INTERNATIONAL STANDARD

ISO 2232

Second edition
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Round drawn wire for general purpose non-alloy steel wire ropes and for large diameter steel wire ropes — Specifications

Fils tréfilés ronds pour câbles d'usages courants en acier non allié et pour câbles en acier de gros diamètre — Spécifications

INTERNATIONAL ISO

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 2232 was prepared by Technical Committee ISO/TC 105, *Steel wire ropes*.

This second edition cancels and replaces the first edition (ISO 2232:1973), of which it constitutes a technical revision.

Annexes A, B and C form an integral part of this International Standard. Annexes D and E are for information only.

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Round drawn wire for general purpose non-alloy steel wire ropes and for large diameter steel wire ropes — Specifications

1 Scope

This International Standard specifies round non-alloy steel drawn wires to be used in the manufacture of

- general purpose steel wire ropes as defined in ISO 2408;
- large diameter steel wire ropes as defined in ISO 8369.

It specifies

- the dimensional tolerances;
- the mechanical characteristics;
- the conditions with which the coating, if any, shall comply;
- the conditions of sampling, control and the terms of acceptance.

It applies to round bright or galvanized (quality A or B) wires of nominal diameters between 0,2 mm and 6 mm.

It does not apply to steel wire taken from manufactured ropes.

It does not apply to wire for ropes for special applications, such as

- winding ropes for mining purposes;
- ropes for aircraft controls;
- ropes for deep drilling equipment;
- ropes for aerial ropeways;
- ropes for elevators;
- ropes for prestressed concrete.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2408:1985, *Steel wire ropes for general purposes — Characteristics*.

ISO 6892:1984, *Metallic materials — Tensile testing*.

ISO 7800:1984, *Metallic materials — Wire — Simple torsion test*.

ISO 7801:1984, *Metallic materials — Wire — Reverse bend test*.

ISO 7802:1983, *Metallic materials — Wire — Wrapping test*.

ISO 8369:1986, *Large diameter steel wire ropes*.

3 Wire characteristics

3.1 General conditions of manufacture

Wire shall be made by the basic open hearth, electric furnace, or basic oxygen steel process, or by equivalent methods.

The finished wires shall not show superficial or internal defects detrimental to their use.

When specified, the wires shall be supplied with a zinc coating applied by the hot-dip or the electrolytic process. For the former case, the zinc used shall be 99,9 % pure.

3.2 Diameter

3.2.1 Nominal diameter, d

The nominal diameter of the wire, in millimetres, is that by which the wire is designated. It shall be the basis on which the values of all characteristics are determined for acceptance of the wire.

3.2.2 Actual diameter

The actual diameter of the wire is the arithmetic mean of two measurements carried out in accordance with 5.1.

It shall be within the limits of tolerance specified in table 1.

Table 1 — Tolerances on diameter

Values in millimetres

Nominal diameter of wire d	Tolerance on diameter	
	Bright wires and galvanized wires quality B	Galvanized wires quality A
$0,2 \leqslant d < 0,4$	$\pm$ 0,01	—
$0,4 \leqslant d < 0,8$	$\pm$ 0,015	$\pm$ 0,03
$0,8 \leqslant d < 1$	$\pm$ 0,02	$\pm$ 0,03
$1 \leqslant d < 1,6$	$\pm$ 0,02	$\pm$ 0,04
$1,6 \leqslant d < 2,4$	$\pm$ 0,03	$\pm$ 0,05
$2,4 \leqslant d < 3,7$	$\pm$ 0,03	$\pm$ 0,06
$3,7 \leqslant d < 5,2$	$\pm$ 0,04	—
$5,2 \leqslant d \leqslant 6$	$\pm$ 0,05	—

3.2.3 Ovality of the wire

The arithmetic difference between the two measurements of the diameter shall be not more than half the tolerance specified in table 1.

3.3 Tensile grades

The tensile grades of wire are:

— 1 570 N/mm^2 for wires of all qualities;

— 1 770 N/mm^2 for bright wires and galvanized wires quality B;

— 1 960 N/mm^2 for bright wires and galvanized wires quality B.

These nominal values are the lower limits of strength. The upper limits are equal to the lower limits in addition to the tolerances specified in table 2.

Table 2 — Tolerances on tensile grade

Nominal diameter of wire d mm	Tolerance on tensile grade N/mm^2
$0,2 \leqslant d < 0,5$	390
$0,5 \leqslant d < 1$	350
$1 \leqslant d < 1,5$	320
$1,5 \leqslant d < 2$	290
$2 \leqslant d$	260

NOTE 1 Other tensile grades may be used on agreement between the manufacturer and the supplier.

The test shall be performed in accordance with 5.2.

