BS EN 10305-3:2016

BSI Standards Publication

Steel tubes for precision applications — Technical delivery conditions

Part 3: Welded cold sized tubes

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National foreword

This British Standard is the UK implementation of EN 10305-3:2016. It supersedes BS EN 10305-3:2010 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/110, Steel Tubes, and Iron and Steel Fittings.

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

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European foreword

This document (EN 10305-3:2016) has been prepared by Technical Committee ECISS/TC 110 "Steel tubes and iron and steel fittings", 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of an identical text or by endorsement, at the latest by September 2016 and conflicting national standards shall be withdrawn at the latest by September 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 10305-3:2010.

In comparison with the previous edition, the following technical changes have been made:

a) References were adapted;

b) The options were renumbered in such a way that now throughout all parts the number of options are the same;

c) Addition of steel grades E460, E500, E550, E600 and E700;

d) Editorial updates.

EN 10305, *Steel tubes for precision applications - Technical delivery conditions* consists of the following parts:

— *Part 1: Seamless cold drawn tubes*

— *Part 2: Welded cold drawn tubes*

— *Part 3: Welded cold sized tubes*

— *Part 4: Seamless cold drawn tubes for hydraulic and pneumatic power systems*

— *Part 5: Welded cold sized square and rectangular tubes*

— *Part 6: Welded cold drawn tubes for hydraulic and pneumatic power systems*

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1 Scope

This European Standard specifies the technical delivery conditions for welded cold sized steel tubes of circular cross section for precision applications with specified outside diameter $D \leq 193{,}7$ mm.

This document may also be applied to other types (excluding square and rectangular) of cross section.

Tubes according to this document are characterized by having precisely defined tolerances on dimensions and a specified maximum surface roughness. Typical fields of application are in the vehicle, furniture and general engineering industries.

2 Normative references

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

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

EN 10021:2006, *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 10052:1993, *Vocabulary of heat treatment terms for ferrous products*

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

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

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

EN ISO 377, *Steel and steel products - Location and preparation of samples and test pieces for mechanical testing (ISO 3773)*

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

EN ISO 4287, *Geometrical product specifications (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters (ISO 4287)*

EN ISO 6892-1, *Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1)*

EN ISO 8492, *Metallic materials - Tube - Flattening test (ISO 8492)*

EN ISO 8493, *Metallic materials - Tube - Drift-expanding test (ISO 8493)*

EN ISO 10893-1, *Non-destructive testing of steel tubes - Part 1: Automated electromagnetic testing of seamless and welded (except submerged arc-welded) steel tubes for the verification of hydraulic leaktightness (ISO 10893-1)*

EN ISO 10893-2, *Non-destructive testing of steel tubes - Part 2: Automated eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections (ISO 10893-2)*

EN ISO 10893-3, *Non-destructive testing of steel tubes - Part 3: Automated full peripheral flux leakage testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for the detection of longitudinal and/or transverse imperfections (ISO 10893-3)*

EN ISO 10893-10, *Non-destructive testing of steel tubes - Part 10: Automated full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal and/or transverse imperfections (ISO 10893-10)*

EN ISO 10893-11, *Non-destructive testing of steel tubes - Part 11: Automated ultrasonic testing of the weld seam of welded steel tubes for the detection of longitudinal and/or transverse imperfections (ISO 10893-11)*

ISO 11484, *Steel products - Employer's qualification system for non-destructive testing (NDT) personnel*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 10020:2000, EN 10021:2006, EN 10052:1993, EN 10266:2003 and the following apply.

3.1
employer
organization for which a person works on a regular basis

Note 1 to entry: The employer may be either the tube manufacturer or a third party organization providing services, such as non-destructive testing (NDT).

3.2
manufacturer
party to produce and to deliver tubes in accordance with this document

Note 1 to entry: Where tubes are delivered through an intermediary, see EN 10021:2006, Clause 6.

3.3
imperfection
discontinuity in the wall or on the pipe surfaces detectable by methods described in this document

Note 1 to entry: Imperfections with a size complying with the acceptance criteria specified in this document are considered to have no practical implication on the intended use of the product.

3.4
defect
imperfection of a size not complying with the acceptance criteria specified in this document

Note 1 to entry: Defects are considered to adversely affect or limit the intended use of the product.

3.5
parent coil
coil originating from the hot rolling process prior to any subsequent operation (pickling, slitting, cold rolling or coating)

4 Symbols

For the purposes of this document, the symbols in EN 10266:2003 apply.

5 Classification and Designation

5.1 Classification

In accordance with the classification system in EN 10020 the steel grades given in Table 2 are non-alloy quality steels except steel grade E700 which is an alloy quality steel.

