

Seamless steel tubes for pressure purposes — Technical delivery conditions —

Part 2: Non-alloy and alloy steel tubes with specified elevated temperature properties

The European Standard EN 10216-2:2002 has the status of a
British Standard

ICS 23.040.10; 77.140.75

National foreword

This British Standard is the official English language version of EN 10216-2:2002. Together with BS EN 10217-2:2002 it replaces BS 3059-2, BS 3602-1, BS 3604-1 and BS 3606:1992 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee ISE/73, Steels for pressure purposes, to Subcommittee ISE/73/1, Steel tubes for pressure purposes, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

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This British Standard, having been prepared under the direction of the Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 26 June 2002

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 40, an inside back cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

English version

Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 2: Non-alloy and alloy steel tubes with specified elevated temperature properties

Tubes sans soudure en acier pour service sous pression -
Conditions techniques de livraison - Partie 2: Tubes en
acier non allié et allié avec caractéristiques spécifiées à
température élevée

Nahtlose Stahlrohre für Druckbeanspruchungen -
Technische Lieferbedingungen - Teil 2: Rohre aus
unlegierten und legierten Stählen mit festgelegten
Eigenschaften bei erhöhten Temperaturen

This European Standard was approved by CEN on 25 April 2002.

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Foreword

This document (EN 10216-2:2002) 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 November 2002, and conflicting national standards shall be withdrawn at the latest by November 2002.

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 EU Directive(s).

For relationship with EU Directive(s), 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 3 : Alloy fine grain steel tubes

Part 4 : Non-alloy and alloy steel tubes with specified low temperature properties

Part 5 : Stainless steel tubes

Another European Standard series covering tubes for pressure purposes is:

EN 10217: Welded steel tubes for pressure purposes

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

1 SCOPE

This Part of EN 10216 specifies the technical delivery conditions in two test categories for seamless tubes of circular cross section, with specified elevated temperature properties, made of non-alloy and alloy steel.

NOTE This Part of EN 10216 may also be applied for tubes of non-circular cross section; necessary modification should be agreed at the time of enquiry and order.

2 NORMATIVE REFERENCES

This European Standard incorporates by date or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For date references, subsequent amendments to or revisions of, any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

The requirements of this European Standard 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 testing (at elevated temperature)*.

EN 10020, *Definitions and classification of grades of steel*.

EN 10021, *General technical delivery requirements for steel and iron products*.

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

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

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

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

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

ENV 10220, *Seamless and welded steel tubes - Dimensions and masses per unit length*

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 10246-1, *Non-Destructive Testing of steel tubes Part 1 : Automatic electromagnetic testing of seamless and welded (except submerged arc welded) ferromagnetic steel tubes for verification of hydraulic leak-tightness*.

EN 10246-5, *Non-Destructive Testing of steel tubes – Part 5: Automatic full peripheral magnetic transducer/flux leakage testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for the detection of longitudinal imperfections*.

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 10246-14, *Non-Destructive Testing of steel tubes - Part 14: Automatic ultrasonic testing of seamless and welded (except submerged arc welded) steel tubes for the detection of laminar imperfections.*

EN 10256, *Non-Destructive Testing of steel tubes - Qualification and competence of level 1 and level 2 NDT personnel.*

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

prEN 10168¹⁾, *Iron and steel products - Inspection documents - List of information and description.*

prEN 10266¹⁾, *Steel tubes, fittings and structural hollow sections - Symbols and definition of terms for use in product standards*

EN ISO 2566-1, *Steel - Conversion of elongation values – Part 1: Carbon and low-alloy steels (ISO 2566-1:1984)*

ISO 14284, *Steel and iron - Sampling and preparation of samples for the determination of chemical composition*

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

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

3 TERMS AND DEFINITIONS

For the purposes of this Part of EN 10216, the terms and definitions given in EN 10020, EN 10021, EN 10052 and prEN 10266 and the following apply:

3.1

test category

classification that indicates the extent and level of inspection and testing

3.2

employer

organisation for which a person works on a regular basis.

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

4 SYMBOLS

For the purpose of this Part of EN 10216, the symbols given in prEN 10266 and the following apply:

- d specified inside diameter;
- $d_{\min}$ specified minimum inside diameter;
- $T_{\min}$ specified minimum wall thickness;
- D_c calculated outside diameter;
- d_c calculated inside diameter;

1) In preparation; until this document is published as a European Standard, the corresponding national standard(s) should be agreed at the time of enquiry and order.

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- T_c calculated wall thickness;
- TC test category

5 CLASSIFICATION AND DESIGNATION

5.1 Classification

In accordance with the classification system in EN 10020, the steel grades P195GH, P235GH and P265GH are classified as non-alloy quality steels and the other steel grades are classified as alloy special steels.

5.2 Designation

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

- the number of this Part of EN 10216;

plus either:

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

or:

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

5.2.2 The steel name of non-alloy steel grades is designated by:

- the capital letter P for pressure purposes;
- the indication of the specified minimum yield strength at room temperature for wall thickness less than or equal to 16 mm, expressed in MPa (see Table 4);
- the symbols GH for elevated temperature.

5.2.3 The steel name of alloy steel grades is designated by the chemical composition (see Table 2) and the symbols for the heat treatment, where specified in column 3 and footnote 3 of Table 1.

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) the quantity (mass or total length or number);
- b) the term "tube";
- c) the dimensions (outside diameter D and wall thickness T or a set of dimensions covered by Option 11) (see Table 6);
- d) the designation of the steel grade in accordance with this Part of EN 10216 (see 5.2);
- e) the test category for non-alloy steel (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 tubes shall be supplied in accordance with the basic specification (see 6.1).

- 1) Cold finishing (see 7.3.2).
- 2) Restriction on copper and tin content (see Table 2).
- 3) Product analysis (see 8.2.2).
- 4) Impact testing (see Table 4).
- 5) Longitudinal impact testing at -10° C for non-alloy steel grades (see Table 4).
- 6) Tensile testing at elevated temperature (see 8.3.2).
- 7) Selection of leak-tightness test method (see 8.4.2.1).
- 8) Non-Destructive Testing for test category 2 tubes for detection of transverse imperfections (see 8.4.2.2).
- 9) Non-Destructive Testing for test category 2 tubes for detection of laminar imperfections (see 8.4.2.2).
- 10) Special ends preparation (see 8.6).
- 11) Set of dimensions other than D and T (see 8.7.1).
- 12) Exact lengths (see 8.7.3).
- 13) The type of inspection document other than the standard document (see 9.2.1).
- 14) Test pressure for hydrostatic leak-tightness test (see 11.8.1).
- 15) Wall thickness measurement away from the ends (see 11.9).
- 16) Non-Destructive Testing method (see 11.11.1).
- 17) Additional marking (see 12.2).
- 18) Protection (see 13).

6.3 Examples of an order

6.3.1 Example 1

100 t of seamless tube with an outside diameter of 168,3 mm, a wall thickness of 4,5 mm, in accordance with EN 10216-2, made of steel grade P265GH, to test category 1 with a 3.1.C inspection certificate in accordance with EN 10204:

100 t - Tube - 168,3 x 4,5 - EN 10216-2 - P265GH - TC1 - Option 13: 3.1.C

6.3.2 Example 2

100 m of seamless tube with a minimum inside diameter of 240 mm, a minimum wall thickness of 40 mm in accordance with Part of EN 10216, made of steel grade 10CrMo9-10, with a 3.1.C inspection certificate in accordance with EN 10204:

100 m - Tube - $d_{\min}$ 240 x $T_{\min}$ 40 - EN 10216-2 - 10CrMo9-10 - Option 13: 3.1.C

7 MANUFACTURING PROCESS

7.1 Steel making process

The steel making process is at the discretion of the manufacturer.

