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# INTERNATIONAL STANDARD



# 559

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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

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## Welded or seamless steel tubes for water, sewage and gas

*Tubes en acier, sans soudure ou soudés, pour canalisations d'eau, d'eaux résiduelles et de gaz*

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[ISO 559:1977](#)

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**Descriptors** : piping, steel tubes, welded pipes, seamless pipes, water pipelines, gas pipelines, specifications, chemical composition, mechanical properties, dimensions, dimensional tolerances, hydraulic tests, mechanical tests, joining, protective coatings, marking.

Price based on 8 pages

## FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

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.

International Standard ISO 559 was developed by Technical Committee ISO/TC 5, *Metal pipes and fittings*, and was circulated to the member bodies in April 1975.

It has been approved by the member bodies of the following countries :

Australia	Hungary	Poland
Austria	India	Romania
Belgium	Israel	South Africa, Rep. of
Brazil	Italy	Spain
Canada	Korea, Rep. of	Sweden
Czechoslovakia	Mexico	Switzerland
Finland	Netherlands	Turkey
France	New Zealand	U.S.A.
Germany	Norway	Yugoslavia

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Japan  
United Kingdom  
U.S.S.R.

This International Standard cancels and replaces ISO Recommendation R 559-1967, of which it constitutes a technical revision.

# Welded or seamless steel tubes for water, sewage and gas

## 1 SCOPE AND FIELD OF APPLICATION

This International Standard gives specifications for seamless and welded steel tubes for the conveyance of gas, water and sewage.

It does not apply to :

- screwed steel tubes,
- tubes used in buildings,
- tubes for the conveyance of hydrocarbons and natural gas which are within the scope of Technical Committee ISO/TC 67, *Materials and equipment for the petroleum and natural gas industries*.

## 2 REFERENCES

- ISO/R 85, *Bend test for steel*.
- ISO/R 167, *Bend test on steel tubes*.
- ISO/R 202, *Flattening test on steel tubes*.
- ISO 336, *Plain end steel tubes, welded or seamless – General table of dimensions and masses per unit length*.
- ISO 375, *Steel – Tensile testing of tube*.
- ISO 2084, *Pipeline flanges for general use – Metric series – Mating dimensions*.
- ISO 2546, *Seamless plain end tubes made from unalloyed steel and without quality requirements*.
- ISO 2547, *Welded plain end tubes made from unalloyed steel and without quality requirements*.
- ISO 2566/I, *Steel – Conversion of elongation values – Part I : Carbon and low alloy steels*.
- ISO 2604/II, *Steel products for pressure purposes – Quality requirements – Part II : Wrought seamless tubes*.
- ISO 2604/III, *Steel products for pressure purposes – Quality requirements – Part III : Electric resistance and induction welded tubes*.

ISO 2604/VI, *Steel products for pressure purposes – Quality requirements – Part VI : Submerged arc welded tubes*.<sup>1)</sup>

ISO 3183, *Ordinary steel line pipe*.<sup>1)</sup>

ISO . . . , *High test line pipe*.<sup>2)</sup>

ISO . . . , *Spiral welded line pipe*.<sup>2)</sup>

## 3 SYMBOLS

$D$  = outside diameter of the tube

$T$  = thickness of the tube

$R_m$  = tensile strength, at ambient temperature, in newtons per square millimetre

$R_e$  = yield stress, at ambient temperature, in newtons per square millimetre

$A$  = percentage elongation after fracture on gauge length  $L_0 = 5,65\sqrt{S_0}$

$p$  = test pressure, in bars

$r$  = radius of mandrel for bend test

$\alpha$  = angle of bend

## 4 GENERAL REQUIREMENTS

### 4.1 Information to be supplied by the purchaser

4.1.1 The purchaser shall state in his enquiry and order the following requirements :

- a) the tube dimensions (outside diameter and thickness selected from table 4);
- b) the steel grade;
- c) the tubemaking process (seamless or welded) : if this is not specified, the process of manufacture is at the option of the manufacturer;

1) At present at the stage of draft.

2) In preparation.

