INTERNATIONAL STANDARD

ISO 19203

First edition
2018-05

Hot-dip galvanized and zinc-aluminium coated high tensile steel wire for bridge cables — Specifications

Fils d'acier à haut carbone galvanisés ou revêtus de zinc-aluminium pour câbles de ponts — Spécifications

Reference number
ISO 19203:2018(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword ... **iv**

1 Scope ... **1**

2 Normative references ... **1**

3 Terms and definitions ... **1**

4 Symbols ... **3**

5 Designation of the product ... **3**

6 Information needed by the manufacturer ... **4**

7 Requirements ... **4**
7.1 Materials and manufacture ... 4
7.2 Standard properties ... 4
7.2.1 Geometrical properties ... 4
7.2.2 Straightness ... 5
7.2.3 Mechanical and coating properties ... 5
7.2.4 Appearance ... 6
7.3 Special properties ... 6
7.4 Traceability ... 6

8 Inspection ... **7**
8.1 Inspection and inspection documents ... 7
8.2 Number of samples and test pieces ... 7
8.3 Evaluation of test results ... 7
8.4 Sorting and reprocessing ... 8

9 Test methods ... **8**
9.1 Testing of standard properties ... 8
9.1.1 Measurement of geometrical characteristics ... 8
9.1.2 Tensile test ... 8
9.1.3 Elasticity modulus test ... 8
9.1.4 Torsion test ... 8
9.1.5 Ductility wrapping test ... 8
9.1.6 Mass of coating ... 8
9.1.7 Adhesive of coating ... 9
9.1.8 Surface quality ... 9
9.2 Testing of special properties ... 9
9.2.1 Uniformity of zinc or zinc-aluminium coating (dipping test) ... 9
9.2.2 Corrosion resistance test ... 9
9.2.3 Axial force fatigue test ... 9
9.2.4 Isothermal stress relaxation test ... 9

10 Delivery conditions ... **9**
10.1 Identification ... 9
10.2 Coil dimensions ... 9
10.3 Coil weight ... 10
10.4 Transport and storage ... 10

Annex A (normative) **Additional test methods — Axial force fatigue test** ... **11**

Annex B (normative) **Additional test methods — Isothermal stress relaxation test** ... **12**

Annex C (informative) **Calculation of the density of steel wire and diameter of bare steel wire** ... **13**

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 17, *Steel wire rod and wire products*.

Hot-dip galvanized and zinc-aluminium coated high tensile steel wire for bridge cables — Specifications

1 Scope

This document specifies the requirements for hot-dip galvanized (hereinafter referred to as zinc coated) and zinc-aluminium coated high tensile wires, which are widely used in parallel wire cables or semi-parallel wire cables for suspension bridges, stay bridges and other structures involving the use of parallel wires.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 752:2004, *Zinc ingots*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

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

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

ISO 7989-2, *Steel wire and wire products — Non-ferrous metallic coatings on steel wire — Part 2: Zinc or zinc-alloy coating*

ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

ISO 10474:2013, *Steel and steel products — Inspection documents*

ISO 15630-3:2010, *Steel for the reinforcement and prestressing of concrete — Test methods — Part 3: Prestressing steel*

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

ISO 16120-4, *Non-alloy steel wire rod for conversion to wire — Part 4: Specific requirements for wire rod for special applications*

ISO 22034-2, *Steel wire and wire products — Part 2: Tolerances on wire dimensions*

ASTM B-997, *Standard specification for Zinc-Aluminum alloy in ingot form for hot-dip coatings*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
wire rod
hot rolled steel delivered in coils, used for cold working treatments such as wire drawing

3.2
bare steel wire
product manufactured by cold working *wire rod* (3.1) that is in a suitable metallurgical condition for cold working

3.3
hot-dip zinc coated steel wire
hot-dip galvanized coated steel wire
steel wire that is coated with zinc in a bath of molten zinc

3.4
zinc-aluminium coated steel wire
steel wire that is coated with zinc-aluminium alloy in a bath of molten zinc-aluminium alloy

Note 1 to entry: In this document, "steel wire" or "wire" refers to zinc or zinc-aluminium coated steel wire, unless otherwise specified.