7.2 Deoxidation process

Steels shall be fully killed.

7.3 Tube manufacture and delivery conditions

7.3.1 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 with 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 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 prEN 10256

7.3.2 The tubes shall be manufactured by a seamless process.

Unless option 1 is specified, the tubes may be either hot or cold finished at the discretion of the manufacturer. The terms " hot finished " and " cold finished " apply to the condition of the tube before it is heat treated in accordance with 7.3.3.

Option 1: *The tubes shall be cold finished before heat treatment.*

7.3.3 The tubes shall be supplied in the relevant heat treatment conditions as specified in Table 1.

8 REQUIREMENTS

8.1 General

When supplied in a delivery condition indicated in clause 7.3 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.

Tubes shall be suitable for hot and cold bending provided the bending is carried out in an appropriate manner.

When tubes are specified in the order by d , $d_{\min}$ or $T_{\min}$ the following equations, with all terms in mm, shall apply for the calculation of outside diameter D_c , inside diameter d_c and wall thickness T_c , instead of D , d and T for the relevant requirements in clauses 8.4.1.4, 10.2.2.2, 11.3, 11.8.1, 11.9, 11.11.4, 12.1 and Table 1, footnote c, Tables 4, 5, 8, 10, 13 and 14:

$$D_c = d + 2T \quad (1)$$

$$D_c = d_{\min} + \frac{\text{tolerance} \cdot \text{of} \cdot d_{\min}}{2} + 2T \quad (2)$$

$$d_c = d_{\min} + \frac{\text{tolerance} \cdot \text{of} \cdot d_{\min}}{2} \quad (3)$$

$$T_c = T_{\min} + \frac{\text{tolerance} \cdot \text{of} \cdot T_{\min}}{2} \quad (4)$$

For tolerance see Tables 8, 9 and 10.

8.2 Chemical composition

8.2.1 Cast analysis

The cast analysis reported by the steel producer shall apply and conform to the requirements of Table 2.

NOTE When welding tubes produced in accordance with this Part of this EN 10216, account should be taken of 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 3 : *Product analysis for the tubes shall be supplied.*

Table 3 specifies the permissible deviations of the product analysis from the specified limits on cast analysis given in Table 2.

Table 1 — Heat treatment conditions

Steel grade		Heat treatment ^a	Austenizing		Tempering	
Steel name	Steel number		Temperature °C	Cooling Medium	Temperature °C	Cooling medium
P195GH	1.0348	+N ^b	880 to 940	Air	-	-
P235GH	1.0345	+N ^b	880 to 940	Air	-	-
P265GH	1.0425	+N ^b	880 to 940	Air	-	-
20MnNb6	1.0471	+N ^b	900 to 960	Air	-	-
16Mo3	1.5415	+N ^b	890 to 950	Air	-	-
8MoB5-4	1.5450	+N ^b	920 to 960	Air	-	-
14MoV6-3	1.7715	+NT ^{b c}	930 to 990	Air	680 to 730	air
10CrMo5-5	1.7338	+NT ^{b c}	900 to 960	Air	650 to 750	air
13CrMo4-5	1.7335	+NT ^{b c}	900 to 960	Air	660 to 730	air
10CrMo9-10	1.7380	+NT ^{b c}	900 to 960	Air	680 to 750	air
11CrMo9-10	1.7383	+QT	900 to 960	Air or Liquid	680 to 750	air
25CrMo4	1.7218	+QT	860 to 900	Air or Liquid	620 to 680	air
20CrMoV13-5-5	1.7779	+QT	980 to 1030	Air or Liquid	680 to 730	air
15NiCuMoNb5-6-4	1.6368	+NT ^c	880 to 980	Air	580 to 680	air
X11CrMo5+I	1.7362+I	+I	890 to 950	Furnace Atmosphere	-	-
X11CrMo5+NT1	1.7362+NT1	+NT1	930 to 980	Air	730 to 770	air
X11CrMo5+NT2	1.7362+NT2	+NT2 ^c	930 to 980	air	710 to 750	air
X11CrMo9-1+I	1.7386+I	+I	950 to 980	Furnace Atmosphere	-	-
X11CrMo9-1+NT	1.7386+NT	+NT ^c	890 to 950	air	720 to 800	air
X10CrMoVNb9-1	1.4903	+NT ^c	1040 to 1090	air	730 to 780	air
X20CrMoV11-1	1.4922	+NT ^c	1020 to 1080	air	730 to 780	air

^a +N = Normalising, +NT = Normalising + Tempering, +QT = Quenching + Tempering (air or liquid), +I = Isothermal Annealing.

^b Normalising includes Normalising Forming.

^c For these steel grades it may be necessary in the case of wall thickness T above 25 mm or T/D > 0,15 to apply quenching and tempering in order to achieve the intended structure and material properties. The decision shall be left to the discretion of the manufacturer but shall be stated to the customer at the time of enquiry and order. Steel tubes treated in such a way shall be designated by the steel name supplemented by the symbol "+QT".

Table 2 — Chemical composition (cast analysis) ^a, in % by mass

Steel grade		C	Si	Mn	P max	S max	Cr	Mo	Ni	Al _{tot}	Cu	Nb	Ti max	V	Cr+Cu +Mo+Ni	Others
Steel name	Steel number															
195GH	1.0348	≤ 0,13	≤ 0,35	≤ 0,70	0,025	0,020	≤ 0,30	≤ 0,08	≤ 0,30	≥ 0,020 ^b	≤ 0,30 ^c	≤ 0,010 ^d	0,040 ^d	≤ 0,02 ^d	≤ 0,70	-
P235GH	1.0345	≤ 0,16	≤ 0,35	≤ 1,20	0,025	0,020	≤ 0,30	≤ 0,08	≤ 0,30	≥ 0,020 ^b	≤ 0,30 ^c	≤ 0,010 ^d	0,040 ^d	≤ 0,02 ^d	≤ 0,70	-
P265GH	1.0425	≤ 0,20	≤ 0,40	≤ 1,40	0,025	0,020	≤ 0,30	≤ 0,08	≤ 0,30	≥ 0,020 ^b	≤ 0,30 ^c	≤ 0,010 ^d	0,040 ^d	≤ 0,02 ^d	≤ 0,70	-
20MnNb6	1.0471	≤ 0,22	0,15 to 0,35	1,00 to 1,50	0,025	0,020	-	-	-	≤ 0,060	≤ 0,30 ^c	0,015 to 0,10	-	-	-	-
16Mo3	1.5415	0,12 to 0,20 ^e	≤ 0,35	0,40 to 0,90	0,025	0,020	≤ 0,30	0,25 to 0,35	≤ 0,30	≤ 0,040	≤ 0,30 ^c	-	-	-	-	-
8MoB5-4	1.5450	0,06 to 0,10	0,10 to 0,35	0,60 to 0,80	0,025	0,020	≤ 0,20	0,40 to 0,50	-	≤ 0,060	≤ 0,30 ^c	-	0,060	-	-	B = 0,002 to 0,006
14MoV63	1.7715	0,10 to 0,15	0,15 to 0,35	0,40 to 0,70	0,025	0,020	0,30 to 0,60	0,50 to 0,70	≤ 0,30	≤ 0,040	≤ 0,30 ^c	-	-	0,22 to 0,28	-	-
10CrMo5-5	1.7338	≤ 0,15	0,50 to 1,00	0,30 to 0,60	0,025	0,020	1,00 to 1,50	0,45 to 0,65	≤ 0,30	≤ 0,040	≤ 0,30 ^c	-	-	-	-	-
13CrMo4-5	1.7335	0,10 to 0,17 ^e	≤ 0,35	0,40 to 0,70	0,025	0,020	0,70 to 1,15	0,40 to 0,60	≤ 0,30	≤ 0,040	≤ 0,30 ^c	-	-	-	-	-
10CrMo9-10	1.7380	0,08 to 0,14	≤ 0,50	0,30 to 0,70	0,025	0,020	2,00 to 2,50	0,90 to 1,10	≤ 0,30	≤ 0,040	≤ 0,30 ^c	-	-	.	-	-
11CrMo9-10	1.7383	0,08 to 0,15	≤ 0,50	0,40 to 0,80	0,025	0,020	2,00 to 2,50	0,90 to 1,10	≤ 0,30	≤ 0,040	≤ 0,30 ^c	-	-	.	-	-

