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Steel wire and wire products —

Part 1: General test methods

Fil et produits de fil en acier —

Partie 1: Méthodes d'essai générales

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22034-1 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 17, *Steel wire rod and wire products*.

ISO 22034 consists of the following parts, under the general title *Steel wire and wire products*:

— *Part 1: General test methods*

— *Part 2: Tolerances on wire dimensions*

Steel wire and wire products —

Part 1:
General test methods

1 Scope

This part of ISO 22034 specifies the methods for the general testing of steel wire and wire products which have been cold worked, annealed or oil hardened and tempered and/or coated and are of constant cross-section (either round or special section). It includes tensile testing, torsion testing, reverse bend testing, a wrapping test, a bend test, a reverse torsion test, a compression test, a deep etch test, a hardness test, a quench hardenability test, a fatigue test, wire cast measurement, artificial ageing, a decarburization test, non-destructive tests, a grain size test, a segregation test, a non-metallic inclusion test and chemical analysis.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*

ISO 404, *Steel and steel products — General technical delivery requirements*

ISO 643, *Steels — Micrographic determination of the apparent grain size*

ISO 3887, *Steels — Determination of depth of decarburization*

ISO 4967, *Steel — Determination of content of nonmetallic inclusions — Micrographic method using standard diagrams*

ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 6892, *Metallic materials — Tensile testing — Method of testing at ambient temperature*

ISO 7800, *Metallic materials — Wire — Simple torsion test*

ISO 7801, *Metallic materials — Wire — Reverse bend test*

ISO 7802, *Metallic materials — Wire — Wrapping test*

ISO 9649, *Metallic materials — Wire — Reverse torsion test*

ISO/TR 9769, *Steel and iron — Review of available methods of analysis*

ISO 16120-1, *Non-alloy steel wire rod for conversion to wire — Part 1: General requirements*

3 Tensile test

3.1 General

The tensile test shall be carried out in accordance with ISO 6892 at ambient temperature.

3.2 Type of test piece

Test pieces shall be selected in accordance with ISO 377, using the full cross-section, i.e. they shall be unmachined portions of wire.

3.3 Preparation of test pieces

The test pieces shall be straightened with care so as not to cause damage, with reference to ISO 377 and ISO 6892.

3.4 Cross-sectional area

The actual test piece dimensions are used for tensile calculations, but the nominal dimensions may be used if specified in the product standard or order. For non-circular wire, the original cross-sectional area may be determined from the mass of a known length and its density.

3.5 Method of gripping the test pieces

When testing smaller diameters (less than or equal to 1 mm), it is recommended that the ends of the wire be wrapped round a circular bar or disc and fastened to avoid breakages of the wire in the gripping zone.

3.6 Tensile testing of knotted wire

Carry out tensile testing of knotted wire in accordance with ISO 6892 with a simple knot in the middle of the test piece.

4 Simple torsion test

The simple torsion test shall be carried out in accordance with ISO 7800. In the event of initial failure, a retest shall be carried out (see ISO 404). Where possible the retest shall be conducted at a speed of (1 ± 0,2) turns/s.

Where the fracture in the torsion test is required to be characterized, it shall be done on the basis of Table 1.

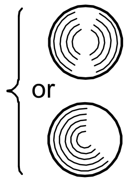
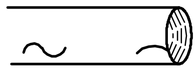
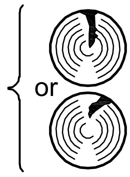
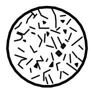
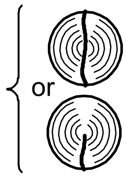
NOTE For small-diameter wire, it may not be possible to make a distinction between some of the types described in Table 1 (e.g. 2b and 3b).

5 Reverse bend test

The reverse bend test shall be carried out in accordance with ISO 7801, with the following amendment for automatic counters.

If the test machine has an automatic counter operating at the limit stops, then the first bend down through 90° counts as one bend and the second bend is represented by the 180° bend in the opposite direction. The last figure obtained before fracture occurs counts as the number of bends.

Table 1 — Evaluation of fractures occurring during torsion test

Type of fracture	Designation		Aspect	Description and characteristics	Fracture plane
Normal torsion fracture	1	a		Smooth — Fracture plane perpendicular to wire axis (or slightly oblique). No cracks in fracture plane.	
		b		Brittle — Fracture plane at an angle of 45° to wire axis. No cracks in fracture plane.	
Fracture with local cracks Regular fracture (material defect)	2	a		Smooth — Fracture plane perpendicular to wire axis and partially cracked.	
		b		Stepped — Part of the fracture plane is still smooth. Partially cracked.	
		c		Irregular fracture plane. No cracks in fracture plane.	
Fracture with spiral cracks over the whole length of the test piece (or a large part of it) Crack formation occurs after a low number (3 to 5) of twists and is best visible at the time of testing.	3	a		Smooth — Fracture plane perpendicular to wire axis and partially or entirely cracked.	
		b		Stepped — Part of the fracture plane is still smooth and partially or entirely cracked.	
		c	 	Brittle — Fracture plane at an angle of 45° and partially or entirely cracked. Or Irregular fracture plane and partially or entirely cracked.	

