INTERNATIONAL STANDARD

ISO 9330-6

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Welded steel tubes for pressure purposes — Technical delivery conditions —

Part 6:
Longitudinally welded austenitic stainless steel tubes

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

Partie 6: Tubes soudés longitudinalement en aciers inoxydables austénitiques

Reference number
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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 9330-6 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 2604-5:1978.

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*

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

— *Part 4: Submerged arc-welded unalloyed and alloyed steel tubes with specified elevated temperature properties*

— *Part 5: Submerged arc-welded unalloyed and alloyed steel tubes with specified low temperature properties*

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

Annexes A and B of this part of ISO 9330 are for information only.

Welded steel tubes for pressure purposes — Technical delivery conditions —

Part 6:
Longitudinally welded austenitic stainless steel tubes

1 Scope

1.1 This part of ISO 9330 specifies the technical delivery conditions for longitudinally welded tubes of circular cross-section, made of austenitic stainless steel, which are applied for pressure and corrosion resisting purposes at room temperature, at low temperatures or at elevated temperatures. These tubes are intended for pressure purposes, for example, for the construction of pressure vessels, chemical plants and steam-generating equipment and for interconnecting pipe work.

Tubes manufactured in accordance with this part of ISO 9330 may have specified room temperature properties, specified low temperature toughness properties and specified proof-stress values at elevated temperatures, as appropriate to the service for which they are intended.

The requirements of appropriate International Standards covering applications (e.g. ISO 1129, ISO 2037, ISO 6759, ISO 7598) 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.

NOTES

1 The word "tube" is synonymous with "pipe".

2 This part of ISO 9330 can also be used as a basis for the manufacture of tubes of non-circular section. In this case, the values quoted in this part of ISO 9330 for chemical analysis and mechanical properties are applicable. All other requirements are by agreement between the purchaser and manufacturer.

This part of ISO 9330 does not cover

a) casing, tubing, drill pipe and linepipe for use by the oil and natural gas industries; and

b) tubes for the transport of gas, water and sewage.

1.2 For the general technical delivery requirements, see ISO 404.

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

ISO 683-13:1986, *Heat treatable steels, alloy steels and free cutting steels — Part 13: Wrought stainless steels.*

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

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

ISO 1127:1992, *Stainless steel tubes — Dimensions, tolerances and conventional masses per unit length.*

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

ISO 2037:1992, *Stainless steel tubes for the food industry.*

ISO 2566-2:1984, *Steel — Conversion of elongation values — Part 2: Austenitic steels.*

ISO 3205:1976, *Preferred test temperatures.*

ISO 3651-1:1976, *Austenitic stainless steels — Determination of resistance to intergranular corrosion — Part 1: Corrosion test in nitric acid medium by measurement of loss in mass (Huey test).*

ISO 3651-2:1976, *Austenitic stainless steels — Determination of resistance to intergranular corrosion — Part 2: Corrosion test in a sulphuric acid/copper sulphate medium in the presence of copper turnings (Monypenny Strauss test).*

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 6759:1980, *Seamless steel tubes for heat exchangers.*

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

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

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

ISO 7598:1988, *Stainless steel tubes suitable for screwing in accordance with ISO 7-1.*

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 9304:1989, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Eddy current testing for the detection of imperfections.*

ISO 9305:1989, *Seamless steel tubes for pressure purposes — Full peripheral ultrasonic testing for the detection of transverse imperfections.*

ISO 9765:1990, *Submerged arc-welded steel tubes for pressure purposes — Ultrasonic testing of the weld seam for the detection of longitudinal and/or transverse 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.*

ISO 11496:1993, *Seamless and welded steel tubes for pressure purposes — Ultrasonic testing of tube ends for the detection of laminar imperfections.*

ISO 12096:1996, *Submerged arc-welded steel tubes for pressure purposes — Radiographic testing of the weld seam for the detection of imperfections.*

ISO 14284:1996, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition.*

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

K = constant factor of deformation

3.3.3 Hydraulic test

p_t = 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 in his enquiry and order the following information:

— the denomination "tube";

— reference to the relevant dimensional standard;

— dimensions (outside diameter × wall thickness or, by agreement, inside diameter × wall thickness) in millimetres (see 7.1);

— length (see 7.2);

— tolerance, if exact lengths greater than 12 m are ordered (see 7.3.2);

— reference to this part of ISO 9330;

— steel grade (see table 1);

— test category (see 9.2);

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

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);

— heat treatment of hot-finished tubes [see 5.3.1 b)];

— special tolerances on outside diameter and on wall thickness (see table 5);

— heat treatment requested (see 6.2.1);

— bevelled tube ends (see 8.2);

— special straightness requirements (see 8.1.10);

— symbol for the type of condition (see 8.1.1 and table 6);

— product chemical analysis (see 9.3);

— determination of proof stress at elevated temperatures (see 9.4.2);
— leak tightness test (see 9.5);
— impact test at room temperature (see 9.9.5.1);
— impact test at low temperature (see 9.4.3 and 9.9.5.2);
— specific marking (see 10.3);
— non-destructive testing for transverse defects (see 9.9.8.3, tubes of test category II);
— non-destructive testing of tube ends for laminar imperfections (see 9.9.8.4);
— corrosion test (see 6.4);
— bar coding (see 10.1);
— protective coating (see clause 11).

4.3 Example of an order

Example of an order for a welded tube conforming to the dimensional standard ISO 1127, with an outside diameter of 168,3 mm, a wall thickness of 4 mm and a standard length (exact length) of 6 m, made of steel grade X 6 CrNiNb 18 11, in type of condition HFS2, to be submitted to specific inspection and testing to test category I involving the issuing of an inspection certificate according to ISO 10474, 3.1.B.

Tube ISO 1127 - 168,3 × 4 - 6 - ISO 9330-6 - X 6 CrNiNb 18 11 - HFS2 - I - ISO 10474 3.1.B

5 Manufacturing process

5.1 Steelmaking process

If he so requests, the purchaser shall be informed of the steelmaking process used.

NOTE — Steels may be cast in ingots, strand cast or prepared by another process which gives equivalent results. When steels of different grades are sequentially strand cast, identification of the resultant transition material is required. The producer should remove the transition material by an established procedure that positively separates the grades.

