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Steel wire for mechanical springs — Part 2: Patented cold-drawn non-alloy steel wire

Fils en acier pour ressorts mécaniques —

Partie 2: Fils en acier non allié, patentés, tréfilés à froid



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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 8458 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 8458-2 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 17, *Steel wire rod and wire products*.

This second edition cancels and replaces the first edition (iso 8458-2:1989) which has been technically revised.

ISO 8458 consists of the following parts, under the general title *Steel wire for mechanical springs*:

- *Part 1: General requirements*
- *Part 2: Patented cold-drawn non-alloy steel wire*
- *Part 3: Oil-hardened and tempered wire*

Steel wire for mechanical springs —

Part 2: Patented cold-drawn non-alloy steel wire

1 Scope

This part of ISO 8458 specifies requirements for cold-drawn non-alloy steel wire for the manufacture of mechanical springs for static duty and dynamic duty applications, complying with the general requirements of ISO 8458-1.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 8458. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 8458 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 7989:1988, *Zinc coatings for steel wire*

ISO 8458-1, *Steel wire for mechanical springs — Part 1: General requirements*

ISO 16120-1:2001, *Non-alloy steel wire rod for conversion to wire — Part 1: General requirements*

ISO 16120-2:2001, *Non-alloy steel wire rod for conversion to wire — Part 2: Specific requirements for general purpose wire rod*

ISO 16120-4:2001, *Non-alloy steel wire rod for conversion to wire — Part 4: Specific requirements for rod for special applications*

3 Classification and designation

The wire diameter ranges and tensile strength grades normally available for static duty and dynamic duty are shown in Table 1.

Table 1 — Tensile strength grades and diameter range

Tensile strength ^a	Static duty	Diameter range	Dynamic duty	Diameter range
Low tensile strength	SL	1-10	—	—
Medium tensile strength	SM	0,30-20,00	DM	0,08-20,00
High tensile strength	SH	0,30-20,00	DH	0,05-20,00
^a For specific applications, other tensile strength requirements may be agreed.				

4 Dimensions and supply conditions

4.1 Dimensional tolerances

The dimensional tolerances on wire diameters shall be in accordance with ISO 8458-1.

4.2 Welds

The wire of a unit coil shall consist of one single length of wire originating from only one heat.

For coiled and cut lengths of wire, welds prior to the last patenting operation are allowed. All other welds shall be removed or, if so agreed, properly marked.

4.3 Cast of the wire

4.3.1 The wire shall be uniformly cast.

4.3.2 By agreement, for sizes up to 5 mm, the cast requirements may be considered as being fulfilled if the following statement is satisfied.

An individual ring taken from the coil and freely hung on a hook may show an axial displacement, f , at the ends of the ring (see Figure 1).

This displacement, f , shall not exceed a value given by the following inequality:

$$f \leq 0,2D/(4\sqrt{d})$$

where

f is the axial displacement in millimetres;

D is the diameter of a free ring in millimetres;

d is the nominal diameter of the wire in millimetres.

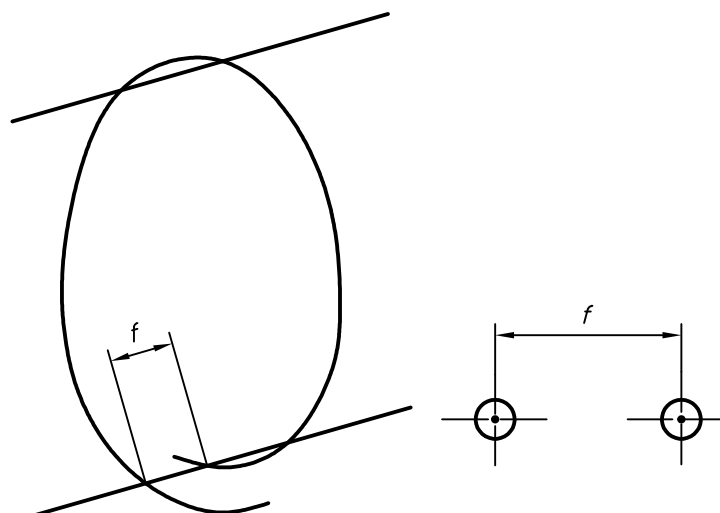


Figure 1 — Cast of wire

4.4 Straightness of cut lengths

For the straightness of cut lengths, the following requirements apply.

