

ICS

Descriptors:

English version

Seamless steel tubes for mechanical and general engineering purposes - Technical delivery conditions - Part 1: Non-alloy and alloy steel tubes

Tubes sans soudure en acier pour utilisation en mécanique générale et en construction mécanique - Conditions techniques de livraison - Partie 1: Tubes en acier non allié et allié

Nahtlose Stahlrohre für den Maschinenbau und allgemeine technische Anwendungen - Technische Lieferbedingungen - Teil 1: Rohre aus unlegierten und legierten Stählen

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee ECISS/TC 29.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This European Standard has been prepared by Technical Committee ECISS/TC29, Steel tubes and fittings for steel tubes, the Secretariat of which is held by UNI/UNSIDER/

In accordance with the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

- 1.1 This part of this European Standard specifies the technical conditions for seamless circular tubes made of non-alloy and alloy steels for mechanical and general engineering purposes. The chemical composition, mechanical properties, dimensions, dimensional tolerances and technological requirements are specified.

Other parts of this European standard in course of preparation are:-

Part 2 : Stainless steel tubes

- 1.2 Another European Standards covering tubes for mechanical and general engineering purposes is:-
pr EN EC029031 : Welded steel tubes for mechanical and general engineering purposes.
- 1.3 Other European Standards being prepared in this area are for precision steel tubes and for hollow bars for machining.

2. Normative References

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

| | |
|-------------|---|
| EN ISO 377 | Steel and steel products - Location of samples and test pieces for mechanical testing (ISO 377:1997) |
| EN 473 | Qualification and certification of NDT personnel-General principles |
| EN ISO 9001 | Quality systems - Model for quality assurance in design/development, production, installation and servicing |
| EN ISO 9002 | Quality systems - Model for quality assurance in production, installation and servicing |
| EN 10002-1 | Metallic materials - Tensile testing Part 1 : Method of test (at ambient temperature) |
| EN 10003-1 | Metallic materials - Brinell hardness Part 1 Test method |
| EN 10020 | Definition and classification of grades of steel |
| EN 10021 | General technical delivery requirements for steel and iron products |
| EN 10027 | Designation systems for steel Part 1 : Steel names principal symbols Part 2 : Steel numbers |
| EN 10045-1 | Metallic materials - Charpy Impact test - Part 1 : Test method |
| EN 10052 | Vocabulary of heat treatment terms of ferrous products |

| | |
|----------------------------|--|
| EN 10083 : 1991 | Quenched and tempered steels Part 1 : Technical delivery conditions for special steels Part 2 : Technical delivery conditions for unalloyed quality steels |
| EN 10168 ¹⁾ | Iron and steel products - Inspection documents - contents |
| EN 10204 | Metallic products - Types of inspection documents (and amendment A1:1995) |
| EN 10246 | 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 | Non-destructive testing of steel tubes Part 7 Automatic full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for the detection of longitudinal imperfections |
| prEN 10246 ¹⁾ | Non-destructive testing of steel tubes Part 3 Automatic eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections |
| prEN 10246 ¹⁾ | 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 |
| pr EN 10266 ¹⁾ | Steel tubes, fittings and steel structural hollow sections - symbols and definitions of terms for use in product standards |
| prEN10256 ¹⁾ | Non-destructive testing of steel tubes- Qualification and competence of level 1 and level 2 NDT personnel |
| ENV 10220 | Seamless and welded steel tubes - Dimensions and masses per unit length |
| EURONORM 23 ²⁾ | End quench hardenability test for steel (Jominy test) |
| EURONORM 103 ²⁾ | Micrograph determination of the ferritic or austenitic grain size of steels |
| ISO 2566-1 | Steel - Conversion of elongation values Part 1 : Carbon and low alloy steels |
| CR 10260 | Designation system for steel : additional symbols for steel names |

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.

²⁾ Until this EURONORM is transformed into a European Standard it can either be implemented or reference made to the corresponding national standards, the list of which is given in Annex B of this European Standard

3.

Definitions

For the purpose of this European standard the following definitions apply in addition to or instead of :the definitions and symbols in EN10020 , EN 10021 , EN10052 , and prEN 10266

- fine grain steel : steel having an austenitic/ferritic grain size equal to or finer than 6 when measured in accordance with EURONORM 103
- normalizing rolling : a rolling process in which the final deformation is carried out in a certain temperature range leading to a material condition equivalent to that obtained after normalizing so that the specified values of the mechanical properties are retained even after normalizing
- As rolled; tubes formed after heating into austenitic region (i.e. above AC3) without subsequent heat treatment (AR)
- annealing : heating at a temperature slightly below AC1 (A)
- TH treatment : heat treatment with the object of achieving a hardness of a given level (TH)
- FP treatment : heat treatment with the object of producing a ferritic and pearlitic structure (FP)
- simulated tensile test : a tensile test carried out on a test sample which has been subjected to a heat treatment (normalized(N) or quenched and tempered(QT)) prior to testing.
- employer: the organization for which the person works on a regular basis. The employer may be either the tube manufacturer or a third party organization providing non-destructive testing (NDT) services.

4. **Classification and designation**

4.1 **Classification**

In accordance with the classification system in EN 10020 the grades in this standard are classified as given in table 1.

4.2 **Designation**

4.2.1 For tubes covered by this part of this European Standard the designation shall consist of:-

- the number of this part of this European Standard (EN EC029086) plus one of the following
- the steel name in accordance with EN 10027 part 1 and CR 10260
- the steel number allocated in accordance with EN 10027 part 2

These are given in Table 1.

Table 1 : Classification and designation of steels

| Usual Heat Treatment Condition | Classification in accordance with EN 10020 | Steel Designation | |
|--------------------------------|--|-------------------|-----------------|
| | | Steel Name | Steel Number |
| AR or N | Non-alloy base steel | E235 | |
| | | E275 | |
| | | E315 | |
| | | E355 | |
| N | Non-alloy quality steel | E275K2 | |
| | | E355K2 | |
| N or QT | Alloy Special Steel | E460K2 | |
| | | E730K2 | |
| N or QT | Non-alloy quality steel (non-alloy special steel) | C22 (or C22E) | 1,0402 (1,1151) |
| | | C35 (or C35E) | 1,0501 (1,1181) |
| | | C45 (or C45E) | 1,0503 (1,1191) |
| | | C60 (or C60E) | 1,0601 (1,1121) |
| | Non-alloy special steel | 38Mn6 | |
| AR or N or QT | Alloy special steel | 20MnV6 | 1,5270 |
| QT | | 25CrMo4 | 1,7218 |
| | | 41Cr4 | 1,7035 |
| | | 30CrMo4 | |
| | | 34CrMo4 | 1,7220 |
| | | 42CrMo4 | 1,7225 |
| | | 36CrNiMo4 | 1,6511 |
| | | 30CrNiMo8 | 1,6580 |
| | | 40NiCrMo7-3-3 | |
| A, TH, FP, N | Non-alloy special steel | C10E | 1,1121 |
| | | C15E | 1,1141 |
| | | C15R | 1,1140 |
| | Alloy special steel | 16MnCr5 | 1,7131 |
| | | 16MnCrS5 | 1,7139 |
| | | 20NiCrMo2-2 | 1,6523 |
| | | 20NiCrMoS2-2 | 1,6526 |

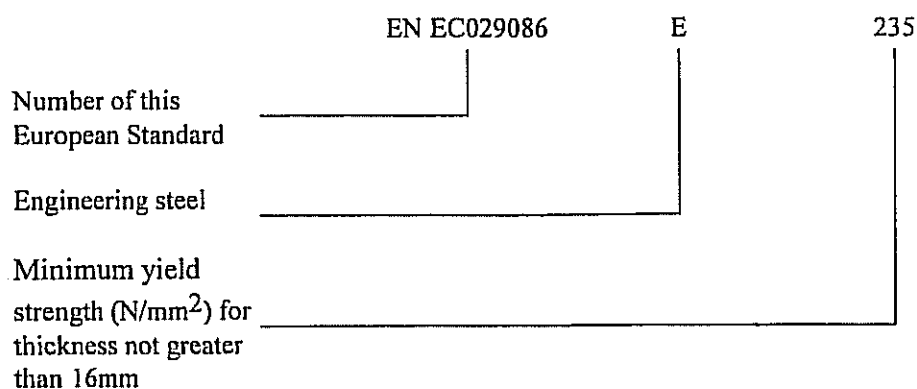
4.2.2 The steel name for non-alloy base steels, non-alloy quality steels and alloy special steels is defined by:

- the capital letter E for engineering steels
- the indication of the minimum specified yield strength (Re) N/mm² for the smallest thickness range
- the alphanumeric K2 when the steel has specified impact properties

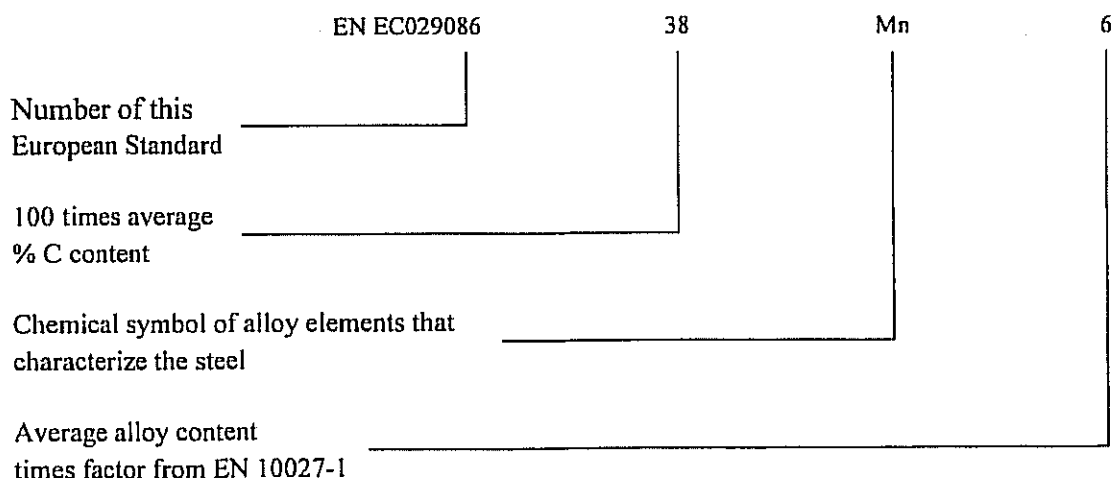
4.2.3 The steel names for carbon manganese quality and special steels with average manganese contents less than 1% have been taken from EN 10083-2.

- 4.2.4 The steel name for carbon manganese special steel with average manganese content greater than 1% are defined in accordance with clause 7.3.2 of EN 10027-1.
- 4.2.5 The steel names for alloy special steels where the content, by weight, of every alloying elements is less than 5% have been taken from EN 10083-1.
- 4.2.6 The steel names for non-alloy special steels for case hardening, with average manganese levels less than 1% are defined in accordance with clause 7.3.1 of EN 10027-1.
- 4.2.7 The steel names for alloy special steels for case hardening, where the content by weight of every alloying elements is less than 5% are defined in accordance with clause 7.3.2 of EN 10027-1.
- 4.2.8 Examples of the designation using the steel name are given below:-

Example 1 (see 4.2.2)



Example 2 (see 4.2.4)



5. Information to be supplied by the purchaser

5.1 Mandatory information

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

- 1) the quantity (number or mass or total length)
- 2) the term "tube"

- 3) the designation according to this European standard (see 4.2)
- 4) the delivery condition (see 6.3)
- 5) the dimensions (outside diameter, wall thickness) (see 7.1)

5.2 Options

A number of options are specified in this European standard, and are listed below with appropriate clause references. In the event that the purchaser does not indicate his wish to implement any of these options at the time of enquiry and the tube shall be supplied in accordance with the basic specification.

- 1) Tubes shall be supplied to chemical analysis and hardness level only (see 6.3.2)
- 2) Tubes shall be supplied to meet hardenability requirement (see 6.3.2)
- 3) Tubes shall be hardness tested (see 6.3.2)
- 4) Tubes shall be supplied descaled (see 6.3.2)
- 5) A simulated tensile test (N) shall be carried out (see 7.3)
- 6) A simulated tensile test (Q) shall be carried out (see 7.3)
- 7) Impact testing of steels from tables 4c and 4d shall be carried out (see 7.3)
- 8) Hardenability testing shall be carried out (see 7.4)
- 9) Non-destructive testing for imperfections shall be carried out (see 7.4.2)
- 10) A leak tightness test shall be carried out (see 7.4.2)
- 11) Tubes shall be supplied in exact lengths (see 7.5.2)
- 12) Specific inspection and testing is required for tube made of non-alloy steel (see 8.1)
- 13) Non-alloy tubes shall be supplied with a test report type 2.2 (see 8.2.1)
- 14) An inspection document type 3.1.A, 3.1.C or 3.2 is required (see 8.2.1)
- 15) Selection of leak tightness test method (see 10.5)
- 16) A special coating for transport and storage shall be applied (see clause 12)

5.3 Example of an order

| | | | | | |
|--------------------|-----------|-------------------|---|------------|------------|
| | 25 tonnes | EN EC029086 E 275 | N | 60,3 x 3,6 | (Option x) |
| Quantity in tonnes | | | | | |
| Designation | | | | | |
| Delivery condition | | | | | |
| Dimensions | | | | | |
| Options required | | | | | |

6. Manufacturing process

6.1 Steelmaking process

The steelmaking process shall be at the discretion of the tube manufacturer.

6.2 Deoxidation process

The method of deoxidation shall be as given in tables 4a, 4b, 4c and 4d.

6.3

Tube manufacture and delivery conditions

6.3.1 The manufacturer and the stockist where products are supplied through a stockist, shall operate a quality system in accordance with EN ISO 9002³⁾.

All NDT activities shall be carried out by qualified and competent level 1 and/or level 2 NDT personnel approved by the employer. At the discretion of the manufacturer these personnel may be qualified in accordance with pr EN 10256 or certificated in accordance with EN 473.

Level 1 and 2 personnel and NDT operations shall be authorised by a level 3 individual approved by the employer and certificated in accordance with EN 473.

6.3.2 Tubes shall be manufactured by a seamless process. The delivery conditions are as-rolled (AR), normalized (N), quenched and tempered (QT), annealed to a maximum hardness level (A), heat treated to a specified hardness range (TH), heat treated to give ferritic and pearlite structure (FP) or to chemical analysis requirements. The purchaser shall specify one of these conditions (See 5.1) and/or select from the following delivery condition options. The standard delivery condition for the different types of steel and the options applicable are given in table 2.

- | | |
|--------------------|--|
| Option 1 (see 5.2) | A hardness test shall replace the tensile test |
| Option 2 (see 5.2) | Tubes shall meet a hardenability requirement (see 7.4) |
| Option 3 (see 5.2) | Tubes shall be hardness tested, the value to be agreed at the time of enquiry and order. |

³⁾ This requirement is also fulfilled by a quality system in accordance with EN ISO 9001.