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Table 2 (continued)

Steel grade		C	Si	Mn	P max	S max	Cr	Mo	Ni	Al _{tot}	Cu	Nb	Ti	V	Cr+Cu +Mo+Ni	Others
Steel name	Steel number															
25CrMo4	1.7218	0,22 to 0,29	≤ 0,40	0,60 to 0,90	0,025	0,020	0,90 to 1,20	0,15 to 0,30	≤ 0,30	≤ 0,040	≤ 0,30 ^c	-	-	-	-	-
20CrMoV13-5-5	1.7779	0,17 to 0,23	0,15 to 0,35	0,30 to 0,50	0,025	0,020	3,00 to 3,30	0,50 to 0,60	≤ 0,30	≤ 0,040	≤ 0,30 ^c	-	-	0,45 to 0,55	-	-
15NiCuMoNb5-6-4	1.6368	≤ 0,17	0,25 to 0,50	0,80 to 1,20	0,025	0,020	≤ 0,30	0,25 to 0,50	1,00 to 1,30	≤ 0,050	0,50 to 0,80	0,015 to 0,045	-	-	-	-
X11CrMo5+I X11CrMo5+NT1 X11CrMo5+NT2	1.7362+I 1.7362+NT1 1.7362+NT2	0,08 to 0,15	0,15 to 0,50	0,30 to 0,60	0,025	0,020	4,00 to 6,00	0,45 to 0,65		≤ 0,040	≤ 0,30 ^c					
X11CrMo9-1+I X11CrMo9-1+NT	1.7386+I 1.7386+NT	0,08 to 0,15	0,25 to 1,00	0,30 to 0,60	0,025	0,020	8,00 to 10,00	0,90 to 1,10		≤ 0,040	≤ 0,30 ^c					
X10CrMoVNb9-1	1.4903	0,08 to 0,12	0,20 to 0,50	0,30 to 0,60	0,020	0,010	8,00 to 9,50	0,85 to 1,05	≤ 0,40	≤ 0,040	≤ 0,30 ^c	0,06 to 0,10	-	0,18 to 0,25	-	N = 0,030 to 0,070
X20CrMoV11-1	1.4922	0,17 to 0,23 ^f	0,15 to 0,50	≤ 1,00	0,025	0,020	10,00 to 12,50	0,80 to 1,20	0,30 to 0,80	≤ 0,040	≤ 0,30 ^c	-	-	0,25 to 0,35	-	-
^a Elements not included in this Table shall not be intentionally added to the steel without the agreement of the purchaser, except for elements which may be added for finishing the cast. All appropriate measures shall be taken to prevent the addition of undesirable elements from scrap or other materials used in the steel making process. ^b This requirement is not applicable provided the steel contains a sufficient amount of other nitrogen binding elements which shall be reported. When using titanium, the producer shall verify that $(Al+Ti/2) \geq 0,020\%$ ^c Option 2: In order to facilitate subsequent forming operations, an agreed maximum copper content lower than indicated and an agreed specified maximum tin content shall apply ^d The content of these elements need not to be reported unless intentionally added to the cast. ^e For wall thickness ≥ 30 mm the carbon content may be increased by 0,02 % for cast and product analysis. ^f The upper carbon value of 0,23 % shall not be exceeded for product analysis.																

Table 3 — Permissible deviations of the product analysis from specified limits on cast analysis given in Table 2

Element	Limiting value for the cast analysis in accordance with Table 2 % by mass	Permissible deviation of the product analysis % by mass
C	$\leq 0,29$	$\pm 0,02$
Si	$\leq 0,40$	$\pm 0,05$
	$> 0,40$ to $\leq 1,00$	$\pm 0,06$
Mn	$\leq 1,00$	$\pm 0,05$
	$> 1,00$ to $\leq 1,50$	$\pm 0,10$
P	$\leq 0,025$	$+ 0,005$
S	$\leq 0,010$	$+ 0,003$
	$> 0,010$ to $\leq 0,020$	$+ 0,005$
Al	$\leq 0,060$	$\pm 0,005$
B	$\leq 0,006$	$\pm 0,001$
Cr	$\leq 1,00$	$\pm 0,05$
	$> 1,00$ to $\leq 10,00$	$\pm 0,10$
	$> 10,00$ to $\leq 12,50$	$\pm 0,15$
Cu	$\leq 0,80$	$\pm 0,05$
Mo	$\leq 0,35$	$\pm 0,03$
	$> 0,35$ to $\leq 1,20$	$\pm 0,04$
N	$\leq 0,070$	$\pm 0,01$
Nb	$\leq 0,10$	$\pm 0,005$
Ni	$\leq 0,35$	$\pm 0,05$
	$> 0,35$ to $\leq 1,30$	$\pm 0,07$
Ti	$\leq 0,060$	$+ 0,010$
V	$\leq 0,10$	$+ 0,01$
	$> 0,10$ to $\leq 0,55$	$\pm 0,03$

8.3 Mechanical properties

8.3.1 Mechanical properties at and below room temperature

The mechanical properties at and below room temperature of the tubes shall conform to the requirements in Table 4 and in clauses 11.3, 11.4, 11.5 and 11.6.

8.3.2 Proof strength at elevated temperature

The minimum proof strength $R_{p0,2}$ values at elevated temperature are given in Table 5.

Option 6: Proof strength $R_{p0,2}$ shall be verified. The test temperature shall be specified at the time of enquiry and order.

8.3.3 Creep rupture strength

The creep rupture strength values are given in annex A for information.

Table 4 — Mechanical properties

Steel grade		Tensile properties at room temperature							Impact properties ^{a b}				
Steel name	Steel number	Upper yield strength or proof strength R_{eH} or $R_{p0.2}$ for Wall Thickness T min.				Tensile Strength R_m	Elongation A min. % ^a		Minimum average absorbed energy KV J at a temperature of °C				
		T ≤ 16	16 < T ≤ 40	40 < T ≤ 60	60 < T ≤ 100		l	t	l			t	
		MPa *	MPa *	MPa *	MPa *	MPa *			20	0	-10	20	0
P195GH	1.0348	195	-	-	-	320 to 440	27	25	-	40 ^c	28 ^d	-	27 ^c
P235GH	1.0345	235	225	215	-	360 to 500	25	23	-	40 ^c	28 ^d	-	27 ^c
P265GH	1.0425	265	255	245	-	410 to 570	23	21	-	40 ^c	28 ^d	-	27 ^c
20MnNb6	1.0471	355	345	335	-	500 to 650	22	20	-	40 ^c	-	-	27 ^c
16Mo3	1.5415	280	270	260	-	450 to 600	22	20	40 ^c	-	-	27 ^c	-
8MoB5-4	1.5450	400	-	-	-	540 to 690	19	17	40 ^c	-	-	27 ^c	-
14MoV6-3	1.7715	320	320	310	-	460 to 610	20	18	40 ^{c f}	-	-	27 ^c	-
10CrMo5-5	1.7338	275	275	265	-	410 to 560	22	20	40 ^c	-	-	27 ^c	-
13CrMo4-5	1.7335	290	290	280	-	440 to 590	22	20	40 ^c	-	-	27 ^c	-
10CrMo9-10	1.7380	280	280	270	-	480 to 630	22	20	40 ^c	-	-	27 ^c	-
11CrMo9-10	1.7383	355	355	355	-	540 to 680	20	18	40 ^c	-	-	27 ^c	-
25CrMo4	1.7218	345	345	345	-	540 to 690	18	15	40 ^{c f}	-	-	27 ^c	-
20CrMoV13-5-5	1.7779	590	590	590	-	740 to 880	16	14	40 ^{c f}	-	-	27 ^c	-
15NiCuMoNb5-6-4	1.6368	440	440	440	440 ^e	610 to 780	19	17	40 ^{c f}	-	-	27 ^c	-

