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Stainless steel wire and strip for springs

Technical delivery conditions

DIN 17 224

Federdraht und Federband aus nichtrostenden Stählen; technische Lieferbedingungen

Supersedes July 1968 edition

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

1 Field of application

1.1 This standard applies to the stainless steels listed in table 1. These steels are commonly used in the form of work-hardened wire up to about 10 mm in diameter or of strip up to about 1,6 mm thick for the manufacture of springs and sprung components which are to be exposed to corrosive agents and occasionally to slightly elevated temperatures (see clause A.1). It does not, however, apply to flat products rolled from wire, known as flat wire.

1.2 Some of the steel grades covered by DIN 17 440 are also used for springs in addition to those listed in table 1, although to a substantially lesser degree.

1.3 Thickness ranges and diameter ranges other than those referred to in subclause 1.1 may be agreed upon at the time of ordering.

1.4 The general technical delivery conditions as specified in DIN 17 010 shall also apply to products supplied in accordance with this standard.

2 Concept

Steels which are particularly resistant to chemically aggressive agents are considered to be **stainless steels**; they generally have a chromium content of not less than 12 %.

The **stainless spring steels** covered by this standard, however, have a chromium content of not less than 16 % and a nickel content of not less than 6,0 %, since the resistance to corrosion required for the products specified in this standard can only be achieved with contents of alloying elements upwards of these minimum levels. Their spring capacity is achieved by means of work hardening and/or heat treatment.

3 Dimensions and permissible dimensional deviations

3.1 Unless otherwise agreed at the time of ordering, dimensional accuracy class C as defined in DIN 2076 shall apply for wire.

3.2 DIN 59 381 shall apply for strip, unless otherwise particularly agreed.

3.3 Unless otherwise agreed at the time of ordering, cold rolled steel strip for springs is supplied with sheared edges (GK). The strip may also, by particular agreement, be supplied with mill edges (NK), or special edges (SK), e.g. with deburred or rolled round edges.

4 Calculation of mass

The nominal mass of steels X 12 CrNi 17 7 (1.4310) and X 7 CrNiAl 17 7 (1.4568) shall be calculated on the basis of a density of 7,90 kg/dm^3, the nominal mass of steel X 5 CrNiMo 18 10 (1.4401) shall be calculated on the basis of a density of 7,95 kg/dm^3.

5 Designations

5.1 Designations of steel grades

The designations of the steel grades have been formulated in accordance with subclause 2.1.2.2 of the Explanatory notes to *DIN-Normenheft* (DIN Standards Booklet) 3, and the material numbers have been formulated in accordance with DIN 17 007 Part 2.

5.2 Designation to be used on ordering

The order shall state the quantity, the product form, the dimensional standard, the designation or material number of the steel grade required, the condition on delivery (see subclause 7.2.2), the number of this standard, the dimensions and, if required, the edge condition (see subclause 3.3).

The designation used on ordering shall be formulated in accordance with the examples given in the dimensional standards.

6 Classification into grades

This standard covers the steel grades listed in table 1 (see also the notes to clause A.1).

7 Requirements

7.1 Processes used in manufacture

7.1.1 Unless otherwise agreed at the time of ordering, the steelmaking process is left to the manufacturer's discretion. The manufacturer shall indicate the process used to the purchaser on request.

7.1.2 The processes used to make the products are left to the manufacturer's discretion.

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7.2 Delivery

7.2.1 Form of supply

Wire and strip are usually supplied in reels or coils; the small diameters or thicknesses are also delivered on spools. A number of reels or spools can be packed onto a single pallet.

Unless otherwise agreed at the time of ordering, the selection among the forms of supply mentioned above remains at the manufacturer's discretion.

7.2.2 Condition on delivery

7.2.2.1 The purchaser shall always specify the condition in which the steel is to be delivered.

The condition on delivery shall be selected from those listed in table 3 and table 4. In special cases the product may, by particular agreement, also be supplied in the conditions generally usual for finished springs, as listed in table A.2.

7.2.2.2 When fine gauge wire is delivered on spools it shall be wound in such a way as to prevent kinking.

7.2.2.3 Each coil or spool shall consist of a single length of wire.

7.2.2.4 The wap diameter of wire supplied on coils may expand when the binding wires are removed, but shall never shrink to less than the coil centre diameter.

7.2.2.5 The spring wire shall be drawn dead cast. Unless otherwise agreed, the requirement shall be considered fulfilled in the case of wire finer than 5 mm in diameter if the ends of the individual wap do not show an axial displacement greater than

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

when tested in accordance with subclause 8.5.6,

where

f is the axial displacement, in mm;

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

d is the diameter of the wire, in mm.

7.2.2.6 Strip or wire in diameters up to about 0,4 mm to be supplied in condition "K" (see tables 3 and 4) are normally supplied with a bright surface finish. Wire in diameters greater than about 0,4 mm may be supplied with either bright or lubricated surface finish, subject to agreement. [1])

Products to be supplied in the "solution annealed" condition may be given either a bright annealed or pickled finish, at the manufacturer's discretion.

7.3 Chemical composition

7.3.1 Table 1 gives the chemical composition as determined in the cast analysis. The purchaser may permit slight deviations from the composition limits if the mechanical properties and functionability of the products are not thereby impaired.