3.4 Reverse bend strength

This test applies only to wire of nominal diameter between 0,5 mm inclusive and 3,7 mm inclusive. For wires of nominal diameter less than 0,5 mm, see 3.6.

The wire shall withstand without breaking the minimum number of reverse bends specified in table 3 for the appropriate diameter, tensile grade and finish. The radius of curvature of the supports for the various wire diameters is also given.

The test shall be performed in accordance with 5.3.

If the tensile grade of a wire lies between two tensile grades given in table 3, then the number of reverse bends for the next upper tensile grade shall be chosen.

NOTE 2 The reverse bend test is not mandatory for wires to comply with this International Standard.

Table 3 — Minimum number of reverse bends

Nominal diameter of wire d mm	Radius of curvature of supports mm	Minimum number of reverse bends			
		Bright wires and galvanized wires quality B			Galvanized wires quality A
		Tensile grade N/mm²			
		1 570	1 770	1 960	1 570
$0,5 \leqslant d < 0,55$	1,75	15	14	13	—
$0,55 \leqslant d < 0,6$		14	13	12	—
$0,6 \leqslant d < 0,65$		12	11	10	—
$0,65 \leqslant d < 0,7$		11	10	9	—
$0,7 \leqslant d < 0,75$	2,5	15	14	13	12
$0,75 \leqslant d < 0,8$		14	13	12	11
$0,8 \leqslant d < 0,85$		13	12	11	10
$0,85 \leqslant d < 0,9$		11	10	9	8
$0,9 \leqslant d < 0,95$		10	9	8	7
$0,95 \leqslant d < 1$		10	9	8	7
$1 \leqslant d < 1,1$	3,75	15	14	13	12
$1,1 \leqslant d < 1,2$		13	12	11	10
$1,2 \leqslant d < 1,3$		12	11	10	9
$1,3 \leqslant d < 1,4$		10	9	8	7
$1,4 \leqslant d < 1,5$		9	8	7	6
$1,5 \leqslant d < 1,6$	5	12	11	10	9
$1,6 \leqslant d < 1,7$		11	10	9	8
$1,7 \leqslant d < 1,8$		10	9	8	7
$1,8 \leqslant d < 1,9$		9	8	7	6
$1,9 \leqslant d < 2$		8	7	6	5
$2 \leqslant d < 2,1$	7,5	13	12	11	10
$2,1 \leqslant d < 2,2$		12	11	10	9
$2,2 \leqslant d < 2,4$		11	10	9	8
$2,4 \leqslant d < 2,5$		10	9	8	7
$2,5 \leqslant d < 2,6$		9	8	7	6
$2,6 \leqslant d < 2,7$		8	7	6	5
$2,7 \leqslant d < 3$		7	6	5	4
$3 \leqslant d < 3,1$	10	11	10	9	8
$3,1 \leqslant d < 3,2$		10	9	8	7
$3,2 \leqslant d < 3,3$		9	8	7	6
$3,3 \leqslant d < 3,4$		9	8	7	6
$3,4 \leqslant d < 3,5$		8	7	6	5
$3,5 \leqslant d < 3,6$		7	6	5	4
$3,6 \leqslant d \leqslant 3,7$		7	6	5	4

3.5 Torsional strength

This test applies only to wire of nominal diameter equal to or greater than 0,5 mm. For wires of diameter less than 0,5, see 3.6.

The wire shall withstand without breaking the minimum number of torsions specified in table 4 for given diameter, tensile grade and finish.

The test shall be performed in accordance with 5.4.

If the tensile grade of a wire lies between two tensile grades given in table 4, then the number of torsions for the next upper tensile grade shall be chosen.

3.6 Tensile test on knotted wire

Wire of nominal diameter less than 0,5 mm with a single knot shall withstand without breaking a load of at least 50 % of the load corresponding to their tensile grade.

The test shall be performed in accordance with 5.5.

NOTE 3 This requirement replaces the reverse bend test (3.4) and torsional strength test (3.5).

3.7 Zinc coating

Two qualities of zinc coating[1] are recognized in this International Standard:

— quality B for tensile grades 1 570 N/mm², 1 770 N/mm² and 1 960 N/mm² and for nominal wire diameters between 0,2 mm inclusive and 6 mm inclusive;

— quality A for tensile grade 1 570 N/mm² and for nominal wire diameters between 0,4 mm inclusive and 3,7 mm exclusive.

The zinc coating process is not specified.

The quality of the coating is defined by the minimum mass of zinc, in grams per square metre, as specified in table 5.

The inspection of zinc coating shall be performed in accordance with 5.6.

4 Sampling and criteria of conformity

The evidence of the wire manufacturer's test made in accordance with an agreed method should be accepted by the ropemaker.

