INTERNATIONAL STANDARD

# ISO 6931-2

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## Stainless steels for springs —

## Part 2:
Strip



*Aciers inoxydables pour ressorts —*
*Partie 2: Bandes*



Reference number
ISO 6931-2 : 1989 (E)

## Foreword

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

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.



International Standard ISO 6931-2 was prepared by Technical Committee ISO/TC 17, *Steel.*



ISO 6931 consists of the following parts, under the general title *Stainless steels for springs*:

— *Part 1: Wire*

— *Part 2: Strip*

Annex A of this part of ISO 6931 is for information only.



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# Stainless steels for springs —

# Part 2: Strip

## 1 Scope

**1.1** This part of ISO 6931 applies to the grades of wrought stainless steels listed in table 1, which are currently generally used in the work-hardened condition in the form of strip up to about 1,6 mm in thickness, for the production of springs and spring parts that are exposed to corrosive effects and sometimes slightly increased temperatures (see annex A, clause A.1).

**1.2** In addition to the steels listed in table 1, certain of the steel grades covered by ISO 683-13 are also used for springs, although to a much lesser extent.

**1.3** In addition to this part of ISO 6931, the general technical delivery requirements of ISO 404 are applicable.



## 2 Normative references

The following standards contains provisions which, through reference in this text, constitute provisions of this part of ISO 6931. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 6931 are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 377 : 1985, *Wrought steel — Selection and preparation of samples and test pieces.*

ISO 404 : 1981, *Steel and steel products — General technical delivery requirements.*

ISO 683-13 : 1986, *Heat-treatable steels, alloy steels and free-cutting steels — Part 13: Wrought stainless steels.*

ISO 6892 : 1984, *Metallic materials — Tensile testing.*

ISO 7438 : 1985, *Metallic materials — Bend test.*

## 3 Ordering

The purchaser shall state in his inquiry and order

a) the steel type (see table 1);

b) the nominal dimensions of the product;

**Table 1 — Chemical composition of the steel (cast analysis)**

| Steel grade designation | Chemical composition[1] % (*m*/*m*) | | | | | | |
|---|---|---|---|---|---|---|---|
| | C max. | Si max. | Mn max. | Al | Cr | Mo | Ni |
| **X 5 CrNi 18 10** | 0,07 | 1,0 | 2,0 | — | 17,0 to 19,0 | — | 8,0 to 11,0 |
| **X 12 CrNi 17 7** | 0,12 | 1,5 | 2,0 | — | 16,0 to 18,0[2] | ⩽0,8 | 6,0 to 9,0[2] |
| **X 6 CrNiMo 17 12 2** | 0,07 | 1,0 | 2,0 | — | 16,5 to 18,5 | 2,0 to 2,5[3] | 10,5 to 13,5 |
| **X 7 CrNiAl 17 7** | 0,09 | 1,0 | 1,0 | 0,75 to 1,50 | 16,0 to 18,0 | — | 6,5 to 7,75 |

1) For all grades ⩽0,045 % (*m*/*m*) P and ⩽0,030 % (*m*/*m*) S.

2) A maximum Cr content of 18,5 % (*m*/*m*) and/or a maximum Ni content of 9,5 % (*m*/*m*) may be agreed upon at the time of enquiry and order.

3) Where the corrosion resistance is of particular importance, one can also agree to the delivery of type 20a of ISO 683 13 with the specifications of this part of ISO 6931 applicable for steel type X 6 CrNiMo 17 12 2.

c) the number of this International Standard (ISO 6931-2);

d) the delivery condition (see 4.2.2);

e) the desired quantity;

f) the required type of document (see 5.1.1).

*Example:*

— 2 t strip of steel X 12 CrNi 17 7 according to ISO 6931-2, thickness = 0,80 mm, width = 250 mm, delivery condition C2:

2 t strip 0,80 × 250
steel X 12 CrNi 17 7 C2 - ISO 6931-2

## 4 Requirements

### 4.1 Manufacture of the steel and of the product

Unless otherwise agreed in the order, the processes used in making the steel and the product are left to the discretion of the manufacturer.

### 4.2. Delivery

#### 4.2.1 Delivery form

**4.2.1.1** Strip is usually supplied in coils and thin strip is also delivered on spools. Several coils or spools may be assembled on a carrier. Unless otherwise agreed in the order, the choice of the delivery form within the context of these specifications is left to the discretion of the manufacturer.

