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**Welded steel tubes for pressure  
purposes — Technical delivery  
conditions —**

Part 4:

**Submerged arc-welded unalloyed and  
alloyed steel tubes with specified elevated  
temperature properties**

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

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*Partie 4: Tubes soudés à l'arc immergé en aciers non alliés et alliés avec  
caractéristiques spécifiées à température élevée*



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Case postale 56 • CH-1211 Geneva 20  
Tel. + 41 22 749 01 11  
Fax + 41 22 749 09 47  
E-mail [copyright@iso.ch](mailto:copyright@iso.ch)  
Web [www.iso.ch](http://www.iso.ch)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

Attention is drawn to the possibility that some of the elements of this part of ISO 9330 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 9330-4 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 19, *Technical delivery conditions for steel tubes for pressure purposes*.

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*

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

# Welded steel tubes for pressure purposes — Technical delivery conditions —

Part 4:

## Submerged arc-welded unalloyed and alloyed steel tubes with specified elevated temperature properties

### 1 Scope

This part of ISO 9330 specifies the technical delivery conditions for submerged arc-welded tubes of circular cross-section, made of unalloyed or alloyed steel with specified elevated temperature properties. These tubes are intended for pressure purposes in cases when the material is also subjected to elevated temperatures, e.g. for the construction of steam generating equipment and for interconnecting pipework.

The requirements of appropriate international application standards and relevant national legal regulations shall be taken into account by the user. For boilers and pressure vessels International Standards ISO 831, ISO 2604 and ISO 5730 are available.

For the general technical delivery requirements, see ISO 404.

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

### 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 9330. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 9330 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 148:1983<sup>1)</sup>, *Steel — Charpy impact test (V-notch)*.

ISO 377:1997, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*.

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

ISO 783:1999, *Metallic materials — Tensile testing at elevated temperature*.

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

ISO 3205:1976, *Preferred test temperatures*.

1) This International Standard has been withdrawn and replaced by ISO 148-1:—, ISO 148-2:1998 and ISO 148-3:1998.

## ISO 9330-4:2000(E)

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 4948-1:1982, *Steels — Classification — Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition.*

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

ISO 5173:1981, *Fusion welded butt joints in steel — Transverse root and face bend test.*

ISO 5177:1981, *Fusion welded butt joints in steel — Transverse side bend test.*

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

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

ISO 6892:1998, *Metallic materials — Tensile testing at ambient temperature.*

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

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 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 12094:1994, *Welded steel tubes for pressure purposes — Ultrasonic testing for the detection of laminar imperfections in strip/plates used in the manufacture of welded tubes.*

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

#### 3.1 Fundamental symbols

$D$  is the specified outside diameter.

$T$  is the 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 Hydraulic test

$p_E$  is the test pressure.

$\sigma$  is the 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:

- a) the denomination "tube";
- b) reference to the relevant dimensional standard;
- c) dimensions (outside diameter  $\times$  wall thickness), see 7.1;
- d) length, see 7.2;
- e) tolerances if exact lengths greater than 12 m are ordered, see 7.3.4;
- f) reference to this part of ISO 9330, i.e. ISO 9330-4;
- g) steel grade, see Table 3;
- h) test category for unalloyed steels, see 9.3.1.

### 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:

- a) dimensions (inside diameter  $\times$  wall thickness) see 7.1;
- b) steelmaking process, see 5.1;
- c) delivery condition, see 5.4;
- d) special straightness requirements, see 7.3.6;
- e) tolerances on the height of the weld seam, see 7.3.2;
- f) bevelled ends, see 8.2;
- g) product analysis, see 10.1.3;
- h) tensile testing of weld for tubes over 219 mm but less than 508 mm outside diameter, see 10.1.3;
- i) determination of proof stress at elevated temperature  $R_{p0,2}$ , see 10.1.3;

- j) impact test, see 10.1.3;
- k) specific marking, see 12.3;
- l) protective coating, see 13;
- m) type of inspection and testing and corresponding document, see 9.2 and 14.

