

English version

Seamless steel tubes for pressure purposes - Technical delivery  
conditions - Part 5: Stainless steel tubes

Tubes en acier sans soudure pour service sous pression -  
Conditions techniques de livraison - Partie 5: Tubes en  
aciers inoxydables

Nahtlose Stahlrohre für Druckbeanspruchungen -  
Technische Lieferbedingungen - Teil 5: Rohre aus  
nichtrostenden Stählen

This European Standard was approved by CEN on 3 March 2004.

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## Foreword

This document (EN 10216-5:2004) has been prepared by Technical Committee ECISS/TC 29 "Steel tubes and fittings for steel tubes", the secretariat of which is held by UNI.

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of an identical text or by endorsement, at the latest by March 2005, and conflicting national standards shall be withdrawn at the latest by March 2005.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of the EU Directive 97/23/EC.

For relationship with the EU Directive 97/23/EC, see informative Annex ZA, which is an integral part of this document.

Other parts of EN 10216 are:

- *Part 1: Non-alloy steel tubes with specified room temperature properties;*
- *Part 2: Non-alloy and alloy steel tubes with specified elevated temperature properties;*
- *Part 3: Alloy fine grain steel tubes;*
- *Part 4: Non-alloy and alloy steel tubes with specified low temperature properties.*

Another European Standard series covering tubes for pressure purposes is:

- EN 10217: *Welded steel tubes for pressure purposes – Technical delivery conditions.*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard : Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

## 1 Scope

This document specifies the technical delivery conditions in two test categories for seamless tubes of circular cross section made of austenitic (including creep resisting steel) and austenitic-ferritic stainless steel which are applied for pressure and corrosion resisting purposes at room temperature, at low temperatures or at elevated temperatures.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

The requirements of this part of EN 10216 rule when they differ from those in the standards and documents referred to below:

EN 10002-1, *Metallic materials - Tensile testing - Part 1: Method of test at ambient temperature.*

EN 10002-5, *Metallic materials - Tensile testing - Part 5: Method of test at elevated temperatures.*

EN 10020:2000, *Definition and classification of grades of steel.*

EN 10021:1993, *General technical delivery conditions for steel and iron products.*

EN 10027-1, *Designation systems for steels - Part 1: Steel names, principal symbols.*

EN 10027-2, *Designation systems for steels - Part 2: Numerical systems.*

EN 10028-7, *Flat products made of steels for pressure purposes - Part 7: Stainless steels.*

EN 10045-1, *Metallic materials - Charpy impact test - Part 1: Test method.*

EN 10052:1993, *Vocabulary of heat treatment terms for ferrous products.*

EN 10088-1, *Stainless steels - Part 1: List of stainless steels.*

EN 10204, *Metallic products - Types of inspection documents.*

EN 10233, *Metallic materials - Tubes - Flattening test.*

EN 10234, *Metallic materials - Tubes - Drift expanding test.*

EN 10236, *Metallic materials - Tubes - Ring expanding test.*

EN 10237, *Metallic materials - Tubes - Ring tensile test.*

EN 10246-2, *Non-destructive testing of steel tubes - Part 2: Automatic eddy current testing of seamless and welded (except submerged arc-welded) austenitic and ferritic-austenitic steel tubes for verification of hydraulic leak tightness.*

EN 10246-6, *Non-destructive testing of steel tubes - Part 6: Automatic full peripheral ultrasonic testing of seamless steel tubes for the detection of transverse imperfections.*

EN 10246-7, *Non-destructive testing of steel tubes - Part 7: Automatic full peripheral ultrasonic testing of seamless and welded (except submerged arc welded) steel tubes for the detection of longitudinal imperfections.*

EN 10246-17, *Non-destructive testing of steel tubes - Part 17: Ultrasonic testing of tube ends of seamless and welded steel tubes for detection of laminar imperfections.*

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EN 10256, *Non-destructive testing of steel tubes - Qualification and competence of level 1 and level 2 non-destructive testing personnel.*

EN 10168, *Steel products - Inspection documents - List of information and description.*

EN 10266:2003, *Steel tubes, fittings and structural hollow sections - Symbols and definitions of terms for use in product standards.*

EN ISO 377, *Steel and steel products - Location and preparation of samples and test pieces for mechanical testing (ISO 377:1997).*

EN ISO 643, *Steels - Micrographic determination of the apparent grain size (ISO 643:2003)*

EN ISO 1127, *Stainless steel tubes - Dimensions, tolerances and conventional masses per unit length (ISO 1127:1992).*

EN ISO 2566-2, *Steel - Conversion of elongation values - Part 2: Austenitic steels (ISO 2566-2:1984).*

EN ISO 3651-2, *Determination of resistance to intergranular corrosion of stainless steels - Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels - Corrosion test in media containing sulfuric acid (ISO 3651.2:1998).*

EN ISO 14284, *Steel and iron - Sampling and preparation of samples for the determination of the chemical composition (ISO 14284:1996).*

CR 10260, *Designation systems for steel - Additional symbols.*

CR 10261, *ECISS Information Circular 11 - Iron and steel - Review of available methods of chemical analysis.*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 10020:2000, EN 10021:1993, EN 10052:1993 and EN 10266:2003 together with the following apply.

#### 3.1

##### **test category**

classification that indicates the extent and level of inspection and testing

#### 3.2

##### **employer**

organization for which a person works on a regular basis

NOTE The employer may be either the tube manufacturer or supplier or a third party organization providing Non-Destructive Testing (NDT) services.

## 4 Symbols

For the purposes of this document, the symbols given in EN 10266 and the following apply:

— TC test category

NOTE See also Table 1 for symbols of the delivery condition.

## 5 Classification and designation

### 5.1 Classification

According to the classification system in EN 10020, the steel grades are classified as:

- austenitic steels (corrosion resisting or creep resisting steels);
- austenitic-ferritic steels.

For more details see EN 10088-1.

### 5.2 Designation

For the tubes covered by this part of EN 10216 the steel designation consists of:

— number of this part of EN 10216 (EN 10216-5);

plus either:

— steel name in accordance with EN 10027-1 and CR 10260;

or:

— steel number allocated in accordance with EN 10027-2.

## 6 Information to be supplied by the purchaser

### 6.1 Mandatory information

The following information shall be supplied by the purchaser at the time of enquiry and order:

- a) quantity (mass or total length or number);
- b) term "tube";
- c) dimensions (outside diameter D and wall thickness T) (see 8.8.1);
- d) designation of the steel grade according to this part of EN 10216 (see 5.2);
- e) test category (see 9.3).

### 6.2 Options

A number of options are specified in this part of EN 10216 and these are listed below. In the event that the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the tube shall be supplied in accordance with the basic specification (see 6.1).

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1. Information about steelmaking process (see 7.1).
2. Delivery condition (see 7.2.4).
3. Specified range for sulphur content (see Table 2, footnote b).
4. Product analysis (see 8.2.2).
5. Additional mechanical tests on samples which have undergone a different or additional heat treatment (see 8.3.1).
6. Impact test at room temperature (see 8.3.1).
7. Agreed mechanical properties at room temperature for austenitic corrosion resisting steel tubes with wall thicknesses greater than 60 mm (see Table 6, footnote a).
8. Agreed mechanical properties at room temperature for austenitic creep resisting steel tubes with wall thicknesses greater than 50 mm (see Table 7, footnote a).
9. Verification of proof strength  $R_{p0,2}$  or  $R_{p1,0}$  at elevated temperatures (see 8.3.2.1).
10. Agreed proof strength values at elevated temperatures for austenitic corrosion resisting steel tubes with wall thicknesses greater than 60 mm (see Table 9, footnote a).
11. Impact test at low temperature (see 8.3.3).
12. Intergranular corrosion test (see 8.4).
13. Selection of leak-tightness test method (see 8.5.2.1).
14. Non-destructive testing for test category 2 tubes with specified outside diameter less than or equal to 101,6 mm and specified wall thickness less than or equal to 5,6 mm for detection of longitudinal imperfections (see 8.5.2.2).
15. Non-destructive testing for test category 2 tubes for detection of transverse imperfections (see 8.5.2.2).
16. Non-destructive testing for test category 2 tubes with specified wall thickness greater than 40 mm for detection of laminar imperfections at tube ends (see 8.5.2.2).
17. Special ends preparation (see 8.7).
18. Exact lengths (see 8.8.3).
19. Sized tube ends for tube of  $D > 219,1$  mm (see Table 12).
20. Tolerance classes D 4 and T 4 for tubes ordered cold finished (see Table 13).
21. Type of inspection document other than the standard document (see 9.2.1).
22. Test pressure for hydrostatic leak-tightness test (see 11.6.1).
23. Wall thickness measurement away from the ends (see 11.7).
24. Additional marking (see 12.2).
25. Special protection (see 13).



## 6.3 Examples of an order

### 6.3.1 Example 1

2 000 m of hot finished descaled seamless tube with an outside diameter of 168,3 mm, a wall thickness of 4,5 mm, in accordance with this part of EN 10216, tolerance classes D 2 and T 2, made of steel grade X2CrNi19-11, to test category 1, with a 3.1.B inspection certificate in accordance with EN 10204:

2 000 m - HFD Tube – 168,3 X 4,5 - EN 10216-5 - X2CrNi19-11 - TC 1

### 6.3.2 Example 2

300 m of cold finished descaled seamless tube with an outside diameter of 42,4 mm, a wall thickness of 2,6 mm, in accordance with this part EN 10216, tolerance classes D 3 and T 3, made of steel grade 1.4301, to test category 2, with intergranular corrosion test (EN ISO 3651-2, method A), verification of proof strength at 300 °C, non-destructive testing for detection of longitudinal and transverse imperfections, with a 3.2 inspection certificate in accordance with EN 10204:

300 m - CFD Tube – 42,4 X 2,6 - EN 10216-5 - 1.4301 – TC 2 - Option 9: 300 °C – Option 12: A – Option 14 - Option 15 - Option 21: 3.2

## 7 Manufacturing process

### 7.1 Steelmaking process

The steelmaking process is at the discretion of the manufacturer, but see option 1.

*Option 1: The purchaser shall be informed about the steelmaking process used. The process shall be reported in the inspection document.*

### 7.2 Tube manufacture and delivery conditions

**7.2.1** All NDT activities shall be carried out by qualified and competent level 1, 2 and/or 3 personnel authorised to operate by the employer.

The qualification shall be in accordance with EN 10256 or, at least, an equivalent to it.

It is recommended that the level 3 personnel be certified in accordance to EN 473 or, at least an equivalent to it.

The operating authorisation issued by the employer shall be in accordance with a written procedure.

NDT operations shall be authorised by a level 3 NDT individual approved by the employer.

**NOTE** The definition of level 1, 2 and 3 can be found in appropriate standards, e.g. EN 473 and EN 10256.

**7.2.2** The tubes shall be manufactured by a seamless process, and may be hot finished or cold finished. The terms " hot finished " and " cold finished " apply to the condition of the tube before it is heat treated in accordance with 7.2.3.

The process of manufacture is left to the discretion of the manufacturer, but see option 2.

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7.2.3 The tubes shall be supplied in the solution annealed condition over their full length in either:

- reference heat treatment conditions;
- solution annealed conditions obtained directly by extrusion and subsequent cooling provided the mechanical properties, corrosion resistance and other properties are in accordance with this part of EN 10216. All specified mechanical properties shall be met even after a subsequent reference heat treatment.

Solution treatment shall consist of heating the tubes uniformly to a temperature within the range given for the steel grade concerned in Tables 6, 7 and 8 and cooling rapidly.

7.2.4 The types of delivery condition of the tubes are given in Table 1.

Unless option 2 is specified, the type of delivery condition is at the discretion of the manufacturer.

**Option 2:** *The delivery condition is specified by the purchaser.*

Table 1 — Delivery conditions <sup>a</sup>

| Symbol <sup>b</sup> | Type of delivery condition           | Surface condition  |
|---------------------|--------------------------------------|--|
| HFD                 | Hot finished heat treated, descaled  | Metallically clean   |
| CFD                 | Cold finished heat treated, descaled | Metallically clean   |
| CFA                 | Cold finished bright annealed        | Metallically bright  |
| CFG                 | Cold finished heat treated, ground   | Metallically bright-ground, the type and degree of roughness shall be agreed at the time of enquiry and order <sup>c</sup>   |
| CFP                 | Cold finished heat treated, polished | Metallically bright-polished, the type and degree of roughness shall be agreed at the time of enquiry and order <sup>c</sup> |

<sup>a</sup> Combinations of the different conditions may be agreed at the time of enquiry and order.

<sup>b</sup> The symbols are abbreviations for type of condition. Example: CFD = Cold Finished Descaled.

<sup>c</sup> The enquiry and the order shall indicate whether the roughness requirement applies on the internal or external tube surface, or internal and external.

## 8 Requirements

### 8.1 General

When supplied in a delivery condition indicated in 7.2.4 and inspected in accordance with clauses 9, 10 and 11, the tubes shall conform to the requirements of this part of EN 10216.

In addition, the general technical delivery requirements specified in EN 10021 shall apply.

### 8.2 Chemical composition

#### 8.2.1 Cast analysis

The cast analysis reported by the steel manufacturer shall apply and conform to the requirements of Tables 2 or 3 for austenitic steels and of Table 4 for austenitic-ferritic steels.

**Option 3:** *(see Table 2).*

NOTE When welding tubes produced in accordance with this part of EN 10216, account should be taken to the fact that the behaviour of the steel during and after welding is dependent not only on the steel, but also on the applied heat treatment and the conditions of preparing for and carrying out the welding.

### 8.2.2 Product analysis

*Option 4: Product analysis for the tubes shall be supplied.*

Table 5 specifies the permissible deviation of the product analysis from the specified limits on cast analysis given in Tables 2, 3 and 4.