5.2 Designation

For the tubes covered by this document the steel designation consists of the number of this document (EN 10305-3) plus either:

a) the steel name in accordance with EN 10027-1; or

b) the steel number in accordance with EN 10027-2.

6 Information to be supplied by the purchaser

6.1 Mandatory information

The following information shall be obtained by the manufacturer at the time of enquiry and order:

a) the quantity (mass or total length or number);

b) the term "tube";

c) the dimensions (see 8.5.1);

d) the steel designation (see 5.2);

e) the delivery condition including the surface condition (see 7.2.1 and 7.2.2);

f) type of tube length and, where applicable, the length (see 8.5.2);

g) type of inspection document (see 9.1).

6.2 Options

A number of options are specified in this document and these are listed below. In the event that 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).

- Option 1: specification of a steel grade not specified in this document (see 8.2);
- Option 3: suitability for hot-dip galvanizing (see 8.2);
- Option 4: surface condition for further processing (see 8.4.1);
- Option 6: removal of internal weld bead (see 8.4.2);

- Option 8: measurement of surface roughness (see 8.4.4);
- Option 9: specific surface roughness (see 8.4.4);
- Option 11: non-destructive testing of the weld seam for the detection of longitudinal imperfections (see 8.4.8);
- Option 12: non-destructive testing for the detection of longitudinal imperfections (see 8.4.8 and 11.7);
- Option 13: non-destructive testing for verification of leak-tightness (see 8.4.8);
- Option 14: specification of a procedure to test transverse welds for the detection of imperfections (see 8.4.8);
- Option 15: specification of a cross section other than circular (see 8.5.1.1);
- Option 16: reduced diameter tolerances (see 8.5.1.2);
- Option 17: unilateral diameter tolerance (see 8.5.1.2);
- Option 19: reduced wall thickness tolerance (see 8.5.1.3);
- Option 20: unilateral wall thickness tolerance (see 8.5.1.3);
- Option 21: another specified length and/or tolerance (see 8.5.2);
- Option 22: reduced maximum deviation from straightness (see 8.5.3);
- Option 23: specified end finishing (see 8.5.4);
- Option 25: flattening or drift expanding test for delivery condition +A or +N (see Table 9);
- Option 26: test unit with tubes from one cast only (see 10.1);
- Option 27: more restrictive requirement on flattening test (see 11.2);
- Option 28: alternative marking (see Clause 12);
- Option 29: delivery without corrosion protection (see Clause 13);
- Option 30: specified corrosion protection (see Clause 13);
- Option 38: unbundled tubes or specific method of packaging (see Clause 13).

6.3 Example of an order

12 000 m tube with an outside diameter of D = 40 mm and a wall thickness of T = 1,5 mm in accordance with this document, made of steel grade E235 in the normalized condition, pickled, to be delivered in standard lengths of 6 m with an 3.1 inspection certificate in accordance with EN 10204.

12 000 m tubes – D 40 x T 1,5 – EN 10305-3 –E235+N – S2 – standard length – inspection certificate 3.1

7 Manufacturing process

7.1 Steelmaking process

The steelmaking process is at the discretion of the manufacturer with the exception that the open hearth (Siemens-Martin) process shall not be employed unless in combination with a secondary steelmaking or ladle refining process.

Steels shall be fully killed.

NOTE This excludes the use of rimming, balanced or semi-killed steel.

7.2 Tube manufacture and delivery conditions

7.2.1 The tubes shall be manufactured from strip by electric welding. The tubes shall not contain strip end welds except for tubes to be supplied coiled for which the delivery conditions +A or +N shall be specified.

Possible surface conditions are:

a) S1 (black);

b) S2 (pickled);

c) S3 (cold rolled);

d) S4 (coated to an agreed condition).

The surface conditions S1 and S3 apply for the strip. The surface condition S2 and S4 may apply for the strip or the tube; the purchaser should, where necessary, indicate the required condition at the time of enquiry and order.

7.2.2 Tubes made of the steel grades E155, E195, E235, E275 and E355 shall be supplied in the delivery condition +CR1 or +A or +N (see Table 1). Tubes made of the grades E190, E220, E260, E320, E370, E420, E460, E500, E550, E600 and E700 shall be supplied in the delivery condition +CR2.

7.2.3 All non-destructive testing (NDT) activities shall be carried out by qualified and competent level 1, 2 and/or 3 personnel authorized to operate by the employer.

The qualification shall be in accordance with ISO 11484 or, at least, an equivalent to it.

It is recommended that the level 3 personnel be certified in accordance with EN ISO 9712 or, at least, an equivalent to it.

The operating authorization issued by the employer shall be in accordance with a written procedure. NDT operations shall be authorized by a level 3 NDT individual approved by the employer.

NOTE The definition of levels 1, 2 and 3 can be found in appropriate standards, e.g. EN ISO 9712 and ISO 11484.

