INTERNATIONAL STANDARD

ISO 9329-1

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Seamless steel tubes for pressure purposes — Technical delivery conditions —

Part 1 :
Unalloyed steels with specified room temperature properties

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

Partie 1 : Aciers non alliés avec caractéristiques spécifiées à température ambiante

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 approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 9329-1 was prepared by Technical Committee ISO/TC 17, *Steel.*

It cancels and replaces ISO 2604-2 : 1975, of which it constitutes a technical revision, together with parts 2, 3 and 4 of ISO 9329.

ISO 9329 consists of the following parts, under the general title *Seamless steel tubes for pressure purposes — Technical delivery conditions* :

— *Part 1 : Unalloyed steels with specified room temperature properties*

— *Part 2 : Unalloyed and alloyed steels with specified elevated temperature properties*

— *Part 3 : Unalloyed and alloyed steels with specified low temperature properties*

— *Part 4 : Austenitic stainless steels*

Annex A of this part of ISO 9329 is for information only.

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Seamless steel tubes for pressure purposes — Technical delivery conditions —

Part 1 : Unalloyed steels with specified room temperature properties

1 Scope

1.1 This part of ISO 9329 specifies the technical delivery conditions for seamless tubes of circular cross-section, made of unalloyed quality steel with specified room temperature properties.

These tubes are intended for pressure purposes including the transport of fluids under pressure.

Certain application standards and regulations permit the use of these tubes up to 350 °C (see annex A).

NOTE — The word "tube" is synonymous with "pipe".

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 9329. 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 9329 are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 377 : 1985, *Wrought steel — Selection and preparation of samples and test pieces.*

ISO 404 : 1981, *Steel and steel products — General technical delivery requirements.*

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

ISO 4200 : 1985, *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 5252 : 1977, *Steel tubes — Tolerance systems.*

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

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

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

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

ISO 9302 : —[1], *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Electromagnetic testing for verification of hydraulic leak-tightness.*

3 Symbols and denominations

3.1 Fundamental symbols

D = specified outside diameter
δ = 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
C = constant factor of deformation

3.3.3 Hydraulic test

P = test pressure
S = stress which occurs in the metal during the test

1) To be published.

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) in millimetres (see 7.1);

— length (see 7.2);

— tolerance for exact lengths greater than 12 m (see 7.3.2);

— reference to this part of ISO 9329;

— steel grade (see table 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 9329 shall be supplemented, if it is deemed necessary by the purchaser, with the indication of one or more of the following optional requirements, which shall be the subject of special agreements :

— steelmaking process (see 5.1);

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

— heat treatment condition (see 5.4);

— requirements concerning possible repair by welding (see 8.1.4);

— special straightness requirements (see 8.1.5);

— product chemical analysis (see 9.2);

— leak-tightness test (see 9.4.2);

— specific marking (see 10.2);

— protective coating (see clause 11).

4.3 Example of an order

Example of an order for a hot-finished seamless tube conforming to the dimensional standard ISO 4200, with an external 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 TS 360 with specified room temperature properties to be submitted to specific inspection and testing involving the issuing of an inspection certificate :

Tube ISO 4200 — 168,3 × 4 — 4 to 8 — ISO 9329-1 — TS 360 — inspection certificate.

5 Manufacturing process

5.1 Steelmaking process

Unless otherwise agreed at the time of ordering, the steelmaking process shall be at the option of the manufacturer.

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

5.2 Deoxidation process

Steels intended for the production of tubes covered by this part of ISO 9329 shall be killed. Semi-killed steels are not permitted.

5.3 Product-making process for tubes

Tubes covered by this part of ISO 9329 shall be manufactured by a seamless process, and may be hot-finished or cold-finished. The terms "hot-finished" and "cold-finished" apply to the condition of the tube before it is heat treated in accordance with 5.4.

5.4 Heat treatment and delivery condition

Tubes shall be supplied either in the hot-finished condition or in one of the heat treatment conditions indicated in table 1.

The choice between these delivery conditions is generally left to the discretion of the manufacturer. However, at the time of enquiry and order, delivery of the tubes in the normalized condition may be agreed upon.