7.3.2 The values for the product analysis may differ from the limiting values for the cast analysis by the amounts stated in table 2.

7.4 Mechanical properties

7.4.1 The values in table 3 shall apply for the tensile strength of spring hard drawn wire, the values in table 4 for that of spring hard rolled strip (see also clause A.2 and figures A.1 to A.4).

7.4.2 Irrespective of the mass of a coil, reel or spool, the maximum variation in tensile strength within the coil, reel or spool shall not exceed 100 N/mm² for strip and wire with a diameter less than 1,6 mm, or 70 N/mm² for wire with a diameter of 1,6 mm or greater.

If, at the time of ordering, proof of uniformity is required as part of the inspection testing, sampling methods shall be agreed.

7.5 Technical properties

7.5.1 For wire with diameters up to 1,5 mm, the pitch of the windings shall be regular on a helical spring which has been wound, extended and then released in accordance with subclause 8.5.3.

7.5.2 Wire greater than 1,5 mm but less than 10 mm in diameter shall satisfy the requirements specified in subclause 8.5.4 with regard to the torsion test (carried out as a reverse torsion test).

7.5.3 When tested in accordance with subclause 8.5.5 using a mandrel radius as specified in table 5, strip shall not show any defects visible to the naked eye.

7.6 Surface condition

7.6.1 The surface of the wire shall be as free from scores as possible. The wire shall show no cracks after the torsion test (reverse torsion test) as specified in subclause 8.5.4.

If these requirements on surface condition are inadequate, e.g. for products intended for springs subject to high dynamic loading, particular agreements shall be met at the time of ordering.

7.6.2 The surface of strip shall be bright and metallically clean, although oil residues from cold rolling do not justify a complaint. Pits, scores, scars and scratches are only permitted to the extent, that the uniformly smooth appearance of the strip, when examined by the naked eye, does not seem to be substantially impaired. See also clause A.6.

8 Testing

8.1 Inspection testing and test certificates

It may be agreed at the time of ordering that one of the test certificates specified in DIN 50 049 be furnished for each delivery. If these agreements require inspection testing to be carried out, the specifications in subclauses 8.2 to 8.5 shall apply.

As a rule, inspection testing is undertaken by the manufacturer's own experts; however, if particularly agreed at the time of ordering, it can also be carried out by a third party, commissioned by the purchaser.

8.2 Acceptance unit

The specifications of table 6 shall apply for the composition of the acceptance unit.

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[1]) The smallest diameter for which the wire can be delivered with a lubricated finish varies from works to works and is also dependent on the lubricating medium used.

8.3 Scope of testing

Unless otherwise agreed at the time of ordering, the tensile test (which is mandatory), the technological tests and the product analysis (only by agreement with the purchaser) shall be carried out to the extent specified in table 6.

8.4 Sampling and preparation of test pieces

8.4.1 The chemical composition, based on cast analysis, shall be supplied by the manufacturer. If a product analysis is to be carried out, the chips shall be taken at regular intervals from the complete cross section of the product under test.

8.4.2 The test pieces for the tensile test and the bend test on strip shall be taken as illustrated in figure 1 and shall be prepared as specified in DIN 50 114 or subclause 8.5.5.

8.4.3 The conditions for the taking of test pieces from wire for the tensile test, the torsion test (reverse torsion test) and the winding test shall be agreed at the time of ordering. The test pieces shall be prepared in accordance with the requirements of DIN 51 210 Part 1 and Part 2, DIN 51 212 and DIN 51 215.

8.5 Test procedure

8.5.1 The chemical composition shall be determined according to the methods [2]) specified by the Chemists' Committee of the *Verein Deutscher Eisenhüttenleute* (Society of German Ferrous Metallurgy Engineers).

8.5.2 The tensile test shall be carried out as described in DIN 50 114, DIN 50 145 and DIN 51 210 Part 1 and Part 2.

8.5.3 The wrapping test shall be carried out by analogy with DIN 51 215 in the following manner:

Coil a test piece approximately 500 mm in length closely around a mandrel approximately 3 X d (d = nominal wire diameter) but no less than 1,0 mm in diameter. Then extend and release the test piece such that the final length of the released spring is at least twice, but not more than four times, the wound length.

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

8.5.4 The torsion test shall be carried out as described in DIN 51 212. In a deviation from these requirements, however, the test piece shall not be twisted until fracture occurs, but shall only be twisted two turns in one direction and two turns in the other. This test is intended to reveal to the naked eye any cracks or surface defects which may be present.

8.5.5 By analogy with the processes of spring manufacture, the bend test requires that a test strip, where possible 20 mm wide, is bent in a press through 90° around a mandrel, the radius of which depends on the thickness of the test piece (see table 5). The axis of bend shall be at 90° to the longitudinal axis of the test piece, i.e. perpendicular to the direction of rolling in the case of longitudinal test pieces and along the direction of rolling in the case of transverse test pieces.

8.5.6 In the test for freedom from corkscrew cast, one free wap shall be taken from wire supplied in coils, after the binding wires have been removed. The wap shall be suspended and the wap diameter D and the axial displacement f of the wire ends measured.

9 Complaints [3])

9.1 External and internal defects shall only be grounds for dispute if they have a noticeably adverse affect on any processing and application appropriate to the steel grade and product form.