**4.2.1.2** Unless otherwise agreed when ordering, cold-rolled strip for springs is delivered with cut edges (CE). After special agreement, the strips can also be supplied with natural edges (NE) or with special edges (SE), for example with trimmed or rounded edges.

#### 4.2.2 Delivery condition

**4.2.2.1** The condition in which the strip is to be delivered shall always be specified by the purchaser.

The delivery conditions possible are those given in table 2.

In special cases, products may, if this is agreed, also be delivered in the treatment conditions given in table A.2 (see annex A), which are normally reserved for finished springs.

**4.2.2.2** In the condition "C", strip shall be delivered with a bright surface.

Strip of steel type X 7 CrNiAl 17 7 in the condition "solution annealed" may be delivered, depending on the manufacturer's choice, with a bright annealed or a pickled surface.



### 4.3 Chemical composition



**4.3.1** The chemical composition of the steels, as given by the cast analysis, shall be in accordance with the specifications in table 1.

**Table 2 — Tensile strength of strip in the spring-hard rolled condition (C) and additionally for steel X 7 CrNiAl 17 7 in the solution annealed condition**

| Steel grade designation | Delivery condition | Tensile strength for a strip thickness, in millimetres [1) 2) 3)] N/mm² | | | | |
|---|---|---|---|---|---|---|
| | | from 0,1 up to 0,25 | above 0,25 up to 0,50 | above 0,50 up to 0,75 | above 0,75 up to 1,0 | above 1,0 up to 1,6[4)] |
| X 5 CrNi 18 10 | C | 1 350 to 1 550 | 1 250 to 1 450 | 1 150 to 1 350 | 1 050 to 1 250 | 1 000 to 1 200 |
| X 12 CrNi 17 7 | C1 | 1 700 to 1 900 | 1 600 to 1 800 | 1 500 to 1 700 | 1 400 to 1 600 | 1 350 to 1 550 |
| | C2 | 2 000 to 2 200 | 1 900 to 2 100 | 1 750 to 1 950 | 1 650 to 1 850 | 1 550 to 1 750 |
| X 6 CrNiMo 17 12 2 | C | 1 300 to 1 500 | 1 200 to 1 400 | 1 100 to 1 300 | 1 000 to 1 200 | 950 to 1 150 |
| X 7 CrNiAl 17 7 | C | 1 600 to 1 800 | 1 550 to 1 750 | 1 450 to 1 650 | 1 300 to 1 500 | 1 100 to 1 300 |
| | Solution annealed | 800 to 1 000 | | | | |

1) After any necessary flattening, the tensile strength is slightly lower. By tempering and artificial ageing, the reduction in strength can be compensated for.

2) For strip with a high deformation stress, lower tensile strength values may be agreed upon.

3) See also 4.4.2.

4) For greater thickness, the tensile strength values shall be agreed upon.

**4.3.2** The permissible deviation between the values specified in table 1 and the product analysis are given in table 3.

**Table 3 — Permissible deviations of the product analysis from the limiting values for cast analysis in table 1**

| Element | Permissible maximum content in the cast analysis<br>$C$ | Permissible deviation[1] |
|---|---|---|
| C | $C \leqslant 0{,}12$ | +0,01 |
| Si | $C \leqslant 1{,}0$<br>$1{,}0 < C \leqslant 1{,}5$ | +0,05<br>+0,10 |
| Mn | $C \leqslant 1{,}0$<br>$1{,}0 < C \leqslant 2{,}0$ | +0,03<br>+0,04 |
| P | $C \leqslant 0{,}045$ | +0,005 |
| S | $C \leqslant 0{,}030$ | +0,005 |
| Al | $0{,}75 \leqslant C \leqslant 1{,}50$ | ±0,10 |
| Cr | $16{,}0 \leqslant C \leqslant 19{,}0$ | ±0,20 |
| Mo | $C \leqslant 0{,}80$<br>$2{,}0 \leqslant C \leqslant 2{,}5$ | ±0,05<br>±0,10 |
| Ni | $6{,}0 \leqslant C \leqslant 10{,}0$<br>$10{,}0 < C \leqslant 13{,}5$ | ±0,10<br>±0,15 |

1) For a cast the deviation of an element in the product analysis may be only below the minimum or only above the maximum value of the range specified for the cast analysis, but not both at the same time.



