INTERNATIONAL STANDARD

ISO 9330-2

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Welded steel tubes for pressure purposes — Technical delivery conditions —

Part 2:
Electric resistance and induction welded unalloyed and alloyed steel tubes with specified elevated temperature properties

Tubes en acier soudés pour service sous pression — Conditions techniques de livraison —

Partie 2: Tubes soudés par résistance électrique et par induction en aciers non alliés et alliés avec caractéristiques spécifiées à température élevée

Reference number
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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9330-2 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 19, *Technical delivery conditions for steel tubes for pressure purposes.*

It constitutes a partial revision of ISO 2604-3:1975.

ISO 9330 consists of the following parts, under the general title *Welded steel tubes for pressure purposes — Technical delivery conditions*:

— *Part 1: Unalloyed steel tubes with specified room temperature properties*

— *Part 2: Electric resistance and induction welded unalloyed and alloyed steel tubes with specified elevated temperature properties (Partial revision of ISO 2604-3:1975)*

— *Part 3: Electric resistance and induction welded unalloyed and alloyed steel tubes with specified low temperature properties (Partial revision of ISO 2604-3:1975)*

— *Part 4: Submerged arc-welded unalloyed and alloyed steel tubes with specified elevated temperature properties (Partial revision of ISO 2604-6:1978)*

— *Part 5: Submerged arc-welded unalloyed and alloyed steel tubes with specified low temperature properties (Partial revision of ISO 2604-6:1978)*

— *Part 6: Longitudinally welded austenitic stainless steel tubes*

Annex A of this part of ISO 9330 is for information only.

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Welded steel tubes for pressure purposes — Technical delivery conditions —

Part 2:
Electric resistance and induction welded unalloyed and alloyed steel tubes with specified elevated temperature properties

1 Scope

1.1 This part of ISO 9330 specifies the technical delivery conditions for electric resistance and induction welded tubes of circular cross-section having wall thickness up to and including 16 mm, made of unalloyed and alloyed steels with specified elevated temperature properties.

These tubes are intended for pressure purposes, in cases when the material is also subjected to elevated temperatures, e.g. for the construction of steam generating equipment and for interconnecting pipework.

The requirements of appropriate international application standards and relevant national legal regulations shall be taken into account by the user. For boilers and pressure vessels, ISO/R 831 and ISO 5730 are available.

The following parts of ISO 9330 are now available or are being prepared:

— *Part 1: Unalloyed steel tubes with specified room temperature properties* (partial revision of ISO 2604-3:1975 and of ISO 2604-6:1978).

— *Part 3: Electric resistance and induction welded unalloyed and alloyed steel tubes with specified low temperature properties* (partial revision of ISO 2604-3:1975).

— *Part 4: Submerged arc-welded unalloyed and alloyed steel tubes with specified elevated temperature properties* (partial revision of ISO 2604-6:1978).

— *Part 5: Submerged arc-welded unalloyed and alloyed steel tubes with specified low temperature properties* (partial revision of ISO 2604-6:1978).

— *Part 6: Longitudinally welded austenitic stainless steel tubes* (revision of ISO 2604-5:1978).

NOTE 1 The English words "tube" and "pipe" are synonymous.

1.2 See ISO 404 for general technical delivery requirements.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 9330. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 9330 are encouraged to investigate the possibility of applying the most recent editions of the

standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 377-1:1989, *Selection and preparation of samples and test pieces of wrought steels — Part 1: Samples and test pieces for mechanical test.*

ISO 377-2:1989, *Selection and preparation of samples and test pieces of wrought steels — Part 2: Samples for the determination of the chemical composition.*

ISO 404:1992, *Steel and steel products — General technical delivery requirements.*

ISO 783:1989, *Metallic materials — Tensile testing at elevated temperature.*

ISO/R 831:1968, *Rules for construction of stationary boilers.*

ISO 1129:1980, *Steel tubes for boilers, superheaters and heat exchangers — Dimensions, tolerances and conventional masses per unit length.*

ISO 2566-1:1984, *Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels.*

ISO 3205:1976, *Preferred test temperatures.*

ISO 3545-1:1989, *Steel tubes and fittings — Symbols for use in specifications — Part 1: Tubes and tubular accessories with circular cross-section.*

ISO 4200:1991, *Plain end steel tubes, welded and seamless — General tables of dimensions and masses per unit length.*

ISO/TR 4949:1989, *Steel names based on letter symbols.*

ISO 5252:1991, *Steel tubes — Tolerance systems.*

ISO 5730:1992, *Stationary shell boilers of welded construction (other than water-tube boilers).*

ISO 6761:1981, *Steel tubes — Preparation of ends of tubes and fittings for welding.*

ISO 6892:1984, *Metallic materials — Tensile testing.*

ISO 7438:1985, *Metallic materials — Bend test.*

ISO 8492:1986, *Metallic materials — Tube — Flattening test.*

ISO 8493:1986, *Metallic materials — Tube — Drift expanding test.*

ISO 8495:1986, *Metallic materials — Tube — Ring expanding test.*

ISO 8496:1986, *Metallic materials — Tube — Ring tensile test.*

ISO 9302:1994, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Electromagnetic testing for verification of hydraulic leak-tightness.*

ISO 9303:1989, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Full peripheral ultrasonic testing for the detection of longitudinal imperfections.*

ISO 9764:1989, *Electric resistance and induction welded steel tubes for pressure purposes — Ultrasonic testing of the weld seam for the detection of longitudinal imperfections.*

ISO/TR 9769:1981, *Steel and iron — Review of available methods of analysis.*

ISO 10332:1994, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Ultrasonic testing for the verification of hydraulic leak-tightness.*

ISO 10474:1991, *Steel and steel products — Inspection documents.*

3 Symbols and denominations

3.1 Fundamental symbols

D = specified outside diameter

D_i = specified inside diameter

T = specified wall thickness

3.2 Symbols for tolerances

See ISO 5252.

