

# Steel wire for mechanical springs —

## Part 2: Oil hardened and tempered spring steel wire

The European Standard EN 10270-2:2001 has the status of a  
British Standard

ICS 77.140.25

# National foreword

This British Standard is the official English language version of EN 10270-2:2001. It supersedes BS 2803:1980 which is withdrawn.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.

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

## Cross-references

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## Summary of pages

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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 19 February 2001.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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of an identical text or by endorsement, at the latest by October 2001, and conflicting national standards shall be withdrawn at the latest by October 2001.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

## 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<sup>1)</sup>, *Determination of the decarburization depth of unalloyed and low alloyed structural steels*.

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<sup>1)</sup> 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 a 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**

| <b>Tensile strength</b> | <b>Static</b> | <b>Medium fatigue</b> | <b>High fatigue</b> |
|-------------------------|---------------|-----------------------|---------------------|
| Low tensile strength    | FDC           | TDC                   | VDC                 |
| Medium tensile strength | FDCrV         | TDCrV                 | VDCrV               |
| High tensile strength   | FDSiCr        | TDSiCr                | VDSiCr              |
| Diameter range (mm)     | 0,50 to 17,00 | 0,50 to 10,00         | 0,50 to 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 the 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 <sup>a</sup> | 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    | <sup>b</sup> |           |
| 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    | <sup>b</sup> |           |
| 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    | <sup>b</sup> |           |
| 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    |           |
| <sup>a</sup> Manganese may be ordered with restricted range, but with a minimum range of 0,20 %<br><sup>b</sup> 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          | $\pm 0,03$                       |
| Si               | SiCr         | $\pm 0,05$                       |
|                  | Other grades | $\pm 0,03$                       |
| Mn               | All          | $\pm 0,04$                       |
| P                | All          | $+ 0,005$                        |
| S                | All          | $+ 0,005$                        |
| Cu               | All          | $+ 0,02$                         |
| Cr               | All          | $\pm 0,05$                       |
| V                | All          | $\pm 0,02$                       |

**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 <sup>a</sup> |       |        |
|                          |                           | FDC <sup>b</sup><br>MPa | FDCrV <sup>b</sup><br>MPa | FDSiCr <sup>b</sup><br>MPa | FDC<br>%                                                     | FDCrV<br>% | FDSiCr<br>% | FDC                                                     | FDCrV | FDSiCr |
| $d = 0,50$               | ± 0,010                   | 1 900 to 2 100          | 2 000 to 2 200            | 2 100 to 2 300             | —                                                            | —          | —           | —                                                       | —     | —      |
| $0,50 < d \leq 0,60$     |                           | 1 900 to 2 100          | 2 000 to 2 200            | 2 100 to 2 300             |                                                              |            |             |                                                         |       |        |
| $0,60 < d \leq 0,80$     |                           | 1 900 to 2 100          | 2 000 to 2 200            | 2 100 to 2 300             |                                                              |            |             |                                                         |       |        |
| $0,80 < d \leq 1,00$     | ± 0,015                   | 1 860 to 2 060          | 1 960 to 2 160            | 2 100 to 2 300             |                                                              |            |             | To be agreed upon                                       |       |        |
| $1,00 < d \leq 1,30$     | ± 0,020                   | 1 810 to 2 010          | 1 900 to 2 100            | 2 070 to 2 260             |                                                              |            |             |                                                         |       |        |
| $1,30 < d \leq 1,40$     |                           | 1 790 to 1 970          | 1 870 to 2 070            | 2 060 to 2 250             |                                                              |            |             |                                                         |       |        |
| $1,40 < d \leq 1,60$     |                           | 1 760 to 1 940          | 1 840 to 2 030            | 2 040 to 2 220             |                                                              |            |             |                                                         |       |        |
| $1,60 < d \leq 2,00$     | ± 0,025                   | 1 720 to 1 890          | 1 790 to 1 970            | 2 000 to 2 180             |                                                              |            |             |                                                         |       |        |
| $2,00 < d \leq 2,50$     |                           | 1 670 to 1 820          | 1 750 to 1 900            | 1 970 to 2 140             |                                                              |            |             |                                                         |       |        |
| $2,50 < d \leq 2,70$     |                           | 1 640 to 1 790          | 1 720 to 1 870            | 1 950 to 2 120             |                                                              |            |             |                                                         |       |        |
| $2,70 < d \leq 3,00$     | ± 0,030                   | 1 620 to 1 770          | 1 700 to 1 850            | 1 930 to 2 100             |                                                              |            |             |                                                         |       |        |
| $3,00 < d \leq 3,20$     |                           | 1 600 to 1 750          | 1 680 to 1 830            | 1 910 to 2 080             |                                                              |            |             |                                                         |       |        |
| $3,20 < d \leq 3,50$     |                           | 1 580 to 1 730          | 1 660 to 1 810            | 1 900 to 2 060             |                                                              |            |             |                                                         |       |        |
| $3,50 < d \leq 4,00$     |                           | 1 550 to 1 700          | 1 620 to 1 770            | 1 870 to 2 030             | 42                                                           | 42         | 42          |                                                         |       |        |