For 500 mm test lengths – 0,5 mm maximum deviation from straightness;

For 1 000 mm test lengths – 2 mm maximum deviation from straightness.

NOTE 1 000 mm test lengths are recommended for wire diameter above 6 mm and 500 mm test lengths for those below.

5 Requirements

5.1 Material

5.1.1 General

Spring wire shall be made from steel complying with ISO 16120-1.

For grades SL, SM and SH the steel shall comply to ISO 16120-2.

For grades DM and DH the steel shall comply with ISO 16120-4.

5.1.2 Chemical composition

The steel is characterized by the heat analysis, which shall be in accordance with the values of Table 2. The permissible deviation of the product analysis from the heat analysis shall be in accordance with ISO 16120-2 or ISO 16120-4.

Table 2 — Chemical composition, % (m/m) (heat analysis)

Grade	C ^a	Si	Mn ^b	P max.	S max.	Cu max.
SL, SM, SH	0,35-1,00	0,10-0,30	0,30-1,20	0,030	0,030	0,20
DH, DM	0,45-1,00	0,10-0,30	0,30-1,20	0,020	0,025	0,12

^a Such a wide range is stipulated in order 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 so wide in order to cope with various processing situations and the broad size range. The real figures per size shall be more restricted.

5.2 Coating and surface finish

5.2.1 The spring wire may be supplied lime coated, borax coated or phosphate coated, and may be produced by either dry drawing or wet drawing.

A metallic coating, where required, be it copper, zinc or zinc/aluminium alloy, shall be applied to the wire.

Other coatings may be agreed upon between the purchaser and the manufacturer.

If no specific surface finish is nominated, it shall be at the manufacturer's discretion.

5.2.2 In the case of zinc and zinc/aluminium alloy coated spring wire, the mass of zinc or zinc/aluminium alloy coating shall satisfy the minimum values specified in Table 3.

Table 3 — Minimum required zinc or zinc/aluminium alloy coating mass

Diameter, d , mm	Coating mass, g/m^2
$0,20 \leq d < 0,25$	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

Other levels may be agreed upon between supplier and manufacturer. The adherence of the coating shall be tested by a wrapping or bend test (see ISO 7989).

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 or zinc/aluminium alloy coated spring steel wire the same torsion values or expect the same dynamic performance (DM and DH) as for the respective uncoated material.

5.3 Surface quality

5.3.1 Surface quality tests shall be applied to wires intended for use in dynamic duty spring only (DM and DH). The radial depth of seams or other surface discontinuities shall be not greater than 1 % of the nominal diameter of the wire.

5.3.2 For spring wire grade DH and DM, the cross-section shall show no completely decarburized layer and partial decarburization shall not have an average radial depth greater than 1,5 % of the nominal diameter of the wire.

5.4 Mechanical properties

The tensile strength of the wire shall be in accordance with Table 4 for the appropriate tensile strength grade, nominal wire diameter and type of spring use.