3.3 Symbols for tests

3.3.1 Tensile test

See ISO 6892.

3.3.2 Flattening test

H = distance between platens

3.3.3 Hydraulic test

PE = test pressure

S = stress which occurs in the metal during the test

4 Information to be supplied by the purchaser

4.1 Mandatory information

The purchaser shall state on his enquiry and order the following information:

— the denomination "tube";

— whether tubes are to be supplied hot-finished or cold-finished (see 5.3);

— reference to the relevant dimensional standard;

— dimensions (outside diameter × wall thickness) in millimetres (see 7.1);

— length (see 7.2);

— tolerances, if exact lengths greater than 12 m are ordered (see 7.3.3);

— reference to this part of ISO 9330;

— steel grade (see table 2);

— test category for unalloyed steels (see 9.2).

4.2 Optional information

Enquiries and orders for tubes in accordance with this part of ISO 9330 shall be supplemented, if it is deemed necessary by the purchaser, with the indication of one or more of the following optional requirements, which shall be the subject of special agreements:

— steelmaking process (see 5.1);

— delivery condition (see 5.4);

— special straightness requirements (see 7.3.5);

— bevelled ends (see 8.2);

— product chemical analysis (see 9.3 and 9.10.1)

— tensile testing of weld for tubes over 219 mm but with an outside diameter less than 508 mm (see 9.4.1.3);

— determination of proof stress at elevated temperature, $R_{p0,2}$ (see 9.4.2);

— leak-tightness test (see 9.5);

— specific marking (see 10.3);

— protective coating (see clause 11);

— type of inspection and testing and corresponding document (see 9.1 and clause 12).

4.3 Example of an order

Example of an order for a welded tube conforming to the dimensional standard ISO 4200, with an outside diameter of 168,3 mm, a wall thickness of 4 mm and a standard length (random length) of 4 m to 8 m, made of steel grade PH 23 with specified elevated temperature properties to be submitted to specific inspection and testing to test category I involving the issuing of an inspection certificate 3.1.B according to ISO 10474:

Tube ISO 4200 - 168,3 × 4 - 4 to 8 - ISO 9330-2 - PH 23 - I - 3.1.B

5 Manufacturing process

5.1 Steelmaking process

If requested, the purchaser shall be informed of the steelmaking process used.

Steels may be cast in ingots or may be strand cast. When steels of different grades are sequentially strand cast, identification of the resultant transitional material is required. The producer shall remove the transitional material by an established procedure that efficiently separates the grades.

5.2 Deoxidation process

Steels intended for the production of tubes covered by this part of ISO 9330 shall be fully killed.

5.3 Product-making process for tubes

Tubes covered by this part of ISO 9330 may be hot-finished or cold-finished (see table 1). The terms "hot-finished" and "cold-finished" apply to the condition of the tube before it is heat treated in accordance with 5.4. Tubes shall be electric resistance or induction (ERW) welded. No filler metal shall be used during the welding process. Unless otherwise agreed, the process of manufacture is left to the discretion of the manufacturer.

NOTES

2 A welded tube is a tubular product obtained by shaping a flat-rolled product and then welding the edges. The welds may be longitudinal.

3 Tubes manufactured by the electric resistance or induction welding process have a longitudinal weld formed by means of pressure applied to the edges of the strip which have been heated to welding temperature by the resistance to the passage of an electric current at, and adjacent to, these surfaces. The electric current may be passed either by direct contact or induction methods. No filler metal is used during the welding process.

4 "Normalized" includes "hot-finished", provided the manufacturer can show that hot finishing produces a technically equivalent metallurgical condition (see tables 1 and 8).

5.4 Delivery conditions

5.4.1 Tubes covered by this part of ISO 9330 shall be delivered in accordance with table 1 and the appropriate heat-treatment conditions indicated in table 8.

The heat-treatment temperatures in table 8 are given as a guide.

5.4.2 By agreement between the purchaser and the manufacturer, the tubes may be delivered in a condition other than the final heat-treated condition given in table 8, in which case they shall be suitable for subsequent manipulation and the purchaser shall be informed of the heat treatment necessary to attain the required properties.

Table 1 — Delivery conditions

Cold/hot formed, welded and hot finished	Cold formed and welded	Cold formed, welded and cold drawn
Heat treatment on full tube according to table 8 or no heat treatment for steel grades PH 23, PH 26, PH 27 and PH 35, if hot finishing produces a technically equivalent metallurgical condition[1)]	Heat treatment on full tube according to table 8	Heat treatment on full tube according to table 8

1) The methods of control to achieve this equivalence have to be agreed between the purchaser and the manufacturer.

6 Metallurgical properties

6.1 Chemical composition

6.1.1 Heat analysis

On heat analysis, the steel shall show the composition given in table 2 appropriate to the specified steel grade.