6 Wrapping test

The wrapping test shall be carried out in accordance with ISO 7802. This test may be used to assess coilability, ductility or the adherence of coatings as specified in the relevant product standard.

7 Bend test

In the bend test, the wire is bent over a mandrel of specified diameter through a specified angle in one operation at ambient temperature. Details will be given in the relevant product standard.

8 Reverse torsion test

The reverse torsion test shall be carried out in accordance with ISO 9649 with the following amendment.

The test shall be used to detect suface defects as well as to assess ductility.

9 Compression test

9.1 Purpose

The purpose of the test is to detect surface defects. This test is not suitable for wires less than 4,0 mm in diameter.

9.2 Principle

A straight test piece of wire equal in length to 1 (or 1,5) times the diameter of the wire is cut out, with cuts at right angles to the wire axis. The test piece is placed on a flat surface on a compression-testing machine and compressed at room temperature in the direction of the wire axis to a specified percentage of its original length. The compressed test piece is examined for surface cracking. The degree of acceptability will be specified in the product standard.

10 Deep etch test

10.1 Purpose

The deep etch test is used for the detection of surface defects.

10.2 Principle

A cold test piece which has undergone deformation by drawing is degreased, where appropriate, by washing and drying. In the case of high-carbon steel, the test piece is stress relieved at 400 °C to 500 °C for 15 min and allowed to cool to ambient temperature before etching. With the exception of test pieces greater than 5,00 mm and test pieces of annealed structures, the test piece is immersed in a mixture of 50 % by volume concentrated hydrochloric acid and 50 % by volume water at a minimum temperature of 60 °C for a period of time equivalent to 2 s for every 0,025 mm of diameter, but for a maximum of 5 min. Test pieces greater than 5,00 mm in diameter and test pieces of annealed structures may be left in the solution for 10 min.

The test piece is examined for surface defects. To determine the depth of defects, the defects shall be filled and the difference in thickness before and after filling recorded as the defect depth. For a definitive assessment of defects, optical micrographical analysis shall be used.

11 Hardness test

Hardness testing shall be in accordance with ISO 6506-1, ISO 6507-1 or ISO 6508-1 as specified in the product standard or in the order. A distinction should preferably be made between surface hardness, core hardness and through hardness.

NOTE There is no relevant relationship between hardness and tensile strength.

12 Quench hardenability test

The test pieces for the quench hardenability test shall be heated in a neutral or reducing furnace atmosphere up to the hardening temperature specified for the steel type, and maintained at this temperature until they are completely austenitized.

They shall then be taken out of the furnace and immediately quenched, in a heavy-duty quenching oil, to complete temperature equalization. The heavy-duty quenching oil shall be at a temperature of (50 ± 10) °C, shall be of sufficient volume and shall be stirred to ensure, in combination with the speed of immersion, that the test pieces reach the temperature of the quenching oil without significant delay. The hardness test specified in Clause 11 shall then be carried out on a suitably prepared test piece. A distinction should

preferably be made between core hardness and through hardness. In cases of dispute, reference shall be made to the Jominy value of the original feedstock for the particular steel.

13 Fatigue test (bend and axial)

The tests used for wire are an axial fatigue test or a rotating bend fatigue test. With these tests, a number of variations are possible. Particularly care has to be taken, therefore, in interpreting the results from one test in relation to those obtained from another test. Such is the complexity of the interpretation that specific instructions will be given in the appropriate product standards.

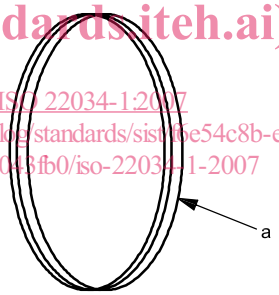
14 Coil set measurements

14.1 General

14.1.1 The coil set of the wire is characterized by the shape of a turn of wire taken from a coil or reel and lying freely on a flat, horizontal surface or, in one of the tests specified below, suspended freely from a bar. On the flat, horizontal surface, the ends of the turn may lie together (closed turn) or apart (open turn).

NOTE For the purposes of this part of ISO 22034, the terms “coil”, “reel”, “spool” and “bobbin” are synonymous.

14.1.2 Cut sufficient wire from the coil or reel to give several full turns of wire (one for each test), ensuring that the wire is not bent or damaged (see Figure 1).



a Cut several turns of wire from the coil and, from this sample, cut a single turn for measurement purposes.

Figure 1 — Sampling of wire

14.1.3 Carry out the measurements specified in 14.2 to 14.4, as required, to determine the degree of circular and helical coil set.

14.2 Circular coil set

To measure the degree of circular coil set, i.e. the inside diameter of the turn, place the turn on a flat, horizontal surface and measure the average diameter (see Figures 2 and 3, which also illustrate the difference between closed and open turns).