EN 10305-1:2002

Steel tubes for precision applications - Technical delivery conditions - Part 1: Seamless cold drawn tubes

1 Scope

This Part of EN 10305 specifies the technical delivery conditions for seamless cold drawn steel tubes of circular cross section for precision applications.
NOTE: This Part of EN 10305 may also be applicable to other types of cross sections.
Tubes manufactured according to this Part of EN 10305 are characterized by having precisely defined dimensional tolerances and a defined surface roughness. Typical fields of application are in the vehicle, furniture and general engineering industries.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications listed hereafter. For dated 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).

- EN 10002-1, Metallic materials - Tensile testing - Part 1: Method of test at ambient temperature.
- EN 10020, Definition and classification of grades of steel.
- EN 10021, General technical delivery conditions for steel products.
- EN 10027-1, Designation systems for steels - Part 1: Steel names.
- EN 10027-2, Designation systems for steels - Part 2: Numerical system.
- EN 10052, Vocabulary of heat treatment terms for iron and steel.
- EN 10204, Metallic products - Types of inspection documents.
- EN 10233, Metallic materials - Tube - Flattening test.
- EN 10234, Metallic materials - Tube - Drift expansion test.
- EN 10246, Non-destructive testing of steel tubes.
- EN 10256, Non-destructive testing of steel tubes - Qualification and competence of level 1 and 2 non-destructive testing personnel.
- EN ISO 377, Steel and steel products - Location and preparation of test pieces for mechanical testing (ISO 377:1997).
- EN ISO 2566-1, Steel - Conversion of elongation values - Part 1: Carbon and low alloy steels (ISO 2566-1:1984).
- prEN 10168, Steel products - Inspection documents - List of information and description.
- ENV 10220, Seamless and welded steel tubes - Dimensions and masses per unit length.

- prEN 10266, Steel tubes, fittings and structural hollow sections - Definitions and symbols for use in product standards.
- EN ISO 4287, Geometrical Product Specifications (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters (ISO 4287:1997).
- CR 10260, Designation system for steel - Additional symbols.

3 Terms and definitions

For the purposes of this Part of EN 10305, the terms and definitions given in EN 10020, EN 10021, EN 10052 and prEN 10266 and the following apply.
3.1 employer: the organization for which a person works on a regular basis.
NOTE: The employer may be the tube manufacturer or a third party organization providing non-destructive testing (NDT) services.

4 Symbols

See prEN 10266.
NOTE: In this Part of EN 10305, "T" is the specified or calculated wall thickness.

5 Classification and designation

5.1 Classification

The steel grades given in Table 2 are classified as non-alloy quality steels according to EN 10020. The steel grades given in Table A.1 are non-alloy quality steels (E255, E410, 26Mn5, 10S10, 15S10, 18S10 and 37S10), non-alloy special steels (C35E and C45E) and alloy special steels (26Mo2, 25CrMo4 and 42CrMo4).

5.2 Designation

The designation of tubes covered by this Part of EN 10305 consists of:
— the number of this Part of EN 10305; plus
— the steel name according to EN 10027-1 and CR 10260; or
— the steel number according to EN 10027-2.

6 Information to be supplied by the purchaser

6.1 Mandatory information

The purchaser shall indicate on enquiry and order the following information:
a) quantity (mass, total length or number);
b) the term "tube";
c) dimensions (see 8.5);
d) steel name according to this Part of EN 10305 (see 5.2);

e) delivery condition including surface condition (see 7.2.1 and 7.2.2);
f) type of tube lengths, and length where applicable (see 8.5.2).