6.1.2 Product analysis

If a check analysis on the product is required (see 9.3), the permissible deviations given in table 3 shall apply to the heat analysis specified in table 2.

The deviations, other than when maxima only are specified, apply either above or below the specified limits of the range, but no both above and below, for the same element from different sample products from the same heat.

When maxima only are specified, the deviations are positive only.

Table 2 — Chemical composition (heat analysis), [% (*m/m*)]

Steel grade[1]		C	Si	Mn	P max.	S max.	Cr	Mo	Al total max.
Unalloyed steels	PH 23	⩽ 0,17	⩽ 0,35	0,40 to 1,20	0,035	0,030	—	—	—
	PH 26	⩽ 0,20	⩽ 0,35	0,50 to 1,40	0,035	0,030	—	—	—
	PH 27	⩽ 0,20	⩽ 0,35	0,90 to 1,50	0,035	0,030	—	—	—
	PH 35	⩽ 0,22	⩽ 0,35	0,90 to 1,60	0,035	0,030	—	—	—
Alloyed steels	16 Mo 3	0,12 to 0,20	0,15 to 0,35	0,40 to 0,90	0,035	0,030	⩽ 0,30	0,25 to 0,35	0,020
	13 CrMo 4-5	0,08 to 0,18	0,15 to 0,35	0,40 to 1,00	0,035	0,030	0,70 to 1,15	0,40 to 0,60	0,020
	11 CrMo 9-10	0,08 to 0,15	0,15 to 0,50	0,30 to 0,70	0,035	0,030	2,00 to 2,50	0,90 to 1,10	0,020

NOTE — Elements not included in this table shall not be intentionally added without the agreement of the purchaser, except for elements which may be added for deoxidation and finishing of the heat. All reasonable precautions shall be taken to prevent the addition of elements from scrap or other materials used in the manufacture, but residual elements may be tolerated, provided that the mechanical properties and applicability are not adversely affected. If the amount of residual elements is likely to affect the weldability of the steel, the content of such elements (heat analysis) shall be stated in the documents mentioned in clause 12.

A maximum copper content of 0,25 % (*m/m*) may be requested by the purchaser in order to facilitate subsequent operations of forming.

1) Designation according to ISO/TR 4949.

Table 3 — Permissible deviations from the specified chemical composition limits given in table 2

Element	Content specified for the ladle analysis % (*m/m*)	Permissible deviation % (*m/m*)
C	⩽ 0,22	± 0,03
Si	⩽ 0,50	± 0,05
Mn	⩽ 1,60	± 0,10
P	⩽ 0,035	+ 0,005
S	⩽ 0,030	+ 0,005
Cr	⩽ 2,50	± 0,10
Mo	⩽ 0,35 > 0,35 ⩽ 1,10	± 0,04 ± 0,05
Al	⩽ 0,020	+ 0,005

6.2 Mechanical properties

6.2.1 At room temperature

The mechanical and technological properties of the tubes covered by this part of ISO 9330, measured at room temperature (23 °C ± 5 °C, see ISO 3205), to be obtained on test pieces selected, prepared and tested in accordance with clause 9, shall comply with the requirements of table 4 for wall thicknesses up to and including 16 mm.

6.2.2 At elevated temperature

6.2.2.1 Proof stress

The minimum proof stress ($R_{p0,2}$) values at elevated temperatures are indicated in table 5.

Table 4 — Mechanical properties at room temperature

Steel grade		Reference heat treatment 1)	Tensile test				Bend test	Drift expanding test			Ring expanding test				
			Tensile strength R_m N/mm²	Upper yield stress or proof stress R_{eH} or $R_{p0,2}$ or $R_{t0,5}$ min. N/mm²	Elongation 2) A min. %		Diameter of mandrel mm	Percentage increase of D for D_i/D			Percentage increase of D for D_i/D				
					l	t		⩽ 0,6	> 0,6 ⩽ 0,8	> 0,8	⩽ 0,5	> 0,5 ⩽ 0,6	> 0,6 ⩽ 0,8	> 0,8 ⩽ 0,9	> 0,9
Unalloyed steels	PH 23	N	360 to 480	235	25	23	3T	12	15	19	30	25	15	10	8
	PH 26	N	410 to 510	265	23	21	4T	10	12	17	30	25	15	10	8
	PH 27	N	460 to 580	270	21	19	4T	8	10	15	30	25	15	10	8
	PH 35	N	510 to 640	355	19	17	4T	8	10	15	30	25	15	10	8
Alloyed steels	16 Mo 3	N	450 to 600	270 3)	22	20	4T	8	10	15	30	20	10	8	6
	13 CrMo 4-5	N + T	440 to 590	290 3)	22	20	4T	8	10	15	30	20	10	8	6
	11 CrMo 9-10	N + T	480 to 630	280	20	18	4T	8	10	15	30	20	10	8	6

1) See 8.3 (N = Normalizing; N + T = Normalizing + Tempering).

2) l = longitudinal; t = transverse.

3) For wall thicknesses below or equal to 10 mm , the minimum value of yield strength is increased by 10N/mm².

6.2.2.2 Stress rupture properties

The long-term stress rupture property (σ_R) values at elevated temperatures are indicated in annex A. It is stressed that they are given for information only.