**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<br>mm                                      | Permissible deviations<br>mm | Tensile strength $R_m$  |                          |                            | Minimum reduction in area after fracture $Z$ for wire grades |           |             | Minimum number of torsions for wire grades <sup>a</sup> |                   |                   |
|                                                                  |                              | FDC <sup>b</sup><br>MPa | FDCV <sup>b</sup><br>MPa | FDSICr <sup>b</sup><br>MPa | FDC<br>%                                                     | FDCV<br>% | FDSICr<br>% | FDC                                                     | FDCV              | FDSICr            |
| 4,00 < $d \leq$ 4,20                                             | ± 0,035                      | 1 540 to 1 690          | 1 610 to 1 760           | 1 860 to 2 020             | 40                                                           | 40        | 40          | To be agreed upon                                       | To be agreed upon | To be agreed upon |
| 4,20 < $d \leq$ 4,50                                             |                              | 1 520 to 1 670          | 1 590 to 1 740           | 1 850 to 2 000             |                                                              |           |             |                                                         |                   |                   |
| 4,50 < $d \leq$ 4,70                                             |                              | 1 510 to 1 660          | 1 580 to 1 730           | 1 840 to 1 990             |                                                              |           |             |                                                         |                   |                   |
| 4,70 < $d \leq$ 5,00                                             |                              | 1 500 to 1 650          | 1 560 to 1 710           | 1 830 to 1 980             |                                                              |           |             |                                                         |                   |                   |
| 5,00 < $d \leq$ 5,60                                             | ± 0,040                      | 1 470 to 1 620          | 1 540 to 1 690           | 1 800 to 1 950             | 38                                                           | 38        | 38          | To be agreed upon                                       | To be agreed upon | To be agreed upon |
| 5,60 < $d \leq$ 6,00                                             |                              | 1 460 to 1 610          | 1 520 to 1 670           | 1 780 to 1 930             |                                                              |           |             |                                                         |                   |                   |
| 6,00 < $d \leq$ 6,50                                             |                              | 1 440 to 1 590          | 1 510 to 1 660           | 1 760 to 1 910             |                                                              |           |             |                                                         |                   |                   |
| 6,50 < $d \leq$ 7,00                                             |                              | 1 430 to 1 580          | 1 500 to 1 650           | 1 740 to 1 890             |                                                              |           |             |                                                         |                   |                   |
| 7,00 < $d \leq$ 8,00                                             | ± 0,045                      | 1 400 to 1 550          | 1 480 to 1 630           | 1 710 to 1 860             | 35                                                           | 35        | 35          | To be agreed upon                                       | To be agreed upon | To be agreed upon |
| 8,00 < $d \leq$ 8,50                                             |                              | 1 380 to 1 530          | 1 470 to 1 620           | 1 700 to 1 850             |                                                              |           |             |                                                         |                   |                   |
| 8,50 < $d \leq$ 10,00                                            |                              | 1 360 to 1 510          | 1 450 to 1 600           | 1 660 to 1 810             |                                                              |           |             |                                                         |                   |                   |
| 10,00 < $d \leq$ 12,00                                           |                              | 1 320 to 1 470          | 1 430 to 1 580           | 1 620 to 1 770             |                                                              |           |             |                                                         |                   |                   |
| 12,00 < $d \leq$ 14,00                                           | ± 0,080                      | 1 280 to 1 430          | 1 420 to 1 570           | 1 580 to 1 730             | 30                                                           | 30        | 30          | To be agreed upon                                       | To be agreed upon | To be agreed upon |
| 14,00 < $d \leq$ 15,00                                           |                              | 1 270 to 1 420          | 1 410 to 1 560           | 1 570 to 1 720             |                                                              |           |             |                                                         |                   |                   |
| 15,00 < $d \leq$ 17,00                                           |                              | 1 250 to 1 400          | 1 400 to 1 550           | 1 550 to 1 700             |                                                              |           |             |                                                         |                   |                   |
|                                                                  |                              | ± 0,090                 |                          |                            |                                                              |           |             |                                                         |                   |                   |
| <sup>a</sup> Requirements for torsions are for $d \geq 0,70$ mm. |                              |                         |                          |                            |                                                              |           |             |                                                         |                   |                   |
| <sup>b</sup> 1 MPa = 1 N/mm <sup>2</sup> .                       |                              |                         |                          |                            |                                                              |           |             |                                                         |                   |                   |

<sup>a</sup> Requirements for torsions are for  $d \geq 0,70$  mm.