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Table 4 (continued)

Steel name	Steel number	Upper yield strength or proof strength R_{eH} or $R_{p0.2}$ for Wall Thickness T min.				Tensile Strength R_m	Elongation A min. % ^a		Minimum average absorbed energy KV J at a temperature of °C				
		T ≤ 16	16 < T ≤ 40	40 < T ≤ 60	60 < T ≤ 100		l	t	l			t	
		MPa *	MPa *	MPa *	MPa *	MPa *			20	0	-10	20	0
X11CrMo5+I	1.7362+I	175	175	175	175	430 to 580	22	20	40 °C	-	-	27 °C	-
X11CrMo5+NT1	1.7362+NT1	280	280	280	280	480 to 640	20	18	40 °C	-	-	27 °C	-
X11CrMo5+NT2	1.7362+NT2	390	390	390	390	570 to 740	18	16	40 °C	-	-	27 °C	-
X11CrMo9-1+I	1.7386+I	210	210	210	-	460 to 640	20	18	40 °C	-	-	27 °C	-
X11CrMo9-1+NT	1.7386+NT	390	390	390	-	590 to 740	18	16	40 °C	-	-	27 °C	-
X10CrMoVNb9-1	1.4903	450	450	450	450	630 to 830	19	17	40 °C ^f	-	-	27 °C	-
X20CrMoV11-1	1.4922	490	490	490	490	690 to 840	17	14	40 °C ^f	-	-	27 °C	

^a l = longitudinal t = transverse^b To be verified when options 4 and/or 5 are/is specified, unless footnote f) applies.^c **Option 4:** Impact energy shall be verified.^d **Option 5:** Longitudinal impact energy shall be verified.^e For wall thickness 60 mm < T ≤ 80 mm.^f Impact test mandatory for wall thickness T ≥ 16 mm.* MPa = 1 N/mm²

Table 5 — Minimum proof strength $R_{p0.2}$ at elevated temperature

Steel grade		Wall thickness mm	Minimum proof strength $R_{p0.2}$ MPa ^a at temperature of °C										
Steel name	Steel number		100	150	200	250	300	350	400	450	500	550	600
P195GH	1.0348	≤16	175	165	150	130	113	102	94	-	-	-	-
P235GH	1.0345	≤ 60	198	187	170	150	132	120	112	108	-	-	-
P265GH	1.0425	≤ 60	226	213	192	171	154	141	134	128	-	-	-
20MnNb6	1.0471	≤ 60	312	292	264	241	219	200	186	174	-	-	-
16Mo3	1.5415	≤ 60	243	237	224	205	173	159	156	150	146	-	-
8MoB5-4	1.5450	≤ 16	368	368	368	368	368	368	368	-	-	-	-
14MoV6-3	1.7715	≤ 60	282	276	267	241	225	216	209	203	200	197	-
10CrMo5-5	1.7338	≤ 60	240	228	219	208	165	156	148	144	143	-	-
13CrMo4-5	1.7335	≤ 60	264	253	245	236	192	182	174	168	166	-	-
10CrMo9-10	1.7380	≤ 60	249	241	234	224	219	212	207	193	180	-	-
11CrMo9-10	1.7383	≤ 60	323	312	304	296	289	280	275	257	239	-	-
25CrMo4	1.7218	≤ 60	-	315	305	295	285	265	225	185	-	-	-
20CrMoV13-5-5	1.7779	≤ 60	-	575	570	560	550	510	470	420	370	-	-
15NiCuMoNb5-6-4	1.6368	≤ 80	422	412	402	392	382	373	343	304	-	-	-
X11CrMo5+I	1.7362+I	≤ 100	156	150	148	147	145	142	137	129	116	-	-
X11CrMo5+NT1	1.7362+NT1	≤ 100	245	237	230	223	216	206	196	181	167	-	-
X11CrMo5+NT2	1.7362+NT2	≤ 100	366	350	334	332	309	299	289	280	265	-	-
X11CrMo9-1+I	1.7386+I	≤ 60	187	186	178	177	175	171	164	153	142	120	-
X11CrMo9-1+NT	1.7386+NT	≤ 60	363	348	334	330	326	322	316	311	290	235	-
X10CrMoVNb9-1	1.4903	≤ 100	410	395	380	370	360	350	340	320	300	270	215
X20CrMoV11-1	1.4922	≤ 100	-	-	430	415	390	380	360	330	290	250	
^a 1 MPa = 1 N/mm ²													

8.4 Appearance and internal soundness

8.4.1 Appearance

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

8.4.1.2 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.

8.4.1.3 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.

8.4.1.4 Any surface imperfection, which is demonstrated to be deeper than 5 % of the wall thickness T or 3 mm whichever is the smaller, shall be dressed.

This requirement does not apply to surface imperfection with a depth equal or less 0,3 mm

8.4.1.5 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.

8.4.2 Internal soundness

8.4.2.1 Leak Tightness

The tubes shall pass a hydrostatic test (see 11.8.1) or electromagnetic test (see 11.8.2) for leak-tightness.

Unless option 7 is specified, the choice of the test method is at the discretion of the manufacturer.

Option 7: *The test method for verification of leak-tightness in accordance with 11.8.1 or 11.8.2 is specified by the purchaser.*

8.4.2.2 Non-Destructive Testing

The tubes of test category 2 shall be subjected to a non-destructive testing for the detection of longitudinal imperfections, in accordance with 11.11.1.

Option 8: *The tubes of test category 2 shall be subjected to a non-destructive testing for the detection of transverse imperfections in accordance with 11.11.2.*

Option 9: *The tubes of test category 2 shall be subjected to a non-destructive testing for the detection of the laminar imperfections in accordance with 11.11.3.*

8.5 Straightness

The deviation from straightness of any tube length L shall not exceed $0,0015 L$. Deviations from straightness over any one metre length shall not exceed 3 mm.

8.6 Preparation of ends

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

Option 10: *The tubes shall be delivered with bevelled ends (see figure 1). The bevel shall have an angle α of 30° $^{+5^\circ}_0$ 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*

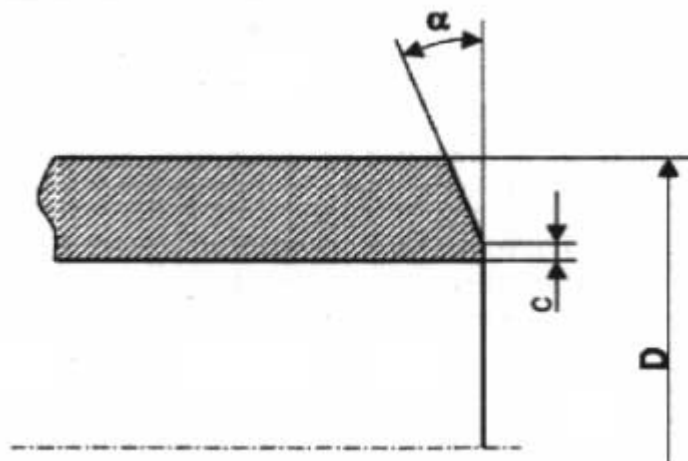


Figure 1 — Tube end bevel

8.7 Dimensions, masses and tolerances

8.7.1 Diameter and wall thickness

Unless option 11 is specified, tubes shall be delivered by outside diameter D and wall thickness T .

