Steel wire for mechanical springs

Part 2: Oil hardened and tempered spring steel wire
English version of DIN EN 10270-2

DIN EN 10270-2

ICS 77.140.25; 77.140.65

Supersedes DIN 17223-2, September 1990 edition.

Stahldraht für Federn – Teil 2: Ölschlussvergüteter Federstahldraht

European Standard EN 10270-2 : 2001 has the status of a DIN Standard.

A comma is used as the decimal marker.

National foreword

This standard has been prepared by ECISS/TC 30/SC 2 'Steel wire for mechanical springs' (Secretariat: Belgium).

The responsible German body involved in its preparation was the *Normenausschuss Eisen und Stahl* (Steel and Iron Standards Committee).

DIN 50602 and DIN 50192 are the standards corresponding to ENV 10247 and EURONORM 104, respectively, referred to in clause 2 of the EN.

Amendments

DIN 17223-2, September 1990 edition, has been superseded by the specifications of EN 10270-2.

Previous editions

DIN 17223: 1955-04; DIN 17223-2: 1964-03, 1990-09.

National Annex NA

Standards referred to

(and not included in Normative references)

DIN 50192 Determination of depth of decarburization of steel

DIN 50602 Metallographic examination – Microscopic examination of special steel using standard diagrams to determine the non-metallic inclusions content

EN comprises 18 pages.

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EN 10270-2

April 2001

ICS 77.140.25; 77.140.65

English version

Steel wire for mechanical springs

Part 2: Oil hardened and tempered spring steel wire

Fils en acier pour ressorts mécaniques – Partie 2: Fils en acier trempés à l'huile et revenus

Stahldraht für Federn – Teil 2: Ölschlussvergüteter Federstahldraht

This European Standard was approved by CEN on 2001-02-19.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Management Centre: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 10270-2 : 2001 E

Contents

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of an identical text or by endorsement, at the latest by October 2001, and conflicting national standards shall be withdrawn at the latest by October 2001.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

1 Scope

1.1 This Part of EN 10270 applies to oil hardened and tempered spring steel wire made from unalloyed or alloyed steels. They are primarily subject to torsional stresses such as in compression and extension springs and in special cases also for applications where the spring wire is subject to bending stresses such as lever springs.

As a rule unalloyed steels are used for applications at room temperature whereas alloyed steels are generally used at a temperature above room temperature. Alloyed steels may also be chosen for above average tensile strengths.

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 10021, *General technical delivery requirements for steel and iron 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*

ENV 10247, *Micrographic examination of the non-metallic inclusion content of steels using standard pictures*

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 decarburzation depth of unalloyed and low alloyed structural steels*

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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.

3 Terms and definitions

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

3.1
oil hardened and tempered spring steel wire
wire that is heat treated in line in the following way: it is first transformed into austenite, quenched in oil or similar quenching medium, followed immediately by tempering by heating to the appropriate temperature

4 Classification and designation

4.1 Classification

This standard deals with all types of hardened and tempered spring steel wire. The grade for normal applications made from unalloyed or alloyed steel has the abbreviation FD and is intended for static applications.

Spring steel wire for medium fatigue levels, such as required for some clutch springs from unalloyed or alloyed steel, has the abbreviation TD.

Spring steel wire from unalloyed steel or alloyed steel intended for use under severe dynamic duty such as for valve springs or other springs with similar requirements has the abbreviation VD.

The diameter ranges for the various wire grades are shown in Table 1.

Table 1 — Spring wire grades

Tensile strength	Static	Medium fatigue	High fatique
Low tensile strength	FDC	TDC	VDC
Medium tensile strength	FDCrV	TDCrV	VDCrV
High tensile strength	FDSiCr	TDSiCr	VDSiCr
Diameter range (mm)	0,50 - 17,00	0,50 - 10,00	0,50 - 10,00

Medium and high fatigue grades TD and VD are characterized by high steel cleanliness, specific chemical, mechanical and technological parameters and a well defined surface condition in relation to the allowable depth of surface defects and decarburization.

The static grade FD is characterized by its chemical, mechanical and technological characteristics as well as by a specified surface condition concerning surface defects and decarburization.