Table 1 — Delivery conditions

Designation	Symbol[a]	Description
Welded and cold sized	+CR1	Normally not heat treated, but suitable for final annealing. [b]
	+CR2	Not intended for heat treatment after the welding and sizing. [c]
Soft annealed	+A	After welding and sizing the tubes are annealed in a controlled atmosphere.
Normalized	+N	After welding and sizing the tubes are normalized in a controlled atmosphere.

[a] In accordance with EN 10027–1.

[b] After annealing or normalizing, the resulting mechanical properties meet the requirements specified in Table 4 for the delivery condition +A or +N, respectively.

[c] If further heat treatment is applied, the resulting mechanical properties may be outside the specified requirements.

8 Requirements

8.1 General

The tubes, when supplied in a delivery condition indicated in Table 1 and inspected in accordance with Clauses 9, 10 and 11, shall comply with the requirements of this document.

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 apply and comply with the requirements of Table 2. A steel grade not specified in this document may be specified (see option 1).

NOTE When subsequently welding tubes produced in accordance with this document, it is important to take account of the fact that the behaviour of the steel during and after welding is dependent not only on the steel composition and the delivery condition but also on the conditions of preparing for and carrying out the welding.

Option 1: *A steel grade not specified in this document with a maximum total content of alloying elements of 5 % and agreed chemical composition, mechanical properties and delivery condition, is specified.*

Where the steel grade specified is a strip grade, the mechanical properties of the tube can be considerably different to those of the strip. Accordingly, in such cases, mechanical properties for the tube should be agreed between the manufacturer and customer at the time of enquiry and order.

Option 3: *The composition of the specified steel grade shall be such that it is suitable for hot-dip galvanizing (see e.g.* EN ISO 1461 *or* EN ISO 14713-2 *for guidance).*

Table 2 — Chemical composition (cast analysis)

Steel grade		in % by mass					
Steel name	**Steel number**	**C** max.	**Si** max.	**Mn** max.	**P** max.	**S** max.	**Al_{total}** [a] min.
E155	1.0033	0,11	0,35	0,70	0,025	0,025	0,015
E190	1.0031	0,10					
E195	1.0034	0,15	0,35	0,70	0,025	0,025	0,015
E220	1.0215	0,14					
E235	1.0308	0,17	0,35	1,20	0,025	0,025	0,015
E260	1.0220	0,16					
E275	1.0225	0,21	0,35	1,40	0,025	0,025	0,015
E320	1.0237	0,20					
E355	1.0580	0,22	0,55	1,60	0,025	0,025	0,020
E370	1.0261	0,21					
E420	1.0575	0,16	0,55	1,70	0,025	0,025	0,020
E460	1.0435	0,16					
E500	1.0519	0,16	0,55	1,70	0,025	0,025	0,020
E550	1.0593	0,16	0,55	1,80	0,025	0,025	0,020
E600	1.0595	0,16	0,60	1,80	0,025	0,025	0,020
E700	1.0987	0,16	0,60	2,10	0,025	0,025	0,020

Elements not quoted in this table (but see footnote [a]) shall not be intentionally added to the steel without the agreement of the purchaser, except for elements which may be added for the purposes of deoxidation and/or nitrogen binding. All appropriate measures shall be taken to prevent the addition of undesirable elements from scrap or other materials used in the steel making process.

[a] This requirement is not applicable provided the steel contains a sufficient amount of other nitrogen binding elements, such as Ti, Nb or V. If added, the content of these elements shall be reported in the inspection document. When using titanium, the manufacturer shall verify that $(Al + Ti/2) \geq 0,020$.

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

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

Element	Limiting value for cast analysis in accordance with Table 2 % by mass	Permissible deviation of the product analysis % by mass
C	≤ 0,22	+ 0,02
Si	≤ 0,55	+ 0,05
Mn	≤ 1,70	+ 0,10
P	≤ 0,025	+ 0,005
S	≤ 0,025	+ 0,005
Al	≥ 0,015	- 0,005

8.3 Mechanical properties

The mechanical properties of the tubes shall conform to the requirements of Tables 4 and 5 and, if specified, to Option 25.

NOTE Subsequent processing (cold or hot) may change the mechanical properties.

Table 4 — Mechanical properties at room temperature for the delivery conditions +CR1, +A and +N

Steel grade		Minimum values for the delivery conditions[a]						
		+CR1[b]		+A		+N		
Steel name	Steel number	R_m MPa	A %	R_m MPa	A %	R_m MPa	R_{eH}[c] MPa	A %
E155	1.0033	290	15	260	28	270 to 410	155	28
E195	1.0034	330	8	290	28	300 to 440	195	28
E235	1.0308	390	7	315	25	340 to 480	235	25
E275	1.0225	440	6	390	22	410 to 550	275	22
E355	1.0580	540	5	450	22	490 to 630	355	22

NOTE The mechanical properties and technological properties of the weld zone may, in the case of the delivery conditions +CR1 and +A, differ from those of the base material.