Table 2 Summary of delivery conditions, related options and physical test requirements

| Applicable table(s) for steel grades | Delivery condition | Physical test requirements | | | | | | | | | |
|---|-----------------------|----------------------------|-----------------|---------------------------|--|-----------------------------------|----------------------------------|---|---|---|--|
| | | Cast analysis | Tensile test | Impact test (option 7) | Hardenability requirement option 3 | hardenability test option 8 | Hardness test (option 1 or 3) | Simulated tensile test (N) option 5 | Simulated tensile test (Q) option 6 | | |
| Tables 4a and 6a | AR ¹⁾ | X | X ²⁾ | - | - | ✓ ²⁾ | - | - | - | - | |
| | N ¹⁾ | X | X | - | - | - | - | - | - | - | |
| Tables 4b and 6b | N | X | X | X | - | - | - | - | - | - | |
| | Q | X | X | X | - | - | - | - | - | - | |
| Table 4c | AR | X | X ²⁾ | ✓ | ✓ | ✓ ²⁾ | ✓ | ✓ | ✓ | ✓ | |
| 6c1 | N | X | X | ✓ | ✓ | ✓ | - | - | - | ✓ | |
| 6c2 | Q | X | X | ✓ | - | ✓ | - | - | - | - | |
| | A | X | - | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | |
| Table 4d | AR ³⁾ | X | - | ✓ | ✓ | ✓ | - | - | - | ✓ | |
| | Q | X | X | ✓ | - | ✓ | - | - | - | - | |
| | A | X | - | ✓ | ✓ | ✓ | - | - | - | ✓ | |
| Table A1 | AR ⁴⁾ | X | - | - | ✓ | ✓ | - | - | - | - | |
| | N | X | - | - | ✓ | ✓ | - | - | - | - | |
| | A | X | - | - | ✓ | ✓ | - | - | - | - | |
| | TH | X | - | - | ✓ | ✓ | - | - | - | - | |
| | FP | X | - | - | ✓ | ✓ | - | - | - | - | |

X= Mandatory requirement ✓ =Optional requirement - = Not applicable
¹⁾ At the manufacturers discretion unless normalised is specified.
²⁾ Hardness test is applicable only when option 1 is specified ; in this case it replaces the tensile test.
³⁾ The AR condition only applies to 25Cr Mo4; 30Cr Mo4-1; 34Cr Mo4.
⁴⁾ May be supplied isothermally annealed at the discretion of the manufacturer.

Table 3 Heat treatment temperatures °C

| Steel name | Steel number | Heat treatment | | | |
|-------------------|--------------|----------------|-----------|---------------------------|---------|
| | | Anneal | Normalize | Austenitize ¹⁾ | Temper |
| E235 | | - | 880-940 | - | - |
| E275 | | - | 880-940 | - | - |
| E315 | | - | 890-950 | - | - |
| E355 | | - | 900-960 | - | - |
| E275K2 | | - | 880-940 | - | - |
| E355K2 | | - | 900-960 | - | - |
| 20 Mn V6 | | - | 900-960 | 900-960 | 580-680 |
| E460K2 | | - | 880-950 | - | - |
| E730K2 | | - | - | 910-950 | 550-680 |
| C22 | | 650-700 | 880-910 | 860-890 ²⁾ | 540-680 |
| C35 | | 650-700 | 860-890 | 840-870 | 540-680 |
| C45 | | 650-700 | 840-870 | 820-850 | 540-680 |
| C60 | | 650-700 | 820-850 | 800-830 | 540-680 |
| 36 Mn 6 | | 650-700 | 850-880 | 820-850 | 540-680 |
| 25 Cr Mo 4 | | 650-700 | 860-900 | 840-870 | 540-680 |
| 41 Cr 4 | | 650-700 | 840-880 | 820-850 | 540-680 |
| 30 Cr Mo 4-1 | | 650-700 | 860-900 | 840-870 | 540-680 |
| 34 Cr Mo 4 | | 650-700 | 850-890 | 830-860 | 540-680 |
| 42 CR Mo 4 | | 650-700 | 840-880 | 820-850 | 540-680 |
| 36 Cr Ni Mo 4 | | 650-700 | 850-880 | 820-850 | 540-680 |
| 30 Cr Ni Mo 8 | | 650-700 | 850-880 | 830-860 ³⁾ | 540-680 |
| 40 Ni Cr Mo 7-3-3 | | 650-700 | 860-890 | 840-870 | 530-680 |

1) Unless otherwise stated temperatures are for water quenching and have to be increased by 10°C for oil quenching
2) Not suitable for oil quenching
3) Oil quenching temperature (not suitable for water quenching)

The heat treatment temperatures shall be in accordance with table 3 or table A2 as appropriate.

At the manufacturers discretion tube may be cold finished. The tube may then be annealed, normalized or quenched and tempered to achieve the required properties.

Note: The cold drawing process leaves residual oil on the tube which may leave a residue when heat treated.

When required tube shall be supplied descaled (see option 4). The amount of descaling shall be agreed at the time of enquiry and order. The method is at the discretion of the manufacturer.

Option 4 (see 5.2) Tubes shall be supplied descaled.

7. Requirements

7.1 General

Tubes, when supplied in a delivery condition specified at the time of enquiry and order (see clause 5) and inspected in accordance with clause 8, shall comply with the requirements of this part of this European Standard.

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

7.2 Chemical composition

7.2.1 The cast analysis reported by the steel producer shall apply and shall comply with the requirements of Tables 4a, 4b, 4c, 4d and A1.

In case of dispute the permissible deviations of a product analysis from the specified analysis limits are given in table 5.

Note: When welding tubes produced according to this part of this European standard, 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 conditions of preparing for and carrying out welding. Not all of the steels specified in this standard are able to be welded unless specialised techniques are employed by specialist welders.

Table 4a Non-alloy base steels (BS)
Chemical Composition (Cast Analysis) in % by mass¹⁾

| Steel Grade | | Deoxidation Type ²⁾ | C max | Si max | Mn max | P max | S max |
|-------------|--------------|--------------------------------|-------|--------|--------|-------|-------|
| Steel Name | Steel Number | | | | | | |
| E235 | | FN | 0,18 | 0,35 | 1,20 | 0,045 | 0,045 |
| E275 | | FN | 0,21 | 0,35 | 1,40 | 0,045 | 0,045 |
| E315 | | FN | 0,21 | 0,30 | 1,50 | 0,045 | 0,045 |
| E355 | | FN | 0,22 | 0,55 | 1,60 | 0,045 | 0,045 |

1) 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 steelmaking process.

2) FN= Rimmed steels not permitted

Table 4b Chemical Composition (Cast Analysis) for tubes with specified impact properties in % by mass

| Steel Grade | Deoxidation Type ¹⁾ | C | | Si | | Mn | | P | S | Cr | Mo | | Ni | | Al Total | | Cu | N | Nb ³⁾ | Ti | V ³⁾ | |
|-------------|--------------------------------|------|------|------|------|------|-----|-------|-------|------|------|------|-------|-------|----------|-------|------|------|------------------|------|-----------------|------|
| | | max | min | max | min | max | min | max | max | max | max | min | max | min | max | max | max | max | max | max | max | min |
| E275K2 | GF | 0,20 | | 0,40 | 0,50 | 1,40 | | 0,035 | 0,030 | 0,30 | | 0,10 | 0,30 | 0,020 | 0,35 | 0,015 | 0,05 | 0,03 | | | | 0,05 |
| E355K2 | GF | 0,20 | | 0,50 | 0,90 | 1,65 | | 0,035 | 0,030 | 0,30 | 0,10 | 0,50 | 0,020 | 0,35 | 0,015 | 0,05 | 0,05 | 0,05 | | | | 0,12 |
| 20 Mn V6 | GF | 0,16 | 0,10 | 0,50 | 1,30 | 1,70 | | 0,035 | 0,040 | - | - | - | 0,010 | - | 0,020 | 0,07 | - | - | - | 0,08 | | 0,15 |
| E460K2 | GF | 0,20 | | 0,60 | 1,00 | 1,70 | | 0,035 | 0,030 | 0,30 | 0,10 | 0,80 | 0,020 | 0,70 | 0,025 | 0,05 | 0,05 | 0,05 | | | | 0,20 |
| E730K2 | GF | 0,20 | | 0,50 | 1,40 | 1,70 | | 0,025 | 0,025 | 0,30 | 0,30 | 0,45 | 0,70 | 0,20 | 0,020 | 0,05 | 0,05 | 0,05 | | | | 0,12 |

1) GF = Fully killed steel containing nitrogen binding elements in amounts sufficient to bind available nitrogen and having a fine grain structure.

2) If sufficient other N-binding elements are present the minimum total Al content does not apply.

3) Nb+V = 0,20 max.

