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Steel tubes for water and sewage

Tubes en acier pour eaux et eaux résiduelles



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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 559 was prepared by Technical Committee ISO/TC 5, *Ferrous metal pipes and metallic fittings*.

This second edition cancels and replaces the first edition (ISO 559:1977), of which it constitutes a technical revision.

Annexes A and B of this International Standard are for information only.

Steel tubes for water and sewage

1 Scope

This International Standard specifies the technical conditions for delivery of seamless and welded steel tubes for the conveyance of water and sewage at temperatures between $-10\text{ }^{\circ}\text{C}$ and $120\text{ }^{\circ}\text{C}$.

It does not apply to steel tubes in accordance with ISO 65 and similar plain end tubes (for service distribution).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard 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 65:1981, *Carbon steel tubes suitable for screwing in accordance with ISO 7-1*.

ISO 404:—¹⁾, *Steel and steel products — General technical delivery requirements*.

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

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

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 9302:1989, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Electromagnetic testing for verification of hydraulic leak-tightness*.

3 Definitions and symbols

3.1 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1.1 seamless tube: Pierced solid product, hot worked and hot or cold finished.

3.1.2 welded tube: Flat product formed into a circular shape and longitudinally or spirally welded.

3.2 Symbols

For the purposes of this International Standard, the following symbols apply; these symbols are in accordance with those specified in ISO 3545-1, ISO 6708 and ISO 6892.

DN	nominal size
D	outside diameter of the tube, in millimetres
T	thickness of the tube, in millimetres
l	distance between the platens of the test machine, in millimetres
M	mass per unit length, in kilograms per metre
R_m	tensile strength, in newtons per square millimetre
R_{eH}	upper yield stress, in newtons per square millimetre

1) To be published. (Revision of ISO 404:1981)

R_{eL}	lower yield stress, in newtons per square millimetre
$R_{p0,2}$	proof stress (0,2 % non-proportional elongation), in newtons per square millimetre
$R_{t0,5}$	proof stress (0,5 % total elongation), in newtons per square millimetre
A	percentage elongation after fracture, expressed as a percentage of the original gauge length (L_0), $L_0 = 5,65\sqrt{S_0}$
S_0	original cross-sectional area of the parallel length, in square millimetres
PE	test pressure, in bar ²⁾
S	stress which occurs in the metal during the hydraulic test, in newtons per square millimetre
K	flattening test constant; it varies depending on the grade of steel

4 Information to be supplied by the purchaser

4.1 Mandatory information

The purchaser shall specify or confirm in his enquiry and order

- the quantity ordered (total tonnage, total length or number of tubes);
- the number of this International Standard;
- the grade of steel;
- the outside diameter and thickness;
- the length;
- the end preparation (bevelled ends or special joints);

NOTE 1 Until International Standards for special joints are available the purchaser should indicate in the enquiry and order the national standards or other specifications which the manufacturer is required to meet.

- the type of external coating and/or interior lining, as agreed previously with the manufacturer;
- the document to be supplied when the tubes are delivered, which is usually either a statement of compliance or an inspection certificate (see 4.2 and clause 12).

2) 1 bar = 0,1 MPa

4.2 Optional requirements

Certain options and supplementary requirements may be specified, including the following:

- the steel-making processes and deoxidation procedures (see 5.1);
- the tube-making process (see 5.2);
- removal of inside seam reinforcement (see 5.2.2);
- delivery of jointers (see 5.2.2);
- delivery condition (see 5.3.1 and 5.3.2);
- ladle analysis (see 6.1.1);
- product analysis (see 6.1.2);
- delivery lengths (see 7.1.3);
- end preparation (see 7.1.4);
- special tolerances on outside diameters (see 7.2.1.2);
- the removal of inside seam reinforcement of both ends of submerged arc welded tubes (see 5.2.2);
- the selection of samples and tests in the presence of the purchaser or of a representative of the purchaser (see 9.1.1);
- special hydraulic test pressure (see 9.2.4.1);
- type of lining or coating (see clause 11);
- type of documents (see clause 12).

