STD·BSI BS EN 10270-1-ENGL 2001 ■ 1624669 0909335 36T ■

BRITISH STANDARD

BS EN
10270-1:2001

Steel wire for mechanical springs —

Part 1: Patented cold drawn unalloyed spring steel wire

The European Standard EN 10270-1:2001 has the status of a British Standard

ICS 77.140.25

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National foreword

This British Standard is the official English language version of EN 10270-1:2001. It supersedes BS 5216:1991 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/26, Steel wire, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

Cross-references

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

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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EN 10270-1

April 2001

ICS 77.140.25; 77.140.65

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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Foreword

This European Standard has been prepared by Technical Committee ECISS/TC 30, Steel wires, the Secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by October 2001, and conflicting national standards shall be withdrawn at the latest by October 2001.

This European Standard for 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.

Part 3: Stainless spring steel wire.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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1 Scope

1.1 This part of EN 10270 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.

1.2 In addition to this part of EN 10270 the general technical delivery requirements of EN 10021 are applicable.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 10002-1, *Metallic materials — Tensile test — Part 1: Method of test (at ambient temperature).*

EN 10016-1, *Non-alloy steel rod for drawing and/or cold rolling — Part 1: General requirements.*

EN 10016-2, *Non-alloy steel rod for drawing and/or cold rolling — Part 2: Specific requirements for general purposes.*

EN 10016-4, *Non-alloy steel rod for drawing and/or cold rolling — Part 4: Specific requirements for rod for special applications.*

EN 10021, *General technical delivery requirements for steel and iron products.*

EN 10052, *Vocabulary of heat treatment terms for ferrous products.*

EN 10204, *Metallic products — Types of inspection documents.*

EN 10218-1:1994, *Steel wire and wire products — General — Part 1: Test methods.*

EN 10218-2:1996, *Steel wire and wire products — General — Part 2: Dimensions and tolerances.*

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

CR 10261, *Iron and steel — Review of available methods of chemical analysis.*

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

ISO 14284, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition.*

EU 104[1)], *Determination of the decarburization depth of unalloyed and low alloyed structural steels.*

[1)] It may be agreed at the time of ordering, until this EURONORM has been adopted as a European Standard, that either this EURONORM or a corresponding national standard should be applied.

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3 Terms and definitions

For the purposes of this standard the following terms and definitions apply.

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 10052)

4 Classification and designation

4.1 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 three 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.		

4.2 Designation

For products supplied according to this standard the designation shall state in the following order:

— the term: spring wire;

— the number of this European Standard: EN 10270-1;

— the wire grade (see Table 1);

— the required nominal diameter selected from Table 3;

— the coating indicated by its abbreviation (see 6.3).

EXAMPLE: Standard designation of a steel spring wire according to this standard of spring wire grade SM, with a nominal diameter of 2,50 mm, phosphate coated:

Spring wire EN 10270-1 - SM - 2,50 ph.

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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 number of this European Standard: EN 10270-1;

c) wire grade, coating and surface finish (see 6.3);

d) the nominal wire diameter;

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

f) the type of inspection document;

g) any particular agreement made.

EXAMPLE 5 t spring steel wire EN 10270-1 - SM - 2,50 ph

on spools of about 500 kg

inspection document EN 10204-3.1.B

6 Requirements

6.1 Material

6.1.1 General

Steel spring wire shall be made from steel corresponding to EN 10016-1 with in addition:

— for SL, SM and SH: EN 10016-2;

— for DM and DH: EN 10016-4.

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 10016-2 and EN 10016-4 respectively.

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Table 2 — Chemical composition, % by mass

Grade	C [a]	Si	Mn [b]	P max.	S max.	Cu max.
SL, SM, SH	0,35-1,00	0,10-0,30	0,50-1,20	0,035	0,035	0,20
DM, DH	0,45-1,00	0,10-0,30	0,50-1,20	0,020	0,025	0,12

[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] The range of manganese content in the table is wide to cope with various processing situations and the broad size range. The actual figures per size shall be more restricted.

