BS EN 10270-1:2024

BSI Standards Publication

Steel wire for mechanical springs

Part 1: Patented cold drawn unalloyed spring steel wire

bsi.

National foreword

This British Standard is the UK implementation of EN 10270-1:2024. It supersedes BS EN 10270-1:2011+A1:2017, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/106, Wire Rod and Wire.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Published by BSI Standards Limited 2024

ISBN 978 0 539 22178 7

ICS 77.140.25

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2024.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 10270-1

February 2024

ICS 77.140.25

Supersedes EN 10270-1:2011+A1:2017

English Version

Steel wire for mechanical springs - Part 1: Patented cold drawn unalloyed spring steel wire

Fils en acier pour ressorts mécaniques - Partie 1: Fils pour ressorts en acier non allié, patentés, tréfilés à froid

Stahldraht für Federn - Teil 1: Patentiert gezogener unlegierter Federstahldraht

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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No. EN 10270-1:2024 E

Contents

European foreword

This document (EN 10270-1:2024) has been prepared by Technical Committee CEN/TC 459 “ECISS – European Committee for Iron and Steel Standardization”[1], the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2024 and conflicting national standards shall be withdrawn at the latest by August 2024.

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

This document will supersede EN 10270-1:2011.

In comparison with the previous edition, the following technical modifications have been made:

— 3.1, added specific requirements for Dynamic duty (D);

— 6.7.3, added “Protection Performance class”.

EN 10270, *Steel wire for mechanical springs* is composed of the following parts:

— *Part 1: Patented cold drawn unalloyed spring steel wire*;

— *Part 2: Oil hardened and tempered spring steel wire*.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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[1] Through its sub-committee SC 6 “Wire rod and wires” (secretariat: AFNOR).

1 Scope

This document applies to patented cold drawn unalloyed steel wire of circular cross-section for the manufacture of mechanical springs for static duty and dynamic duty applications.

General technical delivery requirements can be found in EN 10021.

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.

EN 10021, *General technical delivery conditions for steel products*

EN 10204, *Metallic products - Types of inspection documents*

EN 10218-1, *Steel wire and wire products - General - Part 1: Test methods*

EN 10218-2, *Steel wire and wire products - General - Part 2: Wire dimensions and tolerances*

EN 10244-2, *Steel wire and wire products - Non-ferrous metallic coatings on steel wire - Part 2: Zinc or zinc alloy coatings*

CEN/TR 10261, *Iron and steel - European standards for the determination of chemical composition*

EN ISO 377, *Steel and steel products - Location and preparation of samples and test pieces for mechanical testing (ISO 377)*

EN ISO 3887, *Steels - Determination of the depth of decarburization (ISO 3887)*

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

EN ISO 14284, *Steel and iron - Sampling and preparation of samples for the determination of chemical composition (ISO 14284)*

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

EN ISO 16120-2, *Non-alloy steel wire rod for conversion to wire - Part 2: Specific requirements for general purpose wire rod (ISO 16120-2)*

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

3 Terms and definitions

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

ISO and IEC maintain terminology 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
patented cold drawn wire
wire drawn to size by cold deformation of a starting material that has been subjected to a thermal treatment of patenting (see EN ISO 4885), giving structure suitable for subsequent rolling or drawing

Note 1 to entry: For spring with Dynamic duty (D) according to Table 1, the wire is preferable subjected to continuous patenting to achieve a more homogeneous microstructure.

4 Classification

The grade of spring wire used depends on the stress level and the nature of the duty. Where springs are subjected to static stresses or infrequent dynamic loading a wire grade for static duty (S) shall be used. In the other cases with frequent or predominantly dynamic loading and where small coiling ratios or severe bending radius is required, a wire grade for dynamic duty (D) shall be used. Depending on the stress level, spring wire is manufactured in 3 tensile strength grades: low, medium and high.

Table 1 gives an overview of the different grades.

Table 1 — Spring wire grades

Tensile strength [a]	Static	Dynamic
Low tensile strength	SL	—
Medium tensile strength	SM	DM
High tensile strength	SH	DH
[a] For specific applications, another tensile strength may be agreed.		

5 Information to be supplied by the purchaser

The purchaser shall clearly state in his enquiry or order the product and following information:

a) the desired quantity;

b) the term spring steel wire or straightened and cut lengths;

c) the number of this document: EN 10270-1;

d) the steel grade (see Tables 1 and 2);

e) the nominal wire diameter selected from Table 3 and for cut length the length and the length tolerance class (see Table 7);

f) the coating indicated by its abbreviation and surface finish (see 6.3);

g) the form of delivery and unit mass (see 6.2);

h) the type of inspection document (see 7.1);

i) any particular agreement.

EXAMPLE 5 t patented cold drawn tempered spring steel wire according to this standard, grade SM, nominal diameter 2,50 mm, phosphate coated on spools of about 300 kg; inspection certificate type 3.1 according to EN 10204:

5 t spring steel wire EN 10270-1 — SM-2,50 ph on spools of about 300 kg; EN 10204:—, 3.1.

6 Requirements

6.1 Material

6.1.1 General

Steel spring wire shall be made from steel grades according to:

— for SL, SM and SH EN ISO 16120-2;

— for DM and DH EN ISO 16120-4.

For general requirements, EN ISO 16120-1 applies.

6.1.2 Chemical composition

The chemical composition according to the heat analysis shall comply with the limit values shown in Table 2. The permissible deviation of the product analysis from the heat analysis shall be in accordance with EN ISO 16120-2 and EN ISO 16120-4 respectively.

Table 2 — Chemical composition, % by mass

Grade	C[a]	Si	Mn[b]	P	S	Cu
SL, SM, SH	0,35 to 1,00	0,10 to 0,30	0,40 to 1,20	0,035 max.	0,035 max.	0,20 max.
DM, DH	0,45 to 1,00	0,10 to 0,30	0,40 to 1,20	0,020 max.	0,025 max.	0,12 max.
[a] Such a wide range is stipulated to accommodate the whole range of sizes. For individual sizes the carbon range is substantially more restricted.						
[b] For the manganese content, a different range from the one indicated in the table may be agreed at the time of ordering, with a maximum not exceeding 1,20 % and with a minimum range of 0,20 %.						