Table 4c Chemical composition (cast analysis) for tubes made of non-alloy quality steels and non-alloy special steels in % by mass

| Steel Grade | Steel Number | Deoxidation Type ¹⁾ | Sub Group ²⁾ | C | Si | Mn | P | S |
|-------------|--------------|--------------------------------|-------------------------|------|------|------|-------|-------|
| | | | | min | min | min | max | max |
| C22 | | FF | QS | 0,17 | - | 0,40 | 0,045 | 0,045 |
| C22E | | | SS | | | | 0,035 | 0,035 |
| C35 | | FF | QS | 0,32 | - | 0,40 | 0,045 | 0,045 |
| C35E | | | SS | | | | 0,035 | 0,035 |
| C45 | | FF | QS | 0,42 | - | 0,40 | 0,045 | 0,045 |
| C45E | | | SS | | | | 0,035 | 0,035 |
| C60 | | FF | QS | 0,57 | - | 0,40 | 0,045 | 0,045 |
| C60E | | | SS | | | | 0,035 | 0,035 |
| 38 Mn 6 | | FF | SS | 0,34 | 0,15 | 0,35 | 0,035 | 0,035 |

¹⁾ FF = Fully killed steel containing nitrogen binding elements in amounts sufficient to bind available nitrogen (eg min 0,020% total Al).

²⁾ QS = Quality steel SS = Special steel

Table 4d Chemical composition (cast analysis) for tubes made from alloy special steels in % by mass

| Steel Grade | Steel Name | Steel Number | Deoxidation Type ¹⁾ | C | | Si | Mn | | P | S | Cr | | Mo | | Ni | |
|-----------------|------------|--------------|--------------------------------|------|------|------|------|------|-------|-------|------|------|------|------|------|------|
| | | | | min | max | | min | max | | | min | max | min | max | min | max |
| 25 CrMo 4 | | | FF | 0,22 | 0,29 | 0,40 | 0,60 | 0,90 | 0,035 | 0,035 | 0,90 | 1,20 | 0,15 | 0,30 | - | - |
| 41 Cr 4 | | | FF | 0,38 | 0,45 | 0,40 | 0,60 | 0,90 | 0,035 | 0,035 | 0,90 | 1,20 | - | - | - | - |
| 30 CrMo 4-1 | | | FF | 0,27 | 0,34 | 0,35 | 0,35 | 0,60 | 0,035 | 0,035 | 0,80 | 1,15 | 0,08 | 0,15 | - | - |
| 34 CrMo 4 | | | FF | 0,30 | 0,37 | 0,40 | 0,60 | 0,90 | 0,035 | 0,035 | 0,90 | 1,20 | 0,15 | 0,30 | - | - |
| 42 CrMo 4 | | | FF | 0,38 | 0,45 | 0,40 | 0,60 | 0,90 | 0,035 | 0,035 | 0,90 | 1,20 | 0,15 | 0,30 | - | - |
| 36 CrNiMo 4 | | | FF | 0,22 | 0,40 | 0,40 | 0,50 | 0,80 | 0,035 | 0,035 | 0,90 | 1,20 | 0,15 | 0,30 | 0,90 | 1,20 |
| 30 CrNiMo 8 | | | FF | 0,26 | 0,34 | 0,40 | 0,30 | 0,60 | 0,035 | 0,035 | 1,80 | 2,20 | 0,30 | 0,50 | 1,80 | 2,20 |
| 40 NiCrMo 7-3-3 | | | FF | 0,36 | 0,44 | 0,35 | 0,55 | 0,80 | 0,035 | 0,035 | 0,60 | 0,90 | 0,20 | 0,30 | 1,65 | 2,00 |

¹⁾ FF = Fully killed steel containing nitrogen binding elements in amounts sufficient to bind available nitrogen (eg min 0,020% total AlO).

Table 5 Permissible deviations of the product analysis from the specified limits

| Element | Limiting values for the specified analysis | Deviation of the product analysis from the specified limits |
|----------|--|---|
| C | $\leq 0,20$ | +0,02 |
| | $>0,20 \leq 0,65$ | $\pm 0,03$ |
| Si | $\leq 0,60$ | +0,05 |
| Mn | $\leq 1,40$ | +0,10 |
| | $>1,40 \leq 1,70$ | -0,05 +0,10 |
| P | non-alloy base steel $\leq 0,045$ | +0,010 |
| | other steels $\leq 0,045$ | +0,005 |
| S | non-alloy base steel $\leq 0,045$ | +0,010 |
| | other steels $\leq 0,045$ | +0,005 |
| Nb | $\leq 0,07$ | +0,010 |
| V | $\leq 0,15$ | $\pm 0,02$ |
| Ti | $\leq 0,050$ | +0,01 |
| Cr | $\leq 2,00$ | $\pm 0,05$ |
| | $> 2,00 \leq 2,20$ | $\pm 0,10$ |
| Ni | $\leq 2,00$ | +0,05 |
| | $>2,00 \leq 2,20$ | $\pm 0,10$ |
| Mo | $\leq 0,30$ | $\pm 0,03$ |
| | $>0,30 \leq 0,50$ | $\pm 0,04$ |
| Cu | $\leq 0,35$ | +0,04 |
| N | $\leq 0,025$ | +0,002 |
| Al total | $\geq 0,020$ | -0,005 |
| | $\leq 0,060$ | +0,005 |

7.3 Mechanical Properties

The mechanical properties of the tubes covered by this part of this European Standard are given in table 6a, 6b, 6c1, 6c2, 6d and where applicable clause 10. When annealing, TH treatment or FP treatment are specified (see 6.3.2) the hardness requirements shall be in accordance with Annex C.

When required, for steels in table 4c supplied as rolled or annealed a simulated tensile test (N) may be specified (option 5)

Option 5 (see 5.2) A simulated tensile test (N) shall be carried out

When required, for steels in table 4d supplied as rolled normalized or annealed a simulated test (Q) may be specified (option 6).

Option 6 (see 5.2) A simulated tensile test (Q) shall be carried out

The method of test is at the discretion of the manufacturer.

For non-alloy quality steels and non-alloy special steels in tables 4c and alloy special steels in table 4d impact testing may be specified (option 7). The values to be achieved shall be agreed at the time of enquiry and order.

Option 7 (see 5.2) Impact testing of steels from tables 4c and/or 4d shall be carried out

Table 6a Delivery Condition and Mechanical Properties for tubes made of Non-alloy base steel

| Steel Grade | | Delivery Condition | Tensile Properties | | | | | | | | | | Minimum percentage elongation A, where $L_0 = 5,65 \sqrt{S_0}$ | |
|-------------|--------------|--------------------|--|-----------|----------------------------|------------|----------------------------|---|----------------------------|-----------|-----|----|--|---|
| Steel Name | Steel Number | | Tensile Strength Rm in N/mm ² | | | | | Minimum Yield Strength ReH in N/mm ² | | | | | l | t |
| | | | Nominal Thickness Range mm | | Nominal Thickness Range mm | | Nominal Thickness Range mm | | Nominal Thickness Range mm | | l | t | | |
| | | | ≤ 16 | > 16 ≤ 40 | > 40 ≤ 65 | > 65 ≤ 100 | ≤ 16 | ≥ 16 ≤ 40 | > 40 ≤ 65 | > 65 ≤ 80 | | | > 80 ≤ 100 | |
| E235 | | N or AR | 360 | 360 | 360 | 340 | 235 | 225 | 215 | 205 | 195 | 25 | 23 | |
| E275 | | N or AR | 410 | 410 | 410 | 380 | 275 | 265 | 255 | 245 | 235 | 22 | 20 | |
| E315 | | N or AR | 450 | 450 | 450 | 420 | 315 | 305 | 295 | 280 | 270 | 21 | 19 | |
| E355 | | N or AR | 490 | 490 | 490 | 470 | 355 | 345 | 335 | 315 | 295 | 20 | 18 | |