6.2 Options

A number of options are specified in this Part of EN 10305, listed below. If the purchaser does not indicate his 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. steel grades other than those in this Part of EN 10305 to be specified (see 8.2);
2. to specify a sulphur content range to aid machinability (see 8.2);
3. special surface condition to be specified (see 8.4.1);
4. surface roughness to be measured and reported (see 8.4.1.5);
5. lower surface roughness to be specified, type and limit to be agreed at time of enquiry, measured and reported (see 8.4.1.5);
6. surface to contain only substances which can be easily removed, requirements to be agreed at time of enquiry (see 8.4.1.6);
7. verification of internal soundness by non-destructive testing (see 8.4.2);
8. verification of leak tightness by non-destructive testing (see 8.4.2);
9. non-circular cross sections to be agreed (see 8.5.1.1);
10. tubes to be specified by outside diameter + wall thickness or inside diameter + wall thickness (see 8.5.1.1);
11. reduced diameter tolerance to be specified (see 8.5.1.2);
12. one-sided diameter tolerance to be specified (see 8.5.1.2);
13. reduced eccentricity to be specified (see 8.5.1.3);
14. reduced wall thickness tolerance to be specified (see 8.5.1.4);
15. one-sided wall thickness tolerance to be specified (see 8.5.1.4);
16. length tolerance outside the values of Table 7 to be specified (see 8.5.2);
17. end preparation to be specified (see 8.5.4);
18. specific inspection to be supplied (see 9.1);
19. inspection document type 3.1.A or 3.1.C to be supplied (see 9.2.1);
20. cast analysis report to be supplied (see 10.3);
21. one cast only (see 10.1);
22. alternative marking to be agreed (see 12);
23. no protection to be applied (see 13);
24. particular protection to be applied, to be agreed at time of enquiry (see 13);
25. particular packing to be applied, to be agreed at time of enquiry (see 13).

6.3 Examples of ordering

12 000 m tube 60 x ID 56 according to this Part of EN 10305, steel grade E235, condition +N, random lengths, inspection document 3.1.B according to EN 10204:
12 000 m tube - 60 x ID 56 - EN 10305-1 - E235 +N - random length - Option 18.

7 Manufacturing process

7.1 Steelmaking process

The steelmaking process shall be at the manufacturer's discretion. The steel shall be fully killed.

7.2 Tube manufacture and delivery condition

7.2.1 The tubes shall be manufactured from hot rolled seamless tubes by cold drawing or other suitable processes.
7.2.2 The tubes shall be supplied in one of the delivery conditions given in Table 1.
7.2.3 All non-destructive testing (NDT) activities shall be carried out by qualified and competent level 1, level 2 and/or level 3 personnel authorised by the employer to operate. Qualification shall be in accordance with EN 10256 or an equivalent recognised standard.

Table 1 — Delivery conditions

Designation	Symbol	Description
Cold drawn/hard	+C	No heat treatment after final cold drawing.
Cold drawn/soft	+LC	After final heat treatment there is an amount of cold drawing sufficient to produce some strain hardening.
Cold drawn and stress relieved	+SR	After final cold drawing there is a stress relieving thermal treatment in a controlled atmosphere.
Annealed	+A	After final cold drawing the tubes are annealed in a controlled atmosphere.
Normalized	+N	After final cold drawing the tubes are normalized in a controlled atmosphere.

8 Requirements

8.1 General

Tubes in the delivery conditions as given in Table 1 and inspected in accordance with clauses 9, 10 and 11 shall comply with the requirements of this Part of EN 10305. In addition, the general technical delivery requirements specified in EN 10021 apply.

8.2 Chemical composition

The cast analysis reported by the steel producer shall conform to the requirements given in Table 2 (but see options 1 and 2 or Table A.1). Steel grades other than those in this Part of EN 10305 may be specified (see option 1).
NOTE: For tubes intended for welding, the behaviour of the steel depends on the steel grade, the delivery condition and the preparation and execution of the welding.

Table 2 — Chemical composition (cast analysis), %

Steel grade	Steel name	Steel number	C max. %	Si max. %	Mn max. %	P max. %	S max. %	Al min. %

Steel grade	Steel name	Steel number	C max. %	Si max. %	Mn max. %	P max. %	S max. %	Al min. %
E215	-	1.0212	0,10	0,05	0,70	0,025	0,025	0,025
E235	-	1.0308	0,17	0,35	1,20	0,025	0,025	-
E355	-	1.0580	0,22	0,55	1,60	0,025	0,025	-

NOTES: a) Elements not quoted in this table shall not be intentionally added to the steel without the agreement of the purchaser, but wider ranges than those specified may be necessary to cast a particular analysis. b) See option 2. c) The additions of Nb, Ti and V shall be at the manufacturer's discretion, the content shall be reported.