Preferred outside diameters D and wall thicknesses T have been selected from ENV 10220 and are given in Table 6.

NOTE Dimensions which are different from those in Table 6 may be agreed.

Option 11: The tubes shall be delivered in accordance with one of the following sets of dimensions as specified at the time of enquiry and order:

- outside diameter D and minimum wall thickness T_{min} ;
- inside diameter d and wall thickness T for $d \geq 220$ mm;
- inside diameter d and minimum wall thickness T_{min} for $d \geq 220$ mm;
- minimum inside diameter d_{min} and wall thickness T for $d_{min} \geq 220$ mm;
- minimum inside diameter d_{min} and minimum wall thickness T_{min} for $d_{min} \geq 220$ mm.

Table 6 — Preferred dimensions

dimensions in mm

Outside diameter D			Wall thickness T																				
Series a			1,6	1,8	2	2,3	2,6	2,9	3,2	3,6	4	4,5	5	5,6	6,3	7,1	8	8,8	10	11	12,5	14,2	
10,2																							
	12																						
	12,7																						
13,5																							
		14																					
	16																						
17,2																							
		18																					
	19																						
	20																						
21,3																							
		22																					
	25																						
		25,4																					
26,9																							
		30																					
	31,8																						
	32																						
33,7																							
		35																					
	38																						
	40																						
42,4																							
		44,5																					
48,3																							
	51																						
		54																					
	57																						
60,3																							
	63,5																						
	70																						
		73																					
76,1																							
		82,5																					
88,9																							
	101,6																						
		108																					
114,3																							
	127																						
	133																						
139,7																							
		141,3																					
		152,4																					
		159																					
168,3																							
		177,8																					
		193,7																					
219,1																							
		244,5																					
273																							
323,9																							
355,6																							
406,4																							
457																							
508																							
		559																					
610																							
		660																					
711																							

Table 6 (Continued)

dimensions in mm

Outside diameter D			Wall thickness T																		
Series ^a			16	17,5	20	22,2	25	28	30	32	36	40	45	50	55	60	65	70	80	90	100
1	2	3																			
10,2																					
	12																				
	12,7																				
13,5																					
		14																			
	16																				
17,2																					
		18																			
	19																				
	20																				
21,3																					
		22																			
	25																				
		25,4																			
26,9																					
		30																			
	31,8																				
	32																				
33,7																					
		35																			
	38																				
	40																				
42,4																					
		44,5																			
48,3																					
	51																				
		54																			
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60,3																					
	63,5																				
	70																				
		73																			
76,1																					
		82,5																			
88,9																					
	101,6																				
		108																			
114,3																					
	127																				
	133																				
139,7																					
		141,3																			
		152,4																			
		159																			
168,3																					
		177,8																			
		193,7																			
219																					
		244,5																			
273																					
323,9																					
355,6																					
406,4																					
457																					
508																					
		559																			
610																					
		660																			
711																					

^a series 1 = diameter for which all the accessories needed for the construction of piping system are standardised;
series 2 = diameter for which not all the accessories are standardised ;
series 3 = diameter for special application for which very few standardised accessories exist.

8.7.2 Mass

For the mass per unit length the provisions of ENV 10220 apply except that for the steel grade X11CrMo9-1+I, X11CrMo9-1+NT, X10CrMoVNb9-1 and X20CrMoV11-1 a density of 7,77 kg/dm³ shall be used.

8.7.3 Lengths

Unless option 12 is specified, the tubes shall be delivered in random length. The delivery length range shall be agreed at the time of enquiry and order.

Option 12: The tubes shall be delivered in exact lengths and the length shall be specified at the time of enquiry and order. For the tolerances see 8.7.4.2.

8.7.4 Tolerances

8.7.4.1 Tolerances on diameter and thickness

The diameter and the wall thickness of the tubes shall be within the relevant tolerance limits given in Tables 7, 8, 9, 10 or 11.

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

Table 7 — Tolerances on outside diameter and wall thickness

Outside Diameter <i>D</i> mm	Tolerances on <i>D</i>	Tolerances on <i>T</i> for a <i>T/D</i> ratio			
		≤ 0,025	> 0,025 ≤ 0,050	> 0,050 ≤ 0,10	> 0,10
<i>D</i> ≤ 219,1	± 1% or ± 0.5mm	± 12,5% or ± 0.4mm whichever is the greater			
<i>D</i> > 219,1	whichever is the greater	± 20%	± 15%	± 12,5%	± 10% ^a
^a For outside diameters <i>D</i> ≥ 355,6 mm it is permitted to exceed the upper wall thickness locally by a further 5% of the wall thickness <i>T</i>					

Table 8 — Tolerances on inside diameter and wall thickness

Tolerances on inside diameter			Tolerances on <i>T</i> for a <i>T/d</i> ratio			
<i>d</i>	<i>d_{min}</i>		≤ 0,03	> 0,03 ≤ 0,06	> 0,06 ≤ 0,12	> 0,12
± 1% or ± 2 mm whichever is the greater	+ 2% 0	+ 4 mm or 0 whichever is the greater	± 20%	± 15%	± 12,5%	± 10% ^a
^a For outside diameters <i>D</i> ≥ 355,6 mm it is permitted to exceed the upper wall thickness locally by a further 5% of the wall thickness <i>T</i>						

Table 9 — Tolerances on outside diameter and minimum wall thickness

Outside diameter D mm	Tolerances on D	Tolerances on T_{min} for a T_{min}/D ratio			
		$\leq 0,02$	$> 0,02$ $\leq 0,04$	$> 0,04$ $\leq 0,09$	$> 0,09$
$D \leq 219,1$	$\pm 1\%$ or $\pm 0,5\text{mm}$	+ 28% 0	or + 0,8 mm 0	whichever is the greater	
$D > 219,1$	whichever is the greater	+ 50% 0	+ 35% 0	+ 28% 0	+ 22% ^a 0

^a For outside diameters $D \geq 355,6$ mm it is permitted to exceed the upper wall thickness locally by a further 5% of the wall thickness T

Table 10 — Tolerances on inside diameter and minimum wall thickness

Tolerances on inside diameter		Tolerances on T_{min} for a T_{min}/d ratio		
d	d_{min}	$\leq 0,05$	$> 0,05$ $\leq 0,1$	$> 0,1$
$\pm 1\%$ or ± 2 mm whichever is the greater	+2% or + 4 mm 0 whichever is the greater	+ 35% 0	+ 28% 0	+ 22% ^a 0

^a For outside diameters $D \geq 355,6$ mm it is permitted to exceed the upper wall thickness locally by a further 5% of the wall thickness T

Table 11 — Tolerances on outside diameter and wall thickness for tube ordered cold finished

Tolerance on D	Tolerance on T
$\pm 0,5\%$ or $\pm 0,3$ mm whichever is the greater	$\pm 10\%$ or $\pm 0,2$ mm whichever is the greater

8.7.4.2 Tolerances on exact lengths

The tolerances for exact lengths shall be as given in Table 12.

Table 12 — Tolerances on exact lengths

Dimension in mm

Length L	Tolerance on exact length
$L \leq 6000$	+10 0
$6000 < L \leq 12\,000$	+15 0
$L > 12\,000$	+ by agreement 0

9 INSPECTION

9.1 Types of inspection

Conformity to the requirements of the order, for tubes in accordance with this Part of EN 10216, shall be checked by specific inspection.

9.2 Inspection documents

9.2.1 Types of inspection documents

Unless option 13 is specified, an inspection certificate 3.1.B, in accordance with EN 10204, shall be issued.