4.2 Designation

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

— the term: spring wire;

— the number of this European Standard : EN 10270-2;

— the abbreviation for the wire grade (see Table 1);

— the required nominal diameter selected from Table 4 or Table 5;

EXAMPLE: Standard designation of an oil hardened and tempered steel spring wire according to this standard of wire grade VDC with a nominal diameter of 2,50 mm :

Spring wire EN 10270-2 - VDC - 2,50.

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 10270-2;

c) wire grade (see 4.1);

d) the nominal wire diameter;

e) the form of delivery and unit mass;

f) the type of inspection document;

g) any particular agreement made.

EXAMPLE: 5 t spring wire EN 10270-2 - VDC - 2,50

in coils of about 300 kg

inspection document EN 10204 - 3.1.B.

6 Requirements

6.1 Form of delivery

6.1.1 Oil hardened and tempered wire shall be supplied in coils, on spools or in cut lengths. The wire in coils or on spools shall form one continuous length. Wire in coil may also be supplied on carriers containing one or more coils.

For 'VD' and 'TD' grades no welds are permitted after the heat treatments preceding the final drawing operation; for 'FD' grades no welds shall be made at finished size unless agreed otherwise between the parties.

6.1.2 The supplied wire units shall be tightly bound to ensure that wire spiral waps do not spring out unforeseen. The starting end shall be marked and at the coil ends the wire shall be covered with a protective cap.

6.2 Surface finish

The wire shall be protected against corrosion and mechanical damage. Unless otherwise specified the wire shall be delivered in slightly oiled condition.

6.3 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 limiting values of heat analysis shall be in accordance with Table 3.

6.4 Non metallic inclusions

The 'VD' grades shall be checked for maximum size of inclusion according to ENV 10247. The allowable level of inclusions shall be agreed between the parties at the enquiry and order.

6.5 Mechanical properties

For tensile strength R_m and reduction in area after fracture (Z) the wire grades shall satisfy the values listed in Tables 4 and 5. Reduction of area is measured only for size 1,00 mm and above (see Tables 4, 5 and 11).

The range of the tensile strength values within a coil/reel shall not exceed 50 MPa for the grades 'VD', 60 MPa for the grades 'TD' and 70 MPa for the grades 'FD'.

Table 2 — Chemical composition, % by mass

Grade	C	Si	Mn [a]	P max.	S max.	Cu max.	Cr	V
VDC	0,60-0,75	0,15-0,30	0,50-1,00	0,020	0,020	0,06	[b]	
VDCrV	0,62-0,72	0,15-0,30	0,50-0,90	0,025	0,020	0,06	0,40-0,60	0,15-0,25
VDSiCr	0,50-0,60	1,20-1,60	0,50-0,90	0,025	0,020	0,06	0,50-0,80	
TDC	0,60-0,75	0,10-0,35	0,50-1,20	0,020	0,020	0,10	[b]	
TDCrV	0,62-0,72	0,15-0,30	0,50-0,90	0,025	0,020	0,10	0,40-0,60	0,15-0,25
TDSiCr	0,50-0,60	1,20-1,60	0,50-0,90	0,025	0,020	0,10	0,50-0,80	
FDC	0,60-0,75	0,10-0,35	0,50-1,20	0,030	0,025	0,12	[b]	
FDCrV	0,62-0,72	0,15-0,30	0,50-0,90	0,030	0,025	0,12	0,40-0,60	0,15-0,25
FDSiCr	0,50-0,60	1,20-1,60	0,50-0,90	0,030	0,025	0,12	0,50-0,80	

[a] Manganese may be ordered with restricted range, but with a minimum range of 0,20 %

[b] For heavy wire diameter (above 8,5 mm) chromium may be added up to 0,30 % for proper through hardening.