Option 2: For steel grades E235 and E355 a controlled sulphur content range of 0,015 % to 0,040 % to improve machinability may be specified. This shall be obtained by appropriate desulphurisation followed by resulphurisation or by a low oxygen process.

Table 3 — Permissible deviations of the product analysis from the cast analysis limits

Element	Cast analysis limits, %	Permitted deviation for product analysis, %
C	≤ 0,22	+0,02
Si	≤ 0,55	+0,05
Mn	≤ 1,60	+0,10
P	≤ 0,025	+0,005
S	≤ 0,040	± 0,005
Al	≥ 0,025	-0,005

8.3 Mechanical properties

The mechanical properties of the tubes shall conform to the requirements of Table 4, Table A.3 as appropriate and 11.2 or 11.3 where applicable.
NOTE: Subsequent processing (cold or hot) may affect the mechanical properties.

Table 4 — Mechanical properties at room temperature
Key: Rm = tensile strength (MPa), ReH = yield strength (MPa) (see 11.1), A = elongation after fracture (%), Lo = 80 mm.

Steel grade	+C	+LC	+SR	+A	+N
Steel name/Steel number	Rm / A	Rm / A	Rm / ReH min. / A	Rm / A	Rm / ReH min. / A
E215 / 1.0212	430 / 8	380 / 12	380 / 280 / 16	280 / 30	290 to 430 / 215 / 30
E235 / 1.0308	480 / 6	420 / 10	420 / 350 / 16	315 / 25	340 to 480 / 235 / 25
E355 / 1.0580	640 / 4	580 / 7	580 / 450 / 10	450 / 22	490 to 630 / 355 / 22

NOTES: 1) For calculation of Rm/ReH ratios, the following are recommended: ReH min. = 0,8 Rm for +C, ReH min. = 0,7 Rm for +LC, ReH min. = 0,5 Rm for +A. 2) For tubes with outside diameters ≤ 30 mm and wall thicknesses ≤ 3 mm the minimum value for ReH is reduced by 10 MPa. 3) For E355 in the normalized condition (+N) with outside diameters > 160 mm ReH min. = 420 MPa. 4) The values for Rm and ReH given in this table for the conditions +LC and +SR apply when the test is performed in the temperature range 10 °C to 35 °C. Outside this range the values apply only after agreement.

8.4 Appearance and internal soundness

8.4.1 Appearance

8.4.1.1 The surface condition of the tubes shall be typical of the manufacturing process and heat treatment employed. Any surface imperfections such as ridges, dents, etc. shall be acceptable provided they are within the tolerances specified in this Part of EN 10305.
Option 3: A surface condition suitable for a specific further processing may be specified.
8.4.1.2 Surface imperfections which are considered not acceptable by the purchaser shall be ground or otherwise treated in accordance with 8.4.1.3 or 8.4.1.4.
8.4.1.3 Surface imperfections which are to be ground or otherwise treated shall be removed provided that the resulting tube dimensions are within the specified tolerances. The ground or treated area shall blend smoothly into the surrounding area.
8.4.1.4 Surface imperfections which encroach beyond the specified minimum wall thickness shall be considered defects and tubes containing these shall not conform to this Part of EN 10305.
8.4.1.5 Tubes shall have a smooth outer and inner surface. For +SR, +A and +N the maximum roughness Ra shall be 4 µm on the outside surface. For +C and +LC the maximum roughness Ra shall be 4 µm on both outside and inside surfaces. This requirement applies to tubes with inside diameters ≥ 15 mm.
Option 4: The surface roughness shall be measured and reported.
Option 5: A lower surface roughness may be specified. The type and limit shall be agreed at the time of enquiry and shall be measured and reported.
8.4.1.6 Tubes in the delivery conditions +C or +LC usually have a thin adherent layer of lubricant.
Option 6: The surface shall contain substances which can be easily removed. The requirements shall be agreed at the time of enquiry. For tubes in the delivery condition +SR a conversion layer of lubricant may be partially present. For tubes in the delivery conditions +SR, +A or +N there shall be no adherent scale but discolouration may be present.