5.2 Product-making process for tubes

Tubes covered by this part of ISO 9330 shall be manufactured from appropriately bent hot or cold flat-rolled skelp or plate, longitudinally welded by fusion across the abutting edges, with or without the addition of filler metal, in automated fabrication or for example, in single-piece fabrication. The filler metal used shall be compatible with the parent material. The welds of automatically welded tubes may be smoothed by appropriate methods, for example, by hammering or rolling as part of the manufacturing process (bead conditioned).

For welds with filler metal added there shall be a minimum of two passes deposited, one of which shall be on the inside. Tubes with more than one seam are permitted. All seams shall be tested in accordance with the requirements of this part of ISO 9330.

Tubes with outside diameters not exceeding 168,3 mm may additionally be brought to the required tube dimensions by cold working (see type of condition LWCF2 and LWCF3 in table 6). Fusion-welded austenitic stainless steel tubes shall be as welded, cold finished or bead conditioned.

The terms "as welded", "cold finished" and "bead conditioned" apply to the condition of the tube before heat treatment, if required in accordance with 5.3.

Longitudinally welded cold-finished austenitic stainless steel tubes (LWCF) shall be sufficiently cold worked prior to final heat treatment.

Unless otherwise agreed, the process of manufacture is left to the discretion of the manufacturer.

5.3 Heat treatment and delivery condition

5.3.1 The tubes shall be supplied suitably heat treated over their full length (see table 3) in either

a) the solution-treated condition; or

b) the hot-finished condition for tubes which have been pressed at a temperature within the solution-treatment temperature range in table 3 and cooled rapidly (see 4.2).

5.3.1.1 For type of condition and surface condition of the tubes, see table 6. The selection of the type of condition is left to the discretion of the purchaser (see 4.2 and table 6).

5.3.2 Solution treatment shall consist of heating the tubes uniformly to a temperature within the range given in table 3 and cooling rapidly.

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 for 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 limits specified in table 1.

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 always positive.

6.2 Mechanical and technological 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), shall comply with the requirements of table 3.

NOTE — If heat treatments different from, or additional to, the normal reference heat treatment (which may have an adverse effect on the mechanical properties) are to be carried out after the delivery of the tubes, the purchaser may request, at the time of enquiry and order, additional mechanical tests on samples, that have been given heat treatments different from, or additional to, those given in table 3. The heat treatment of the samples and the mechanical properties to be obtained from tests on them should be agreed between the purchaser and manufacturer at the time of enquiry and order.

6.2.2 At elevated temperature

6.2.2.1 The minimum proof-stress values, $R_{p0,2}$ and $R_{p1,0}$, at elevated temperatures are indicated in table 4.

NOTE — The values are not normally subjected to verification but, if verification is required by the purchaser, 9.4.2 should be referred to.

6.2.2.2 Estimates of the average stress rupture properties are given in annex A, for information.

Table 1 — Chemical composition (heat analysis), of austenitic steels for welded tubes

Steel grade 1)	Chemical composition, % (*m/m*) 2)								
	C	Si max.	Mn max.	P max.	S max.	Cr	Mo	Ni	Others
X 2 CrNi 18 10	≤ 0,030	1,00	2,00	0,045	0,030	17,00 to 19,00	—	9,00 to 12,00	—
X 5 CrNi 18 9	≤ 0,07	1,00	2,00	0,045	0,030	17,00 to 19,00	—	8,00 to 11,00	—
X 6 CrNiNb 18 10	≤ 0,08	1,00	2,00	0,045	0,030	17,00 to 19,00	—	9,00 to 12,00	Nb ≥ 10 × % C ≤ 1,00 3)
X 6 CrNiTi 18 10	≤ 0,08	1,00	2,00	0,045	0,030	17,00 to 19,00	—	9,00 to 12,00	Ti ≥ 5 × % C ≤ 0,80
X 2 CrNiMo 17 12	≤ 0,030	1,00	2,00	0,045	0,030	16,50 to 18,50	2,00 to 2,50	11,00 to 14,00	—
X 2 CrNiMo 17 13	≤ 0,030	1,00	2,00	0,045	0,030	16,50 to 18,50	2,50 to 3,00	11,50 to 14,50	—
X 5 CrNiMo 17 12	≤ 0,07	1,00	2,00	0,045	0,030	16,50 to 18,50	2,00 to 2,50	10,50 to 13,50	—
X 6 CrNiMoTi 17 12	≤ 0,08	1,00	2,00	0,045	0,030	16,50 to 18,50	2,00 to 2,50	11,00 to 14,00	Ti ≥ 5 × % C ≤ 0,80
X 6 CrNiMoNb 17 12	≤ 0,08	1,00	2,00	0,045	0,030	16,50 to 18,50	2,00 to 2,50	11,00 to 14,00	Nb ≥ 10 × % C ≤ 1,00 3)
X 5 CrNiMo 17 13	≤ 0,07	1,00	2,00	0,045	0,030	16,50 to 18,50	2,50 to 3,00	11,00 to 14,00	—
X 2 CrNiN 18 10	≤ 0,030	1,00	2,00	0,045	0,030	17,00 to 19,00	—	8,50 to 11,50	N: 0,12 to 0,22
X 2 CrNiMoN 17 13	≤ 0,030	1,00	2,00	0,045	0,030	16,50 to 18,50	2,50 to 3,00	11,50 to 14,50	N: 0,12 to 0,22

1) The designations were made according to the rules stated in ISO/TR 4949.

2) Elements not included in this table shall not be intentionally added without the agreement of the purchaser, other than for the purpose of finishing the heat. If, in special cases, the purchaser considers that the level or residual elements is important in relation to the mechanical and technological properties of the steel in the intended application, the cast (ladle) analysis limits for such elements shall be agreed upon at the time of enquiry or order. The agreed elements shall then be analysed and the values reported.

3) Niobium content includes tantalum determined as niobium.

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	≤ 0,030 > 0,030	+ 0,005 + 0,01
Si	≤ 1,00	+ 0,05
Mn	≤ 2,00	+ 0,05
P	≤ 0,045	+ 0,005
S	≤ 0,030	+ 0,003
Cr	≤ 19,0	± 0,20
Mo	≤ 3,00	± 0,08
N	≤ 0,22	± 0,02
Nb	≤ 1,00	± 0,05
Ni	≤ 14,50	± 0,15
Ti	≤ 0,80	± 0,15

6.2.3 At low temperature

The minimum longitudinal impact values and the test temperature shall be agreed upon at the time of enquiry and ordering. For information, absorbed energy values at various temperatures are described in annex B.