Table 3 — Permissible deviation of the product analysis from the limiting values for the heat analysis

Chemical element	Wire grade	Permissible deviation, % by mass
C	All	± 0,03
Si	SiCr	± 0,05
	other grades	± 0,03
Mn	All	± 0,04
P	All	+ 0,005
S	All	+ 0,005
Cu	All	+ 0,02
Cr	All	± 0,05
V	All	± 0,02

Table 4 — Mechanical and technological properties and quality requirements for wire grades FDC, FDCrV and FDSiCr

1	2	3	4	5	6	7	8	9	10	11
Nominal wire diameter (mm)	Permissible deviations mm	Tensile strength R_m			Minimum reduction in area after fracture Z for wire grades			Minimum number of torsions for wire grades[a]		
		FDC [b] MPa	FDCrV [b] MPa	FDSiCr [b] MPa	FDC %	FDCrV %	FDSiCr %	FDC	FDCrV	FDSiCr
$d = 0{,}50$	± 0,010	1900 to 2100	2000 to 2200	2100 to 2300	-	-	-	-	-	-
$0{,}50 < d \leq 0{,}60$		1900 to 2100	2000 to 2200	2100 to 2300						
$0{,}60 < d \leq 0{,}80$		1900 to 2100	2000 to 2200	2100 to 2300				To be agreed upon	To be agreed upon	To be agreed upon
$0{,}80 < d \leq 1{,}00$	± 0,015	1860 to 2060	1960 to 2160	2100 to 2300						
$1{,}00 < d \leq 1{,}30$		1810 to 2010	1900 to 2100	2070 to 2260						
$1{,}30 < d \leq 1{,}40$	± 0,020	1790 to 1970	1870 to 2070	2060 to 2250						
$1{,}40 < d \leq 1{,}60$		1760 to 1940	1840 to 2030	2040 to 2220						
$1{,}60 < d \leq 2{,}00$		1720 to 1890	1790 to 1970	2000 to 2180						
$2{,}00 < d \leq 2{,}50$	± 0,025	1670 to 1820	1750 to 1900	1970 to 2140	45	45	45			
$2{,}50 < d \leq 2{,}70$		1640 to 1790	1720 to 1870	1950 to 2120						
$2{,}70 < d \leq 3{,}00$		1620 to 1770	1700 to 1850	1930 to 2100						
$3{,}00 < d \leq 3{,}20$	± 0,030	1600 to 1750	1680 to 1830	1910 to 2080						
$3{,}20 < d \leq 3{,}50$		1580 to 1730	1660 to 1810	1900 to 2060	42	42	42			
$3{,}50 < d \leq 4{,}00$		1550 to 1700	1620 to 1770	1870 to 2030						

Table 4 — Mechanical and technological properties and quality requirements for wire grades FDC, FDCrV and FDSiCr (continued)

1	2	3	4	5	6	7	8	9	10	11
Nominal wire diameter (mm)	Permissible deviations mm	Tensile strength R_m			Minimum reduction in area after fracture Z for wire grades			Minimum number of torsions for wire grades [a]		
		FDC [b] MPa	FDCrV [b] MPa	FDSiCr [b] MPa	FDC %	FDCrV %	FDSiCr %	FDC	FDCrV	FDSiCr
$4,00 < d \leq 4,20$	± 0,035	1540 to 1690	1610 to 1760	1860 to 2020	40	40	40	To be agreed upon	To be agreed upon	To be agreed upon
$4,20 < d \leq 4,50$		1520 to 1670	1590 to 1740	1850 to 2000						
$4,50 < d \leq 4,70$		1510 to 1660	1580 to 1730	1840 to 1990						
$4,70 < d \leq 5,00$		1500 to 1650	1560 to 1710	1830 to 1980						
$5,00 < d \leq 5,60$		1470 to 1620	1540 to 1690	1800 to 1950	38	38	38			
$5,60 < d \leq 6,00$	± 0,040	1460 to 1610	1520 to 1670	1780 to 1930						
$6,00 < d \leq 6,50$		1440 to 1590	1510 to 1660	1760 to 1910	35	35	35			
$6,50 < d \leq 7,00$		1430 to 1580	1500 to 1650	1740 to 1890						
$7,00 < d \leq 8,00$	± 0,045	1400 to 1550	1480 to 1630	1710 to 1860						
$8,00 < d \leq 8,50$		1380 to 1530	1470 to 1620	1700 to 1850	32	32	32			
$8,50 < d \leq 10,00$	± 0,050	1360 to 1510	1450 to 1600	1660 to 1810						
$10,00 < d \leq 12,00$	± 0,070	1320 to 1470	1430 to 1580	1620 to 1770	30	30	30			
$12,00 < d \leq 14,00$	± 0,080	1280 to 1430	1420 to 1570	1580 to 1730						
$14,00 < d \leq 15,00$		1270 to 1420	1410 to 1560	1570 to 1720	-	-	-			
$15,00 < d \leq 17,00$	± 0,090	1250 to 1400	1400 to 1550	1550 to 1700						

[a] Requirements for torsions are for $d \geq 0,70$ mm.