8.4.2 Internal soundness

The purchaser has the option to specify verification of internal soundness by non-destructive testing (see options 7 and 8).
Option 7: Verification of internal soundness by non-destructive testing for the detection of longitudinal imperfections.
Option 8: Verification of leak tightness by non-destructive testing.

8.5 Dimensions and tolerances

8.5.1 Outside diameter, inside diameter and wall thickness

8.5.1.1 Round tubes (see option 9) shall be specified by outside diameter and inside diameter unless option 10 is specified.
Option 9: Non-circular cross sections to be agreed.
Option 10: Tubes to be specified by outside diameter + wall thickness or inside diameter + wall thickness.
8.5.1.2 The tolerances on diameter and wall thickness shall be as given in Table 5 based on the sizes given in ENV 10220. For intermediate sizes the tolerance corresponding to the next larger size shall

apply. The diameter tolerances include ovality. The tolerances in Table 5 apply to tubes in the delivery conditions +C or +LC. For tubes in the delivery conditions +SR, +A or +N the tolerances on diameter shall be subject to the corrective factors given in Table 6. Other tolerances may be specified (see options 11 and 12).

Option 11: Reduced tolerance on diameter to be specified.

Option 12: One-sided tolerance on diameter to be specified.

8.5.1.3 Eccentricity: Reduced eccentricity may be specified (see option 13).

8.5.1.4 Wall thickness tolerances: Reduced (see option 14) or one-sided (see option 15) tolerances may be specified.

Table 5 — Tolerances for round tubes

(Summary; full details in ENV 10220)

Wall thickness T mm	Outside diameter D mm	Tolerance on diameter mm	Wall thickness tolerance mm
≤ 3.0	≤ 30	±0.20	±0.15
> 3.0 to 6.0	≤ 30	±0.25	±0.20
...	...	...	...

Table 6 — Corrective factors for tolerances on diameter for heat treated tubes

(Based on T/D ratio; e.g., T/D >0.10: 1.0; T/D ≤0.05: 1.2)

Option 13: Reduced eccentricity to be specified. The maximum eccentricity shall be agreed at the time of enquiry.

Option 14: Reduced wall thickness tolerance to be specified.

Option 15: One-sided wall thickness tolerance to be specified.

8.5.2 Lengths

Random lengths or exact lengths, with tolerances as in Table 7 (for ≤500 mm or >8000 mm, agree at enquiry, see option 16).

Table 7 — Length tolerances

Length l mm	Tolerance mm
≤ 6000	+10 / 0
> 6000 to 8000	+15 / 0

Option 16: Length tolerances outside the values of Table 7 to be specified.

8.5.3 Straightness

The maximum deviation from straightness shall be 1 mm per 1000 mm of tube length.

8.5.4 Ends

Option 17: Ends to be prepared in a particular way to be specified.

9 Inspection

9.1 Type of inspection

Unless option 18 is specified, the tubes shall be supplied with non-specific inspection.
Option 18: Specific inspection to be supplied.

9.2 Inspection documents

9.2.1 Type of inspection document: Inspection documents shall be issued in accordance with EN 10204. Unless otherwise agreed, the default is type 2.2. For specific inspection the type shall be 3.1.B.
Option 19: Inspection document type 3.1.A or 3.1.C to be supplied.
9.2.2 Content: The content of the inspection document shall be in accordance with prEN 10168.

9.3 Summary of inspection and tests

See Table 8.

Table 8 — Summary of inspection and tests

Characteristic	Method	Frequency
Chemical composition	10.3	See 10.1
Tensile properties	11.1	See 10.1
Flattening test or drift expansion test	11.2 or 11.3	See 10.1
Dimensions	11.4	See 9.4
Roughness	11.5	Option 4 or 5
Visual examination	11.6	See 9.4
NDT for longitudinal imperfections	11.7.1	Option 7
NDT for leak tightness	11.7.2	Option 8

9.4 Checking of dimensions, mass, performance and surface quality
The checking of dimensions, mass, performance and surface quality shall be carried out by the manufacturer in accordance with his own procedures.