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, individualized or on carriers, or a spool or spoolless core 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 and above.

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

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

1	2	3	4	5	6	7	8	9	10	11	12	13
Wire diameter d [a]		Mass kg/1 000 m	Tensile strength R_m [c] [d] [e] For wire grades					Minimum reduction in area after fracture Z for wire grades SL, SM, SH, DM and DH	Minimum number of twists in the torsion test for wire grades SL, SM, SH, DM and DH	Permissible depth of surface defects for wire grades DM, DH	Permissible decarburization depth for wires grades DM, DH	Wire diameter d (nominal size)
Nominal size mm	Permissible deviations mm		SL MPa	SM MPa	DM MPa	SH MPa	DH [f] MPa	%	[d]	mm	mm	mm
0,05	± 0,003	0,015 4					2 800 to 3 520		coiling test as specified in 7.4.3	- [g]	- [g]	0,05
0,06		0,022 2					2 800 to 3 520					0,06
0,07		0,030 2					2 800 to 3 520					0,07
0,08		0,039 5					2 800 to 3 480					0,08
0,09		0,049 9					2 800 to 3 430					0,09
0,10	± 0,004	0,061 7					2 800 to 3 380					0,10
0,11		0,074 6					2 800 to 3 350					0,11
0,12		0,088 8					2 800 to 3 320					0,12
0,14		0,121					2 800 to 3 250					0,14
0,16		0,158					2 800 to 3 200					0,16
0,18	± 0,005	0,200					2 800 to 3 160					0,18
0,20		0,247					2 800 to 3 110					0,20
0,22		0,298					2 770 to 3 080					0,22
0,25		0,385					2 720 to 3 010					0,25
0,28	± 0,008	0,488					2 680 to 2 970					0,28
0,30		0,555		2 370 to 2 650	2 370 to 2 650	2 660 to 2 940	2 660 to 2 940					0,30
0,32		0,631		2 350 to 2 630	2 350 to 2 630	2 640 to 2 920	2 640 to 2 920					0,32
0,34		0,713		2 330 to 2 600	2 330 to 2 600	2 610 to 2 890	2 610 to 2 890					0,34
0,36		0,799		2 310 to 2 580	2 310 to 2 580	2 590 to 2 870	2 590 to 2 870					0,36
0,38		0,890		2 290 to 2 560	2 290 to 2 560	2 570 to 2 850	2 570 to 2 850					0,38

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

1	2	3	4	5	6	7	8	9	10	11	12	13
Wire diameter d[a]		Mass kg/1 000 m	Tensile strength R_m [c] [d] [e] For wire grades					Minimum reduction in area after fracture Z for wire grades SL, SM, SH, DM and DH	Minimum number of twists in the torsion test for wire grades SL, SM, SH, DM and DH	Permissible depth of surface defects for wire grades DM, DH	Permissible decarburization depth for wire grades DM, DH	Wire diameter d (nominal size)
Nominal size mm	Permissible deviations mm		SL MPa	SM MPa	DM MPa	SH MPa	DH[f] MPa	%	[d]	mm	mm	mm
0,40	± 0,008	0,985		2 270 to 2 550	2 270 to 2 550	2 560 to 2 830	2 560 to 2 830		coiling test as specified in 7.4.3	- [g]	- [g]	0,40
0,43		1,14		2 250 to 2 520	2 250 to 2 520	2 530 to 2 800	2 530 to 2 800					0,43
0,45		1,25		2 240 to 2 500	2 240 to 2 500	2 510 to 2 780	2 510 to 2 780					0,45
0,48		1,42		2 220 to 2 480	2 220 to 2 480	2 490 to 2 760	2 490 to 2 760					0,48
0,50		1,54		2 200 to 2 470	2 200 to 2 470	2 480 to 2 740	2 480 to 2 740					0,50
0,53		1,73		2 180 to 2 450	2 180 to 2 450	2 460 to 2 720	2 460 to 2 720					0,53
0,56		1,93		2 170 to 2 430	2 170 to 2 430	2 440 to 2 700	2 440 to 2 700					0,56
0,60		2,22		2 140 to 2 400	2 140 to 2 400	2 410 to 2 670	2 410 to 2 670					0,60
0,63		2,45		2 130 to 2 380	2 130 to 2 380	2 390 to 2 650	2 390 to 2 650					0,63
0,65	± 0,010	2,60		2 120 to 2 370	2 120 to 2 370	2 380 to 2 640	2 380 to 2 640					0,65
0,70		3,02		2 090 to 2 350	2 090 to 2 350	2 360 to 2 610	2 360 to 2 610					0,70
0,75		3,47		2 070 to 2 320	2 070 to 2 320	2 330 to 2 580	2 330 to 2 580					0,75
0,80	± 0,015	3,95		2 050 to 2 300	2 050 to 2 300	2 310 to 2 560	2 310 to 2 560		25	1 % max. of wire diameter	1.5 % max. of wire diameter	0,80
0,85		4,45		2 030 to 2 280	2 030 to 2 280	2 290 to 2 530	2 290 to 2 530					0,85
0,90		4,99		2 010 to 2 260	2 010 to 2 260	2 270 to 2 510	2 270 to 2 510					0,90
0,95		5,59		2 000 to 2 240	2 000 to 2 240	2 250 to 2 490	2 250 to 2 490					0,95
1,00		6,17	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					1,00
1,05	± 0,020	6,80	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					1,05
1,10		7,46	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				1,10
1,20		8,88	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					1,20