### 4.3 Example of an order

Example of an order conforming to the dimensional standard ISO 4200, with an outside diameter of 457 mm, a wall thickness of 10 mm and a standard length (random length) of 4 m to 8 m, made of steel grade PH 23 with specified elevated temperature properties to be submitted to specific inspection and testing to test category I involving the issuing of an inspection document 3.1 B in accordance with ISO 10474:1991.

**Tube ISO 4200 - 457 × 10 - 4 to 8 - ISO 9330-4 - PH 23 - I - 3.1.B**

## 5 Manufacturing process

### 5.1 Steelmaking process

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

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

### 5.2 Deoxidation process

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

### 5.3 Product-making process for tubes

A welded tube is obtained by shaping a flat-rolled product and then welding the edges. The weld may be longitudinal or helical.

Tubes shall be submerged arc-welded (SAW) using at least one run on the inside and one run on the outside of the tube. Unless otherwise agreed, the process of manufacture is left to the discretion of the manufacturer, provided that the welding method and welder/welding operator have been approved in accordance with a qualified procedure.

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, if applicable.

### 5.4 Delivery condition

5.4.1 Tubes covered by this part of ISO 9330 shall be delivered in accordance with Table 1 and when appropriate the heat treatment conditions indicated in Table 2.

5.4.2 By agreement between the purchaser and the manufacturer the tubes may be delivered in a condition other than the final delivery condition in which case they shall be suitable for subsequent manipulation and the purchaser shall be informed of any treatment necessary to obtain the specified properties.



Table 1 — Delivery conditions

Grade	Delivery condition	
	Cold formed	Hot formed
PH 23, PH 26, PH 29, PH 35	As-welded, not heat-treated	Welded, normalized on full tube
	Welded, heat treatment on full tube	
16 Mo 3, 13 CrMo 4-5, 11 CrMo 9-10	Welded, heat treatment on full tube	

Table 2 — Heat treatment conditions

Steel grade		Reference heat treatment <sup>a</sup>	Austenitizing temperature °C	Cooling medium	Tempering temperature °C	Cooling medium
Unalloyed steels	PH 23	N <sup>b</sup>	880-940	Air	—	—
	PH 26	N <sup>b</sup>	880-940	Air	—	—
	PH 29	N <sup>b</sup>	880-940	Air	—	—
	PH 35	N <sup>b</sup>	880-940	Air	—	—
Alloyed steels	16 Mo 3	N	890-950	Air	—	—
	13 CrMo 4-5	N + T	900-960	Air	660-730	Air
	11 CrMo 9-10	N + T	900-960	Air	680-750	Air

<sup>a</sup> N = normalizing; N + T = normalizing + tempering.

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

## 6 Metallurgical properties

### 6.1 Chemical composition

#### 6.1.1 Heat analysis

The heat analysis reported by the steel producer shall apply and comply with the requirements given in Table 3.

**Table 3 — Chemical composition (heat analysis), % (m/m)**

Steel grade <sup>a</sup>		C	Si	Mn	P max.	S max.	Cr	Mo	Al (total) max.	Others
Unalloyed steels	PH 23	≤ 0,17	0,10-0,30	0,30-0,80	0,035	0,03	—	—	—	b
	PH 26	≤ 0,21	0,10-0,35	0,40-1,20	0,035	0,03	—	—	—	b
	PH 29	≤ 0,22	0,10-0,40	0,65-1,40	0,035	0,03	—	—	—	b
	PH 35	≤ 0,22 <sup>c</sup>	0,15-0,55	1,00-1,50 <sup>c</sup>	0,035	0,03	—	—	—	b, d
Alloyed steels	16 Mo 3	0,12-0,20 <sup>e</sup>	0,15-0,35	0,40-0,80	0,035	0,03	—	0,25-0,35	0,02	b
	13 CrMo 4-5	0,10-0,17 <sup>e</sup>	0,15-0,35	0,40-0,70	0,035	0,03	0,7-1,1	0,40-0,60	0,02	b
	11 CrMo 9-10	0,08-0,15	0,15-0,40	0,30-0,70	0,035	0,03	2,0-2,5	0,90-1,20	0,02	b

NOTE Elements not included in this table should 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 should be taken to prevent the addition of elements from scrap or other materials used in the manufacture, but residual elements may be present 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) should be stated in the documents mentioned in clause 14.