6.3 Weldability

Steels intended for the production of tubes covered by this part of ISO 9330 are regarded as being weldable. However, 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 very much on the conditions of preparing and carrying out the welding.

7 Dimensions, masses and tolerances

7.1 Outside diameters, wall thicknesses and masses

The outside diameters, wall thicknesses and masses of the tubes covered by this part of ISO 9330 should be selected from those in ISO 4200 and ISO 1129.

7.2 Lengths

7.2.1 The enquiry and order shall state whether the tubes are to be delivered with random lengths (see 7.2.2) or with exact lengths (see 7.2.3).

7.2.2 If the tubes are to be delivered with random lengths, their lengths shall be within the length range in which they usually fall in normal production. The relevant length ranges are dependent on the diameter and wall thickness of the tube, as well as on the production facilities of the manufacturer, and shall be agreed upon at the time of ordering.

7.2.3 If the tubes are to be delivered with exact lengths, the length tolerances given in 7.3.3 shall apply.

7.3 Tolerances

7.3.1 Tolerances on outside diameter and wall thickness, excluding the weld seam

The outside diameters and the wall thicknesses of the tubes covered by this part of ISO 9330 shall be within the tolerance limits given in table 6 (see 9.6).

Within areas where the tube surface has been dressed by mechanical machining (such as grinding), it is permissible to exceed the minus deviation on the outside diameter over a length of not more than 1 m, provided that the wall thickness remains within the lower tolerance limits.

Table 5 — Minimum 0,2 % proof stress $R_{p0,2}$ values at elevated temperature

Steel grade		Reference heat treatment[1)]	Minimum proof stress $R_{p0,2}$, N/mm^2									
			Temperature, °C									
			150	200	250	300	350	400	450	500	550	600
Unalloyed steels	PH 23	N	185	165	145	127	116	110	106	—	—	—
	PH 26	N	216	194	171	152	141	134	130	—	—	—
	PH 27	N	247	223	198	177	167	158	153	—	—	—
	PH 35	N	270	255	235	215	200	180	170	—	—	—
Alloyed steels	16 Mo 3	N	237	224	205	173	159	155	150	145	—	—
	13 CrMo 4-5	N+T	230	220	210	183	169	164	161	156	150	145
	11 CrMo 9-10	N+T	241	233	224	219	212	207	194	180	160	137

1) N = Normalizing; N + T = Normalizing + Tempering.

Table 6 — Tolerances on outside diameter and wall thickness

Tolerances on D	Tolerance (see ISO 5252) on T
± 0,75 % with a minimum of ± 0,5 mm	± 10 % with a minimum of ± 0,2 mm

7.3.2 Tolerances on wall thickness in the weld area

The heights of the external and internal weld seam shall be within the tolerance limits indicated in table 7 (see 9.6).

Table 7 — Tolerances on height of weld seam

External weld seam	Trimmed flush
Internal weld seam	Trimmed with a maximum height of 0,30 mm. The wall thickness remaining after trimming shall not be less than that permitted by table 6.

7.3.3 Tolerances on exact lengths

For lengths up to and including 6 m: $^{+10}_{0}$ mm

For lengths above 6 m up to and including 12 m: $^{+15}_{0}$ mm

For lengths greater than 12 m, the plus tolerances are to be agreed between the purchaser and manufacturer.

7.3.4 Ovality

The ovality shall be determined as a percentage using the following formula (see ISO 3545-1):

$$\text{Ovality} = 100 \times \frac{D_{max} - D_{min}}{D}$$

where D_{max} and D_{min} are the maximum and minimum outside diameters (respectively) measured in the same cross-section.

For tubes having $D < 406$ mm, the ovality is included in the limits of the diameter tolerances.

For tubes having $D \geqslant 406$ mm, the ovality shall not exceed 2 % if the D/T ratio is less than 100. If the D/T ratio is equal to or greater than 100, the tolerance on ovality shall be agreed between the purchaser and manufacturer.

7.3.5 Straightness

All tubes shall be reasonably straight. For tubes over 50 mm in diameter, the deviation from straightness shall not exceed 0,002 × L (L = length).

Deviation from straightness over any length of 1 m shall not exceed 3 mm.

Special requirements regarding straightness shall be the subject of an agreement.

8 Technical delivery conditions

8.1 Appearance and soundness

8.1.1 The tubes shall have smooth internal and external surfaces with the degree of smoothness depending on the method of manufacture.

8.1.2 The tubes shall have a workmanlike finish but small imperfections are permissible, provided that the thickness remains within the tolerance limits.

8.1.3 Larger surface imperfections may be dressed, provided that the thickness after dressing remains within the lower tolerance limits.

8.1.4 Repairs to tubes shall only be carried out by grinding or machining; peening or welding are not permitted.

8.2 Preparation of ends

Tubes are normally delivered with square-cut ends; by agreement between the purchaser and manufacturer at the time of ordering they can also be delivered with bevelled ends (see ISO 6761). The ends shall be free from excessive burrs.

8.3 Delivery conditions

The tubes are delivered in the heat-treated condition indicated in table 8.

9 Inspection and testing

9.1 Type of inspection and testing and type of inspection documents

9.1.1 Tubes manufactured according to this part of ISO 9330 shall be subjected to specific inspections and tests in accordance with ISO 404.

9.1.2 Tubes delivered in accordance with this part of ISO 9330 are provided with an inspection certificate of type 3.1.B according to ISO 10474.