The addition of micro-alloying elements may be agreed between the manufacturer and the purchaser.

NOTE Some diameter ranges require particular attention for residuals. Therefore, no figures are mentioned for chromium, nickel, molybdenum, tin, etc., leaving room for special arrangements between purchaser and supplier, dependent on their mutual processing conditions. This is also the case for the aluminium content.

6.2 Form of delivery

The wire shall be delivered in unit packages of a coil (singles, carriers or formers), spools, spoolless cores or as straight lengths. Unless otherwise agreed at the time of ordering, the form of delivery will be coils; straight lengths shall be supplied in bundles.

6.3 Coating and surface finish

The spring wire may be supplied phosphate coated (ph) either dry drawn or wet drawn, copper coated (cu), zinc (Z) or zinc/aluminium (ZA) coated.

Other coatings, considered as special, can be agreed between the purchaser and the supplier (see Annex A).

If no specific surface finish is specified, the type of finish shall be at the manufacturer's discretion.

In addition, the wire can be ordered with an oiled surface for all surface finishes.

6.4 Mechanical properties

For the tensile strength (R_m) and reduction in area after fracture (Z), the wire grades shall satisfy the values listed in Table 3. Reduction of area shall be measured only for wire diameter 0,80 mm < d.

The range of tensile strength values within a unit package shall not exceed the values of Table 4.

Table 3 — Mechanical properties [a] and quality requirements for wire grades SL, SM, DM, SH and DH

1	2	3	4	5	6	7	8	9	10	11	12
Wire diameter *d*		**Tensile strength R_m [b c d]**					**Minimum reduction in area after fracture *Z* for wire grades SL, SM, SH, DM and DH**	**Minimum number of twists in the torsion test N_t for wire grades SL, SM, SH, DM and DH [c]**	**Permissible depth of surface defects for wire grades DM, DH**	**Permissible decarburization depth for wire grades DM, DH**	**Mass [h] kg/1 000 m**
		For wire grades									
Nominal size	**Permissible deviations**	**SL**	**SM**	**DM**	**SH**	**DH [e]**					
mm	mm	MPa	MPa	MPa	MPa	MPa	%		mm	mm	
d = 0,05						2 800 to 3 520					0,015 4
0,05 < d ≤ 0,06						2 800 to 3 520					0,022 2
0,06 < d ≤ 0,07	±0,003					2 800 to 3 520					0,030 2
0,07 < d ≤ 0,08						2 800 to 3 480					0,039 5
0,08 < d ≤ 0,09						2 800 to 3 430					0,049 9
0,09 < d ≤ 0,10						2 800 to 3 380					0,061 7
0,10 < d ≤ 0,11						2 800 to 3 350					0,074 6
0,11 < d ≤ 0,12	±0,004					2 800 to 3 320		coiling test			0,088 8
0,12 < d ≤ 0,14						2 800 to 3 250		as specified in	- [f]	- [f]	0,121
0,14 < d ≤ 0,16						2 800 to 3 200		7.4.3			0,158

1	2	3	4	5	6	7	8	9	10	11	12
0,16 < *d* ≤ 0,18	±0,005					2 800 to 3 160					0,200
0,18 < *d* ≤ 0,20						2 800 to 3 110					0,247
0,20 < *d* ≤ 0,22						2 770 to 3 080					0,298
0,22 < *d* ≤ 0,25						2 720 to 3 010					0,385
0,25 < *d* ≤ 0,28	±0,008					2 680 to 2 970					0,488
0,28 < *d* ≤ 0,30			2 370 to 2 650	2 370 to 2 650	2 660 to 2 940	2 660 to 2 940					0,555
0,30 < *d* ≤ 0,32			2 350 to 2 630	2 350 to 2 630	2 640 to 2 920	2 640 to 2 920					0,631
0,32 < *d* ≤ 0,34			2 330 to 2 600	2 330 to 2 600	2 610 to 2 890	2 610 to 2 890					0,713
0,34 < *d* ≤ 0,36			2 310 to 2 580	2 310 to 2 580	2 590 to 2 870	2 590 to 2 870					0,799
0,36 < *d* ≤ 0,38			2 290 to 2 560	2 290 to 2 560	2 570 to 2 850	2 570 to 2 850					0,890
0,38 < *d* ≤ 0,40			2 270 to 2 550	2 270 to 2 550	2 560 to 2 830	2 560 to 2 830					0,985
0,40 < *d* ≤ 0,43			2 250 to 2 520	2 250 to 2 520	2 530 to 2 800	2 530 to 2 800					1,14
0,43 < *d* ≤ 0,45			2 240 to 2 500	2 240 to 2 500	2 510 to 2 780	2 510 to 2 780		coiling test			1,25
0,45 < *d* ≤ 0,48			2 220 to 2 480	2 220 to 2 480	2 490 to 2 760	2 490 to 2 760		as specified in	- [f]	- [f]	1,42
0,48 < *d* ≤ 0,50	±0,008		2 200 to 2 470	2 200 to 2 470	2 480 to 2 740	2 480 to 2 740		7.4.3			1,54