**Table 2 — Chemical composition (cast analysis) <sup>a</sup> of austenitic corrosion resisting steels, in % by mass (continued)**

| Steel grade       |              | C<br>max | Si     | Mn     | P<br>max | S<br>max           | N            | Cr             | Cu | Mo           | Nb           | Ni                          | Ti          | Others |
|-------------------|--------------|----------|--------|--------|----------|--------------------|--------------|----------------|----|--------------|--------------|-----------------------------|-------------|--------|
| Steel name        | Steel number |          |        |        |          |                    |              |                |    |              |              |                             |             |        |
| X2CrNi18-9        | 1.4307       | 0,030    | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015 <sup>b</sup> | ≤ 0,11       | 17,50 to 19,50 | —  | —            | —            | 8,00 to 10,00 <sup>c</sup>  | —           | —      |
| X2CrNi19-11       | 1.4306       | 0,030    | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015 <sup>b</sup> | ≤ 0,11       | 18,00 to 20,00 | —  | —            | —            | 10,00 to 12,00 <sup>d</sup> | —           | —      |
| X2CrNiN18-10      | 1.4311       | 0,030    | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015              | 0,12 to 0,22 | 17,00 to 19,50 | —  | —            | —            | 8,50 to 11,50               | —           | —      |
| X5CrNi18-10       | 1.4301       | 0,07     | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015 <sup>b</sup> | ≤ 0,11       | 17,00 to 19,50 | —  | —            | —            | 8,00 to 10,50               | —           | —      |
| X6CrNiTi18-10     | 1.4541       | 0,08     | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015              | —            | 17,00 to 19,00 | —  | —            | —            | 9,00 to 12,00 <sup>d</sup>  | 5xC to 0,70 | —      |
| X6CrNiNb18-10     | 1.4550       | 0,08     | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015              | —            | 17,00 to 19,00 | —  | —            | 10xC to 1,00 | 9,00 to 12,00 <sup>d</sup>  | —           | —      |
| X1CrNi25-21       | 1.4335       | 0,020    | ≤ 0,25 | ≤ 2,00 | 0,025    | 0,010              | ≤ 0,11       | 24,00 to 26,00 | —  | ≤ 0,20       | —            | 20,00 to 22,00              | —           | —      |
| X2CrNiMo17-12-2   | 1.4404       | 0,030    | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015 <sup>b</sup> | ≤ 0,11       | 16,50 to 18,50 | —  | 2,00 to 2,50 | —            | 10,00 to 13,00 <sup>e</sup> | —           | —      |
| X5CrNiMo17-12-2   | 1.4401       | 0,07     | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015 <sup>b</sup> | ≤ 0,11       | 16,50 to 18,50 | —  | 2,00 to 2,50 | —            | 10,00 to 13,00              | —           | —      |
| X1CrNiMoN25-22-2  | 1.4466       | 0,020    | ≤ 0,70 | ≤ 2,00 | 0,025    | 0,010              | 0,10 to 0,16 | 24,00 to 26,00 | —  | 2,00 to 2,50 | —            | 21,00 to 23,00              | —           | —      |
| X6CrNiMoTi17-12-2 | 1.4571       | 0,08     | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015 <sup>b</sup> | —            | 16,50 to 18,50 | —  | 2,00 to 2,50 | —            | 10,50 to 13,50 <sup>c</sup> | 5xC to 0,70 | —      |
| X6CrNiMoNb17-12-2 | 1.4580       | 0,08     | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015              | —            | 16,50 to 18,50 | —  | 2,00 to 2,50 | 10xC to 1,00 | 10,50 to 13,50              | —           | —      |
| X2CrNiMoN17-13-3  | 1.4429       | 0,030    | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015              | 0,12 to 0,22 | 16,50 to 18,50 | —  | 2,50 to 3,00 | —            | 11,00 to 14,00 <sup>d</sup> | —           | —      |
| X3CrNiMo17-13-3   | 1.4436       | 0,05     | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015 <sup>b</sup> | ≤ 0,11       | 16,50 to 18,50 | —  | 2,50 to 3,00 | —            | 10,50 to 13,00 <sup>d</sup> | —           | —      |
| X2CrNiMo18-14-3   | 1.4435       | 0,030    | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015 <sup>b</sup> | ≤ 0,11       | 17,00 to 19,00 | —  | 2,50 to 3,00 | —            | 12,50 to 15,00              | —           | —      |
| X2CrNiMoN17-13-5  | 1.4439       | 0,030    | ≤ 1,00 | ≤ 2,00 | 0,040    | 0,015              | 0,12 to 0,22 | 16,50 to 18,50 | —  | 4,00 to 5,00 | —            | 12,50 to 14,50              | —           | —      |

| Steel grade        |              | C<br>max | Si     | Mn     | P<br>max | S<br>max | N            | Cr             | Cu           | Mo           | Nb | Ni             | Ti                 | Others              |
|--------------------|--------------|----------|--------|--------|----------|----------|--------------|----------------|--------------|--------------|----|----------------|--------------------|---------------------|
| Steel name         | Steel number |          |        |        |          |          |              |                |              |              |    |                |                    |                     |
| X1NiCrMoCu31-27-4  | 1.4563       | 0,020    | ≤ 0,70 | ≤ 2,00 | 0,030    | 0,010    | ≤ 0,11       | 26,00 to 28,00 | 0,70 to 1,50 | 3,00 to 4,00 | —  | 30,00 to 32,00 | —                  | —                   |
| X1NiCrMoCu25-20-5  | 1.4539       | 0,020    | ≤ 0,70 | ≤ 2,00 | 0,030    | 0,010    | ≤ 0,15       | 19,00 to 21,00 | 1,20 to 2,00 | 4,00 to 5,00 | —  | 24,00 to 26,00 | —                  | —                   |
| X1CrNiMoCuN20-18-7 | 1.4547       | 0,020    | ≤ 0,70 | ≤ 1,00 | 0,030    | 0,010    | 0,18 to 0,25 | 19,50 to 20,50 | 0,50 to 1,00 | 6,00 to 7,00 | —  | 17,50 to 18,50 | —                  | —                   |
| X1NiCrMoCuN25-20-7 | 1.4529       | 0,020    | ≤ 0,50 | ≤ 1,00 | 0,030    | 0,010    | 0,15 to 0,25 | 19,00 to 21,00 | 0,50 to 1,50 | 6,00 to 7,00 | —  | 24,00 to 26,00 | —                  | —                   |
| X2NiCrAlTi32-20    | 1.4558       | 0,030    | ≤ 0,70 | ≤ 1,00 | 0,020    | 0,015    | —            | 20,00 to 23,00 | —            | —            | —  | 32,00 to 35,00 | 8X(C+N)<br>to 0,60 | Al: 0,15<br>to 0,45 |

a Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.

b For products to be machined a controlled sulphur content of 0,015 % to 0,030 % is permitted by agreement provided the resistance to corrosion is still satisfied for the intended purpose.

**Option 3:** A sulphur content of 0,015 % to 0,030 % is specified.

c Where for special reasons, e.g. hot workability it is necessary to minimize the deltaferrite content, or with the aim of low permeability, the maximum nickel content may be increased by 0,50 %.

d Where for special reasons, e.g. hot workability it is necessary to minimize the deltaferrite content, or with the aim of low permeability, the maximum nickel content may be increased by 1,00 %.

e Where for special reasons, e.g. hot workability it is necessary to minimize the deltaferrite content, or with the aim of low permeability, the maximum nickel content may be increased by 1,50 %.

Table 3 - Chemical composition (cast analysis) <sup>a</sup> of austenitic creep resisting steels, in % by mass

| Steel grade                        |              | C            | Si           | Mn           | P<br>max | S<br>max | N            | Cr             | Cu     | Mo           | Nb                | Ni             | Ti              | Others   |
|------------------------------------|--------------|--------------|--------------|--------------|----------|----------|--------------|----------------|--------|--------------|-------------------|----------------|-----------------|--|
| Steel name                         | Steel number |              |              |              |          |          |              |                |        |              |                   |                |                 |  |
| X6CrNi18-10                        | 1.4948       | 0,04 to 0,08 | ≤ 1,00       | ≤ 2,00       | 0,035    | 0,015    | ≤ 0,11       | 17,00 to 19,00 | -      | -            | -                 | 8,00 to 11,00  | -               | -  |
| X7CrNiTi18-10                      | 1.4940       | 0,04 to 0,08 | ≤ 1,00       | ≤ 2,00       | 0,040    | 0,015    | ≤ 0,11       | 17,00 to 19,00 | -      | -            | -                 | 9,00 to 13,00  | 5x(C+N) to 0,80 | -  |
| X7CrNiNb18-10                      | 1.4912       | 0,04 to 0,10 | ≤ 1,00       | ≤ 2,00       | 0,040    | 0,015    | ≤ 0,11       | 17,00 to 19,00 | -      | -            | 10xC to 1,20      | 9,00 to 12,00  | -               | -  |
| X6CrNiTiB18-10                     | 1.4941       | 0,04 to 0,08 | ≤ 1,00       | ≤ 2,00       | 0,035    | 0,015    | -            | 17,00 to 19,00 | -      | -            | -                 | 9,00 to 12,00  | 5xC to 0,80     | B: 0,0015 to 0,0050  |
| X6CrNiMo17-13-2                    | 1.4918       | 0,04 to 0,08 | ≤ 0,75       | ≤ 2,00       | 0,035    | 0,015    | ≤ 0,11       | 16,00 to 18,00 | -      | 2,00 to 2,50 | -                 | 12,00 to 14,00 | -               | -  |
| X5NiCrAlTi31-20 (+RA) <sup>b</sup> | 1.4958(+RA)  | 0,03 to 0,08 | ≤ 0,70       | ≤ 1,50       | 0,015    | 0,010    | -            | 19,00 to 22,00 | ≤ 0,50 | -            | ≤ 0,10            | 30,00 to 32,50 | 0,20 to 0,50    | Al: 0,20 to 0,50<br>Al+Ti: ≤ 0,70<br>Co: ≤ 0,5<br>Ni+Co = 30,0 to 32,5 |
| X8NiCrAlTi32-21                    | 1.4959       | 0,05 to 0,10 | ≤ 0,70       | ≤ 1,50       | 0,015    | 0,010    | -            | 19,00 to 22,00 | ≤ 0,50 | -            | -                 | 30,00 to 34,00 | 0,25 to 0,65    | Al: 0,20 to 0,65   |
| X3CrNiMoBN17-13-3                  | 1.4910       | ≤ 0,04       | ≤ 0,75       | ≤ 2,00       | 0,035    | 0,015    | 0,10 to 0,18 | 16,00 to 18,00 | -      | 2,00 to 3,00 | -                 | 12,00 to 14,00 | -               | B: 0,0015 to 0,0050  |
| X8CrNiNb16-13                      | 1.4961       | 0,04 to 0,10 | 0,30 to 0,60 | ≤ 1,50       | 0,035    | 0,015    | -            | 15,00 to 17,00 | -      | -            | 10xC to 1,20      | 12,00 to 14,00 | -               | -  |
| X8CrNiMoVNb16-13                   | 1.4988       | 0,04 to 0,10 | 0,30 to 0,60 | ≤ 1,50       | 0,035    | 0,015    | 0,06 to 0,14 | 15,50 to 17,50 | -      | 1,10 to 1,50 | 10xC to 1,20      | 12,50 to 14,50 | -               | V: 0,60 to 0,85  |
| X8CrNiMoNb16-16                    | 1.4981       | 0,04 to 0,10 | 0,30 to 0,60 | ≤ 1,50       | 0,035    | 0,015    | -            | 15,50 to 17,50 | -      | 1,60 to 2,00 | 10xC to 1,20<br>c | 15,50 to 17,50 | -               | -  |
| X10CrNiMoMnNbVB15-10-1             | 1.4982       | 0,06 to 0,15 | 0,20 to 1,00 | 5,50 to 7,00 | 0,035    | 0,015    | -            | 14,00 to 16,00 | -      | 0,80 to 1,20 | 0,75 to 1,25      | 9,00 to 11,00  | -               | V: 0,15 to 0,40<br>B 0,003 to 0,009                                    |

<sup>a</sup> Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.

<sup>b</sup> Recrystallizing annealed condition.

<sup>c</sup> Including Ta.

Table 4 - Chemical composition (cast analysis) <sup>a</sup> of austenitic-ferritic steels, in % by mass

| Steel grade                  |              | C<br>max | Si              | Mn              | P<br>max | S<br>max | N               | Cr                | Cu              | Mo              | Ni              | Others             |
|------------------------------|--------------|----------|-----------------|-----------------|----------|----------|-----------------|-------------------|-----------------|-----------------|-----------------|--------------------|
| Steel name                   | Steel number |          |                 |                 |          |          |                 |                   |                 |                 |                 |                    |
| X2CrNiMoN22-5-3              | 1.4462       | 0,030    | ≤ 1,00          | ≤ 2,00          | 0,035    | 0,015    | 0,10 to<br>0,22 | 21,00 to<br>23,00 | –               | 2,50 to<br>3,50 | 4,50 to<br>6,50 | –                  |
| X2CrNiMoSi18-5-3             | 1.4424       | 0,030    | 1,40 to<br>2,00 | 1,20 to<br>2,00 | 0,035    | 0,015    | 0,05 to<br>0,10 | 18,00 to<br>19,00 | –               | 2,50 to<br>3,00 | 4,50 to<br>5,20 | –                  |
| X2CrNiN23-4 <sup>b</sup>     | 1.4362       | 0,030    | ≤ 1,00          | ≤ 2,00          | 0,035    | 0,015    | 0,05 to<br>0,20 | 22,00 to<br>24,00 | 0,10 to<br>0,60 | 0,10 to<br>0,60 | 3,50 to<br>5,50 | –                  |
| X2CrNiMoN25-7-4 <sup>b</sup> | 1.4410       | 0,030    | ≤ 1,00          | ≤ 2,00          | 0,035    | 0,015    | 0,20 to<br>0,35 | 24,00 to<br>26,00 | –               | 3,00 to<br>4,50 | 6,00 to<br>8,00 | –                  |
| X2CrNiMoCuN25-6-3            | 1.4507       | 0,030    | ≤ 0,70          | ≤ 2,00          | 0,035    | 0,015    | 0,15 to<br>0,30 | 24,00 to<br>26,00 | 1,00 to<br>2,50 | 2,70 to<br>4,00 | 5,50 to<br>7,50 | –                  |
| X2CrNiMoCuWN25-7-4           | 1.4501       | 0,030    | ≤ 1,00          | ≤ 1,00          | 0,035    | 0,015    | 0,20 to<br>0,30 | 24,00 to<br>26,00 | 0,50 to<br>1,00 | 3,00 to<br>4,00 | 6,00 to<br>8,00 | W: 0,50 to<br>1,00 |

<sup>a</sup> Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.

