INTERNATIONAL STANDARD

ISO 9330-3

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Welded steel tubes for pressure purposes — Technical delivery conditions —

Part 3:
Electric resistance and induction welded unalloyed and alloyed steel tubes with specified low temperature properties

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

Partie 3: Tubes soudés par résistance électrique et par induction en aciers non alliés et alliés avec caractéristiques spécifiées à basse température

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 9330-3 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*

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Welded steel tubes for pressure purposes — Technical delivery conditions —

Part 3:
Electric resistance and induction welded unalloyed and alloyed steel tubes with specified low 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 low temperature toughness properties. These tubes are intended for low temperature piping systems.

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 5730 is available.

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

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

— *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 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 148:1983, *Steel — Charpy impact test (V-notch).*

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 643:1983, *Steels — Micrographic determination of the ferritic or austenitic grain size.*

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 9769:1991, *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 Hyraulic 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 (voir 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 1);

— 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);

— 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 9.4.3);

— 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 hot-finished 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 PL 21 with specified low temperature properties to be submitted to specific inspection and testing to test category II involving the issuing of an inspection certificate 3.1.B according to ISO 10474:

Tube Hot-finished ISO 4200 - 168,3 × 4 - 4 to 8 - ISO 9330-3 - PL 21 - II - 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.

Table 1 — Chemical composition (heat analysis) [% (*m/m*)]

Steel grade[1]		C	Si	Mn	P max.	S max.	Al total min.	Mo	Ni	V max.	Nb max.
Unalloyed steels	PL 21	⩽ 0,17	⩽ 0,35	0,40 to 1,00	0,030	0,025	0,015[2]	—	—	—	—
	PL 23	⩽ 0,19	⩽ 0,35	0,60 to 1,20	0,030	0,025	0,015[2]	—	—	—	—
	PL 25	⩽ 0,17	⩽ 0,35	0,60 to 1,20	0,030	0,025	0,015[2]	—	—	—	—
	PL 26	⩽ 0,20	⩽ 0,35	0,80 to 1,40	0,030	0,025	0,015[2]	—	—	—	—
Alloyed steels	11 MnNi 5-3	⩽ 0,14	⩽ 0,50	0,70 to 1,50	0,030	0,025	0,020[3]	—	0,30[4] to 0,80	0,05	0,05
	13 MnNi 6-3	⩽ 0,18	⩽ 0,50	0,85 to 1,65	0,030	0,025	0,020[3]	—	0,30[4] to 0,80	0,05	0,05
	12 Ni 14	⩽ 0,15	0,15 to 0,35	0,30 to 0,85	0,025	0,020	—	—	3,25 to 3,75	0,05	—
	X 12 Ni 5	⩽ 0,15	⩽ 0,35	0,30 to 0,80	0,025	0,020	—	—	4,50 to 5,30	0,05	—

NOTE — Elements not included in this table may 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.

1) Designation according to ISO/TR 4949.

2) Metallic aluminium content. Where the total aluminium content is determined, the result shall be deemed to meet this requirement, provided the total aluminium content value obtained is not less than 0,018 % (*m/m*). In cases of dispute, the metallic aluminium content shall be determined. Alternatively, an austenitic grain size of 6 or finer, determined in accordance with ISO 643, can be agreed upon. By agreement between the interested parties, aluminium may be replaced by other elements having a similar effect.

3) Total aluminium content. By agreement between the interested parties, aluminium may be replaced by other elements having a similar effect.

4) The lower limit value for the nickel content may be reduced to not less than 0,15 % (*m/m*) by mass for tubes with wall thickness not exceeding 10 mm.

5.3 Product-making process for tubes

Tubes covered by this part of ISO 9330 may be hot-finished or cold-finished. 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 7).

5.4 Delivery conditions

5.4.1 Tubes covered by this part of ISO 9330 shall be supplied suitably heat treated over their full length. The following heat treatments shall be used, depending on the type of steel (see table 7):

— normalizing;

— normalizing and tempering;

— quenching and tempering.

6 Metallurgical properties

6.1 Chemical composition

6.1.1 Heat analysis

On heat analysis, the steel shall show the composition given in table 1 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 2 shall apply to the heat analysis specified in table 1.