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

Table 5 — Mechanical and technological properties and quality requirements for wire grades TDC, TDCrV, TDSiCr, VDC, VDCrV and VDSiCr

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Nominal wire diameter (mm)	Permissible deviations mm	Tensile strength R_m for wire grades			Minimum reduction in area after fracture Z for wire grades			Minimum number of torsions for wire grades [a]					
		TDC [b] VDC MPa	TDCrV [b] VDCrV MPa	TDSiCr [b] VDSiCr MPa	TDC VDC %	TDCrV VDCrV %	TDSiCr VDSiCr %	TDC VDC		TDCrV VDCrV		TDSiCr VDSiCr	
								right	left	right	left	right	left
$d \leq 0{,}50$		1850 to 2000	1910 to 2060	2080 to 2230				-	-	-	-	-	-
$0{,}50 < d \leq 0{,}60$	± 0,010	1850 to 2000	1910 to 2060	2080 to 2230	-	-	-						
$0{,}60 < d \leq 0{,}80$		1850 to 2000	1910 to 2060	2080 to 2230				6	24	6	12	6	0
$0{,}80 < d \leq 1{,}00$	± 0,015	1850 to 1950	1910 to 2060	2080 to 2230									
$1{,}00 < d \leq 1{,}30$		1750 to 1850	1860 to 2010	2080 to 2230									
$1{,}30 < d \leq 1{,}40$	± 0,020	1700 to 1800	1820 to 1970	2060 to 2210				6	16	6	8	5	0
$1{,}40 < d \leq 1{,}60$		1700 to 1800	1820 to 1970	2060 to 2210									
$1{,}60 < d \leq 2{,}00$		1670 to 1770	1770 to 1920	2010 to 2160	50	50	50						
$2{,}00 < d \leq 2{,}50$	± 0,025	1630 to 1730	1720 to 1860	1960 to 2100				6	14				
$2{,}50 < d \leq 2{,}70$		1600 to 1700	1670 to 1810	1910 to 2010					12				
$2{,}70 < d \leq 3{,}00$		1600 to 1700	1670 to 1810	1910 to 2010									
$3{,}00 < d \leq 3{,}20$	± 0,030	1570 to 1670	1670 to 1770	1910 to 2010						6	4	4	0
$3{,}20 < d \leq 3{,}50$		1570 to 1670	1670 to 1770	1910 to 2010				6	10				
$3{,}50 < d \leq 4{,}00$		1550 to 1650	1620 to 1720	1860 to 1960									
$4{,}00 < d \leq 4{,}20$	± 0,035	1550 to 1650	1570 to 1670	1860 to 1960	45	45	45	6	8				
$4{,}20 < d \leq 4{,}50$		1550 to 1650	1570 to 1670	1860 to 1960									

Table 5 — Mechanical and technological properties and quality requirements for wire grades TDC, TDCrV, TDSiCr, VDC, VDCrV and VDSiCr (continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Nominal wire diameter (mm)	Permissible deviations mm	Tensile strength R_m for wire grades			Minimum reduction in area after fracture Z for wire grades			Minimum number of torsions for wire grades [a]					
		TDC [b] VDC MPa	TDCrV [b] VDCrV MPa	TDSiCr [b] VDSiCr MPa	TDC VDC %	TDCrV VDCrV %	TDSiCr VDSiCr %	TDC VDC		TDCrV VDCrV		TDSiCr VDSiCr	
								right	left	right	left	right	left
$4,50 < d \leq 4,70$	± 0,035	1540 to 1640	1570 to 1670	1810 to 1910	45	45	45	6	6	6	4	3	0
$4,70 < d \leq 5,00$		1540 to 1640	1570 to 1670	1810 to 1910									
$5,00 < d \leq 5,60$		1520 to 1620	1520 to 1620	1810 to 1910									
$5,60 < d \leq 6,00$	± 0,040	1520 to 1620	1520 to 1620	1760 to 1860				6	4				
$6,00 < d \leq 6,50$		1470 to 1570	1470 to 1570	1760 to 1860	40		40						
$6,50 < d \leq 7,00$		1470 to 1570	1470 to 1570	1710 to 1810		40							
$7,00 < d \leq 8,00$	± 0,045	1420 to 1520	1420 to 1520	1710 to 1810				-	-	-	-	-	-
$8,00 < d \leq 9,00$		1390 to 1490	1390 to 1490	1670 to 1770	38		35						
$9,00 < d \leq 10,00$	± 0,050	1390 to 1490	1390 to 1490	1670 to 1770									

