



Specification for Aluminium piping systems

Part 1. Dimensions, materials and construction of components

Gr 8
British Standards Institution

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Committee reference PVE/10/3 Draft for comment 73/31245 DC

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- | | |
|--|---|
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- | | |
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| Aluminium Federation | Copper Development Association |
| British Electrical and Allied Manufacturers' Association | High Pressure Pipework Consultative Committee |
| British Valve Manufacturers' Association | Ministry of Defence |

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Specification for Aluminium piping systems

Part 1. Dimensions, materials and construction of components

Spécification des circuits de tuyauteries en aluminium

Partie 1. Dimensions, matériaux et construction des composants

Spezifikation für Aluminiumrohrsysteme

Teil 1. Abmessungen, Werkstoffe und Konstruktion von Bestandteilen

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Foreword

This British Standard has been prepared under the authority of the Pressure Vessels Industry Standards Committee.

The standard is being published in two Parts.

Part 1. Dimensions, materials and construction of components

*Part 2. Design of pipework systems

Pipe dimensions in this standard are based on BS 1600 'Dimensions of steel pipe for the petroleum industry' Part 2 'Metric units'. Wall thicknesses have been based on the same standard for sizes up to 20 in, and on plate thicknesses in accordance with BS 1470 for sizes over 20 in. Fittings have been dimensioned to ensure compatibility. Flange dimensions are based on BS 4504 'Flanges and bolting for pipes, valves and fittings. Metric Series' Part 1 'Ferrous' and on BS 1560 'Steel pipe flanges (nominal sizes ½ in to 24 in) for the petroleum industry' Part 2 'Metric dimensions'.

Information is given on materials, properties, design stresses and pressure temperature ratings which should aid designers, but this Part of the standard is not intended to be comprehensive for the construction of aluminium piping systems.

Preferred sizes are given in metric dimensions but it has been recognized in the preparation of this standard that established practice calls for the provision of a standard which is compatible with existing inch standards, in particular, dimensions in accordance with petroleum industry practice.

*Part 2 is in course of preparation. In the interim period before its publication, attention is drawn to the design stress data in BS 1500 'Fusion welded pressure vessels for general purposes' Part 3 'Aluminium' and to BS 3351 'Piping systems for petroleum refineries and petrochemical plants'.

British Standard Specification for Aluminium piping systems

Part 1. Dimensions, materials and construction of components

Section one. General

1. Scope

This Part of this British Standard specifies the dimensions and construction of wrought aluminium and aluminium alloy pipes, flanges and fittings for cryogenic and chemical industry applications in the pressure range 6 bar* to 66.6 bar. It should be used in conjunction with Part 2 of this standard.

The standard covers extruded and drawn seamless pipes, welded pipes and fittings as follows: 45° long radius elbows, 90° long and short radius elbows, long radius return bends, concentric and eccentric reducers, equal tees, reducing tees and caps; welding neck, slip-on and blind flanges. Dimensions and tolerances are included, or reference is made to appropriate standards. Materials and manufacturing methods are covered, as also are inspection, testing and marking requirements. Pressure/temperature ratings are given. This Part of the standard also covers requirements for cleaning and preparation for despatch.

For information regarding design stresses at given temperatures, reference should be made to Part 2 of this standard.

2. References

The titles of the British Standards referred to in this standard are listed on the inside back cover.

3. Information to be supplied by the purchaser

The following information shall be stated by the purchaser in his enquiry and/or order:

- (a) type and quantity of pipe, flanges and fittings;
- (b) nominal size(s) and thicknesses or schedule numbers;
- (c) material specification and condition;
- (d) seamless or fabricated;
- (e) end preparation for welding;
- (f) hydrostatic and other non-destructive test requirements for fabricated pipes and/or fittings;
- (g) certification requirements;
- (h) additional information to be given by the purchaser (see Part 2 of this standard).