Table 4 — Tensile strength requirements

Nominal Diameter mm ^a	Tensile strength, N/mm ²				
	Type SL	Type SM	Type DM	Type SH	Type DH ^b
0,05					2 800 to 3 520
0,06					2 800 to 3 520
0,07					2 800 to 3 520
0,08			2 780 to 3 100		2 800 to 3 480
0,09			2 740 to 3 060		2 800 to 3 430
0,10			2 710 to 3 020		2 800 to 3 380
0,11			2 690 to 3 000		2 800 to 3 350
0,12			2 660 to 2 960		2 800 to 3 320
0,14			2 620 to 2 910		2 800 to 3 250
0,16			2 570 to 2 860		2 800 to 3 200
0,18			2 530 to 2 820		2 800 to 3 160
0,20			2 500 to 2 790		2 800 to 3 110
0,22			2 470 to 2 760		2 770 to 3 080
0,25			2 420 to 2 710		2 720 to 3 010
0,28			2 390 to 2 670		2 680 to 2 970
0,30		2 370 to 2 650	2 370 to 2 650	2 660 to 2 940	2 660 to 2 940
0,32		2 350 to 2 630	2 350 to 2 630	2 640 to 2 920	2 640 to 2 920
0,34		2 330 to 2 600	2 330 to 2 600	2 610 to 2 890	2 610 to 2 890
0,36		2 310 to 2 580	2 310 to 2 580	2 590 to 2 890	2 590 to 2 890
0,38		2 290 to 2 560	2 290 to 2 560	2 570 to 2 850	2 570 to 2 850
0,40		2 270 to 2 550	2 270 to 2 550	2 560 to 2 830	2 570 to 2 830
0,43		2 250 to 2 520	2 250 to 2 520	2 530 to 2 800	2 570 to 2 800
0,45		2 240 to 2 500	2 240 to 2 500	2 510 to 2 780	2 570 to 2 780
0,48		2 220 to 2 480	2 240 to 2 500	2 490 to 2 760	2 570 to 2 760
0,50		2 200 to 2 470	2 200 to 2 470	2 480 to 2 740	2 480 to 2 740
0,53		2 180 to 2 450	2 180 to 2 450	2 460 to 2 720	2 460 to 2 720
0,56		2 170 to 2 430	2 170 to 2 430	2 440 to 2 700	2 440 to 2 700
0,60		2 140 to 2 400	2 140 to 2 400	2 410 to 2 670	2 410 to 2 670
0,63		2 130 to 2 380	2 130 to 2 380	2 390 to 2 650	2 390 to 2 650

Table 4 (continued)

Nominal Diameter mm ^a	Tensile strength, N/mm ²				
	Type SL	Type SM	Type DM	Type SH	Type DH ^b
0,65		2 120 to 2 370	2 120 to 2 370	2 380 to 2 640	2 380 to 2 640
0,70		2 090 to 2 350	2 090 to 2 350	2 360 to 2 610	2 360 to 2 610
0,80		2 050 to 2 300	2 050 to 2 300	2 310 to 2 560	2 310 to 2 560
0,85		2 030 to 2 280	2 030 to 2 280	2 290 to 2 530	2 290 to 2 530
0,90		2 010 to 2 260	2 010 to 2 260	2 270 to 2 510	2 270 to 2 510
0,95		2 000 to 2 240	2 000 to 2 240	2 250 to 2 490	2 250 to 2 490
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
1,05	1 710 to 1 950	1 960 to 2 220	1 960 to 2 220	2 210 to 2 450	2 210 to 2 450
1,10	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
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
1,25	1 660 to 1 900	1 910 to 2 130	1 910 to 2 130	2 140 to 2 380	2 140 to 2 380
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
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
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
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
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
1,80	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
1,90	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
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
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
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
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
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
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
2,80	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
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
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
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
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
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
4,00	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
4,25	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
4,50	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
4,75	1 270 to 1 470	1 480 to 1 670	1 480 to 1 670	1 680 to 1 840	1 680 to 1 840
5,00	1 260 to 1 450	1 460 to 1 650	1 460 to 1 650	1 660 to 1 830	1 660 to 1 830
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

Table 4 (continued)

Nominal Diameter mm ^a	Tensile strength, N/mm ²				
	Type SL	Type SM	Type DM	Type SH	Type DH ^b
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
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
6,30	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
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
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
7,50	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
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
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
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
9,50	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
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
10,50		1 220 to 1 380	1 220 to 1 380	1 390 to 1 550	1 390 to 1 550
11,00		1 210 to 1 370	1 210 to 1 370	1 380 to 1 530	1 380 to 1 530
12,00		1 180 to 1 340	1 180 to 1 340	1 350 to 1 500	1 350 to 1 500
12,50		1 170 to 1 320	1 170 to 1 320	1 330 to 1 480	1 330 to 1 480
13,00		1 160 to 1 310	1 160 to 1 310	1 320 to 1 470	1 320 to 1 470
14,00		1 130 to 1 280	1 130 to 1 280	1 290 to 1 440	1 290 to 1 440
15,00		1 110 to 1 260	1 110 to 1 260	1 270 to 1 410	1 270 to 1 410
16,00		1 090 to 1 230	1 090 to 1 230	1 240 to 1 390	1 240 to 1 390
17,00		1 070 to 1 210	1 070 to 1 210	1 220 to 1 360	1 220 to 1 360
18,00		1 050 to 1 190	1 050 to 1 190	1 200 to 1 340	1 200 to 1 340
19,00		1 030 to 1 170	1 030 to 1 170	1 180 to 1 320	1 180 to 1 320
20,00		1 020 to 1 150	1 020 to 1 150	1 160 to 1 300	1 160 to 1 300
Note 1 1 N/mm ² = 1 MPa.					
Note 2 For straightened and cut lengths, the ultimate tensile strength may be up to 10 % lower; the torsion values are also lowered by straightening and cutting operations.					
^a For intermediate values of the wire diameter the specifications given for the next larger diameter are applicable.					
^b For DH grades in the size range 0,08 mm to 0,18 mm, a restricted tensile strength range of 300 N/mm ² within the specified range may be negotiated.					