9.2 The purchaser shall afford the manufacturer the opportunity to judge whether a complaint is justified by submitting the material objected or samples of the material delivered.

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[2]) *Handbuch für das Eisenhüttenlaboratorium* (Handbook for the Ferrous Metallurgy Laboratory), volume 2: *Die Untersuchung der metallischen Stoffe* (Investigation of metallic materials), Düsseldorf 1966; volume 5 (supplementary volume):
A 4.4 – *Aufstellung empfohlener Schiedsverfahren* (List of recommended arbitration procedures),
B – *Probenahmeverfahren* (Sampling procedures),
C – *Analysenverfahren* (Methods of analysis),
most recent editions each.

[3]) See Explanatory notes to DIN 17 010.

Table 1. **Chemical composition of the steels (cast analysis)**

Steel grade		Chemical composition [1]), in % by mass						
Designation	Material number	C max.	Si max.	Mn max.	Al	Cr	Mo	Ni
X 12 CrNi 17 7	1.4310	0,12	1,5	2,0	–	16,0 to 18,0	≦0,8	6,0 to 9,0
X 5 CrNiMo 18 10	1.4401	0,07	1,0	2,0	–	16,5 to 18,5	2,0 to 2,5	10,5 to 13,5
X 7 CrNiAl 17 7	1.4568	0,09	1,0	1,0	0,75 to 1,50	16,0 to 18,0	–	6,5 to 7,75

[1]) No more than 0,045 % P and 0,030 % S for all grades.

Table 2. **Permissible deviation of the product analysis from the limiting values for the cast analysis as specified in table 1**

Element	Permissible maximum content in the cast analysis	Permissible deviation [1]) of the product analysis from the limiting values for the cast analysis as specified in table 1
C	≦ 0,12	+ 0,01
Si	≦ 1,0 > 1,0 ≦ 1,5	+ 0,05 + 0,10
Mn	≦ 1,0 > 1,0 ≦ 2,0	+ 0,03 + 0,04
P	≦ 0,045	+ 0,005
S	≦ 0,030	+ 0,005
Al	≧ 0,75 ≦ 1,50	± 0,10
Cr	≧ 16,0 ≦ 18,5	± 0,20
Mo	≦ 0,80 ≧ 2,0 ≦ 2,5	+ 0,05 ± 0,10
Ni	≧ 6,0 ≦ 10,0 > 10,0 ≦ 13,5	± 0,10 ± 0,15

[1]) The deviation shown by an element in the product analysis from the cast analysis within one cast shall lie only below the minimum value or above the maximum value of the range specified for a cast, but not both at the same time.

Table 3. Tensile strength and reduction in area after fracture of wire in the spring hard drawn condition (K) and additionally for steel X 7 CrNiAl 17 7 (1.4568) in the solution annealed condition

Steel grade: Designation	Steel grade: Material number	Delivery condition	Tensile strength 1), 2), 3) for a diameter, in mm (N/mm²): up to 0,2	over 0,2 up to 0,4	over 0,4 up to 0,7	over 0,7 up to 1,0	over 1,0 up to 1,5	over 1,5 up to 2,0	over 2,0 up to 2,8	over 2,8 up to 4,0	over 4,0 up to 6,0	over 6,0 up to 8,0	over 8,0 up to 10,0	Reference values for the increase in tensile strength as a result of tempering or artificial ageing (see table A.2) N/mm²	Reduction in area after fracture for diameters over 1,5 up to 10,0 mm %
X 12 CrNi 17 7	1.4310	K	2200 to 2450	2100 to 2350	2000 to 2250	1900 to 2150	1800 to 2050	1700 to 1950	1600 to 1850	1500 to 1750	1400 to 1650	1300 to 1550	1250 to 1500	60 to 200 4)	> 40
X 5 CrNiMo 18 10	1.4401	K	1650 to 1900	1600 to 1850	1600 to 1850	1500 to 1750	1400 to 1650	1350 to 1600	1300 to 1550	1200 to 1450	1100 to 1350	1050 to 1300	–	60 to 150 4)	
X 7 CrNiAl 17 7	1.4568	K	2000 to 2250	1950 to 2200	1850 to 2100	1800 to 2050	1700 to 1950	1600 to 1850	1500 to 1750	1400 to 1650	1300 to 1550	–	–	260 to 400 4)	
		Solution annealed	800 to 1000											5)	

1) After straightening into bars the tensile strength is reduced by up to about 10 %. The loss in strength can almost be compensated for by tempering or artificial ageing.

2) Lower tensile strength values may be agreed for wire with a high deformation requirement.

3) A tighter range may be agreed on ordering.

4) See also figure A.1.

5) Wire with diameters about 0,4 mm and greater has a tensile strength of about 1300 to 1450 N/mm² after two stage artificial ageing (solution annealed and two stage artificial ageing as in table A.2); the tensile strength is about 950 to 1100 N/mm² after the first artificial ageing cycle (see also figure A.3).