Section two. Materials and manufacture

4. Pipes, flanges and fittings

4.1 Condition. The condition of pipes, flanges or fittings manufactured in accordance with this standard is the metallurgical condition as supplied to the

*1 bar = 10^5 N/m² = 100 kPa.

purchaser. Such condition depends upon the method of manufacture and it shall be agreed between purchaser and supplier. The metallurgical condition is defined in clause 6 of BS 1470: 1972.

4.2 Manufacture

4.2.1 Seamless pipe. Seamless pipes supplied in accordance with this standard shall conform to the following requirements.

- (a) Extruded aluminium pipe shall be made by the mandrel method.
- (b) Drawn aluminium pipe shall be made from blooms made by the mandrel method.

4.2.2 Welded pipe. Welded pipes supplied in accordance with this standard shall have been manufactured from sheet, strip or plate by fusion welding using an inert gas shielded process in accordance with BS 3019: Part 1 or BS 3571: Part 1. The welds may be either longitudinal or helical. Resistance, high frequency induction and other forms of welding may be employed by agreement between manufacturer and purchaser. The qualification requirements for welders and welding operators, the welding procedure employed in the manufacture of pipe, and welding materials shall be in accordance with Part 2 of this standard.

NOTE. Part 2 is in course of preparation. In the interim period before publication, attention is drawn to the welding procedure requirements of BS 3351.

4.2.3 Fittings. Seamless fittings may be made by any suitable manufacturing process.

Fabricated fittings shall be welded in accordance with BS 3019: Part 1 or BS 3571: Part 1 by manual or automatic inert gas arc welding processes using filler metal of composition as recommended in these standards unless otherwise agreed between purchaser and manufacturer.

The qualification requirements for welders and welding operators, the welding procedure employed in the manufacture of fabricated fittings and welding material shall be in accordance with Part 2 of this standard.

NOTE. Part 2 is in course of preparation. In the interim period before publication, attention is drawn to the welding procedure requirements of BS 3351.

4.3 Materials. Pipes, flanges and fittings shall be manufactured from materials listed in table 1, unless otherwise agreed between the manufacturer and purchaser.

Table 1. Materials

Material type	BS 1470 plate, sheet and strip	BS 1471 drawn tube	BS 1472 forging stock and forgings	BS 1474 extruded round tube and sections
1B	S1B	T1B	F1B	E1B
N3	NS3	—	—	—
N4	NS4	NT4	NF4	NE4
N5	NS5	NT5	NF5	NE5
N8	NS8	NT8	NF8	NE8
H9	—	HT9	HF9	HE9
H30	HS30	HT30	HF30	HE30
N51	BS 4300/8	BS 4300/10	BS 4300/11	BS 4300/12

5. Bolting materials

Bolting materials may be selected from the following, due attention being given to their mechanical and other properties for specific applications.

5.1 Aluminium alloy

Table 2. Aluminium alloy bolting materials

Material	BS spec.	Size o.d. mm	Condition	Type of alloy
HB30	1473	≤ 12	TF	Al Mg Si Mn
HE30	1474	> 12	TF	Al Si1 Mg Mn
HB15	1473	≤ 12	TF	Al Cu4 Si Mg
HE15	1474	> 12	TF	Al Cu4 Si Mg
NB6	1473	≤ 12	H4	Al Mg5

5.2 Stainless steel stud bolts and nuts

Stud bolts in accordance with BS 4882 grade B8, B8X, B8T or B8C
M M M M

Material BS 1506-801 grade B, BS 1506-821 grade Ti or BS 1506-821 grade Nb.

Nuts in accordance with BS 4882 grade 8, 8T or 8C
M M M

Material BS 1506-801 B, BS 1506-821 grade Ti or BS 1506-821 grade Nb.

5.3 Copper alloy stud bolts and nuts

Stud bolts silicon copper alloy half-hard temper
Material BS 2874 designation CS101 (Cu 94.8 % min., Si 2.8 % min., 3.8 % max.)

Nuts aluminium bronze in accordance with BS 2874, designation CA104, Al 10 %, Ni 5 %, Fe 5 %, Cu base)

NOTE 1. Many copper alloys are suitable for low temperature usage but it is important to use an alloy having a high shear stress, e.g. BS 2874, types CS101, CA103 and CA104.