Table 6b Delivery Condition and Mechanical Properties for steels with specified impact properties

| Steel Grade | Steel Number | Delivery Condition | Tensile Properties | | | | | | Minimum percentage elongation A, where $L_0 = 5,65 \sqrt{S_0}$ | Impact Properties | | |
|-------------|--------------|--------------------|--|------|---|------|----------------------------|------|--|-------------------|---|----|
| | | | Tensile Strength Rm in N/mm ² | | Minimum Yield Strength ReH in N/mm ² | | Nominal Thickness Range mm | | | | Average absorbed energy KV min J at test temperature of -20°C | |
| | | | Nominal Thickness Range mm | | Nominal Thickness Range mm | | Nominal Thickness Range mm | | l | t | | |
| | | | ≤ 16 | > 16 | ≤ 16 | > 16 | ≤ 16 | > 16 | > 65 | > 80 | | |
| | | | ≤ 40 | > 40 | ≤ 40 | > 40 | ≤ 40 | > 40 | ≤ 80 | ≤ 100 | | |
| E275K2 | | N | 410 | 410 | 275 | 380 | 265 | 255 | 245 | 235 | 20 | 40 |
| E355K2 | | N | 490 | 490 | 355 | 470 | 345 | 335 | 315 | 295 | 18 | 40 |
| 20 Mn V6 | | N | 600 | 560 | 450 | 500 | 420 | 390 | 375 | 360 | 17 | 40 |
| | | AR | 650 | 620 | 470 | - | 450 | - | - | - | 17 | 15 |
| E460K2 | | Q | 700 | 650 | 590 | 520 | 540 | 480 | 455 | 420 | 14 | 40 |
| | | N | 550 | 550 | 460 | 520 | 440 | 430 | 410 | 390 | 19 | 40 |
| E730K2 | | Q | 790 | 750 | 730 | 680 | 670 | 620 | 580 | 540 | 15 | 40 |

Table 6c1 Mechanical properties for tubes made of non-alloy special steels and alloy quality steels
Delivery Condition - N

| Steel Grade | Minimum Tensile Strength Rm in N/mm ² | | | Minimum Yield Strength ReH in N/mm ² | | | Minimum percentage elongation A, where L _o = 5,65 √ So | | | | | | |
|-------------|---|------------|------------|--|------------|------------|--|------------|------------|------------|----|----|--|
| | Nominal Thickness in mm | | | Nominal Thickness in mm | | | Nominal Thickness in mm | | | | | | |
| Steel Name | ≤16 | >16 ≤40 | >40 ≤80 | ≤16 | >16 ≤40 | >40 ≤80 | ≤16 | >16 ≤40 | >16 ≤40 | >40 ≤80 | | | |
| C22 | 420 | 400 | 380 | 260 | 240 | 220 | 21 | 19 | 24 | 22 | 24 | 22 | |
| C22E | | | | | | | | | | | | | |
| C35 | 520 | 500 | 480 | 300 | 280 | 270 | 17 | 15 | 19 | 17 | 21 | 19 | |
| C35E | | | | | | | | | | | | | |
| C45 | 610 | 590 | 570 | 350 | 330 | 320 | 16 | 14 | 17 | 15 | 17 | 15 | |
| C45E | | | | | | | | | | | | | |
| C60 | 720 | 700 | 670 | 390 | 350 | 340 | 13 | 11 | 14 | 12 | 14 | 12 | |
| C60E | | | | | | | | | | | | | |
| 38 Mn 6 | 670 | 620 | 570 | 400 | 380 | 360 | 14 | 12 | 15 | 13 | 16 | 14 | |

**Table 6c2 Mechanical properties for tubes made of non-alloy special steels and alloy quality steels
Delivery Condition - Q**

| Steel Grade | Minimum Tensile Strength Rm in N/mm ² | | | | Minimum Yield Strength ReH in N/mm ² | | | | Minimum percentage elongation A, where L _o = 5,65 √ S _o | | | | | | | | | | | | | |
|-------------|---|-----|-----|-----|--|-----|-----|-----|--|----|----|-----|-----|----|----|-----|-----|----|----|-----|-----|----|
| | ≤8 | >8 | >20 | >50 | ≤8 | >8 | >20 | >50 | Nominal Thickness in mm | | | | | | | | | | | | | |
| | Nominal Thickness in mm | | | | Nominal Thickness in mm | | | | Nominal Thickness in mm | | | | | | | | | | | | | |
| Steel Name | Steel Number | ≤8 | >8 | >20 | >50 | ≤8 | >8 | >20 | >50 | ≤8 | >8 | >20 | >50 | ≤8 | >8 | >20 | >50 | ≤8 | >8 | >20 | >50 | |
| C22 | | 500 | 470 | 440 | 420 | 340 | 290 | 270 | 260 | 20 | 18 | 20 | 22 | 20 | 22 | 20 | 22 | 20 | 22 | 20 | 22 | 20 |
| C22E | | | | | | | | | | | | | | | | | | | | | | |
| C35 | | 630 | 600 | 550 | 500 | 430 | 380 | 320 | 290 | 17 | 15 | 17 | 20 | 18 | 19 | 17 | 20 | 18 | 20 | 18 | 20 | 18 |
| C35E | | | | | | | | | | | | | | | | | | | | | | |
| C45 | | 700 | 650 | 630 | 600 | 490 | 430 | 370 | 340 | 14 | 12 | 14 | 17 | 14 | 16 | 14 | 17 | 15 | 17 | 15 | 17 | 15 |
| C45E | | | | | | | | | | | | | | | | | | | | | | |
| C60 | | 850 | 800 | 750 | 710 | 580 | 520 | 450 | 420 | 11 | 9 | 11 | 14 | 11 | 13 | 11 | 14 | 12 | 14 | 12 | 14 | 12 |
| C60E | | | | | | | | | | | | | | | | | | | | | | |
| 38 Mn 6 | | 850 | 750 | 650 | 550 | 620 | 570 | 470 | 400 | 13 | 11 | 14 | 15 | 13 | 14 | 12 | 15 | 13 | 16 | 14 | 16 | 14 |

Table 6d Mechanical Properties for tubes made of alloy special steels
Delivery Condition - Q

| Steel Grade | Minimum Tensile Strength R _m in N/mm ² | Minimum Yield Strength ReH in N/mm ² | | Minimum percentage elongation A, where L ₀ = 5,65 √ S ₀ | | | | | | | | | | | | |
|-------------------|---|--|------|--|------|------|-----|-----|-----|----|----|----|----|----|----|----|
| | | ≤8 | >8 | ≤8 | >8 | ≤2 | >20 | ≤5 | >50 | ≤8 | | | | | | |
| Steel Name | Steel Number | Nominal Thickness in mm | | Nominal Thickness in mm | | | | | | | | | | | | |
| | | ≤8 | >8 | ≤8 | >8 | ≤2 | >20 | ≤5 | >50 | ≤8 | | | | | | |
| | | | | t | t | t | t | t | t | t | | | | | | |
| 25 Cr Mo 4 | 900 | 800 | 700 | 650 | 700 | 600 | 450 | 400 | 12 | 10 | 14 | 12 | 15 | 13 | 16 | 14 |
| 41 Cr 4 | 1000 | 900 | 800 | - | 800 | 660 | 560 | - | 11 | 9 | 12 | 10 | 14 | 12 | - | - |
| 30 Cr Mo 4-1 | 950 | 850 | 750 | 700 | 750 | 630 | 520 | 480 | 12 | 10 | 13 | 11 | 14 | 12 | 15 | 13 |
| 34 Cr Mo 4 | 1100 | 900 | 800 | 750 | 800 | 650 | 550 | 500 | 11 | 9 | 12 | 10 | 14 | 12 | 15 | 13 |
| 42 Cr Mo 4 | 1100 | 1000 | 900 | 800 | 900 | 750 | 650 | 550 | 10 | 8 | 11 | 9 | 12 | 10 | 13 | 11 |
| 36 Cr Ni Mo 4 | 1100 | 1000 | 900 | 800 | 900 | 800 | 700 | 600 | 10 | 8 | 11 | 9 | 12 | 10 | 13 | 11 |
| 30 Cr Ni Mo 8 | 1250 | 1250 | 1100 | 1000 | 1050 | 1050 | 900 | 800 | 9 | 7 | 9 | 7 | 10 | 8 | 11 | 9 |
| 40 Ni Cr Mo 7-3-3 | 1150 | 1050 | 1000 | 900 | 950 | 870 | 800 | 750 | 9 | 7 | 10 | 8 | 11 | 9 | 12 | 10 |

When reduced width impact test pieces are used the mean value of the three test pieces shall meet the minimum average value (KV_p) calculated using the following equation:

$$KV_p = KV \cdot f$$

where *f* is the actual test piece width divided by the standard test piece width,

The width of reduced width test pieces shall be reported.

