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SPECIFICATION FOR

FERROUS PIPES AND PIPING INSTALLATIONS

FOR & IN CONNECTION WITH LAND BOILERS

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THIS BRITISH STANDARD, having been approved by the Mechanical Engineering Industry Standards Committee and endorsed by the Chairman of the Engineering Divisional Council, was published under the authority of the General Council on 24th November, 1967.

First published, August, 1938.
First revision, January, 1942.
Second revision, January, 1954.
Third revision, November, 1967.

The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 4000, fully indexed and with a note of the contents of each, will be found in the British Standards Yearbook, price 15s. The BS Yearbook may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

BS 10. Flanges and bolting for pipes, valves and fittings.
BS 21. Pipe threads.
BS 639. Covered electrodes for the manual metal-arc welding of mild steel and medium-tensile steel.
BS 759. Valves, gauges and other safety fittings for application to boilers and to piping installations for and in connection with boilers.
BS 1113. Water-tube boilers.
BS 1387. Steel tubes and tubulars suitable for screwing to BS 21 pipe threads.
BS 1452. Grey iron castings.
BS 1501-6. Steels for use in the chemical, petroleum and allied industries.
BS 1740. Wrought pipe fittings, iron and steel (screwed B.S.P. thread).
BS 1821. Class I oxy-acetylene welding of steel pipelines and pipe assemblies for carrying fluids.
BS 1965. Butt-welding fittings for pressure purposes.
Part 1. Carbon steel.
Part 2. Austenitic stainless steel.
BS 2079. Steam receivers and separators.
BS 2493. Molybdenum and chromium-molybdenum low alloy steel electrodes for manual metal-arc welding.
BS 2633. Class I arc welding of ferritic steel pipework for carrying fluids.
BS 2640. Class II oxy-acetylene welding of steel pipelines and pipe assemblies for carrying fluids.
BS 2790. Cylindrical land steam boilers of welded construction (other than water-tube boilers).
BS 2971. Class II metal-arc welding of steel pipelines and pipe assemblies for carrying fluids.
BS 3100. Steel castings for general engineering purposes.
BS 3601. Steel pipes and tubes for pressure purposes. Carbon steel: ordinary duties.
BS 3602. Steel pipes and tubes for pressure purposes. Carbon steel: high duties.
BS 3604. Steel pipes and tubes for pressure purposes. Low and medium alloy steel.
BS 3605. Steel pipes and tubes for pressure purposes. Austenitic stainless steel.
BS 3799. Forged steel pipe fittings, screwed and socket-welding for the petroleum industry.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

The following BSI references relate to the work on this standard:
Committee reference MEE/34/8 Draft for comment D64/11493

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CO-OPERATING ORGANIZATIONS

The Mechanical Engineering Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

*Associated Offices' Technical Committee
*Association of Consulting Engineers
Association of Mining Electrical and Mechanical Engineers
*Board of Trade
British Chemical Plant Manufacturers' Association
British Compressed Air Society
British Electrical and Allied Manufacturers' Association
British Gear Manufacturers' Association
British Internal Combustion Engine Manufacturers' Association
*British Iron and Steel Federation
*British Mechanical Engineering Federation
British Pump Manufacturers' Association
*Crown Agents for Oversea Governments and Administrations
*Electricity Council, the Central Electricity Generating Board and the Area Boards in England and Wales
*Engineering Equipment Users' Association
*Gas Council
*Institute of Marine Engineers
*Institution of Civil Engineers
*Institution of Gas Engineers
*Institution of Heating and Ventilating Engineers
*Institution of Mechanical Engineers
Institution of Mechanical Engineers (Automobile Division)
Institution of Production Engineers
Locomotive and Allied Manufacturers' Association of Great Britain
London Transport Board
Machine Tool Trades Association
Ministry of Defence
*Ministry of Labour (H.M. Factory Inspectorate)
*Ministry of Power
Ministry of Public Building and Works
Ministry of Technology—National Engineering Laboratory
Ministry of Transport
National Coal Board
*National Physical Laboratory (Ministry of Technology)
Radio Industry Council
Royal Institute of British Architects

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

Association of Shell Boilermakers
British Non-Ferrous Metals Federation
British Railways Board
British Welding Research Association
Combustion Engineering Association
Copper Development Association
Institute of Welding
Institution of Engineers and Shipbuilders in Scotland
Lloyd's Register of Shipping
Ministry of Defence, Navy Department
Tank and Industrial Plant Association
Water-Tube Boilermakers' Association
Manufacturers of boilers and pressure vessels
Manufacturers of pipes and tubes

BRITISH STANDARD SPECIFICATION FOR

FERROUS PIPES AND PIPING INSTALLATIONS FOR AND IN CONNECTION WITH LAND BOILERS

FOREWORD

This British Standard, first published in 1938 and subsequently revised in 1942 and 1954, forms one of a series for boiler installations, the preparation of which was authorized by the Mechanical Engineering Industry Standards Committee of the BSI.