If requested at the time of enquiry and order, the tubes shall be supplied with an inspection certificate of type 3.1.A or 3.1.C or 3.2 according to ISO 10474.

9.1.3 The specific inspections and tests described in 9.3 to 9.8 shall be carried out and the compliance of their results with the requirements shall be stated in inspection certificate 3.1.A, 3.1.B, 3.1.C or 3.2 according to ISO 10474.

In addition, the document shall include

a) the results of all inspections and tests pertaining to supplementary requirements (see 4.2);

b) the symbols, code letters or code numbers relating the order and the test pieces to the corresponding batches and tested tubes;

c) the actual heat treatment carried out (see 5.4):

d) the results of heat analysis (see 6.1.1).

9.2 Test categories

Unalloyed steel tubes shall be subjected to the inspection and tests indicated in table 9 for the category agreed upon at the time or ordering.

Alloyed steel tubes shall be subjected to the tests indicated in table 9 for category II.

9.3 Testing of chemical composition

9.3.1 A check analysis of chemical composition of the tubes may be agreed upon at the time of ordering (see 9.10.1).

9.3.2 The number of samples to be taken shall be agreed upon by the parties involved at the time of ordering.

9.3.3 The samples shall be taken in accordance with ISO 377-2. The samples may be taken either

a) from the test pieces used for the verification of the mechanical properties,

or

b) from drillings taken through the whole thickness of the tube or from a solid section, at the same location as for the mechanical test pieces.

Table 8 — Heat-treated conditions

Steel grade		Reference heat treatment conditions[1]	Austenitizing temperature °C	Cooling medium	Tempering temperature °C	Cooling medium
Unalloyed steels	PH 23	N[2]	880 to 940	Air	—	—
	PH 26	N[2]	880 to 940	Air	—	—
	PH 27	N[2]	880 to 940	Air	—	—
	PH 35	N[2]	880 to 940	Air	—	—
Alloyed steels	16 Mo 3	N	890 to 950	Air	—	—
	13 CrMo 4-5	N + T	900 to 960	Air	660 to 730	Air
	11 CrMo 9-10	N + T	900 to 960	Air	680 to 750	Air

1) N = Normalizing; N + T = Normalizing + Tempering.

2) The hot-finished tubes may be delivered in the non-treated condition at the discretion of the manufacturer, provided that the hot finishing produces a technically equivalent metallurgical condition. The methods of control to ensure equivalence of structure shall be the subject of a previous agreement between the purchaser and the manufacturer.

Table 9 — Test categories

Tests		Test category	
		I	II
Mandatory tests	Heat analysis [see 9.1.3 d)]	X	X
	Visual examination (see 9.7)	X	X
	Dimensional testing (see 9.6)	X	X
	Leak-tightness, hydraulic or non-destructive (see 9.10.5)	X	X
	Tensile test on base material at room temperature (see 9.10.2.1)	X	X
	Tensile test on weld at room temperature (see 9.10.2.1)	X	X
	Flattening or bend or ring tensile test (see 9.10.3)	X	X
	Drift or ring expanding test (see 9.10.4)	X	X
	Non-destructive testing of the weld (see 9.10.6.1)	X	—
	Non-destructive testing for longitudinal defects (see 9.10.6.2)	—	X
	Material identification of alloyed steels (see 9.9)	—	X
Optional tests 1)	Check analysis of chemical composition (see 9.10.1)	X	X
	Tensile test at elevated temperature (see 9.10.2.2)	X	X

1) By agreement at the time of enquiry and order.

9.4 Testing of mechanical and technological characteristics

9.4.1 At room temperature

9.4.1.1 Batch

The delivery shall be divided into batches. For tubes which are not heat treated, a batch shall consist only of tubes of the same steel grade, from the same heat and manufacturing process and having the same nominal outside diameter and wall thickness.

For tubes which are heat treated, a batch shall consist only of tubes of the same steel grade, from the same heat and manufacturing process, and having the same nominal outside diameter and wall thickness, subjected to the same finishing treatment in a continuous furnace or heat treated in the same furnace charge in a batch-type furnace.

Each batch shall comprise 100 tubes. The remaining tubes shall be subdivided between the batches if there are 50 or less than 50 tubes; they shall be regarded as a batch if there are more than 50.

If the total number of tubes is less than 100, they constitute one batch.

9.4.1.2 Number of products sampled per test unit

Each test unit consists of

— one tube per batch for test category I;

— two tubes per batch for test category II.

9.4.1.3 Number of tests

For each test unit, the following tests shall be carried out:

— one tensile test on the base material for each tube (see 9.10.2.1)

— one tensile test on the weld on each tube (see 9.10.2.1) for tubes with outside diameter $D \geqslant 508$ mm,

for tubes with 219 mm $< D <$ 508 mm a tensile test on the weld is not carried out unless otherwise agreed at the time of ordering,

for tubes with $D \leqslant 219$ mm a tensile test on the weld is not carried out;

— two flattening tests or bend tests or one ring tensile test on each tube (see 9.10.3);

— one drift or ring expanding test on each tube (see 9.10.4).

9.4.1.4 Selection of samples and test pieces

Samples and test pieces shall be taken at the tube ends and in accordance with the requirements of ISO 377-1.