[a] R_m: tensile strength; R_{eH}: upper yield strength (but see 11.1); A: elongation after fracture. For symbols for the delivery conditions, see Table 1.

[b] Depending on the degree of cold forming the strip material and sizing the as welded tube, the yield strength may nearly be as high as the tensile strength. For calculation purposes yield strength values of $R_{eH} \geq 0,7\ R_m$ are recommended in the +CR1 condition.

[c] For tubes with outside diameter ≤ 30 mm and wall thickness ≤ 3 mm the R_{eH} minimum values are 10 MPa lower than the values given in this table.

Table 5 — Mechanical properties at room temperature for the delivery condition +CR2

Steel grade		Minimum values for the delivery condition[a] +CR2		
Steel name	Steel number	R_m MPa	R_{eH} MPa	A %
E190	1.0031	270	190	26
E220	1.0215	310	220	23
E260	1.0220	340	260	21
E320	1.0237	410	320	19
E370	1.0261	450	370	15
E420	1.0575	490	420	12
E460	1.0435	510	460	9
E500	1.0519	540	500	8
E550	1.0593	590	550	7
E600	1.0595	640	600	6
E700	1.0987	740	700	5

NOTE The mechanical and technological properties of the weld zone may differ from those of the base material.

[a] R_m: tensile strength; R_{eH}: upper yield strength (but see 11.1); A: elongation after fracture. For the symbol for the delivery condition, see Table 1.

8.4 Appearance and internal soundness

8.4.1 The internal and external surface finish of the tubes shall be typical of the manufacturing process and, where applicable, the heat treatment employed.

***Option 4**: A surface condition suitable for special further processing is specified by the purchaser.*

Normally, the finish and surface condition shall be workmanlike such that any surface imperfections requiring dressing can be identified. Any surface imperfections, which in accordance with the manufacturer's experience might be considered defects as specified in 8.4.5, shall be dressed in accordance with 8.4.6, or the tube or part of tube shall be rejected.

8.4.2 The external weld bead shall be removed flush with the surface. The height of the internal weld is not limited, unless option 6 is specified.

***Option 6:** The height of the internal weld bead shall not exceed a specified value or be removed.*

The wall thickness in the weld area shall not be lower than the specified minimum wall thickness.

8.4.3 Outside the weld area, the roughness on the outside surface shall be: $Ra \leq 4$ µm.

8.4.4 Verification of surface roughness and/or improved levels of roughness may be specified (see options 8 and 9).

***Option 8**: The surface roughness shall be measured in accordance with 11.5 and reported.*

***Option 9:** A specific surface roughness of agreed type and limiting value is specified. The roughness shall be measured and reported.*

8.4.5 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 document.

8.4.6 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.

8.4.7 Tubes in the delivery condition +A or +N shall be free of loose scale but may show discoloration.

8.4.8 Verification of internal soundness by non-destructive testing may be specified by the purchaser (see options 11 to 13).

Option 11: *Non-destructive testing of the weld seam for the detection of longitudinal imperfections shall be carried out in accordance with 11.7.1 is specified.*

Option 12: *Non-destructive testing of the full tube circumference for the detection of longitudinal imperfections in accordance with 11.7.1 is specified.*

Option 13: *Non-destructive testing for verification of leak tightness shall be carried out in accordance with 11.7.2.*

Strip end welds on tubes to be supplied coiled shall be subjected to additional testing. The testing method is left to the discretion of the manufacturer, unless option 14 is specified.

Option 14: *A testing procedure (with agreed type of test and acceptance criteria) for the detection of imperfections in transverse welds is specified.*

8.5 Dimensions and tolerances

8.5.1 Outside diameter and wall thickness

8.5.1.1 Circular tubes shall be specified by outside diameter and wall thickness (but see option 15).

Cross sections other than circular may be specified.

Option 15: *A cross section other than circular (except square and rectangular) is specified and the position of the weld line, a) or b) or c) or d), is specified by the purchaser. The deviation of the weld line from a specified position shall be:*

a) narrow side (from the centre line): ± 10 % of side length or ± 3 mm whichever is the greater;

b) wide side (from the centre line): ± 10 % of side length or ± 3 mm whichever is the greater;

c) corner: the weld shall be within the corner radius defined by C_1 and C_2 (see EN 10305-5, Figure 1);

d) any other position: agreed tolerance.

8.5.1.2 Preferred diameters and wall thicknesses, as well as diameter tolerances and masses per unit length, are given in Table 6.