1	2	3	4	5	6	7	8	9	10	11	12
0,50 < *d* ≤ 0,53			2 180 to 2 450	2 180 to 2 450	2 460 to 2 720	2 460 to 2 720					1,73
0,53 < *d* ≤ 0,56			2 170 to 2 430	2 170 to 2 430	2 440 to 2 700	2 440 to 2 700					1,93
0,56 < *d* ≤ 0,60			2 140 to 2 400	2 140 to 2 400	2 410 to 2 670	2 410 to 2 670					2,22
0,60 < *d* ≤ 0,63			2 130 to 2 380	2 130 to 2 380	2 390 to 2 650	2 390 to 2 650					2,45
0,63 < *d* ≤ 0,65			2 120 to 2 370	2 120 to 2 370	2 380 to 2 640	2 380 to 2 640					2,60
0,65 < *d* ≤ 0,70	±0,010		2 090 to 2 350	2 090 to 2 350	2 360 to 2 610	2 360 to 2 610					3,02
0,70 < *d* ≤ 0,75			2 070 to 2 320	2 070 to 2 320	2 330 to 2 580	2 330 to 2 580					3,47
0,75 < *d* ≤ 0,80			2 050 to 2 300	2 050 to 2 300	2 310 to 2 560	2 310 to 2 560					3,95
0,80 < *d* ≤ 0,85	±0,015		2 030 to 2 280	2 030 to 2 280	2 290 to 2 530	2 290 to 2 530					4,45
0,85 < *d* ≤ 0,90			2 010 to 2 260	2 010 to 2 260	2 270 to 2 510	2 270 to 2 510					4,99
0,90 < *d* ≤ 0,95			2 000 to 2 240	2 000 to 2 240	2 250 to 2 490	2 250 to 2 490					5,59
0,95 < *d* ≤ 1,00		1 720 to 1 970	1 980 to 2 220	1 980 to 2 220	2 230 to 2 470	2 230 to 2 470					6,17
1,00 < *d* ≤ 1,05		1 710 to 1 950	1 960 to 2 200	1 960 to 2 200	2 210 to 2 450	2 210 to 2 450					6,80
1,05 < *d* ≤ 1,10	±0,020	1 690 to 1 940	1 950 to 2 190	1 950 to 2 190	2 200 to 2 430	2 200 to 2 430	40	25	1 % max. of wire diameter	1,5 % max. of wire diameter	7,46
1,10 < *d* ≤ 1,20		1 670 to 1 910	1 920 to 2 160	1 920 to 2 160	2 170 to 2 400	2 170 to 2 400					8,88

1	2	3	4	5	6	7	8	9	10	11	12
1,20 < *d* ≤ 1,25	±0,020	1 660 to 1 900	1 910 to 2 140	1 910 to 2 140	2 150 to 2 380	2 150 to 2 380	40	25	1 % max. of wire diameter	1,5 % max. of wire diameter	9,63
1,25 < *d* ≤ 1,30		1 640 to 1 890	1 900 to 2 130	1 900 to 2 130	2 140 to 2 370	2 140 to 2 370					10,42
1,30 < *d* ≤ 1,40		1 620 to 1 860	1 870 to 2 100	1 870 to 2 100	2 110 to 2 340	2 110 to 2 340					12,08
1,40 < *d* ≤ 1,50		1 600 to 1 840	1 850 to 2 080	1 850 to 2 080	2 090 to 2 310	2 090 to 2 310		22			13,90
1,50 < *d* ≤ 1,60		1 590 to 1 820	1 830 to 2 050	1 830 to 2 050	2 060 to 2 290	2 060 to 2 290					15,8
1,60 < *d* ≤ 1,70		1 570 to 1 800	1 810 to 2 030	1 810 to 2 030	2 040 to 2 260	2 040 to 2 260					17,8
1,70 < *d* ≤ 1,80	±0,025	1 550 to 1 780	1 790 to 2 010	1 790 to 2 010	2 020 to 2 240	2 020 to 2 240					20,0
1,80 < *d* ≤ 1,90		1 540 to 1 760	1 770 to 1 990	1 770 to 1 990	2 000 to 2 220	2 000 to 2 220					22,3
1,90 < *d* ≤ 2,00		1 520 to 1 750	1 760 to 1 970	1 760 to 1 970	1 980 to 2 200	1 980 to 2 200					24,7
2,00 < *d* ≤ 2,10		1 510 to 1 730	1 740 to 1 960	1 740 to 1 960	1 970 to 2 180	1 970 to 2 180					27,2
2,10 < *d* ≤ 2,25		1 490 to 1 710	1 720 to 1 930	1 720 to 1 930	1 940 to 2 150	1 940 to 2 150					31,2
2,25 < *d* ≤ 2,40		1 470 to 1 690	1 700 to 1 910	1 700 to 1 910	1 920 to 2 130	1 920 to 2 130					35,5
2,40 < *d* ≤ 2,50		1 460 to 1 680	1 690 to 1 890	1 690 to 1 890	1 900 to 2 110	1 900 to 2 110					38,5
2,50 < *d* ≤ 2,60		1 450 to 1 660	1 670 to 1 880	1 670 to 1 880	1 890 to 2 100	1 890 to 2 100					41,7

1	2	3	4	5	6	7	8	9	10	11	12
2,60 < *d* ≤ 2,80	±0,030	1 420 to 1 640	1 650 to 1 850	1 650 to 1 850	1 860 to 2 070	1 860 to 2 070	35	16	1 % max. of wire diameter	1,5 % max. of wire diameter	48,3
2,80 < *d* ≤ 3,00		1 410 to 1 620	1 630 to 1 830	1 630 to 1 830	1 840 to 2 040	1 840 to 2 040					55,5
3,00 < *d* ≤ 3,20		1 390 to 1 600	1 610 to 1 810	1 610 to 1 810	1 820 to 2 020	1 820 to 2 020					63,1
3,20 < *d* ≤ 3,40		1 370 to 1 580	1 590 to 1 780	1 590 to 1 780	1 790 to 1 990	1 790 to 1 990					71,3
3,40 < *d* ≤ 3,60		1 350 to 1 560	1 570 to 1 760	1 570 to 1 760	1 770 to 1 970	1 770 to 1 970					79,9
3,60 < *d* ≤ 3,80		1 340 to 1 540	1 550 to 1 740	1 550 to 1 740	1 750 to 1 950	1 750 to 1 950					89,0
3,80 < *d* ≤ 4,00	±0,030	1 320 to 1 520	1 530 to 1 730	1 530 to 1 730	1 740 to 1 930	1 740 to 1 930					98,6
4,00 < *d* ≤ 4,25	±0,035	1 310 to 1 500	1 510 to 1 700	1 510 to 1 700	1 710 to 1 900	1 710 to 1 900		16			111
4,25 < *d* ≤ 4,50		1 290 to 1 490	1 500 to 1 680	1 500 to 1 680	1 690 to 1 880	1 690 to 1 880		12			125
4,50 < *d* ≤ 4,75		1 270 to 1 470	1 480 to 1 670	1 480 to 1 670	1 680 to 1 860	1 680 to 1 860					139
4,75 < *d* ≤ 5,00		1 260 to 1 450	1 460 to 1 650	1 460 to 1 650	1 660 to 1 840	1 660 to 1 840					154
5,00 < *d* ≤ 5,30		1 240 to 1 430	1 440 to 1 630	1 440 to 1 630	1 640 to 1 820	1 640 to 1 820		11			173
5,30 < *d* ≤ 5,60		1 230 to 1 420	1 430 to 1 610	1 430 to 1 610	1 620 to 1 800	1 620 to 1 800		11			193
5,60 < *d* ≤ 6,00		1 210 to 1 390	1 400 to 1 580	1 400 to 1 580	1 590 to 1 770	1 590 to 1 770		10			222

