The failure of any specimen to comply with the requirements of section 5 shall be cause for the rejection of the wire rope from which it was taken, except that a manufacturer may, at his own expense, in the presence of the Inspector, take two further samples from each length of rope rejected, and subject these samples to a re-test. The inspector may accept a length of rope shown to conform to all the requirements of this International Standard by this re-test.

A complete report of the tests shall be prepared and supplied with the despatch documents.

7 STORAGE AND PACKING

7.1 Protection

All carbon steel ropes shall be coated with a protective compound designed to shield them from corrosion before they are wound onto the reel on which they are despatched.

7.2 Packing

7.2.1 *Ordinary packing*

The rope shall be wound on a reel designed for the purpose. The diameter of the barrel of the reel shall exceed 40 times the diameter of the rope.

The flanges and the barrel of the reel shall be covered with waterproof material and painted with a water resistant compound before the rope is wound onto the reel.

When it is fully wound, the exposed surface shall be covered with a layer of inert waterproof material held down by appropriate means.

7.2.2 *Special packing*

Any special packing must be specified in the order.

7.3 Marking

A label shall be fixed on the reel bearing the following information :

Carbon (or corrosion-resisting) steel wire rope

International Standard 2020

Name of manufacturer

Nominal diameter

Type of construction

Length

Number of order

Test report number(s)

Inspection stamps

1) While awaiting the publication of an ISO test procedure dealing with this subject, an endurance test can be carried out in accordance with a relevant national specification.

TABLE 1 – **Principal properties of wire ropes**

1	2	3	4	5	6	7	8	9
Nominal diameter of wire rope		**Construction**	**Measured diameter**		**Minimum breaking load**		**Increase in diameter after cutting**	**Approximate mass per 100 m**
			minimum	maximum	Carbon steel	Corrosion resisting steel	maximum	
mm	in		mm	mm	kN	kN	mm	kg
1.6	1/16	7 × 7	1.6	1.8	2.15	2.15	0.23	1.2
2.4	3/32	7 × 7[1)]	2.4	2.7	4.10	4.10	0.25	2.4
3.2	1/8	7 × 19	3.2	3.5	8.90	7.85	0.28	4.6
4	5/32	7 × 19	4.0	4.4	12.45	10.70	0.43	6.7
4.8	3/16	7 × 19	4.8	5.2	18.60	16.50	0.48	9.7
5.6	7/32	7 × 19	5.6	6.0	24.90	22.25	0.51	12.8
6.4	1/4	7 × 19	6.4	6.8	31.20	28.40	0.53	16.4

1) A 7 × 19 construction is permitted for this diameter rope, as long as it has the properties specified.

TABLE 2 – **Elongation test**

1	2	3	4	5	6	7	8	9	10	11	12
Nominal diameter of wire rope		**Minimum breaking load**		**Prestretching load** 63 % minimum breaking load		**Load at 1st reading** 5 % minimum breaking load		**Load at 2nd reading** 60 % minimum breaking load		**Maximum percentage elongation** Elongation × 100 / Gauge length	
		C	CR	C	CR	C	CR	C	CR	C	CR
mm	in	kN	kN	kN	kN	kN	kN	kN	kN	1)	1)
2.4	3/32	4.12	4.12	2.60	2.60	0.21	0.21	2.45	2.45	0.80	0.80
3.2	1/8	8.92	7.85	5.65	4.95	0.45	0.39	5.40	4.70	0.85	0.95
4	5/32	12.45	10.69	7.85	6.70	0.63	0.54	7.45	6.40	0.95	1.00
4.8	3/16	18.63	16.48	11.80	10.40	0.93	0.82	11.20	9.80	0.95	1.00
5.6	7/32	24.91	22.26	15.70	14.00	1.25	1.12	14.90	13.35	0.95	1.00
6.4	1/4	31.09	28.44	19.60	17.90	1.56	1.42	18.60	17.10	0.95	1.00

Code : C = carbon steels; CR = corrosion resisting steels.

1) The suitability of these limits is being kept under review.