## 4.4 Mechanical properties

**4.4.1** For the tensile strength of spring-hard rolled strip, the data in table 2 apply.

**4.4.2** Regardless of the mass of the coil or spool, the maximum difference in tensile strength between the two ends of a coil or spool shall be 100 N/mm² (see also 5.2).

## 4.5 Technological properties, surface condition and inner soundness

### 4.5.1 Technological properties and surface condition

**4.5.1.1** The strip shall have adequate bending ability. Unless otherwise agreed, the reference data given in table 4 apply. Cracks visible with the naked eye are not permitted.

**4.5.1.2** The surface of the strips shall be bright and metallically clean, but oil films from cold-rolling do not justify reclaims. Pits, grooves, scars and scratches are only permitted to the extent that they do not impair the performance of the spring. See also 4.5.1.1 and annex A, clause A.6.

**4.5.1.3** If, for strip which is intended for high-duty springs, the requirements according to 4.5.1.1 and 4.5.1.2 are not sufficient, particular agreements shall be met at the time of inquiry and order.

### 4.5.2 Inner soundness

The products shall be free from internal defects that could impair their application to a more than negligible extent. Tests appropriate for an assessment of the internal characteristics shall be agreed upon at the time of ordering.

## 4.6 Dimensions and dimensional tolerances

The dimensions and the tolerances allowable on dimensions shall be stated in the order as long as there are no International Standards to cover them.

**Table 4 — Reference data[1] for the bending ability[2] of strip**

| Steel grade designation | Delivery condition | Bending ability[2] for a strip thickness, in millimetres | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0,1 to 0,50 | | above 0,50 to 0,75 | | above 0,75 to 0,9[3] | |
| | | For a direction of the axis of bend | | | | | |
| | | transverse | longitudinal | transverse | longitudinal | transverse | longitudinal |
| | | to direction of rolling | | | | | |
| X 5 CrNi 18 10 | C | ⩽3,5 | ⩽13 | ⩽4,5 | ⩽14 | ⩽4,5 | ⩽14 |
| X 12 CrNi 17 7 | C1 | ⩽2,5 | ⩽11 | ⩽2,5 | ⩽11 | ⩽3,5 | ⩽11 |
| | C2 | ⩽3,5 | ⩽13 | ⩽5 | ⩽13 | ⩽5 | ⩽14 |
| X 6 CrNiMo 17 12 2 | C | ⩽3,5 | ⩽13 | ⩽4,5 | ⩽14 | ⩽4,5 | ⩽14 |
| X 7 CrNiAl 17 7 | C | ⩽7 | ⩽20 | ⩽7 | ⩽20 | ⩽7 | ⩽20 |

1) At present, unless otherwise agreed, the value shall be regarded as reference data until more safe experiences are available.

2) Bending ability $r/\delta$ ($r$ = mandrel radius, $\delta$ = strip thickness).

3) For greater strip thicknesses, no values can as yet be given.

# 5 Testing

## 5.1 Agreement on tests and documents

**5.1.1** For each delivery, the issue of any document according to ISO 404 shall be agreed upon at the time of inquiry and order.

**5.1.2** If, in accordance with such an agreement, specific inspection is to be carried out, the specifications given in 5.2 to 5.4 shall be observed.

## 5.2 Number of tests

The data in table 5 apply for the composition of test units and for the number of tests per test unit, subject to the following exception for tensile strength.

If proof of uniformity of tensile strength (in accordance with 4.4.2) is agreed upon at the time of ordering, a test piece shall be taken from both ends of each coil or spool. If, from one coil of hot-rolled material, several coils or spools of cold-rolled strip are produced and if these are numbered in sequence, it is only necessary to take a test piece from the beginning of each consecutively produced coil or spool.

## 5.3 Selection and preparation

### 5.3.1 General

The general conditions given in ISO 377 for the selection and preparation of samples and test pieces shall apply.

### 5.3.2 Product analysis

For product analysis, the selection and preparation of samples shall be carried out in conformity with the requirements of ISO 377.

### 5.3.3 Tensile and bending tests

The test pieces for the tensile test and the bending test shall be taken in accordance with figure 1 and prepared in accordance with ISO 6892 and 5.4.2.2 respectively.