1	2	3	4	5	6	7	8	9	10	11	12
6,00 < *d* ≤ 6,30	±0,040	1 190 to 1 380	1 390 to 1 560	1 390 to 1 560	1 570 to 1 750	1 570 to 1 750		9			245
6,30 < *d* ≤ 6,50		1 180 to 1 370	1 380 to 1 550	1 380 to 1 550	1 560 to 1 740	1 560 to 1 740		9			260
6,50 < *d* ≤ 7,00		1 160 to 1 340	1 350 to 1 530	1 350 to 1 530	1 540 to 1 710	1 540 to 1 710		9			302
7,00 < *d* ≤ 7,50	±0,045	1 140 to 1 320	1 330 to 1 500	1 330 to 1 500	1 510 to 1 680	1 510 to 1 680	30	7 [g]			347
7,50 < *d* ≤ 8,00		1 120 to 1 300	1 310 to 1 480	1 310 to 1 480	1 490 to 1 660	1 490 to 1 660		7 [g]			395
8,00 < *d* ≤ 8,50		1 110 to 1 280	1 290 to 1 460	1 290 to 1 460	1 470 to 1 630	1 470 to 1 630		6 [g]			445
8,50 < *d* ≤ 9,00		1 090 to 1 260	1 270 to 1 440	1 270 to 1 440	1 450 to 1 610	1 450 to 1 610		6 [g]			499
9,00 < *d* ≤ 9,50	±0,050	1 070 to 1 250	1 260 to 1 420	1 260 to 1 420	1 430 to 1 590	1 430 to 1 590		5 [g]			559
9,50 < *d* ≤ 10,00		1 060 to 1 230	1 240 to 1 400	1 240 to 1 400	1 410 to 1 570	1 410 to 1 570		5 [g]			617
10,00 < *d* ≤ 10,50	±0,070	-	1 220 to 1 380	1 220 to 1 380	1 390 to 1 550	1 390 to 1 550		-			680
10,50 < *d* ≤ 11,00			1 210 to 1 370	1 210 to 1 370	1 380 to 1 530	1 380 to 1 530					746
11,00 < *d* ≤ 12,00	±0,080		1 180 to 1 340	1 180 to 1 340	1 350 to 1 500	1 350 to 1 500					888

1	2	3	4	5	6	7	8	9	10	11	12
12,00 < *d* ≤ 12,50	±0,080	-	1 170 to 1 320	1 170 to 1 320	1 330 to 1 480	1 330 to 1 480	28	-	1 % max. of wire diameter	1,5 % max. of wire diameter	963
12,50 < *d* ≤ 13,00			1 160 to 1 310	1 160 to 1 310	1 320 to 1 470	1 320 to 1 470					1 042
13,00 < *d* ≤ 14,00			1 130 to 1 280	1 130 to 1 280	1 290 to 1 440	1 290 to 1 440					1 208
14,00 < *d* ≤ 15,00	±0,090		1 110 to 1 260	1 110 to 1 260	1 270 to 1 410	1 270 to 1 410					1 387
15,00 < *d* ≤ 16,00			1 090 to 1 230	1 090 to 1 230	1 240 to 1 390	1 240 to 1 390					1 578
16,00 < *d* ≤ 17,00			1 070 to 1 210	1 070 to 1 210	1 220 to 1 360	1 220 to 1 360					1 782
17,00 < *d* ≤ 18,00			1 050 to 1 190	1 050 to 1 190	1 200 to 1 340	1 200 to 1 340					1 998
18,00 < *d* ≤ 19,00	±0,100		1 030 to 1 170	1 030 to 1 170	1 180 to 1 320	1 180 to 1 320					2 225
19,00 < *d* ≤ 20,00			1 020 to 1 150	1 020 to 1 150	1 160 to 1 300	1 160 to 1 300					2 466

[a] Wire with diameter 20 mm < *d* diameter is used. Where such wire is specified, the parties shall agree upon the properties and requirements at the time of enquiry and order.

[b] For sizes not mentioned, the required strength shall be derived from the mathematical formulae given in A.4.

[c] For straightened and cut lengths, the tensile strength values may be up to 10 % lower, torsion values are also lowered by the straightening and cutting operation.

[d] 1 MPa = 1 N/mm^2.

[e] For diameters 0,05 mm ≤ *d* ≤ 0,18 mm, a restricted tensile strength range of 300 MPa within the specified range may be agreed.

[f] Because of the small wire diameter, measurement of the depth of defects or depth of decarburization can only be carried out with difficulty. For this reason, no maximum value is specified for this diameter range.

[g] Guideline values; not mandatory for acceptance.

[h] Mass values are valid only for the upper limit of the diameter range. Mass values for interim diameter values can be calculated according to the following formula: m = d^2 x 0,062 kg / (1 000 m x mm^2).

Table 4 — Permissible tensile strength range within a single unit package in MPa

Nominal diameter *d* mm	SL, SM, SH	DM, DH
$d \leq 0{,}80$	150	150
$0{,}80 < d \leq 1{,}60$	120	100
$1{,}60 < d$	120	70

The requirements apply to unit packages, the mass of which in kilograms does not exceed the value of 250 x *d* (*d* = wire diameter in mm) or a maximum value of 1 000 kg.

In cases of coils of greater mass, appropriate agreements shall be made.

6.5 Technological properties

6.5.1 Coiling test

In order to assess the uniformity of the wire in the coiling deformation and its surface condition, the coiling test shall be carried out on wire with a diameter $d \leq 0{,}70$ mm for the grades DM, SH and DH.

