International Standard

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Second edition
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Steel for the prestressing of concrete —

Part 2: Cold-drawn wire

Acier pour armatures de précontrainte —
Partie 2: Fil tréfilé à froid

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Foreword

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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 document 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).

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This document was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 16, *Steels for the reinforcement and prestressing of concrete*.

This second edition cancels and replaces the first edition (ISO 6934-2:1991), which has been technically revised.

The main changes are as follows:

— ISO 7800 and ISO 15630-3 are referenced as inspection method standards;

— the following are added for mill coil wire in Table 1:

  — requirements of maximum value of maximum tensile load and minimum constriction;

  — notes for characteristic 0,1 % proof forces;

  — notes for confidence interval of characteristic value;

— requirements and criteria of torsion test and stress corrosion for mill coil wire;

— fatigue test method for mill coil wire;

— the following diameter are added for stress-relieved wire in Table 2:

  — 1 570 MPa: 6,25 mm, 7,5 mm, 9,5 mm, 10,5 mm;

  — 1 670 MPa: 7,5 mm;

  — 1 770 MPa: 7 mm;

  — 1 860 MPa: 4 mm, 5 mm, 6 mm, 7 mm;

— requirements and criteria of stress corrosion test, fatigue test method and maximum value of maximum tensile load are added for stress-relieved wire;

— notes of “arrow-head” rupture and confidence interval of characteristic value are added in Table 2;

— Figure A.3 has been added in Annex A;

— Figure A.1 and Figure A.2 have been updated.

A list of all parts in the ISO 6934 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Steel for the prestressing of concrete —

Part 2:
Cold-drawn wire

1 Scope

This document specifies requirements for round, cold-drawn, high-tensile steel wire, that is either plain, indented, spiral ribbed or crimped. The product is supplied as mill coil wire or straightened and stress-relieved wire in coils or cut lengths, according to the general requirements specified in ISO 6934-1.

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 6934-1, *Steel for the prestressing of concrete — Part 1: General requirements*

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

ISO 15630-3:2019, *Steel for the reinforcement and prestressing of concrete — Test methods — Part 3: Prestressing steel*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6934-1 apply.

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

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

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

4 Test methods

The test methods for all properties except "Torsion" shall be in accordance with ISO 15630-3.

5 Conditions of manufacture

The wire shall be manufactured from high carbon steel in accordance with ISO 6934-1.

The wire shall be supplied without welds or other joints.

6 Surface configuration

There are several types of surface configuration (spiral ribs, indentations, crimps), the purpose of which is to improve bond properties between wire and concrete. The type of surface configuration shall be agreed between purchaser and manufacturer.

Examples of indentations, crimps and spiral ribs are given in Annex A.

7 Properties

7.1 General

The designations, data for information and required properties are given in Table 1 and Table 2.

7.2 Dimensions and properties of mill coil wire

7.2.1 Dimensions, masses and tensile properties

See Table 1.

7.2.2 Elongation and ductility

The percentage total elongation at maximum force, measured on a length of 200 mm, shall be not less than 1,5 %.

All wires shall show a ductile fracture with a constriction visible to the naked eye.

All wires shall withstand a reverse bend test around the bend radius given in Table 1. The number of bends shall not be lower than four for plain wires, not be lower than three for indented and spiral ribbed wires.

Table 1 — Dimensions, masses and tensile properties of mill coil wire

Nominal diameter	Nominal tensile strength[a]	Nominal cross-sectional area	Mass per length		Characteristic[b]				Bend radius	Mini. reduction of area
			Nominal[c]	Permissible deviation	Maximum force	Maximum value of maximum force[d]	0,1 % Proof force[e]	Mini. number of twists in the torsion test		
mm	N/mm^2	mm^2	g/m	g/m	kN	kN	kN	N	mm	%
8	1 470	50,3	395	±5,9	73,9	84,0	59,1	11	20	30
8	1 570	50,3	395	±5,9	79	89,0	63,2	11	20	30
7	1 570	38,5	302	±4,3	60,4	68,1	48,3	12	20	30
7	1 670	38,5	302	±4,3	64,3	72,0	51,4	12	20	30
6	1 670	28,3	222	±3,7	47,3	52,9	37,8	12	15	30
6	1 770	28,3	222	±3,7	50,1	55,8	40,1	12	15	30
5	1 670	19,6	154	±3,1	32,7	36,7	26,2	12	15	35
5	1 770	19,6	154	±3,1	34,7	38,6	27,8	12	15	35
4	1 670	12,6	98,9	±2,0	21	23,6	16,8	24	10	35
4	1 770	12,6	98,9	±2,0	22,3	24,8	17,8	24	10	35
3	1 770	7,07	55,5	±1,5	12,5	13,9	10	—	7,5	35