## 5.4 Methods of test

### 5.4.1 Chemical analysis

In cases of dispute, the methods used for chemical analysis shall be those established by the relevant International Standards. If no International Standards are available, the methods shall be agreed upon at the time of inquiry and order.



**Table 5 — Test units and amount of testing during acceptance tests**

| Quality requirement [1] | [2] | Test unit | Number of products per test unit | Number of samples per product | Number of test pieces per sample |
|---|---|---|---|---|---|
| Product analysis [3] | o | Cast | [4] | 1 | 1 |
| Tensile test without checking the uniformity of tensile strength | m | Cast and production batch [5] | 1 per 10 coils or spools or part thereof | 1 | 1 |
| Tensile test for checking the uniformity of tensile strength | o | Cast and production batch [5] | [6] | [6] | [6] |
| Bending ability | o | Cast and production batch [5] | To be agreed when ordering | | |

1) If other tests are required, for example for the determination of the modulus of elasticity, this shall be agreed when ordering.

2) m = the test shall be carried out in each case;
o = the test shall be carried out only if agreed when ordering.

3) If no product analysis is ordered, the chemical composition according to the cast analysis shall be given by the manufacturer for the elements listed in table 1.

4) Unless otherwise agreed when ordering, one test piece shall be taken per cast.

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

6) See 5.2.

### 5.4.2 Tensile and bending tests

**5.4.2.1** The tensile test shall be carried out in accordance with ISO 6892.

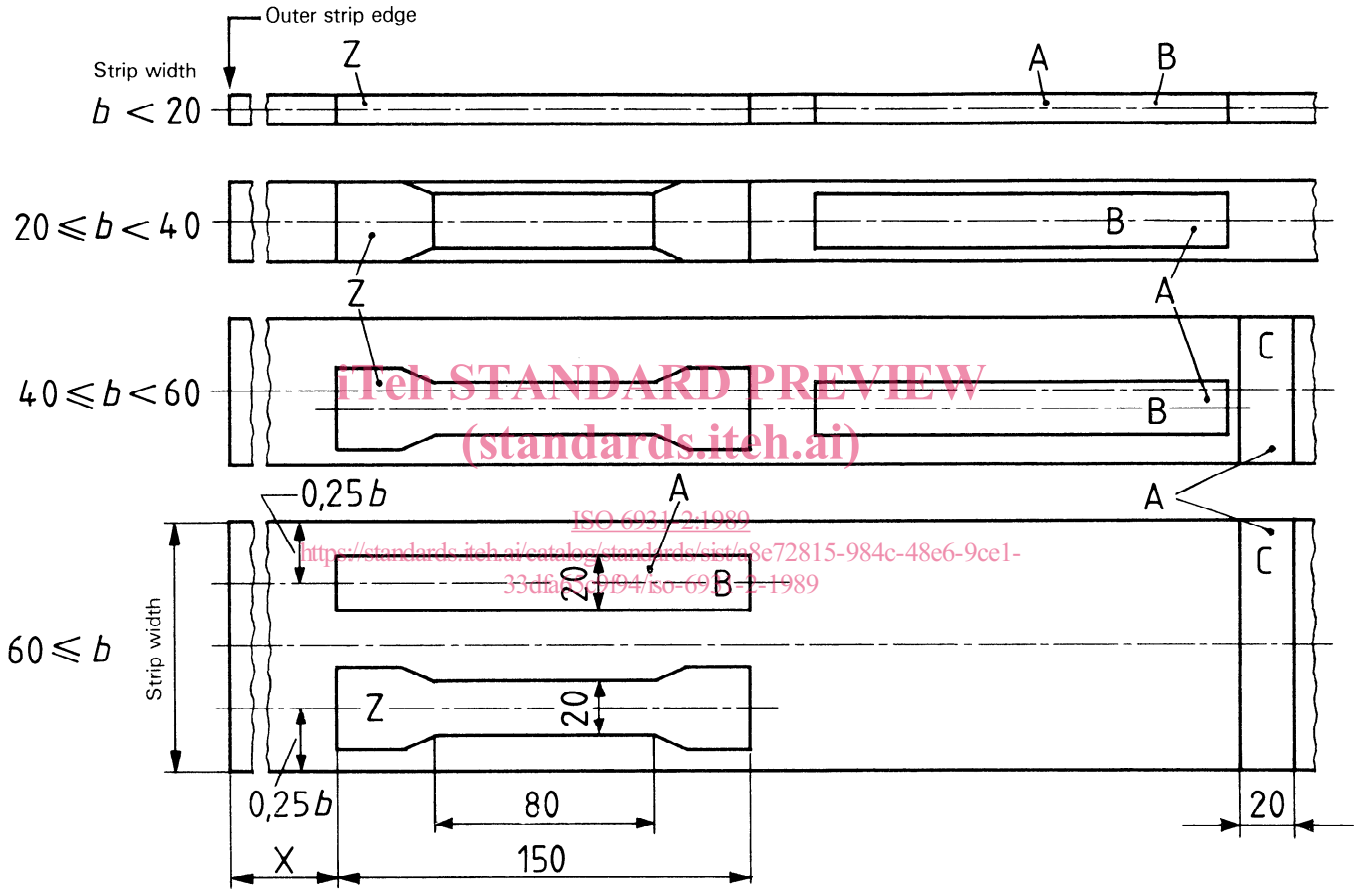
**5.4.2.2** By analogy with the process of spring manufacture, to check the bending ability, a test strip, if possible 20 mm in width, is bent through 90° under a press around a mandrel with a radius matched to the thickness of the test piece (see table 4). Bending is carried out perpendicularly to the longitudinal axis of the test piece, i.e. transverse to the direction of rolling in the case of longitudinal test pieces and parallel to the direction of rolling in the case of transverse test pieces.