The purchaser should specify his requirements in the enquiry and order.

If the options and particular requirements are not specified in the enquiry and order, their choice will be at the discretion of the manufacturer.

4.3 Designation

The tubes shall be designated, in the sequence given, by the following:

- the type of product (seamless or welded tube);
- the number of this International Standard;
- the grade of steel;
- the outside diameter and the thickness.

EXAMPLE

Submerged arc welded steel tubes in accordance with ISO 559, of steel grade ST360, of outside diameter 1016 mm and thickness 8,8 mm, in random lengths, shall be designated as follows:

Submerged arc welded tubes ISO 559-ST360-1016 × 8,8

5 Manufacturing process

5.1 Steel-making processes and deoxidation procedures

The steel-making processes and deoxidation procedures are at the choice of the manufacturer. At the request of the purchaser, the manufacturer shall state the steel-making processes and deoxidation procedures used.

5.2 Tube-making process

5.2.1 Seamless tubes

Seamless tubes shall be manufactured using a seamless process by hot working with or without subsequent cold finishing.

5.2.2 Welded tubes

Welded tubes shall be manufactured from hot-rolled steel strip, sheet or plate, by longitudinal or spiral welding as shown in table 1.

Table 1 — Welding processes

Type of welding process ¹⁾	Butt welding	Electric resistance, including induction welding	Submerged arc welding
Longitudinal	X	X ¹⁾	X
Spiral	—	X ¹⁾	X
1) See 5.3.2.			

The production process for submerged arc welded tubes shall include at least one welding pass on the inside and at least one welding pass on the outside. Where specified by the purchaser, both ends shall have the inside seam reinforcement removed for a distance to be agreed (see 4.2).

Butt welded tubes and electric resistance, including induction welded, tubes shall be delivered with the

external weld upset removed. By agreement between the manufacturer and the purchaser, the internal weld upset may be trimmed. Butt welded and electric resistance, including induction welded, tubes shall not have skelp end welds.

Unless otherwise specified in the enquiry and order, submerged arc welded tubes may be delivered in short lengths welded together, i.e. jointers, provided that the joints are made by the same method of welding and inspected to the same standards as those used for the manufacture of the tubes (see 4.2 and 9.1.3.1).

5.2.3 Choice of the tube-making process

If the tube-making process, and in particular the type of welding, is not specified in the enquiry or order, this process is at the option of the manufacturer.

5.3 Heat treatment, delivery condition

5.3.1 Seamless tubes

Seamless tubes shall be delivered in a metallurgical condition permitting the manufacturer to guarantee the properties given in table 5.

At the purchaser's request, he shall be informed of the delivery condition.

5.3.2 Welded tubes

The delivery conditions for welded tubes are given in table 2. At the purchaser's request, he shall be informed of the delivery condition.

Table 2 — Delivery conditions for welded tubes

Manufacturing process	Delivery condition (all grades)
Submerged arc welding	Tubes as welded with or without cold expansion Heat-treated tubes
Butt welding or electric resistance including induction welding	As-welded tubes Tubes with weld area heat treated Heat-treated tubes
Butt welding or electric resistance including induction welding with subsequent hot rolling	At the option of the manufacturer — as-hot-rolled tubes — heat-treated tubes
Butt welding or electric resistance including induction welding with subsequent cold finishing	Heat-treated tubes

6 Chemical composition, mechanical properties and weldability

6.1 Chemical composition

Table 3 — Chemical composition (ladle analysis) of steels for seamless and welded tube

Steel grade ¹⁾	Chemical composition, %			Deoxidation condition	
	C max.	P max.	S max.	seamless tubes	welded tubes
ST320 ²⁾	—	0,050	0,050		Not specified
ST360	0,17	0,045	0,045	Killed	Rimming Semi-killed Killed
ST410 ³⁾	0,21	0,045	0,045	Killed	Semi-killed Killed
ST430 ³⁾	0,21	0,045	0,045	Killed	Semi-killed Killed
ST500 ⁴⁾	0,22	0,045	0,045	Specially killed	Specially killed
1) In accordance with ISO/TR 7003, the first letter "S" means "steel" and the second letter "T" means "tube". 2) Only for welded tubes. 3) Provisionally grades 410 and 430 may be used indifferently if agreed at the time of the order. 4) Si 0,55 % max., Mn 1,6 % max.					