In the test as described further in 7.4.3, the test piece shall exhibit a defect-free surface without splits or fracture, a uniform pitch of the turns after coiling and a fair dimensional regularity of its diameter.

Although the usefulness of the coiling test is not generally recognized, it has been retained since it offers the possibility of revealing internal stresses. If doubtful test results are obtained, the wire concerned should not be rejected immediately, but efforts should be made by the parties concerned to elucidate the cause.

6.5.2 Simple torsion test

For assessing the deformability, fracture behaviour and surface condition, the torsion test shall be carried out for all wire grades on wires in the nominal diameter range 0,70 mm < $d \leq$ 10,00 mm. The minimum number of turns specified in Table 3 for diameters $d \leq 7{,}00$ mm is mandatory. For wires exceeding this size, they shall be taken only as indicative values.

In executing the test according to 7.4.5, the required number of turns shall be achieved before the test piece fractures. The fracture of the torsion test piece shall be perpendicular to the wire axis (see EN 10218-1: Types 1a, 2a or 3a).

Spring back resilience cracks or spring back fractures (“spoon” or “secondary” fractures) are not considered in the evaluation. In each case, a uniform distortion of both fragments shall be present although the pitch of the turns need not be the same in the two parts. In the case of grade DH, no surface cracks visible to the naked eye shall be present after the torsion test (only type “1a” fracture is acceptable).

6.5.3 Wrapping test

The wrapping test may be applied (see 7.4.4) to wire with a diameter $d \leq 3{,}00$ mm. The wire shall not show sign of fracture when close wrapped eight turns around a mandrel of a diameter equal to that of the wire.

6.5.4 Simple bend test

Where requested, the bend test may be applied to wire with a diameter 3,00 mm < *d*. The wire shall withstand the test without any sign of failure.

NOTE In some applications, the material is severely deformed by bending. Such is the case for extension springs with tight hooks, springs with bend on legs, spring wire forms, etc. In such cases, the bend test provides for a wire test very close to the actual use.

6.6 Supply conditions of wire on coils/reels and spools

6.6.1 General

The wire of a unit package shall consist of one single length of wire originating from only one heat. For grades DM and DH only, the welds prior to the last patenting operation are allowed; all other welds shall be removed, or if so agreed upon - properly marked.

For the wire grades SL/SM/SH, welds are allowed at the size of the last patenting treatment. For other welds, the treatment of the welds shall be subject to an arrangement between the parties involved, depending on wire diameter and application.

6.6.2 Coil size

The coil internal diameter of coils shall at least satisfy the values given in Table 5, unless otherwise agreed.

Table 5 — Wire diameter and associated minimum coil internal diameter

Nominal diameter d [a] mm	Minimum internal diameter mm
$0,25 < d \leq 0,28$	100
$0,28 < d \leq 0,50$	150
$0,50 < d \leq 0,70$	180
$0,70 < d \leq 1,60$	250
$1,60 < d \leq 4,50$	400
$4,50 < d$	500
[a] For wire diameter $d \leq 0,25$ mm, specific agreements shall be made between the parties at time of enquiry or order.	

6.6.3 Cast of wire

The wire shall be uniformly cast. Unless otherwise specified, the wap diameter of wire supplied in coils/reels may expand when the binding wires are removed, but should usually not retract to an internal diameter smaller than the original cast diameter other than by agreement between supplier and purchaser. The expansion shall be approximately even within a single package and within all the units in a production batch.

6.6.4 Helix cast of wire

The wire shall be dead cast. The requirement shall be considered fulfilled in the case of wire diameter $d \leq 5,00$ mm in diameter if the following condition is satisfied:

An individual wap taken from a coil/reel or bobbin and freely hung on hook may show an axial displacement "f_a" at the ends of the wap (see Figure 1); this displacement "f_a" shall not exceed a value given by the following formula:

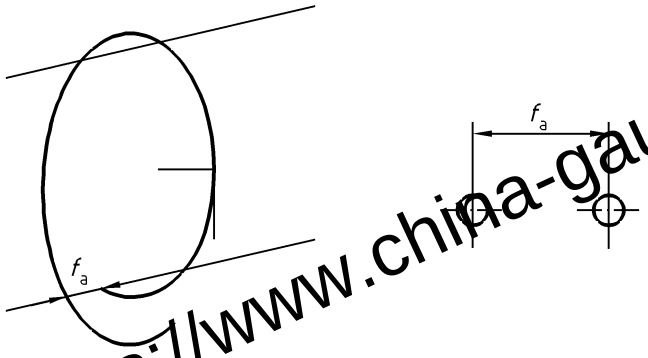
$$f_\alpha \leq \frac{0,2\,W}{\sqrt[4]{d}}$$

where

f_a is the axial displacement, in mm;

W is the diameter of a free wap, in mm;

d is the diameter of the wire, in mm.



Key
f_a is the axial displacement in mm

Figure 1 — Helix cast of wire

6.6.5 Other tests for cast of wire

Where appropriate, other methods for testing the cast, as specified in EN 10218-1, may be agreed at the time of enquiry and order.

6.7 Surface quality

6.7.1 The surface of the wire shall be smooth and as free as possible from grooves, tears, rust and other surface defects, which have a noticeable adverse effect on the application of the wire.

6.7.2 Surface quality tests (see 7.4.7 and 7.4.8) shall be applied to wires intended for use in dynamic duty springs only (DM and DH). Such tests shall be done in accordance with EN 10218-1.

— The radial depth of the seams or other surface defects shall be not greater than 1 % of the nominal diameter of the wire;

— the cross-section of spring wire grades DM and DH shall show no completely decarburized layer. Partial decarburization as indicated by grain boundary ferrite of an amount in excess of that present in the main portion or “core” of the section, shall not have a radial depth greater than 1,5 % of the nominal diameter of the wire.

6.7.3 In the case of zinc or zinc/aluminium coated spring wire, the amount of zinc or zinc/aluminium on the wire surface shall satisfy the minimum values specified in Table 6.

Other levels may be agreed between supplier and purchaser (see footnote [b] in Table 6). The adherence of the coating shall be tested by a wrapping test (see 7.4.11) according to EN 10244-2. Reference values for corrosion resistance that the wire may have are specified in Annex B, Table B.1.