Table 4. **Tensile strength of strip in the spring hard rolled condition (K) and additionally for steel X 7 CrNiAl 17 7 (1.4568) in the solution annealed condition**

Steel grade: Designation	Steel grade: Material number	Delivery condition	Tensile strength[1], [2] for a strip thickness, in mm: from 0,1 up to 0,25 (N/mm²)	over 0,25 up to 0,50	over 0,50 up to 0,75	over 0,75 up to 1,0	over 1,0 up to 1,6	Reference values for the increase in tensile strength as a result of tempering or artificial ageing (see table A.2) N/mm²
X 12 CrNi 17 7	1.4310	K 1	1700 to 1900	1600 to 1800	1500 to 1700	1400 to 1600	1350 to 1550	50 to 200[3]
		K 2	2000 to 2200	1900 to 2100	1750 to 1950	1650 to 1850	1550 to 1750	
X 5 CrNiMo 18 10	1.4401	K	1300 to 1500	1200 to 1400	1100 to 1300	1000 to 1200	950 to 1150	50 to 150[3]
X 7 CrNiAl 17 7	1.4568	K	1600 to 1800	1550 to 1750	1450 to 1650	1300 to 1500	1100 to 1300	200 to 400[3]
		Solution annealed	800 to 1000					[4]

[1] The tensile strength is slightly reduced after any straightening which may be necessary. This loss in strength can almost be compensated for by tempering or artificial ageing.
[2] Lower tensile strength values may be agreed for strip with a high deformation requirement.
[3] See also figure A.2.
[4] Strip with thicknesses from about 0,15 mm has a tensile strength of about 1300 to 1450 N/mm² after two stage artificial ageing (solution annealed and two stage artificial ageing as in table A.2); the tensile strength is about 950 to 1100 N/mm² after the first artificial ageing cycle (see also figure A.4).

Table 5. **Reference data for the bending ability[1] of strip in the 90° bend test**

Steel grade: Designation	Steel grade: Material number	Delivery condition	Bending ability[1] for strip thickness[2], in mm: 0,1 to 0,50 — transverse to the direction of rolling	0,1 to 0,50 — parallel[3] to the direction of rolling	over 0,50 up to 0,75 with the axis of bend transverse to the direction of rolling	over 0,50 up to 0,75 — parallel[3] to the direction of rolling	over 0,75 up to 0,9[2] — transverse[3] to the direction of rolling	over 0,75 up to 0,9[2] — parallel[3] to the direction of rolling
X 12 CrNi 17 7	1.4310	K 1	≦ 2,5	≦ 11	≦ 2,5	≦ 11	≦ 3,5	≦ 11
		K 2	≦ 3,5	≦ 13	≦ 5	≦ 13	≦ 5	≦ 14
X 5 CrNiMo 18 10	1.4401	K	≦ 3,5	≦ 13	≦ 4,5	≦ 14	≦ 4,5	≦ 14
X 7 CrNiAl 17 7	1.4568	K	≦ 7	≦ 20	≦ 7	≦ 20	≦ 7	≦ 20

[1] Bending ability in the 90° bend test *r/s* (*r* = bending mandrel radius, *s* = strip thickness).
[2] No values can as yet be given for greater strip thicknesses.
[3] Since these values are requested less frequently and are thus also less well substantiated, and since the maintenance of these values is not necessary in all cases, these are reference values. If these values are of significance, "valid values" shall be agreed as appropriate.

Table 6. **Acceptance units and scope of testing for inspection testing**

Product		Quality requirement 1)		Acceptance unit	Number of		
Strip	Wire		2)		specimens per acceptance unit	test sections per specimen	test pieces per test section
X	X	Chemical composition of the product	By agreement	Cast	3)	1	1
X	X 4)	Tensile test	O	Cast and production batch 5)	1 for each part of 10 coils or strips	1 6)	1 6)
X		Bending ability	By agreement	Cast and production batch 5)	The scope of testing shall be agreed on ordering.		
	X 7)	Wrapping test					
	X 8)	Torsion test (reverse torsion test)					

1) If other tests are required, e.g. determination of the modulus of elasticity or the spring bending limit, this shall be agreed on ordering.

2) O = the test is mandatory in each case; by agreement = the test is only carried out if so agreed at the time of ordering.

3) Unless otherwise agreed at the time of ordering, one specimen shall be taken per cast.

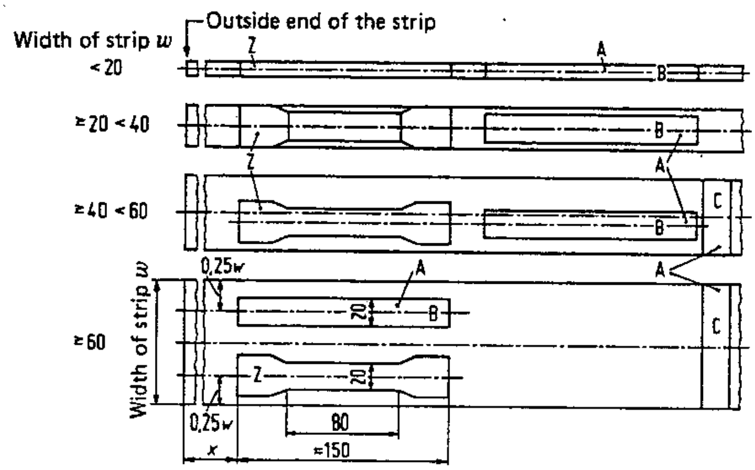
4) The reduction in area after fracture shall be determined in addition to the tensile strength for diameters greater than 1,5 mm and less than 10,0 mm.