[a] The nominal tensile strength is for designation purposes only and is calculated from the nominal cross-sectional area and the characteristic maximum force and rounded off to the nearest 10 N/mm^2.

[b] In view of the small tolerance on mass per unit length, characteristic forces have been specified rather than stresses.

[c] The mass per length is calculated by adopting conventionally the value 7,85 kg/dm^3 as the density of steel.

[d] In order to prove the suitability of the material, which is only used in certain applications (e.g. for railway sleepers, piles or tanks) there is a requirement for a force at 1 % total elongation to be at least 80 % of the characteristic maximum force.

[e] The characteristic 0,1 % proof forces are approximately 80 % of the characteristic maximum force.

[f] At least 95 % of the population under consideration shall have characteristic values equal to or above the characteristic value specified.

Table 1 *(continued)*

Nominal diameter	Nominal tensile strength[a]	Nominal cross-sectional area	Mass per length		Characteristic[b]				Bend radius	Mini. reduction of area
			Nominal[c]	Permissible deviation	Maximum force	Maximum value of maximum force[d]	0,1 % Proof force[e]	Mini. number of twists in the torsion test		
mm	N/mm^2	mm^2	g/m	g/m	kN	kN	kN	N	mm	%
3	1 860	7,07	55,5	±1,5	13,2	14,6	10,5	—	7,5	35
2,5	1 860	4,91	38,5	±1,25	9,13	10,1	7,3	—	7,5	35
2,5	1 960	4,91	38,5	±1,25	9,62	10,6	7,7	—	7,5	35

[a] The nominal tensile strength is for designation purposes only and is calculated from the nominal cross-sectional area and the characteristic maximum force and rounded off to the nearest 10 N/mm^2.

[b] In view of the small tolerance on mass per unit length, characteristic forces have been specified rather than stresses.

[c] The mass per length is calculated by adopting conventionally the value 7,85 kg/dm^3 as the density of steel.

[d] In order to prove the suitability of the material, which is only used in certain applications (e.g. for railway sleepers, piles or tanks) there is a requirement for a force at 1 % total elongation to be at least 80 % of the characteristic maximum force.

[e] The characteristic 0,1 % proof forces are approximately 80 % of the characteristic maximum force.

[f] At least 95 % of the population under consideration shall have characteristic values equal to or above the characteristic value specified.

7.2.3 Relaxation

The relaxation at 1 000 h at an initial force of 70 % of the characteristic maximum force specified in Table 1 shall be not more than 10 %.

If required, the same test shall be performed at an initial force of 60 % of the characteristic maximum force (see Table 1). The maximum relaxation is then 8 %.

7.2.4 Fatigue

If agreed between purchaser and manufacturer, the material shall withstand, without failure, 2 x 10^6 cycles of a stress fluctuating down from a maximum stress of 70 % of the nominal tensile strength. The stress range shall be 200 N/mm^2 for plain wire and 180 N/mm^2 for intended and spiral ribbed wire.

The test requirements shall be in accordance with ISO 15630-3:2019, Clause 10.

7.2.5 Torsion

If agreed between purchaser and manufacturer, torsion test shall be conducted in accordance with ISO 7800 for mill coil wire used in prestressing concrete cylinder pipe. The minimum number of twists in torsion test is specified in Table 1.