NOTE The usual coating processes can alter the properties of the steel wire. The ductility and endurance of the wire can thereby be reduced so that one cannot guarantee for zinc coated spring steel wire the same torsion values or expect the same dynamic performance (DM and DH) as for the respective uncoated material.

Table 6 — Minimum required zinc or zinc/aluminium coating mass

Nominal diameter *d* mm	Minimum coating mass [a, b] g/m²
0,20 ≤ *d* < 0,25	20
0,25 ≤ *d* < 0,40	25
0,40 ≤ *d* < 0,50	30
0,50 ≤ *d* < 0,60	35
0,60 ≤ *d* < 0,70	40
0,70 ≤ *d* < 0,80	45
0,80 ≤ *d* < 0,90	50
0,90 ≤ *d* < 1,00	55
1,00 ≤ *d* < 1,20	60
1,20 ≤ *d* < 1,40	65
1,40 ≤ *d* < 1,65	70
1,65 ≤ *d* < 1,85	75
1,85 ≤ *d* < 2,15	80
2,15 ≤ *d* < 2,50	85
2,50 ≤ *d* < 2,80	95
2,80 ≤ *d* < 3,20	100
3,20 ≤ *d* < 3,80	105
3,80 ≤ *d* ≤ 10,00	110

[a] The requirements for the zinc coating correspond to class C of EN 10244-2.

[b] In cases when different coating weights are required, preference will be given to referring to coating weights as defined in EN 10244-2 (example: class D of EN 10244-2).

6.8 Dimensions and dimensional tolerances

6.8.1 Dimensional tolerances

a) Coiled wire:

The tolerances on diameter shall fulfil the requirements specified in Table 3 and are in accordance with EN 10218-2.

1) T5 for diameters $d \leq 0{,}80$ mm;

2) T4 for diameters 0,80 mm < $d \leq 10{,}00$ mm;

3) T3 for diameters 10,00 mm < d.

Where the required tolerance level is different from that mentioned in Table 3, it shall be agreed at the time of order.

b) Wire in straightened and cut lengths.

The requirements for length tolerances and straightness are as specified in EN 10218-2. The tolerance on the nominal length shall only be in plus keeping the same tolerance range (see Table 7).

Table 7 — Tolerances on the length of cut lengths

Nominal length *L* mm	Tolerance		
	Class 1	Class 2	Class 3
$L \leq 300$	$^{+1,0}_{0}$ mm	$^{+1,0}_{0}$ %	$^{+2,0}_{0}$ %
$300 < L \leq 1\,000$	$^{+2,0}_{0}$ mm		
$1\,000 < L$	$^{+0,2}_{0}$ %		

The tolerance for the diameter of the wire after straightening needs to be wider to cope with the increase of the section as a result of some straightening process. The acceptable level is shown in Table 8.

Table 8 — Diameter tolerance for straightened and cut lengths

Nominal diameter *d* mm	Tolerance mm	
	Lower tolerance	Upper tolerance
$0,05 \leq d < 0,12$	-0,005	+0,007
$0,12 \leq d < 0,22$	-0,005	+0,008
$0,22 \leq d < 0,26$	-0,005	+0,009
$0,26 \leq d < 0,37$	-0,006	+0,012
$0,37 \leq d < 0,47$	-0,008	+0,015
$0,47 \leq d < 0,65$	-0,008	+0,018
$0,65 \leq d < 0,80$	-0,010	+0,022
$0,80 \leq d < 1,01$	-0,015	+0,030
$1,01 \leq d < 1,35$	-0,020	+0,040
$1,35 \leq d < 1,78$	-0,020	+0,045
$1,78 \leq d < 2,01$	-0,025	+0,055
$2,01 \leq d < 2,35$	-0,025	+0,060
$2,35 \leq d < 2,78$	-0,025	+0,065
$2,78 \leq d < 3,01$	-0,030	+0,075
$3,01 \leq d < 3,35$	-0,030	+0,080
$3,35 \leq d < 4,01$	-0,030	+0,090
$4,01 \leq d < 4,35$	-0,035	+0,100
$4,35 \leq d < 5,01$	-0,035	+0,110
$5,01 \leq d < 5,45$	-0,035	+0,120
$5,45 \leq d < 6,01$	-0,040	+0,130

Nominal diameter *d* mm	Tolerance mm	
	Lower tolerance	Upper tolerance
6,01 ≤ *d* < 7,12	-0,040	+0,150
7,12 ≤ *d* < 7,67	-0,045	+0,160
7,67 ≤ *d* < 9,01	-0,045	+0,180
9,01 ≤ *d* < 10,01	-0,050	+0,200
10,01 ≤ *d* < 11,12	-0,070	+0,240
11,12 ≤ *d* < 12,01	-0,080	+0,260
12,01 ≤ *d* < 14,52	-0,080	+0,300
14,52 ≤ *d* < 17,34	-0,090	+0,350
17,34 ≤ *d* < 18,37	-0,090	+0,370
18,37 ≤ *d* < 20,01	-0,100	+0,400

6.8.2 Out of roundness

The difference between the maximum and minimum diameter of the wire at the same cross section shall not be more than 50 % of the total permissible deviation specified in Table 3.

7 Testing and inspection

7.1 Inspection and inspection documents

Products conforming to this standard shall be delivered with specific testing according to EN 10021 and the relevant inspection document according to EN 10204, agreed at the time of enquiry and order.

The inspection document shall include the following information:

— heat analysis;

— result of the tensile test (R_m and Z);

— result of the torsion test (N_t);

— actual wire diameter;

— coating mass (where applicable);

— results of optional tests agreed.

7.2 Extent of testing for specific inspection

The extent of testing shall be in accordance with Table 10.

7.3 Sampling

Sampling and testing preparation shall be in accordance with EN ISO 377 and EN ISO 14284. Samples shall be taken at the end of the units. Table 10/column 8 gives further details.

7.4 Test methods

7.4.1 Chemical composition

Unless otherwise agreed at the time of ordering, the choice of a suitable physical or chemical method of analysis for the determination of product analysis shall be at the discretion of the supplier.

In cases of dispute, the analysis shall be carried out by a laboratory approved by the two parties. The method of analysis to be applied shall be agreed upon, where possible in accordance with CEN/TR 10261.