5.5 Technological properties

5.5.1 Wrapping test

The wrapping test may be applied to wires with a nominal diameter of less than 3 mm. The wire shall not show any sign of fracture when closely coiled for at least four turns around a mandrel of diameter equal to that of the wire.

5.5.2 Torsion test

5.5.2.1 The torsion test shall be applied to wires with nominal diameter from 0,70 mm to 6,00 mm, and subject to negotiation for wires with nominal diameters over 6 mm and up to and including 10 mm.

5.5.2.2 The wire shall withstand being twisted, without failure, the number of turns given in Table 5, on a gauge length equivalent to 100 wire diameters.

For sizes over 3 mm, other gauge lengths may be used, in which case the number of twists shall be adjusted in proportion to the gauge length.

Table 5 — Torsion test requirement

Nominal diameter, mm <i>d</i>	Minimum number of twists	
	Static	Dynamic
$0,69 < d \leq 1,40$	20	25
$1,4 < d \leq 2,0$	18	22
$2,0 < d \leq 3,5$	16	20
$3,5 < d \leq 6,0$	14	18
$6 < d \leq 8$	7 ^a	9 ^a
$8 < d \leq 10$	5 ^a	7 ^a

^a Guidance values, not mandatory for acceptance.

5.5.2.3 The test shall be continued until fracture, wherein the primary fracture shall be perpendicular to the axis of the wire and the surface shall not be split. During fly-back of the wire, secondary fractures may occur and these shall be ignored.

5.5.3 Bend test

Where requested, the bend test may be applied to wires with nominal diameter greater than 3 mm.

The wire shall not show any sign of fracture when bent through an angle of 180° to form a U around a mandrel of diameter equal to twice the wire diameter for sizes above 3,0 mm to 6,5 mm, and equal to × 3 the wire diameter for sizes above 6,5 mm.

5.5.4 Coiling test

The coiling test may be applied to wires with nominal diameter not greater than 0,7 mm.

The test piece shall exhibit a defect-free surface without splits or fracture, a uniform pitch of the turns after coiling and a dimensional regularity of the coil.

6 Inspection and testing

6.1 Test methods and other requirements

Test methods and other requirements shall be in accordance with ISO 8458-1. See Table 6.

Table 6 — Summary of the information on test methods and requirements

Test method	Wire grades and diameter ranges	Requirement
Chemical analysis	All	Optional
Tensile test	All	Mandatory
Wrapping test	$d < 3$ mm	Optional
Torsion test	$0,7 \text{ mm} \leq d \leq 6,0 \text{ mm}$ $6 \text{ mm} < d \leq 10 \text{ mm}$	Mandatory Optional
Bend test	$d > 3$ mm	Optional
Coiling test	$d \leq 0,7$ mm	Optional
Cast of wire	All	Mandatory
Surface defects	DM, DH	Mandatory
Decarburization	DM, DH	Mandatory
Coating mass	Z and ZA	Optional
Coating adherence	Z and ZA	Mandatory

6.2 Extent of testing

The extent of testing shall be in accordance with Table 7.

Table 7 — Acceptance unit and number of samples and test pieces

Type of requirement	Number of samples or test pieces
Product analysis	1
Tensile test	10 % ^a
Wrapping test	10 % ^a
Bend test	
Torsion test	
Surface discontinuity	
Decarburization	
Coating adherence	
Coating mass	To be agreed
Coiling test	
Dimensions	100 %
^a 10 % of the wire units in the production batch (= test unit), up to a maximum of 10 samples. However, for 20 or fewer coils, a minimum of 2 samples shall be tested.	