9.4.1.5 Location and orientation of the test pieces

9.4.1.5.1 Test piece for the tensile test on the base material

The test piece for the tensile test on the base material is either a full tube section or a test piece taken in a direction either longitudinal or transverse to the axis of the tube in accordance with the requirements of ISO 6892.

At the manufacturer's option

— for tubes with an outside diameter D equal to or less than 219,1 mm, the test is carried out either on a tube section or on a test piece taken in a direction longitudinal to the axis of the tube. In the latter case, the test piece shall be taken away from the weld. The test piece shall represent the full thickness of the tube and shall not be flattened before testing.

— for tubes with 219,1 mm $< D <$ 508 mm, the test piece is taken in a direction either longitudinal or transverse to the axis of the tube. The test piece shall not be taken next to the weld.

For tubes with $D \geqslant 508$ mm, the test piece shall be taken in a direction transverse to the axis of the tube. The test piece shall not be taken next to the weld.

9.4.1.5.2 Test piece for the tensile test on the weld

The test piece for the tensile test on the weld shall be taken transverse to the weld, with the weld at the centre of the test piece. The test piece shall be a strip section with the full thickness of the tube, and the weld bead may be removed.

9.4.1.5.3 Test piece for the flattening test

For tubes with an external diameter $D \leqslant 406$ mm, the test piece for the flattening test shall consist of a tube section, in conformity with ISO 8492.

For tubes with $D > 406$ mm, the flattening test may be carried out on a half-ring section of the tube.

9.4.1.5.4 Test piece for the bend test

The test piece for the bend test consists of a section cut in the tube in accordance with the requirements of ISO 7438, with the weld at the centre of the test piece.

9.4.1.5.5 Test piece for the drift or ring expanding test or ring tensile test

The test piece for the drift or ring expanding test or ring tensile test consists of a tube section, in conformity with ISO 8493 or ISO 8495 or ISO 8496, respectively.

9.4.2 At elevated temperature

Determination of the proof stress ($R_{p0,2}$) may be agreed upon at the time of ordering. The temperature and number of test pieces (see 9.10.2.2) shall be established at this time.

9.5 Leak-tightness test

9.5.1 All the tubes shall be submitted to a leak-tightness test.

9.5.2 Unless otherwise specified by the purchaser, the hydraulic leak-tightness test may be replaced, at the discretion of the manufacturer, by a non-destructive test (see 9.10.5.2).

9.6 Dimensional testing

The tubes shall be checked with respect to dimensions by suitable methods.

The tolerance on diameter is normally measured across the diameter; however, for tubes where $D > 457$ mm, this tolerance may be measured by a circumference tape. In the case of dispute, the tolerance shall be that measured across the diameter.

Unless otherwise specified at the time of enquiry and order, the wall thickness shall be measured at the tube ends.

The ovality shall be measured across the diameter at the pipe ends, for a distance of 100 mm.

9.7 Visual examination

The tubes shall be submitted to a visual examination to confirm, in particular, their conformity with the requirements of 8.1 and 8.2 .

9.8 Non-destructive testing

The tubes of test category I shall all be submitted to a non-destructive inspection of the weld seam (see 9.10.6.1).

The tubes of test category II shall all be submitted to a non-destructive inspection for longitudinal defects (see 9.10.6.2).

9.9 Material identification of alloyed steels

Each alloyed steel tube shall be tested by an appropriate method to ensure that the correct grade has been supplied.

9.10 Test methods and results

9.10.1 Chemical analysis

9.10.1.1 If agreed at the time of ordering, a check analysis shall be carried out (see 9.3.1 and 9.3.2).

9.10.1.2 The elements shall be determined in conformity with the methods considered in the corresponding International Standards. Spectrographic analysis is permitted.

9.10.1.3 The results shall comply with the values in table 2, taking into account the permissible deviations given in table 3.

9.10.1.4 In the case of dispute about analytical methods, the chemical composition shall be determined in accordance with a reference method in one of the International Standards listed in ISO/TR 9769.

9.10.2 Tensile test

9.10.2.1 At room temperature

9.10.2.1.1 The tensile test shall be carried out at room temperature in conformity with ISO 6892 (see 9.4.1.3, 9.4.1.5.1 and 9.4.1.5.2).

9.10.2.1.2 The tensile strength (R_m), the proof stress ($R_{p0,2}$) or the upper yield stress (R_{eH}) and the percentage elongation after fracture (A) shall be determined during the tensile test of the base metal. For unalloyed steel tubes the proof stress, total elongation ($R_{t0,5}$) can be determined instead of the proof stress ($R_{p0,2}$). The tensile strength (R_m) shall be determined during the tensile test on the weld.

The percentage elongation after fracture shall be reported with reference to a gauge length of $5{,}65\sqrt{S_o}$, where S_o is the original cross-sectional area of the test piece. If other gauge lengths are used, the corresponding elongation referred to a gauge length of $5{,}65\sqrt{S_o}$ shall be obtained in accordance with ISO 2566-1.

9.10.2.1.3 The results of the tensile test shall comply with the values in table 4 for the steel grade concerned.

9.10.2.2 At elevated temperature

9.10.2.2.1 If agreed at the time of ordering, a tensile test at elevated temperature shall be carried out (see 9.4.2) in accordance with ISO 783.