10 Sampling

10.1 Test units

A test unit shall consist of tubes of the same steel grade, the same size, the same manufacturing process, the same delivery condition and the same heat treatment batch not exceeding 300 m or 500 tubes (the greater). Any remainder of less than 50 tubes may be distributed evenly among the test units.
Option 21: One cast only.

10.2 Preparation of samples and test pieces

Samples and test pieces shall be taken in accordance with EN ISO 377. Tensile test pieces shall be either the full tube section or a longitudinal strip. For the flattening test or drift expansion test the full cross section shall be used.

10.3 Determination of chemical composition

The determination of the chemical composition shall be carried out on the cast analysis reported by the steel producer.
Option 20: Cast analysis report to be supplied.

11 Test methods

11.1 Tensile test

The tensile test shall be carried out at room temperature in accordance with EN 10002-1 and shall determine Rm, ReH. In the absence of a yield (Re) phenomenon, Rp0,2 or Rt0,5 shall be determined. In case of dispute, Rp0,2 shall apply. The elongation after fracture A shall be determined using Lo = 5,65 √So. For the conversion of values, see EN ISO 2566-1.

11.2 Flattening test

The flattening test shall be carried out in accordance with EN 10233 where the wall thickness T ≤ 15 % of the outside diameter D. The tube shall be flattened between parallel plates until opposite walls of the tube meet. The height H of the section thus flattened shall be H = (D + T)(1 + C), where C is given in Table 9. After the test, there shall be no evidence of cracks or openings on the surface of the tube.

Table 9 — Values of C for the flattening test

Steel grade	C
E215, E235	0,09
E355	0,07

11.3 Drift expansion test

The drift expansion test shall be carried out in accordance with EN 10234 using a conical mandrel with a 60° angle. The test is applicable to tubes with outside diameters ≤ 150 mm and wall thicknesses ≤ 10 mm. The inside diameter of the tube shall be increased by the percentage given in Table 10. After the test there shall be no evidence of cracks or openings on the inside or outside surface of the tube.

Table 10 — Expansion percentages for the drift expansion test
NOTE: For E355 the expansion is 15 % for D ≤ 50 mm and 10 % for D > 50 mm.

Steel grade	Outside diameter D mm	Expansion %
E215	≤ 25	20
	> 25	15
E235	≤ 25	18
	> 25	12
E355	All	15 to 10

11.4 Check of dimensions

Check the specified dimensions and straightness (measured over a length ≥ 100 mm at the end of the tube).

11.5 Measurement of roughness

Axial measurement in accordance with EN ISO 4287.

11.6 Visual examination

In accordance with 8.4.1.

11.7 Non-destructive testing

11.7.1 For the detection of longitudinal imperfections: Eddy current testing (EN 10246-3, acceptance level E3), magnetic particle testing (EN 10246-5, acceptance level F3) or ultrasonic testing (EN 10246-7, acceptance level U3).
11.7.2 For leak tightness: In accordance with EN 10246-1.

11.8 Retests, sorting and reprocessing

In accordance with EN 10021.

12 Marking

Bundles shall be marked with the manufacturer's name, dimensions, number of this Part of EN 10305, steel name/number, cast number (if option 21), delivery condition, and inspection level for specific inspection.
Option 22: Alternative marking to be agreed.

13 Protection and packaging

Tubes shall be given temporary protection against corrosion at the manufacturer's option (option 23: no protection; option 24: particular protection agreed).
NOTE: Tubes without protection are susceptible to corrosion. Bundles shall be suitable for safe transport.
Option 25: Particular packing method to be specified to avoid damage to surface or straightness.

Annex A (normative) - Requirements for additional steel grades

Table A.1 — Chemical composition (cast analysis), %
(Summary; full table includes grades like E255 (1.0305): C ≤0.21, Mn 0.40-1.10; C35E (1.1181): C 0.32-0.39, Mn ≤0.40; etc.)

Table A.2 — Permissible deviations of product analysis
(Similar to Table 3, e.g., C ≤0.55: +0.02; Si ≤0.50: +0.03.)

Table A.3 — Mechanical properties

(Minimum Rm, ReH, A for additional grades, e.g., E255 +N: 520-680 / 255 / 22.)

Annex B (informative)

(Correspondence between old heat treatment symbols and new ones; refer to original standard for details.)