If the ropemaker wishes to have acceptance tests carried out, the size of sample and the acceptance criteria shall be as given in table 6. To ensure representative sampling, the test lengths shall be taken at random.

If the number of defectives is greater than is shown in the third column of table 6, then all the units (units of product) shall be tested (100 %), but only for the defective characteristic(s).

In the case where one (or more) of these new tests is/are not satisfactory, the unit(s) represented by this test length does/do not conform.

Acceptance or refusal of a lot which does not conform shall be decided by agreement between the interested parties.

5 Tests

5.1 Measurement of diameter

The diameter shall be determined from two measurements in two perpendicular directions on the same section and the same diametrical plane using a micrometer accurate to 0,01 mm.

5.2 Tensile test

The tensile test shall be carried out in accordance with ISO 6892. The rate of stressing may be greater than that specified in ISO 6892 in view of the number of tests on wire involved in the inspection of the batch. However, it shall not exceed a rate producing an elongation of 25 % of the distance between grips within 1 min. The length of the test piece shall preferably be such that the distance between the grips of the testing machine is 100 mm.

In case of dispute, the tensile test shall be performed strictly in accordance with ISO 6892, particularly with regard to the rate of stressing.

5.3 Reverse bend test

The test shall be carried out in accordance with ISO 7801 with supports of radius of curvature specified in table 3.

1) Zinc coating quality AB is being used less and less; however, its wire characteristics are given in annex C.

Table 4 — Minimum number of torsions

Nominal diameter of wire d mm	Minimum number of torsions			
	Bright wires and galvanized wires quality B			Galvanized wires quality A
	Tensile grade N/mm²			
	1 570	1 770	1 960	1 570
$0,5 \leqslant d < 1$	30	28	25	19
$1 \leqslant d < 1,3$	29	26	23	18
$1,3 \leqslant d < 1,8$	28	25	22	17
$1,8 \leqslant d < 2,3$	26	24	21	17
$2,3 \leqslant d < 3$	24	22	19	14
$3 \leqslant d < 3,5$	22	20	17	12
$3,5 \leqslant d < 3,7$	20	18	—	10
$3,7 \leqslant d < 3,8$	19	17	—	—
$3,8 \leqslant d < 4$	19	17	—	—
$4 \leqslant d < 4,2$	18	15	—	—
$4,2 \leqslant d < 4,4$	17	13	—	—
$4,4 \leqslant d < 4,6$	16	12	—	—
$4,6 \leqslant d < 4,8$	15	10	—	—
$4,8 \leqslant d < 5$	14	9	—	—
$5 \leqslant d < 5,2$	14	—	—	—
$5,2 \leqslant d < 5,4$	11	—	—	—
$5,4 \leqslant d < 5,6$	8	—	—	—
$5,6 \leqslant d \leqslant 6$	6	—	—	—

Table 5 — Minimum mass of zinc

Nominal diameter of wire[1] d mm	Minimum mass of zinc g/m²	
	Coating quality B	Coating quality A
$0,2 \leqslant d < 0,25$	15	—
$0,25 \leqslant d < 0,4$	20	—
$0,4 \leqslant d < 0,5$	30	75
$0,5 \leqslant d < 0,6$	40	90
$0,6 \leqslant d < 0,7$	50	110
$0,7 \leqslant d < 0,8$	60	120
$0,8 \leqslant d < 1$	70	130
$1 \leqslant d < 1,2$	80	150
$1,2 \leqslant d < 1,5$	90	165
$1,5 \leqslant d < 1,9$	100	180
$1,9 \leqslant d < 2,5$	110	205
$2,5 \leqslant d < 3,2$	125	230
$3,2 \leqslant d < 3,7$	135	250
$3,7 \leqslant d < 4$	135	—
$4 \leqslant d < 4,5$	150	—
$4,5 \leqslant d < 5,5$	165	—
$5,5 \leqslant d \leqslant 6$	180	—

1) Diameter of galvanized wire before removal of the zinc coating.

Table 6 — Sizes of lot and sample and number of defectives

Size[1]		Number of defectives for	
of lot N	of sample n [2]	conformity	non-conformity
$2 \leqslant N \leqslant 15$	8	0	1
$16 \leqslant N \leqslant 50$	13	0	1
$51 \leqslant N \leqslant 90$	20	1	2
$91 \leqslant N \leqslant 150$	32	1	2
$151 \leqslant N \leqslant 280$	50	2	3
$281 \leqslant N \leqslant 500$	80	3	4

1) The definitions of size of lot and size of sample are given in annex D.

2) If the size of a lot is less than n, a test shall be carried out on each unit.

5.4 Simple torsion test

The test shall be carried out in accordance with ISO 7800, with the number of torsions specified in table 4.