NOTE — The values are not normally subjected to verification but, if verification is required by the purchaser, 9.4.3 and the steel grade selection given in annex B should be referred to.

6.3 Weldability

Steels intended for the production of tubes covered by this part of ISO 9330 are generally regarded as being weldable. However, account should be taken of the fact that the behaviour of the steel during and after welding depends not only on the steel, but also very much on the conditions of preparing and carrying out the welding and the final use for the steel.

6.4 Corrosion resistance

6.4.1 The corrosion resistance considerations contained in this part of ISO 9330 relates to intergranular corrosion. Other types of corrosion or effects of the various corrosion media found in use is not the subject of this part of ISO 9330.

6.4.2 If specific corrosion tests are required, they shall be agreed upon at the time of enquiry and order. The conditions and the evaluation of the results of testing shall also be established at this time.

For resistance to intergranular corrosion, requirements shall be agreed upon, for example on the basis of the intergranular corrosion tests given in ISO 3651-1 or ISO 3651-2.

6.4.3 The data given in table 3 shall apply for the resistance of the steels to intergranular corrosion, when tested as specified in ISO 3651-2 (see 9.4.4 and 9.6.6).

Guideline values for the limit temperature in the case of intergranular corrosion stress are indicated in table 4.

Table 3 — Mechanical properties at room temperature, heat treatment and corrosion resistance of the austenitic steels for welded tubes (applicable for wall thicknesses up to 50 mm) 1)

Steel grade	Tensile test: Proof stress $R_{p0,2}$ min.	Tensile test: Proof stress $R_{p1,0}$ min.	Tensile test: Tensile strength R_m 2)	Tensile test: Elongation 2) A		Impact test: KV min.		Flattening test: Constant K	Drift expanding test: Increase of D for D_i/D %			Usual reference heat-treatment conditions: Symbol 6)	Solution temperature 7) 8)	Cooling in 9)	Intergranular corrosion-resistance 10)
	N/mm²	N/mm²	N/mm²	l 3) %	t 3) %	l 3) 4) J	t 3) 5) J		< 0,6	> 0,6 < 0,8	> 0,8		C		
X 2 CrNi 18 10	180	215	480 to 680	40	35	85	55	0,09	9	15	17	Q	1 000 to 1 100 11)	w, a	g
X 5 CrNi 18 9	195	230	500 to 700	40	35	85	55	0,09	9	15	17	Q	1 000 to 1 100 11)	w, a	g 12)
X 6 CrNiNb 18 10	205	240	510 to 740	35	30	85	55	0,09	9	15	17	Q	1 020 to 1 120 11)	w, a	g
X 6 CrNiTi 18 10	200	235	510 to 710	35	30	85	55	0,09	9	15	17	Q	1 020 to 1 120 11)	w, a	g
X 2 CrNiMo 17 12	190	225	490 to 690	40	35	85	55	0,09	9	15	17	Q	1 020 to 1 120 11)	w, a	g
X 2 CrNiMo 17 13	190	225	490 to 690	40	35	85	55	0,09	9	15	17	Q	1 020 to 1 120 11)	w, a	g
X 5 CrNiMo 17 12	205	240	510 to 710	40	35	85	55	0,09	9	15	17	Q	1 020 to 1 120 11)	w, a	g 12)
X 6 CrNiMoTi 17 12	210 12)	245 12)	510 to 710 12)	35	30	85	55	0,09	9	15	17	Q	1 020 to 1 120 11)	w, a	g
X 6 CrNiMoNb 17 12	215	250	510 to 740	35	30	85	55	0,09	9	15	17	Q	1 020 to 1 120 11)	w, a	g
X 5 CrNiMo 17 13	205	240	510 to 710	40	30	85	55	0,09	9	15	17	Q	1 020 to 1 120 11)	w, a	g 12)
X 2 CrNiN 18 10	270	305	550 to 750	35	30	85	55	0,09	9	15	17	Q	1 000 to 1 100 11)	w, a	g
X 2 CrNiMoN 17 13	280	315	580 to 780	35	30	85	55	0,09	9	15	17	Q	1 020 to 1 120 11)	w, a	g

1) For wall thicknesses greater than 50 mm, the values to be obtained shall be the subject of agreement between the purchaser and manufacturer at the time of ordering.

2) The upper value of tensile strength may be exceeded by 70 N/mm² and the minimum values of elongation A may be 5 units less, in the case of tubes which are supplied in conditions LW1, LW2, LW3 and LW4 described in table 6 and which are not in the solution treated and quenched condition.

3) l = longitudinal; t = transverse.

4) Applicable only in cases where transverse test pieces cannot be taken (see 9.4.1.5.5).

5) Applicable for wall thicknesses greater than 20 mm.

6) Q = quenched.

7) The indications are for guidance only, except in cases where testing of reference test pieces is required.

8) In the case of heat treatment in continuous furnaces, the temperature of the furnace atmosphere should normally be in the upper part of the given range or even exceed it.

9) w = water; a = air; cooling sufficiently rapid.

10) When tested in accordance with ISO 3651-2: g = given up to the limit temperatures indicated in the last column of table 4.

11) In the case of heat treatment during processing after delivery, the lower part of the given solution temperature range is to be aimed for. If, during hot working, the temperature was not below the specified lower limit of solution temperature, the following temperatures are sufficient for repeat heat treatment; 980 C in the case of Mo-free steals; 1 000 C in the case of steels with < 3 % (m/m) Mo; 1 020 C in the case of steels with > 3 % (m/m) Mo.

12) Only for wall thicknesses not exceeding 6 mm.