6.1.1 Ladle analysis

On ladle analysis the steel shall show the chemical composition, corresponding to the specified grade, specified in table 3. At the purchaser's request, he shall receive a report of the ladle analysis (see 4.2).

6.1.2 Product analyses

If a check analysis on the tubes is specified in the order (see 4.2), the permissible deviations specified in table 4 shall apply to the limits of the ladle analysis specified in table 3.

Table 4 — Permissible deviations from the limits of the ladle analysis

Element	Permissible deviation, % Killed and semi-killed steel
C	+ 0,03
P	+ 0,005
S	+ 0,005

6.2 Mechanical properties

6.2.1 The mechanical properties of seamless or welded tubes are specified in table 5.

6.2.2 Seamless, butt welded and electric resistance, including induction welded, tubes shall meet the requirements for the flattening test.

Submerged arc welded tubes shall meet the requirements for the bend test.

At the option of the manufacturer, the flattening test may be replaced by a bend test.

6.3 Weldability

The steels complying with this International Standard are generally regarded as being weldable, but it should be noted that weldability not only depends on the grade of steel, but is influenced by the welding conditions, and the construction and service conditions of the pipe line.

Table 5 — Mechanical properties of seamless and welded tubes of thickness less than or equal to 25 mm (see 9.2.1.1)

Grade	Yield stress or proof stress ¹⁾ N/mm ²	R_m N/mm ²	A min.	
			longitudinal	transverse
ST320	185	$320 \leq R_m \leq 500$	15	13
ST360	225	$360 \leq R_m \leq 500$	23	21
ST410	245	$410 \leq R_m \leq 550$	21	19
ST430	265	$430 \leq R_m \leq 570$	21	19
ST500	345	$500 \leq R_m \leq 650$	21	19
NOTE — For the area of the weld seam the value of the yield stress and the minimum value of the tensile strength given may be used for calculation purposes.				
1) For thicknesses greater than 16 mm, the value of the yield stress or proof stress may be reduced by 10 N/mm ² .				

Table 6 — Dimensions and masses per unit length

Nominal size DN	Outside diameter <i>D</i> mm	Series							
		B		C		D		E	
		<i>T</i> mm	<i>M</i> kg/m	<i>T</i> mm	<i>M</i> kg/m	<i>T</i> mm	<i>M</i> kg/m	<i>T</i> mm	<i>M</i> kg/m
50	60,3	2	2,88	2,3	3,29	2,3	3,29	2,9	4,11
65	76,1	2,3	4,19	2,6	4,71	2,6	4,71	2,9	5,24
80	88,9	2,3	4,91	2,9	6,15	2,9	6,15	3,2	6,76
100	114,3	2,6	7,16	2,9	7,97	3,2	8,77	3,6	9,83
125	139,7	2,6	8,79	3,2	10,8	3,6	12,1	4	13,4
150	168,3	2,6	10,6	3,2	13,0	4	16,2	4,5	18,2
200	219,1	2,6	13,9	3,6	19,1	4,5	23,8	6,3	33,1
250	273	3,6	23,9	4	26,5	5	33	6,3	41,1
300	323,9	4	31,6	4,5	35,4	5,6	44	7,1	55,5
350	355,6	4	34,7	5	43,2	5,6	48,3	8	68,6
400	406,4	4	39,7	5	49,5	6,3	62,2	8,8	86,3
450	457	4	44,7	5	55,7	6,3	70	10	110
500	508	5	62	5,6	69,4	6,3	77,9	11	135
600	610	5,6	83,5	6,3	93,8	6,3	93,8	12,5	184
700	711	6,3	109	7,1	123	7,1	123	14,2	244
800	813	7,1	141	8	159	8	159	16	314
900	914	8	179	8,8	196	10	223	17,5	387
1 000	1 016	8,8	219	10	248	10	248	20	491
1 050	1 067	8,8	230	10	251	11	186	—	—
1 100	1 118	8,8	244	10	273	11	300	—	—
1 200	1 219	10	298	11	328	12,5	372	—	—
1 400	1 422	12,5	435	14,2	493	14,2	493	—	—
1 600	1 626	14,2	564	16	635	16	635	—	—
1 800	1 829	14,2	634	16	715	17,5	782	—	—
2 000	2 032	16	795	17,5	869	20	992	—	—
2 200	2 235	17,5	957	20	1 093	22,2	1 211	—	—
2 500	2 540	20	1 243	22,2	1 379	25	1 551	—	—