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

1	2	3	4	5	6	7	8	9	10	11	12	13
Wire diameter d[a]		Mass kg/1 000 m	Tensile strength R_m [c] [d] [e] For wire grades					Minimum reduction in area after fracture Z for wire grades SL, SM, SH, DM and DH	Minimum number of twists in the torsion test for wire grades SL, SM, SH, DM and DH	Permissible depth of surface defects for wire grades DM, DH	Permissible decarburization depth for wire grades DM, DH	Wire diameter d (nominal size)
Nominal size mm	permissible deviations mm		SL MPa	SM MPa	DM MPa	SH MPa	DH[f] MPa	%	[d]	mm	mm	mm
1,25	± 0,020	9,63	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	1,25
1,30		10,42	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					1,30
1,40		12,08	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					1,40
1,50		13,90	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			1,50
1,60		15,8	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					1,60
1,70		17,8	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					1,70
1,80	± 0,025	20,0	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					1,80
1,90		22,3	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					1,90
2,00		24,7	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					2,00
2,10		27,2	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					2,10
2,25		31,2	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					2,25
2,40		35,5	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					2,40
2,50		38,5	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					2,50
2,60		41,7	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					2,60
2,80	± 0,030	48,3	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		16			2,80
3,00		55,5	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					3,00
3,20		63,1	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					3,20
3,40		71,3	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					3,40
3,60		79,9	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					3,60
3,80		89,0	1 340 to 1 740	1 550 to 1 740	1 550 to 1 740	1 750 to 1 950	1 750 to 1 950					3,80

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

1	2	3	4	5	6	7	8	9	10	11	12	13
Wire diameter d[a]		Mass kg/1 000	Tensile strength R_m [c d e] For wire grades					Minimum reduction in area after fracture Z for wire grades SL, SM, SH, DM and DH	Minimum number of twists in the torsion test for wire grades SL, SM, SH, DM and DH	Permissible depth of surface defects for wire grades DM, DH	Permissible decarburization depth for wire grades DM, DH	Wire diameter d (nominal size)
Nominal size mm	permissible deviations mm		SL MPa	SM MPa	DM MPa	SH MPa	DH[f] MPa	%	[d]	mm	mm	mm
4,00	± 0,030	98,6	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	35	16	1 % max. of wire diameter	1.5 % max. of wire diameter	4,00
4,25	± 0,035	111	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					4,25
4,50		125	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			4,50
4,75		139	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					4,75
5,00		154	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					5,00
5,30		173	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			5,30
5,60	± 0,040	193	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			5,60
6,00		222	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			6,00
6,30		245	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			6,30
6,50		260	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			6,50
7,00		302	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			7,00
7,50	± 0,045	347	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[h]			7,50
8,00		395	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[h]			8,00
8,50		445	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[h]			8,50
9,00		499	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[h]			9,00
9,50	± 0,050	559	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[h]			9,50
10,00		617	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[h]			10,00
10,50	± 0,070	680	-	1 220 to 1 380	1 220 to 1 380	1 390 to 1 550	1 390 to 1 550		-			10,50
11,00		746		1 210 to 1 370	1 210 to 1 370	1 380 to 1 530	1 380 to 1 530					11,00
12,00	± 0,080	888		1 180 to 1 340	1 180 to 1 340	1 350 to 1 500	1 350 to 1 500					12,00