5) The production batch is defined as the quantity of production subjected to the same heat treatment conditions and having the same cross-sectional reduction.

6) See subclause 7.4.2.

7) Only for diameters up to 1,5 mm.

8) Only for diameters greater than 1,5 mm and less than 10,0 mm.



Z ..... tensile test piece with gauge length L_0 = 80 mm and, where possible, a width of 20 mm as specified in DIN 50 114.

A ..... test piece for determining the bending ability, width 20 mm, where possible

B ..... parallel test piece for bending transverse to the direction of rolling

C ..... transverse test piece for bending parallel to the direction of rolling

x ..... For referee testing, the test pieces shall be taken at a length of at least one coil circumference from the inside or outside end of the coil.

Figure 1. Position of test piece (dimensions in mm)

Appendix A
Supplementary information

A.1 Notes on the classification into grades

Depending on the stresses involved, the maximum temperature of use of steel X 12 CrNi 17 7 (1.4310) can be between 120 and 250 °C.

If maximum corrosion resistance is required for the steels contained in this standard, and also where a maximum temperature of use between 120 and 250 °C is required, the austenitic steel X 5 CrNiMo 18 10 (1.4401) can be used.

The maximum temperature of use of the precipitation hardenable austenitic-martensitic steel X7 CrNiAl 17 7 (1.4568) can be between 250 and 350 °C depending on the stressing; this steel has high fatigue strength and increased high-temperature strength, but reduced corrosion resistance.

The three steels have different values for the modulus of elasticity and the shear modulus (see table A.1). It should be noted that the values for the modulus of elasticity and the shear modulus fall as the temperature increases.

A.2 Influence of tempering or artificial ageing on the tensile strength

A.2.1 Tempering or, in the case of steel X7 CrNiAl 17 7 (1.4568) artificial ageing as indicated in table A.2, will increase the tensile strength values and thereby produce improved spring properties as compared with the spring hard drawn condition. In addition, this type of treatment also reduces the processing stresses produced by the spring shaping. Consequently, final tempering or precipitation hardening of the finished springs as a matter of principle is recommended. Reference data on the increase in tensile strength which can be achieved after tempering or artificial ageing are given in tables 3 and 4 and figures A.1 and A.2.

A.2.2 The solution annealed condition of steel X7 CrNiAl 17 7 (1.4568) can be converted into the spring hard condition (mild spring hardness) by means of a two stage heat treatment after processing into springs (see table A.2). Data regarding the tensile strength after two stage heat treatment from the quenched condition are given in tables 3 and 4 and figures A.3 and A.4.

A.3 Bending limit of strip intended for the manufacture of springs

Table A.3 contains reference data for the bending limit of strip intended for the manufacture of springs.

A.4 Physical properties

Table A.1 gives reference data for the modulus of elasticity and the shear modulus.

A.5 Magnetic properties

Steels X 12 CrNi 17 7 (1.4310) and X 5 CrNiMo 18 10 (1.4401) can hardly be magnetized at all in the soft condition; steel X 12 CrNi 17 7 (1.4310), however, becomes strongly magnetizable, to a greater or lesser degree, as a result of cold working, whereas steel X 5 CrNiMo 18 10 (1.4401) remains practically unmagnetizable. Steel X 7 CrNiAl 17 7 (1.4568) is clearly magnetizable even in the soft condition; the magnetizability is further enhanced by cold working.

A.6 Average peak-to-valley height of strip

The surface quality of strip is characterized by a reference value for the average peak-to-valley height R_a: R_a no greater than 0,6 µm.

A.7 Information on further processing and heat treatment

A.7.1 Shaping

Shaping is effected by cold deformation such as stamping, coining, bending or coiling. It should be noted that the shaping properties of wire or strip strain hardened to spring hardness are limited. Depending on the shaping requirements, a lower tensile strength may be agreed upon at the time of ordering in the case of wire and strip made of steels X 12 CrNi 17 7 (1.4310) and X 7 CrNiAl 17 7 (1.4568) (see footnote 2 to tables 3 and 4). If a higher degree of shaping is required, the possibility of supplying wire and strip made of steel X 7 CrNiAl 17 7 (1.4568) in the solution annealed condition should be noted. It is recommended that this be discussed with the manufacturer.

A.7.2 Heat treatment

A.7.2.1 Table A.2 contains information on the heat treatment to which, on principle, the finished springs are to be subjected in order to achieve as high a strength as possible and thus also good elastic properties.

The spring manufacturer should, as a rule, proceed in accordance with the data contained in table A.2. Differing tempering temperatures may also be stipulated, depending on the requirements or operating conditions, e. g.:

A temperature range of 150 to 200 °C with tempering times of about 20 hours can be selected for steels X 12 CrNi 17 7 (1.4310) and X 5 CrNiMo 18 10 (1.4401). This does not yet give rise to any noticeable annealing colours. However, only about 2/3 of the increase in strength and the other values is achieved. The tempering temperature can be increased to 480 °C for special temperature stress requirements.

A.7.2.2 The springs shall be thoroughly cleaned before the heat treatment. If the annealing colours produced by the heat treatment are not permissible for reasons of appearance or because of the effect on resistance to corrosion, the heat treatment may be carried out in a protective atmosphere, or another suitable surface treatment, which does not impair the spring properties to any great extent, may be used.