<sup>b</sup> Patented steel grade.

**Table 5 - Permissible deviations of the product analysis from specified limits on cast analysis given in Tables 2, 3 and 4**

| Element    | Limiting value for the cast analysis according to Tables 2, 3 and 4 % by mass | Permissible deviation of the product analysis <sup>a</sup> % by mass |
|------------|---|--|
| Carbon     | ≤ 0,030   | + 0,005  |
|            | > 0,030 ≤ 0,15  | ± 0,01   |
| Silicon    | ≤ 2,00  | ± 0,05   |
| Manganese  | ≤ 1,00  | + 0,03   |
|            | > 1,00 ≤ 2,00   | ± 0,04   |
|            | > 2,00 ≤ 7,00   | ± 0,10   |
| Phosphorus | ≤ 0,030   | + 0,003  |
|            | > 0,030 ≤ 0,040   | + 0,005  |
| Sulphur    | ≤ 0,015   | + 0,003  |
|            | > 0,015 ≤ 0,030   | + 0,005  |
| Nitrogen   | ≤ 0,35  | ± 0,01   |
| Aluminium  | ≤ 0,65  | ± 0,10   |
| Boron      | ≥ 0,001 5 ≤ 0,009 0   | ± 0,0003   |
| Chromium   | > 14,00 ≤ 20,00   | ± 0,20   |
|            | > 20,00 ≤ 28,00   | ± 0,25   |
| Cobalt     | ≤ 0,50  | + 0,10   |
| Copper     | ≤ 1,00  | ± 0,07   |
|            | > 1,00 ≤ 2,50   | ± 0,10   |
| Molybdenum | ≤ 0,60  | ± 0,03   |
|            | > 0,60 ≤ 1,75   | ± 0,05   |
|            | > 1,75 ≤ 7,00   | ± 0,10   |
| Niobium    | ≤ 1,25  | ± 0,05   |
| Nickel     | > 3,50 ≤ 5,00   | ± 0,07   |
|            | > 5,00 ≤ 10,00  | ± 0,10   |
|            | > 10,00 ≤ 20,00   | ± 0,15   |
|            | > 20,00 ≤ 35,00   | ± 0,20   |
| Titanium   | ≤ 0,80  | ± 0,05   |
| Vanadium   | ≤ 0,85  | ± 0,03   |
| Tungsten   | ≤ 1,00  | ± 0,05   |

<sup>a</sup> If several product analyses are carried out on one cast, and the contents of an individual element determined lie outside the permissible range of the chemical composition specified for the cast analysis, then it is only allowed to exceed the permissible maximum value or to fall short of the permissible minimum value, but not both for one cast.



### 8.3 Mechanical properties

#### 8.3.1 At room temperature

The mechanical properties of the tubes at room temperature shall conform to the relevant requirements in Tables 6, 7 and 8 and in clause 11.

If heat treatments different from, or additional to, the reference heat treatment are to be carried out after the delivery of the tubes, the purchaser may request, at the time of enquiry and order, additional mechanical tests on samples, that have been given heat treatments different from or additional to, those given in Tables 6, 7 and 8. The heat treatment of the samples and the mechanical properties to be obtained from tests on them shall be agreed between the purchaser and the manufacturer at the time of enquiry and order.

**Option 5:** *Additional mechanical tests on samples which have undergone a different or additional heat treatment shall be carried out.*

**Option 6:** *Impact test shall be carried out at room temperature (see Tables 6, 7 and 8).*

**Option 7:** (see Table 6, footnote a).

**Option 8:** (see Table 7, footnote a).

#### 8.3.2 At elevated temperature

##### 8.3.2.1 Proof strength

The minimum proof strength  $R_{p0,2}$  and  $R_{p1,0}$  values at elevated temperatures are specified in Tables 9, 10 and 11.

**Option 9:** *Proof strength  $R_{p0,2}$  or  $R_{p1,0}$  (for austenitic-ferritic steels in Table 11 only  $R_{p0,2}$  apply) shall be verified. The test temperature shall be agreed at the time of enquiry and order.*

**Option 10:** (see Table 9, footnote a).

##### 8.3.2.2 Creep rupture strength

Annex A gives mean values as preliminary data about creep rupture strength.

NOTE Steel grades not mentioned in Table A.1 are not intended for use in the creep range.

#### 8.3.3 At low temperature

Impact energy values at specified low temperature shall conform to the requirements in Tables 6 and 8.

**Option 11:** *Impact test at low temperature shall be carried out.*

**Table 6 - Mechanical properties for wall thicknesses up to 60 mm<sup>a</sup> of austenitic corrosion resisting steels in the solution annealed condition (+AT) and information about intergranular corrosion (continued)<sup>b</sup>**

| Steel grade                     |        | Tensile properties at room temperature <sup>c</sup> |                                |  |                  |          | Impact properties <sup>c</sup>                 |       |           | Reference heat treatment conditions     |                         | Resistance to intergranular corrosion |                         |
|---------------------------------|--------|---|--------------------------------|--|------------------|----------|--|-------|-----------|---|-------------------------|---------------------------------------|-------------------------|
|                                 |        | Proof strength                                      |                                | Tensile strength<br><i>R<sub>m</sub></i> | Elongation       |          | Minimum average absorbed energy KV<br><i>J</i> |       |           |   |                         |                                       |                         |
|                                 |        | <i>R<sub>p0,2</sub></i><br>min                      | <i>R<sub>p1,0</sub></i><br>min |  | <i>A</i> min (%) | <i>l</i> | <i>t</i>                                       | at RT | at -196°C | Solution temperature <sup>d</sup><br>°C | Cooling in <sup>e</sup> | <i>f</i>                              | Method in EN ISO 3651-2 |
| MPa                             | MPa    | MPa   | <i>l</i>                       | <i>t</i>                                 |                  |          |  |       |           |   |                         |                                       |                         |
| X2CrNi18-9                      | 1.4307 | 180   | 215                            | 460 to 680                               | 40               | 35       | 100  | 60    | 60        | 1 000 to 1 100                          | w, a                    | yes                                   | A                       |
| X2CrNi19-11                     | 1.4306 | 180   | 215                            | 460 to 680                               | 40               | 35       | 100  | 60    | 60        | 1 000 to 1 100                          | w, a                    | yes                                   | A                       |
| X2CrNiN18-10                    | 1.4311 | 270   | 305                            | 550 to 760                               | 35               | 30       | 100  | 60    | 60        | 1 000 to 1 100                          | w, a                    | yes                                   | A                       |
| X5CrNi18-10                     | 1.4301 | 195   | 230                            | 500 to 700                               | 40               | 35       | 100  | 60    | 60        | 1 000 to 1 100                          | w, a                    | yes <sup>g</sup>                      | A                       |
| X6CrNiTi18-10 (cold finish)     | 1.4541 | 200   | 235                            | 500 to 730                               | 35               | 30       | 100  | 60    | 60        | 1 020 to 1 120                          | w, a                    | yes                                   | A                       |
| X6CrNiTi18-10 (hot finish)      | 1.4541 | 180   | 215                            | 460 to 680                               | 35               | 30       | 100  | 60    | 60        | 1 020 to 1 120                          | w, a                    | yes                                   | A                       |
| X6CrNiNb18-10                   | 1.4550 | 205   | 240                            | 510 to 740                               | 35               | 30       | 100  | 60    | 60        | 1 020 to 1 120                          | w, a                    | yes                                   | A                       |
| X1CrNi25-21                     | 1.4335 | 180   | 210                            | 470 to 670                               | 45               | 40       | 100  | 60    | 60        | 1 030 to 1 110                          | w, a                    | yes                                   | A                       |
| X2CrNiMo17-12-2                 | 1.4404 | 190   | 225                            | 490 to 690                               | 40               | 30       | 100  | 60    | 60        | 1 020 to 1 120                          | w, a                    | yes                                   | A                       |
| X5CrNiMo17-12-2                 | 1.4401 | 205   | 240                            | 510 to 710                               | 40               | 30       | 100  | 60    | 60        | 1 020 to 1 120                          | w, a                    | yes <sup>g</sup>                      | A                       |
| X1CrNiMoN25-22-2                | 1.4466 | 260   | 295                            | 540 to 740                               | 40               | 30       | 100  | 60    | 60        | 1 070 to 1 150                          | w, a                    | yes                                   | A or B                  |
| X6CrNiMoTi17-12-2 (cold finish) | 1.4571 | 210   | 245                            | 500 to 730                               | 35               | 30       | 100  | 60    | -         | 1 020 to 1 120                          | w, a                    | yes                                   | A                       |
| X6CrNiMoTi17-12-2 (hot finish)  | 1.4571 | 190   | 225                            | 490 to 690                               | 35               | 30       | 100  | 60    | 60        | 1 020 to 1 120                          | w, a                    | yes                                   | A                       |
| X6CrNiMoNb17-12-2               | 1.4580 | 215   | 250                            | 510 to 740                               | 35               | 30       | 100  | 60    | -         | 1 020 to 1 120                          | w, a                    | yes                                   | A                       |
| X2CrNiMoN17-13-3                | 1.4429 | 295   | 330                            | 580 to 800                               | 35               | 30       | 100  | 60    | 60        | 1 020 to 1 120                          | w, a                    | yes                                   | A                       |
| X3CrNiMo17-13-3                 | 1.4436 | 205   | 240                            | 510 to 710                               | 40               | 30       | 100  | 60    | 60        | 1 020 to 1 120                          | w, a                    | yes <sup>g</sup>                      | A                       |
| X2CrNiMo18-14-3                 | 1.4435 | 190   | 225                            | 490 to 690                               | 40               | 30       | 100  | 60    | 60        | 1 020 to 1 120                          | w, a                    | yes                                   | A                       |

| Steel grade        |              | Tensile properties at room temperature <sup>c</sup> |                                |  |            |    | Impact properties <sup>c</sup>              |           |    | Reference heat treatment conditions     |                         | Resistance to intergranular corrosion |                         |
|--------------------|--------------|---|--------------------------------|--|------------|----|---|-----------|----|---|-------------------------|---------------------------------------|-------------------------|
|                    |              | Proof strength                                      |                                | Tensile strength<br><br><i>R<sub>m</sub></i> | Elongation |    | Minimum average absorbed energy KV<br><br>J |           |    | Solution temperature <sup>d</sup><br>°C | Cooling in <sup>e</sup> | f                                     | Method in EN ISO 3651-2 |
|                    |              | <i>R<sub>p0.2</sub></i><br>min                      | <i>R<sub>p1.0</sub></i><br>min |  | A min (%)  |    | at RT                                       | at -196°C |    |   |                         |                                       |                         |
| Steel name         | Steel number | MPa   | MPa                            | MPa  | l          | t  | l   | t         | t  |   |                         |                                       |                         |
| X2CrNiMoN17-13-5   | 1.4439       | 285   | 315                            | 580 to 800                                   | 35         | 30 | 100   | 60        | 60 | 1 060 to 1 140                          | w, a                    | yes                                   | A                       |
| X1NiCrMoCu31-27-4  | 1.4563       | 215   | 245                            | 500 to 750                                   | 40         | 35 | 120   | 90        | 60 | 1 070 to 1 150                          | w, a                    | yes                                   | B or C                  |
| X1NiCrMoCu25-20-5  | 1.4539       | 230   | 250                            | 520 to 720                                   | 35         | 30 | 120   | 90        | 60 | 1 060 to 1 140                          | w, a                    | yes                                   | C                       |
| X1CrNiMoCuN20-18-7 | 1.4547       | 300   | 340                            | 650 to 850                                   | 35         | 30 | 100   | 60        | 60 | 1 140 to 1 200                          | w, a                    | yes                                   | C                       |
| X1NiCrMoCuN25-20-7 | 1.4529       | 270   | 310                            | 600 to 800                                   | 35         | 30 | 100   | 60        | 60 | 1 120 to 1 180                          | w, a                    | yes                                   | C                       |
| X2NiCrAlTi32-20    | 1.4558       | 180   | 210                            | 450 to 700                                   | 35         | 30 | 120   | 90        | 60 | 950 to 1 050                            | w, a                    | yes                                   | A                       |

<sup>a</sup> For wall thicknesses greater than 60 mm the mechanical properties are subject to agreement at the time of enquiry and order. **Option 7:** Agreed mechanical properties for wall thicknesses greater than 60 mm apply.

<sup>b</sup> Inspection and testing to be carried out are summarised in Table 15.

<sup>c</sup> l = longitudinal; t = transverse.

<sup>d</sup> The maximum temperatures are for guidance only.

<sup>e</sup> w = water; a = air; cooling sufficiently rapid.

<sup>f</sup> When tested according to EN ISO 3651-2 (Appropriate method, A or B or C, as indicated) up to the limit temperatures indicated in the last column of Table 9.

<sup>g</sup> In delivery condition. (Normally not fulfilled in the sensitized condition).