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

1	2	3	4	5	6	7	8	9	10	11	12	13
Wire diameter d [a]		Mass kg/1 000	Tensile strength R_m [c] [d] [e] For wire grades					Minimum reduction in area after fracture Z for wire grades SL, SM, SH, DM and DH	Minimum number of twists in the torsion test for wire grades SL, SM, SH, DM and DH	Permissible depth of surface defects for wire grades DM, DH	Permissible decarburization depth for wire grades DM, DH	Wire diameter (nominal size)
Nominal size mm	permissible deviations mm		SL MPa	SM MPa	DM MPa	SH MPa	DH [f] MPa	%	[d]	mm	mm	mm
12,50	± 0,080	963	-	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	12,50
13,00		1 042		1 160 to 1 310	1 160 to 1 310	1 320 to 1 470	1 320 to 1 470					13,00
14,00		1 208		1 130 to 1 280	1 130 to 1 280	1 290 to 1 440	1 290 to 1 440					14,00
15,00	± 0,090	1 387		1 160 to 1 260	1 160 to 1 260	1 270 to 1 410	1 270 to 1 410					15,00
16,00		1 578		1 090 to 1 230	1 090 to 1 230	1 240 to 1 390	1 240 to 1 390					16,00
17,00		1 782		1 070 to 1 210	1 070 to 1 210	1 220 to 1 360	1 220 to 1 360					17,00
18,00		1 998		1 050 to 1 190	1 050 to 1 190	1 200 to 1 340	1 200 to 1 340					18,00
19,00	± 0,100	2 225		1 030 to 1 170	1 030 to 1 170	1 180 to 1 320	1 180 to 1 320					19,00
20,00		2 466		1 020 to 1 150	1 020 to 1 150	1 160 to 1 300	1 160 to 1 300					20,00

[a] For intermediate values of wire diameter, the values specified for the next higher diameter shall apply (for tensile strength see [c]).

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

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

[d] 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.

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

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

[g] 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.

[h] Guideline values; not mandatory for acceptance.

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

Diameter range (mm)	SL, SM, SH	DM, DH
d <0,80	150	150
0,80 ≤ d < 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 $250 \times d$ (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 up to 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.

NOTE 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 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 of 0,70 mm to 10 mm. The minimum number of turns specified in Table 3 for diameters up to 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 10218-1:1994, 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 (see 7.4.4) may be applied to wire with a diameter equal or less than 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.

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6.5.4 Bend test

Where requested, the bend test may be applied to wire with a diameter greater than 3,00 mm. 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

Wire diameter [a] (mm)	**Minimum internal diameter** (mm)
$0,25 \leq d < 0,28$	100
$0,28 \leq d < 0,50$	150
$0,50 \leq d < 0,70$	180
$0,70 \leq d < 1,60$	250
$1,60 \leq d < 4,50$	400
$4,50 \leq d$	500

[a] For wire diameter below 0,25 mm specific agreements shall be made between the parties.

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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 finer than 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" at the ends of the wap (see Figure 1); this displacement "f" shall not exceed a value given by the following equation:

$$f \leq \frac{0{,}2\,D}{\sqrt[4]{d}}$$

where:

f is the axial displacement in mm;

D is the diameter of a free wap in mm;

d is the diameter of the wire in mm.