- d) the quantity ordered (total tonnage, or length, or number of tubes);
- e) the specified length (see 5.2);
- f) the types of documents to be supplied;
- g) if an analysis on the tube is required (see 4.4.2).

4.1.2 Until International Standards for the coating of tubes and the finishing of ends are available, the purchaser shall indicate in the enquiry and order the national standards or other specifications to which the manufacturer shall work, provided these operations are to be carried out by the manufacturer (see clause 8).

4.2 Manufacture of the steel

The steelmaking process and the deoxidation practice shall be at the option of the steel manufacturer. If so requested on the enquiry and order, the purchaser shall be informed of the deoxidation practice used.

4.3 Manufacture of the product

4.3.1 Seamless tubes

The tubes shall be of one of the grades of steel specified in 4.4 and 4.5, shall be manufactured by a seamless process and shall be hot finished.

4.3.2 Welded tubes

The tubes shall be manufactured from hot-rolled steel strip, sheet or plate of one of the grades of steel specified in 4.4 and 4.5. The welding process shall be butt welding, electric resistance or induction welding or submerged arc welding with a longitudinal or spiral seam.

4.4 Chemical composition

4.4.1 Ladle analysis

The percentage chemical composition for ladle analysis is given in table 1.

TABLE 1 – Chemical composition, in %

	TS0/TW0	TS1/TW1	TS4/TW4	TS9/TW9
C max.		0,16	0,17	0,21
Si max.			0,35	0,35
Mn		0,30 to 0,70	0,40 to 0,80	0,40 to 1,20
P max.	0,060	0,050	0,045	0,045
S max.	0,060	0,050	0,045	0,045

NOTE – For tubes with thickness  $\geq 12,5$  mm the C and Mn content may be increased to :  
 TW1 : C  $\leq 0,21$ , Mn  $\leq 0,90$   
 TW4 : C  $\leq 0,22$ , Mn  $\leq 1,00$   
 TW9 : C  $\leq 0,25$ .  
 For welded tubes the carbon content of grades TW1 and TW4 in rimmed and semi-killed steels may be 0,19 % max.

4.4.2 Product analysis

If the order specifies a check analysis on seamless or welded tubes made from killed steel, the permissible deviations given in table 2 shall apply to the ladle analysis specified in table 1 for the same cast.

TABLE 2 – Permissible deviation, in %, in relation to the specified composition

	Permissible deviation, in %, in relation to the specified composition
C	+ 0,03
Si	+ 0,05
Mn	$\pm 0,10^*$
P	+ 0,005
S	+ 0,005

\* For manganese, the deviations apply either above or below the specified limits of the range but not both above and below for different sample products from the same cast.

NOTE – The limits shown in table 2 for sulphur and phosphorus are not applicable for steel TS0/TW0.

4.5 Mechanical properties of the tube

Mechanical properties for both seamless and welded tubes are given in table 3.

ISO 559:1977

TABLE 3 – Mechanical properties

	TS0/TW0	TS1/TW1	TS4/TW4	TS9/TW9
$R_m$ N/mm <sup>2</sup>	320 to 520	320 to 440	360 to 480	410 to 530
$R_e$ N/mm <sup>2</sup>		$\geq 195$	$\geq 215$	$\geq 235$
A* %	$\geq 15$	$\geq 25$	$\geq 22$	$\geq 21$

\* The percentage elongation shall be related to a gauge length  $L_0 = 5,65 \sqrt{S_0}$ . If other gauge lengths are used, the corresponding elongation on  $L_0 = 5,65 \sqrt{S_0}$  shall be obtained in conformity with ISO 2566. In the case of dispute, the gauge length  $L_0 = 5,65 \sqrt{S_0}$  shall be used.

NOTE – The mechanical properties for steels TS0/TW0 are not guaranteed but are for guidance only.

4.6 Conditions for use

The steels covered by this International Standard are generally considered as being weldable.

The tubes shall be suitable for fabrication by all normal processes.

4.7 Appearance and soundness

4.7.1 The tubes shall have smooth internal and external surfaces, the degree of smoothness depending on the method of manufacture. The tubes shall have a workman-like finish but small imperfections are permissible, provided that the thickness remains within the lower tolerance limits.