For intermediate sizes, the tolerances of the next greater size apply.

The diameter tolerances include the out-of-roundness. For a maximum distance of 100 mm, the ends may, due to the cutting method, have diameters outside the tolerances.

The diameter tolerances given in Table 6 apply for tubes in delivery conditions +CR1 and +CR2. Depending on the ratio of wall thickness and diameter the diameter tolerances of heat treated tubes in delivery condition +A and +N are given by consideration of the corrective factors in Table 7. Other diameter tolerances may be specified (see options 16 and 17).

Option 16: *A reduced diameter tolerance is specified.*

Option 17: *The diameter tolerances shall be unilateral, within the corresponding tolerance range specified in Table 6.*

Table 6 — Sizes and diameter tolerances

Dimensions in millimetres

Outside diameter D and tolerances		Wall thickness T (mm)															
		0,6	0,8	1	1,2	1,5	1,8	2	2,2	2,5	3	3,5	4	4,5	5	5,5	6
		Mass per unit length (kg/m)															
6	±0,12	0,080	0,103	0,123													
8		0,109	0,142	0,173	0,201	0,240											
10		0,139	0,182	0,222	0,260	0,314											
12		0,169	0,221	0,271	0,320	0,388	0,453	0,493									
15		0,213	0,280	0,345	0,408	0,499	0,586	0,641	0,694								
16		0,228	0,300	0,370	0,438	0,536	0,630	0,691	0,749								
18		0,257	0,339	0,419	0,497	0,610	0,719	0,789	0,857	0,956							
19		0,272	0,359	0,444	0,527	0,647	0,764	0,838	0,911	1,02	1,18						
20	±0,15	0,287	0,379	0,469	0,556	0,684	0,808	0,888	0,966	1,08	1,26						
22		0,317	0,418	0,518	0,616	0,758	0,897	0,986	1,07	1,20	1,41						
25		0,361	0,477	0,592	0,704	0,869	1,03	1,13	1,24	1,39	1,63						
28		0,405	0,537	0,666	0,793	0,980	1,16	1,28	1,40	1,57	1,85	2,11					
30		0,435	0,576	0,715	0,852	1,05	1,25	1,38	1,51	1,70	2,00	2,29					
32	±0,20		0,616	0,765	0,911	1,13	1,34	1,48	1,62	1,82	2,15	2,46					
35				0,838	1,00	1,24	1,47	1,63	1,78	2,00	2,37	2,72					
38				0,912	1,09	1,35	1,61	1,78	1,94	2,19	2,59	2,98	3,35				
40				0,962	1,15	1,42	1,70	1,87	2,05	2,31	2,74	3,15	3,55				
42				1,01	1,21	1,50	1,78	1,97	2,16	2,44	2,89	3,32	3,75				
42,4				1,02	1,22	1,51	1,80	1,99	2,18	2,46	2,91	3,36	3,79				
44	±0,25			1,06	1,27	1,57	1,87	2,07	2,27	2,56	3,03	3,50	3,95				
45				1,09	1,30	1,61	1,92	2,12	2,32	2,62	3,11	3,58	4,04				
48,3				1,17	1,39	1,73	2,06	2,28	2,50	2,82	3,35	3,87	4,37	4,86			
50				1,21	1,44	1,79	2,14	2,37	2,59	2,93	3,48	4,01	4,54	5,05			
51					1,47	1,83	2,18	2,42	2,65	2,99	3,55	4,10	4,64	5,16			
55	±0,30				1,59	1,98	2,36	2,61	2,86	3,24	3,85	4,45	5,03	5,60			
57					1,65	2,05	2,45	2,71	2,97	3,36	4,00	4,62	5,23	5,83			
60					1,74	2,16	2,58	2,86	3,14	3,55	4,22	4,88	5,52	6,16	6,78	7,39	
63,5					1,84	2,29	2,74	3,03	3,33	3,76	4,48	5,18	5,87	6,55	7,21	7,87	
70	±0,35				2,04	2,53	3,03	3,35	3,68	4,16	4,96	5,74	6,51	7,27	8,01	8,75	
76					2,21	2,76	3,29	3,65	4,00	4,53	5,40	6,26	7,10	7,93	8,75	9,56	
80	±0,40				2,33	2,90	3,47	3,85	4,22	4,78	5,70	6,60	7,50	8,38	9,25	10,1	
89						3,24	3,87	4,29	4,71	5,33	6,36	7,38	8,38	9,38	10,4	11,3	12,3
90						3,27	3,92	4,34	4,76	5,39	6,44	7,47	8,48	9,49	10,5	11,5	12,4
100	±0,50					3,64	4,36	4,83	5,31	6,01	7,18	8,33	9,47	10,6	11,7	12,8	13,9
101,6						3,70	4,43	4,91	5,39	6,11	7,29	8,47	9,63	10,8	11,9	13,0	14,1
108	±0,60					3,94	4,71	5,23	5,74	6,50	7,77	9,02	10,3	11,5	12,7	13,9	15,1
114							4,98	5,52	6,07	6,87	8,21	9,54	10,9	12,2	13,4	14,7	16,0
120							5,25	5,82	6,39	7,24	8,66	10,1	11,4	12,8	14,2	15,5	16,9
127	±0,8						5,56	6,17	6,77	7,68	9,17	10,7	12,1	13,6	15,0	16,5	17,9
133							5,82	6,46	7,10	8,05	9,62	11,2	12,7	14,3	15,8	17,3	18,8
139,7							6,12	6,79	7,46	8,46	10,1	11,8	13,4	15,0	16,6	18,2	19,8
159	±1,0						6,98	7,74	8,51	9,65	11,5	13,4	15,3	17,1	19,0	20,8	22,6
168							7,38	8,19	9,00	10,2	12,2	14,2	16,2	18,1	20,1	22,0	24,0
193,7									10,4	11,8	14,1	16,4	18,7	21,0	23,3	25,5	27,8