7.2.6 Stress corrosion test

If agreed between purchaser and manufacturer, the product with exception of nominal diameters 2,5 mm and 3,0 mm shall withstand without crack after the test. The volume of test solution A shall be 2 500 ml~3 000 ml, and the length of jaws shall not be less than 1 000 mm. During the test, the test force shall be kept at 70 % ± 2 % of the characteristic value of the maximum force, the testing time shall not be less than 75 hours , other test requirements shall be in accordance with ISO 15630-3:2019,Clause 11.

7.3 Dimensions and properties of stress-relieved wire

7.3.1 Dimensions, masses and tensile properties

See Table 2.

7.3.2 Elongation and ductility

The percentage total elongation at maximum force, measured on a length of 200 mm, shall be not less than 3,5 %. All wires shall show a ductile fracture with a constriction visible to the naked eye.

All wires shall withstand a reverse bend test around the bend radius given in the last column of Table 2. The minimum number of bends is four for plain wires and three for indented and spiral ribbed wires.

Table 2 — Dimensions, masses and tensile properties of stress-relieved wire

Nominal diameter	Nominal tensile strength [a]	Nominal cross-sectional area	Mass per length		Characteristic [b]				Bend radius
			Nominal [c]	Permissible deviation	Maximum force	Maximum value of maximum force	Proof force 0,1 % [d][e][f]	Proof force 0,2 % [d][f]	
mm	N/mm^2	mm^2	g/m	g/m	kN	kN	kN	kN	mm
12,2	1 470	117	918	±10,5	172	195	138	141	30
12,2	1 570	117	918	±10,5	184	207	147	151	30
10,5	1 570	86,59	680	±9,0	136	153	109	120	30
10	1 470	78,5	617	±8,6	115	131	92,3	94,3	25
10	1 570	78,5	617	±8,6	123	139	98,6	101	25
9,5	1 570	70,88	556	±8,2	111	125	89,0	97,9	25
9	1 470	63,6	499	±7,2	93,5	106	74,8	76,7	25
8	1 570	50,3	395	±5,9	79,0	89,0	65,6	67,1	20
8	1 670	50,3	395	±5,9	84,0	94,1	69,7	71,4	20
7,5	1 570	44,18	347	±6,5	69,4	78,2	57,6	61,0	20
7,5	1 670	44,18	347	±6,5	73,8	82,6	61,3	64,9	20
7	1 570	38,5	302	±4,3	60,4	68,1	50,1	51,3	20
7	1 670	38,5	302	±4,3	64,3	72,0	53,4	54,7	20
7	1 770	38,5	302	±4,3	68,1	68,1	56,5	57,9	20
7	1 860	38,5	302	±4,3	71,6	79,3	59,4	60,9	20
6,25	1 570	30,68	241	±5,4	48,2	54,3	40,0	42,4	20

[a] The nominal tensile strength is for designation purposes only and is calculated from the nominal cross-sectional area and the characteristic maximum force and rounded off to the nearest 10 N/mm^2.

[b] In view of the small tolerance on mass per unit length, characteristic forces have been specified rather than stresses.

[c] The mass per length is calculated by adopting conventionally the value 7,85 kg/dm^3 as the density of steel.

[d] For wires of diameter larger than 8 mm, the characteristic 0,1 % and 0,2 % proof forces are approximately 80 %, respectively 82 %, of the characteristic maximum force. For wires 8 mm and smaller, the corresponding figures are approximately 83 %, respectively 85 %.

[e] The modulus of elasticity may be taken to be 205 kN/mm^2 ± 10 kN/mm^2

[f] 0,1 % proof force is mandatory, and 0,2 % proof force is for information only (see IS0 6934-1), except when otherwise agreed.

[g] Ruptures in “arrow-head” are prohibited. In case of dispute, the percentage reduction of area shall be determined, and the value shall be ≥ 25 % for plain wire and ≥ 20 % for indented and spiral ribbed wire.

[h] At least 95 % of the population under consideration shall have characteristic values equal to or above the characteristic value specified.