**Table 7 - Mechanical properties for wall thicknesses up to 50 mm <sup>a</sup> of austenitic creep resisting steels in the solution annealed condition (+AT) and information about intergranular corrosion <sup>b</sup>**

| Steel grade            |              | Tensile properties at room temperature <sup>c</sup> |                          |                  |            |    | Impact properties at room temperature <sup>c</sup> |    | Reference heat treatment conditions     |                         | Resistance to intergranular corrosion |                         |
|------------------------|--------------|---|--------------------------|------------------|------------|----|--|----|---|-------------------------|---------------------------------------|-------------------------|
|                        |              | Proof strength                                      |                          | Tensile strength | Elongation |    | Minimum average absorbed energy KV                 |    | Solution temperature <sup>d</sup><br>°C | Cooling in <sup>e</sup> | f                                     | Method in EN ISO 3651-2 |
|                        |              | R <sub>p0,2</sub><br>min                            | R <sub>p1,0</sub><br>min | R <sub>m</sub>   | A min (%)  |    | J  |    |   |                         |                                       |                         |
| Steel name             | Steel number | MPa   | MPa                      | MPa              | l          | t  | l  | t  |   |                         |                                       |                         |
| X6CrNi18-10            | 1.4948       | 185   | 225                      | 500 to 700       | 40         | 30 | 100  | 60 | 1 000 to 1 080                          | w, a                    | no                                    | A                       |
| X7CrNiTi18-10          | 1.4940       | 190   | 220                      | 510 to 710       | 35         | 30 | 100  | 60 | 1 100 to 1 150                          | w, a                    | no                                    | A                       |
| X7CrNiNb18-10          | 1.4912       | 205   | 240                      | 510 to 710       | 40         | 30 | 100  | 60 | 1 070 to 1 125                          | w, a                    | no                                    | A                       |
| X6CrNiTiB18-10         | 1.4941       | 195   | 235                      | 490 to 680       | 35         | 30 | 100  | 60 | 1 070 to 1 150                          | w, a                    | no                                    | A                       |
| X6CrNiMo17-13-2        | 1.4918       | 205   | 245                      | 490 to 690       | 35         | 30 | 100  | 60 | 1 020 to 1 100                          | w, a                    | no                                    | A                       |
| X5NiCrAlTi31-20        | 1.4958       | 170   | 200                      | 500 to 750       | 35         | 30 | 120  | 80 | 1 150 to 1 200                          | w, a                    | no                                    | A                       |
| X5NiCrAlTi31-20 + RA   | 1.4958+RA    | 210   | 240                      | 500 to 750       | 35         | 30 | 120  | 80 | 920 to 1 000 <sup>g</sup>               | w,a                     | no                                    | A                       |
| X8NiCrAlTi32-21        | 1.4959       | 170   | 200                      | 500 to 750       | 35         | 30 | 120  | 80 | 1 150 to 1 200 <sup>h</sup>             | w, a                    | no                                    | A                       |
| X3CrNiMoBN17-13-3      | 1.4910       | 260   | 300                      | 550 to 750       | 35         | 30 | 120  | 80 | 1 020 to 1 100                          | w, a                    | no                                    | A                       |
| X8CrNiNb16-13          | 1.4961       | 205   | 245                      | 510 to 690       | 35         | 22 | 100  | 60 | 1 050 to 1 100                          | w, a                    | no                                    | A                       |
| X8CrNiMoVNb16-13       | 1.4988       | 255   | 295                      | 540 to 740       | 30         | 20 | 60   | 40 | 1 100 to 1 150 <sup>i</sup>             | w, a                    | no                                    | A                       |
| X8CrNiMoNb16-16        | 1.4981       | 215   | 255                      | 530 to 690       | 35         | 22 | 100  | 60 | 1 050 to 1 100                          | w,a                     | no                                    | A                       |
| X10CrNiMoMnNbVB15-10-1 | 1.4982       | 220   | 270                      | 540 to 740       | 35         | 30 | 100  | 60 | 1 050 to 1 150                          | w, a                    | no                                    | A                       |

<sup>a</sup> For wall thicknesses greater than 50 mm the mechanical properties are subject to agreement at the time of enquiry and order. **Option 8: Agreed mechanical properties for wall thicknesses greater than 50 mm apply.**

<sup>b</sup> Inspection and testing to be carried out are summarised in Table 15.

<sup>c</sup> l = longitudinal; t = transverse.

<sup>d</sup> The maximum temperatures are for guidance only.

<sup>e</sup> w = water; a = air; cooling sufficiently rapid.

<sup>f</sup> When tested according to EN ISO 3651-2 (Appropriate method, A or B or C, as indicated) up to the limit temperatures indicated in the last column of Table 10.

<sup>g</sup> After solution annealing the grain size shall be 1 to 5 according to EN ISO 643.

<sup>h</sup> After solution annealing the grain size according to EN ISO 643 shall be 1 to 5 for cold worked tube and 5 or coarser for hot extruded tube.

<sup>i</sup> Additionally to be tempered at 750 °C to 800 °C, 1 to 5 h and air cooling.

**Table 8 - Mechanical properties for wall thicknesses up to 30 mm of austenitic-ferritic steels in the solution annealed condition (+AT) and information about intergranular corrosion <sup>a</sup>**

| Steel grade         |              | Tensile properties at room temperature <sup>b</sup> |                           |                    |       | Impact properties <sup>b</sup>          |       |           | Reference heat treatment conditions |                         | Resistance to intergranular corrosion |                         |
|---------------------|--------------|---|---------------------------|--------------------|-------|---|-------|-----------|-------------------------------------|-------------------------|---------------------------------------|-------------------------|
|                     |              | Proof strength<br>$R_{p0,2}$<br>min.                | Tensile strength<br>$R_m$ | Elongation         |       | Minimum average absorbed energy KV<br>J |       |           |                                     |                         |                                       |                         |
|                     |              |   |                           | $R_{p0,2}$<br>min. | $R_m$ | A min (%)                               | at RT | at -40 °C | Solution temperature <sup>c</sup>   | Cooling in <sup>d</sup> | e                                     | Method in EN ISO 3651-2 |
| Steel name          | Steel number | MPa   | MPa                       | l                  | t     | l                                       | t     | t         |                                     |                         |                                       |                         |
| X2CrNiMoN22-5-3     | 1.4462       | 450   | 640 to 880 <sup>f</sup>   | 22                 | 22    | 120                                     | 90    | 40        | 1 020 to 1 100                      | w, a                    | yes                                   | B                       |
| X2CrNiMoSi18-5-3    | 1.4424       | 480   | 700 to 900                | 30                 | 30    | 120                                     | 80    | -         | 975 to 1 050                        | w, a                    | yes                                   | A                       |
| X2CrNiN23-4         | 1.4362       | 400   | 600 to 820                | 25                 | 25    | 120                                     | 90    | 40        | 950 to 1 050                        | w, a                    | yes                                   | A                       |
| X2CrNiMoN25-7-4     | 1.4410       | 550   | 800 to 1000               | 20                 | 20    | 100                                     | 100   | 40        | 1 040 to 1 120                      | w, a                    | yes                                   | B or C                  |
| X2CrNiMoCuN25-6-3   | 1.4507       | 500   | 700 to 900                | 20                 | 20    | 100                                     | 100   | 40        | 1 040 to 1 120                      | w                       | yes                                   | B                       |
| X2CrNiMoCuWN 25-7-4 | 1.4501       | 550   | 800 to 1 000              | 20                 | 20    | 100                                     | 100   | 40        | 1 040 to 1 120                      | w                       | yes                                   | B or C                  |

<sup>a</sup> Inspection and testing to be carried out are summarised in Table 15.

<sup>b</sup> l = longitudinal; t = transverse.

<sup>c</sup> The maximum temperatures are for guidance only.

<sup>d</sup> w = water; a = air; cooling sufficiently rapid.

<sup>e</sup> When tested according to EN ISO 3651-2 (Appropriate method, A or B or C, as indicated) up to the limit temperatures indicated in the last column of Table 11.

<sup>f</sup> For cold finished and solution annealed tubes the maximum tensile strength is 920 MPa.

**Table 9 - Minimum proof strength  $R_{p0,2}$  and  $R_{p1,0}$  at elevated temperatures for wall thicknesses up to 60 mm<sup>a</sup> of austenitic corrosion resisting steels in the solution annealed condition (+AT) and guideline for the limit temperature for intergranular corrosion (continued)**

| Steel grade                                   |              | $R_{p0,2}$ , min MPa<br>at a temperature (°C) of |     |     |     |     |     |     |     |     |     |     | $R_{p1,0}$ , min MPa<br>at a temperature (°C) of |     |     |     |     |     |     |     |     |     |     | Limit temp. <sup>b</sup><br>°C |
|---|--------------|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------------------------------|
| Steel name                                    | Steel number | 50   | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 50   | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 |                                |
| X2CrNi18-9                                    | 1.4307       | 165  | 145 | 130 | 118 | 108 | 100 | 94  | 89  | 85  | 81  | 80  | 200  | 180 | 160 | 145 | 135 | 127 | 121 | 116 | 112 | 109 | 108 | 350                            |
| X2CrNi19-11                                   | 1.4306       | 165  | 145 | 130 | 118 | 108 | 100 | 94  | 89  | 85  | 81  | 80  | 200  | 180 | 160 | 145 | 135 | 127 | 121 | 116 | 112 | 109 | 108 | 350                            |
| X2CrNiN18-10                                  | 1.4311       | 255  | 205 | 175 | 157 | 145 | 136 | 130 | 125 | 121 | 119 | 118 | 282  | 240 | 210 | 187 | 175 | 167 | 160 | 156 | 152 | 149 | 147 | 400                            |
| X5CrNi18-10                                   | 1.4301       | 180  | 155 | 140 | 127 | 118 | 110 | 104 | 98  | 95  | 92  | 90  | 218  | 190 | 170 | 155 | 145 | 135 | 129 | 125 | 122 | 120 | 120 | 300                            |
| X6CrNiTi18-10 (cold finish.)<br>(hot finish.) | 1.4541       | 190  | 176 | 167 | 157 | 147 | 136 | 130 | 125 | 121 | 119 | 118 | 222  | 208 | 195 | 185 | 175 | 167 | 161 | 156 | 152 | 149 | 147 | 400                            |
|   | 1.4541       | 162  | 147 | 132 | 118 | 108 | 100 | 94  | 89  | 85  | 81  | 80  | 201  | 181 | 162 | 147 | 137 | 127 | 121 | 116 | 112 | 109 | 108 | 400                            |
| X6CrNiNb18-10                                 | 1.4550       | 195  | 175 | 165 | 155 | 145 | 136 | 130 | 125 | 121 | 119 | 118 | 232  | 210 | 195 | 185 | 175 | 167 | 161 | 156 | 152 | 149 | 147 | 400                            |
| X1CrNi25-21                                   | 1.4335       | 170  | 150 | 140 | 130 | 120 | 115 | 110 | 105 | -   | -   | -   | 200  | 180 | 170 | 160 | 150 | 140 | 135 | 130 | -   | -   | -   | 400                            |
| X2CrNiMo17-12-2                               | 1.4404       | 182  | 165 | 150 | 137 | 127 | 119 | 113 | 108 | 103 | 100 | 98  | 217  | 200 | 180 | 165 | 153 | 145 | 139 | 135 | 130 | 128 | 127 | 400                            |
| X5CrNiMo17-12-2                               | 1.4401       | 196  | 175 | 158 | 145 | 135 | 127 | 120 | 115 | 112 | 110 | 108 | 230  | 210 | 190 | 175 | 165 | 155 | 150 | 145 | 141 | 139 | 137 | 300                            |
| X1CrNiMoN25-22-2                              | 1.4466       | 230  | 195 | 170 | 160 | 150 | 140 | 135 | -   | -   | -   | -   | 262  | 225 | 205 | 190 | 180 | 170 | 165 | -   | -   | -   | -   | 400                            |
| X6CrNiMoTi17-12-2 (cold fin.)<br>(hot fin.)   | 1.4571       | 202  | 185 | 177 | 167 | 157 | 145 | 140 | 135 | 131 | 129 | 127 | 234  | 208 | 195 | 185 | 175 | 167 | 161 | 156 | 152 | 149 | 147 | 400                            |
|   | 1.4571       | 182  | 166 | 152 | 137 | 127 | 118 | 113 | 108 | 103 | 100 | 98  | 201  | 181 | 162 | 147 | 137 | 127 | 121 | 116 | 112 | 109 | 108 | 400                            |
| X6CrNiMoNb17-12-2                             | 1.4580       | 202  | 186 | 177 | 167 | 157 | 145 | 140 | 135 | 131 | 129 | 127 | 240  | 221 | 206 | 196 | 186 | 175 | 169 | 164 | 160 | 158 | 157 | 400                            |
| X2CrNiMoN17-13-3                              | 1.4429       | 255  | 215 | 195 | 175 | 165 | 155 | 150 | 145 | 140 | 138 | 136 | 290  | 245 | 225 | 205 | 195 | 185 | 180 | 175 | 170 | 168 | 166 | 400                            |
| X3CrNiMo17-13-3                               | 1.4436       | 195  | 175 | 158 | 145 | 135 | 127 | 120 | 115 | 112 | 110 | 108 | 228  | 210 | 190 | 175 | 165 | 155 | 150 | 145 | 141 | 139 | 137 | 300                            |
| X2CrNiMo18-14-3                               | 1.4435       | 180  | 165 | 150 | 137 | 127 | 119 | 113 | 108 | 103 | 100 | 98  | 217  | 200 | 180 | 165 | 153 | 145 | 139 | 135 | 130 | 128 | 127 | 400                            |
| X2CrNiMoN17-13-5                              | 1.4439       | 260  | 225 | 200 | 185 | 175 | 165 | 155 | 150 | -   | -   | -   | 290  | 255 | 230 | 210 | 200 | 190 | 180 | 175 | -   | -   | -   | 400                            |
| X1NiCrMoCu31-27-4                             | 1.4563       | 210  | 190 | 175 | 160 | 155 | 150 | 145 | 135 | 125 | 120 | 115 | 240  | 220 | 205 | 190 | 185 | 180 | 175 | 165 | 155 | 150 | 146 | 550                            |
| X1NiCrMoCu25-20-5                             | 1.4539       | 221  | 205 | 190 | 175 | 160 | 145 | 135 | 125 | 115 | 110 | 105 | 244  | 235 | 220 | 205 | 190 | 175 | 165 | 155 | 145 | 140 | 135 | 400                            |
| X1CrNiMoCuN20-18-7                            | 1.4547       | 267  | 230 | 205 | 190 | 180 | 170 | 165 | 160 | 153 | 148 | -   | 306  | 270 | 245 | 225 | 212 | 200 | 195 | 190 | 184 | 180 | -   | 400                            |

| Steel grade        |              | $R_{p0,2}$ , min MPa<br>at a temperature (°C) of |     |     |     |     |     |     |     |     |     |     | $R_{p1,0}$ , min MPa<br>at a temperature (°C) of |     |     |     |     |     |     |     |     |     |     | Limit temp. <sup>b</sup><br>°C |
|--------------------|--------------|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------------------------------|
| Steel name         | Steel number | 50   | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 50   | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 |                                |
| X1NiCrMoCuN25-20-7 | 1.4529       | 254  | 230 | 210 | 190 | 180 | 170 | 165 | 160 | -   | -   | -   | 296  | 270 | 245 | 225 | 215 | 205 | 195 | 190 | -   | -   | -   | 400                            |
| X2NiCrAlTi32-20    | 1.4558       | 168  | 155 | 145 | 140 | 135 | 130 | 125 | 120 | 110 | 100 | 90  | 198  | 185 | 175 | 170 | 165 | 160 | 155 | 150 | 140 | 130 | 120 | 400                            |

<sup>a</sup> For wall thicknesses greater than 60 mm the proof strength values are subject to agreement at the time of enquiry and order. **Option 10:** Agreed proof strength values for wall thicknesses greater than 6 mm apply.