Table 4 — Minimum 0,2 % and 1 % proof-stress values at elevated temperatures for the quenched condition and guideline for the limit temperature in the case of intercrystalline corrosive stress (applicable for wall thicknesses up to 50 mm) 1)

Steel grade	$R_{p0,2}$ min. 2) N/mm²										$R_{p1,0}$ min. 2) N/mm²										Limit temperature 3) C
	Temperature C										Temperature C										
	150	200	250	300	350	400	450	500	550	600	150	200	250	300	350	400	450	500	550	600	
X 2 CrNi 18 10	116	104	96	88	84	81	78	76	74	72	150	137	128	122	116	110	108	106	102	100	350
X 5 CrNi 18 9	126	114	106	98	93	89	86	84	81	79	160	147	139	132	125	120	117	115	112	109	300 4)
X 6 CrNiNb 18 10	162	153	147	139	133	129	126	124	122	121	192	182	172	166	162	159	157	155	153	151	400
X 6 CrNiTi 18 10	149	144	139	135	129	124	119	116	111	108	179	172	164	158	152	148	143	140	138	135	400
X 2 CrNiMo 17 12	130	120	109	101	96	90	87	84	81	79	161	149	139	133	127	123	119	115	112	110	400
X 2 CrNiMo 17 13	130	120	109	101	96	90	87	84	81	79	161	149	139	133	127	123	119	115	112	110	400
X 5 CrNiMo 17 12	144	132	121	113	107	101	98	95	92	90	172	159	150	143	137	133	129	125	121	119	300 4)
X 6 CrNiMoTi 17 12	(148)	(137)	(126)	(117)	(111)	(105)	(102)	(99)	(95)	(93)	(183)	(169)	(159)	(152)	(147)	(142)	(138)	(133)	(129)	(127)	400
X 6 CrNiMoNb 17 12	(153)	(141)	(130)	(121)	(115)	(109)	(106)	(102)	(99)	(97)	(186)	(172)	(163)	(155)	(150)	(145)	(141)	(136)	(132)	(130)	400
X 5 CrNiMo 17 13	144	132	121	113	107	101	98	95	92	90	172	159	150	143	137	133	129	125	121	119	300 4)
X 2 CrNiN 18 10	169	155	143	135	129	123	119	115	113	110	201	182	172	163	156	149	144	140	136	131	400
X 2 CrNiMoN 17 13	178	164	154	146	140	136	132	129	126	124	208	192	180	172	166	161	157	152	149	144	400

1) For wall thicknesses greater than 50 mm, the values to be obtained shall be the subject of agreement between the purchaser and manufacturer at the time of ordering.

2) The values were derived, as far as possible, from the regression lines given in various TC 17/SC 18 documents. Values given in parentheses were derived from the regression lines for the nearest appropriate steels.

3) Up to these temperatures, the material should, within 100 000 h, not have changed so as to show susceptibility of intercrystalline corrosion, when tested in conformity with ISO 3651-1 and ISO 3651-2.

4) Only for wall thicknesses not exceeding 6 mm.

7 Dimensions, masses and tolerances

7.1 Diameters, wall thicknesses and masses

The outside diameters, wall thicknesses and masses of the tubes covered by this part of ISO 9330 shall be selected from those given in ISO 1127 and ISO 4200.

For special fields of application, tubes should be selected from ISO 1129, ISO 2037 and ISO 6759.

By agreement between the purchaser and the manufacturer, tubes specified by inside diameter and wall thicknesses can be supplied. In this case, the dimensions and the tolerances required have to be agreed upon at the time of enquiry and order.

7.2 Lengths

7.2.1 It shall be stated in the enquiry and order 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 2 m to 7 m in which they usually fall during normal production.

7.2.3 If the tubes are to be delivered with exact lengths, the length tolerances given in 7.3.2 shall apply.

7.3 Tolerances

7.3.1 Tolerances on outside diameter and wall thickness

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). The permissible dimensional deviations for outside diameter and wall thicknesses of the tube depend on the tube manufacturing process, the steel grade and the method of subsequent treatment.

The special tolerances required by ISO 2037 and ISO 6759 are not included in this part of ISO 9330.

Within areas where the tube surface has been dressed by mechanical machining (such as grinding), for example, as a result of instructions received for the performance of non-destructive testing, 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.

The tolerances on ovality and eccentricity are included in the tolerances on diameter and wall thickness.

Table 5 — Tolerances on outside diameter and wall thickness

Outside diameter, D mm	Outside diameter		Wall thickness	
	ISO tolerance class	Permissible deviation	ISO tolerance class	Permissible deviation
$D \leq 168,3$	D2	± 1,0 % with a minimum ± 0,5 mm	T3	± 10 % with a minimum ± 0,2 mm
	D3 D4	In special cases ± 0,75 % with a minimum ± 0,3 mm ± 0,5 % with a minimum ± 0,1 mm	T4	In special cases ± 0,75 % with a minimum ± 0,15 mm
$D > 168,3$	—	± 1,0 % with a maximum ± 3 mm	T3	± 10 % with a minimum ± 0,2 mm

7.3.2 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 applicable tolerances shall be agreed between the purchaser and manufacturer.

8 Technical delivery conditions

8.1 Appearance and soundness

8.1.1 The surface condition of the tube is at the option of the manufacturer. However, the purchaser may specify one of the surface conditions indicated in table 6 or another condition, as required.

8.1.2 The tubes shall be clean and free from such defects as can be established by visual inspection in accordance with this part of ISO 9330 (see 9.7).

8.1.3 The tubes shall have a finish and surface condition which permits surface imperfections or marks requiring dressing to be identified.

NOTE — Any special requirements for surface condition should be agreed between the purchaser and the manufacturer at the time of enquiry and order.

8.1.4 It shall be permissible to dress by grinding or machining surface marks and imperfections such as scabs, seams, tears, laps, slivers or gouges, provided that the thickness of the tube after dressing does not fall below the nominal thickness by more than the tolerance specified in this part of ISO 9330. Repair by welding is not permitted.

Weld defects in tubes welded by a process using filler metal may be repaired at the option of the manufacturer, but tubes shall be repaired only before heat treatment or cold finishing respectively; except that defects found after initial heat treatment may be repaired provided that such tubes are heat treated again. The repaired regions shall be non-destructively tested; in addition, the tube shall be tested for leak tightness.

8.1.5 Surface imperfections which encroach on the minimum wall thickness shall be considered as defects and shall be deemed not to comply with this part of ISO 9330.

8.1.6 All dressed areas shall blend smoothly into the contour of the tube.

8.1.7 Tubes welded without the addition of filler metal shall, unless otherwise agreed between the parties concerned, be dressed flush externally at the weld, so that the tube appears smooth and circular to the eye.