NOTE 2. In most applications, care should be taken to provide electrical insulation between copper and aluminium components in order to prevent bi-metallic corrosion.

Bi-metallic corrosion can occur where copper alloy bolts are used on aluminium or aluminium alloy assemblies.

Either

(a) the bolts should be electrically insulated from the aluminium components or

(b) a protective film should be used to prevent air or condensed moisture coming into contact with the metal.

Liberal application of petroleum jelly loaded with zinc filling has been found effective in some environments, but it should be noted that this could constitute a hazard in plants handling liquid oxygen.

5.4 9 % nickel steel stud bolts and nuts

Stud bolts and nuts in accordance with ASTM A-353-70 or BS 4882.

6. Compensating washers for flange joint bolting

6.1 When flanges are bolted together there may be a difference in contraction between the bolt and the flanges due to the difference in coefficient of contraction between the flange and bolting material and also due to the temperature gradient from the pipe wall to periphery of the flange. This can cause a flange joint to leak when it is under pressure and at low temperature. This is particularly so when aluminium flanges are used with copper alloy or stainless steel bolts. It is possible to design a washer to insert under the nut on one side of the flange assembly to compensate for this unequal contraction.

6.2 The washer material must have a very low contraction coefficient and a high tensile strength. A suitable material which has been used successfully is 36 % nickel/64 % iron. It is desirable that compensating washers be made readily identifiable by means of identification grooves of the form shown in figure 1.

6.3 It is first necessary to calculate the contraction of the flanges. Then calculate the length of bolt, which will have the same contraction as the flanges, and the difference between the calculated length of the bolt and the thickness of the flange assembly is the height of the compensating washer of a material specified in 6.2.

BS 5222 : Part 1 : 1975

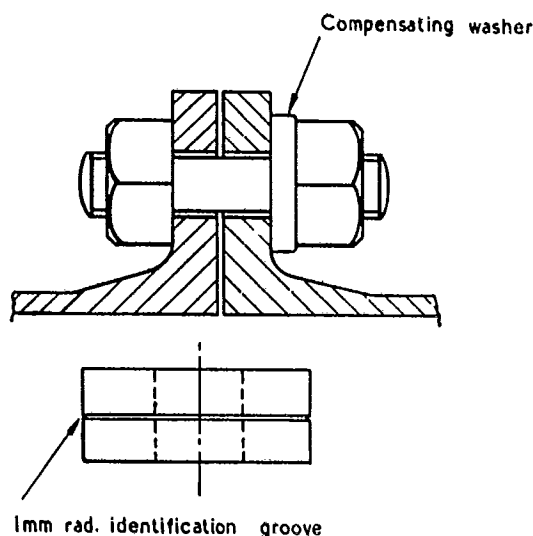


Figure 1. Compensating washer

7. Gasket materials

7.1 Gaskets and jointing may be:

- natural or synthetic rubber or plastics (including PTFE), with or without reinforcement;
- compressed asbestos fibre;
- wire mesh reinforced compressed asbestos fibre;
- metal jacketed, asbestos filler;
- spiral wound metal with filler;
- metal rings, flat;
- metal rings, corrugated;
- metal rings, formed sections.

For limiting dimensions of gaskets see BS 3381, BS 4865: Parts 1 and 2 or BS 1560: Part 2: 1970, appendix F covering recommendations for the choice of gaskets for flanged joints employing raised, male/female and tongue/groove flange facings.

7.2 Compressed asbestos fibre shall be in accordance with BS 2815 or BS 1832.

Section three. Dimensions and tolerances of components

8. Pipes

8.1 Dimensions. The preferred dimensions of aluminium alloy pipes are given in table 3.

8.2 Tolerances. Where the variation in size of tube within the tolerance laid down by BS 1471, BS 1474 and BS 4300/10 and /12 may give rise to an unacceptable level of mis-match, closer control on dimensions should be the subject of an agreement between purchaser and supplier.