4.7.2 Surface imperfections may be dressed provided that the thickness after dressing remains within the lower tolerance limit.

4.7.3 Peening of surface defects is not permitted.

4.7.4 In the case of submerged arc welded tubes, repair of the weld is permitted (see 7.4.4).

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

## 5 DIMENSIONS

5.1 The outside diameters, the thicknesses and the masses per unit length are given in table 4 for the four series of thicknesses A, B, C and U; these values have been extracted from ISO 336.

TABLE 4 – Dimensions and masses per unit length

Nominal size	Outside diameter mm	Series A		Series B		Series C		Series U	
		T mm	Mass kg/m	T mm	Mass kg/m	T mm	Mass kg/m	T mm	Mass kg/m
40	48,3			2,3	2,61	2,6	2,93		
50	60,3			2,3	3,29	2,9	4,11		
65	76,1			2,6	4,71	2,9	5,24		
80	88,9	2,6	5,53	2,9	6,15	3,2	6,76		
100	114,3	2,6	7,16	3,2	8,77	3,6	9,83		
125	139,7	2,9	9,78	3,6	12,1	4,0	13,4		
150	168,3	3,2	13,0	4,0	16,2	4,5	18,2		
200	219,1	3,6	19,1	4,5	23,8	5,9	31,0		
250	273	4,0	26,5	5,0	33,0	6,3	41,4		
300	323,9	4,0	31,6	5,6	44,0	7,1	55,5		
350	355,6	4,5	39,0	5,6	48,3	8,0	68,6		
400	406,4	4,5	44,6	6,3	62,2	8,8	86,3		
450	457	5,0	55,7	6,3	70,0	10,0	110		
500	508	5,6	69,4	6,3	77,9	11,0	135		
600	610	5,6	83,5	6,3	93,8	12,5	184		
700	711	6,3	109	7,1	123	12,5	215		
750	762	6,3	117	8,0	149	12,5	231		
800	813	7,1	141	8,0	159	12,5	247		
900	914	8,0	179	10,0	223	14,2	315		
1 000	1 016	8,8	219	10,0	248	14,2	351		
1 200	1 220							10,0	298
1 400	1 420							11,0	382
1 600	1 620							12,5	496
1 800	1 820							12,5	557
2 000	2 020							12,5	619
2 200	2 220							14,2	772

**5.2 Lengths**

**5.2.1 Random lengths**

Depending on the dimensions and the manufacturing procedure, the ranges of standard lengths are as follows :

- 4 to 8 m
- 6 to 13 m
- 10 to 18 m

For random lengths, 90 % of the lengths shall be greater than the minimum length, but 10 % of the lengths may be 25 % shorter than the minimum length.

**5.2.2 Limited lengths**

When limited lengths are ordered they shall be supplied with a tolerance of  $\pm 500$  mm.

**5.2.3 Cut lengths**

When cut lengths are ordered, they shall be subject to the following tolerances :

- cut lengths  $\leq 6$  m :  $\begin{matrix} + 10 \\ 0 \end{matrix}$  mm
- cut lengths  $> 6$  m :  $\begin{matrix} + 15 \\ 0 \end{matrix}$  mm

**6 TOLERANCES**

**6.1 Tolerance on outside diameter**

**6.1.1** The tolerance is  $\pm 1$  % with a minimum of  $\pm 0,5$  mm.

Ovality shall be within the limits of tolerance on the diameter.

**6.1.2** Depending upon the type of joint (see annex A) closer limits for the ends of tube of outside diameter  $\geq 219,1$  mm may be agreed between the purchaser and the manufacturer.

**6.1.3** For tubes of outside diameter equal to or greater than 355,6 mm the tolerance on the outside diameter shall be checked by taping the circumference.

**6.2 Tolerance on thickness**

**6.2.1 Seamless tubes**

Plus tolerance : limited by the tolerance on the mass.

Minus tolerance :  $- 12,5$  %; however, this tolerance may attain  $- 15$  % on isolated areas on a length not exceeding twice the outside diameter of the pipe with a maximum of 300 mm and provided this reduction in thickness affects only the external surface of the pipe.