[a] Requirements for torsions are for $d \geq 0,70$ mm

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

6.6 Technological properties

6.6.1 Coiling test

In order to assess the uniformity of the wire in the coiling deformation and its surface condition the coiling test may be carried out on samples up to 0,70 mm diameter.

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

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.

6.6.2 Torsion test

The torsion test is carried out for assessing deformability, fracture behaviour and surface condition for sizes from 0,70 mm to 6,00 mm. The wires grades 'VD' and 'TD' shall satisfy the minimum requirements of Table 5.

The fracture of the torsion test piece shall be smooth and perpendicular to the wire axis. The fracture shall be type 1a as per EN 10218-1. The rupture shall show no longitudinal cracks.

For the grade 'FD' wire the torsion test is applied for sizes from 0,70 mm to 6,00 mm. The test piece shall be twisted in one direction until fracture. The fracture shall show a flat surface type 1a or 3a according to EN 10218-1:1994.

Minimum values for the numbers of torsions required for grade 'FD' may be agreed at the time of order.

6.7 Surface quality

6.7.1 The surface of the wire shall be smooth and permissible depth of surface defects at the coil ends shall be in accordance with Table 6.

By in-line control of surface defects the areas of the coil with defects above the level of Table 7 shall be marked. In-line testing is not performed for FD-grades.

The number of defective parts that can be tolerated may be agreed between the parties.

Table 6 — Permissible depth of surface defects (mm)

Wire grade	VD	TD	FD
C	0,005 *d*	0,008 *d*	0,010 *d*
CrV	0,007 *d*	0,008 *d*	0,010 *d*
SiCr	0,010 *d*	0,013 *d*	0,015 *d*

Table 7 — Permissible surface defects by in-line control

Diameter range		Max. depth of defect [a]	
From	Up to but not included	VD	TD
2,50 mm	5,00 mm	40µm	60µm
5,00 mm	6,00 mm	50µm	60µm
6,00 mm	8,00 mm	60µm	0,01d
[a] Other values may be agreed at the time of enquiry and order.			

6.7.2 Surface decarburization

The wire grades according to this standard shall be free from total decarburization. The maximum depths of the partially decarburized zone shall be checked at the end of the coils. The permissible depth is shown in Table 8.

Table 8 — Permissible depth of surface decarburization (mm)

Wire grade	VD	TD	FD
C	0,005 *d*	0,008 *d*	0,010 *d*
CrV	0,007 *d*	0,008 *d*	0,010 *d*
SiCr	0,010 *d*	0,013 *d*	0,015 *d*

6.8 Dimensions and dimensional tolerances

6.8.1 Dimensional tolerances

— Wire in coils

The tolerances level for the wire diameter is based on EN 10218-2:1996 level:

–T5 for wire diameter up to and including 0,80 mm;

–T4 for 0,80 mm up to 10,00 mm;

–T3 above 10,00 mm.

— Wire in 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 9).

Table 9 — Tolerances on the length of cut lengths

Nominal length L (mm)	Tolerance (mm)	
	Class 1	Class 2
$L \leq 300$	+ 1,0 mm 0 mm	
$300 < L \leq 1000$	+ 2,0 mm 0 mm	+1% 0%
$1000 < L$	+ 0,2% 0%	

6.8.2 Out of roundness

The out of roundness, i.e. 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 Tables 4 and 5.

7 Testing and inspection

7.1 Inspection and inspection documents

Products according 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.