7.4.2 Tensile test

The tensile test at room temperature shall be carried out according to EN ISO 6892-1, on samples with the full cross-section of the wire. For the calculation of the tensile strength, the actual cross-section based on the actual wire diameter is applied.

7.4.3 Coiling test

The coiling test shall be carried out in the following manner: A test piece — approximately 500 mm in length — shall be closely wound, under slight but reasonably uniform tension on a mandrel three to three and a half times the nominal diameter. The mandrel diameter shall however be at least 1,00 mm. The close coil shall be stretched so that after releasing the stress it sets to approximately three times its original length.

The surface condition of the wire and the regularity of the spring pitch and individual windings shall be inspected with the test piece in this condition.

7.4.4 Wrapping test

The wrapping test shall be carried out according to EN 10218-1; the wire shall be wrapped 8 turns around a mandrel with a diameter equal to the wire diameter.

7.4.5 Simple torsion test

For the torsion test, the test piece shall be clamped into the device in such manner that its longitudinal axis is aligned to the axis of the clamping heads and the test piece remains straight during the test. One clamping head shall be turned at as uniform a speed of rotation as possible until the test piece fractures. Rotating speed shall be as specified in EN 10218-1 (as a function of wire diameter). The number of complete rotations of the turning clamping head is counted. The free length between grips shall be uniformly 100 x d (d = nominal diameter of the wire) with a maximum of 300 mm.

7.4.6 Simple bend test

For the bend test, a wire sample of sufficient length shall be bent in U form around a mandrel with a diameter equal to twice the wire diameter 3,00 mm < d ≤ 6,50 mm and equal to three times the wire diameter 6,50 mm < d. For practical reasons, the wire shall be deemed to have met the requirements of this standard if it withstands bending around a mandrel smaller than the one specified. In carrying out the test, the wire shall be free to move longitudinally in the forming device.

7.4.7 Surface defects

Testing for surface defects shall be carried out on test pieces from the ends of the wire units after deep etching or on micro sections. It may be agreed for wire diameter d ≤ 2,00 mm at the time of order, that microscopic testing be carried out immediately after the last heat treatment.

The deep etch test shall be carried out according to EN 10218-1.

In cases where the sensitivity of eddy current testing is adequate, this method may be used by agreement.

In cases of dispute, the result of measurement on the micro section applies.

7.4.8 Decarburization

Decarburization shall be inspected by microscope in accordance with EN ISO 3887 on a transverse metallographic test piece, suitably etched with a magnification of x 200. The depth of decarburization is considered as being the mean of 8 measurements at the ends of four diameters located at 45° to each other, starting from the zone of maximum decarburization and avoid starting from a defective zone. In the calculation of the above mean value, any measuring point of the seven remaining situated in a local surface defect shall not be taken into account in the calculation.

It may be agreed for wire diameter $d \leq 2{,}00$ mm at the time of ordering that testing be carried out immediately after the last heat treatment.

7.4.9 Diameter

The diameter shall be measured using limit gauges, a micrometer or any other appropriate method. The out of roundness shall be determined as the difference between the maximum and minimum diameters at any one cross-section. For wire diameter $d \leq 0{,}65$ mm the relative value of individual measurement (see A.3) shall be taken into consideration because the measurements are situated at the limit of the technical capability for the instruments.

7.4.10 Zinc and zinc/aluminium coating

The zinc or zinc/aluminium coating shall be measured according to EN 10244-2 by the volumetric method or the gravimetric method.

7.4.11 Adherence of coating

Adherence of zinc or zinc/aluminium coating mass shall be tested for wire diameter $d \leq 5{,}00$ mm in accordance with EN 10244-2 by a wrapping test on a mandrel of $3 \times d$.

7.5 Retests

Retests shall be performed according to EN 10021.

8 Marking and packaging

Each unit shall be properly marked and identified so as to permit traceability and reference to the inspection documents.

The labels shall withstand normal handling and contact with oil; they shall show the information according to Table 9. Other information shall be the subject of an arrangement between the parties.

Wire shipments shall be suitably protected against mechanical damage and/or contamination during transport.

Table 9 — Information on the labels [a]

Designation	+
Manufacturer	+
Nominal diameter	+
Spring wire grade	+
Surface finish	(+)
Heat number	(+)
Identification number	+
Coating	(+)

[a] The symbols in the table mean:
+ The information shall be mentioned on the labels.
(+) The information shall be mentioned on the labels if so agreed.

Table 10 — Extent of testing and sampling for specific inspection and summary of the information on test procedure and requirements

	1	2	3	4	5	6	7	8	9	10
	Test method	**Applies to**	**Mandatory /optional[a]**	**Test unit**	**Number of products per test unit**	**Number of samples per product**	**Number of test pieces per sample**	**Sampling**	**Test procedure according to**	**Requirements see ...**
1	Product analysis	All grades All diameters	o[b]	Quantity supplied per heat	1	1	1	EN ISO 14284	7.4.1	6.1.2
2	Tensile test R_m	All grades All diameters	m	Quantity supplied per production batch[d]	10 %[c]	1	1	Test pieces taken from the ends of the coils	7.4.2	6.4
2a	Reduction of area Z	All grades 0,80 mm < d	m							
3	Coiling test	DM, SH, DH $d \leq 0{,}70$ mm	o		The scope of testing shall be agreed on ordering				7.4.3	6.5.1
3a	Wrapping test	All grades $d \leq 3$ mm	o						7.4.4	6.5.3
3b	Bend test	All grades 3 mm < d	o						7.4.6	6.5.4
4	Torsion test	All grades 0,70 mm < $d \leq 10$ mm	m		10 %[c]	1	1		7.4.5	6.5.2
5	Wire cast characteristics	All grades All diameters	m						6.6.3	6.6.3
5a	Helix wire cast characteristics	All grades $d \leq 5$ mm	m						6.6.4	6.6.4

	1	2	3	4	5	6	7	8	9	10
	Test method	**Applies to**	**Mandatory /optional[a]**	**Test unit**	**Number of products per test unit**	**Number of samples per product**	**Number of test pieces per sample**	**Sampling**	**Test procedure according to**	**Requirements see ...**
6	Testing for surface defects	DM, DH All diameters	m						7.4.7	6.7
7	Testing for decarburization	DM, DH All diameters	m						7.4.8	6.7.2
8	Check on dimensions	All grades All diameters	m		100 %				7.4.9	6.8
9	Testing of coating mass	Z and ZA All diameters	m		Number to be agreed at the order				7.4.10	6.7.3
9a	Coating adherence	Z and ZA $d \leq 5$ mm	m		10 %[c]	1	1		7.4.11	6.7.3

[a] m (= mandatory): the test shall be carried out in each case / o (= optional): the test is carried out only if so agreed at the order.