For grade TSO and for the lower tolerance, the above percentages are increased to  $- 15$  % and  $- 18$  % respectively.

**6.2.2 Welded tubes**

**6.2.2.1 APART FROM THE WELD**

Plus tolerance : not limited

Minus tolerance :  $- 10$  %

**6.2.2.2 ON THE WELD**

**6.2.2.2.1 Butt welded and electric resistance welded tubes**

The height of the external weld bead shall not exceed  $0,3$  mm  $+ 0,05 T$ .

The height of the internal weld bead shall not exceed 1,5 mm.

By agreement between the purchaser and the manufacturer and if specified in the order, the internal weld bead of electric resistance welded tubes can be trimmed : the maximum height of the internal weld bead in this case shall not exceed  $0,3$  mm  $+ 0,05 T$ .

**6.2.2.2.2 Tubes welded by submerged arc welding**

The maximum height of the weld bead inside or outside shall not exceed the following values :

- ISO 559:1977  $T \leq 8$  mm : 3 mm
- $8$  mm  $< T \leq 14$  mm : 3,5 mm
- $T > 14$  mm : 4,8 mm

**6.3 Tolerance on mass**

$\pm 10$  % per tube

$\pm 7,5$  % per minimum lot of 10 tonnes.

**7 INSPECTION AND TESTS**

**7.1 Tests to be carried out**

The manufacturer shall be responsible for carrying out the following inspection and tests at his works :

- a) visual inspection (see 7.3)
- b) hydraulic test (see 7.4)
- c) tensile test (see 7.5.2.1)
- d) whole tube bend test, flattening test or bend test (see 7.5.2.2, 7.5.2.3, 7.5.2.4)

**7.2 Test temperature**

All tests shall be carried out at ambient temperature.

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**7.3 Visual inspection**

Every tube in the order shall be visually inspected in conformity with 4.7.

**7.4 Hydraulic test**

**7.4.1** Every tube shall be hydraulically tested at the manufacturer's works to a pressure of  $p = 50$  bar. In the case of welded tubes, the test pressure shall be reduced, if necessary, so that the stress in the tube does not exceed 40 % of the minimum tensile strength of the material. The pressure shall be maintained for at least 5 s.

**7.4.2** Alternatively, the manufacturer may substitute for the hydraulic test a non-destructive test which gives equivalent assurance of leak tightness.

**7.4.3** Any tubes failing to pass the tests in 7.4.1 or 7.4.2 shall be rejected.

**7.4.4** Any submerged arc welded pipe whose weld has been repaired shall be retested by one of the tests in 7.4.1 or 7.4.2.

**7.5 Mechanical tests**

**7.5.1 Type and number of tests**

The tests include a tensile test, whole tube bend test, a flattening or a bend test on a section cut from the tube, depending on the method of manufacture, size and number of tubes.

A lot is made up of a number of tubes defined in tables 5 to 8, of the same dimensions and made from the same grade of steel.

If the number of tubes is smaller than the number specified in these tables, they shall be regarded as one lot.

TABLE 5 – Seamless tubes

Type of test Diameter	Tensile long on body of tube
$D \leq 139,7$	1 per 400
$139,7 < D \leq 323,9$	1 per 200
$323,9 < D$	1 per 100

TABLE 6 – Butt welded tubes

Type of test Diameter	Tensile	Whole tube bend test*	Flattening test*
	base metal	base metal plus weld	base metal plus weld
$D \leq 60,3$	1 per 400	1 per 400	—
$60,3 < D < 139,7$	1 per 400	—	1 per 400

\* These tests are not carried out on tubes made from TW0 grade.

TABLE 7 – Electric resistance welded tubes

Type of test Diameter	Tensile		Flattening*	
	base metal	weld	base metal plus weld	
			TW1	TW4 and 9
$D \leq 139,7$	1 per 400	—	1 per 400	1 per 100
$139,7 < D < 219,1$	1 per 200	—	1 per 400	1 per 100
$219,1 \leq D \leq 323,9$	1 per 200	1 per 200	1 per 200	1 per 100
$323,9 < D$	1 per 100	1 per 100	1 per 200	1 per 100

\* This test is not carried out on tubes made from TW0 grade.