Requirements for pipe materials, dealt with in Parts 2 and 3 of the 1954 edition are not included in the present edition. For information on the materials and the standard sizes of steel pipes applicable to this standard, reference should be made to the following specifications:

BS 3601. Steel pipes and tubes for pressure purposes.
Carbon steel: ordinary duties.
BS 3602. Steel pipes and tubes for pressure purposes.
Carbon steel: high duties.
BS 3604. Steel pipes and tubes for pressure purposes: Low and medium alloy steel.
BS 3605. Steel pipes and tubes for pressure purposes. Austenitic stainless steel.
BS 1387. Steel tubes and tubulars suitable for screwing to BS 21 pipe threads.

Integral piping, i.e. 'that piping within the whole of the circulatory system of the boiler between the water inlet valve and the steam stop valve and in the case of a reheater, between the reheater inlet header and the reheater outlet header' is excluded from this standard and is dealt with in BS 1113 'Water-tube boilers' and BS 2790 'Cylindrical land steam boilers of welded construction (other than water-tube boilers)'.

This applies also to certain pipework, e.g. water gauge pipes, connected to the boiler pressure parts or to the pipes forming the main circulatory system but not connected to external equipment or to atmosphere.

Information regarding the criteria used for the determination of design stress values for ferritic materials is given in Appendix E.

In preparing this revision the committee recognize the increasing use of austenitic steels in boiler piping installations and consideration is being given to the preparation of a suitable addendum to cover these steels. As an interim measure, recommended maximum design stress values for one grade of austenitic steel are included in Appendix F for guidance to users of this material.

NOTE. When it is required to convert values in this standard from inch/pound units into metric units it is recommended that the tables contained in BS 350, 'Conversion factors and tables', be used.

SPECIFICATION

1. GENERAL

1.1 SCOPE

This British Standard applies to the design and construction of the ferrous pipework connecting a land boiler to engine, turbine or industrial plant and all auxiliary pipework in connection therewith together with the pipes and pipe fittings forming parts of such installations for:

(1) pipes of any bore where the pressure exceeds 50 lbf/in²,
(2) pipes over 10 in bore for steam at pressures up to and including 50 lbf/in².

NOTE. The term 'pipe fitting' in this standard includes tees, elbows, and specials, but excludes everything covered by BS 759, 'Valves, gauges and other safety fittings for application to boilers and to piping installations for and in connection with boilers.'

The standard applies to the use of carbon steel for design temperatures up to 900°F (482°C), and to the use of alloy steel for design temperatures up to 1100°F (593°C).

It does not apply to the component parts of the boiler unit or to integral piping, which are dealt with in BS 1113 'Water-tube boilers' and BS 2790 'Cylindrical land steam boilers of welded construction (other than water-tube boilers)'.

Steam receivers and separators are also excluded from this standard (see BS 2079, 'Steam receivers and separators').

1.2 SYMBOLS

The symbols used in the formulae in this standard are defined as follows:

D = outside diameter* in inches of the pipe.

d = bore* in inches of the pipe. This should not be confused with nominal bore which is an accepted designation associated with outside diameters of standard rolling sizes.

t_f = minimum thickness in inches of pipe calculated by the appropriate formula.

t_b = minimum thickness in inches of pipe before bending = t_f + bending allowance.

t_m = minimum thickness in inches of branch or main at a branch position.

* These diameters are subject to manufacturing tolerances but these tolerances are not to be used in the evaluation of formulae.

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t = thickness (preferably specified from the appropriate pipe standard) which, after allowance for manufacturing tolerance, gives a remainder of not less than t_r, t_b or t_m as the case may be.

T = design temperature in degrees Fahrenheit.

p = design pressure in pounds-force per square inch.

f = maximum permissible design stress in pounds-force per square inch.

e = weld efficiency factor.

p_t = hydraulic test pressure in pounds-force per square inch.

1.3 INFORMATION TO BE SUPPLIED BY THE PURCHASER

The purchaser shall state in all enquiries and orders:

(1) The design pressure and temperature determined in accordance with 1.4.

NOTE. It is the responsibility of the purchaser to ensure that the requirements of 1.4 are fulfilled.

(2) The name of the inspecting authority, if any.

(3) Whether or not the purchaser or his representative desires to witness the tests.

(4) Whether or not the purchaser desires to receive test certificates.

(5) For steel castings, whether or not repair by welding is permitted without the previous sanction of the purchaser or his representatives (see BS 3100* Clause 13).