In addition, the general specifications in ISO 7438 apply.

## 6 Complaints

The conditions for dealing with complaints laid down in ISO 404 shall apply.

Dimensions in millimetres






**Key:**

A Bending test piece, as far as possible with a width of 20 mm.

B Longitudinal test piece for bending transverse to rolling direction.

C Transverse test piece for bending parallel to rolling direction.

x In cases of dispute, the samples shall be taken at a distance of at least one lap from the inner or outer end of the coil.

Z Tensile test piece, for example a test piece having a gauge length of $L_o$ = 80 mm and a width of 20 mm, as specified in ISO 6892.

**Figure 1 — Test pieces**

# Annex A
(informative)

# Additional information

## A.1 Indications for classification of steel grades

Depending on stress, the maximum temperature of use of the steels X 5 CrNi 18 10 and X 12 CrNi 17 7 may be between 120 °C and 250 °C. If greatest resistance to corrosion is required for one of the steels covered by this part of ISO 6931, the austenitic steel X 6 CrNiMo 17 12 2 may be used, also depending on stress for a maximum temperature of use between 120 °C and 250 °C. The maximum temperature of use of the precipitation-hardenable austenitic-martensitic steel X 7 CrNiAl 17 7 may be between 250 °C and 300 °C depending on stress. This steel has a high fatigue strength and an increased strength at elevated temperatures, but a reduced resistance to corrosion.

The four grades of steel have slightly different values for the modulus of elasticity, determined on longitudinal test pieces, and for the shear modulus (see table A.1). It should be taken into account that with increasing temperature the values of the modulus of elasticity and the shear modulus decrease.

## A.2 Alteration of tensile strength by tempering or artificial ageing

**A.2.1** Tempering or, in the case of steel X 7 CrNiAl 17 7, artificial ageing as indicated in table A.2 will increase tensile strength values as compared with the spring hard-drawn condition. A treatment of this kind will also remove the processing stresses produced by the spring forming.

Consequently, final tempering or precipitation hardening of the finished springs is a basic recommendation. Reference data on the increase in tensile strength which can be achieved after tempering or artificial ageing are given in figure A.1.

**A.2.2** The solution-annealed condition of steel X 7 CrNiAl 17 7 can be converted into a harder condition by means of a double heat treatment after processing into springs (see figure A.2 and table A.2), but this condition will not be as hard as cold-worked material that has been given an appropriate heat treatment.