TABLE 8 – Submerged arc welded tubes

Type of test Diameter	Tensile		Root bend test and* face bend test on weld	
	base metal	weld	base metal	weld
$D \leq 139,7$	1 per 400	—	1 per 50	1 per 50
$139,7 < D < 219,1$	1 per 200	—	1 per 50	1 per 50
$219,1 \leq D \leq 323,9$	1 per 200	1 per 200	1 per 50	1 per 50
$323,9 < D$	1 per 100	1 per 100	1 per 50	1 per 50

\* These tests are not carried out on tubes made from TW0 grade.

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**7.5.2 Definition of tests**

**7.5.2.1 TENSILE TEST**

**7.5.2.1.1** The tensile test shall be carried out in accordance with ISO 375.

**7.5.2.1.2** The tensile strength  $R_m$ , the yield stress  $R_e$  and the elongation  $A$  shall be determined, subject to the characteristic values given in table 3. The values of the yield stress or proof stress shall be determined for an elongation of 0,5 % under load.

For tubes of a diameter less than 219,1 mm this test shall be carried out on a test piece cut longitudinally from the tube.

For tubes of a diameter equal to or greater than 219,1 mm this test shall, at the option of the manufacturer, be carried out on a specimen cut longitudinally or transversely from the tube.

For welded tubes, the test piece shall be taken from a position away from the weld.

The yield stress  $R_e$  shall not be determined on TSO and TW0 grades (see table 3).

**7.5.2.1.3 Tensile test on the weld**

For resistance welded or submerged arc welded tubes a further test shall be carried out on the weld. The test pieces for this test shall be taken at right angles to the weld, the weld itself being located in the centre of the specimen.

The test pieces shall be tested at the full thickness of the tubes from which they were taken. The weld bead shall not be dressed. The yield stress and the elongation need not be determined during the test on the weld.

During this test the tubes will have to meet the requirements laid down in table 3.

**7.5.2.2 WHOLE TUBE BEND TEST**

The bend test on the tube shall be carried out in conformity with ISO/R 167, using an internal bending radius  $r = 6D$  through an angle of  $\alpha = 90^\circ$ ; the weld shall be placed at  $45^\circ$  to the direction of the applied force.

**7.5.2.3 FLATTENING TEST**

**7.5.2.3.1** The flattening test shall be carried out in accordance with ISO/R 202.

**7.5.2.3.2** For welded tubes of grades TW1 and TW4 the test shall be carried out with the weld at  $90^\circ$  to the direction of the applied force. For grade TW9, test specimens from successive lots shall be placed such that the weld is alternately at  $0^\circ$  and  $90^\circ$  to the direction of the applied force.

No opening of the weld shall take place until the distance between the platens reaches the value  $X$  specified in table 9.

No crack or flaw shall appear in the metal away from the weld until the distance between the platens reaches the value  $Y$  specified in table 9.

TABLE 9 – Flattening test on welded tubes

	Steel TW9	Steel TW1 and 4
$X$	$\frac{2}{3}D$	$\frac{3}{4}D$
$Y$	$\frac{1}{3}D$	$\frac{3}{5}D$

**7.5.2.4 BEND TEST ON A SECTION CUT FROM TUBE**

The bend test shall be carried out in accordance with ISO/R 85.

The test shall be carried out on a test piece taken from a position away from the weld and on test pieces containing the weld. The test piece taken from the position away from the weld may be replaced by a test piece taken from the flat product. For the test pieces which include the weld, the weld shall be dressed and shall be in the middle of the test piece and transverse to the axis. The test piece shall be doubled over cold, in the direction of original curvature (face bend test) and in the opposite direction (root bend test) around a mandrel with a diameter equal to 8 times the specified thickness of the tube.

After the test, the test pieces shall, during normal visual inspection, be free from cracks or flaws. However, a small premature rupture at the ends shall not be considered a cause for rejection.