7.4 Hardenability

Except when steels are ordered in the quenched and tempered delivery condition, hardenability values for the steel grades given in tables 4c, 4d and the alloy grades in Annex A may be required (see option 2) the values to be achieved are given in Annex D. Unless otherwise agreed (see option 8) this requirement can be demonstrated by calculation.

Option 8 (see 5.2) Hardenability testing in accordance with EURONORM 23 shall be carried out.

7.5 Appearance and soundness

7.5.1 Appearance

7.5.1.1 Tubes shall be free from external and internal surface defects that can be established by visual examination.

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

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

7.5.1.4 Surface imperfections which encroach on the minimum wall thickness shall be considered defects and tube containing these shall be deemed not to conform to this part of this European Standard.

7.5.2 Soundness

When required tubes, supplied with specific inspection and testing shall be subjected to non-destructive testing for imperfections to inspection level E4 (see option 9).

Option 9 (see 5.2) Non-destructive testing for the full length of each tube shall be carried out in accordance with 10.6.

When required, tubes supplied with specific inspection and testing, shall be subjected to a leak tightness test (see option 10).

Option 10 (see 5.2) Leak tightness testing of each tube shall be carried out in accordance with 10.5.

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

7.6 Dimensions, masses, length, tolerances and sectional properties

7.6.1 General

The tolerances on outside diameter and out of roundness do not apply within 100mm of the end of the tube end.

7.6.2 Outside diameters, wall thickness and masses

Preferred outside diameters and wall thicknesses for tube covered by this part of this European Standard have been selected from ENV 10220 and are given in Table 7.

The masses for these dimensions are given in ENV 10220.

Note: Dimensions which are not included in Table 7 may be agreed at the time of enquiry and order.

7.6.3 Length

The tubes shall be delivered in random lengths, unless otherwise specified (see option 11). The manufacturer shall inform the purchaser of the lengths to be supplied at the time of enquiry and order.

Option 11 (see clause 5.2) The tubes shall be delivered in exact lengths, the length to be specified at the time of enquiry and order, for tolerances see 7.6.4.

7.6.4 Tolerances

7.6.4.1 Tolerances on outside diameter and thickness

The outside diameter and thickness of the tubes covered by this part of this European Standard shall be within the tolerance limits given in table 8.

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

Table 8 Tolerances on outside diameter and on thickness

| Outside Diameter mm | Tolerances on D | Tolerances on T for a T/D ratio | | | |
|---------------------|--|--|------------------|-----------------|-------|
| | | <0,025 | >0,025 ≤0,050 | >0,050 ≤0,10 | >0,10 |
| D ≤ 219,1 | ±1% or ±0.5mm whichever is the greater | ± 12.5% or ±0,4mm whichever is the greater | | | |
| D > 219,1 | ±1% | ±20% | ±15% | ±12.5% | ±10% |

7.6.4.2 Tolerances on Exact Length

The tolerances shall be as given in table 9.

Table 9 Tolerances on Exact Lengths

| Length Range L (mm) | Tolerance (mm) |
|---------------------|----------------|
| ≤ 6000 | +10 0 |
| 6000 < L ≤ 12000 | +15 0 |
| > 12000 | By agreement |

7.6.5 Sectional Properties

The nominal sectional properties shall be calculated from nominal dimensions using the formulae given in Annex B.

7.7 **Straightness**

The deviation from straightness of tubes, shall be measured at the point of maximum departure of the from a straight line connecting its two ends and shall be not more than 0,15% of the total length. Special requirements regarding straightness and the method of measurement may be agreed at the time of enquiry and order. in cases of dispute the deviation shall be measured relative to a straight edge or taut line.

8. **Inspection and testing**

8.1 **Types of Inspection and Testing**

The compliance with the requirements of the order for tubes supplied in accordance with this part of this European Standard shall be checked by:-

- non-specific inspection and testing (see EN 10021) for tubes made of non-alloy base steels unless otherwise specified (see option 12)
- specific inspection and testing (see EN 10021) for tubes made of non-alloy quality steels, non-alloy special steels and alloy special steels.

Option 12 (see 5.2) Tubes made of non-alloy base steels shall be supplied with specific inspection and testing

8.2 **Inspection Documents**

8.2.1 **Types of inspection documents**

The following inspection documents, in accordance with EN 10204, shall be issued:-

- certificate of compliance with order type 2.1 for non-specific inspection (see option 13)

Option 13 (see 5.2) Inspection document type 2.2 shall be supplied

- inspection certificate type 3.1.B, for tubes supplied with specific inspection and testing (see option 14)

Option 14 (see 5.2) Inspection document type 3.1.A, 3.1.C or 3.2 shall be supplied.

- When an inspection documents type 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 testing and produce the inspection document. In the case of inspection report 3.2 it shall be agreed which party issue the document.

8.2.2 **Content of inspection documents**

The content of the inspection document shall be in accordance with EN 10168 as shown in 8.2.2.1, 8.2.2.2 and 8.2.2.3.

Table 10 Requirements for Inspection and tests

| Types of inspection or test | | Non-specific inspection and testing | Specific inspection and testing | Reference paragraph |
|-----------------------------|--|-------------------------------------|---------------------------------|---------------------|
| Mandatory | Cast Analysis | 1 representative | 1/cast | 7.2 |
| | Tensile Test | Manufacturers procedure | 1/test unit | 7.3 ; 10.1 |
| | Impact test ¹⁾ | Not applicable | 1 set/test unit | 7.3 ; 10.2 |
| | Dimensional inspection | See 10.7 | | |
| | Visual examination | See 10.8 | | |
| | Material identification of alloy steel tubes | Not applicable | 1/tube | 10.9 |
| Optional | Hardenability test | Not applicable | 1/cast | 7.4 ; 10.3 |
| | Hardness test | Not applicable | 1/test unit | 6.3.2 , 10.4 |
| | Simulated tensile test (N or Q) | Not applicable | 1/cast | 7.3 ; 10.1 |
| | Leak tightness | Not applicable | individual | 7.5.2 ; 10.5 |
| | Non-destructive test for imperfections | Not applicable | individual | 7.5.2 ; 10.6 |
| 1) K2 grades only. | | | | |

8.2.2.1 For tubes supplied with non-specified inspection and testing the certificate of compliance with the order shall contain the following codes and information:-

- A - commercial transactions and parties involved
- B - description of products to which the inspection document applies
- Z - authentication

8.2.2.2 For tubes supplied with non-specific inspection and testing and a test report type 2.2 it shall contain the following codes and information.

- A - commercial transactions and parties involved
- B - description of products to which the inspection document applies
- C01-C02 - for the location of samples and direction of test pieces;
- C10-C13 - tensile test report;
- C60-C69 - other tests (eg options invoked which require test pieces);
- C71-C92 - chemical composition a representative analysis;
- D01 - checking the marking and identification, the surface appearance, the shape and the dimensions
- Z - authentication

8.2.2.3 For tubes supplied with specific inspection and testing the inspection certificate type 3.1.A, 3.1.B or 3.1.C or inspection report type 3.2 shall contain the following codes and information:

| | | |
|---------|---|--|
| A | - | commercial transactions and parties involved |
| B | - | description of products to which the inspection document applies |
| C01-C02 | - | for the location of samples and direction of test pieces |
| C11-C13 | - | for tensile tests; |
| C60-C69 | - | other tests (eg options invoked which require test pieces); |
| C71-C92 | - | chemical composition on cast analysis; |
| D01 | | the marking and identification, the surface appearance, the shape and the dimensions |
| D02-D99 | - | for other tests (eg options invoked which do not require test pieces) |
| Z | | authentication |

8.3 Summary of inspection and testing

Inspection and testing shall be carried out as stated in table 10.