Table A.1. **Reference data for the modulus of elasticity and shear modulus of wire and strip (average values)** [1], [2], [3]

Steel grade		Modulus of elasticity [1] in the		Shear modulus [2] in the	
Designation	Material number	condition on delivery K (kN/mm²)	condition K + A [4] (kN/mm²)	condition on delivery K (kN/mm²)	condition K + A [5] (kN/mm²)
X 12 CrNi 17 7	**1.4310**	185	195	70	73
X 5 CrNiMo 18 10	**1.4401**	180	190	68	71
X 7 CrNiAl 17 7	**1.4568**	195	200	73	78

1) The reference data for the modulus of elasticity apply for measurements on longitudinal test pieces in the tensile test as specified in DIN 50 145 at a mean tensile strength of 1800 N/mm²; at a mean tensile strength of 1300 N/mm² the values are 6 kN/mm² lower. Intermediate values can be interpolated.

2) The reference data for the shear modulus apply to measurements, using the torsion pendulum, on wires with a diameter not greater than 2,8 mm and a mean tensile strength of 1800 N/mm²; at a mean tensile strength of 1300 N/mm² the values are 2 kN/mm² lower. Intermediate values can be interpolated. Values obtained using the Elastomat are not always comparable with those obtained using the torsion pendulum.

3) Lower values can be recorded on the finished springs. This shall be taken into consideration when calculating the springs.

4) See tables 3, 4 and A.2 and figures A.1 and A.2.

5) See tables 3 and A.2 and figure A.1.

Table A.2. **Information on the heat treatment of springs made from wire and strip [1])**

Steel grade		Condition	Heat treatment [2])								
			Tempering or single artificial ageing			Two stage artificial ageing					
						1st stage			2nd stage		
Designation	Material number		Tem-perature °C	Duration	Cooling medium	Tem-perature °C	Duration min	Cooling medium	Tem-perature °C	Duration	Cooling medium
X 12 CrNi 17 7	1.4310	K + A	250 to 450	30 min to 24 h	Air						
X 5 CrNiMo 18 10	1.4401	K + A	250 to 450	30 min to 24 h	Air						
X 7 CrNiAl 17 7	1.4568	K + artificial ageing	480 to 550	1 to 2 h	Air						
		Solution annealed + two stage artificial ageing [3])				760 to 820	30 to 40	In water/ air to below 12 °C [4])	480 to 550	1 to 2 h	Air

[1]) See the values for the corresponding increase in tensile strength in tables 3 and 4 and figures A.1 to A.4 respectively.

[2]) The optimum heat treatment conditions can be very different. The spring manufacturer shall select the heat treatment conditions accordingly (see also subclause A.7.2).

[3]) With the exception of wire up to about 0,4 mm in diameter and strip up to about 0,15 mm thick, the properties that can be attained are largely independent of the dimensions of the product. In the case of very thin wire and strip, two stage heat treatment only produces a relatively small increase in tensile strength.

[4]) Lower maximum temperatures may be needed if it is attempted to obtain a higher tensile strength than is given in figures A.3 and A.4.

Table A.3. **Reference data for the bending limit [1]) of strip intended for the manufacture of springs**

Steel grade		Condition [2])	Spring bending limit [1]) for strip thickness, in mm			
Designation	Material number		0,1 to 0,25	over 0,25 up to 0,50	over 0,50 up to 0,75	over 0,75 up to 1,0 [3])
			N/mm²			
X 12 CrNi 17 7	**1.4310**	K 1 + A	800 to 1100	750 to 1050	650 to 950	600 to 900
		K 2 + A	1100 to 1400	1000 to 1300	850 to 1150	750 to 1050
X 5 CrNiMo 18 10	**1.4401**	K + A	[4])			
X 7 CrNiAl 17 7	**1.4568**	K + A	1600 to 2200	1550 to 2100	1450 to 1850	1050 to 1450

[1]) The bending limit of strip intended for the manufacture of springs (spring bending limit) shall be determined in accordance with DIN 50 151.
[2]) See tables 4 and A.2.
[3]) It is not possible to give values for greater thicknesses of strip.
[4]) No values have previously been demanded for the spring bending limit of this steel, and thus no satisfactory documentation is available.

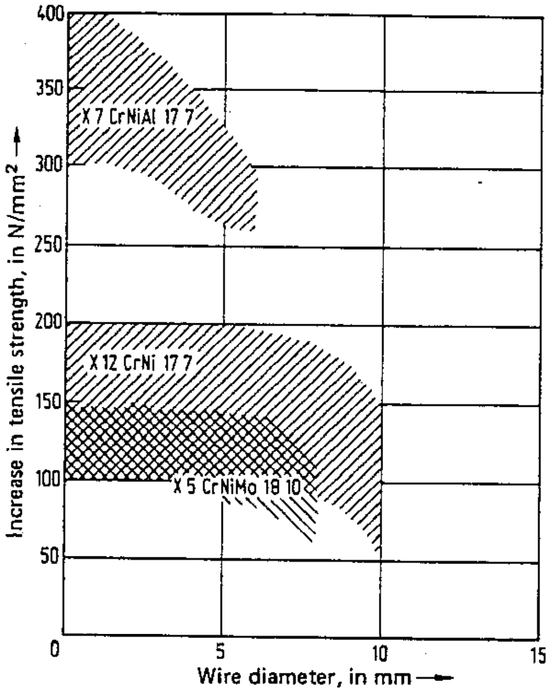


Figure A.1. Reference values for the increase in tensile strength of cold drawn wire as a result of tempering or single artificial ageing (see table A.2)