9.10.2.2.2 The proof stress ($R_{p0,2}$) of the base material shall be determined during the tensile test.

9.10.2.2.3 The result of the tensile test shall comply with the values in table 5 at the selected temperature.

9.10.3 Flattening or bend test or ring tensile test

9.10.3.1 General

At the option of the manufacturer, either a flattening test or a bend test or a ring tensile test shall be carried out at room temperature (see 9.4.1.3) for tubes with an outside diameter above or equal to 200 mm; for tubes with an outside diameter below 200 mm and above or equal to 152,4 mm, the flattening test or the ring tensile test is usually carried out; for tubes with an outside diameter below 152,4 mm, only the flattening test is usually carried out.

9.10.3.2 Flattening test

The flattening tests (see 9.4.1.3) shall be carried out according to ISO 8492.

For the two flattening tests, the weld shall be at 0° and 90° (or equivalent) to the direction of the approach of the platens, respectively.

The test shall be carried out in two stages:

a) firstly, no crack shall appear in the weld up to the moment when the distance between the platens reaches two-thirds of the outside diameter of the tube;

b) then, the base material shall not crack up to the moment when the distance between the platens reaches one-third of the outside diameter of the tube.

A slight incipient crack at the edges shall not be regarded as a justification for rejection.

9.10.3.3 Bend test

9.10.3.3.1 The bend test (see 9.4.1.3) shall be carried out in accordance with ISO 7438. One of the two test pieces shall be doubled over, cold, in the direction of initial curvature and the other in the opposite direction around a mandrel with a diameter as indicated in table 4 for the steel grade concerned. The weld line being positioned at the centre of the test piece and the weld bead removed.

9.10.3.3.2 After testing, the test piece shall show no crack or flaw, but slight premature failure at the edges shall not be considered a cause for rejection.

9.10.3.4 Ring tensile test

9.10.3.4.1 The ring tensile test is only applicable for tubes with an outside diameter equal to or greater than 152,4 mm.

The test shall be carried out in accordance with ISO 8496.

9.10.3.4.2 The tube section (see 9.4.1.5.5) shall be subjected to strain in the circumferential direction until fracture occurs, the weld line being placed at 90° to the line of pull.

9.10.3.4.3 After testing, the test piece shall show no crack visible without the use of magnifying aids.

9.10.4 Drift expanding test or ring expanding test

9.10.4.1 General

At the option of the manufacturer, either a drift expanding test or a ring expanding test shall be carried out at room temperature (see 9.4.1.3).

9.10.4.2 Drift expanding test

9.10.4.2.1 The drift expanding test shall be carried out in accordance with ISO 8493.

It is carried out on tubes with outside diameter up to 150 mm and a wall thickness up to 9 mm.

The end of the tube section (see 9.4.1.5.5) shall be expanded on a conical mandel until the increase in the outside diameter of the expanded tube reaches the value indicated in table 4 for the steel grade concerned.

9.10.4.2.2 After testing, the test piece shall show no crack or flaw, but slight premature failure at the edges shall not be considered a cause for rejection.

9.10.4.3 Ring expanding test

9.10.4.3.1 The ring expanding test shall be carried out in accordance with ISO 8495.

The tube section (see 9.4.1.5.5) shall be expanded until the increase in the outside diameter reaches the value indicated in table 4 for the steel grade concerned.

9.10.4.3.2 After testing, the test piece shall show no crack or flaw, but slight premature failure at the edges shall not be considered a cause for rejection.

9.10.5 Leak-tightness test

9.10.5.1 Hydraulic test

If the leak-tightness test is carried out by a hydraulic test, the test pressure is defined, up to a maximum of 80 bar, by the following equation:

$$PE = 20 \times \frac{S \times T}{D}$$

where

PE is the test presssure, in bars;

D is the specified outside diameter, in millimetres;

T is the specified wall thickness, in millimetres;

S is the stress, in newtons per square millimetre, correspondint to 80 % of the specified minimum value of R_{eH} or $R_{p0,2}$ or $R_{t0,5}$ (see table 4) for the steel grade concerned.

The test pressure shall be maintained for at least 5 s.

The tube shall withstand the test without showing leaks or deformation beyond the limits of the dimensional tolerances.

9.10.5.2 Non-destructive test

If the tube is not submitted to the hydraulic test defined in 9.10.5.1, it shall be submitted to a non-destructive test (see 9.5.2), namely:

a) an electromagnetic test in accordance with ISO 9302,

or

b) an ultrasonic test in accordance with ISO 10332.

9.10.6 Non-destructive testing

9.10.6.1 Tubes of test category I shall be submitted to non-destructive testing of the weld seam in accordance with ISO 9764, with acceptance level L3.

9.10.6.2 Tubes of test category II shall be submitted to ultrasonic testing of the full periphery for longitudinal defects in accordance with ISO 9303, with acceptance level L2.

9.11 Invalidation of the tests

See ISO 404.

9.12 Retests

See ISO 404.

9.13 Sorting or reprocessing

See ISO 404.

10 Marking

10.1 Marking to be applied

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

The marking shall include the following information:

— the mark of the manufacturer of the tubes;

— the designation of the steel grade;

— the heat number or a code number;

— the inspector's mark;

— a number or mark by which the tubes can be identified with the inspection certificate or inspection report;

— reference to this part of ISO 9330.

10.2 Methods

10.2.1 Tubes with outside diameter up to and including 76,1 mm

The symbols indicated in 10.1 shall be indelibly marked on a label attached firmly to each bundle or box.