Table 1 — Heat treatment conditions

Steel grade (see table 2)	Annealing below the transformation range	Normalizing
	Temperature °C	Temperature °C
TS 360 TS 410 TS 430 TS 500	640 to 700	870 to 940

6 Metallurgical properties

6.1 Chemical composition

6.1.1 Ladle analysis

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

Table 2 — Chemical composition (ladle analysis)[1], % (m/m)

Steel grade[2]	C max.	Si max.	Mn	P max.	S max.
TS 360	0,17	0,35	0,30 to 0,80	0,040	0,040
TS 410 TS 430	0,21	0,35	0,40 to 1,20	0,040	0,040
TS 500[3]	0,22	0,55	⩽ 1,60	0,040	0,040

1) Elements not included in this table shall not be intentionally added without the agreement of the purchaser, except for elements such as aluminium which may be added for finishing the cast. All reasonable precautions shall be taken to prevent the addition of elements from scrap or other materials used in the manufacture; however residual elements may be tolerated, provided that the mechanical properties and applicability are not adversely affected.

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

2) Provisional designation pending an International Standard on this subject.

3) Additions of niobium, titanium and vanadium are permitted at the discretion of the manufacturer, unless otherwise agreed between the purchaser and the manufacturer, up to the levels permitted for non-alloyed steels in ISO 4948-1. In this case, the test certificate should state the level of these elements.

6.1.2 Product analysis

If a check analysis on the product is required (see 9.2), the permissible deviations given in table 3 shall apply to the ladle analysis specified in table 2.

Other than when maxima only are specified, the deviations 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 cast.

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

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

Element	Permissible deviation % (m/m)
C	+ 0,03
Si	+ 0,05
Mn	± 0,10
P	+ 0,005
S	+ 0,005

6.2 Mechanical properties

The mechanical properties of the tubes covered by this part of ISO 9329, measured at room temperature (23 °C ± 5 °C), are given in table 4.

Table 4 — Mechanical properties at room temperature

Steel grade	Tensile test (see 9.3 and 9.7.2)						Flattening test (see 9.3 and 9.7.3.2)		Bend test (see 9.3 and 9.7.3.3)
	Tensile strength R_m	Upper yield stress or proof stress R_{eH} or $R_{p0,2}$[1] min. for thicknesses in mm			Elongation[2] A min.		Constant C for δ/D ratio		Diameter of mandrel
	N/mm²	$\delta \leqslant 16$ N/mm²	$16 < \delta \leqslant 40$ N/mm²	$40 < \delta \leqslant 65$ N/mm²	l %	t	$\delta/D \leqslant 0,15$	$\delta/D > 0,15$	mm
TS 360	360 to 500	235	225	215	25	23	0,09	0,08	3 δ
TS 410	410 to 550	255	245	235	22	20	0,07	0,06	4 δ
TS 430	430 to 570	275	265	255	21	19	0,07	0,06	4 δ
TS 500	500 to 650	355	345	[3]	21[3]	19[3]	0,07	0,06	4 δ

1) For thicknesses greater than 65 mm, the value to be obtained shall be the subject of agreement between the manufacturer and the purchaser at the time of ordering.

2) l = longitudinal; t = transverse.

3) For thicknesses greater than 40 mm, the values for R_{eH} and A shall be the subject of agreement between the manufacturer and the purchaser at the time of ordering.

6.3 Weldability

Steels intended for the production of tubes covered by this part of ISO 9329 are generally 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 essentially, on the conditions of preparing and carrying out the welding and the final use for the steel.

7 Dimensions, masses and tolerances

7.1 Outside diameters, wall thicknesses and masses

The outside diameters, thicknesses and masses of the tubes covered by this part of ISO 9329 shall be selected from those in ISO 4200.

7.2 Lengths

7.2.1 It shall be stated on 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 usual production ranges. The relevant length ranges are dependent on the diameter and wall thickness of the tube, and on the production facilities of the manufacturer. They 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 7.3.2 shall apply.

7.3 Tolerances

7.3.1 Tolerances on outside diameter and on wall thickness

The outside diameters and the wall thicknesses of the tubes covered by this standard shall be within the tolerance limits given in table 5 (see 9.5).

Ovality is included in the tolerances on diameter as quoted in table 5.

Eccentricity is included in the tolerances on wall thickness as quoted in table 5.