7 Dimensions, masses and tolerances

7.1 Dimensions and masses

7.1.1 Diameters and thicknesses

Table 6 gives a selection of preferred outside diameters and thicknesses selected from ISO 4200:1991, table 1. If for particular applications other dimensions are necessary, they shall be selected from ISO 4200:1991, table 2.

7.1.2 Masses

The masses per unit length are given in table 6. For intermediate dimensions, see ISO 4200.

7.1.3 Lengths

The tubes may be ordered in

- random lengths,

- approximate lengths, or

- exact lengths.

The ranges of random lengths and the minimum average lengths are given in table 7.

The ranges of lengths depend on the dimensions and manufacturing process of the tube.

Table 7 — Random lengths

Lengths in metres

Length ranges	Minimum average length in 100 % of shipment
3 to 8	6
4 to 11	8
5,5 to 14	11
6,5 to 16,5	13,5
7,5 to 18	14,5

7.1.4 End preparation

Annex A gives a schematic representation of the main joints in current use. The tubes may be ordered with

- plain square cut ends (see 7.2.7.1),
- bevelled ends (see 7.2.7.2),
- sleeve joints (see figure A.3 and figure A.4),
- flanged joints (see figure A.5), or
- special joints (see figure A.6).

7.2 Tolerances

7.2.1 Outside diameter

7.2.1.1 The permissible deviation of the outside diameter for seamless and welded tubes shall be not greater than

- for seamless tubes: $\pm 1\%$ with a minimum of $\pm 0,5\text{ mm}$ (tolerance class D2 of ISO 5252:1991), and
- for welded tubes: see table 8.

Table 8 — Tolerance on outside diameter for welded tubes

Outside diameter <i>D</i> mm	Tolerance
$D \leq 219,1$	$\pm 1\%$ with a minimum of $\pm 0,5\text{ mm}$
$219,1 < D \leq 914$	$\pm 0,75\%$ with a maximum of $\pm 5\text{ mm}$
$914 < D$	$\pm 0,75\%$ with a maximum of $\pm 10\text{ mm}$

7.2.1.2 By agreement between the manufacturer and the purchaser, and depending on the type of joint, closer tolerances obtained by sizing the ends of the tubes may be agreed as specified in 7.2.1.2.1 to 7.2.1.2.3.

7.2.1.2.1 For plane and bevelled end tube the tolerances are as follows:

$D \leq 273\text{ mm}$: $\begin{matrix} +1,6 \\ -0,4 \end{matrix}\text{ mm}$

$273\text{ mm} < D < 508\text{ mm}$: $\begin{matrix} +2,4 \\ -0,8 \end{matrix}\text{ mm}$

7.2.1.2.2 For plain end welded tubes of outside diameter greater than or equal to 508 mm, the tolerance on outside diameter on tube ends shall be not more than $\begin{matrix} +2,4 \\ -0,8 \end{matrix}\text{ mm}$.