<sup>a</sup> Classification in accordance with ISO 4948-1; designation in accordance with ISO/TR 4949.

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

<sup>c</sup> For tubes with wall thickness > 30 mm the upper limit of the carbon content may be increased by 0,02 % but (C + Mn/6) shall never exceed 0,47 % (m/m).

<sup>d</sup> At the discretion of the manufacturer additions of niobium, titanium and vanadium are permitted up to levels permitted for the non-alloyed steels listed in ISO 4948-1:1982, unless otherwise agreed upon between the purchaser and the manufacturer. In such a case the test certificate shall state the level of these elements.

<sup>e</sup> For tubes with wall thickness > 30 mm the upper limit of the carbon content may be increased by 0,02 % (m/m).

### 6.1.2 Product analysis

If a product analysis is required (see 10.1.3), the permissible deviations given in Table 4 shall apply to the heat analysis specified in Table 3.

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.

**Table 4 — Permitted deviations from the specified chemical composition limits given in Table 3**

Element	Content specified for the heat analysis % (m/m)	Permissible deviation % (m/m)
C	$\leq 0,22$	$\pm 0,03$
Si	$\leq 0,55$	$\pm 0,05$
Mn	$\leq 1,50$	$\pm 0,10$
P	$\leq 0,035$	+ 0,005
S	$\leq 0,030$	+ 0,005
Cr	$\leq 2,50$	$\pm 0,10$
Mo	$\leq 0,35$	$\pm 0,04$
	$0,30 \leq 1,20$	$\pm 0,05$
Al	$\leq 0,020$	+ 0,005

6.2 Mechanical properties

6.2.1 At room temperature

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

Table 5 — Mechanical properties at room temperature

Steel grade		Tensile test					Bend test	Impact test	
		Tensile strength	$R_{eH}$ or $R_{p0,2}$ or $R_{t0,5}$ min. for wall thickness <sup>a</sup>			Elongation <sup>b</sup> A min.		Diameter of the mandrel	Transverse <sup>c</sup>
		$R_m$	< 16 mm	> 16 mm ≤ 40 mm	> 40 mm ≤ 60 mm	<i>l</i>	<i>t</i>		
		N/mm <sup>2</sup>	N/mm <sup>2</sup>			%		mm	J
Unalloyed steels	PH 23	360-480	235	225	215	25	23	3T	27
	PH 26	410-530	265	255	245	21	19	4T	27
	PH 29	460-580	290	280	270	23	21	4T	27
	PH 35	510-640	355	335	315	19	17	4T	27
Alloyed steels	16 Mo 31	450-600	270 <sup>d</sup>	270	260	22	20	4T	27 <sup>e</sup>
	3 CrMo 4-5	440-590	290 <sup>d</sup>	290	280	22	20	4T	27
	11 CrMo 9-10	480-630	280	280	280	20	18	4T	27

<sup>a</sup> For wall thicknesses > 60 mm, the values to be obtained shall be the subject of agreement between the purchaser and the manufacturer at the time of ordering.

<sup>b</sup> *l* = longitudinal; *t* = transversal.

<sup>c</sup> Applicable for wall thicknesses > 30 mm, unless otherwise indicated.

<sup>d</sup> For wall thicknesses ≤ 10 mm the minimum value of yield strength may be increased by 10 N/mm<sup>2</sup>.

<sup>e</sup> Applicable for wall thicknesses > 10 mm.