8.2.1 *Nominal pipe sizes up to and including 300 mm.* All pipe tolerances are to be in accordance with the appropriate BS pipe specification (i.e. BS 1471, BS 1474 and BS 4300/10 and /12).

8.2.2 *Nominal pipe sizes 350 mm up to and including 500 mm.* Tolerances shall be in accordance with the standards listed in 8.2.1 except that tolerances on the

outside diameter of the pipe which are not covered therein shall be in accordance with table 4.

8.2.3 *Nominal pipe sizes 600 mm up to and including 1000 mm.* As these pipes are fabricated from plate, the tolerances will be in accordance with the following paragraphs.

Thickness and weight shall be governed by the requirement of the specification for which the plate, sheet or strip used to fabricate the tube is manufactured, unless agreed otherwise by the manufacturer and purchaser and stated in the order.

8.2.3.1 *General.* The pipes shall be circular within the limits defined in 8.2.3.2 and 8.2.3.3. Measurements shall be made to the surface of the parent plate and not to a weld, fitting or other raised part.

Pipes may be measured for out-of-roundness either when laid flat on their sides or when set up on end. When pipes are checked whilst lying on their side, each measurement for diameter shall be repeated after turning the pipe through 90° about its longitudinal axis. The two measurements for each diameter shall be averaged and the amount of out-of-roundness calculated from the average values so determined.

There shall be no flats or peaks at welded seams and any local departure from circularity shall be gradual.

8.2.3.2 *Circumference.* Unless otherwise agreed, the external circumference of the completed pipe shall not depart from the calculated circumference by more than the amounts listed in table 5, column 2.

8.2.3.3 *Out-of-roundness of pipes.* The difference between the maximum and minimum external diameters, measured at any one cross section, of the pipes designed to operate under external pressure shall not exceed the values given in table 5, column 3.

The profile, measured on the outside of the pipe by means of a gauge of the designed form, will have a length equal to one-quarter of the external diameter of the pipe and shall not depart from the designed form by more than the amount given in table 5, column 4. (This amount corresponds to x in clause 2.)

8.2.4 *Helically welded pipe.* The thickness and diameter of each pipe shall be within the following tolerances:

- (a) thickness (apart from any external reinforcement of weld) + 10 %,
- 5 %;
- (b) outside diameter ± 1 %.

9. Flanges and bolting

Flange dimensions shall be in accordance with tables 12 to 27 appropriate to flange system used, e.g. BS 4504: Part 1 or BS 1560: Part 2, except that note should be taken that thickness dimensions have been changed to take into account the mechanical properties of aluminium and aluminium alloys.

Diameters and threads shall be in accordance with BS 4882 and appropriate to the flange system used.

Gasket dimensions shall be in accordance with BS 4865: Parts 1 and 2, BS 1560: Part 2 or BS 3381 as appropriate to the flange system used.

Table 3. Dimensions of pipes

Nominal pipe size		o.d.	Thicknesses					
			Range A	Range B	Range C	Range D	Range E	Range F
in	mm	mm	mm	mm	mm	mm	mm	mm
1/4	8	13.7		1.65	2.24			3.02
3/8	10	17.1		1.65	2.31			3.2
1/2	15	21.3		2.11	2.77			3.73
3/4	20	26.7		2.11	2.87			3.91
1	25	33.4		2.77	3.38			4.55
1 1/4	40	48.3		2.77	3.68			5.08
2	50	60.3		2.77	3.91			5.54
3	80	88.9		3.05	5.49			7.62
4	100	114.3		3.05	6.02			8.56
6	150	168.3		3.40	7.11			10.97
8	200	219.1		3.76	8.18			12.7
10	250	273		4.19	9.27			15.09
12	300	323.9		4.57	9.52		10.31	17.47
14	350	355.6		4.78	9.52		11.13	
16	400	406.4		4.78	9.52		12.7	
18	450	457		4.78	9.52		14.27	
20	500	508		5.54	9.52		15.09	
24	600	610	3	6	10	13	18	
28	700	711	3	8	10	13	18	
30	750	762	3	8	10	13	18	
32	800	812	3	8	10	13	18	
36	900	914	3	8	10	13	20	
40	1000	1016	5		10	13	20	

NOTE 1. For the nominal pipe sizes 1/4 in to 20 in, the thickness ranges correspond with the thicknesses in the following schedules in table 1 of BS 1600: Part 2.