**Table A.1 — Reference data for the modulus of elasticity and rigidity (mean values)** [1) 2) 3)]

| Steel grade | Modulus of elasticity [1)] in the | | Modulus of rigidity [2)] in the | |
|---|---|---|---|---|
| | delivery condition C | condition C + T [4)] | delivery condition C | condition C + T [4)] |
| | kN/mm² | | kN/mm² | |
| X 5 CrNi 18 10 | 185 | 195 | 70 | 73 |
| X 12 CrNi 17 7 | 185 | 195 | 70 | 73 |
| X 6 CrNiMo 17 12 2 | 180 | 190 | 68 | 71 |
| X 7 CrNiAl 17 7 | 195 | 200 | 73 | 78 |

1) The reference data for the modulus of elasticity are applicable to measurements on longitudinal tensile test pieces for a mean tensile strength of 1 800 N/mm²; for a mean tensile strength of 1 300 N/mm², the values are 6 kN/mm² lower. Intermediate values may be interpolated.

2) The reference data for the modulus of rigidity are applicable to wires with a diameter $\leqslant$ 2,8 mm for measurements by means of a torsion pendulum for a mean tensile strength of 1 800 N/mm². For a mean tensile strength of 1 300 N/mm², the values are 2 kN/mm² lower. Intermediate values may be interpolated. Values ascertained by means of an Elastomat are not always comparable with values ascertained by means of a torsion pendulum.

3) For the finished spring, lower values may be ascertained. Therefore, standards for calculation of springs may specify values different from those given here on the basis of measurements of wire.

4) See table A.2, figure A.1 and table 3.

## A.3 Physical properties

Reference data for the modulus of elasticity and shear modulus are given in table A.1.

## A.4 Magnetic properties

It should be noted that, depending upon chemical composition and treatment condition, these steels have some degree of magnetic permeability.

## A.5 Guidelines for processing and heat treatment

### A.5.1 Processing

Forming is carried out by cold deformation. Therefore, account has to be taken of the fact that the deformability of spring-hard cold-worked strip is limited. Depending on the forming requirements, a lower tensile strength may be agreed upon when ordering (see footnote 2 to table 3).

If greater forming is required, the possibility of supplying strip made of steel X 7 CrNiAl 17 7 in the solution-annealed condition should be noted. It is recommended that this be discussed with the manufacturer.

### A.5.2 Heat treatment

**A.5.2.1** Table A.2 contains reference data on heat treatment to be carried out on finished springs in order to achieve suitable strengths and elastic properties. In special cases, modified heat treatments, to be determined by practical trials, will be necessary to meet specific requirements.

**A.5.2.2** The springs should be thoroughly cleaned before heat treatment. If the colours produced by heat treatment are not permissible for visual or corrosion-resistance reasons, the heat treatment may be carried out in a protective atmosphere, or a suitable cleaning process may be used which does not impair the spring properties.

### A.5.3 Peening with globular abrasives

If the springs are to be peened, care should be taken that the peened surface is not adversely affected, for example by using stainless grit.

## A.6 Mean surface roughness

The surface quality of strip is characterized by an approximate value for the mean surface roughness $R_a \leqslant 0{,}6$ µm.



**Table A.2 — Reference data for heat treatment of springs made of strip** [1] (see also A.5.2)



| Steel grade designation | Condition | Heat treatment | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Tempering [2] | | | Artificial ageing | | | | | |
| | | | | | 1st stage | | | 2nd stage | | |
| | | Temperature °C | Duration | Means of cooling | Temperature °C | Duration | Means of cooling | Temperature °C | Duration | Means of cooling |
| X 5 CrNi 18 10<br>X 12 CrNi 17 7<br>X 6 CrNiMo 17 12 2 | C + T | 250 to 450 | 30 min to 24 h | air | | | | | | |
| X 7 CrNiAl 17 7 | C + T [3] | 480 to 550 | 1 h to 2 h | air | | | | | | |
| | Solution-annealed + double artificial ageing [4] | | | | 760 to 820 | 30 min to 40 min | In water/air to < 12 °C [5] | 480 to 550 | 1 h to 2 h | air |

1) See the classification of the tensile strength data in table 2 and figures A.1 and A.2.

2) The optimum tempering conditions may be very different. The spring manufacturer shall choose the tempering conditions answering the purpose; see also A.5.2.1.

3) Artificial ageing.

4) With the exception of strip less than approximately 0,15 mm in thickness, the properties that can be achieved are largely independent of the dimensions of the product.

For very thin strip, a second heat treatment only produces a relatively small increase in tensile strength.

5) Lower maximum temperatures may be suitable if it is attempted to obtain a higher tensile strength range than that indicated in figure A.2.