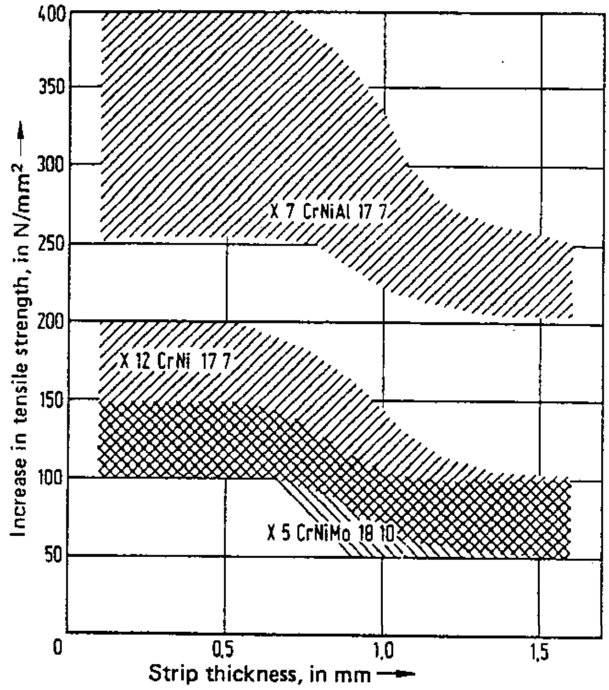


Figure A.2. Reference values for the increase in tensile strength of cold rolled strip as a result of tempering or single artificial ageing (see table A.2)

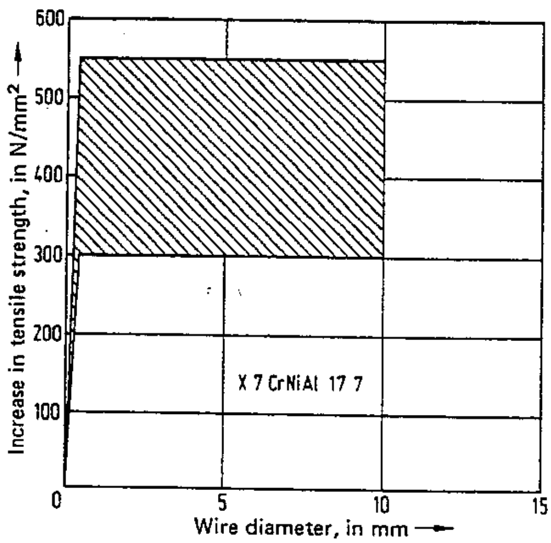


Figure A.3. Reference values for the increase in tensile strength of solution annealed wire made from steel X 7 CrNiAl 17 7 after two stage artificial ageing (see also footnote 5 to table 3)

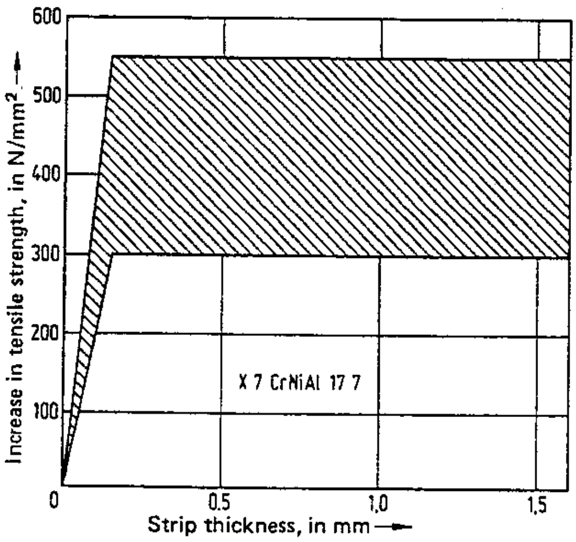


Figure A.4. Reference values for the increase in tensile strength of solution annealed strip made from steel X 7 CrNiAl 17 7 after two stage artificial ageing (see also footnote 4 to table 4)

Standards and other documents referred to

DIN 2076	Round spring wire; dimensions, weights, permissible deviations
DIN 17 007 Part 2	Material numbers; system used in main group 1: steel
DIN 17 010	General technical delivery conditions for steel and steel products
DIN 17 440	Stainless steels; quality specifications
DIN 50 049	Documents on materials testing
DIN 50 114	Testing of metals; tensile test on sheet or strip less than 3 mm thick, not using an extensometer
DIN 50 145	Testing of metals; tensile test
DIN 50 151	Testing of metals; spring steel bending test with precision measurement
DIN 51 210 Part 1	Testing of metals; tensile test on wire, not using an extensometer
DIN 51 210 Part 2	Testing of metals; tensile test on wire, using an extensometer
DIN 51 212	Testing of metals; torsion test on wire
DIN 51 215	Testing of metals; wrapping test on wire, general specifications
DIN 59 381	Steel flat products; cold rolled stainless and heat resisting steels, dimensions, permissible deviations of dimension, form and weight
DIN-Normenheft 3	Designations and material numbers for ferrous materials in DIN Standards and Iron and steel material sheets

Handbuch für das Eisenhüttenlaboratorium [4]):

volume 2: *Die Untersuchung der metallischen Stoffe*; Düsseldorf 1966;

volume 5 (supplementary volume): A4. 4 – *Aufstellung empfohlener Schiedsverfahren,*

B – *Probenahmeverfahren,*

C – *Analysenverfahren,*

most recent editions each.