7.2.1.2.3 For special joints the tolerances shall be agreed between the manufacturer and purchaser at the time of enquiry and order.

7.2.1.3 Tolerances on outside diameter shall be checked at the ends on a minimum distance of 100 mm, in conformity with the methods given in 9.2.6.

7.2.2 Thickness

7.2.2.1 Body of the tube

The permissible tolerances on the thickness of the body of tubes are given in table 9 for seamless tubes and in table 10 for welded tubes away from the weld.

Eccentricity shall be within the limits of the tolerances.

7.2.2.2 Weld area

The tolerances for the weld area of welded tubes are given in table 11.

Table 9 — Tolerance on thickness for seamless tubes

Outside diameter <i>D</i> mm	Tolerance on <i>T</i>
$D \leq 114,3$	$\pm 0,5\text{ mm}$
$114,3 < D \leq 273$	$\begin{pmatrix} +17,5 \\ -12,5 \end{pmatrix} \%$ with a minimum of $\pm 0,5\text{ mm}$
$273 < D$	$\begin{pmatrix} +20,0 \\ -12,5 \end{pmatrix} \%$

7.2.3 Ovality

Ovality shall be within the limits of the tolerance on outside diameter *D* (see 7.2.1).

7.2.4 Length (see ISO 5252)

7.2.4.1 Random lengths

The random length of the tubes shall be within the ranges given in table 7 and shall comply with the corresponding minimum average length in 100 % of shipment.

Lengths below or above the limits of the length ranges ordered may be delivered if this has been agreed between the manufacturer and the purchaser when ordering the tubes.

Table 10 — Tolerance on thickness for welded tubes

Thickness T mm	Tolerance	
	mm	%
	Butt and electric resistance, including induction welded, tubes, and submerged arc welded tubes manufactured from coils	Submerged arc welded tubes manufactured from plate
$T \leq 3,2$	$+0,30$ $-0,25$	—
$3,2 < T \leq 5$	$\pm 0,35$	$+10$ ¹⁾ -10
$5 < T \leq 8$	$\pm 0,4$	$+10$ ¹⁾ -10
$8 < T \leq 25$	$\pm 0,5$	$+10$ ¹⁾ -10
1) The upper limit is governed by the tolerance on mass.		

Table 11 — Tolerances for the weld area

Weld bead		Butt welded tubes	Electric resistance, including induction welded tubes	Submerged arc welded tubes
Outside		rolled flush	trimmed flush	$T \leq 8$ mm: max. 3 mm $8 \text{ mm} < T \leq 14,2$ mm: max. 3,5 mm $T > 14,2$ mm: max. 4,8 mm
Inside	not removed	max.: 1,5 mm	max.: 1,5 mm	$T > 14,2$ mm: max. 4,8 mm —
	if removed	max.: $0,15T$	max.: $0,3 \text{ mm} + 0,05T$	

7.2.4.2 Approximate lengths

The tolerance on approximate lengths shall not exceed ± 500 mm.

7.2.4.3 Exact lengths

Exact lengths shall be subject to the following tolerances:

- lengths less than 6 m: $+10$
 -0 mm
- lengths greater than 6 m: $+15$
 -0 mm

7.2.5 Straightness

Tubes shall be essentially straight. The total deflection shall not exceed 0,2 % of the total length of the tube.

7.2.6 Mass

The tolerance on mass per lot or on one tube of 10 t min. is $\pm 7,5$ %.

7.2.7 End finish (see ISO 6761)

7.2.7.1 Plain square cut ends

The ends of the tubes shall be cut nominally square with the axis of the tube and shall be free from burrs.