[b] The results of the cast analysis for the elements listed in Table 1 for the grade concerned shall be notified to the customer in all cases.

[c] 10 % of the wire units in the production batch, at least 2 but no more than 10 coils/reels or spools.

[d] A production batch is defined as a quantity of production originating from the same cast, which has been subjected to the same conditions of heat treatment, and drawn with the same reduction in cross-section and with the same surface finish.

Annex A
(informative)

Additional information

A.1 Definition of surface condition of the wire

A.1.1 Drawing condition

All cold drawn spring wire is commonly shaped by drawing. A distinction as to the method of drawing can be made between:

— dry drawn (d): drawn through pulverized lubricants such as soap, stearates or similar substances;

— paste drawn (ps): drawn through very viscous greases of mineral oil base, tallow, synthetic waxes or similar substances;

— grey bright (gr): drawn through rape oil, thin-bodied mineral oils or similar substances;

— wet drawn (w): drawn through aqueous emulsions of greases or oil emulsions;

— liquor finished (l): drawn through aqueous solutions with or without addition of metal salts.

A.1.2 Surface treatment

The surface for spring wire generally has a coating for facilitating wire drawing and spring forming. Exceptionally the material is uncoated. Common surface coatings are:

— bright (b): without any special coating: standard borax coating or lime-coating may be applied;

— phosphate coated (ph): the wire has been treated in a solution to form a metal-phosphate layer on the surface;

— reddish (rd): the surface is covered with a thin copper, generally a conversion coating;

— copper plated (cu): the surface is covered with a (uniform) thick copper coating;

— galvanized (Z): the surface is covered with a zinc coating;

— zinc/aluminium coated (ZA): the surface is covered with a Zn/Al coating, if no coating composition is specified between the costumer and the supplier a Zn95/Al5 coating is used;

— yellow coated (y): this applies only to liquor finished products whereby a mixture of tin salts and copper salts are added at the liquor finishing;

— white (liquor finished) (wh): this applies to liquor finished products whereby tin salts are added for liquor finishing.

A.1.3 Abbreviations

— When no particular drawing condition is required, abbreviations for the surface coating only is used (see A.1.2) by adding it to the wire size.

EXAMPLE 1 2,5 mm phosphate coated spring wire: 2,5 ph.

Depending on the size, the wire is in the dry drawn (d) or wet drawn (w) condition.

— For other drawing conditions or when the purchaser explicitly wishes to obtain a wet drawn or a dry drawn surface condition it is indicated by a combination of the abbreviation of the coating followed by the abbreviation for the drawing condition.

EXAMPLE 2 3,0 mm grey bright phosphate coated spring wire: 3,0 ph gr.

1,5 mm wet drawn reddish spring wire: 1,5 rd w.

A.2 Physical characteristics at room temperature

A.2.1 Modulus of elasticity and shear modulus

The modulus of elasticity is assumed to be 206 GPa and the shear modulus 81,5 GPa.

A.2.2 Density

Unless specifically measured, the density of the steel wire is assumed to be 7,85 kg/dm^3.

A.3 Accuracy of measuring instruments

In order to guarantee the accuracy of the values measured, the accuracy of the measuring instrument, is 10 times higher than the allowable tolerance for the measured values.

For diameters below 0,65 mm, such instruments are not industrially available. Nevertheless, because of the impact of the real diameter on the spring characteristics, tolerances of 3 µm,5 µm and 8 µm are specified. This means that everything possible is done to keep all parameters which can influence the accuracy constant, such as temperature, dust, etc. Also, each value can only be attributed a relative value. However, practice shows that by taking several measurements one gets a fair indication of the exact value.

A.4 Tensile strength formula

Where smaller wire diameters than those mentioned in Table 3 appear to be necessary for static grades, the tensile strength is calculated from the following formulae:

— for grade SL: R_{av} = 1 845 — 700 lg d;

— for grade SM: R_{av} = 2 105 — 780 lg d

where

d diameters in mm;

R_{av} the average tensile strength in MPa.

The range is the same as specified in Table 3 for wire grade DH for the same wire diameter.

DM grade has the tensile strength as SM; for SH the values of DH apply.

A.5 Indication for the use of cold drawn spring steel wire

Table A.1 gives indicative information for the use of the various spring steel wire grades:

Table A.1

Spring wire grades	To be used for
SL	Tension, compression or torsion springs, which are predominantly subjected to low static stress.
SM	Tension, compression or torsion springs, which are subjected to medium high static stresses or rarely to dynamic stresses.
DM	Tension compression or torsion springs, which are subjected to medium high dynamic stresses. Also, for wire forms which require severe bending.
SH	Tension, compression or torsion springs, which are subjected to high static stresses or slightly dynamic stresses.
DH	Tension, compression or torsion springs or wire forms, which are subjected to high static stresses or medium level dynamic stresses.

Annex B
(informative)

Protection performance classes

Table B.1 — Minimum corrosion resistance

Protection performance class	Min. test duration before 5 % dark brown rust (h) [a]
A	24
B	48
C	72
D	96
E	120
F	144
G	168
H	240
I	360
J	480
K	720
[a] According to EN ISO 9227.	

If the costumer requires corrosion resistance test on the wire, the protection performance class of Table B.1 can be used as a reference.

Only the protection performance classes A to D are applicable with zinc coating.

Bibliography

EN ISO 4885, *Ferrous materials - Heat treatments - Vocabulary (ISO 4885)*

EN ISO 9227, *Corrosion tests in artificial atmospheres - Salt spray tests (ISO 9227)*

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