[4]) *Verlag Stahleisen mbH*, Postfach 8229, D-4000 Düsseldorf 1.

Previous editions

DIN 17 224: 04.55; 07.68

Amendments

See Explanatory notes for the amendments made to the July 1968 edition.

Explanatory notes

1. This standard contains the following substantial amendments in comparison with the July 1968 edition of Preliminary Standard DIN 17 224:

a) The lower limit for the nickel content of steel X 12 CrNi 17 7 (material number 1.4310) has been reduced from 7,0 to 6,0 %. It is intended, that when *Stahl-Eisen Werkstoffblatt* 400 – Stainless rolled and forged steels – is revised, a nickel content of 6,0 to 9,0 % will also be specified for this steel.

In connection with the reduction of the lower limit for nickel when this steel is used as a spring material, the steel manufacturers have pointed out that, as a consequence of the content of chromium present and the intentional addition of molybdenum, there is no danger of a degradation of the corrosion properties.

b) A table has been included giving the deviations from the limiting values in the cast analysis permitted in the product analysis.

c) The strength levels K 115, K 130 and K 145 previously additionally included for strip have been deleted as, in the view of the spring manufacturers, they are not necessary and a footnote permits the agreement on lower tensile strength values where there are high requirements on deformability (this footnote has now also been extended to cover wire).

d) Where, in the previous edition of this standard, a tensile strength range of 25 kg/mm^2 (corresponding to 250 N/mm^2) was specified, the range has been narrowed to 200 N/mm^2 by raising the lower limit, in order to accommodate the more stringent requirements on the tolerances for the finished product. The range for wire was not narrowed correspondingly, however, a tighter tolerance can be specified for this at the time or ordering.

e) The specifications for the 90° bending ability of strip have been extended to cover thicknesses greater than 0,75 to 0,90 mm. It has been possible for the first time to include data for steel X 5 CrNiMo 18 10 (material number 1.4401).

f) The specifications relating to the modulus of elasticity and shear modulus of wire and strip have been revised. It should be noted that lower values can be recorded when testing finished springs; the values given in table A.1 are not those to be used for the calculation of springs, those in DIN 2088, (Preliminary Standard) DIN 2089 Part 1 and Part 2 are to be used instead.

g) In order to make these more readily comprehensible, the specifications relating to the scope of testing have been given in a table, which also specifies the acceptance unit.

h) The torsion test (carried out as a reverse torsion test) has been adopted for the assessment of the surface quality of wire with diameter greater than 1,5 mm.

i) Flat wire (flats rolled from wire), which is not held as stock and for which there is not a great demand, has been dropped from the field of application, since it does not comply with the specifications of this standard with regard to, for example, the achievable values for the tensile strength and the spring bending limit.

j) DIN 59 381, and not DIN 1544, is now quoted as the dimensional standard for strip.

k) Specifications regarding the average peak-to-valley height of strip have been adopted.

l) The reference values for the increase in tensile strength of work-hardened products as a consequence of tempering or single artificial ageing, and of solution annealed products made from steel X 7 CrNiAl 17 7 as a consequence of two stage artificial ageing have been represented in graph form.

m) The requirement on "freedom from corkscrew cast" for wire with a diameter less than 5 mm has been specified precisely by means of a formula giving a maximum permissible axial displacement.

n) The standard has been editorially revised throughout.

2. The Explanatory notes to the Preliminary Standard DIN 17 224 (July 1968 edition) listed a number of items which it was wished to add to a revised version of the standard. Of these, it has still not yet been possible to include specifications on particle size and degree of purity. The inclusion of fatigue strength graphs was not favoured; it was proposed that graphs of this nature be included in the standards on the calculation of springs.

3. It was agreed that although tensile strength values can not be considered the property characterizing spring behaviour, knowledge of them was generally sufficient as a characteristic value and that agreement on further characteristic values is only necessary in special cases. Since, however, there is still uncertainty over appropriate criteria for the behaviour in use of springs, and proof of this, users and manufacturers of springs have decided to instigate a study of this question.

4. It is not possible, because of the varying contents of transformation martensite, which for their part are in turn influenced by the chemical composition, the degree of transformation and the heat treatment, and their differing effects on the corrosion resistance of a single steel grade, to give generally valid information on the behaviour of the steels against various corrosive media and types of corrosion. These relationships are further complicated by the influence of the surface condition (e.g. annealing colours) and the corrosive stress.

5. The European Coal and Steel Community (ECSC) is at present preparing a corresponding EURONORM (number 151). Judging by the progress of the discussions at the time of the publication of this standard there will be as great a technical correspondence as possible.

International Patent Classification

G 01 N 3/00
F 16 F 1/00
C 22 C 38/00
B 21 F 35/00
B 21 D 11/10