10.2.2 Tubes with outside diameter larger than 76,1 mm

The symbols indicated in 10.1 shall be marked on each tube, at a distance of approximately 300 mm from one end.

10.2.3 Paints used for marking

If paints are used for marking, they shall be as free as practicable from lead, copper, zinc and tin.

10.3 Specific marking

Other marking may be applied if specifically requested in the order.

11 Protection

The tubes are normally delivered without protection or with the manufacturer's normal mill protection.

If special protection is to be applied, this shall be specified in the enquiry and order.

12 Documents

Documents issued shall conform with 9.1.

13 Claims after delivery

See ISO 404.

Annex A
(informative)

Long-term stress rupture at elevated temperatures

Table A.1 — Long-term stress rupture values at elevated temperatures
(for information only)

	Steel grade	Heat treatment[1)]	Rupture time	Estimated average long term stresses for rupture[2)] R N/mm² — Temperature, °C																												
			h	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600	610	620	630	640	650	660
Unalloyed steels	PH 23 PH 26	N	10 000	213	197	181	166	151	138	125	112	100	89	78	67	67																
			30 000	192	176	161	147	133	120	107	95	84	73	63	52	42																
			50 000	183	167	152	138	125	112	100	88	77	66	56	46	(35)																
			100 000	(171)	(155)	(141)	(127)	(114)	(102)	(90)	(78)	(67)	(57)	(47)	36																	
			150 000	(164)	(149)	(134)	(121)	(108)	(96)	(84)	(73)	(62)	(52)	(41)	29																	
			200 000	(159)	(144)	(130)	(116)	(104)	(92)	(80)	(69)	(58)	(48)	(37)	23																	
			250 000	(155)	(140)	(126)	(113)	(101)	(89)	(77)	(66)	(55)	(45)	(34)																		
	PH 27 PH 35	N	10 000	291	266	243	221	200	180	161	143	126	110	96	84	74																
			30 000	262	237	214	192	171	151	132	115	99	86	74	65	57																
			50 000	248	223	200	177	156	136	118	102	87	75	65	57	50																
			100 000	227	203	179	157	136	117	100	85	73	63	55	(47)	(41)																
			150 000	215	190	167	144	124	105	89	76	65	56	(49)	(42)	(34)																
			200 000	(206)	(181)	(157)	(135)	(115)	(97)	(82)	(70)	(60)	(52)	(44)	(37)																	
			250 000	(199)	(174)	(150)	(128)	(108)	(91)	(77)	(66)	(56)	(48)	(41)	(32)																	
Alloyed steels	16 Mo 3	N	10 000								298	273	247	222	196	171	147	125	102	82	64											
			30 000								273	244	216	187	159	134	113	93	76	61	49											
			50 000								260	229	200	172	144	119	99	80	66	53	(42)											
			100 000								(239)	(208)	(178)	148	123	101	81	66	(53)	(42)												
			150 000								(226)	(197)	(168)	(139)	(114)	(91)	(74)	(60)	(48)													
			200 000								(217)	(188)	(159)	(130)	(105)	(84)	(69)	(55)	(45)													
			250 000								(210)	(180)	(151)	(124)	(100)	(80)	(65)	(52)	(42)													
	13 CrMo 4-5	N + T	10 000											304	273	239	209	179	154	129	109	91	76	64	53	44						
			30 000											267	233	200	169	140	116	96	79	66	54	44	36	(29)						
			50 000											239	207	177	149	124	101	82	68	55	45									
			100 000											210	177	146	121	99	81	67	54	43	35									
			150 000											(194)	(161)	(132)	(108)	(87)	71	57	46	38	(31)									
			200 000											(180)	(148)	(122)	(99)	(79)	(64)	(52)	(42)	(34)	(28)									
			250 000											(170)	(139)	(114)	(91)	(74)	(59)	(48)	(39)	(32)	(26)									
	11 CrMo 9-10	N + T	10 000								(309)	(285)	(263)	240	219	196	176	155	137	122	108	96	85	76	68	61						
			30 000								(276)	(254)	(233)	213	192	172	152	134	118	103	90	79	70	61	54	48						
			50 000								(257)	(236)	(217)	(197)	(177)	158	(139)	(123)	107	93	80	71	62	54	47	42						
			100 000								(221)	(204)	(186)	(170)	(153)	(137)	(122)	(107)	93	79	69	59	51	44	(38)	(34)						
			150 000								(209)	(192)	(175)	(159)	(141)	(126)	(110)	(95)	(82)	(73)	(63)	(54)	47	40	(35)	(30)						
			200 000								(203)	(186)	(169)	(152)	(135)	(119)	(103)	(89)	(77)	(68)	(58)	(50)	(43)	(37)	(32)	(28)						
			250 000								(198)	(181)	(164)	(147)	(130)	(113)	(98)	(84)	(74)	(64)	(55)	(47)	(41)	(35)	(30)	(26)						

1) N = Normalizing; N + T = Normalizing + Tempering.

2) Values which have involved extrapolation are indicated in brackets.

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ICS 23.040.10; 77.140.30; 77.140.75

Descriptors: pipes (tubes), pressure pipes, metal tubes, alloy steels, unalloyed steels, steel tubes, welded tubes, specifications, delivery condition, dimensions, dimensional tolerances, mechanical properties, chemical composition, tests, marking.

Price based on 16 pages