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;

— results of optional tests agreed.

7.2 Extent of testing for specific inspection

The extent of testing shall be in accordance with Table 11.

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 11/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.

7.4.4 Torsion test

The torsion test shall be carried out on a test piece of 300 mm in length. The test piece shall be clamped in the devices in such a manner that its longitudinal axis is aligned to the axis of the clamping heads and remains straight during the test under a force corresponding to 1 % of the maximal force (F_m). One clamping head is turned at a uniform speed of rotation, not exceeding the following maximum speeds.

The maximum speed for carrying out the torsion test shall be:

for diameter below 1,00 mm	60 turns/min
1,00 mm $\leq d <$ 3,00 mm	30 turns/min
3,00 mm $\leq d$	15 turns/min

For the grade 'FD' the test is continued in one direction until fracture. For wire grades 'TD' and 'VD' the test piece is first twisted in one direction - the number of twists indicated in Table 5 - and is then twisted in the other direction until fracture.

7.4.5 Surface defects

Testing for surface defects shall be carried out on test pieces taken from both ends of the wire units either by deep etching or microscopically, using polished metallographic sections. It may be agreed for wire diameters below 2,00 mm at the time of enquiry and ordering that microscopic testing be carried out immediately after the last heat treatment.

The deep etch test shall be executed according to EN 10218-1 or alternatively by the following method :

The section of the wire to be tested shall be first suitably degreased, followed by etching using a solution of 50 volume % hydrochloric acid and 50 volume % water, heated to $\binom{75+5}{0}$ °C, until the diameter has been reduced by about 1 % with a maximum of 0,03 mm. If surface defects are detected, their depth shall be determined using, for example polished section, or by the stylus method. Cases of dispute shall be settled on the basis of the radial depth measured at a magnification of x 200.

For the grades of the type 'TD' and 'VD' in the diameter range 2,50 mm to 8,00 mm the total length of the coil shall be tested in line by an appropriate non-destructive test. All the areas with defects above the allowable level as shown in Table 7 shall be clearly and permanently marked.

7.4.6 Decarburization

The depth of decarburization shall be inspected by metallographic means. The test pieces are taken at the ends of the wire unit. Evaluation shall be performed on the transverse section of test pieces etched with nital and under magnification of x 200 in accordance with EU 104.

7.4.7 Diameter

The diameter shall be measured using limit gauges, a micrometer or any suitable method. The out of roundness shall be determined as the difference between the maximum and minimum diameters at any one cross-section.

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 at least the information according to Table 10. Other information shall be subject to an arrangement between the parties.

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

Table 10 — Information on the labels [a]

Wire grade	VD	TD	FD
Designation	+	+	+
Manufacturer	+	+	+
Nominal diameter	+	+	+
Spring wire grade	+	+	+
Cast number	+	+	(+)
Identification number	+	+	(+)

[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 11 — Extent of testing and sampling for specific inspection and summary of the information on test procedures 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 acc. to	Requirements see.....
1	Product analysis	All	o [b]	Quantity Supplied per heat	1	1	1	As per ISO 14284	7.4.1	6.3 [b]
2	Tensile test *Rm* *Z*	All > 1 mm	m	Quantity coils supplied per production batch [d]	10 %[c]	1	1	Test pieces taken from the ends of coils	7.4.2	6.5 [d]
3	Coiling test	All ≤ 0,70 mm	o		The scope of testing shall be agreed on ordering				7.4.3	6.6.1
4	Torsion test [e]	VD, TD FD	m o						7.4.4	6.6.2
5	Non metallic inclusion	VD TD	m o						ENV 10247	6.4
6	Testing for surface defects	FD TD, VD	o m						7.4.5	6.7.1
7	Testing for decarburization	FD TD, VD	o m						7.4.6	6.7.2
8	Check on dimensions	All	m		100 %	1	1		7.4.7	6.8

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

[b] The results of the heat analysis for the elements listed in Table 2 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.

[e] Only for diameters over 0,70 and up to 6,00 mm.

Annex A (informative)
Additional information

A.1 Modulus of elasticity and shear modulus at room temperature

The modulus of elasticity is assumed to be 206 GPa and the shear modulus 79,5 GPa.