<sup>b</sup> 1 MPa = 1 N/mm<sup>2</sup>

**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<br>mm | Permissible deviations<br>mm | Tensile strength $R_m$ for wire grades |                                    |                                      | Minimum reduction in area after fracture $Z$<br>for wire grades |                     |                       | Minimum number of torsions for wire grades <sup>a</sup> |                                |                                  |    |    |    |    |   |   |
|                             |                              | TDC <sup>b</sup><br>VDC<br>MPa         | TDCrV <sup>b</sup><br>VDCrV<br>MPa | TDSiCr <sup>b</sup><br>VDSiCr<br>MPa | TDC<br>VDC<br>%                                                 | TDCrV<br>VDCrV<br>% | TDSiCr<br>VDSiCr<br>% | TDC<br>VDC<br>right   left                              | TDCrV<br>VDCrV<br>right   left | TDSiCr<br>VDSiCr<br>right   left |    |    |    |    |   |   |
| $d = 0,50$                  |                              | 1 850 to 2 000                         | 1 910 to 2 060                     | 2 080 to 2 230                       | —                                                               | —                   | —                     | —                                                       | —                              | —                                | —  | —  | —  |    |   |   |
| $0,50 < d \leq 0,60$        | $\pm 0,010$                  | 1 850 to 2 000                         | 1 910 to 2 060                     | 2 080 to 2 230                       |                                                                 |                     |                       |                                                         |                                |                                  |    |    |    |    |   |   |
| $0,60 < d \leq 0,80$        |                              | 1 850 to 2 000                         | 1 910 to 2 060                     | 2 080 to 2 230                       |                                                                 |                     |                       |                                                         |                                |                                  | 6  | 24 | 6  | 12 | 6 | 0 |
| $0,80 < d \leq 1,00$        | $\pm 0,015$                  | 1 850 to 1 950                         | 1 910 to 2 060                     | 2 080 to 2 230                       |                                                                 |                     |                       |                                                         |                                |                                  |    |    |    |    |   |   |
| $1,00 < d \leq 1,30$        |                              | 1 750 to 1 850                         | 1 860 to 2 010                     | 2 080 to 2 230                       | 50                                                              | 50                  | 50                    |                                                         |                                |                                  |    |    |    |    |   |   |
| $1,30 < d \leq 1,40$        | $\pm 0,020$                  | 1 700 to 1 800                         | 1 820 to 1 970                     | 2 060 to 2 210                       |                                                                 |                     |                       |                                                         |                                |                                  | 6  | 16 | 6  | 8  | 5 | 0 |
| $1,40 < d \leq 1,60$        |                              | 1 700 to 1 800                         | 1 820 to 1 970                     | 2 060 to 2 210                       |                                                                 |                     |                       |                                                         |                                |                                  |    |    |    |    |   |   |
| $1,60 < d \leq 2,00$        |                              | 1 670 to 1 770                         | 1 770 to 1 920                     | 2 010 to 2 160                       |                                                                 |                     |                       |                                                         |                                |                                  |    |    |    |    |   |   |
| $2,00 < d \leq 2,50$        | $\pm 0,025$                  | 1 630 to 1 730                         | 1 720 to 1 860                     | 1 960 to 2 100                       | 50                                                              | 50                  | 50                    | 6                                                       | 14                             | 6                                | 4  | 4  | 0  |    |   |   |
| $2,50 < d \leq 2,70$        |                              | 1 600 to 1 700                         | 1 670 to 1 810                     | 1 910 to 2 010                       |                                                                 |                     |                       |                                                         | 12                             |                                  |    |    |    |    |   |   |
| $2,70 < d \leq 3,00$        |                              | 1 600 to 1 700                         | 1 670 to 1 810                     | 1 910 to 2 010                       |                                                                 |                     |                       |                                                         |                                |                                  |    |    |    |    |   |   |
| $3,00 < d \leq 3,20$        | $\pm 0,030$                  | 1 570 to 1 670                         | 1 670 to 1 770                     | 1 910 to 2 010                       |                                                                 |                     |                       |                                                         |                                |                                  |    |    |    |    |   |   |
| $3,20 < d \leq 3,50$        |                              | 1 570 to 1 670                         | 1 670 to 1 770                     | 1 910 to 2 010                       | 45                                                              | 45                  | 45                    | 6                                                       | 10                             | 6                                | 4  | 4  | 0  |    |   |   |
| $3,50 < d \leq 4,00$        |                              | 1 550 to 1 650                         | 1 620 to 1 720                     | 1 860 to 1 960                       |                                                                 |                     |                       |                                                         |                                |                                  |    |    |    |    |   |   |
| $4,00 < d \leq 4,20$        | $\pm 0,035$                  | 1 550 to 1 650                         | 1 570 to 1 670                     | 1 860 to 1 960                       |                                                                 |                     |                       |                                                         |                                |                                  |    |    |    |    |   |   |
| $4,20 < d \leq 4,50$        |                              | 1 550 to 1 650                         | 1 570 to 1 670                     | 1 860 to 1 960                       |                                                                 |                     |                       |                                                         |                                |                                  |    |    |    |    |   |   |