9. Sampling

9.1 Frequency of tests

9.1.1 Test Unit

In the case of specific inspection a test unit shall comprise of tubes of the same grade and dimensions manufactured by the same process and in the same delivery condition.

The quantity of tubes per test unit shall conform to table 11.

Table 11 Quantity per test unit

| Outside Diameter D mm | Maximum mass of tubes per Test Unit tonnes |
|-----------------------------|--|
| ≤ 114,3 | 40 |
| >114,3 ≤ 323,9 | 50 |
| >323,9 | 75 |

9.1.2.1 Number of samples/test unit

One sample tube shall be taken from each test unit.

9.2 Preparation of samples and test pieces

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

9.2.1.1 General

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

9.2.1.2 Test piece for the tensile test

The test piece for the tensile test of the parent material shall be taken in accordance with the requirements of EN 10002-1.

At the manufacturers discretion

- For tubes with an outside diameter less than or equal to 219.1mm, the test piece shall be either a full tube section or a strip section and be taken in a direction longitudinal to the axis of the tube.

For tubes with an outside diameter greater than 219.1mm but less than or equal to 508mm, the test piece shall be taken in a direction either longitudinal or transverse to the axis of the tube. The test piece is either a strip section or machined round bar specimen from an unflattened sample.

- For tubes with an outside diameter greater than 508mm the test piece shall be taken in a direction transverse to the axis of the tube.

9.2.1.3 Test piece for the impact test

Standard Charpy V-notch test pieces in accordance with EN 10045-1 shall be taken. If the nominal product thickness is such that standard test pieces cannot be produced without flattening of the section, the test shall be carried out using test pieces of width less than 10mm but not less than 5mm. In all cases, the largest obtainable width shall be used.

Tubes shall not be subject to impact testing where test pieces of width 5mm or greater cannot be obtained.

Test pieces shall be taken and prepared such that the axis of the notch is perpendicular to the surface of the tube.

The direction of testing is at the discretion of the manufacturer.

9.2.1.4 Test piece for hardenability test (jominy)

Test pieces shall be prepared in accordance with EURONORM 23.

9.2.1.5 Test piece for hardness test (Brinell)

Test pieces shall be prepared in accordance with EN 10003-1

10. Test Methods

10.1 Tensile Test

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

- the tensile strength (Rm.);
- the upper yield strength (ReH);
If a yield phenomenon is not present the 0,2% proof strength (Rp 0,2) or the 0,5% total extension (Rt 0,5) shall be determined. In case of dispute the 0,2% proof strength (Rp 0,2) shall apply
- the percentage elongation after fracture with reference to a gauge length of $5.6\sqrt{S_0}$;
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 given in ISO 2566-1.

10.2 Impact Test

The test shall be carried out in accordance with EN 10045-1 at -20°C.

10.3 Hardenability Test

The test shall be carried out in accordance with EURONORM 23.

10.4 **Hardness test**

The test shall be carried out in accordance with EN 10003-1

10.5 **Leak Tightness Test**

10.5.1 **General**

The test shall be carried out in accordance with 10.5.2 or 10.5.3. The choice of test method is at the discretion of the manufacturer (see option 15).

Option 15 (see 5.2) The test method for verification of leak tightness according to 10.5.2 or 10.5.3 is chosen by the purchaser.

10.5.2 **Hydrostatic Test**

The hydrostatic test shall be carried out at a test pressure of 70 bar or P, calculated from the following equation, whichever is the lower.

$$P = \frac{20 ST}{D}$$

Where

| | | |
|---|---|--|
| P | = | test pressure in bar |
| D | = | specified outside diameter (mm) |
| T | = | specified wall thickness (mm) |
| S | = | stress in newtons per square mm corresponding to 70% of the specified minimum yield strength (see table 4) for the steel grade concerned |

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

Note: This hydrostatic leak tightness test is not a strength test.

10.5.3 **Electromagnetic Test**

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

10.6 **Non-destructive Testing**

Testing shall be carried out in accordance with one of the following non-destructive testing standards to the acceptance level indicated.

| | | |
|------------|---|---------------------|
| EN 10246-3 | - | acceptance level E4 |
| EN 10246-5 | - | acceptance level F4 |
| EN 10246-7 | - | acceptance level U4 |

The choice of method is at the discretion of the manufacturer.

10.7 **Dimensional Inspection**

Specified dimensions shall be verified.

A gauge is used normally for measuring the outside diameter, however for tubes with D equal to or greater than 406,4 mm this may be measured using a circumference tape. The wall thickness shall be measured at the tube ends.

10.8 **Visual examination**

Tubes shall be visually examined for compliance with the requirement of 7.4.1.

10.9 **Material Identification**

Each tube from alloy steel in the tables 4d and A1 shall be tested by an appropriate method to assure that the correct grade is being supplied.

10.10 **Retests, sorting and reprocessing**

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

11. **Marking**

11.1 Except as provided for in 11.2, for tubes which are supplied bundled, each tube shall be marked by suitable and durable methods such as painting, stamping, adhesive labels or attached tags with the following:

- the manufacturers name or trademark
- the designation eg EN EC029086 - E275
- the symbol for the delivery condition, eg "N", where applicable
- in the case of specific inspection, the mark of the inspection representative and an identification number (eg order or item number) which permits the correlation of the product or delivery unit to the related document

Example of marking

X-EN EC029086 - E275 - N - Y - Z

X = manufacturers name or trademark
Y = mark of inspection representative
Z = identification number (eg order or item number)

11.2 Where the products are supplied bundled, the marking required in 11.1 may be on a label which shall be securely attached to the bundle.

12. **Protection**

The tubes shall be delivered without protection unless otherwise specified (see option 16).

Option 16 (see 5.2) Tubes shall be specially protected for transit and storage. The type of coating shall be agreed at the time of enquiry and order.



Annex A (Normative) Non-alloy and alloy special steels (QS) for case hardening

Table A1 Chemical Composition (Cast Analysis) in % by mass

| Grade | Deoxidation Type 1) | C | | Si | | Mn | | P | | S | | Cr | | Mo | | Ni | |
|-------------------|---------------------|------|------|------|------|------|------|-------|-------|-------|------|------|------|------|------|------|------|
| | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| C10E | FF | 0,07 | 0,13 | 0,40 | 0,40 | 0,30 | 0,60 | 0,035 | - | 0,035 | - | - | - | - | - | - | - |
| C15E | FF | 0,12 | 0,18 | 0,40 | 0,40 | 0,30 | 0,80 | 0,035 | - | 0,035 | - | - | - | - | - | - | - |
| C15R | FF | 0,12 | 0,18 | 0,40 | 0,40 | 0,30 | 0,80 | 0,035 | 0,020 | 0,040 | - | - | - | - | - | - | - |
| 16 Mn Cr 5 | FF | 0,14 | 0,19 | 0,40 | 0,40 | 1,00 | 1,30 | 0,035 | - | 0,035 | 0,80 | 1,10 | - | - | - | - | - |
| 16 Mn Cr S 5 | FF | 0,14 | 0,19 | 0,40 | 0,40 | 1,00 | 1,30 | 0,035 | 0,020 | 0,040 | 0,80 | 1,10 | - | - | - | - | - |
| 20 Ni Cr Mo 2-2 | FF | 0,17 | 0,23 | 0,40 | 0,40 | 0,65 | 0,95 | 0,035 | - | 0,035 | 0,35 | 0,70 | 0,15 | 0,25 | 0,40 | 0,70 | 0,70 |
| 20 Ni Cr Mo S 2-2 | FF | 0,17 | 0,23 | 0,40 | 0,40 | 0,65 | 0,95 | 0,035 | 0,020 | 0,040 | 0,35 | 0,70 | 0,15 | 0,25 | 0,40 | 0,70 | 0,70 |

1) FF = Fully killed steel containing nitrogen binding elements in amounts sufficient to bind available nitrogen (eg min 0,020% total aluminium)