Special requirements regarding tolerances on outside diameter and on wall thickness shall be the subject of an agreement.

7.3.2 Tolerance 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 tolerance shall be agreed between the purchaser and the manufacturer.

8 Appearance and soundness

8.1 Appearance

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

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

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

8.1.4 Surface defects shall not be repaired by hammering. Repair by welding may be permitted by agreement and according to a process agreed between the parties concerned.

8.1.5 The tubes shall be reasonably straight. Special requirements regarding straightness shall be the subject of an agreement.

8.2 Ends

Tubes shall be delivered with nominally square-cut ends, free from excessive burrs.

Table 5 — Tolerances on outside diameter and on wall thickness

Outside diameter mm	Tolerances on D	Tolerances on δ for a δ/D ratio			
		$\leqslant$ 0,025	> 0,025 < 0,05	> 0,05 < 0,10	> 0,10
$D \leqslant$ 101,6	± 1 %[1] with a min. ± 0,5 mm	± 12,5 % with a min. ± 0,4 mm			
$D >$ 101,6		± 20 %	± 15 %	± 12,5 %	± 10 %
1) ± 1,5 % for hot-expanded tubes.					

9 Inspection and testing

9.1 Documents on inspection and testing

9.1.1 Table 6 gives a survey of the inspection procedures and the type of documents considered in ISO 404 which may be agreed upon at the time of enquiry and order for deliveries according to this part of ISO 9329.

9.1.2 If in accordance with the agreements at the time of enquiry and order a test report (TR) is to be provided, this shall include

a) a statement that the material complies with the requirements of the order;

b) the results of a tensile test.

9.1.3 If in accordance with the agreements at the time of ordering an inspection certificate (IC or ICP) or an inspection report (IR) (see table 6) is to be provided, the specific inspections and tests described in 9.2 to 9.6 shall be carried out and their results shall be stated in the document.

In addition, the document shall include

a) the result of the ladle 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 and tested tubes.

Table 6 — Applicable inspection procedures and types of documents

Symbol	Inspection and testing procedure	Type of document
TR	Non-specific testing and inspection[1]	Test report
IC	Specific testing and inspection[2] by the qualified department of the manufacturer's works	Inspection certificate signed by the representative of the qualified department of the manufacturer's works
ICP	Specific inspection and testing[2] in the presence of the purchaser or an organization designated by the purchaser	Inspection certificate signed by the purchaser or an organization designated by the purchaser
IR		Inspection report signed by the manufacturer and purchaser or his representative

1) Non-specific inspection and testing means the inspection and testing carried out by the manufacturer in accordance with his own procedures, on products made by the same manufacturing process, but not necessarily on the products actually supplied.

2) Specific inspection and testing means the inspection and testing procedure carried out on the products to be supplied, in order to verify whether these products comply with the requirements of the order.

9.2 Testing of chemical composition

9.2.1 A test of the chemical composition of the tubes may be agreed upon at the time of ordering (see 9.7.1).

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

9.2.3 The samples shall be taken in accordance with ISO 377. The samples shall be taken either from the test pieces used for the verification of the mechanical properties, or from drillings through the whole thickness of the tube at the same location as for the mechanical test samples.

9.3 Testing of mechanical and technological characteristics

9.3.1 Batch

When specific inspection is required, the delivery shall be divided into batches. A batch is formed by tubes of the same or similar outside diameter, the same or similar wall thickness, the same steel grade, the same manufacturing process and the same heat treatment conditions. The number of tubes per batch shall comply with table 7.

Table 7 — Number of tubes per batch

Outside diameter range mm	Number of tubes per batch[1]
$D \leqslant 114{,}3$	400
$114{,}3 < D \leqslant 323{,}9$	200
$323{,}9 < D$	100

1) Any residual fraction of the batch is considered as a batch.

9.3.2 Number of test pieces

From each batch

— one tensile test piece (see 9.7.2) and

— one flattening or bend test piece or ring tensile test piece (see 9.7.3) shall be taken.

9.3.3 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.

9.3.4 Location and orientation of the test pieces

9.3.4.1 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 below 220 mm, the test is carried out either on a full tube section or on a test piece taken in a direction longitudinal to the axis of the tube;

— for tubes with an outside diameter equal to or greater than 220 mm, the test piece is taken in a direction either longitudinal or transverse to the axis of the tube.