Table 7 — Diameter tolerances for heat treated tubes

T/D-ratio	Tolerance of Table 6 to be multiplied by
≥ 0,05	1
0,05 > *T/D* ≥ 0,025	1,5
< 0,025	2

8.5.1.3 Depending on the wall thickness *T*, the following tolerances are specified:

a) $T \leq 1{,}5$ mm: ± 0,15 mm;

b) $T > 1{,}5$ mm: ± 0,1 *T* or ± 0,35 mm whichever is the smaller.

The plus tolerance does not apply to the weld area. Other wall thickness tolerances may be specified (see options 19 and 20).

Option 19: *A reduced wall thickness tolerance is specified.*

Option 20: *A unilateral wall thickness tolerance within the tolerance range specified in 8.5.1.3, first paragraph, is specified.*

8.5.2 Lengths

The type of tube length shall be specified at the time of enquiry and order by either:

a) standard length, meaning a length of 6 m whose tolerance shall be $^{+50}_{0}$ mm; or

b) exact length (but see option 21), meaning specified lengths with tolerances as given in Table 8. For specified lengths ≤ 500 mm or > 8 000 mm, tolerances shall be agreed in accordance with Table 8.

Table 8 — Tolerances for exact lengths

Length *L* mm	**Tolerance** mm
≤ 500	+ by agreement 0
500 < *L* ≤ 2 000	$^{+3}_{0}$
2 000 < *L* ≤ 5 000	$^{+5}_{0}$
5 000 < *L* ≤ 8 000	$^{+10}_{0}$
> 8 000	+ by agreement 0

Option 21: *Another length and/or tolerance is specified.*

8.5.3 Straightness

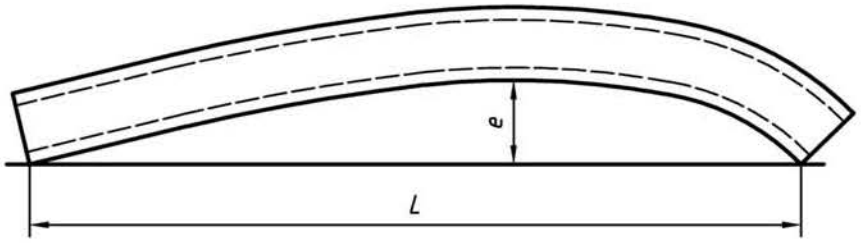
For tubes, other than coiled tubing, with an outside diameter greater than 15 mm, the deviation from straightness of any tube length L shall not exceed 0,002 L.

Deviations from straightness over one metre length shall not exceed 3 mm, unless option 22 is specified.

Option 22: *A reduced maximum deviation from straightness is specified.*

For exact lengths less than 1 000 mm with an outside diameter $D > 15$ mm, the deviation from straightness of any tube length L measured in accordance with Figure 1 shall not exceed 0,003 L.

NOTE For tubes with an outside diameter $D \leq 15$ mm a maximum deviation from specified straightness and the inspection method to be used may be agreed.



Key

L tube length

e deviation from straightness

Figure 1 — Measurement of deviation from straightness *e*

8.5.4 Preparation of ends

The tubes shall be delivered with square cut ends. The ends shall be free of harmful burrs.

Option 23: *A specified end finishing shall be carried out.*

9 Inspection

9.1 Types of inspection

Products complying with this document shall be ordered and delivered with one of the inspection documents as specified in EN 10204. The type of document shall be agreed upon at the time of enquiry and order. If the order does not contain any specification of this type, a test report 2.2 shall be issued.