A length of 100*d* for the test piece between grips is preferred. If this length cannot be adopted, an alternative length shall be chosen at the wire manufacturer's discretion. In this case, the minimum number of torsions which the wire shall withstand shall be proportional to the number specified in table 4 for a test length of 100*d*.

5.5 Tensile test on knotted wire

The test shall be carried out in accordance with ISO 6892 with a simple knot in the middle of the test piece.

5.6 Inspection of zinc coating

The determination of mass of zinc shall be carried out in accordance with annex A. For wires of quality A and B, an adhesion test shall be carried out in accordance with annex B.

6 Certificate

According to the purchaser's order, one of the following control documents may be established.

6.1 Certificate of conformity

By this certificate, the manufacturer acknowledges that the conditions as specified in the purchaser's order are fulfilled.

6.2 Full works certificate

This certificate shall give the results of tests carried out by the manufacturer in accordance with this International Standard.

6.3 Certificate of acceptance

In particular cases, when requested by the purchaser, tests may be undertaken after manufacture in the presence of the purchaser or his representative. The test results shall be provided in the certificate of acceptance, which is equivalent to a full works certificate.

7 Marking

Each delivery unit shall be marked and identified by a durable label, securely fixed to each coil or bobbin, clearly indicating at least the following:

a) the name of the manufacturer or supplier;

b) the indications relative to the wire (diameter, surface condition, tensile grade, mass or length per delivery unit);

c) the number of the customer's order;

d) the number of the bobbin or coil.

8 Information to be supplied by the purchaser

The purchaser shall indicate with the order:

a) reference to this International Standard;

b) the nominal diameter of the wire;

c) the surface finish (bright, galvanized quality B or A);

d) the tensile grade of wire;

e) the type of certificate to be supplied by the manufacturer;

f) the mass or length of the delivery unit.

Annex A
(normative)

Determination of mass of zinc deposited per unit surface area

A.1 General

Two methods are recognized: the gravimetric method described in ISO 1460 and the gas volumetric method described below.

The gas volumetric method is the easiest to carry out. In case of dispute, however, the gravimetric method shall be used.

A.2 Gas volumetric method

A.2.1 Principle

The zinc coating of a test specimen of wire of given dimensions is dissolved in a hydrochloric acid solution. The mass of zinc so dissolved is determined by measuring the volume of hydrogen released during dissolution of the coating (gas volumetric method). By relating the mass of zinc determined in this way to the surface area of the test specimen measured after dissolving the coating, the mass of zinc deposited per unit surface area is obtained (rate of galvanization).

A.2.2 Reagents

A.2.2.1 Hydrochloric acid, solution of suitable concentration.

A.2.2.2 Inhibitor, for example hexamethylene tetramine ($C_6H_{12}N_4$), antimony(III) chloride ($SbCl_3$) or antimony(III) oxide (Sb_2O_3).

A.2.3 Apparatus

The apparatus used consists of the following elements (see figure A.1).

A.2.3.1 Tube, graduated in millilitres at least, with a tap at each end.

A.2.3.2 Flask, with a nozzle near the bottom connected by a rubber tube to a nozzle near the bottom of the graduated tube, as shown in figure A.1.

A.2.3.3 Beaker, for holding the test specimen after removal of the zinc coating.

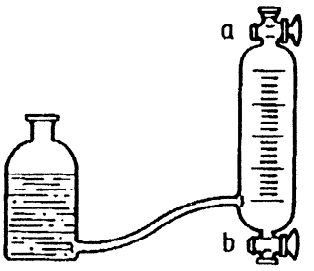

Figure A.1

A.2.4 Preparation of test specimens

After carefully straightening the samples of wire, test specimens shall be cut to a length of

300 mm for wires less than 1 mm in diameter;

150 mm for wires 1 mm to 1,49 mm in diameter;

100 mm for wires 1,5 mm to 3 mm in diameter;

50 mm for wires of more than 3 mm in diameter.

NOTE 4 Test specimens more than 100 mm long may be cut into several pieces of approximately equal length prior to insertion into the graduated tube.

A.2.5 Procedure

With tap **b** closed, the graduated tube and part of the flask are filled with hydrochloric acid solution (A.2.2.1) containing a suitable inhibitor (A.2.2.2).

The level of the liquid in the graduated tube (A.2.3.1) is raised to just under tap **a** by raising the acid reservoir flask (A.2.3.2). The level in the tube and flask should be the same.

After introducing the test specimen into the graduated tube through tap **a**, tap **a** is closed and the hydrogen released by the action of the acid on the zinc coating is allowed to accumulate in the upper part of the graduated tube.

When hydrogen is no longer released, the flask is lowered in relation to the graduated tube so as to bring the levels of the solution in the tube and in the