Range B – schedule 10 S Range E – schedule 40
Range C – standard wall Range F – schedule 80

For pipe sizes exceeding 20 in, the thicknesses take account of the thicknesses of plates in BS 1470 from which welded pipe is made.

NOTE 2. In selecting the thicknesses for a given application, account should be taken of the lower mechanical properties of aluminium compared with steel.

Table 4. Tolerances on outside diameters of pipes

Nominal pipe size	± tolerance (mm) on outside diameters for nominal thickness (mm) of								
	5	6	7	8	9	10	10-15	15-20	20-25
mm									
350	2.44	2.34	2.26	2.11	2.08	2.03	1.98	1.96	1.93
400		2.69	2.62	2.51	2.39	2.34	2.29	2.26	2.24
450			2.90	2.82	2.69	2.60	2.54	2.51	2.49
500			3.10	3.00	2.87	2.79	2.72	2.64	2.60

Table 5. Tolerances for pipes fabricated from plate

Nominal pipe size	Circumferential tolerance	Difference between maximum and minimum outside diameter	Maximum departure from designed form (see 8.2.3.3)
mm			mm
550 and 600	± 4.5 mm	1 % o.d.	2
700 up to and including 900	$\pm 1/4$ %	1 % o.d.	3
1000	$\pm 1/4$ %	1 % o.d.	4

10. Fittings

10.1 Dimensions

10.1.1 General. The dimensions of the following factory-made welding fittings in wrought aluminium and aluminium alloy shall conform to tables 7, 8, 9, 10 and 11:

- 45° long radius elbows (see table 7);
- 90° long and short radius elbows (see table 7);
- long radius return bends (see table 7);
- concentric and eccentric reducers (see table 8);
- equal tees (see table 9);
- reducing tees (see table 10);
- caps (see table 11).

Tolerances on dimensions shall be in accordance with 10.2.

A fitting in accordance with this standard shall be identified by the nominal size, thickness or range, and

purity or alloy of the pipe (see table 3) to which it is intended to correspond in strength.

10.1.2 Body thickness of fittings. The body thickness of fittings shall be such that their actual bursting pressure is not less than the computed bursting pressure of straight seamless pipe of the same or equivalent material, the same size and the same nominal wall thickness.

Where stress analysis indicates that other requirements are necessary, these shall be the subject of agreement between manufacturer and purchaser.

10.1.3 Dimensions of welding ends. The dimensions of the welding ends shall match those of the equivalent straight pipe in table 3, subject to the tolerances in 10.2.

In order to obtain the proper dimensions at the welding ends, it is permissible to machine the inside of the fittings to a taper of not less than 1 in 4.