Option 13: *One of the inspection documents 3.1.A, 3.1.C or 3.2 in accordance with EN 10204 shall be issued*

If an inspection document 3.1.A, 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 inspection report 3.2 it shall be agreed which party shall issue the certificate.

9.2.2 Content of inspection documents

The content of the inspection document shall be in accordance with prEN 10168.

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 if applicable;
- Z - validation.

9.3 Summary of inspection and testing

Non-alloy steel tubes shall be inspected and tested in accordance with test category 1 or test category 2 as specified at the time of inquiry and order (see 6.1).

Alloy steel tubes shall be inspected and tested in accordance with test category 2 (see Table 13).

Inspection and testing to be carried out are summarised in Table 13.

Table 13 — Summary of inspection and testing

Type of inspection and test		Frequency of Testing	Refer to	Test category (TC)	
				1	2
Mandatory tests	Cast analysis	One per cast	8.2.1 - 11.1	X	X
	Tensile test at room temperature	One per sample tube	8.3.1 - 11.2.1	X	X
	Flattening test for D < 600 mm and T/D ratio ≤ 0,15 but T ≤ 40 mm or ^a		8.3 - 11.3 -11.4	X	X
	Ring tensile test for D > 150 mm and T ≤ 40 mm		8.3 - 11.5 - 11.6	X	X
	Drift expanding test for D ≤ 150 mm and T ≤ 10 mm or ^{a b}				
	Ring expanding test for D ≤ 114.3 mm and T ≤ 12,5 mm		8.3 - 11.7	X	X
	Impact test at 20° C for Group A ^c	Each tube	8.4.2.1 - 11.8	X	X
	Leak tightness test	8.7.1 - 11.9		X	X
	Dimensional inspection	11.10		X	X
	Visual examination	Each tube	8.4.2.2 - 11.11.1	--	X
	NDT for the detection of longitudinal imperfections		11.12	X	X
	Material identification of alloy steels				
Optional tests	Product analysis (Option 3)	One per cast	8.2.2 - 11.1	X	X
	Tensile test at elevated temperature (Option 6)	One per cast and same heat treatment condition	8.3.2 - 11.2.2	X	X
	Impact test for Group B ^c (Option 4)	One per sample tube	8.3 - 11.7	X	X
	Longitudinal impact test at -10°C for non-alloy steel grades (Option 5)		8.3 - 11.7	X	X
	Wall thickness measurement away from tube ends (Option 15)	8.7.1 - 11.9		X	X
	NDT for the detection of transverse imperfections (Option 8)	Each tube	8.4.2.2 - 11.11.2	--	X
	NDT for the detection of laminar imperfections (Option 9)		8.4.2.2 - 11.11.3	--	X
^a The choice of flattening or ring tensile test and of drift expanding test or ring expanding test is at the manufacturer's discretion.					
^b For steel grades X10CrMoVNb9-1 and X20CrMoV11-1 tubes, the flattening or ring tensile test and the drift expanding test or ring expanding test shall be carried out at one end of 20 % of the tubes of each test unit.					
^c Group A: tubes having wall thickness T ≥ 16 mm manufactured from steel grades 14MoV6-3, 25CrMo4, 20CrMoV13-5-5, 15NiCuMoNb5-6-4, X10CrMoVNb9-1 and X20CrMoV11-1					
Group B: All tubes except group A.					

10 SAMPLING

10.1 Frequency of tests

10.1.1 Test unit

For normalised formed 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.

For tubes which are furnace heat treated 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.

The number of tubes per test unit shall conform to Table 14.

Table 14 — Number of tubes per test unit

Outside diameter D mm	Maximum number of tubes per test unit
$D \leq 114,3$	200
$114,3 < D \leq 323,9$	100
$D > 323,9$	50

10.1.2 Number of sample tubes per test unit

The following number of sample tubes shall be selected from each test unit :

- test category 1: one sample tube;
- test category 2: two sample tubes; when the total number of tubes is less than 20, only one sample tube

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 the mechanical test samples, in accordance with ISO 14284.

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

10.2.2.1 General

Samples and test pieces shall be taken at the tube ends and in accordance with the requirements of EN ISO 377.

10.2.2.2 Test pieces for tensile tests

The test pieces for the tensile tests at room temperature shall be prepared in accordance with EN 10002-1.

The test piece for the tensile tests at elevated temperature shall be prepared in accordance with 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 and shall be taken in a direction longitudinal to the axis of the tube;
- for tubes with an outside diameter $D > 219,1$ mm the test piece shall either a machined test piece with circular cross section from an unflattened sample or a strip section and be taken in a direction either longitudinal or transverse to the axis of the tube.

10.2.2.3 Test pieces for flattening test, ring tensile test, drift expanding test and ring expanding test

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

10.2.2.4 Test pieces for impact test

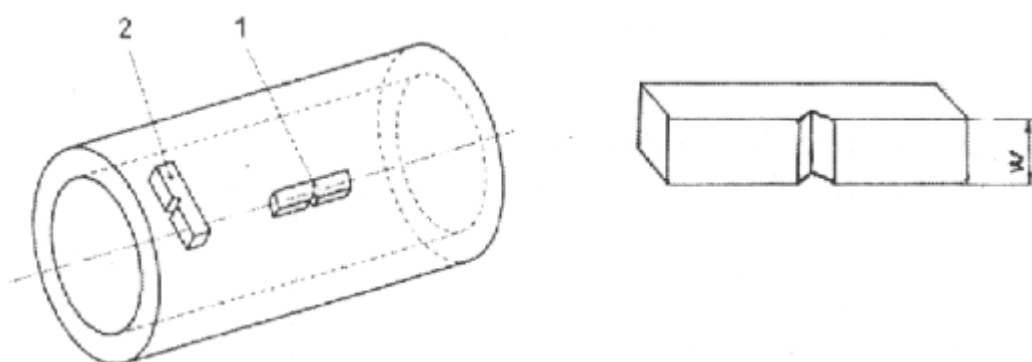
Three standard Charpy V-notch test pieces shall be prepared in accordance with EN 10045-1. If the wall thickness is such that standard test pieces cannot be produced without flattening of the section, then test pieces of width less than 10 mm, but not less than 5 mm shall be prepared; the largest obtainable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

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

Unless otherwise specified (see Option 5), 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:

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

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

Figure 2 — Impact test piece orientation

11 TEST METHODS

11.1 Chemical analysis

The elements to be determined and reported shall be those specified in Table 2. 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 Tensile test at room temperature

The test shall be carried out at room temperature in accordance with EN 10002-1, and the following determined:

- the tensile strength (R_m);
- the upper yield strength (R_{eH}) or if a yield phenomenon is not present the 0,2 % proof strength ($R_{p0,2}$);

- the percentage elongation after fracture with a reference to a gauge length (L_0) of $5,65 \cdot \sqrt{S_0}$; if a non-proportional test piece is used, the percentage elongation value shall be converted to the value for a gauge length $L_0 = 5,65 \cdot \sqrt{S_0}$ using the conversion Tables in EN ISO 2566-1.

11.2.2 Tensile test at elevated temperature

The test shall be carried out in accordance with EN 10002-5 at the temperature agreed at the time of enquiry and order (see 6.2) and the proof strength ($R_{p0,2}$) shall be determined.

11.3 Flattening test

The test shall be carried out in accordance with 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:

$$H = \frac{(1+C)}{C + (T/D)} x T \quad (6)$$

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 (given in Table 15).