7.2.7.2 Bevelled ends (V-chamfer with root face)

Tubes ordered with welding bevels at the tube ends shall be subject to the following tolerances:

- angle of the chamfer for welding: 30° $+5^\circ$
 -0
- width of root face: $1,6 \text{ mm} \pm 0,8 \text{ mm}$

7.2.7.3 Expanded ends for sleeve joints

The permissible deviations for expanded tube ends for sleeve joints, as shown in figure A.3 and figure A.4, shall be agreed upon at the time of the order.

8 Appearance and soundness

The tubes shall have smooth internal and external surfaces consistent with the method of manufacture. The tubes shall have a workmanlike finish but small imperfections are permissible provided that the thickness remains within the negative tolerance limits.

Surface imperfections may be dressed provided that the thickness after dressing remains within the negative tolerance limits.

Defects in the weld seam of submerged arc welded tubes may be repaired by welding at the discretion of the manufacturer. The repaired area shall be submitted to a non-destructive test and a leak tightness test.

9 Inspection and testing

9.1 General requirements

9.1.1 Place of inspection and testing

The selection of samples, the preparation of test pieces and the tests shall be carried out in the works of the manufacturer. If so specified, the selection of samples and the tests shall be carried out in the presence of the purchaser or of a representative of the purchaser.

9.1.2 Summary of tests

The tubes shall be submitted in the works of the manufacturer to the types and numbers of tests specified in table 12.

9.1.3 Definition of a lot, selection and preparation of test pieces

9.1.3.1 Lot

For the purposes of testing, tubes shall be divided into lots. Depending on the outside diameter of the tubes, a lot shall comprise the following number of tubes of the same grade, dimensions, process of manufacture, delivery condition and, where applicable, heat treatment:

$D \leq 76,1$ mm: 1 000 tubes

$76,1 \text{ mm} < D \leq 139,7$ mm: 400 tubes

$139,7 \text{ mm} < D \leq 323,9$ mm: 200 tubes

$D > 323,9$ mm: 100 tubes

If the number of tubes is smaller than the specified number of tubes for a lot, this smaller quantity shall be regarded as a lot. If the number of tubes is greater than the specified number of tubes for a lot, the remaining tubes, if there are 50 or less, shall be sub-divided between the lots. They shall be regarded as a lot if there are over 50.

Submerged arc welded tubes containing skelp end welds shall be divided into lots as defined above. The same type and number of tests per lot shall be

applied to the skelp end welds as are applied to the seam weld.

9.1.3.2 Selection and preparation of test pieces

The tensile test, flattening test and bend test shall be carried out on test pieces taken from the end of a sample tube selected at random from each lot.

9.1.3.3 Tensile test

9.1.3.3.1 The tensile test piece shall be prepared in accordance with ISO 6892.

9.1.3.3.2 Depending on the type of tube (see 9.1.3.3.3 to 9.1.3.3.5), the test piece may be

- a full section of the tube,
- a strip test piece taken longitudinally to the tube axis, in which case the gauge length shall not be flattened, or
- a test piece taken transverse to the tube axis, in which case the gauge length may be flattened provided that the test piece is stress relieved at a temperature below 500 °C.

9.1.3.3.3 For seamless tubes, the test piece shall be taken parallel to the axis of the tube for diameters $D < 219$ mm; at the choice of the manufacturer, it may be taken transverse to the tube axis for diameters $D \geq 219$ mm.

9.1.3.3.4 For welded tubes and to determine the mechanical properties in the body of the tube, the test piece shall be taken at a position around the circumference 90° to the weld. The test piece shall be taken parallel to the axis of the tube for diameters $D < 219$ mm; at the choice of the manufacturer, it may be taken transverse to the tube axis for diameters $D \geq 219$ mm.

9.1.3.3.5 For testing the weld of tubes with diameters $D > 219,1$ mm, the test piece shall be taken transverse to the weld, the weld being placed at the centre of the test piece; the weld reinforcement may be removed.