**8 FINISHING OF ENDS – COATINGS**

**8.1 Preparation of ends**

The end finish must be defined in the order with reference to the system of jointing. Annex A gives a schematic representation of the main types of joints in current use.

**8.2 Coatings**

**8.2.1** Until special standards on coatings and protections for tubes forming the subject of this International Standard are published, it is considered useful to list in annex B, under indicative headings, a short description of certain types of internal and external coatings.<sup>1)</sup>

**8.2.2** The internal coatings of tubes employed for the conveyance of potable water must satisfy the sanitary regulations in force in the user country.

**9 MARKING**

**9.1** The tubes shall be legibly marked to show the identification symbols for the trademark of the manufacturer of the tube and the grade of steel.

*Example :* X . . . . . TS4.

**9.2** By agreement between the parties, other methods of marking may be specified in the order.

**10 CERTIFICATE**

When required by the purchaser in the order, the manufacturer shall supply a certificate stating that the tubes comply with this International Standard.

1) This problem will be studied internationally by ISO (joint study between TC5/SC1 and TC67/SC1) in co-operation with the West European Regional Committee on Pipe Corrosion and Pipe Protection (CEOCOR).



ANNEX A

**SCHEMATIC REPRESENTATION OF THE MAIN TYPES OF JOINTS**

Flange joints shall be made in conformity with ISO 2084.

Welded joints shall be made in conformity with the ISO publications drawn up by TC 44, *Welding*.



FIGURE 1 – Butt weld

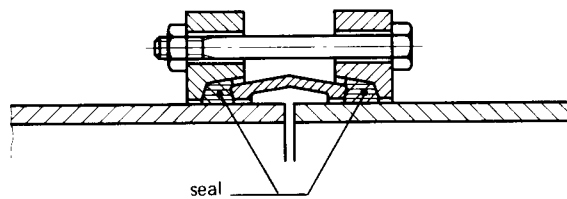


FIGURE 2 – Slip-on coupling

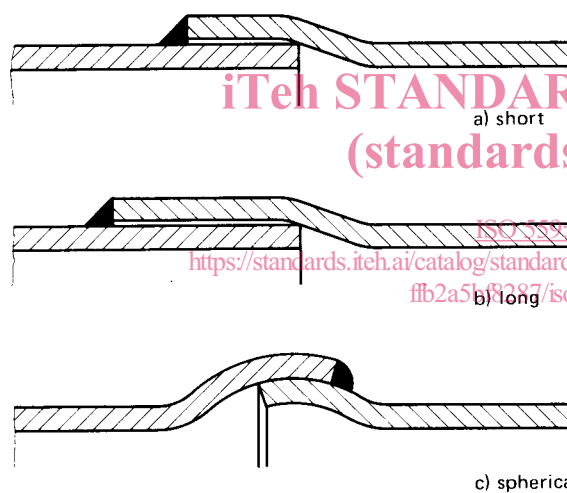


FIGURE 3 – Sleeve joint

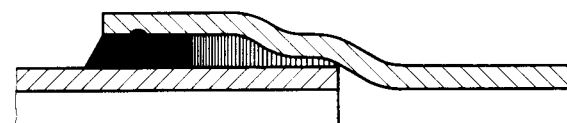


FIGURE 4 – With special end

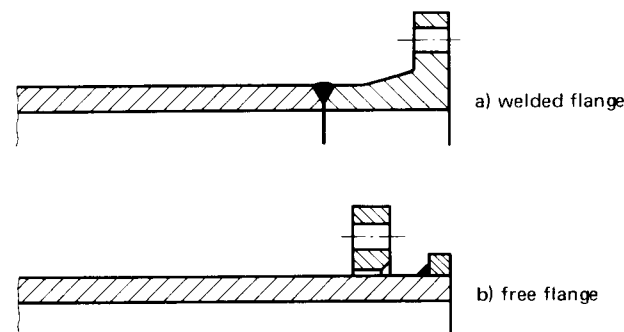


FIGURE 5 – Flange joints

NOTE — For the execution of the connections shown in figures 3 and 4 the end can be obtained by preparing the pipe end, or by butt welding, or coupling pieces.