Table 15 — Flattening test - Constant factor of deformation C

Steel grade		
Steel name	Steel number	C
P195GH	1.0348	0,09
P235GH	1.0345	0,09
P265GH	1.0425	0,07
20MnNb6	1.0471	0,07
16Mo3	1.5415	0,07
8MoB5-4	1.5450	0,05
14MoV63	1.7715	0,05
10CrMo5-5	1.7338	0,08
13CrMo4-5	1.7335	0,07
10CrMo9-10	1.7380	0,07
11CrMo9-10	1.7383	0,07

Steel grade		
Steel name	Steel number	C
25CrMo4	1.7218	0,06
20CrMoV13-5-5	1.7779	0,05
15NiCuMoNb5-6-4	1.6368	0,05
X11CrMo5+I	1.7362+I	0,05
X11CrMo5+NT1	1.7362+NT1	0,05
X11CrMo5+NT2	1.7362+NT2	0,05
X11CrMo9-1+I	1.7386+I	0,05
X11CrMo9-1+NT	1.7386+NT	0,05
X10CrMoVNb9-1	1.4903	0,05
X20CrMoV11-1	1.4922	0,05

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.

11.4 Ring tensile test

The test shall be carried out in accordance with 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).

11.5 Drift expanding test

The test shall be carried out in accordance with EN 10234.

The tube section shall be expanded with a 60° conical tool until the percentage increase in outside diameter shown in Table 16 is reached.

Table 16 — Drift expanding test requirements

Steel grade		% increase in outside diameter for d/D^a		
Steel name	Steel number	$\leq 0,6$	$> 0,6 \leq 0,8$	$> 0,8$
P195GH	1.0348	12	15	19
P235GH	1.0345	10	12	17
P265GH	1.0425	8	10	15
20MnNb6	1.0471	8	10	15
16Mo3	1.5415	8	10	15
8MoB5-4	1.5450	8	10	15
14MoV63	1.7715	8	10	15
10CrMo5-5	1.7338	8	10	15
13CrMo4-5	1.7335	8	10	15
10CrMo9-10	1.7380	8	10	15
11CrMo9-10	1.7383	8	10	15
25CrMo4	1.7218	6	8	12
20CrMoV13-5-5	1.7779	6	8	12
15NiCuMoNb5-6-4	1.6368	8	10	15
X11CrMo5+I	1.7362+I	8	10	15
X11CrMo5+NT1	1.7362+NT1	8	10	15
X11CrMo5+NT2	1.7362+NT2	8	10	15
X11CrMo9-1+I	1.7386+I	8	10	15
X11CrMo9-1+NT	1.7386+NT	8	10	15
X10CrMoVNb9-1	1.4903	8	10	15
X20CrMoV11-1	1.4922	6	8	12
^a $d = D - 2T$				

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.

11.6 Ring expanding test

The test shall be carried out in accordance with EN 10236.

The tube section shall be expanded with a conical tool until it breaks. The surface outside the fracture zone shall be free from cracks or breaks. However, slight incipient cracks at its edges shall not be regarded as justification for rejection.

11.7 Impact test

11.7.1 The test shall be carried out in accordance with EN 10045-1 at the temperature given in Table 4.

11.7.2 The mean value of the three test pieces shall meet the requirements given in Table 4. One individual value may be below the specified value, provided that it is not less than 70 % of that value.

11.7.3 If the width (W) of the test piece is less than 10 mm, the measured impact energy (KV_p) shall be converted to the calculated impact energy (KV_c) using the following equation:

$$KV_c = \frac{10 \times KV_p}{W} \quad (7)$$

where:

- KV_c is the calculated impact energy, in J;
- KV_p is the measured impact energy, in J;
- W is the width of the test piece, in mm.

The calculated impact energy KV_c shall conform to the requirements given in 11.7.2.

11.7.4 If the requirements of 11.7.2 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 the six tests shall be equal to or greater than the specified minimum average value;

not more than two of the 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.

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

11.8 Leak tightness test

11.8.1 Hydrostatic test

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

$$P = 20 \frac{S \times T}{D} \quad (8)$$

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 yield strength (see Table 4) for the steel grade concerned.

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

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

2) 1 bar = 100 kPa

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

Option 14: A test pressure different from that specified in 11.8.1 and corresponding to stresses below 90% of the specified minimum yield strength (see Table 4) for the steel grade concerned is specified.

11.8.2 Electromagnetic test

The test shall be carried out in accordance with EN 10246-1.

11.9 Dimensional inspection

Specified dimensions, including straightness, shall be verified.

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

Unless option 15 is specified the wall thickness shall be measured at both tube ends.

Option 15: The wall thickness shall be measured away from the tube ends in accordance with an agreed procedure.

11.10 Visual examination

Tubes shall be visually examined to ensure conformity to the requirements of 8.4.1.

11.11 Non-destructive testing

11.11.1 Tubes of test category 2 shall be subjected to a Non-Destructive Testing for the detection of longitudinal imperfections, in accordance with EN 10246-7, to acceptance level U2, sub-category C or EN 10246-5 acceptance level F2.

Unless option 16 is specified, the selection of the test method is at the discretion of the manufacturer.

Option 16: The test method is specified by the purchaser.

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

11.11.2 If option 8 is specified (see 8.4.2.2), the tubes shall be subjected to ultrasonic testing for the detection of transverse imperfections in accordance with EN 10246-6 to acceptance level U2, sub-category C.

11.11.3 If option 9 is specified (see 8.4.2.2), the tubes shall be subjected to ultrasonic testing for the detection of the laminar imperfections in accordance with EN 10246-14 to acceptance level U2.

11.11.4 For tubes ordered by minimum wall thickness $T_{\min}$ (see option 11), the acceptance level shall apply to the calculated wall thickness T_c as determined in accordance with the formula stated in clause 8.1.

11.12 Material identification

Each tube made from alloy steel (see 5.1) shall be tested by an appropriate method to ensure that the correct grade is being supplied.

11.13 Retests, sorting and reprocessing

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

12 MARKING

12.1 Marking to be applied

The marking shall be indelibly marked on each tube at least at one end. For tubes with outside diameter $D \leq 51$ mm the marking on tubes may be replaced by the marking on a label attached to the bundle or box.

The marking shall include the following information:

- the manufacturer's name or trade mark ;
- the number of this European standard and the steel name (see 5.2);
- the test category in case of non-alloy steel grades;
- the cast number or a code number;
- the mark of the inspection representative;
- an identification number (e.g. order or item number) which permits the correlation of the product or delivery unit to the related document.

Example of marking:

X - EN 10216-2 - P265GH - TC1 - Y- Z₁ - Z₂

where:

- X is the manufacturer's mark;
- TC1 is the designation of the test category 1;
- Y is the cast number or a code number;
- Z₁ is the mark of the inspection representative;
- Z₂ is the identification number.

12.2 Additional marking

Option 17: *Additional marking, as agreed upon at the time of enquiry and order, shall be applied.*

13 PROTECTION

The tubes shall be delivered without a temporary protective coating.

Option 18: *A temporary protective coating or durable coating and/or lining shall be applied.*

Annex A

(Informative)

Creep rupture strength values

The creep rupture strength values of steel grades covered by this Part of EN 10216 are given in Table A1.