9.1.3.4 Bend and flattening tests

The test piece for the flattening test shall be prepared in accordance with ISO 8492 and the test piece for the bend test with the weld at the centre shall be prepared in accordance with ISO 7438. The weld reinforcement may be removed in the test piece for the bend test.

Table 12 — Types and numbers of tests

Type of test	Seamless tubes	Butt welded tubes	Electric resistance, including induction welded tubes	Submerged arc welded tubes
Tensile test	1 per lot on test piece or full tube section	1 per lot on base metal or full tube section	$D \leq 219,1$ mm 1 per lot on base metal or full tube section	
			$D > 219,1$ mm 1 per lot on base metal or full tube section and, in addition, 1 per lot on weld area	
Flattening test	1 per lot	2 per lot (1 test 0° and 1 test 90°)	2 per lot (1 test 0° and 1 test 90°)	—
Bend test	1)	1)	1)	2 per lot (1 test on weld face and 1 test on weld root)
Hydraulic or non-destructive test	All	All	All	All
Visual inspection	All	All	All	All
Dimension check	All	All	All	All
Non-destructive testing of the weld	—	—	All	All
Product analysis	By agreement			
1) As an alternative to the flattening test (see 6.2.2).				

9.2 Test methods and results

9.2.1 Tensile test

9.2.1.1 The tensile test shall be carried out in accordance with ISO 6892.

The following characteristics shall be determined on test pieces taken from the body of the tube:

tensile strength, R_m

percentage elongation after fracture, A

yield stress, R_{eH} or R_{eL} , or proof stress $R_{t0,5}$

9.2.1.2 If the upper yield stress R_{eH} does not occur, the proof stress $R_{p0,2}$ or the 0,5 % total elongation proof stress $R_{t0,5}$ shall be determined.

9.2.1.3 For test pieces from the weld, only the tensile strength R_m shall be determined.

9.2.1.4 The values obtained shall as a minimum be equal to those shown in table 5 for the respective steel grade and for the orientation of the test piece.

9.2.2 Flattening test

9.2.2.1 The flattening test shall be carried out in accordance with ISO 8492.

The test piece shall be flattened without showing defects until the distance H between the platens is

$$H = \frac{(1 + K)T}{K + (T/D)}$$

with

$K = 0,09$ for grades ST320 and ST360;

$K = 0,07$ for grades ST410, ST430 and ST500.

9.2.2.2 For electric resistance, including induction welded, tubes or butt welded tubes the test shall be carried out with the position of the weld at 90° to the applied force.

No opening of the weld shall take place until the specified distance H between the platens is reached. Slight premature failure at the edges shall not be considered as a cause for rejection.

9.2.2.3 For seamless, butt welded and electric resistance, including induction welded, tubes, at the option of the manufacturer the flattening test may be substituted by a bend test carried out in the direction of the original curvature.

9.2.3 Bend test

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

9.2.3.2 For seamless tubes, butt welded tubes and electric resistance, including induction welded, tubes the test piece shall be bent in the direction of the original curvature. For welded tubes the weld shall be positioned at the centre of the test piece. The bend value shall be equal to the value of H for the flattening test (see 9.2.2.1).

9.2.3.3 For submerged arc welded tubes, with the exception of tubes in grade ST320, one test piece shall be bent through 180° in the direction of the original curvature (face bend test), and the other in the opposite direction (root bend test), around a mandrel with a diameter eight times the specified thickness of the tube.

9.2.3.4 After the test, the test piece shall not show to the naked eye any cracks or flaws. However, small premature cracks at the edges shall not be considered as a cause for rejection.

9.2.4 Leak tightness test

9.2.4.1 Hydraulic test

Each tube shall be subjected to a hydraulic test at a pressure PE determined using the following formula:

$$PE = \frac{20ST}{D}$$

where $S = 60\%$ of R_{eH} (see table 5).

Unless otherwise agreed, the hydraulic pressure shall not exceed 50 bar (5 MPa). The test pressure shall be maintained for at least 5 s.