The internal projection of the weld bead shall be within 10 % of the specified thickness, with a minimum of 0,5 mm and a maximum of 3 mm.

A misalignment of the abutting edges shall not exceed:

— for wall thickness $T \leqslant 12{,}7$ mm: 1,6 mm;

— for wall thickness $T > 12{,}7$ mm: 0,125 T or 3 mm, whichever is the smaller.

8.1.8 For tubes welded with the addition of filler metal and supplied in the as-welded or welded and heat-treated condition, the outside and inside weld reinforcement shall not exceed the following maximum height:

— for the external weld bead: 0,5 T or 3 mm, whichever is the smaller;

— for the internal weld bead: 0,25 T or 3 mm, whichever is the smaller.

Table 6 — Type of condition and surface condition of tubes

Symbol	Type of condition	Surface condition 1)
LW1 2)	Tubes welded from surface condition F4 *) or F5 *) plate, sheet or strip, not pickled	Metallically clean
LW2 2)	Tubes welded from surface condition F4 *) or F5 *) plate, sheet or strip, heat treated, pickled	Metallically bright
LWHT1 2)	Tubes welded from surface condition F4 *) or F5 *) plate, sheet or strip, heat treated, pickled	
LWHT2 2)	Tubes welded from surface condition F4 *) or F5 *) plate, sheet or strip, bright heat treated	
LW3 2)	Tubes welded from surface condition F7 *), F8 *) or F9 *) plate, sheet or strip, not pickled	Metallically clean, except for the weld, essentially smoother than for type LW1
LW4 2)	Tubes welded from surface condition F7 *), F8 *) or F9 *) plate, sheet or strip, pickled	Metallically bright, except for the weld, essentially smoother than for types LW2 and LWHT2
LWHT3 2)	Tubes welded from surface condition F7 *), F8 *) or F9 *) plate, sheet or strip, heat treated, pickled	
LWHT4 2)	Tubes welded from surface condition F7 *), F8 *) or F9 *) plate, sheet or strip, bright heat treated	
LWCF1 3)	Tubes welded from surface condition F7 *), F8 *) or F9 *) plate, sheet or strip, heat treated, pickled or bright heat treated, if appropriate, cold formed	
LWCF2	Tubes welded from surface condition F4 *), F5 *), F7 *), F8 *) or F9 *) plate, sheet or strip, heat treated if appropriate, at least 20 % cold formed, heat treated, with recrystallized weld metal, pickled	Metallically bright weld scarcely recognizable
LWCF3	Tubes welded from surface condition F4 *), F5 *), F7 *), F8 *) or F9 *) plate, sheet or strip, heat treated if appropriate, at least 20 % cold formed, bright heat treated with recrystallized weld metal	
LWG	Ground 3)	Metallically bright-ground, the type and degree of grinding shall be agreed upon at the time of enquiry and order 5)
LWP	Polished 4)	Metallically bright-polished, the type and degree of polishing shall be agreed upon at the time of enquiry and order 5)

1) See also 8.1.
2) Letter B (bead-conditioned) is to be appended to the symbol for the type of condition of tubes having smoothed welds (see 5.3).
3) The mechanical properties specified in table 3 do not apply for this type of condition. If required, they shall be agreed upon at the time or ordering.
4) Conditions LW4, LWHT3, LWHT4, LWCF2 or LWCF3 are usually used as the starting condition.
5) The order shall indicate in each case whether grinding or polishing is to be performed internally or externally, or internally and externally.
*) See ISO 683-13.

8.1.9 Larger surface imperfections may be dressed, except for the condition "polished", provided that the thickness after dressing remains within the lower tolerance limits.

8.1.10 All tubes shall be reasonably straight. For tubes over 50 mm in diameter, deviation from straightness over the entire tube length L shall not exceed 0,002 L.

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.

8.2 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.

9 Inspection and testing

9.1 Documents on inspection and testing

9.1.1 Table 7 gives a survey of the inspection procedures and the type of documents considered in ISO 10474 in conjunction with ISO 404 which may be agreed upon at the time of enquiry and order for deliveries according to this part of ISO 9330.

9.1.2 If, in accordance with the agreement at the time of ordering, an inspection certificate (ISO 10474 — 3.1.A or 3.1.B or 3.1.C) or an inspection report (ISO 10474 — 3.2) is to be provided (see table 7 and 9.2), the specific inspection and tests described in 9.3 to 9.8 shall be carried out and the compliance of their results shall be stated in the document.

In addition, the document shall include

a) the result of the heat analysis;

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

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

d) the actual heat treatment carried out (see 5.3).

9.2 Test categories

The tubes shall be subjected to the inspection and tests indicated in table 8 for the category agreed at the time of ordering.

Test categories I and II only apply to the inspection certificate (ISO 10474 — 3.1.A or 3.1.B or 3.1.C) or an inspection report (ISO 10474 — 3.2).

9.3 Testing of chemical composition

9.3.1 A check analysis of the chemical composition of the tubes may be agreed upon at the time of enquiry and ordering (see 9.9.1).

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

9.3.3 The samples shall be taken in accordance with ISO 14284. The samples may be taken either

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

b) at the same location as for the mechanical test pieces.

Table 7 — Applicable inspection procedures and types of documents

Standard designation according to ISO 10474:1991	Document	Type of control	Contents of document	Delivery conditions	Document validated by
2.2	Test report	Non-specific	With mention of test results carried out on the basis of non-specific inspection and testing	In accordance with the requirements of the order and, if required, also in accordance with official regulations and the corresponding technical rules	The manufacturer
2.3	Specific test report	Specific	With mention of test results carried out on the basis of specific inspection and testing		
3.1.A	Inspection certificate 3.1.A			In accordance with official regulations and the corresponding technical rules	The inspector designated in the official regulations
3.1.B	Inspection certificate 3.1.B			In accordance with the specifications of the order and, if required, also in accordance with official regulations and the corresponding technical rules	The manufacturer's authorized representative independent of the manufacturing department
3.1.C	Inspection certificate 3.1.C			In accordance with the specifications of the order	The purchaser's authorized representative
3.2	Inspection report 3.2				The manufacturer's authorized representative, independent of the manufacturing department, and the purchaser's authorized representative

9.4 Testing of mechanical and technological characteristics

9.4.1 At room temperature

9.4.1.1 Batch

When specific inspection is required, the delivery shall be divided into batches.