3.5
stabilized wire
steel wire that is given a final thermo-mechanical treatment

3.6
out-of-round
arithmetic difference between the maximum and minimum diameters of the steel wire at the same cross section

3.7
semi-parallel wire cable
specified number of steel wires bundled together with a maximum lay angle of 4°

Note 1 to entry: Semi-parallel wire cables are usually used for cable stayed bridge and suspenders for suspension and arch bridges.

3.8
unit of manufacture
coil of steel wire produced from one coil of *wire rod* (3.1)

3.9
unit of product
coil of steel wire delivered to a customer

Note 1 to entry: The unit of product is either the *unit of manufacture* (3.8) or a smaller coil cut from a unit of manufacture.

3.10
unit of inspection
quantity of product presented at any one time for examination and release purposes

3.11
inspection
conformity evaluation by observation and judgement accompanied as appropriate by measurement, testing or gauging

3.12
factory production control
permanent internal production control exercised by the manufacturer

3.13
standard property
property prescribed as part of *factory production control* (3.12) requirements for every unit of *inspection* (3.10)

3.14
special property
property prescribed that are not determined as part of *factory production control* (3.12) requirements

3.15
maximum
value which no test result shall exceed

3.16
minimum
value below which no test result shall fall

3.17
unit heat of steel
quantity of steel corresponding to the same single melting operation identified by a single number so designated by the steel manufacturer(s)

4 Symbols

Symbol	Unit	Designation	Reference
A	%	percentage of elongation after fracture	7.2.3
d	mm	nominal diameter of the steel wire	7.2, 7.3, Annex A, Annex C
E	GPa	modulus of elasticity	7.2.3, 9.1.3
ε_x	—	value of the strain for a force equal to x	9.1.3
Fm	KN	minimum ultimate tensile force (or guaranteed ultimate tensile force), $Fm = R_m \times Sn$	9.1.3
F_r	KN	fluctuating force range in the axial load fatigue test	7.3
h_b	mm	bow height in the plane of bow	7.2
R_m	MPa	ultimate tensile strength	7.2, 7.3
L_0	mm	gauge length (without force on the test piece)	7.2, 9.1.2
$R_{p0,2}$	MPa	0,2 % offset proof strength	7.2
Sn	mm^2	nominal cross sectional area of the steel wire	7.2, 7.3

5 Designation of the product

The steel wire shall be ordered in accordance with this document and be designated as follows:

a) ISO 19203;

b) nominal diameter, in millimetres;

c) nominal tensile strength, in MPa;

d) coating type;

e) a suffix “R” to indicate when relaxation properties are specified, e.g. 1 960R.

NOTE “Zn” is used for hot-dip zinc coated and “ZnAl” for zinc-aluminium alloy coated.

EXAMPLE 1 Zinc coated steel wire with nominal diameter 5 mm and nominal tensile strength 1 960 MPa is designated

ISO 19203-5,00-1960-Zn

EXAMPLE 2 Zinc-aluminium coated steel wire with nominal diameter 7 mm and nominal tensile strength 1 860 MPa is designated

ISO 19203-7,00-1860-ZnAl

EXAMPLE 3 Zinc coated steel wire with nominal diameter 5 mm and nominal tensile strength 1 960 MPa, when relaxation property specified, is designated

ISO 19203-5,00-1960R-Zn

6 Information needed by the manufacturer

The following information shall be obtained by the manufacturer at the time of enquiry and order:

— designation of the product in accordance with Clause 5;

— packaging and protection requirements and, in the case of products supplied in bundles, the maximum mass of the bundles;

— requirements for documentary information to accompany the delivery (i.e. delivery note, type and content of inspection document, copies of force/extension diagrams);

— special requirements for labelling.

7 Requirements

7.1 Materials and manufacture

7.1.1 The bare steel wires shall be produced from wire rod that conforms to ISO 16120-1 and ISO 16120-4.

7.1.2 Zinc ingot metal shall conform to ZN3 or higher under ISO 752:2004, 6.1. ZnAl ingot shall conform to ASTM B 997.

7.1.3 Bare steel wires shall be zinc or zinc-aluminium coated after drawing.

7.1.4 Coated wires may be stabilized depending on the final product relaxation requirement. Stabilized steel wire requirements shall be specified by the customer.