<sup>b</sup> Up to these temperatures, the material should, within 100 000 h, not have changed so as to show susceptibility to intergranular corrosion, when tested in conformity with EN ISO 3651-2. See also Table 6.

**Table 10 - Minimum proof strength  $R_{p0,2}$  and  $R_{p1,0}$  at elevated temperatures for wall thicknesses up to 50 mm of austenitic creep resisting steels in the solution annealed condition (+AT) and guideline for the limit temperature for intergranular corrosion**

| Steel grade            |              | $R_{p0,2}$ , min MPa<br>Temperature (°C) |     |     |     |     |     |     |     |     |     |     | $R_{p1,0}$ , min MPa<br>Temperature (°C) |     |     |     |     |     |     |     |     |     |     | Limit temp. <sup>a</sup><br>°C |
|------------------------|--------------|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------------------------------|
| Steel name             | Steel number | 50                                       | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 50                                       | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 |                                |
| X6CrNi18-10            | 1.4948       | 174                                      | 157 | 142 | 127 | 117 | 108 | 103 | 98  | 93  | 88  | 83  | 201                                      | 191 | 172 | 157 | 147 | 137 | 132 | 127 | 122 | 118 | 113 | 400                            |
| X7CrNiTi18-10          | 1.4940       | 172                                      | 156 | 145 | 135 | 128 | 124 | 120 | 116 | 113 | 111 | 109 | 207                                      | 191 | 179 | 170 | 163 | 159 | 155 | 151 | 148 | 146 | 144 | 400                            |
| X7CrNiNb18-10          | 1.4912       | 190                                      | 171 | 162 | 153 | 147 | 139 | 133 | 129 | -   | 124 | -   | 225                                      | 204 | 192 | 182 | 172 | 166 | 162 | 159 | -   | 155 | -   |                                |
| X6CrNiTiB18-10         | 1.4941       | 180                                      | 162 | 152 | 142 | 137 | 132 | 127 | 123 | 118 | 113 | 108 | 219                                      | 201 | 191 | 181 | 176 | 172 | 167 | 162 | 157 | 152 | 147 | 400                            |
| X6CrNiMo17-13-2        | 1.4918       | 184                                      | 177 | 162 | 147 | 137 | 127 | 122 | 118 | 113 | 108 | 103 | 228                                      | 211 | 194 | 177 | 167 | 157 | 152 | 147 | 142 | 137 | 132 | 400                            |
| X5NiCrAlTi31-20        | 1.4958       | 157                                      | 140 | 127 | 115 | 105 | 95  | 90  | 85  | 82  | 80  | 75  | 180                                      | 160 | 147 | 135 | 125 | 115 | 110 | 105 | 102 | 100 | 95  | 400                            |
| X5NiCrAlTi31-20 +RA    | 1.4958+RA    | 195                                      | 180 | 170 | 160 | 152 | 145 | 137 | 130 | 125 | 120 | 115 | 225                                      | 205 | 193 | 180 | 172 | 165 | 160 | 155 | 150 | 145 | 140 | 400                            |
| X8NiCrAlTi32-21        | 1.4959       | 157                                      | 140 | 127 | 115 | 105 | 95  | 90  | 85  | 82  | 80  | 75  | 180                                      | 160 | 147 | 135 | 125 | 115 | 110 | 105 | 102 | 100 | 95  | 400                            |
| X3CrNiMoBN17-13-3      | 1.4910       | 234                                      | 205 | 187 | 170 | 159 | 148 | 141 | 134 | 130 | 127 | 124 | 273                                      | 240 | 220 | 200 | 189 | 178 | 171 | 164 | 160 | 157 | 154 | 400                            |
| X8CrNiNb16-13          | 1.4961       | 197                                      | 175 | 166 | 157 | 147 | 137 | 132 | 128 | 123 | 118 | 118 | 231                                      | 205 | 195 | 186 | 176 | 167 | 162 | 157 | 152 | 147 | 147 | 400                            |
| X8CrNiMoVNb16-13       | 1.4988       | 239                                      | 215 |     | 196 |     | 177 |     | 167 |     | 157 | 152 | 273                                      | 245 |     | 226 |     | 206 |     | 196 |     | 186 | 181 | 400                            |
| X8CrNiMoNb16-16        | 1.4981       | 202                                      | 195 |     | 177 |     | 157 |     | 147 |     | 137 | 137 | 242                                      | 225 |     | 206 |     | 186 |     | 177 |     | 167 | 167 | 400                            |
| X10CrNiMoMnNbVB15-10-1 | 1.4982       | 213                                      | 188 | 171 | 161 | 153 | 148 | 145 | 144 | 141 | 139 | 136 | 254                                      | 232 | 210 | 195 | 190 | 187 | 184 | 182 | 179 | 178 | 175 | 400                            |

<sup>a</sup> Up to these temperatures, the material should, within 100 000 h, not have changed so as to show susceptibility to intergranular corrosion, when tested in conformity with EN ISO 3651-2. See also Table 7.



**Table 11 - Minimum proof strength  $R_{p0,2}$  at elevated temperatures for wall thicknesses up to 30 mm of austenitic-ferritic steels in the solution annealed (+AT) condition and guideline for the limit temperature for intergranular corrosion**

| Steel grade        |              | $R_{p0,2}$ min MPa<br>Temperature °C |     |     |     |                  |
|--------------------|--------------|--------------------------------------|-----|-----|-----|------------------|
| Steel name         | Steel number | 50                                   | 100 | 150 | 200 | 250 <sup>a</sup> |
| X2CrNiMoN22-5-3    | 1.4462       | 415                                  | 360 | 335 | 310 | 295              |
| X2CrNiMoSi18-5-3   | 1.4424       | 430                                  | 370 | 350 | 330 | 325              |
| X2CrNiN23-4        | 1.4362       | 370                                  | 330 | 310 | 290 | 280              |
| X2CrNiMoN25-7-4    | 1.4410       | 530                                  | 480 | 445 | 420 | 405              |
| X2CrNiMoCuN25-6-3  | 1.4507       | 485                                  | 450 | 420 | 400 | 380              |
| X2CrNiMoCuWN25-7-4 | 1.4501       | 502                                  | 450 | 420 | 400 | 380              |

<sup>a</sup> Up to this temperature, the material should, within 100 000 h, not have changed so as to show susceptibility to intergranular corrosion, when tested in conformity with EN ISO 3651-2. See also Table 8.

## 8.4 Corrosion resistance

The information given in Tables 6, 7 and 8 refer to the resistance of the steels to intergranular corrosion when tested in accordance with EN ISO 3651-2 to the indicated method A or B or C.

Guideline values for the limit temperature for susceptibility to intergranular corrosion are indicated in Tables 9, 10 and 11.

**Option 12:** A test for the resistance to intergranular corrosion shall be carried out.

If other specific corrosion tests are required, they shall be agreed at the time of enquiry and order.

## 8.5 Appearance and soundness

### 8.5.1 Appearance

**8.5.1.1** The tubes shall be free from external and internal surface defects that can be detected by visual examination.

**8.5.1.2** The internal and external surface finish of the tubes shall be typical of the manufacturing process and, where applicable, the heat treatment employed. Normally the finish and surface condition shall be such that any surface imperfections requiring dressing can be identified.

**8.5.1.3** It shall be permissible to dress, only by grinding or machining, surface imperfections provided that, after doing so, the wall thickness in the dressed area is not less than the specified minimum wall thickness. All dressed areas shall blend smoothly into the contour of the tube.

**8.5.1.4** Surface imperfections which encroach on the specified minimum wall thickness shall be considered defects and tubes containing these shall be deemed not to conform to this part of EN 10216.

### 8.5.2 Soundness

#### 8.5.2.1 Leak-tightness

The tubes shall pass a hydrostatic test (see 11.6.1) or an eddy current test (see 11.6.2) for leak-tightness.

Unless option 13 is specified, the choice of the test method is at the discretion of the manufacturer.

**Option 13:** The test method for verification of leak-tightness according to 11.6.1 or 11.6.2 is specified by the purchaser.

### 8.5.2.2 Non-destructive testing

The tubes of test category 2 with outside diameter greater than 101,6 mm or wall thickness greater than 5,6 mm shall be submitted to a non-destructive testing for the detection of longitudinal imperfections, according to 11.9.1.

**Option 14:** The tubes of test category 2 with specified outside diameter less than or equal to 101,6 mm and specified wall thickness less than or equal to 5,6 mm shall be submitted to a non-destructive testing for the detection of longitudinal imperfections according to 11.9.1.

**Option 15:** The tubes of test category 2 shall be submitted to a non-destructive testing for the detection of transverse imperfections according to 11.9.2.

**Option 16:** The tubes of test category 2 with specified wall thickness greater than 40 mm shall be submitted to a non-destructive testing for the detection of the laminar imperfections at the tube ends according to 11.9.3.

## 8.6 Straightness

The deviation from straightness of any tube length L shall not exceed 0,001 5 L. Deviations from straightness over any one meter length shall not exceed 3 mm.

## 8.7 Preparation of ends

Tubes shall be delivered with square cut ends. The ends shall be free from excessive burrs.

**Option 17:** Tubes with wall thickness  $T \geq 3,2$  mm shall be delivered with bevelled ends (see Figure 1). The bevel shall have an angle  $\alpha$  of  $30^\circ \begin{smallmatrix} +5^\circ \\ 0 \end{smallmatrix}$  with a root face C of  $1,6 \text{ mm} \pm 0,8 \text{ mm}$ , except that for wall thickness T greater than 20 mm, an agreed alternative bevel may be specified.

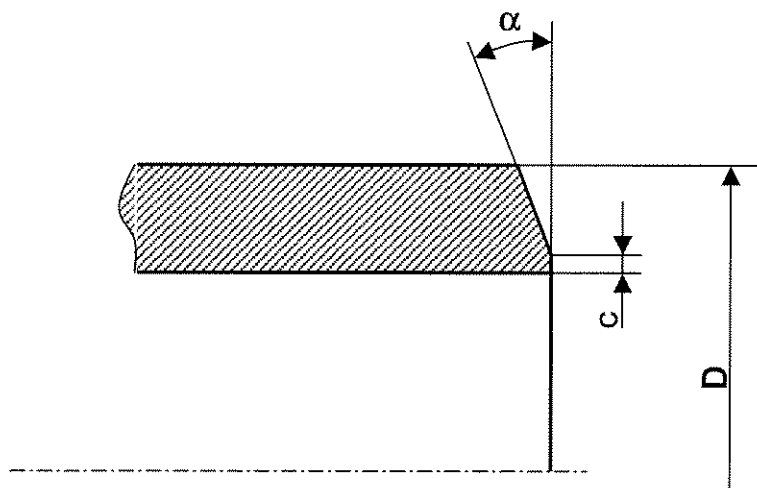


Figure 1 — Tube end bevel

## 8.8 Dimensions, masses and tolerances

### 8.8.1 Outside diameter and wall thickness

Tubes shall be ordered by outside diameter  $D$  and wall thickness  $T$ . Preferred outside diameters  $D$  and wall thicknesses  $T$  are given in EN ISO 1127.

### 8.8.2 Mass

For the calculation of mass per unit length the density values given in EN 10088-1, Table A.1 to Table A.4 and EN 10028-7, Table A.1 shall be used.

### 8.8.3 Lengths

Unless option 18 is specified, the tubes shall be delivered in random lengths. The delivery range shall be agreed at the time of enquiry and order.

**Option 18:** The tubes shall be delivered in exact lengths and the length shall be specified at the time of enquiry and order. The tolerances on these lengths shall conform to 8.8.4.2.

### 8.8.4 Tolerances

#### 8.8.4.1 Tolerances on outside diameter and wall thickness

The diameter and the wall thickness of the tubes shall be within the relevant tolerance limits given in Table 12 for hot finished tubes and in Table 13 for cold finished tubes. Tolerance classes T1 to T4 and D1 to D4 were taken from EN ISO 1127.

Out of roundness is included in the tolerances on diameter and eccentricity is included in the tolerances on wall thickness.

**Table 12 - Tolerances on outside diameter  $D$  and wall thickness  $T$  for tubes ordered hot finished**

| Outside diameter<br>$D$ | Tolerances on<br>$D$ |   | Tolerances on $T$ |   |
|-------------------------|----------------------|---|-------------------|---|
|                         | Tolerance class      | Permissible deviation   | Tolerance class   | Permissible deviation                                     |
| 30 ≤ $D$ ≤ 219,1        | D 2                  | ± 1,0 % or ± 0,5 mm<br>whichever is the greater               | T 1               | ± 15 % or ± 0,6 mm whichever is the greater <sup>b</sup>  |
|                         |                      |   | T 2               | ± 12,5 % or ± 0,4 mm whichever is the greater             |
| 219,1 < $D$ ≤ 610       | D 1                  | ± 1,5 % or ± 0,75 mm<br>whichever is the greater <sup>a</sup> |                   | + 22,5 %<br>– 15 % <sup>c</sup>                           |
|                         |                      |   | T 1               | ± 15% or ± 0,6 mm whichever is the greater <sup>d</sup>   |
|                         |                      |   | T 2               | ± 12,5% or ± 0,4 mm whichever is the greater <sup>e</sup> |

<sup>a</sup> **Option 19:** The tubes shall be ordered with sized ends. In this case a permissible deviation of the outside diameter of ± 0,6 % applied to the tube ends over a length of approx. 100 mm.