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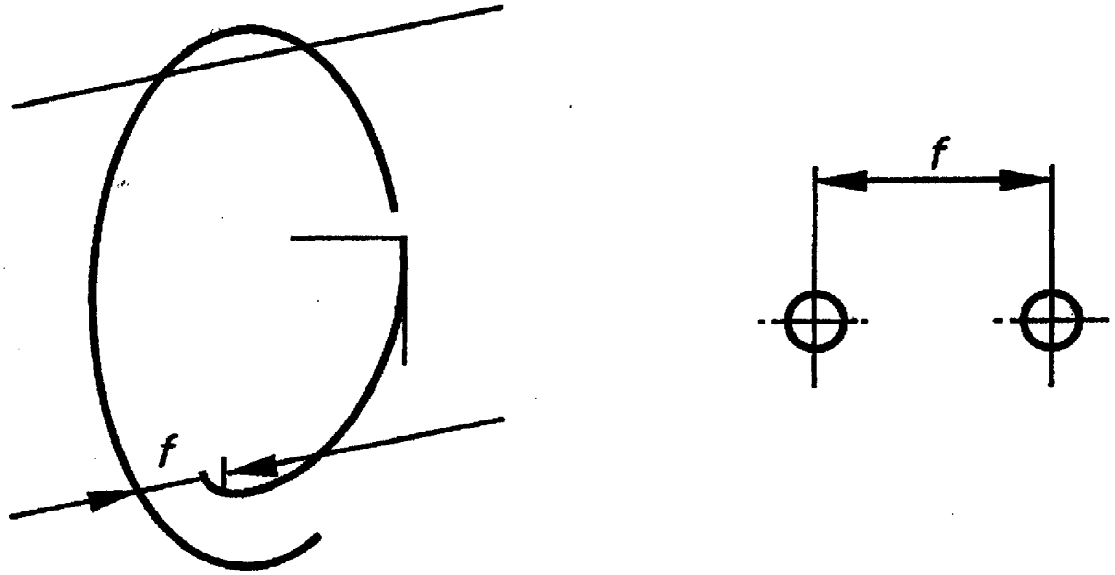


Figure 1 — Helix cast of wire

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.

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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).

— 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. The adherence of the coating shall be tested by a wrapping test (see 7.4.11) according to EN 10244-2.

NOTE The usual coating processes may alter the properties of the steel wire. The ductility and endurance of the wire may 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

Diameter (mm)	**Coating mass** (g/m^2) [a]
$0{,}20 \leq d < 0{,}25$	20
$0{,}25 \leq d < 0{,}40$	25
$0{,}40 \leq d < 0{,}50$	30
$0{,}50 \leq d < 0{,}60$	35
$0{,}60 \leq d < 0{,}70$	40
$0{,}70 \leq d < 0{,}80$	45
$0{,}80 \leq d < 0{,}90$	50
$0{,}90 \leq d < 1{,}00$	55
$1{,}00 \leq d < 1{,}20$	60
$1{,}20 \leq d < 1{,}40$	65
$1{,}40 \leq d < 1{,}65$	70
$1{,}65 \leq d < 1{,}85$	75
$1{,}85 \leq d < 2{,}15$	80
$2{,}15 \leq d < 2{,}50$	85
$2{,}50 \leq d < 2{,}80$	95
$2{,}80 \leq d < 3{,}20$	100
$3{,}20 \leq d < 3{,}80$	105
$3{,}80 \leq d \leq 10{,}00$	110

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

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6.8 Dimensions and dimensional tolerances

6.8.1 Dimensional tolerances

— Coiled wire.

The tolerances on the diameter are specified in Table 3.

This is based on EN 10218-2:1996.

— T5 for diameters below 0,80 mm;

— T4 for diameters from 0,80 mm up to 10,00 mm;

— T3 for diameters over 10,00 mm.

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

— Wire in straightened and cut lengths.