Table 2 *(continued)*

Nominal diameter	Nominal tensile strength [a]	Nominal cross-sectional area	Mass per length		Characteristic [b]				Bend radius
			Nominal [c]	Permissible deviation	Maximum force	Maximum value of maximum force	Proof force 0,1 % [d][e][f]	Proof force 0,2 % [d][f]	
mm	N/mm²	mm²	g/m	g/m	kN	kN	kN	kN	mm
6	1 670	28,3	222	±3,7	47,3	52,9	39,3	40,2	15
6	1 770	28,3	222	±3,7	50,1	55,8	41,6	42,6	15
6	1 860	28,3	222	±3,.7	52,6	58,3	43,7	44,7	15
5	1 670	19,6	154	±3,1	32,7	36,7	27,2	27,8	15
5	1 770	19,6	154	±3,1	34,7	38,6	28,8	29,5	15
5	1 860	19,6	154	±3,1	36,5	40,4	30,3	31,0	15
4	1 670	12,6	98,9	±2,0	21,0	23,6	17,5	17,9	10
4	1 770	12,6	98,9	±2,0	22,3	24,8	18,5	19,0	10
4	1 860	12,6	98,9	±2,0	23,4	26,0	19,4	19,9	10

[a] The nominal tensile strength is for designation purposes only and is calculated from the nominal cross-sectional area and the characteristic maximum force and rounded off to the nearest 10 N/mm².

[b] In view of the small tolerance on mass per unit length, characteristic forces have been specified rather than stresses.

[c] The mass per length is calculated by adopting conventionally the value 7,85 kg/dm³ as the density of steel.

[d] For wires of diameter larger than 8 mm, the characteristic 0,1 % and 0,2 % proof forces are approximately 80 %, respectively 82 %, of the characteristic maximum force. For wires 8 mm and smaller, the corresponding figures are approximately 83 %, respectively 85 %.

[e] The modulus of elasticity may be taken to be 205 kN/mm² ± 10 kN/mm²

[f] 0,1 % proof force is mandatory, and 0,2 % proof force is for information only (see IS0 6934-1), except when otherwise agreed.

[g] Ruptures in "arrow-head" are prohibited. In case of dispute, the percentage reduction of area shall be determined, and the value shall be ≥ 25 % for plain wire and ≥ 20 % for indented and spiral ribbed wire.

[h] At least 95 % of the population under consideration shall have characteristic values equal to or above the characteristic value specified.

7.3.3 Relaxation

The relaxation at 1 000 h at an initial force of 70 % of the characteristic maximum force specified in Table 2 shall be determined.

If requested, the relaxation at 1 000 h shall be determined also at initial forces of 60 % and 80 % of the characteristic maximum force (see Table 2). The maximum relaxation values are listed in Table 3.

Table 3 — Maximum relaxation values

Initial force in percentage of the characteristic maximum force	Relaxation class	
	Relax 1	Relax 2
	%	%
60	4,5	1,0
70	8,0	2,5
80	12,0	4,5

7.3.4 Fatigue

If agreed between purchaser and manufacturer, the material shall withstand, without failure, 2 x 10^6 cycles of a stress fluctuating down from a maximum stress of 70 % of the nominal tensile strength. The stress range shall be 200 N/mm² for plain wire and 180 N/mm² for indented and spiral ribbed wire.

In the absence of data use 100 N/mm^2 provisionally as the stress range for crimped wire.

The test requirements shall be in accordance with ISO 15630-3:2019, Clause 10.

7.3.5 Stress corrosion test

If agreed between purchaser and manufacturer, the material shall withstand, without crack, after stress corrosion resistance test at 80 % of the actual tensile strength in solution A, the agreed time shall meet the median value of not less than 5 h, and a single sample should not be less than 2 h, other test requirements shall be in accordance with ISO 15630-3:2019, Clause 11.

8 Designation

The wire shall be ordered in accordance with ISO 6934-1 and be designated as follows.

a) IS0 6934-2;

b) letter referring to treatment:

   M = mill coil wire (see ISO 6934-1)

   S = stress-relieved wire (see ISO 6934-1);

c) letter referring to wire surface (see ISO 6934-1):

   P = plain

   I = indented

   C = crimped

   R = spiral ribbed;

d) nominal diameter, in millimetres;

e) nominal tensile strength, in newtons per square millimetre;

f) relaxation class (Relax 1 or Relax 2).