7.1.5 Welding points present in steel wire rod before the drawing process are acceptable if agreed between manufacturer and customer.

Mechanical properties of the welding points and the number of welding points shall be agreed between the manufacturer and the customer.

7.2 Standard properties

7.2.1 Geometrical properties

The geometrical properties shall be defined by a nominal diameter, *d*, permitted deviation on nominal diameter and out-of-round which all include the metallic coating, see Table 1.

NOTE 1 Generally, 5 mm steel wires are used in the main cables of suspension bridges, and 7 mm wires in cables of cable-stayed bridges. Steel wires with other dimensions can be supplied if agreed between the manufacturer and the customer.

NOTE 2 The calculation of the density of steel wires and diameter of bare steel wire is described in Annex C.

Table 1 — Nominal diameters, permitted deviation and out-of-round

Nominal diameter, d[a] mm	Permitted deviation on nominal diameter mm	Out-of-round mm
5,00	±0,06	≤ 0,06
7,00	±0,07	≤ 0,07

[a] The nominal values and tolerance include the wire coating.

7.2.2 Straightness

7.2.2.1 General

The steel wire shall be uniform in straightness along its length commensurate with the requirements specified in 7.2.2.2, and there shall not be defects, such as bend, twist, etc.

7.2.2.2 Bow height

The bow height (h_b), which indicates the straightness of the product, shall be determined by measuring, in the plane of the bow, the distance between the steel wire and a line joining the ends of a rule of length 1 m in contact with the wire, lying on a flat horizontal surface with a flatness tolerance of 1 mm/m (see Figure 1).

The maximum bow height shall be agreed by the manufacturer and the customer.

Dimensions in millimetres

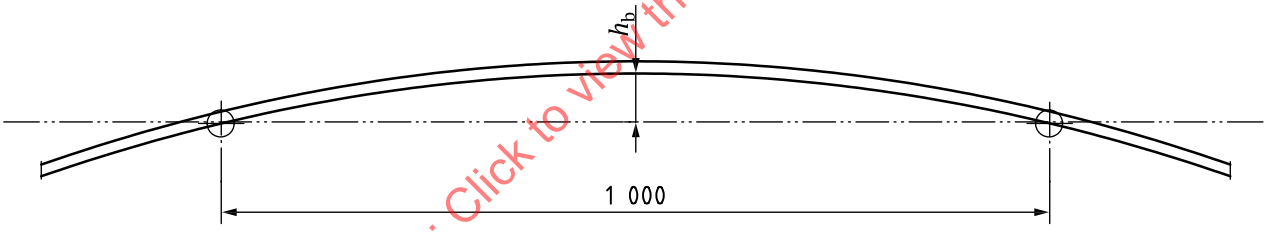

Figure 1 — Measurement of bow height

7.2.3 Mechanical and coating properties

The mechanical and coating properties of the steel wires shall conform to Table 2.

Table 2 — Typical diameter, mechanical and coating properties of steel wires

Property	Nominal tensile strength grade, MPa				
	1 570	1 670	1 770[c]	1 860[c]	1 960[c]
Typical nominal diameter d	5,0 mm and 7,0 mm				
Ultimate tensile strength R_m, MPa[a]	1 570 ≤ R_m < 1 770	1 670 ≤ R_m < 1 870	1 770 ≤ R_m < 1 970	1 860 ≤ R_m < 2 060	1 960 ≤ R_m < 2 160
0,2 % offset proof strength $R_{p0,2}$, MPa (minimum)[a,b]	1 180	1 250	1 330	1 400	1 470
Elongation after fracture A, % (minimum)	4,0 (on a gauge length L_0 of 250 mm)				
Modulus of elasticity E, GPa	200 ± 10				

[a] Tensile strength and proof strength shall be calculated from the nominal cross-sectional area.

[b] The minimum proof strength shall be 0,75 × nominal tensile strength grade, rounded to the nearest 10 MPa.