Tubes showing leakage shall be regarded as not complying with this International Standard.

9.2.4.2 Non-destructive test

The hydraulic test may be replaced, at the option of the manufacturer, by a non-destructive test carried out as specified in ISO 9302.

9.2.5 Visual inspection

The appearance and soundness of the tubes shall be checked by a visual inspection of the outside and inside surfaces.

9.2.6 Dimension check

The tubes shall be checked for compliance with the outside diameter and thickness specifications.

The thickness shall be checked at the ends of the tubes.

For tubes of outside diameter $D < 508$ mm, the outside diameter may be checked using a bar gauge or caliper, or by measuring the circumference using a tape.

For tubes of outside diameter $D \geq 508$ mm, the outside diameter shall be checked by measuring the circumference using a tape.

9.2.7 Non-destructive test of the weld³⁾

For all types of welded tube, unless the tube has been submitted to a non-destructive test in place of the hydraulic test according to 9.2.4.1, the weld area shall be submitted to a non-destructive test according to a suitable technique and procedure at the choice of the manufacturer.

9.3 Invalidation of tests

The specifications given in ISO 404 apply.

9.4 Retest

The specifications given in ISO 404 apply.

10 Marking

10.1 Tubes (uncoated and coated) manufactured in accordance with this International Standard shall be marked, in the sequence given, as follows:

- the manufacturer's trade-mark or trade-name;
 - the grade of steel (in accordance with table 3);
 - the number of this International Standard (i.e. ISO 559);
 - W for welded tubes and S for seamless tubes;
- and, in addition, for tubes with an inspection certificate,
- the inspector's mark.

10.2 Coated tubes may require additional marking in accordance with relevant International Standards.

3) The test conditions and the acceptance criteria will be specified at a later date on the basis of studies being carried out by ISO/TC 17/SC 19.

11 Lining or coating

All linings and/or coatings shall comply with relevant International Standards or with specifications agreed between the purchaser and manufacturer.

NOTE 2 ISO/TC 5/SC 1 is currently preparing three draft International Standards on

- epoxy powder external coatings,
- polyethylene external coatings, and

- cement mortar internal linings.

12 Documents

The documents shall be drafted in accordance with the appropriate clause of ISO 404.

If neither of the documents specified in 4.1, nor any other document as specified in ISO 404, is requested the tubes shall be delivered with a statement of compliance only.

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Annex A (informative)

Schematic representation of the main types of joint

The types of joint shown in this annex are examples; other types are acceptable.

Flange joints should be made in conformity with ISO 7005-2.

Welded joints should be made in conformity with the International Standards prepared by ISO/TC 44, *Welding*.



Figure A.1 — Butt weld

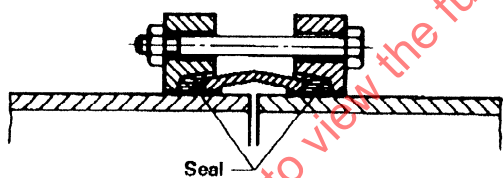


Figure A.2 — Slip-on coupling

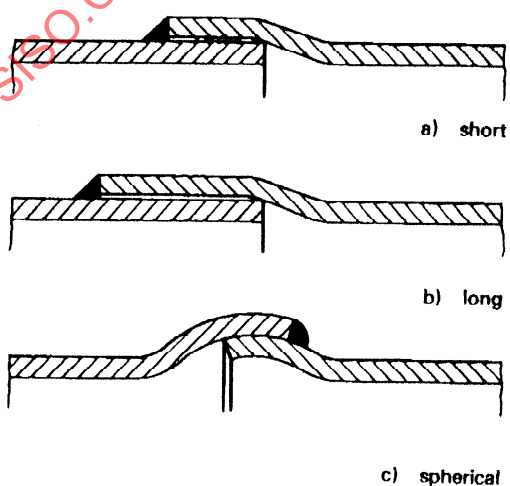


Figure A.3 — Sleeve joint