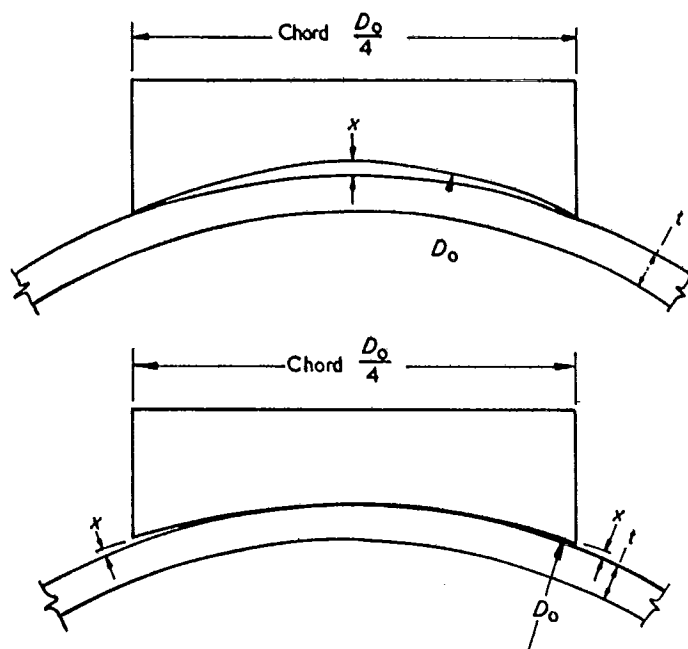


Figure 2. Out-of-roundness of pipes

BS 5222 : Part 1 : 1975

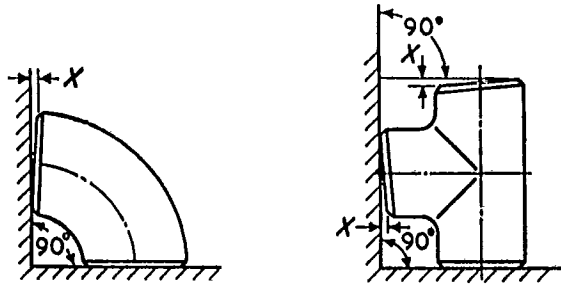


Figure 3. Typical examples of off-square tolerance x checked against reference planes

10.1.4 Welding end preparation. The profiles, dimensions and tolerances for welded ends shall be specified by the purchaser.

10.2 Tolerances

10.2.1 Thickness. The thickness of a fitting shall at all points be at least 87.5 % of the nominal thickness by which it is identified (see table 3).

10.2.2 Outside diameters at welding ends. The following are the tolerances permitted on the outside diameters of fittings at their welding ends:

Nominal sizes smaller than 80 mm (3 in)	mm + 1.6 - 0.8
Nominal sizes 80 mm (3 in) up to and including 100 mm (4 in)	± 1.6

Nominal sizes 150 mm (6 in) up to and including 200 mm (8 in)	mm + 2.4 - 1.6
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Nominal sizes 250 mm (10 in) up to and including 450 mm (18 in)	+ 4.0 - 3.2
---	----------------

Nominal sizes 500 mm (20 in) and larger	+ 6.4 - 4.8
---	----------------

10.2.3 Inside diameters at welding ends. The following are the tolerances permitted on the inside diameters of fittings at their welding ends. For this purpose, inside diameter equals outside diameter minus twice the nominal thickness, as given in table 3.

Nominal sizes smaller than 80 mm (3 in)	mm ± 0.8
Nominal sizes 80 mm (3 in) up to and including 200 mm (8 in)	± 1.6
Nominal sizes 250 mm (10 in) up to and including 450 mm (18 in)	± 2.0
Nominal sizes 500 mm (20 in) and larger	± 3.5

Where closer inside diameter tolerances are required, at the welding ends or in the bore of fittings, these shall be the subject of agreement between purchaser and manufacturer.

10.2.4 Off-square tolerances. Off-square tolerances shall be as shown in table 6 and figure 3.

10.2.5 Other dimensions. The tolerances permitted on dimensions other than those specified above are as shown in table 6.

Table 6. Tolerances on dimensions of fittings

1 Fitting	2 Dimension	3 Nominal sizes	4 Tolerance
90° elbows 45° elbows Tees	Centre to end	mm Up to and including 200 250 and over	mm ± 1.6 ± 2.4
Return bends	Centre to centre	Up to and including 200 250 and over	± 6.4 ± 9.5
	Back to face	All sizes	± 6.4
	Alignment F (see table 7)	Up to and including 200 250 and over	± 0.8 ± 1.6
Reducers	End to end	Up to and including 200 250 and over	± 1.6 ± 2.4
Caps	End to face E or E_1 (see table 11)	Up to and including 100 150 and over	± 3.2 ± 6.4
All fittings	Off-square tolerance x between any two machined ends (see figure 3)	Up to and including 100	0.8
		125 and 150	1.2
		200 to 600	1.6