<sup>b</sup> Applies to tubes with wall thickness  $T$  ≤ 0,01  $D$  and  $T$  ≤ 4 mm.

<sup>c</sup> Applies to tubes with wall thickness  $T$  ≤ 0,05  $D$ .

<sup>d</sup> Applies to tubes with wall thickness  $T$ : 0,05  $D$  <  $T$  ≤ 0,09  $D$ .

<sup>e</sup> Applies to tubes with wall thickness  $T$  > 0,09  $D$ .

**Table 13 - Tolerances on outside diameter D and wall thickness T for tubes ordered cold finished**

| Tolerances on D ≤ 219,1 mm |   | Tolerances on T  |   |
|----------------------------|---|------------------|---|
| Tolerance class            | Permissible deviation                         | Tolerance class  | Permissible deviation                         |
| D 3                        | ± 0,75 % or ± 0,3 mm whichever is the greater | T 3              | ± 10 % or ± 0,2 mm whichever is the greater   |
| D 4 <sup>a</sup>           | ± 0,5 % or ± 0,1 mm whichever is the greater  | T 4 <sup>a</sup> | ± 7,5 % or ± 0,15 mm whichever is the greater |

<sup>a</sup> **Option 20:** Tolerance classes D 4 and T 4 is specified for tubes ordered cold finished

**8.8.4.2 Tolerance on exact lengths**

The tolerances for exact lengths shall be as given in Table 14.

**Table 14 - Tolerances on exact lengths**

Dimensions in mm

| Length L           | Tolerance on exact length |
|--------------------|---------------------------|
| L ≤ 6 000          | + 5<br>0                  |
| 6 000 < L ≤ 12 000 | + 10<br>0                 |
| L > 12 000         | + by agreement<br>0       |

**9 Inspection**

**9.1 Type of inspection**

Conformity to the requirements of the order, for tubes according to this part of EN 10216, shall be verified by specific inspection.

When an inspection document 3.1.B is specified the material manufacturer shall state in the confirmation of the order whether he is operating according to a "quality-assurance system", certified by a competent Body established within the Community, and whether he has undergone a specific assessment for materials.

NOTE See the EU Directive 97/23/EC Annex I section 4.3 third paragraph.

**9.2 Inspection documents**

**9.2.1 Types of inspection documents**

Unless option 21 is specified, an inspection certificate 3.1.B, according to EN 10204, shall be issued.

**Option 21:** One of the inspection documents 3.1.C or 3.2 according to EN 10204 shall be issued.

If an inspection document 3.1.C or 3.2 is specified, the purchaser shall notify the manufacturer of the name and address of the organisation or person who is to carry out the inspection and produce the inspection document. In the case of the inspection report 3.2 it shall be agreed which party shall issue the certificate.

NOTE Document 3.1.A is not acceptable for compliance with the EU Directive 97/23/EC.

### 9.2.2 Content of inspection documents

The content of the inspection document shall be according to EN 10168.

In all types of inspection documents a statement on the conformity of the products delivered with the requirements of this specification and the order shall be included.

The inspection certificate or inspection report shall contain the following codes and information:

- A commercial transactions and parties involved;
- B description of products to which the inspection document applies;
- C02-C03 direction of the test pieces and testing temperature;
- C10-C13 tensile test;
- C40-C43 impact test, if applicable;
- C60-C69 other tests (e.g. flattening);
- C71-C92 chemical composition on cast analysis (product analysis if applicable);
- D01 marking and identification, surface appearance, shape and dimensional properties;
- D02-D99 leak-tightness test, NDT, material identification;
- Z validation.

In addition for inspection document 3.1.B the manufacturer shall state the references to the certificate (see 9.1) of the appropriate "quality-assurance system", if applicable.

### 9.3 Summary of inspection and testing

The tubes shall be inspected and tested in accordance with test category 1 or test category 2 as specified at the time of enquiry and order (see 6.1).

Inspection and testing to be carried out are summarised in Table 15.

## 10 Sampling

### 10.1 Test unit

For heat treated tubes, a test unit shall comprise tubes of the same specified diameter and wall thickness, the same steel grade, the same cast, the same manufacturing process, subjected to the same finishing treatment in a continuous furnace or heat treated in the same furnace charge in a batch-type furnace.

For extruded tubes, a test unit shall comprise tubes of the same specified diameter and wall thickness, the same steel grade, the same cast, the same manufacturing process.

The number of tubes, in random manufacturing lengths<sup>1)</sup> per test unit shall be max 100.

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<sup>1)</sup> The random manufacturing lengths may differ from the delivery length (see 8.8.3).

Table 15 - Summary of inspection and testing

| Type of inspection and test |   | Frequency of testing   |  | Refer to | Testing standard |
|-----------------------------|---|--|--|----------|------------------|
|                             |   | Test category 1  | Test category 2  |          |                  |
| Mandatory tests             | Cast analysis   | one per cast   | one per cast   | 11.1     |                  |
|                             | Tensile test at room temperature  | one per test unit  | two per test unit  | 11.2.1   | EN 10002-1       |
|                             | Flattening test <sup>a</sup> or   | one per test unit  | 10 % per test unit (at least one per test unit)                  | 11.3.1   | EN 10233         |
|                             | Ring tensile test <sup>a</sup> or   |  |  | 11.3.2   | EN 10237         |
|                             | Drift expanding test <sup>a</sup> or  |  |  | 11.3.3   | EN 10234         |
|                             | Ring expanding test <sup>a</sup>  |  |  | 11.3.4   | EN 10236         |
|                             | Leak tightness test   | each tube  | each tube  | 11.6     | EN 10246-2       |
|                             | Dimensional inspection  |  |  | 11.7     |                  |
|                             | Visual examination  |  |  | 11.8     |                  |
|                             | NDT for the detection of longitudinal imperfections for D > 101,6 mm or T > 5,6 mm              | -  | each tube  | 11.9     | EN 10246-7       |
| Material identification     | each tube   |  | 11.10  |          |                  |
| Optional tests              | Product analysis (option 4)   | one per cast   | one per cast   | 11.1     |                  |
|                             | Tensile test at elevated temperature (option 9)   | as agreed upon or one per cast and same heat treatment condition | as agreed upon or one per cast and same heat treatment condition | 11.2.2   | EN 10002-5       |
|                             | Impact test at room temperature (option 6)  |  |  | 11.4     | EN 10045-1       |
|                             | Impact test at low temperature (option 11)  |  |  | 11.4     | EN 10045-1       |
|                             | Intergranular corrosion test (option 12)  |  |  | 11.5     | EN ISO 3651-2    |
|                             | Wall thickness measurement away from tube ends (option 23)                                      | each tube  | each tube  | 11.7     |                  |
|                             | NDT for the detection of longitudinal imperfections for D ≤ 101,6 mm and T ≤ 5,6 mm (option 14) | -  |  | 11.9     | EN 10246-7       |
|                             | NDT for the detection of transverse imperfections (option 15)                                   | -  |  | 11.9     | EN 10246-6       |
|                             | NDT for the detection of laminar imperfections at tubes ends for T > 40 mm. (option 16)         | -  |  | 11.9     | EN 10246-17      |

<sup>a</sup> Testing method is at the manufacturer's discretion in accordance with Table 16.

10.2 Preparation of samples and test pieces

10.2.1 Selection and preparation of samples for product analysis

Samples for product analysis shall be taken from the test pieces or samples for mechanical testing or from the whole thickness of the tube at the same location as for the mechanical test samples, according to EN ISO 14284.

## 10.2.2 Location, orientation and preparation of samples and test pieces for mechanical tests

### 10.2.2.1 General

Samples and test pieces shall be taken at the tube ends and according to the requirements of EN ISO 377.

### 10.2.2.2 Test pieces for tensile test

The test pieces for tensile tests at room temperature shall be prepared according to EN 10002-1.

The test pieces for tensile tests at elevated temperature shall be prepared according to EN 10002-5.

At the manufacturer's discretion:

- for tubes with an outside diameter  $D \leq 219,1$  mm the test piece shall be either a full tube section or a strip section or a machined circular cross section ( $T > 10$  mm) and shall be taken in a direction either transverse, where possible, or longitudinal to the axis of the tube;
- for tubes with an outside diameter  $D > 219,1$  mm, the test piece shall either be a machined circular cross section ( $T > 10$  mm) from an unflattened sample or a strip section and be taken in a direction either transverse, where possible, or longitudinal to the axis of the tube.

### 10.2.2.3 Test pieces for flattening, ring tensile, drift expanding and ring expanding tests

The test pieces for the flattening, ring tensile, drift expanding and ring expanding tests shall consist of a full tube section according to EN 10233, EN 10237, EN 10234 or EN 10236 respectively.

### 10.2.2.4 Test pieces for impact test

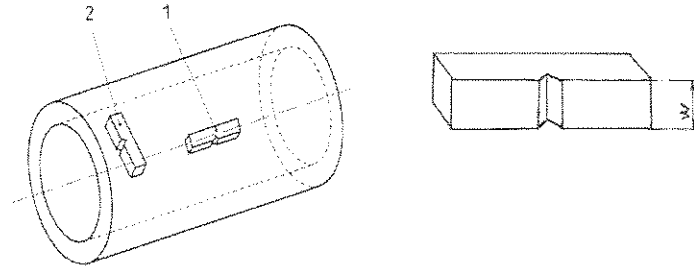
Three standard Charpy V-notch test pieces shall be prepared according to EN 10045-1. If the nominal product thickness is such that standard test pieces cannot be produced without flattening of the section, then the test pieces of width less than 10 mm, but not less than 5 mm shall be prepared; the largest obtainable width shall be used.

Where test pieces of at least 5 mm width cannot be obtained, the tubes shall not be subjected to impact testing.

The test pieces shall be taken transverse to the tube axis unless  $D_{\min}$ , as calculated by the following equation, is greater than the specified outside diameter, in which case longitudinal test pieces shall be used:

$$D_{\min} = (T-5) + [756,25 / (T-5)] \quad (1)$$

The test pieces shall be prepared such that the axis of the notch is perpendicular to the surface of the tube, see Figure 2.



**Key**

- 1 Longitudinal test piece
- 2 Transverse test piece

Notch oriented perpendicular to tube axis

**Figure 2 — Impact test piece orientation**

**10.2.2.5 Test pieces for intergranular corrosion test**

The test pieces for the intergranular corrosion test shall be prepared according to EN ISO 3651-2.

**11 Test methods**

**11.1 Chemical analysis**

The elements to be determined and reported shall be those specified in Tables 2, 3 and 4. The choice of a suitable physical or chemical analytical method for the analysis shall be at the discretion of the manufacturer. In case of dispute the method used shall be agreed between manufacturer and purchaser taking into account CR 10261.

**11.2 Tensile test**

**11.2.1 At room temperature**

The test shall be carried out at room temperature according to EN 10002-1, and the following determined:

- tensile strength ( $R_m$ );
- 0,2 % proof strength ( $R_{p0,2}$ ) and, where applicable, the 1,0 % proof strength ( $R_{p1,0}$ );
- percentage elongation after fracture with reference to a gauge length ( $L_0$ ) of  $5,65 \sqrt{S_0}$ ; if a non proportional test piece is used, the percentage elongation value shall be converted to the value for a gauge length  $L_0 = 5,65 \sqrt{S_0}$  using the conversion tables in EN ISO 2566-2.

**11.2.2 At elevated temperature**

The test shall be carried out according to EN 10002-5 at the temperature agreed at the time of enquiry and order (see 6.2) and the 0,2 % proof strength ( $R_{p0,2}$ ) and, where applicable, the 1,0 % proof strength ( $R_{p1,0}$ ) shall be determined.



### 11.3 Technological tests

Depending on the tube dimensions one of the tests given in Table 16 shall be carried out.

**Table 16 – Technological tests**

| Outside diameter<br>D<br>mm | Wall thickness T<br>mm       |                                  |                                   |
|-----------------------------|------------------------------|----------------------------------|-----------------------------------|
|                             | < 2                          | 2 ≤ T ≤ 16                       | 16 < T ≤ 40                       |
| ≤ 18                        | Flattening test <sup>a</sup> | Flattening test <sup>a</sup>     | -                                 |
| > 18 ≤ 150                  | Flattening test <sup>a</sup> | Ring expanding test <sup>a</sup> | Flattening test <sup>b</sup>      |
| > 150                       | -                            | Ring tensile test                | Ring tensile test <sup>c, d</sup> |

<sup>a</sup> The test may, at the discretion of the manufacturer, be replaced by drift expanding test for wall thicknesses ≤ 10 mm.  
<sup>b</sup> For T/D ≤ 0,15.  
<sup>c</sup> The test may, at the discretion of the manufacturer, be replaced by flattening test for T/D ≤ 0,15.  
<sup>d</sup> Inside diameter ≥ 100 mm.

#### 11.3.1 Flattening test

The test shall be carried out according to EN 10233.

The tube section shall be flattened in a press until the distance  $H$  between the platens reaches the value given by the following equation:

$$H = \frac{1+C}{C+T/D} \times T \quad (2)$$

where

$H$  is the distance between platens, in mm, to be measured under load;

$D$  is the specified outside diameter, in mm;

$T$  is the specified wall thickness, in mm;

$C$  is the constant factor of deformation, which is:

- 0,09 for austenitic steels and
- 0,07 for austenitic-ferritic steels.

After testing, the test piece shall be free from cracks or breaks. However, slight incipient cracks at its edges shall not be regarded as justification for rejection.

#### 11.3.2 Ring tensile test

The test shall be carried out according to EN 10237.