**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<br>mm | Permissible deviations<br>mm | Tensile strength $R_m$ for wire grades |                                    |                                      | Minimum reduction in area after fracture $Z$<br>for wire grades |                     |                       | Minimum number of torsions for wire grades <sup>a</sup> |                    |                         |                        |                           |                          |
|                             |                              | TDC <sup>b</sup><br>VDC<br>MPa         | TDCrV <sup>b</sup><br>VDCrV<br>MPa | TDSiCr <sup>b</sup><br>VDSiCr<br>MPa | TDC<br>VDC<br>%                                                 | TDCrV<br>VDCrV<br>% | TDSiCr<br>VDSiCr<br>% | TDC<br>VDC<br>right                                     | TDC<br>VDC<br>left | TDCrV<br>VDCrV<br>right | TDCrV<br>VDCrV<br>left | TDSiCr<br>VDSiCr<br>right | TDSiCr<br>VDSiCr<br>left |
|                             |                              |                                        |                                    |                                      |                                                                 |                     |                       |                                                         |                    |                         |                        |                           |                          |
| 4,50 < $d \leq$ 4,70        | ± 0,035                      | 1 540 to 1 640                         | 1 570 to 1 670                     | 1 810 to 1 910                       | 45                                                              | 45                  | 45                    | 6                                                       | 6                  | 6                       | 4                      | 3                         | 0                        |
| 4,70 < $d \leq$ 5,00        |                              | 1 540 to 1 640                         | 1 570 to 1 670                     | 1 810 to 1 910                       |                                                                 |                     |                       | 6                                                       | 6                  | 6                       |                        |                           |                          |
| 5,00 < $d \leq$ 5,60        |                              | 1 520 to 1 620                         | 1 520 to 1 620                     | 1 810 to 1 910                       | 40                                                              | 40                  | 40                    | 6                                                       | 4                  |                         |                        |                           |                          |
| 5,60 < $d \leq$ 6,00        |                              | 1 520 to 1 620                         | 1 520 to 1 620                     | 1 760 to 1 860                       |                                                                 |                     |                       |                                                         |                    |                         |                        |                           |                          |
| 6,00 < $d \leq$ 6,50        | ± 0,040                      | 1 470 to 1 570                         | 1 470 to 1 570                     | 1 760 to 1 860                       | 40                                                              | 40                  | 40                    |                                                         | —                  | —                       | —                      | —                         | —                        |
| 6,50 < $d \leq$ 7,00        |                              | 1 470 to 1 570                         | 1 470 to 1 570                     | 1 710 to 1 810                       |                                                                 |                     |                       |                                                         |                    |                         |                        |                           |                          |
| 7,00 < $d \leq$ 8,00        | ± 0,045                      | 1 420 to 1 520                         | 1 420 to 1 520                     | 1 710 to 1 810                       | 38                                                              |                     | 35                    | —                                                       | —                  | —                       | —                      | —                         | —                        |
| 8,00 < $d \leq$ 9,00        |                              | 1 390 to 1 490                         | 1 390 to 1 490                     | 1 670 to 1 770                       |                                                                 |                     |                       |                                                         |                    |                         |                        |                           |                          |
| 9,00 < $d \leq$ 10,00       | ± 0,050                      | 1 390 to 1 490                         | 1 390 to 1 490                     | 1 670 to 1 770                       |                                                                 |                     |                       |                                                         |                    |                         |                        |                           |                          |

<sup>a</sup> Requirements for torsions are for  $d \geq 0,70$  mm

<sup>b</sup> 1 MPa = 1 N/mm<sup>2</sup>.