9.3.4.2 The test piece for the bend test consists of a section cut in the tube transversely, 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 with rectangular section having a width of 38 mm and a thickness of 19 mm.

9.3.4.3 The test piece for the flattening test consists of a tube section, in conformity with ISO 8492.

9.4 Leak-tightness test

9.4.1 The tubes shall all be submitted to a leak-tightness test.

9.4.2 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 9.7.4.2).

9.5 Dimensional testing

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

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

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

9.6 Visual examination

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

9.7 Test methods and results

9.7.1 Chemical analysis

9.7.1.1 If agreed at the time of ordering, a check analysis shall be carried out (see 9.2.1 and 9.2.2).

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

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

9.7.2 Tensile test

9.7.2.1 The tensile test shall be carried out at room temperature in conformity with ISO 6892. (See 9.3.2 and 9.3.4.1.)

9.7.2.2 The tensile strength (R_m), the proof stress ($R_{p0,2}$) or the upper yield stress (R_{eH}) and the percentage elongation after fracture (A) shall be determined during the tensile test.

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

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

9.7.3 Flattening or bend test or ring tensile test

9.7.3.1 General

One of the tests in 9.7.3.2, 9.7.3.3 or 9.7.3.4 shall be carried out. The choice of the test shall be at the option of the manufacturer, unless otherwise specified by the purchaser at the time of order.

9.7.3.2 Flattening test

9.7.3.2.1 The test shall be carried out according to ISO 8492. 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 :

$$H = \frac{1 + C}{C + \frac{\delta}{D}} \times \delta$$

where

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

D is the specified outside diameter, in millimetres;

δ is the specified wall thickness, in millimetres;

C is the constant factor of deformation (see table 4).

9.7.3.2.2 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.

9.7.3.3 Bend test

9.7.3.3.1 The test shall be carried out in accordance with ISO 7438.

9.7.3.3.2 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.

9.7.3.4 Ring tensile test

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

9.7.4 Leak-tightness test

9.7.4.1 Hydraulic test

If the leak-tightness test is carried out by a hydraulic test, the test pressure is defined, up to a maximum of 70 bar, by the following equation :

$$P = 20 \frac{S \times \delta}{D}$$

where

P is the test pressure, in bars;

D is the specified outside diameter, in millimetres;

δ 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_{eH} or $R_{p0,2}$ (see table 4) for the steel grade concerned.

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

The tube shall withstand the test without showing leaks or visible deformation.

9.7.4.2 Non-destructive test

If the tube is not submitted to the hydraulic test defined in 9.7.4.1, it shall be submitted to a non-destructive test (see 9.4.2), for example an electromagnetic test according to ISO 9302 or an ultrasonic test[1].

9.8 Invalidation of the tests

See ISO 404.

9.9 Retests

See ISO 404.

9.10 Sorting or reprocessing

See ISO 404.

10 Marking

10.1 Marking to be applied

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

The marking shall include the following information :

— the mark of the manufacturer of the tubes;

— the designation of the steel grade, with the addition of the letter N if the order specified a normalizing treatment;

— if an inspection certificate (IC or ICP) (see table 6) or an inspection report (IR) (see table 6) were requested, the mark of the inspector;

— reference to this part of ISO 9329.

10.2 Specific marking

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

11 Protection

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

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

12 Documents

Documents issued shall conform with 9.1.

13 Claims after delivery

See ISO 404.

1) An International Standard covering ultrasonic testing of steel tubes is now in course of preparation.

Annex A
(informative)

Elevated temperature proof stress

The values given in table A.1 are not guaranteed and are given for information only. They are not subject to verification and may be amended at some time in the future.

Table A.1 — Values for $R^{t}_{p0,2}$ at elevated temperatures, N/mm^2

Grade	Temperature, °C					
	100	150	200	250	300	350
TS 360	185	175	165	145	120	110
TS 410	210	195	185	170	145	135
TS 430	215	200	190	175	155	140
TS 500	250	240	230	215	195	180

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Descriptors : steels, unalloyed steels, pipes (tubes), metal tubes, steel tubes, seamless tubes, specifications, dimensions, delivery conditions, tests, marking.

Price based on 8 pages