The tube section shall be subjected to strain in the circumferential direction until fracture occurs.

After fracture the test pieces shall not show any visible cracks without the use of magnifying aids (excluding the fracture point).

**11.3.3 Drift expanding test**

The test shall be carried out according to EN 10234.

The tube section shall be expanded with a 60° conical tool until the % increase in outside diameter shown in Table 17 is reached.

**Table 17 - Drift expanding test requirements**

| % increase in outside diameter for d/D <sup>a</sup> |                 |       |
|---|-----------------|-------|
| ≤ 0,6   | 0,6 < d/D ≤ 0,8 | > 0,8 |
| 9   | 15              | 17    |
| <sup>a</sup> d = D - 2T.                            |                 |       |

After testing, the test piece shall (excluding the fracture point) be free from cracks or breaks. However, slight incipient cracks at its edges shall not be regarded as justification for rejection.

**11.3.4 Ring expanding test**

The test shall be carried out according to EN 10236.

The tube section shall be expanded with a conical tool until it breaks. If an expansion of 40 % of the inside diameter for austenitic steels and of 30 % for austenitic-ferritic steels is reached the test may be considered as finished.

The surface outside the fracture zone shall excluding the fracture point be free from cracks or breaks. However, slight incipient cracks at its edges shall not be regarded as justification for rejection.

**11.4 Impact test**

**11.4.1** The test shall be carried out according to EN 10045-1 at the temperature specified by the applicable option (see 6.2).

**11.4.2** The mean value of the three test pieces shall meet the requirements given in Tables 6, 7 or 8. One individual value may be below the specified value, provided that it is not less than 70 % of that value.

**11.4.3** If the width (*W*) of the test piece is less than 10 mm, the measured impact energy (*KV<sub>p</sub>*) shall be converted to impact energy (*KV<sub>c</sub>*) using the following equation:

$$KV_c = \frac{10 \times KV_p}{W} \tag{3}$$

where

- *KV<sub>c</sub>* is the calculated impact energy, in J;
- *KV<sub>p</sub>* is the measured impact energy, in J;
- *W* is the width of the test piece, in mm.

The calculated impact energy *KV<sub>c</sub>* shall comply with the requirements given in 11.4.2.

**11.4.4** If the requirements of 11.4.2 are not met, then an additional set of three test pieces may be taken at the discretion of the manufacturer from the same sample and tested. To consider the test unit as conforming, after testing the second set, the following conditions shall be satisfied simultaneously:

- the average value of six tests shall be equal to or greater than the specified minimum average value;

- not more than two of six individual values may be lower than the specified minimum average value;
- not more than one of the six individual values may be lower than 70 % of the specified minimum average value.

**11.4.5** The dimensions in millimetres of the test pieces, the measured impact energy values and the resulting average value shall be reported.

### 11.5 Intergranular corrosion test

The intergranular corrosion test shall be carried out according to EN ISO 3651-2 to the specified method (A or B or C).

### 11.6 Leak tightness test

#### 11.6.1 Hydrostatic test

The hydrostatic test shall be carried out at a test pressure  $P$  of 70 bar<sup>2)</sup> or at a test pressure calculated using the following equation, whichever is lower:

$$P = 20 \frac{S \times T}{D} \quad (4)$$

where

$P$  is the test pressure, in bar;

$D$  is the specified outside diameter, in mm;

$T$  is the specified wall thickness, in mm;

$S$  is the stress, in MPa, corresponding to 70 % of the specified minimum proof strength ( $R_{p0,2}$ ) (see Tables 6, 7 and 8) for the steel grade concerned.

The test pressure shall be held for not less than 5s for tubes with an outside diameter  $D$  less than or equal to 457 mm and for not less 10 s for tubes with an outside diameter greater than 457 mm.

The tube shall withstand the test without showing leakage or visible deformation.

NOTE This hydrostatic leak-tightness test is not a strength test.

**Option 22:** A test pressure different from that specified in 11.6.1 and corresponding to a stress below 90 % of the specified minimum proof strength ( $R_{p0,2}$ ) (see Tables 6, 7 and 8) for the steel grade concerned is specified.

#### 11.6.2 Eddy current test

The test shall be carried out according to EN 10246-2.

### 11.7 Dimensional inspection

Specified dimensions, including straightness, shall be verified.

The outside diameter shall be measured at the tube ends. For tubes with outside diameter  $D \geq 406,4$  mm, the diameter may be measured using a circumference tape.

Unless option 23 is specified the wall thickness shall be measured at both tube ends.

<sup>2)</sup> 1 bar = 100 kPa.

*Option 23: The wall thickness shall be measured away from the tube ends according to an agreed procedure.*

## 11.8 Visual examination

Tubes shall be visually examined to ensure conformity to the requirements of 8.5.1.

## 11.9 Non-destructive testing

**11.9.1** Tubes of test category 2 with outside diameter  $D > 101,6$  mm or wall thickness  $T > 5,6$  mm shall be subjected to ultrasonic testing for the detection of longitudinal imperfections, according to EN 10246-7, to acceptance level U2, sub-category C.

Regions at the tube ends not automatically tested shall either be subjected to manual/semi-automatic ultrasonic testing according to EN 10246-7 to acceptance level U2, sub-category C or be cropped off.

If option 14 (see 8.5.2.2) is specified, the tubes with outside diameter  $D \leq 101,6$  mm and wall thickness  $T \leq 5,6$  mm shall be subjected to ultrasonic testing for the detection of longitudinal imperfections according to EN 10246-7 to acceptance level U2, sub-category C.

**11.9.2** If option 15 (see 8.5.2.2) is specified, the tubes shall be subjected to ultrasonic testing for the detection of transverse imperfections according to EN 10246-6 to acceptance level U2, sub-category C.

**11.9.3** If option 16 (see 8.5.2.2) is specified the tubes shall be subjected to ultrasonic testing for the detection of the laminar imperfections at the tube ends according to EN 10246-17.

## 11.10 Material identification

Each tube shall be tested by an appropriate method to ensure that the correct grade is being supplied.

## 11.11 Retests, sorting and reprocessing

For retests, sorting reprocessing the requirements of EN 10021 shall apply.

## 12 Marking

### 12.1 Marking to be applied

Depending on the size of the tubes, the following marking shall either be applied on a label attached to the bundle or the box of tubes, or be marked indelibly on each tube at least at one end.

The marking shall include the following information:

- manufacturer's name or trade mark;
- dimension of the tubes;
- number of this part of EN 10216 and the steel name (or number) (see 5.2);
- cast number or a code number;
- test category;
- mark of the inspection representative;
- identification number (e.g. order or item number) which permits the correlation of the product or delivery unit to the related document,

and at the discretion of the manufacturer:

- symbol identifying the delivery condition (see Table 1).

Example of marking:

X – 168,3 X 4,5 – EN 10216-5 – 1.4301 – TC1 – HFD – Y – Z<sub>1</sub> – Z<sub>2</sub>

where

- X is the manufacturer's mark;
- TC1 is the designation of the test category 1;
- HFD is the identification of the delivery condition;
- Y is the cast number or a code number;
- Z<sub>1</sub> is the mark of the inspection representative;
- Z<sub>2</sub> is the identification number.

### 12.2 Additional marking

*Option 24: Additional marking, as agreed upon at the time of enquiry and order, shall be applied.*

### 13 Handling and packaging

The tubes shall be protected from carbon steel strapping, which shall not come into contact with the tubes.

*Option 25: If special protection is to be applied, this shall be specified at the time of enquiry and order*

## Annex A (informative)

### Reference data of strength values for creep rupture of austenitic steels in the solution annealed condition

NOTE 1 The values given in Table A.1 are mean values of the scatter band considered until now.

NOTE 2 The strength values for creep rupture given up to the elevated temperatures listed in Table A.1 do not mean that the steels can be used in continuous duty up to these temperatures. The governing factor is the total stressing during operation. Where relevant, the oxidation conditions should also be taken into account.

Table A.1 - Creep rupture strength values (*continued*)

| Steel designation |        | Temperature <sup>a</sup><br>°C | Creep rupture strength <sup>b</sup> in MPa for |           |           |           |
|-------------------|--------|--------------------------------|--|-----------|-----------|-----------|
| name              | number |                                | 10 000 h                                       | 100 000 h | 200 000 h | 250 000 h |
| X6CrNi18-10       | 1.4948 | 500                            | 250  | 192       | 176       | --        |
|                   |        | 510                            | 239  | 182       | 166       | --        |
|                   |        | 520                            | 227  | 172       | 156       | --        |
|                   |        | 530                            | 215  | 162       | 146       | --        |
|                   |        | 540                            | 203  | 151       | 136       | --        |
|                   |        | 550                            | 191  | 140       | 125       | --        |
|                   |        | 560                            | 177  | 128       | 114       | --        |
|                   |        | 570                            | 165  | 117       | 104       | --        |
|                   |        | 580                            | 154  | 107       | 95        | --        |
|                   |        | 590                            | 143  | 98        | 86        | --        |
|                   |        | 600                            | 132  | 89        | 78        | --        |
|                   |        | 610                            | 122  | 81        | 70        | --        |
|                   |        | 620                            | 113  | 73        | 62        | --        |
|                   |        | 630                            | 104  | 65        | 55        | --        |
|                   |        | 640                            | 95   | 52        | 49        | --        |
|                   |        | 650                            | 87   | 58        | 43        | --        |
|                   |        | 660                            | 80   | 47        | 34        | --        |
|                   |        | 670                            | 73   | 42        | 38        | --        |
|                   |        | 680                            | 67   | 37        | 30        | --        |
| 690               | 61     | 32                             | 26   | --        |           |           |
| 700               | 55     | 28                             | 22   | --        |           |           |
| 710               | (45)   | (22)                           | --   | --        |           |           |
| 720               | (41)   | (20)                           | --   | --        |           |           |
| 730               | (38)   | (18)                           | --   | --        |           |           |
| 740               | (36)   | (16)                           | --   | --        |           |           |
| 750               | (34)   | (15)                           | --   | --        |           |           |
| X7CrNiTi18-10     | 1.4940 | 550                            | 186  | 142       | --        | --        |
|                   |        | 575                            | 162  | 110       | --        | --        |
|                   |        | 600                            | 135  | 83        | --        | --        |
|                   |        | 625                            | 111  | 65        | --        | --        |
|                   |        | 650                            | 88   | 49        | --        | --        |
|                   |        | 675                            | 67   | 36        | --        | --        |
|                   |        | 700                            | 49   | 25        | --        | --        |
|                   |        | 725                            | 38   | 19        | --        | --        |
|                   |        | 750                            | 31   | 14        | --        | --        |
|                   |        | 775                            | 24   | 11        | --        | --        |
| 800               | 20     | 8                              | --   | --        |           |           |

| Steel designation |        | Temperature <sup>a</sup><br>°C | Creep rupture strength <sup>b</sup> in MPa for |           |           |           |
|-------------------|--------|--------------------------------|--|-----------|-----------|-----------|
| name              | number |                                | 10 000 h                                       | 100 000 h | 200 000 h | 250 000 h |
| X7CrNiNb18-10     | 1.4912 | 540                            | 253  | 186 *     | 169 *     | --        |
|                   |        | 550                            | 237  | 172 *     | 156 *     | --        |
|                   |        | 580                            | 192  | 135 *     | 122 *     | --        |
|                   |        | 600                            | 166  | 115 *     | 102 *     | --        |
|                   |        | 620                            | 142  | 97 *      | 86 *      | --        |
|                   |        | 650                            | 112  | 74 *      | 64 *      | --        |
|                   |        | 670                            | 96   | 61        | (51) *    | --        |
|                   |        | 700                            | 74   |           | --        | --        |
| X6CrNiTiB18-10    | 1.4941 | 550                            | 230  | 170       | 150       | --        |
|                   |        | 560                            | 220  | 150       | 130       | --        |
|                   |        | 570                            | 210  | 140       | 120       | --        |
|                   |        | 580                            | 190  | 120       | 110       | --        |
|                   |        | 590                            | 170  | 110       | 100       | --        |
|                   |        | 600                            | 160  | 100       | 90        | --        |
|                   |        | 610                            | 140  | 92        | 82        | --        |
|                   |        | 620                            | 130  | 84        | 74        | --        |
|                   |        | 630                            | 120  | 76        | 66        | --        |
|                   |        | 640                            | 110  | 68        | 60        | --        |
|                   |        | 650                            | 100  | 62        | 54        | --        |
|                   |        | 660                            | 90   | 56        | 48        | --        |
|                   |        | 670                            | 82   | 50        | 43        | --        |
| 680               | 74     | 44                             | 40   | --        |           |           |
| 690               | 66     | 39                             | 38   | --        |           |           |
| 700               | 60     | 35                             | 29   | --        |           |           |
| X6CrNiMo17-13-2   | 1.4918 | 550                            | 250  | 175       | --        | --        |
|                   |        | 560                            | 235  | 164       | --        | --        |
|                   |        | 570                            | 220  | 153       | --        | --        |
|                   |        | 580                            | 205  | 142       | --        | --        |
|                   |        | 590                            | 190  | 131       | --        | --        |
|                   |        | 600                            | 175  | 120       | --        | --        |
|                   |        | 610                            | 160  | 109       | --        | --        |
|                   |        | 620                            | 147  | 98        | --        | --        |
|                   |        | 630                            | 135  | 88        | --        | --        |
|                   |        | 640                            | 123  | 78        | --        | --        |
|                   |        | 650                            | 111  | 69        | --        | --        |
|                   |        | 660                            | 100  | 60        | --        | --        |
|                   |        | 670                            | 91   | 52        | --        | --        |
| 680               | 82     | 46                             | --   | --        |           |           |
| 690               | 73     | 40                             | --   | --        |           |           |
| 700               | 65     | 34                             | --   | --        |           |           |