For tubes that are not heat treated, a batch shall consist only of tubes of the same steel grade, from the same heat, the same 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, the same manufacturing process and having the same nominal outside diameter and wall thickness. These tubes are subjected to the same finishing treatment in a continuous furnace, or heat treated in the same furnace charge in a batch-type furnace.

Table 8 — Test categories

Tests		Test category I	Test category II
Mandatory	Visual examination (see 9.7)	X	X
	Dimensional testing (see 9.6)	X	X
	Leak tightness, hydraulic or non-destructive (see 9.9.7)	X	X
	Tensile test at room temperature (see 9.9.2.1)	X	X
	Flattening or bend or ring tensile test (see 9.9.3)	X	X
	Tensile test on the weld (see 9.9.2.1)	—	—
	Drift or ring expanding test (see 9.9.4)	X	X
	Non-destructive testing of the weld seam (see 9.9.8.1)	X	X
	Non-destructive testing for longitudinal defects (see 9.9.8.2)	—	X
	Non-destructive testing for transverse defects (see 9.9.8.3)	—	X
	Non-destructive testing of tube ends for laminar imperfections (see 9.9.8.4)	—	X
	Steel type verification (see 9.9.9)	X	X
Optional [1]	Check analysis of chemical composition (see 9.9.1)	X	X
	Tensile test at elevated temperature (see 9.9.2.2)	X	X
	Impact test at room temperature (see 9.9.5.1)	X	X
	Impact test at low temperature if the thickness of the tube is $\geqslant$ 6 mm (see 9.9.5.2)	X	X
	Intergranular corrosion test (see 6.4 and 9.9.6)	X	X

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

Each batch shall be comprised of 100 tubes. The remainder 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 over 50 tubes. If the total number of tubes is less than 100, they constitute one batch.

9.4.1.2 Number of sample products per test unit

Each test unit consists of

— one tube per batch for test category I;

— two tubes per batch for test category II, for tests other than those described in 9.9.3 and 9.9.4;

— 10 % of the batch for test category II, for those tests described in 9.9.3 and 9.9.4.

9.4.1.3 Number of tests

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

— one tensile test on each tube (see 9.9.2.1);

— one tensile test on the weld on each tube (see 9.9.2) for tubes with outside diameter greater than 219,1 mm; for tubes with outside diameter less than or equal to 219,1 mm, a tensile test on the weld is not carried out;

— two flattening tests or bend tests or ring tensile tests on each tube (see 9.9.3);

— one drift or one ring expanding test on each tube, where appropriate (see 9.9.4).

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

The test piece for the tensile test 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 less than or equal to 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;

— for tubes with an outside diameter greater than 219,1 mm, the test piece is taken in a direction either longitudinal or transverse to the axis of the tube.

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

The test piece for the flattening test shall consist of a tube section, in conformity with ISO 8492. This test shall not apply for tubes with an outside diameter above 400 mm.

9.4.1.5.4 Test piece for the bend test

The test piece for the bend test shall consist of a section cut from the tube in accordance with the requirements of ISO 7438. For tubes with a wall thickness greater than 20 mm, the test piece may consist of a segment in a transverse direction, with rectangular section, 38 mm wide and 19 mm thick.

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, ISO 8495 or ISO 8496, respectively. This test shall not apply for tubes with an outside diameter above 400 mm.

9.4.1.5.6 Test pieces for the impact test

Impact testing may be agreed upon at the time of ordering. If so, a set of three ISO V-notch full size (10 mm × 10 mm) test pieces shall be taken from each sample tube transverse to the tube axis, provided that the dimension of the tube permits this without flattening of the test piece; otherwise, the test pieces shall be taken longitudinal to the tube axis.

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.

In the case of tubes with a wall thickness exceeding 30 mm, the centre line of the test piece shall have a distance from the external surface equal to one-quarter of the wall thickness, or shall be positioned as close as possible to this location.

9.4.2 At elevated temperature

The determination of proof stresses, $R_{p0,2}$ and $R_{p1,0}$, may be agreed upon at the time of ordering. The temperature and number of test pieces (see 9.9.2.2) shall also be established at this time.

9.4.3 At low temperature

For tubes with a wall thickness greater than or equal to 6 mm, the determination of low temperature impact properties may be agreed upon at the time of ordering. The temperature for the impact test shall also be established at this time.

The form and dimensions of test pieces shall be in accordance with ISO 148.

For the impact test, the test piece shall be taken longitudinal to the tube axis.

9.4.4 Intergranular corrosion test

If a test for the resistance to intergranular corrosion is required, the number of test pieces per test unit shall be agreed upon.

Details for the selection and preparation of samples and test pieces may also be agreed upon at the time of enquiry and order.

9.5 Leak-tightness test

9.5.1 The tubes shall all 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 9.9.7.2).

9.6 Dimensional testing

The tubes shall be checked with respect to dimensions.

The tolerance on diameter is normally measured across the diameter; however, for tubes where the outside diameter is greater than 168,3 mm, this tolerance may be measured on the circumference using a 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.

9.7 Visual examination

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

9.8 Non-destructive testing

9.8.1 The tubes shall all be subjected to non-destructive testing of the weld seam (see 9.9.8.1).

9.8.2 The tubes of test category II shall all be submitted to a non-destructive inspection for longitudinal defects (see 9.9.8.2).

9.8.3 If agreed at the time of enquiry and ordering, tubes of test category II may also be submitted to non-destructive testing for transverse defects (see 9.9.8.3).

9.8.4 If agreed at the time of enquiry and ordering, tubes with wall thicknesses greater than 40 mm may also be submitted to a non-destructive testing of tube ends for the detection of laminar imperfections (see 9.9.8.4).

9.9 Test methods and results

9.9.1 Chemical analysis

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

9.9.1.2 The elements shall be determined in conformity with the methods considered in the corresponding International Standards.

Spectrographic analysis is permitted.

9.9.1.3 The results shall comply with the values in table 1, taking into account the permissible deviations given in table 2.

9.9.1.4 In the case of dispute about analytical methods, the chemical composition shall be determined in accordance with a reference method taken from an International Standard listed in ISO/TR 9769.

9.9.2 Tensile test

9.9.2.1 At room temperature

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

9.9.2.1.2 The tensile strength (R_m), the proof stresses, $R_{p0,2}$ and $R_{p1,0}$, and the percentage elongation after fracture (A) shall be determined during the tensile test.