Table A2 Heat treatment temperature in °C

| Steel Name | Steel Number | Heat Treatment | | | |
|-------------------|--------------|----------------|---------|----------|---------|
| | | A | TH | FP | N |
| C10E | | 650-700 | - | 900-1000 | 900-920 |
| C15E, C15R | | 650-700 | - | 900-1000 | 890-920 |
| 16 Mn Cr 5 | | 650-700 | 850-950 | 900-1000 | 840-870 |
| 16 Mn Cr S 5 | | 650-700 | 850-950 | 900-1000 | 840-870 |
| 20 Ni Cr Mo 2-2 | | 650-700 | 850-950 | 900-1000 | 850-880 |
| 20 Ni Cr Mo S 2-2 | | 650-700 | 850-950 | 900-1000 | 850-880 |

Annex B (Normative)

Formulae for calculation of nominal sectional properties

The nominal sectional properties for tubes are calculated from the following geometric properties using the formulae given below:-

| | | | | |
|---|-----------------|------------|---|---------------------|
| Nominal outside diameter | - | (D) | - | (mm) |
| Nominal thickness | - | (T) | - | (mm) |
| Nominal inside diameter | - | (d = D-2T) | - | (mm) |
| Superficial area/unit length | As | = | $\frac{\pi D}{10^3}$ | (m ² /m) |
| Cross sectional area | A | = | $\frac{\pi(D^2 - d^2)}{4 \times 10^2}$ | (cm ²) |
| Mass per length | M | = | 0,785A | (kg/m) |
| Second moment of area | I | = | $\frac{\pi(D^4 - d^4)}{64 \times 10^4}$ | (cm ⁴) |
| Radius of gyration | i | = | $\sqrt{\frac{I}{A}}$ | (cm) |
| Elastic section modulus | W _{el} | = | $\frac{2I \times 10}{D}$ | (cm ³) |
| Plastic section modulus | W _{pl} | = | $\frac{D^3 - d^3}{6 \times 10^3}$ | (cm ³) |
| Torsional Inertia constant (polar moment of inertia) | I _t | = | 2I | (cm ⁴) |
| Torsional modulus constant | C _t | = | 2W _{el} | (cm ³) |

Annex C (Normative) Hardness requirements for annealed steel tubes

Table C1 Maximum hardness level of annealed 1) tubes (HB max)

| Steel Name | Steel Number | HB max | Steel Name | Steel Number | HB max |
|--------------|--------------|--------|-------------------|--------------|--------|
| C22 | | 156 | 36 Cr Ni Mo 4 | | 241 |
| C35 | | 183 | 30 Cr Ni Mo 8 | | 248 |
| C45 | | 207 | 40 Ni Cr Mo 7-3-3 | | 248 |
| C60 | | 241 | C10 | | 131 |
| 38 Mn 6 | | 223 | C15 | | 146 |
| 25 Cr Mo 4 | | 212 | 16 Mn Cr 5 | | 207 |
| 41 Cr 4 | | 241 | 16 Mn Cr S 5 | | 207 |
| 30 Cr Mo 4-1 | | 223 | 20 Ni Cr Mo 2-2 | | 210 |
| 34 Cr Mo 4 | | 223 | 20 Ni Cr Mo S 2-2 | | 210 |
| 42 Cr Mo 4 | | 241 | | | |

1) A, TH and FP delivery conditions

st

Annex D (Normative) Mechanical Properties (Hardenability) - Limiting values for C scale Rockwell hardness

Table D1 Non-alloy special steels

| Steel Grade | | Distance in mm from the quenched end HRC hardness | | | | | | | | | | | | | | | |
|-------------|-----------------|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Steel Name | Steel Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 13 | 15 | 20 | 25 | 30 |
| C22E | | By agreement | | | | | | | | | | | | | | | |
| | Limits of Range | By agreement | | | | | | | | | | | | | | | |
| | max | | | | | | | | | | | | | | | | |
| | min | | | | | | | | | | | | | | | | |
| C35E | | 58 | 57 | 55 | 53 | 49 | 41 | 34 | 31 | 28 | 27 | 26 | 25 | 24 | 23 | 20 | - |
| | max | 48 | 40 | 33 | 24 | 22 | 20 | - | - | - | - | - | - | - | - | - | - |
| | min | 62 | 61 | 61 | 60 | 57 | 51 | 44 | 37 | 34 | 33 | 32 | 31 | 30 | 29 | 28 | 27 |
| C45E | | 55 | 51 | 37 | 30 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | - | - | - |
| | max | 67 | 66 | 65 | 63 | 62 | 59 | 54 | 47 | 39 | 37 | 36 | 35 | 34 | 33 | 31 | 30 |
| | min | 60 | 57 | 50 | 39 | 35 | 33 | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 23 | 21 |
| 38 Mn 6 | | 58 ¹⁾ | - | 57 | - | 55 | - | 51 | - | 47 | - | 42 | 37 | 34 | 31 | 29 | - |
| | max | 51 ¹⁾ | - | 47 | - | 40 | - | 33 | - | 27 | - | 23 | 21 | 20 | - | - | - |
| | min | | | | | | | | | | | | | | | | |

1) Distance 1.5mm from quenched end

Annex D (Normative)
Table D2 Alloy special steels

| Steel Grade | | Limits of Range | Distance in mm from the quenched end HRC hardness ✓ | | | | | | | | | | | | | | | | |
|-------------------|--------------|-----------------|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--|
| Steel Name | Steel Number | | 1.5 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | | |
| 25 Cr Mo 4 | | max | 52 | 52 | 51 | 50 | 48 | 46 | 43 | 41 | 37 | 35 | 33 | 32 | 31 | 31 | 31 | | |
| | | min | 44 | 43 | 40 | 37 | 34 | 32 | 29 | 27 | 23 | 21 | 20 | - | - | - | - | - | |
| 41 Cr 4 | | max | 61 | 61 | 60 | 59 | 58 | 56 | 54 | 52 | 46 | 42 | 40 | 38 | 37 | 36 | 35 | | |
| | | min | 53 | 52 | 50 | 47 | 41 | 37 | 34 | 32 | 29 | 26 | 23 | 21 | - | - | - | - | |
| 30 Cr Mo 4-1 | | max | 56 | 55 | 54 | 50 | 48 | 45 | 40 | 39 | 35 | 33 | 33 | 31 | 31 | 30 | 29 | | |
| | | min | 49 | 46 | 43 | 35 | 32 | 29 | 26 | 26 | 24 | 23 | 22 | - | - | - | - | - | |
| 34 Cr Mo 4 | | max | 57 | 57 | 57 | 56 | 55 | 54 | 53 | 52 | 48 | 45 | 43 | 41 | 40 | 40 | 39 | | |
| | | min | 49 | 49 | 48 | 45 | 42 | 39 | 36 | 36 | 34 | 30 | 27 | 26 | 25 | 24 | 24 | 24 | |
| 42 Cr Mo 4 | | max | 61 | 61 | 61 | 60 | 60 | 59 | 59 | 59 | 58 | 53 | 51 | 48 | 47 | 46 | 45 | | |
| | | min | 53 | 53 | 52 | 51 | 49 | 43 | 40 | 40 | 37 | 34 | 32 | 31 | 30 | 30 | 29 | 29 | |
| 36 Cr Ni Mo 4 | | max | 59 | 59 | 58 | 58 | 57 | 57 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | | |
| | | min | 51 | 50 | 49 | 49 | 48 | 47 | 46 | 45 | 43 | 41 | 39 | 38 | 36 | 34 | 33 | 33 | |
| 30 Cr Ni Mo 8 | | max | 56 | 56 | 56 | 56 | 55 | 55 | 55 | 55 | 55 | 54 | 54 | 54 | 54 | 54 | 54 | | |
| | | min | 48 | 48 | 48 | 48 | 47 | 47 | 47 | 46 | 46 | 45 | 45 | 44 | 44 | 43 | 43 | 43 | |
| 40 Ni Cr Mo 7-3-3 | | max | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 59 | 58 | 58 | 57 | 57 | 56 | 56 | | |
| | | min | 53 | 53 | 53 | 53 | 53 | 53 | 52 | 52 | 49 | 47 | 46 | 44 | 43 | 42 | 42 | 40 | |