[c] A higher number of torsions can be agreed upon between manufacturer and customer.

Table 2 *(continued)*

Property			Nominal tensile strength grade, MPa				
			1 570	1 670	1 770[c]	1 860[c]	1 960[c]
Number of torsions (minimum)	5,0 mm	On a length of 100 d	14	14	12	10	8
	7,0 mm		12	12	10	8	6
Ductility wrapping			No fracture after 8 turns over a mandrel of diameter 3 *d*				
Mass of coating (minimum)			300 g/m^2				
Adhesion of coating			No peel-off after 8 turns over a mandrel of diameter 5 *d*				

[a] Tensile strength and proof strength shall be calculated from the nominal cross-sectional area.

[b] The minimum proof strength shall be 0,75 × nominal tensile strength grade, rounded to the nearest 10 MPa.

[c] A higher number of torsions can be agreed upon between manufacturer and customer.

7.2.4 Appearance

The coating applied to the steel wire shall be reasonably smooth and as evenly distributed as industrial technology allows and shall not show discontinuities such as bare patches, dross contamination, etc.

NOTE The Zn95Al5 zinc-aluminium alloy might show difference in colour and become darker with time. This does not affect the corrosion protection performance.

7.3 Special properties

The special properties of the steel wires which are optionally agreed between the manufacturer and the customer at the time of enquiry or order shall conform to Table 3.

Table 3 — Special properties of steel wires

Property	5,0 mm and 7,0 mm
Uniformity of coating (minimum)	Where requested, 4 times at a dipping time of 60 s
Corrosion resistance[a]	Where requested, Zn class A[b], DBR (dark brown rust) not more than 5 % after a period of 500 h when subjected to the neutral salt spray test. Zn95Al5 class A[b], DBR not more than 5 % after a period of 2 000 h when subjected to the neutral salt spray test.
Tensile fatigue[c]	Where requested, No breakage at 0,45 R_m, *Fr/Sn* = 350 MPa, for ≥ 2,0 × 10^6 cycles
Relaxation 1 000 h at 0,70 R_m, 20 °C	Where requested, not more than 2,5 %

[a] More advanced metallic coatings may be supplied by agreement between manufacturer and customer.

[b] Class A relates to thick coatings (generally final coating).

[c] Alternative limits may be agreed between manufacturer and customer.

7.4 Traceability

The manufacturer shall use suitable means to ensure the conformity of products and identify the status of products with respect to monitoring and measurement requirements throughout production, and delivery.

The manufacturer shall control the unique identification of the product and shall retain the documented information necessary to enable traceability.

8 Inspection

8.1 Inspection and inspection documents

Inspection shall be carried out by the manufacturer in accordance with Clause 7 before delivery. The inspection documents shall be based on inspection certificate 3.1, 3.2 under ISO 10474:2013, Clause 5.

The type of the inspection certificate shall be agreed between the manufacturer and the customer.

8.2 Number of samples and test pieces

The finished steel wires shall be sampled and tested in accordance with Table 4.

Uniformity of coating, salt spray, fatigue and isothermal tests shall be conducted where requested. Frequency of sampling and testing for salt spray shall be agreed between the manufacturer and the customer.

Table 4 — Frequency of sampling and testing of steel wire

Property	Frequency of sampling and testing
Diameter	One test every unit of manufacture
Out-of-round	
Surface quality	
Tensile strength	
Elongation after fracture	
0,2 % offset proof strength	
Modulus of elasticity	One test every 10 units of manufacture
Number of torsions	
Ductility wrapping	
Straightness	
Mass of coating	
Adhesion of coating	
Uniformity of coating	
Axial force fatigue	One test per unit heat of steel
Isothermal stress relaxation	

8.3 Evaluation of test results

The material shall be deemed to conform to the requirements of this specification if all the results of tests conform to the specified values. If these conditions are not met then the following procedures shall apply.

When results do not conform to the requirements then two additional samples shall be taken from the unit of product concerned by each failed result and these shall be tested for the property concerned. If the two additional results conform to the requirements of this document then the unit of product shall be deemed to conform to this document. If one or more of these additional tests does not conform to the specifications, the unit of product concerned shall be rejected. In addition, all units of product from the last good result until the next good result shall be tested for the defected properties.