Table 2 — Permissible deviations from the specified chemical composition limits given in table 1

Element	Content specified for the heat analysis % (*m/m*)	Permissible deviation % (*m/m*)
C	⩽ 0,20	+ 0,03
Si	⩽ 0,50	± 0,05
Mn	⩽ 1,65	± 0,10
P	⩽ 0,030	+ 0,005
S	⩽ 0,025	+ 0,005
Al	⩾ 0,020	− 0,005
Ni	⩽ 0,85 > 0,85 ⩽ 3,75 > 3,75 ⩽ 5,30	± 0,05 ± 0,07 ± 0,10
V	⩽ 0,05	± 0,01
Nb	⩽ 0,05	± 0,01

The deviations, other than when maxima only are specified, apply either above or below the specified limits of the range, but not 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.

When minima only are specified, the deviations are negative only.

6.2 Mechanical properties

6.2.1 At room temperature

The mechanical 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 3 under the heat-treatment conditions indicated in table 7.

6.2.2 At low temperature

Table 4 gives minimum values for the impact energy, as determined on ISO V-notch test pieces, used to characterize the cold-toughness of the various steel grades at low temperature (see also footnote 2 to table 4).

Impact tests shall be carried out at the lowest temperature indicated in table 4 for each steel grade (see also 9.10.7.1), except that higher temperatures shown may be agreed upon between the purchaser and manufacturer.

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.

Table 3 — Mechanical properties at room temperature

	Steel grade	Tensile test				Bend test	Drift expanding test			Ring expanding test				
		Reference heat treatment 1)	Tensile strength R_m	Upper yield stress or proof stress R_{eH} or $R_{p0,2}$ or $R_{t0,5}$ min.	Elongation for wall thicknesses A min.	Diameter of mandrel	Percentage increase of D for D_i/D			Percentage increase of D for D_i/D				
							≤ 0,6	> 0,6 ≤ 0,8	> 0,8	≤ 0,5	> 0,5 ≤ 0,6	> 0,6 ≤ 0,8	> 0,8 ≤ 0,9	> 0,9
			N/mm²	N/mm²	%	mm								
Unalloyed steels	PL 21	N	360 to 480	215	24	4T	12	15	19	30	25	15	10	8
	PL 23	N	410 to 530	235	22	4T	10	12	17	30	25	15	10	8
	PL 25	Q + T	360 to 490	255	21	—	—	—	—	—	—	—	—	—
	PL 26	N	460 to 580	265	21	4T	8	10	15	30	25	15	10	8
Alloyed steels	11 MnNi 5-3	N	410 to 530	285	22	—	—	—	—	—	—	—	—	—
	13 MnNi 6-3	N	490 to 610	355	20	—	—	—	—	—	—	—	—	—
	12 Ni 14	Q + T	440 to 590	245	16	—	6	8	12	—	—	—	—	—
	X 12 Ni 5	Q + T	510 to 710	390	17	—	—	—	—	—	—	—	—	—

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

Table 4 — Impact properties at low temperature

Steel grade		Orientation of test pieces with respect to tube axis	Minimum impact test value, KV [1) 2)] (J) (average of three test pieces) · Temperature, °C									
			− 196	− 120	− 110	− 100	− 90	− 60	− 50	− 40	− 20	+ 20
Unalloyed steels	PL 21	Longitudinal								40	45	55
	PL 23	Longitudinal Transverse[3)]							27	40 27	45 30	50 35
	PL 25	Longitudinal Transverse[3)]							40 27	45 30	50 35	60 40
	PL 26	Longitudinal Transverse[3)]							27	40 27	45 30	50 35
Alloyed steels	11 MnNi 5-3 13 MnNi 6-3	Longitudinal Transverse[3)]						40 27	45 30	50 35	55 40	70 45
	12 Ni 14	Longitudinal Transverse[3)]				40 27	45 30	50 35	55 35	55 40	60 45	65 45
	X 12 Ni 5	Longitudinal Transverse[3)]		40 27	45 30	50 30	55 35	65 45	65 45	65 45	70 50	70 50

1) Single values not less than 70 % of the average value.

2) The values apply to standard 10 mm × 10 mm test pieces. For different sizes of test pieces, see 9.10.7.1.

3) Transverse test pieces shall be used only by agreement.

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 on 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 5 (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 — Tolerances on outside diameter and wall thickness

Tolerances on D	Tolerance (see ISO 5252) on T
± 0,75 % with a minimum of ± 0,35 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 6 (see 9.6).

Table 6 — 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 5.

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 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 $0{,}002 \times L$ (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 medthod 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 7.