EXAMPLE Stress-relieved indented wire of nominal diameter 7 mm and nominal strength 1 570 N/mm^2 with class 1 relaxation is designated:

ISO 6934-2-SI-7-1570-Relax 1.

9 Delivery conditions

9.1 General

Delivery conditions shall be in accordance with ISO 6934-1 and the following requirements.

9.2 Coil size

The internal diameter of mill coil wire coils shall be agreed between purchaser and manufacturer.

Stress-relieved wire shall be wound into large diameter coils, in order to avoid a change in mechanical properties and to ensure straightness (see 9.3).

An example of suitable diameters is given in Annex B. The minimum coil diameter shall be not less than 200 times the wire diameter.

9.3 Curvature of stress-relieved wires

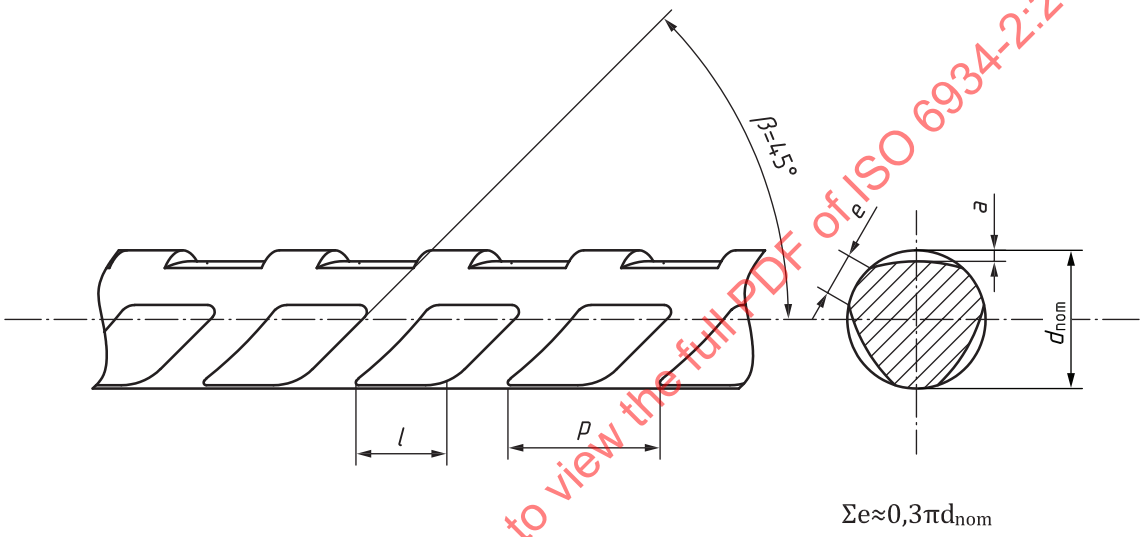
When a length of wire is lying free on a plain surface, the maximum bow height from a baseline 1 m in length, measured from the inside of the curve, shall be not greater than 25 mm for any wire diameter.

Annex A
(informative)

Examples of indentations, crimps and spiral ribs

A.1 Indentations

The following example indicates a widely used arrangement of indentations. The nominal dimensions of the indentations related to nominal wire diameters are as shown in Figure A.1 and Table A.1. Other forms of indentations may be used.



Key

l	length of indentations	*p*	pitch of indentations
e	width of ribs	*a*	depth of indentations

Figure A.1 — Indentations

Table A.1 — Nominal indentation dimensions

Dimensions in millimetres

Nominal wire diameter	Nominal indentation dimensions		
	Depth	Length *l*	Pitch
d_{nom}	a	min.	min.
≤5,0	0,12 ± 0,05	3,5	5,5
>5,0	0,15 ± 0,05	5,0	8,0

A.2 Crimps

The following example indicates two methods of crimping, helical and uni-planar. The total wave height (excluding the wire diameter) and pitch of crimping are shown in Figure A.2 and Table A.2. Other forms of crimping may be used.