

INTERNATIONAL  
STANDARD

**ISO**  
**9330-2**

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

**iTeh STANDARD PREVIEW**

**Part 2:**

**(Electric resistance and induction 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 —*

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

INTERNATIONAL

**ISO**



Reference number  
ISO 9330-2:1997(E)

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## Foreword

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

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

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

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

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

- *Part 1: Unalloyed steel tubes with specified room temperature properties*
- *Part 2: Electric resistance and induction welded unalloyed and alloyed steel tubes with specified elevated temperature properties (Partial revision of ISO 2604-3:1975)*
- *Part 3: Electric resistance and induction welded unalloyed and alloyed steel tubes with specified low temperature properties (Partial revision of ISO 2604-3:1975)*
- *Part 4: Submerged arc-welded unalloyed and alloyed steel tubes with specified elevated temperature properties (Partial revision of ISO 2604-6:1978)*
- *Part 5: Submerged arc-welded unalloyed and alloyed steel tubes with specified low temperature properties (Partial revision of ISO 2604-6:1978)*
- *Part 6: Longitudinally welded austenitic stainless steel tubes*

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

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

## Part 2:

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

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### 1 Scope

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

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

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

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

- *Part 1: Unalloyed steel tubes with specified room temperature properties* (partial revision of ISO 2604-3:1975 and of ISO 2604-6:1978).
- *Part 3: Electric resistance and induction welded unalloyed and alloyed steel tubes with specified*

*low temperature properties* (partial revision of ISO 2604-3:1975).

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

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

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

NOTE 1 The English words “tube” and “pipe” are synonymous.

**1.2** See ISO 404 for general technical delivery requirements.

### 2 Normative references

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

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

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

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

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

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

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

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

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

ISO 3205:1976, *Preferred test temperatures.*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

### 3 Symbols and denominations

#### 3.1 Fundamental symbols

$D$  = specified outside diameter

$D_i$  = specified inside diameter

$T$  = specified wall thickness

#### 3.2 Symbols for tolerances

See ISO 5252.

#### 3.3 Symbols for tests

##### 3.3.1 Tensile test

See ISO 6892.

##### 3.3.2 Flattening test

$H$  = distance between platens

### 3.3.3 Hydraulic test

PE = test pressure

S = stress which occurs in the metal during the test

## 4 Information to be supplied by the purchaser

### 4.1 Mandatory information

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

- the denomination “tube”;
- whether tubes are to be supplied hot-finished or cold-finished (see 5.3);
- reference to the relevant dimensional standard;
- dimensions (outside diameter × wall thickness) in millimetres (see 7.1);
- length (see 7.2);
- tolerances, if exact lengths greater than 12 m are ordered (see 7.3.3);
- reference to this part of ISO 9330;
- steel grade (see table 2);
- test category for unalloyed steels (see 9.2).

### 4.2 Optional information

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

- steelmaking process (see 5.1);
- delivery condition (see 5.4);
- special straightness requirements (see 7.3.5);

- bevelled ends (see 8.2);
- product chemical analysis (see 9.3 and 9.10.1)
- tensile testing of weld for tubes over 219 mm but with an outside diameter less than 508 mm (see 9.4.1.3);
- determination of proof stress at elevated temperature,  $R_{p0,2}$  (see 9.4.2);
- leak-tightness test (see 9.5);
- specific marking (see 10.3);
- protective coating (see clause 11);
- type of inspection and testing and corresponding document (see 9.1 and clause 12).

### 4.3 Example of an order

Example of an order for a welded tube conforming to the dimensional standard ISO 4200, with an outside diameter of 168.3 mm, a wall thickness of 4 mm and a standard length (random length) of 4 m to 8 m, made of steel grade PH 23 with specified elevated temperature properties to be submitted to specific inspection and testing to test category I involving the issuing of an inspection certificate 3.1.B according to ISO 10474:

**Tube ISO 4200 - 168,3 × 4 - 4 to 8 - ISO 9330-2 - PH23 - I - 3.1.B**

## 5 Manufacturing process

### 5.1 Steelmaking process

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

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

## 5.2 Deoxidation process

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

## 5.3 Product-making process for tubes

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

### NOTES

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

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

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

## 5.4 Delivery conditions

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

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

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

Table 1 — Delivery conditions

Cold/hot formed, welded and hot finished	Cold formed and welded	Cold formed, welded and cold drawn
Heat treatment on full tube according to table 8  or  no heat treatment for steel grades PH 23, PH 26, PH 27 and PH 35, if hot finishing produces a technically equivalent metallurgical condition <sup>1)</sup>	Heat treatment on full tube according to table 8	Heat treatment on full tube according to table 8
1) The methods of control to achieve this equivalence have to be agreed between the purchaser and the manufacturer.		

## 6 Metallurgical properties

### 6.1 Chemical composition

#### 6.1.1 Heat analysis

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

#### 6.1.2 Product analysis

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

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

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



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

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

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

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

1) Designation according to ISO/TR 4949.

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### 6.2 Mechanical properties

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

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

#### 6.2.1 At room temperature

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

#### 6.2.2 At elevated temperature

##### 6.2.2.1 Proof stress

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

**Table 4 — Mechanical properties at room temperature**

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

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

2) l = longitudinal; t = transverse.

3) For wall thicknesses below or equal to 10 mm, the minimum value of yield strength is increased by 10N/mm<sup>2</sup>.

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### 6.2.2.2 Stress rupture properties

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

### 6.3 Weldability

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

## 7 Dimensions, masses and tolerances

### 7.1 Outside diameters, wall thicknesses and masses

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

### 7.2 Lengths

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

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

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

### 7.3 Tolerances

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

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

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

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

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

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