The percentage elongation after fracture shall be reported with reference to a gauge length of $5{,}65\sqrt{S_0}$ where S_0 is the original cross-sectional area. If other gauge lengths are used, the corresponding elongation referred to a gauge length of $5{,}65\sqrt{S_0}$ shall be obtained in accordance with ISO 2566-2.

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

9.9.2.2 At elevated temperature

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

9.9.2.2.2 The proof stresses, $R_{p0,2}$ and $R_{p1,0}$, shall be determined during the tensile test.

9.9.2.2.3 The result of the tensile test shall comply with the values given in table 4 at the selected temperature.

9.9.3 Flattening test or bend test or ring tensile test

9.9.3.1 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 of an outside diameter above or equal to 200 mm. For tubes with an outside diameter less than 200 mm and greater than or equal to 152,4 mm, the flattening test or the ring tensile test is usually carried out. For tubes with an external diameter below 152,4 mm, only the flattening test is usually carried out.

9.9.3.2 Flattening test

9.9.3.2.1 The flattening test shall be carried out in conformity with ISO 8492.

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

The tube section or the tube end shall be flattened in a press, up to the moment when the distance H between the platens reaches the value given by the following formula:

$$H = \frac{1+K}{K+\frac{T}{D}} \times T$$

where

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

D is the specified outside diameter, in millimetres;

T is the specified wall thickness, in millimetres;

K is the constant factor of deformation (see table 3).

9.9.3.2.2 After testing, the test piece shall be free from cracks or breaks. However, a slight incipient crack at the edges shall not be regarded as a justification for rejection.

When tubes with low D/T ratios are tested, because the strain imposed due to geometry is unreasonably high on the inside surface of the "6 o'clock" and "12 o'clock" locations, cracks at these locations shall not be cause for rejection if the D/T ratio is less than 10.

9.9.3.3 Bend test

9.9.3.3.1 The bend test (see 9.4.1.3) shall be carried out in accordance with ISO 7438. The test piece shall be bent at room temperature in the direction of initial curvature through an angle of 180°, around a mandrel with a diameter equal to 3 T.

9.9.3.3.2 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.

9.9.3.4 Ring tensile test

9.9.3.4.1 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.

9.9.3.4.2 The tube section (see 9.4.1.5.4) shall be subjected to strain in the circumferencial direction. The weld line shall be placed at 90 ° to the line of pull, until fracture occurs.

9.9.3.4.3 After testing, the test piece shall not show any cracks that are visible without the use of magnifying aids.

9.9.4 Drift expanding test or ring expanding test

9.9.4.1 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).

9.9.4.2 Drift expanding test

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

The drift expanding test 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 9.4.1.5.4) shall be expanded on a conical mandrel until the increase in the outside diameter of the expanded tube reaches the value indicated in table 3 for the steel grade concerned.

9.9.4.2.2 After testing, the test piece shall not show any cracks or flaws, but slight premature failure at the edges shall not be considered a cause for rejection.

9.9.4.3 Ring expanding test

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

The test piece shall be expanded until fracture occurs and shall then be inspected. If a 40 % expansion is reached (referred to the inside diameter), the test may be considered as finished.

9.9.5 Impact test

9.9.5.1 At room temperature

9.9.5.1.1 If agreed at the time of enquiry and ordering and if the wall thickness of the tube is greater than or equal to 6 mm, impact testing at room temperature shall be carried out (see 9.4.1.5.6) in accordance with ISO 148. The mean value of the three test pieces shall be taken.

9.9.5.1.2 The test is regarded as having fulfilled the requirements of this part of ISO 9330 if the mean value of the three test pieces corresponds to the minimum value given in table 3 for the relevant steel grade; only one individual value may fall short of this minimum value by up to 30 %.

9.9.5.1.3 If the mean value of the three test pieces is below the minimum specified value, or if one individual value is less than the minimum specified value by more than 30 %, then three further test pieces shall be taken from the sample tube and shall be tested in accordance with ISO 148.

9.9.5.1.4 The mean value of all six tests shall correspond to the minimum value given in table 3 for the relevant steel grade; of the six individual values, only two may fall below this minimum value, and of these two only one by more than 30 %.

9.9.5.2 At low temperature

9.9.5.2.1 If agreed at the time of ordering, and if the wall thickness of the tube is greater than or equal to 6 mm, the low temperature impact test shall be carried out (see 9.4.3) in conformity with ISO 148 at a temperature selected from annex B and agreed between the interested parties at the time of enquiry and ordering. The mean value of the three test pieces shall be taken.

9.9.5.2.2 The test is regarded as having fulfilled the requirement of this part of ISO 9330 if the mean value of the three test pieces corresponds to the agreed values given in annex B for the relevant steel grade; only one individual value may fall short of this minimum value by up to 30 %.

9.9.5.2.3 If the mean value of the three test pieces is below the minimum specified value, or if one individual value is less than the minimum specified value by more than 30 %, then three further test pieces shall be taken from the sample tube and shall be tested in accordance with ISO 148.

9.9.5.2.4 The mean value of all six tests shall correspond to the minimum value given in annex B for the relevant steel grade; of the six individual values, only two may fall below this minimum value, and of these two only one by more than 30 %.

9.9.6 Intergranular corrosion test

Unless otherwise agreed, tests on corrosion resistance shall be carried out in accordance with ISO 3651-1 or ISO 3651-2.

9.9.7 Leak-tightness test

9.9.7.1 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:

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

where

p_t is the test pressure, 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, corresponding to 80 % of the specified minimum value of $R_{p0,2}$ (see table 3) 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 deformations beyond the limits of the dimensional tolerances.

9.9.7.2 Non-destructive test

If the tube is not submitted to the hydraulic test described in 9.9.7.1, 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; or

c) a special test, being either

   1) the bubble test film technique using air under water at a test pressure of 6 bar. The test pressure shall be maintained for 5 s;

   2) the bubble test film technique using air and a bubble-forming solution at a test pressure of 0,3 bar.

9.9.8 Non-destructive testing

9.9.8.1 All tubes shall be subjected to non-destructive testing of the weld seam as follows:

a) either ultrasonic testing in accordance with ISO 9765, with acceptance level L3; or

b) radiographic testing in accordance with ISO 12096, with acceptance level R3; or

c) eddy current testing in accordance with ISO 9304, with an acceptance level as shown in annex A.