9.2 Inspection documents

9.2.1 Types of inspection documents

In the case of non-specific inspection a test report 2.2 in accordance with EN 10204 shall be issued.

When specific inspection is requested, an inspection certificate 3.1 or 3.2 in accordance with EN 10204 shall be issued. If an inspection certificate 3.2 is ordered, the purchaser shall additionally supply to the manufacturer the name and address of the organization or person nominated to carry out the inspection. It shall be agreed which party shall issue the certificate.

9.2.2 Content of inspection documents

9.2.2.1 The content of the inspection document shall be in accordance with EN 10168 as shown in 9.2.2.2 and 9.2.2.3.

9.2.2.2 For tubes supplied with non-specific inspection the test report 2.2 shall contain the following codes and information:

A	commercial transactions and parties involved;
B	description of products to which the inspection document applies;
C10 to C13	tensile test;
C60 to C69	other tests;
C71 to C92	chemical composition;
D01	marking and identification, surface appearance, shape and dimensional properties;
Z	validation.

9.2.2.3 For tubes supplied with specific inspection the inspection certificate 3.1 or 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;
C10 to C13	tensile tests;
C60 to C69	other tests;
C71 to C92	chemical composition (cast analysis);
D01	marking and identification, surface appearance, shape and dimensional properties;
D02 to D99	other (optional) tests (e.g. roughness measurement, NDT for defects);
Z	validation.

9.3 Summary of inspection and testing

Inspection and testing shall be carried out as stated in Table 9 and 10.1.

Table 9 — Summary of inspection and testing

Type of inspection or test		Frequency of testing[a]		Reference
		Non-specific inspection	Specific inspection	
Mandatory	Chemical analysis	M	M	8.2
	Tensile test	M	One per test unit	8.3, 11.1
	Dimensional inspection	M	M	8.5, 11.4
	Visual examination	M	M	11.6
Optional	Flattening test or drift expanding test (Option 25)[b]	M	One per test unit	11.2, 11.3
	Roughness measurement (Options 8 and 9)	not applicable	One per test unit	8.4.4, 11.5
	NDT of the weld seam on longitudinal imperfections (Option 11)	not applicable	Each individual tube	8.4.8, 11.7.1
	NDT for longitudinal imperfections (Option 12)			8.4.8, 11.7.1
	NDT for verification of leak tightness (Option 13)			8.4.8, 11.7.2
	NDT of the transverse weld seam for imperfections (Option 14)			8.4.8, 11.7.3

[a] M: According to manufacturer's procedure.

[b] ***Option 25:*** *For tubes in the delivery condition soft annealed (+A) or normalized (+N) a flattening test or a drift expanding test shall be carried out. The test method is at the discretion of the manufacturer.*

10 Sampling

10.1 Test unit

A test unit is defined as a quantity of tubes of the same steel grade and dimensions continuously manufactured by the same process and in the same delivery condition heat treated, where applicable, in the same batch and the same heat treatment facility.

NOTE In the case of a continuous heat treatment furnace a batch is the lot heat treated without intermission with the same process parameters.

A test unit shall comprise not more than 2 t or 3 000 m or 500 tubes or the parent coil for non-heat treated tubes, whichever is the greater mass. Residual quantities of less than 50 tubes may be combined with one ore more test unit(s).

Option 26: *The test unit shall only contain tubes from one cast.*

10.2 Preparation of samples and test pieces

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

10.2.1.1 General

Samples and test pieces shall be taken at the tube ends and in accordance with EN ISO 377 from one sample tube per test unit.

10.2.1.2 Test pieces for the tensile test

The test pieces shall be prepared in accordance with EN ISO 6892-1. At the manufacturer's discretion the test piece is either a full tube section or a strip section not containing the weld seam taken in a direction longitudinal to the axis of the tube.

10.2.1.3 Test pieces for the flattening or drift expanding test

The test pieces shall consist of a full tube section, in accordance with EN ISO 8492 or EN ISO 8493 respectively.

10.2.2 Test pieces for roughness measurement

The test pieces should be taken from the same location as for the mechanical tests. At the manufacturer's discretion the test piece shall be either a full tube section or be taken in a direction longitudinal to the axis of a full section at random.

11 Test methods

11.1 Tensile test

The test shall be carried out at room temperature in accordance with EN ISO 6892-1 and the following determined:

a) the tensile strength R_m;

b) the upper yield strength R_{eH};

   If a yield phenomenon is not present the 0,2 % proof strength $R_{p0,2}$ or the 0,5 % proof strength (total extension) $R_{t0,5}$ shall be determined. In case of dispute, the 0,2 % proof strength $R_{p0,2}$ shall apply.

c) the percentage elongation A after fracture with a reference to a gauge length L_0 of $5,65\sqrt{S_0}$.