| Steel designation |                        | Temperature <sup>a</sup><br>°C | Creep rupture strength <sup>b</sup> in MPa for |           |           |           |
|-------------------|------------------------|--------------------------------|--|-----------|-----------|-----------|
| name              | number                 |                                | 10 000 h                                       | 100 000 h | 200 000 h | 250 000 h |
| X5NiCrAlTi31-20   | 1.4958                 | 500                            | 290  | 215       | (196)     | --        |
|                   |                        | 510                            | 279  | 205       | (186)     | --        |
|                   |                        | 520                            | 267  | 195       | (176)     | --        |
|                   |                        | 530                            | 254  | 184       | (166)     | --        |
|                   |                        | 540                            | 240  | 172       | (155)     | --        |
|                   |                        | 550                            | 225  | 160       | (143)     | --        |
|                   |                        | 560                            | 208  | 147       | (130)     | --        |
|                   |                        | 570                            | 190  | 133       | (117)     | --        |
|                   |                        | 580                            | 172  | 119       | (105)     | --        |
|                   |                        | 590                            | 155  | 106       | (93)      | --        |
|                   |                        | 600                            | 140  | 95        | (83)      | --        |
|                   |                        | 610                            | 128  | 85        | (74)      | --        |
|                   |                        | 620                            | 118  | 78        | (68)      | --        |
|                   |                        | 630                            | 109  | 72        | (63)      | --        |
|                   |                        | 640                            | 103  | 67        | (59)      | --        |
|                   |                        | 650                            | 97   | 63        | (55)      | --        |
|                   |                        | 660                            | 91   | 59        | (52)      | --        |
| 670               | 85                     | 55                             | (48)   | --        |           |           |
| 680               | 80                     | 52                             | (45)   | --        |           |           |
| 690               | 74                     | 48                             | (41)   | --        |           |           |
| 700               | 69                     | 44                             | (38)   | --        |           |           |
| X5NiCrAlTi31-20   | 1.4958+RA <sup>c</sup> | 500                            | 315  | 258       | (242)     | --        |
|                   |                        | 510                            | 297  | 241       | (225)     | --        |
|                   |                        | 520                            | 280  | 224       | (207)     | --        |
|                   |                        | 530                            | 262  | 206       | (190)     | --        |
|                   |                        | 540                            | 243  | 189       | (172)     | --        |
|                   |                        | 550                            | 224  | 171       | (155)     | --        |
|                   |                        | 560                            | 204  | 153       | (138)     | --        |
|                   |                        | 570                            | 184  | 136       | (122)     | --        |
|                   |                        | 580                            | 165  | 119       | (106)     | --        |
|                   |                        | 590                            | 147  | 104       | (92)      | --        |
|                   |                        | 600                            | 131  | 90        | (80)      | --        |
|                   |                        | 610                            | 117  | 79        | (70)      | --        |
|                   |                        | 620                            | 106  | 70        | (62)      | --        |
|                   |                        | 630                            | 96   | 62        | (55)      | --        |
|                   |                        | 640                            | 87   | 56        | (49)      | --        |
|                   |                        | 650                            | 80   | 51        | (44)      | --        |
|                   |                        | 660                            | 73   | 46        | (40)      | --        |
| 670               | 67                     | 42                             | (36)   | --        |           |           |
| 680               | 61                     | 38                             | (33)   | --        |           |           |
| 690               | 55                     | 34                             | (29)   | --        |           |           |
| 700               | 50                     | 30                             | (26)   | --        |           |           |



| Steel designation |        | Temperature <sup>a</sup> | Creep rupture strength <sup>b</sup> in MPa for |           |           |           |
|-------------------|--------|--------------------------|--|-----------|-----------|-----------|
| name              | number | °C                       | 10 000 h                                       | 100 000 h | 200 000 h | 250 000 h |
| X8NiCrAl Ti32-21  | 1.4959 | 700                      | 74,0   | 50,0      | (44,0)    | --        |
|                   |        | 710                      | 68,0   | 45,0      | (39,4)    | --        |
|                   |        | 720                      | 62,0   | 40,9      | (35,5)    | --        |
|                   |        | 730                      | 56,0   | 37,4      | (32,2)    | --        |
|                   |        | 740                      | 51,5   | 34,3      | (29,3)    | --        |
|                   |        | 750                      | 47,5   | 31,6      | (26,8)    | --        |
|                   |        | 760                      | 43,7   | 29,1      | (24,6)    | --        |
|                   |        | 770                      | 40,5   | 27,0      | (22,4)    | --        |
|                   |        | 780                      | 37,5   | 24,9      | (20,7)    | --        |
|                   |        | 790                      | 35,0   | 23,1      | (19,0)    | --        |
|                   |        | 800                      | 32,6   | 21,4      | (17,5)    | --        |
|                   |        | 810                      | 30,4   | 19,8      | (16,2)    | --        |
|                   |        | 820                      | 28,4   | 18,4      | (15,1)    | --        |
|                   |        | 830                      | 26,5   | 17,0      | (14,0)    | --        |
|                   |        | 840                      | 24,7   | 15,7      | (13,0)    | --        |
|                   |        | 850                      | 23,0   | 14,4      | (12,1)    | --        |
|                   |        | 860                      | 21,4   | 13,3      | (11,2)    | --        |
|                   |        | 870                      | 19,9   | 12,2      | (10,3)    | --        |
|                   |        | 880                      | 18,4   | 11,2      | (9,5)     | --        |
|                   |        | 890                      | 17,0   | 10,3      | (8,7)     | --        |
|                   |        | 900                      | 15,6   | 9,4       | (8,0)     | --        |
| 910               | 14,4   | 8,6                      | (7,3)  | --        |           |           |
| 920               | 13,2   | 7,8                      | (6,7)  | --        |           |           |
| 930               | 12,1   | 7,1                      | (6,2)  | --        |           |           |
| 940               | 11,1   | 6,4                      | (5,6)  | --        |           |           |
| 950               | 10,1   | 5,8                      | (5,0)  | --        |           |           |
| 960               | 9,2    | 5,3                      | (4,5)  | --        |           |           |
| 970               | 8,4    | 4,8                      | (4,1)  | --        |           |           |
| 980               | 7,7    | 4,4                      | (3,7)  | --        |           |           |
| 990               | 7,0    | 4,0                      | (1,3)  | --        |           |           |
| 1000              | 6,4    | 3,7                      | (1,0)  | --        |           |           |
| X3CrNiMoBN17-13-3 | 1.4910 | 550                      | 290  | 220       | (200)     | --        |
|                   |        | 560                      | 272  | 202       | (184)     | --        |
|                   |        | 570                      | 254  | 186       | (166)     | --        |
|                   |        | 580                      | 237  | 170       | (151)     | --        |
|                   |        | 590                      | 220  | 155       | (137)     | --        |
|                   |        | 600                      | 205  | 141       | (122)     | --        |
|                   |        | 610                      | 190  | 127       | (113)     | --        |
|                   |        | 620                      | 174  | 114       | (100)     | --        |
|                   |        | 630                      | 162  | 102       | (91)      | --        |
|                   |        | 640                      | 148  | 92        | (81)      | --        |
|                   |        | 650                      | 135  | 83        | (73)      | --        |
|                   |        | 660                      | 122  | 75        | (65)      | --        |
|                   |        | 670                      | 112  | 68        | (58)      | --        |
|                   |        | 680                      | 102  | 61        | (52)      | --        |
|                   |        | 690                      | 93   | 56        | (46)      | --        |
|                   |        | 700                      | 84   | 52        | (46)      | --        |
|                   |        | 710                      | 78   | 48        | (39)      | --        |
|                   |        | 720                      | 71   | 45        | (36)      | --        |
|                   |        | 730                      | 65   | 41        | (34)      | --        |
|                   |        | 740                      | 58   | 37        | (31)      | --        |
| 750               | 52     | 34                       | (28)   | --        |           |           |
| 760               | 48     | 31                       | (26)   | --        |           |           |
| 770               | 44     | 28                       | (24)   | --        |           |           |
| 780               | 41     | 25                       | (21)   | --        |           |           |
| 790               | 37     | 22                       | (19)   | --        |           |           |
| 800               | 33     | 20                       | (17)   | --        |           |           |

| Steel designation |        | Temperature <sup>a</sup><br>°C | Creep rupture strength <sup>b</sup> in MPa for |           |           |           |
|-------------------|--------|--------------------------------|--|-----------|-----------|-----------|
| name              | number |                                | 10 000 h                                       | 100 000 h | 200 000 h | 250 000 h |
| X8CrNiNb16-13     | 1.4961 | 580                            | 182  | 129       | 115       | --        |
|                   |        | 590                            | 170  | 119       | 105       | --        |
|                   |        | 600                            | 157  | 108       | 94        | --        |
|                   |        | 610                            | 145  | 98        | 85        | --        |
|                   |        | 620                            | 134  | 89        | 77        | --        |
|                   |        | 630                            | 124  | 80        | 69        | --        |
|                   |        | 640                            | 113  | 72        | 61        | --        |
|                   |        | 650                            | 103  | 64        | 53        | --        |
|                   |        | 660                            | 93   | 57        | 47        | --        |
|                   |        | 670                            | 84   | 50        | 41        | --        |
|                   |        | 680                            | 76   | 44        | 36        | --        |
|                   |        | 690                            | 70   | 39        | 31        | --        |
|                   |        | 700                            | 64   | 34        | 27        | --        |
|                   |        | 710                            | 59   | 30        | 25        | --        |
|                   |        | 720                            | 55   | 27        | 22        | --        |
| 730               | 51     | 25                             | 19   | --        |           |           |
| 740               | 47     | 22                             | 17   | --        |           |           |
| 750               | 44     | 20                             | 15   | --        |           |           |
| X8CrNiMoVNb16-13  | 1.4988 | 580                            | 299  | 209       | 180       | --        |
|                   |        | 590                            | 274  | 189       | 164       | --        |
|                   |        | 600                            | 250  | 172       | 147       | --        |
|                   |        | 610                            | 228  | 156       | 132       | --        |
|                   |        | 620                            | 207  | 139       | 117       | --        |
|                   |        | 630                            | 189  | 125       | 105       | --        |
|                   |        | 640                            | 173  | 111       | 93        | --        |
| 650               | 157    | 98                             | 82   | --        |           |           |
| X8CrNiMoNb16-16   | 1.4981 | 580                            | 270  | 186       | 162       | --        |
|                   |        | 590                            | 246  | 169       | 147       | --        |
|                   |        | 600                            | 225  | 152       | 132       | --        |
|                   |        | 610                            | 205  | 136       | 118       | --        |
|                   |        | 620                            | 186  | 122       | 103       | --        |
|                   |        | 630                            | 169  | 107       | 91        | --        |
|                   |        | 640                            | 152  | 94        | 80        | --        |
|                   |        | 650                            | 137  | 83        | 71        | --        |
|                   |        | 660                            | 124  | 75        | 63        | --        |
|                   |        | 670                            | 111  | 66        | 55        | --        |
|                   |        | 680                            | 100  | 59        | 49        | --        |
|                   |        | 690                            | 91   | 51        | 42        | --        |
|                   |        | 700                            | 83   | 44        | 35        | --        |
|                   |        | 710                            | 77   | 37        | 29        | --        |
|                   |        | 720                            | 70   | 31        | 24        | --        |
| 730               | 64     | 26                             | 20   | --        |           |           |
| 740               | 59     | 23                             | 17   | --        |           |           |
| 750               | 54     | 20                             | 15   | --        |           |           |

| Steel designation       |        | Temperature <sup>a</sup> | Creep rupture strength <sup>b</sup> in MPa for |           |           |           |
|-------------------------|--------|--------------------------|--|-----------|-----------|-----------|
| name                    | number | °C                       | 10 000 h                                       | 100 000 h | 200 000 h | 250 000 h |
| X10CrNiMoMnNbVB 15-10-1 | 1.4982 | 600                      | 241  | 199       | 183       | 177       |
|                         |        | 610                      | 231  | 185       | 165       | 158       |
|                         |        | 620                      | 221  | 167       | 143       | 134       |
|                         |        | 630                      | 210  | 147       | 118       | 109 *     |
|                         |        | 640                      | 198  | 122       | 97        | 90 *      |
|                         |        | 650                      | 184  | 100       | 82        | 78 *      |
|                         |        | 660                      | 167  | 84        | 72        | 69 *      |
|                         |        | 670                      | 147  | 74        | 64        | 62 *      |
|                         |        | 680                      | 124  | 66        | 58        | 56 *      |
|                         |        | 690                      | 102  | 59        | 52        | 51 *      |
|                         |        | 700                      | 86   | 54        | 48        | 46 *      |
|                         |        | 710                      | 75   | 49        | 43        | 42 *      |
|                         |        | 720                      | 67   | 45        | 39        | 37 *      |
|                         |        | 730                      | 61   | 40 *      | 35 *      | --        |
|                         |        | 740                      | 55   | 36 *      | --        | --        |
|                         |        | 750                      | 51   | 30 *      | --        | --        |
|                         |        | 760                      | 46   | --        | --        | --        |
| 770                     | 42     | --                       | --   | --        |           |           |
| 780                     | 38     | --                       | --   | --        |           |           |

<sup>a</sup> For cooling conditions see Table 7.

<sup>b</sup> Values in parantheses involve time and/or stress extrapolation; values with asterisk involve time extrapolation.

<sup>c</sup> +RA = recrystallizing annealed condition.

## Annex ZA (informative)

### Clauses of this part of EN 10216 addressing essential safety requirements of the EU Directive 97/23/EC

This part of EN 10216 has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive No. 97/23/EC on Pressure Equipment.

**Warning:** Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

**Table ZA.1 – Correspondence between this part of EN 10216 and the EU Directive 97/23/EC Annex I**

| Clauses/sub-clauses<br>of this part of<br>EN 10216 | Essential Requirements (ERs) of the EU<br>Directive 97/23/EC | Qualifying remarks/<br>Notes              |
|--|--|---|
| 8.3 and 8.4  | Annex I, 4.1 a   | Appropriate material<br>properties        |
| 7.2 and 8.5  | Annex I, 4.1 d   | Suitable for the<br>processing procedures |
| 9 and 10   | Annex I, 4.3   | Documentation                             |

## Bibliography

EN 473, *Non destructive testing - Qualification and certification of NDT personnel - General principles.*

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