The choice of method is at the discretion of the manufacturer, dependent on the processing stage and dimensions of the tube.

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

9.9.8.3 Tubes of test category II shall also be submitted to ultrasonic testing for transverse defects in accordance with ISO 9305, with acceptance level L2.

9.9.8.4 Tubes with wall thicknesses greater than 40 mm shall also be submitted to ultrasonic testing of tube ends for the detection of laminar imperfections, in accordance with ISO 11496.

9.9.9 Steel type verification

A suitable method shall be used to verify that the steel type verified has been produced.

9.10 Invalidation of the tests

See ISO 404.

9.11 Retests

See ISO 404.

9.12 Sorting or reprocessing

See ISO 404.

10 Marking

10.1 Marking to be applied

The following marking, either as text or in the form of bar coding, 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.

The marking shall include the following information:

— the mark of the manufacturer or the tubes;

— the designation of the steel grade;

— the heat number or a code number;

— the designation of the test category;

— the mark of the inspector, in the case of third-party inspection;
— a number or mark by which the tubes can be identified with the inspection certificate or inspection report, if applicable;
— reference to this part of ISO 9330;
— the symbol specified in table 6 identifying the type of condition of the tube, if requested.

10.2 Methods

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

All or part of the required information may be continuously marked along the tube length.

For tubes with an outside diameter up to and including 31,8 mm, the symbols may be indelibly marked on a label attached firmly to each bundle or box.

10.2.2 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 Disputes

See ISO 404.

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Annex A
(informative)

Stress rupture properties at elevated temperatures of austenitic steels

Steel grade	Reference heat treatment [1) 2)]	Rupture time h	Estimated average stresses for rupture [3)], N/mm^2 — Temperature, °C															
			540	550	560	570	580	590	600	610	620	630	640	650	660	670	680	690
X 7 CrNi 18 9	Q	10 000	—	176	164	152	142	131	122	113	104	95	87	79	73	67	61	56
		30 000	—	147*	135*	126*	115*	105*	96*	88*	80*	74	67	61	55	50	44*	(40)*
		50 000	—	134*	123*	113*	103*	94*	85*	78*	72*	65*	58*	52*	47*	41*	(36)*	(32)*
		100 000	—	115*	105*	98*	89*	81*	74*	68*	61*	55*	50*	45*	(40)*	(35)*	(30)*	(26)*
		150 000	—	108*	99*	89*	81*	74*	67*	60*	54*	49*	43*	(39)*	(34)*	(30)*	(26)*	(23)*
		200 000	—	102*	93*	84*	76*	69*	62*	56*	50*	45*	(40)*	(35)*	(31)*	(27)*	(24)*	(21)
		250 000	—	97*	88*	79*	73*	66*	59*	53*	47*	42*	(37)*	(33)*	(29)*	(25)*	(22)*	—
X 7 CrNiTi 18 10	Q	10 000																
		30 000																
		50 000																
		100 000																
		150 000																
		200 000																
		250 000																
X 7 CrNiNb 18 10	Q	10 000																
		30 000																
		50 000																
		100 000																
		150 000																
		200 000																
		250 000																
X 7 CrNiMo 17 12	Q	10 000	247	233	220	206	193	180	167	156	142	130	119	108	97	87	78	70
		30 000	222	208	195	181	168	155	143	131	119	107	97	87	78	69	62	56
		50 000	210	197	183*	170	157	144	132	120	108	97	87	78	70	62	56	51
		100 000	194*	181*	167*	154*	141	128	116	105	94	84	75	67	60	54	49*	(44)*
		150 000	185*	172*	158*	145*	132	120	108	97	86	77*	69*	61*	55*	50*	(45)*	—
		200 000	178*	164*	151*	138*	125	113	102	91	81	72*	65*	58*	52*	47*	(43)*	—
		250 000	173*	159*	146*	133*	120*	108*	97*	87*	77*	69*	61*	55*	50*	(45)*	—	—

1) Q = quenched.

2) For temperatures and cooling conditions, see table 3.

3) Values marked with "*" involved extended time extrapolation. Values given in parentheses involved stress extrapolation.

Estimated average stresses for rupture 3), N/mm²																									
Temperature, °C																									
700	710	720	730	740	750	760	770	780	790	800	810	820	830	840	850	860	870	880	890	900	910	920	930	940	950
48	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(35)*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(27)*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(23)*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(20)*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
63	57	52	47	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
51	48	(42)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
46	(42)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

3) Values marked with "*" involved extended time extrapolation. Values given in parentheses involved stress extrapolation.

Annex B
(informative)

Typical impact properties at low temperature for the quenched condition of austenitic steels for welded tubes

Steel grade	Wall thickness mm	Minimum impact test value *KV* [1)] in joules, average of three tests (see 9.9.5.2)									
		Temperature, °C									
		0	– 20	– 40	– 50	– 80	– 100	– 120	– 150	– 170	– 195
X 2 CrNi 18 10	≤ 16	86	86	82	82	78	78	74	74	71	71
X 5 CrNi 18 9	≤ 16	86	86	82	82	78	78	74	74	71	71
X 6 CrNiNb 18 10	≤ 16	78	78	74	74	71	71	67	67	63	63
X 6 CrNiTi 18 10	≤ 16	78	78	74	74	71	71	67	67	63	63
X 2 CrNiMo 17 12	≤ 16	78	78	74	74	71	71	67	67	63	63
X 2 CrNiMo 17 13	≤ 16	78	78	74	74	71	71	67	67	63	63
X 5 CrNiMo 17 12	≤ 16	78	78	74	74	71	71	67	67	63	63
X 6 CrNiMoTi 17 12											
X 6 CrNiMoNb 17 12											
X 5 CrNiMo 17 13	≤ 16	78	78	74	74	71	71	67	67	63	63
X 2 CrNiN 18 10											
X 2 CrNiMoN 17 13											

1) The values apply to standard 10 mm x 10 mm test pieces. Where it is necessary to use subsize test specimens, the values shall be agreed between the interested parties (see also 9.4.3 and 9.9.5.2).

ICS 23.040.10; 77.140.30

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

Price based on 27 pages