## 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 of up to 0,70 mm in 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 <i>d</i> | 0,008 <i>d</i> | 0,010 <i>d</i> |
| CrV        | 0,007 <i>d</i> | 0,008 <i>d</i> | 0,010 <i>d</i> |
| SiCr       | 0,010 <i>d</i> | 0,013 <i>d</i> | 0,015 <i>d</i> |

**Table 7 — Permissible surface defects by in-line control**

| Diameter range                                                            |                        | Max. depth of defect <sup>a</sup> |               |
|---------------------------------------------------------------------------|------------------------|-----------------------------------|---------------|
| From                                                                      | Up to but not included | VD                                | TD            |
| 2,50 mm                                                                   | 5,00 mm                | 40 µm                             | 60 µm         |
| 5,00 mm                                                                   | 6,00 mm                | 50 µm                             | 60 µm         |
| 6,00 mm                                                                   | 8,00 mm                | 60 µm                             | 0,01 <i>d</i> |
| <sup>a</sup> 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 <i>d</i> | 0,008 <i>d</i> | 0,010 <i>d</i> |
| CrV        | 0,007 <i>d</i> | 0,008 <i>d</i> | 0,010 <i>d</i> |
| SiCr       | 0,010 <i>d</i> | 0,013 <i>d</i> | 0,015 <i>d</i> |

## 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 $L$<br>mm | Tolerance<br>mm  |             |
|--------------------------|------------------|-------------|
|                          | Class 1          | Class 2     |
| $L \leq 300$             | + 1,0 mm<br>0 mm | +1 %<br>0 % |
| $300 < L \leq 1000$      | + 2,0 mm<br>0 mm |             |
| $1000 < L$               | + 0,2 %<br>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; |
| $1,00 \text{ mm} \leq d < 3,00 \text{ mm}$ | 30 turns/min; |
| $3,00 \text{ mm} \leq d$                   | 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  $\left( \begin{smallmatrix} 75+5 \\ 0 \end{smallmatrix} \right) ^\circ\text{C}$ , 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  $\times 200$ .

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  $\times 200$  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 <sup>a</sup>**

| Wire grade                                                                                                                                                                 | VD | TD | FD  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|-----|
| Designation                                                                                                                                                                | +  | +  | +   |
| Manufacturer                                                                                                                                                               | +  | +  | +   |
| Nominal diameter                                                                                                                                                           | +  | +  | +   |
| Spring wire grade                                                                                                                                                          | +  | +  | +   |
| Cast number                                                                                                                                                                | +  | +  | (+) |
| Identification number                                                                                                                                                      | +  | +  | (+) |
| <sup>a</sup> The symbols in the table mean:<br>+: The information shall be mentioned on the labels;<br>(+): 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 | <sup>a</sup>   | 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 subclause | Requirements, see subclause |
| 1 | Product analysis            | All                    | o <sup>b</sup> | Quantity supplied per heat                                | 1                                                | 1                             | 1                                | As per ISO 14284                             | 7.4.1                                       | 6.3 <sup>b</sup>            |
| 2 | Tensile test $R_m$<br>$Z$   | All<br><br>> 1 mm      | m              | Quantity coils supplied per production batch <sup>d</sup> | 10 % <sup>c</sup>                                | 1                             | 1                                | Test pieces taken from the ends of the coils | 7.4.2                                       | 6.5 <sup>d</sup>            |
| 3 | Coiling test                | All<br><br>≤ 0,70 mm   | o              |                                                           | The scope of testing shall be agreed on ordering |                               |                                  |                                              | 7.4.3                                       | 6.6.1                       |
| 4 | Torsion test <sup>e</sup>   | VD, TD<br>FD           | m<br>o         |                                                           |                                                  |                               |                                  |                                              | 7.4.4                                       | 6.6.2                       |
| 5 | Non metallic inclusion      | VD<br>TD               | m<br>o         |                                                           |                                                  |                               |                                  |                                              | ENV 10247                                   | 6.4                         |
| 6 | Testing for surface defects | FD<br>TD, VD           | o<br>m         | The scope of testing shall be agreed on ordering          |                                                  |                               |                                  | 7.4.5                                        | 6.7.1                                       |                             |
| 7 | Testing for decarburization | FD<br>TD, VD           | o<br>m         |                                                           |                                                  |                               |                                  | 7.4.6                                        | 6.7.2                                       |                             |
| 8 | Check on dimensions         | All                    | m              |                                                           |                                                  |                               |                                  | 100 %                                        | 1                                           | 1                           |

<sup>a</sup> 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.

<sup>b</sup> 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.

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

<sup>d</sup> 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.

<sup>e</sup> Only for diameters over 0,70 and up to 6,00 mm.

<sup>a</sup> 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.

<sup>b</sup> 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.

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<sup>e</sup> 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.

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