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.B 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.

Table 7 — Heat-treated conditions

Steel grade		Reference heat treatment[1]	Normalizing temperature °C	Tempering temperature °C	Quenching and tempering		
					Hardening temperature °C	Cooling medium[2]	Tempering temperature °C
Unalloyed steels	PL 21	N	900 to 940	—	—	—	—
	PL 23	N	890 to 930	—	—	—	—
	PL 25	Q + T	—	—	890 to 930	Water or oil	600 to 680
	PL 26	N	890 to 930	—	—	—	—
Alloyed steels	11 MnNi 5-3	N[3]	890 to 940	(580 to 640)	—	—	—
	13 MnNi 6-3	N[3]	890 to 940	(580 to 640)	—	—	—
	12 Ni 14	Q + T[4]	830 to 880	580 to 640	820 to 880	Water or oil	580 to 660
	X 12 Ni 5	Q + T[4]	800 to 850	580 to 640	800 to 850	Water or oil	580 to 660

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

2) When choosing the cooling medium, the influence of other parameters, such as dimensions and quenching temperature, on properties and crack susceptibility should be taken into account. Other cooling media, such as synthetic quenchants, may also be used.

3) Tempering can occasionally be necessary after normalizing. In this case, the manufacturer shall inform the purchaser accordingly and shall state the tempering temperature as well.

4) If the product's dimensions so permit, normalizing (with subsequent tempering if necessary) may be carried out at the manufacturer's discretion instead of quenching and tempering. In this case, the manufacturer shall inform the purchaser accordingly.

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 indicates in table 8 for the category agreed upon at the time or ordering.

Alloyed steel tubes shall be subjected to the tests indicated in table 8 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 sampled 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.

9.4 Testing of mechanical and technological characteristics

9.4.1 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.

Table 8 — 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 (see 9.10.2)	X	X
	Impact test (see 9.10.7)	X	X
	Tensile test on weld (see 9.10.2)	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
	Non-destructive testing for transverse defects (voir 9.10.6.3)	—	X

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

For tubes which are heat treated, a batch shall consist only of tubes of the same steel grade, from te 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.

9.4.2 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.

9.4.3 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);

— one tensile test on the weld on each tube (see 9.10.2) for tubes with outside diameter $D \geqslant 508$ mm; for tubes with $D > 219$ mm to $D < 508$ 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;

— one set of three impact tests on each sample tube (see 9.4.5.6), if the wall thickness permits the preparation of test pieces with width at least 5 mm (see 9.10.7);

— 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).

9.4.4 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.

9.4.5 Location and orientation of the test pieces

9.4.5.1 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 $D \leqslant 219{,}1$ 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.

9.4.5.2 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.

9.4.5.3 Test piece for the flattening test

For tubes with $D \leqslant 406$ 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.

9.4.5.4 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.

9.4.5.5 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.

9.4.5.6 Test pieces for the impact test

For the impact test (see ISO 148), a set of three ISO V-notch test pieces shall be taken from each sample tube longitudinal to the tube axis.

By agreement at the time of ordering, test pieces can be taken transverse to the tube axis, provided that the dimension of the tube permits this without flattening of the test piece.

The minimum outside diameter D_{min} in millimetres, of the pipe necessary to take transversal test pieces may be calculated as a function of the wall thickness T by

$$D_{min} = (T - 5) + \frac{756{,}25}{(T - 5)} \text{ in mm}$$

The test pieces shall be taken and prepared in such a way that the axis of the notch is perpendicular to the surface of the tube.

9.4.5.6.1 The dimensions of the test pieces should preferably be 10 mm × 10 mm. Test pieces having a width of less than 10 mm, but not below 5 mm, are also permitted.

9.4.5.6.2 In the case of test pieces less than 10 mm wide, the two faces perpendicular to the notch shall only be machined by the amount necessary to obtain a minimum dimension of 5 mm.

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.

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 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).

If agreed at the time of enquiry and order, tubes of test category II may also be submitted to non-destructive testing for transverse defects (see 9.10.6.3).

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 1, taking into account the permissible deviations given in table 2.

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 The tensile test shall be carried out at room temperature in conformity with ISO 6892 (see 9.4.3, 9.4.5.1 and 9.4.5.2).

9.10.2.2 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.

9.10.2.3 The results of the tensile test shall comply with the values in table 3 for the steel grade concerned.

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 9.4.3) 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 9.4.3) 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;