All units of product with non-conforming results shall be rejected and the manufacturer shall immediately take measures to determine the reason and rectify the fault.

8.4 Sorting and reprocessing

The manufacturer has the right to carry out sorting or reprocessing of non-conforming products, either before or after retests. The manufacturer shall report non-conforming products to the customer before sorting or reprocessing and then submit these products as a new test unit in accordance with 8.2. If the inspections conform to this document and are agreed by customer, these products can be delivered as qualified products. If requested, the manufacturer shall inform the customer which method of sorting or reprocessing is used.

9 Test methods

9.1 Testing of standard properties

9.1.1 Measurement of geometrical characteristics

The geometrical characteristics shall be measured with an instrument of a resolution of at least the following:

— 0,01 mm for the diameter of steel wires;

— 1,0 mm for the straightness.

Nominal diameter and out-of-round shall be measured in accordance with ISO 22034-2.

9.1.2 Tensile test

9.1.2.1 The tensile test of steel wires shall be conducted in accordance with ISO 6892-1.

9.1.2.2 Elongation after fracture shall be determined in accordance with ISO 6892-1. Gauge length L_0 is 250 mm.

9.1.3 Elasticity modulus test

The modulus of elasticity (E) shall be determined from the slope of the linear portion of the force-extension diagram in the range between 0,2 Fm and 0,6 Fm, divided by the nominal cross-sectional area of the test piece (Sn).

$$E = [(0{,}6\,F\mathrm{m} - 0{,}2\,F\mathrm{m})/(\varepsilon_{0{,}6F\mathrm{m}} - \varepsilon_{0{,}2F\mathrm{m}})]/S\mathrm{n}$$

The slope may be calculated either by a linear regression of the measured data stored in a data storage facility or by a best-fit visual technique over the above-defined portion of the registered curve.

9.1.4 Torsion test

The torsion test shall be carried out in accordance with ISO 7800, irrespective of the characteristics of fracture.

9.1.5 Ductility wrapping test

The ductility wrapping test consists of winding a coated wire to a specified number of turns around a mandrel to form a closely wrapped helix. The test shall be conducted in accordance with ISO 7802.

9.1.6 Mass of coating

The coating mass test shall be conducted in accordance with ISO 7989-2.

9.1.7 Adhesive of coating

The adhesion test shall be conducted in accordance with ISO 7802.

9.1.8 Surface quality

Surface quality shall be inspected by visual means (reference to ISO 7989-2).

9.2 Testing of special properties

9.2.1 Uniformity of zinc or zinc-aluminium coating (dipping test)

The uniformity of zinc or zinc-aluminium coating (dipping test) shall be conducted in accordance with ISO 7989-2.

9.2.2 Corrosion resistance test

The corrosion resistance test (salt spray) shall be conducted in accordance with ISO 9227.

9.2.3 Axial force fatigue test

The axial force fatigue test shall be in accordance with Annex A.

9.2.4 Isothermal stress relaxation test

The isothermal stress relaxation test shall be in accordance with Annex B.

10 Delivery conditions

10.1 Identification

Unless otherwise agreed, each coil of steel wire shall carry a label giving the following information:

— relevant designation in accordance with ISO 19203:2018, Clause 5;

— nominal diameter;

— nominal tensile strength grade;

— coil number related to the test certificate;

— heat number;

— net weight;

— date of manufacture;

— manufacturer's name and plant.

10.2 Coil dimensions

The diameter of coil for delivery shall be sufficiently large to ensure that the coil can be uncoiled without difficult, and without affecting the mechanical properties and the straightness of the product. Manufacturer and customer shall agree with the coil dimensions before production.

10.3 Coil weight

The steel wires used in parallel wire cables or semi-parallel wire cables shall be the designated length without joints. The manufacturer and the customer shall agree on the coil weight before production.

10.4 Transport and storage

Steel wires in transit and storage shall be protected against damage and contamination, particularly from substances or liquids which are likely to produce or encourage corrosion.