Table 17 Creep rupture strength values

Steel grade		Temperature	Creep rupture strength values for (MPa) ^{a b c d}			
Steel name	Steel number	°C	10 000 h	100 000 h	200 000 h	250 000 h
P235GH P265GH		400	182	141	128	122
		410	166	128	115	109
		420	151	114	102	97
		430	138	100	89	86
		440	125	88	77	74
		450	112	77	66	64
		460	100	66	56	54
		470	88	56	46	44
		480	77	47	30	33
		490	67	39	26	--
		500	58	32	24	--
20MnNb6		400	243	179	157*	150*
		410	221	157	135*	128*
		420	200	136	115*	108*
		430	180	117	97*	91*
		440	161	100	82*	77*
		450	143	85	70*	66*
		460	126	73	60*	56*
		470	110	63	52*	48*
		480	96	55	44*	41*
		490	84	47	37*	32*
		500	74	41	--	--
16Mo3		450	298	236	218	210
		460	273	205	188	179
		470	247	176	158	148
		480	221	149	129	122
		490	196	124	105	98
		500	171	102	84	78
		510	148	83	67	63
		520	125	65	53	50
		530	104	51	42	38
		540	84	40	34	--
		550	64	32	25	--
14MoV6-3		450	377	305	282	275
		460	349	276	255	247
		470	324	249	226	220
		480	298	224	202	195
		490	274	200	179	171
		500	249	177	158	150
		510	225	155	136	129
		520	203	135	117	110
		530	181	117	101	95
		540	162	102	86	82
		550	143	87	74	70
		560	126	75	63	59
		570	112	65	54	50
		580	97	58	47	43
		590	85	48	40	37
		600	74	41	34	32

Table A 1 (continued)

Steel grade		Temperature °C	Creep rupture strength values for (MPa) ^{a b c d}			
Steel name	Steel number		10 000 h	100 000 h	200 000 h	250 000 h
10CrMo5-5 13CrMo4-5		450	377	290	264	257
		460	347	258	233	225
		470	319	227	203	193
		480	292	198	175	164
		490	264	170	148	138
		500	238	145	123	114
		510	209	121	102	92
		520	181	100	82	73
		530	155	80	66	58
		540	131	65	51	46
		550	109	53	41	37
		560	90	44	35	31
		570	74	38	30	--
		580	60	31	25	--
		590	50	26	--	--
		600	41	20	--	--
10CrMo9-10		450	308	229	204	196
		460	284	212	188	180
		470	261	194	172	165
		480	238	177	156	150
		490	216	160	140	143
		500	195	141	124	118
		510	176	124	108	103
		520	158	105	94	88
		530	142	95	80	76
		540	126	81	68	64
		550	111	70	57	54
		560	99	61	49	46
		570	88	53	43	40
		580	78	46	38	34
		590	69	40	33	30
		600	60	35	28	26
11CrMo9-10		400	382	313		
		410	355	269		
		420	333	272		
		430	312	255		
		440	294	238		
		450	276	221		
		460	259	204		
		470	242	187		
		480	225	170		
		490	208	153		
		500	191	137		
		510	174	122		
		520	157	107		

Table A 1 (continued)

Steel grade		Temperature °C	Creep rupture strength values for (MPa) ^{a b c d}			
Steel name	Steel number		10 000 h	100 000 h	200 000 h	250 000 h
20CrMoV13-5-5		420	470	420		
		430	440	370		
		440	410	310		
		450	360	260		
		460	310	220		
		470	270	190		
		480	240	165		
		490	210	145		
		500	186	127		
		510	169	114		
		520	152	101		
		530	134	87		
		540	117	74		
		550	98	59		
15NiCuMoNb5-6-4		400	402	373		
		410	385	349		
		420	368	325		
		430	348	300		
		440	328	273		
		450	304	245		
		460	274	210		
		470	242	175		
		480	212	139		
		490	179	104		
X11CrMo5-I		500	147	69		
		450	196	147	130	126
		460	180	133	118	114
		470	166	119	107	102
		480	152	108	96	90
		490	140	98	86	81
		500	128	89	76	72
		510	116	79	67	63
		520	105	69	58	55
		530	95	62	52	49
		540	85	55	46	43
		550	77	49	41	38
		560	69	44	36	34
		570	63	38	31	29
		580	58	34	27	25
		590	50	30	24	--
		600	45	26	22	--
X11CrMo5+NT1 X11CrMo5+NT2		610	41	24	--	--
		620	37	--	--	--
		630	33	--	--	--
		450	--	270	237	226
		460	--	225	202	189
		470	242	188	170	159
		480	215	157	141	131
		490	188	131	116	108
		500	164	113	96	90
		510	145	96	80	75
		520	128	82	68	64
		530	113	70	58	54
		540	100	60	48	45
		550	88	50	40	37
		560	78	--	--	-
		570	69	--	--	--
		580	60	--	--	--
		590	53	--	--	--
		600	46	--	--	--

Table A 1 (continued)

Steel grade		Temperature °C	Creep rupture strength values for (MPa) ^{a b c d}			
Steel name	Steel number		10 000 h	100 000 h	200 000 h	250 000 h
X11CrMo9+I		460	275	190		
		470	240	170		
		480	210	150		
		490	190	130		
		500	170	115		
		510	152	102		
		520	134	89		
		530	118	78		
		540	104	67		
		550	90	58		
		560	78	49		
		570	68	42		
		580	60	37		
		590	53	33		
		600	48	30		
X11CrMo9+NT		450	335	276	259	
		460	308	253	236	
		470	284	231	215	
		480	261	211	196	
		490	239	192	177	
		500	219	174	160	
		510	200	156	142	
		520	182	139	126	
		530	164	123	111	
		540	148	107	95	
		550	132	92	80	
		560	117	78	67	
		570	102	66	55	
		580	89	55	45	
		590	77	45	37	
		600	65	37	32	
		610	55	31	27	
		620	47	27	24	
		630	40	24	--	
		640	34	21	--	
		650	30	--	--	
X10CrMoVNb9-1		500	289	258*	246*	
		510	271	239*	227*	
		520	254	220*	208*	
		530	234	201*	189*	
		540	216	183*	171*	
		550	199	166	154*	
		560	182	150	139*	
		570	166	134	124*	
		580	151	120	110*	
		590	136	106	97*	
		600	123	94	86*	
		610	110	83	75*	
		620	99	73	65*	
		630	89	65	57*	
		640	79	56	49*	
		650	70	49	42*	
		660	62	42*	35*	
		670	55	36*	--	

Table A 1 (continued)

Steel grade		Temperature	Creep rupture strength values for (MPa) ^{a b c d}			
Steel name	Steel number	°C	10 000 h	100 000 h	200 000 h	250 000 h
X20CrMoV11-1		480	348	289	270	
		490	319	263	242	
		500	292	236	218	
		510	269	212	194	
		520	247	188	170	
		530	225	167	149	
		540	205	147	129	
		550	184	128	112	
		560	165	111	96	
		570	147	95	81	
		580	130	81	68	
		590	113	69	58	
		600	97	59	49	
		610	84	51	42	
		620	72	43	36	
		630	61	36	30	
		640	52	31	--	
		650	44	26	--	

^a The values listed in the Table are values suggested by ECCC (1) and are average values from scatter range determined from existing data which will be assessed from time to time after test results are available and corrected if necessary. The values for the steel grades 14MoV6-3 and X10CrMoVNb9-1 have been obtained by new evaluation. For the remaining steel grades the values were obtained from creep rupture strength values given in national and international standards

^b The creep rupture strength values given up to the elevated temperature listed in the Table, do not mean that the steels can be used in continuous duty up to the these temperatures. A governing factor is the total stress during operation.

^c For the creep rupture strength values indicated in the Table the extrapolation times are always less than a factor of three unless indicated by an asterisk (*).

^d 1 MPa = 1 N/mm²

Annex ZA (informative)

CLAUSES OF THIS EUROPEAN STANDARD ADDRESSING ESSENTIAL REQUIREMENTS OR OTHER PROVISIONS OF EU DIRECTIVES

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

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

The clauses of this European Standard are likely to support the essential requirements of section 4 of annex 1, "Essential safety requirements" of the Pressure Equipment Directive 97/23/EC.

Compliance with this European Standard provides one means of conforming with the specific essential requirements of the Directive concerned.

Bibliography

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

(1) Results of investigations of the European Creep Collaborative Committee (ECCC, WG 3.2), Submitted to ECISS/TC 29 by fax of 1998-04-03 (Document ECISS/TC 29/SC 1 N. 245).

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