The requirements for length tolerances and straightness are as in EN 10218-2:1996. The tolerance on the nominal length shall only be in plus, keeping the same tolerance range (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 mm 0 mm		
$300 < L \leq 1000$	+2,0 mm 0 mm	+1 % 0 %	+2 % 0 %
$1\,000 < L$ -	+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.

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.

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Table 8 — Diameter tolerance for straightened and cut lengths

Nominal diameter (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
$6,01 \leq d < 7,12$	−0,040	+0,150
$7,12 \leq d < 7,67$	−0,045	+0,160
$7,67 \leq d < 9,01$	−0,045	+0,180
$9,01 \leq d < 10,01$	−0,050	+0,200
$10,01 \leq d < 11,12$	−0,070	+0,240
$11,12 \leq d < 12,01$	−0,080	+0,260
$12,01 \leq d < 14,52$	−0,080	+0,300
$14,52 \leq d < 17,34$	−0,090	+0,350
$17,34 \leq d < 18,37$	−0,090	+0,370
$18,37 \leq d < 20,01$	−0,100	+0,400

7 Testing and inspection

7.1 Inspection and inspection documents

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

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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 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 CR 10261.

7.4.2 Tensile test

The tensile test shall be carried out according to EN 10002-1, 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.

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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 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 (not exceeding one rotation per second) until the test piece fractures. The number of complete rotations of the turning clamping head is counted. The free length between grips shall be uniformly $100 \times d$ (d = nominal diameter of the wire) with a maximum of 300 mm.

7.4.6 Bending test

For the bending 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 for sizes above 3,00 mm to 6,50 mm and equal to three times the wire diameter for sizes above 6,50 mm. 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 microsections. It may be agreed for wire diameters below 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 microsection applies.

7.4.8 Decarburization

Decarburization shall be inspected by microscope in accordance with EU 104 on a transverse metallographic test piece, suitably etched with a magnification of × 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 avoiding 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 diameters less than 2,00 mm at the time of ordering that testing be carried out immediately after the last heat treatment.

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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. Below 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 shall be tested for wire diameters up to 5 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	(+)
Cast 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.

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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 wire grades	[a]	Test unit	Number of products per test unit	Number of samples per product	Number of test pieces per sample	Sampling	Test procedure in accordance with sub-clause	Requirements, see sub-clause
1	Product analysis	all	0 [b]	Quantity supplied per heat	1	1	1	ISO 14284	7.4.1	6.1.2 [b]
2	Tensile test R_m Z	All ≥ 0,80 mm	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 [d]
3	Coiling test	DM, SH, DH ≤ 0,70 mm	o		The scope of testing shall be agreed on ordering				7.4.3	6.5.1
3a	Wrapping test	All ≤ 3 mm	o						7.4.4	6.5.3
3b	Bending test	All ≤ 3 mm	o						7.4.6	6.5.4
4	Torsion test [e]	All	m						7.4.5	6.5.2 [d]
5	Testing for Freedom from twists	All	m						6.6.3 6.6.4	6.6.3 6.6.4
6	Testing for Surface defects	DM, DH	m		10 % [c]	1	1		7.4.7	6.7 [d]
7	Testing for decarburization	DM, DH	m						7.4.8	6.7.2 [d]
8	Check on dimensions	All	m		100 %				7.4.9	6.8 [d]
9	Testing of coating mass	Z and ZA	o		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 is to be carried out in each case; or 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.
[e] Only for diameters over 0,70 and up to 10 mm.

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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 will be 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 95/Al 5 coating;

— 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.

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A.1.3 Abbreviations

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

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

Depending on the size the wire will be 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 shall be indicated by a combination of the abbreviation of the coating followed by the abbreviation for the drawing condition.

EXAMPLE: 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 should be 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 3,5 and 8µm are specified. This means that everything possible should be 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 shall be calculated from the following formulae:

— For grade SL: $R_{av} = 1845 - 700 \log d$.

— For grade SM: $R_{av} = 2105 - 780 \log d$.

where:

d is diameters in mm;

R_{av} is the average tensile strength in MPa.

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

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DM grade shall have 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

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