If a non-proportional test piece is used, the percentage elongation value shall be converted to the value for a gauge length $L_0 = 5,65\sqrt{S_0}$ using the conversion tables given in EN ISO 2566-1.

11.2 Flattening test

The test shall be carried out in accordance with EN ISO 8492 provided the wall thickness T is less than 15 % of the outside diameter. The tube section shall be flattened in a press until the distance H between the platens reaches the value given by the following formula:

$$H = \frac{(1+C)\,x\,T}{C + \frac{T}{D}} \qquad (1)$$

where

H is the distance between the platens, in millimetres (mm), to be measured under load;

D is the specified outside diameter, in millimetres (mm);

T is the specified wall thickness, in millimetres (mm);

C is a factor, the value of which is given in Table 10, unless option 27 is specified.

Table 10 — Values of factor *C* (delivery conditions +A and +N)

Steel grade		*C*
Steel name	**Steel number**	
E155	1.0033	0,10
E195	1.0034	0,09
E235	1.0308	0,09
E275	1.0225	0,07
E355	1.0580	0,07

Option 27: *A higher value of factor C is specified.*

After testing, the test piece shall be free from cracks or breaks. However, a slight cracking at the edges shall not be considered cause for rejection.

11.3 Drift expanding test

The test shall be carried out in accordance to EN ISO 8493 with a 60° conical mandrel. The tube section shall be expanded until the percentage increase in outside diameter shown in Table 11 is reached.

Table 11 — Requirements for the drift expanding test (delivery conditions +A and +N)

Steel grade		% increase of the diameter *D* for	
Steel name	**Steel number**	$T \leq 4$ mm	$T > 4$ mm
E155	1.0033	22	17
E195	1.0034	20	15
E235	1.0308	18	12
E275	1.0225	15	10
E355	1.0580	15	10

After testing, the test piece shall be free from cracks or breaks. However, a slight cracking at the edges shall not be considered cause for rejection.

11.4 Dimensional inspection

Specified dimensions, including straightness, shall be verified. Diameter measurements shall be carried out at a distance of ≥ 100 mm from the tube ends (see 8.5.1.2).

11.5 Roughness measurement

Roughness shall be measured in the axial direction in accordance with EN ISO 4287 outside the weld bead.

11.6 Visual examination

The tubes shall be visually examined for compliance with the requirements of 8.4.1.

11.7 Non-destructive testing

11.7.1 Testing for longitudinal imperfections

Non-destructive testing of the weld seam or of the full tube circumference for the detection of longitudinal imperfections shall be carried out at the discretion of the manufacturer, either prior to or after sizing, in accordance with one or more of the following methods:

a) eddy current testing: EN ISO 10893-2, acceptance level E3 or E3H;

b) magnetic transducer/flux leakage testing: EN ISO 10893-3, acceptance level F3;

c) ultrasonic testing: EN ISO 10893-10, acceptance level U3C;

d) ultrasonic testing: EN ISO 10893-11, acceptance level U3.

11.7.2 Leak-tightness

Non-destructive testing for verification of leak-tightness shall be carried out in accordance with EN ISO 10893-1.

11.7.3 Testing of transverse welds for imperfections

See 8.4.8 and option 14.

11.8 Retests, sorting and reprocessing

For retests, sorting and reprocessing EN 10021 applies.

12 Marking

Unless option 28 is specified, the following marking shall be shown on a label attached to the package unit or, where necessary for identification, to the single tube:

a) the manufacturer's name or trade mark;

b) the specified dimensions;

c) the number of this European Standard;

d) the steel name or number;

e) the delivery condition including the surface condition (symbol);

f) the cast number, when option 26 applies;

g) in the case of specific inspection, an identification number (e.g. order or item number) which permits the correlation of the product or delivery unit to the related document.

Option 28: *Alternative marking is specified.*

13 Protection and packaging

The tubes shall be delivered with a temporary corrosion protection. The type of protection shall be at the discretion of the manufacturer, unless option 29 or 30 is specified.

Option 29: *The tubes shall be delivered without corrosion protection.*

Option 30: *The tubes shall be delivered with a specified corrosion protection to be agreed at the time of enquiry and order.*

NOTE Unprotected tubes are prone to corrosion at any stage of storage or transportation.

The tubes shall be delivered bundled, unless option 38 is specified.

Option 38: *Supply of unbundled tubes or application of a specific packaging method is specified.*

Bibliography

[1] EN ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods (ISO 1461)*

[2] EN ISO 9712, *Non-destructive testing - Qualification and certification of NDT personnel (ISO 9712)*

[3] EN ISO 14713-2, *Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures - Part 2: Hot dip galvanizing*

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