1.4 DESIGN PRESSURES AND TEMPERATURES

For the purposes of this British Standard the pressures and temperatures for which pipes and pipe fittings are designed, shall be as follows:

1.4.1 Design pressure for steam piping

(1) The design pressure for piping beyond the steam stop valve shall be the design pressure of the boiler, i.e. not less than the highest pressure at which any safety valve is to be set to lift, except that:

a. where the design temperature of the piping exceeds 800°F (427°C) in the case of carbon steels and 950°F (510°C) in the case of alloy steels,

and *b.* where the total capacity of the safety valves on the superheater is not less than 20% of the total evaporative capacity of the boiler,

the design pressure of the steam piping shall be the highest pressure at which any superheater safety valve is to be set to lift, provided that in no case shall the design pressure of the piping be less than 90% of the design pressure of the boiler.

(2) Where there is no superheater, the design pressure of the piping shall be the design pressure of the boiler.

(3) In reheat systems where the design temperature of the piping exceeds 800°F (427°C) in the case of carbon steels and 950°F (510°C) in the case of alloy steels, the design pressure shall be the lowest pressure to which any safety valve on the reheat system is to be set to lift.

(4) In reheat systems where the design temperature of the piping does not exceed 800°F (427°C) in the case of carbon steels and 950°F (510°C) in the case of alloy steels the design pressure shall be the highest pressure at which any safety valve on the reheat system is to be set to lift.

(5) For reduced pressure systems, the pressure may be controlled at a value below that in the originating piping system by a reducing valve or by the pressure drop across a fixed restriction such as an orifice or the blading of the turbine.

Where no protective device as hereinafter described is fitted, the design pressure shall be the greatest pressure therein attainable under the most arduous operating condition, i.e. with the originating piping system operating at its design pressure, with the upstream valves, including any reducing valves or restrictions fully open, and with the downstream valves (other than non-return valves) fully closed.

Where a protective device is fitted consisting of a safety valve or valves or a suitable appliance for cutting off automatically the supply of steam at a predetermined pressure, the design pressure for piping systems having a design temperature not exceeding 800°F (427°C) in the case of carbon steels and 950°F (510°C) in the case of alloy steels shall be that to which the pressure under the most arduous condition is limited by the proper operation of such a device. Where similar provisions are made on piping systems with a design temperature above 800°F (427°C) in the case of carbon steels and above 950°F (510°C) in the case of alloy steels, the design pressure shall be the highest controlled operating pressure, provided that the average pressure in any one year does not exceed the rated pressure, and that the fluctuations in controlled pressure at no time exceed 20% above the design value.

1.4.2 Design pressure for feed piping. The design pressure shall be the maximum pressure which can be communicated to the pipe line i.e. the maximum pressure which can be generated at the outlet of the boiler feed pumps, except where a relief valve or other protective device is fitted, when it shall be the highest set pressure thereof.

1.4.3 Design temperature for steam piping. The design temperature for steam piping shall be:

(1) For main steam piping, the rated temperature at the superheater outlet.

(2) For reheated steam piping, the rated temperature at the reheater outlet.

(3) For other steam piping, the highest rated temperature at the higher temperature end of the pipes.

Provided in all cases that in service:

(4) the temperature on the average during any one year of operation does not exceed the design temperature, and

(5) normal fluctuations in temperature do not exceed the design temperature by more than 25 degF (14 degC), and

(6) abnormal fluctuations in temperature do not exceed the design temperature by more than:

35 degF (19·4 degC) for a maximum of 400 hours in any one year,

60 degF (33·3 degC) for a maximum of 80 hours in any one year.

Where the maximum temperature exceeds the limits in (4) (5) and (6) the design temperature shall be increased by the amount of the excess.

* BS 3100, 'Steel castings for general engineering purposes'.

1.4.4 Blow-down pipes. The design conditions for blow-down pipes, whether run separately into a tank or sump, or into a common header, shall be the design boiler pressure and the corresponding saturated steam temperature. The design basis for a blow-down header common to a number of boilers and discharging freely into an adequately vented tank or sump shall be half the design boiler pressure and the saturated steam temperature corresponding to this lower pressure, provided that under maximum flow conditions this pressure is not exceeded.

1.4.5 Drain pipes. Drain pipes on the inlet side of steam traps and of drain valves shall be treated as steam pipes at the design conditions appropriate to the apparatus or main which they drain.

Drain pipes on the outlet side of steam traps and of drain valves shall be treated as steam pipes at the design pressure of the apparatus or main which they drain and at a design temperature of 200 degF (111 degC) less than that of the apparatus or main.

A common drain main of sufficient cross section, discharging freely into an adequately vented tank or sump, may be treated as a saturated steam pipe at half the design pressure of the drain pipes provided that under maximum flow conditions this pressure is not exceeded.

1.4.6 Safety valve discharge piping. The design pressure of the discharge piping shall be the maximum pressure which can be imposed upon it, but in no case less than 50 lbf/in² and shall be calculated by the methods given in Appendix B. The design temperature for the discharge piping shall be 200 degF (111 degC) less than that of the steam at the valve inlet.

1.5 MATERIALS

1.5.1 Steel pipes. Steel pipes shall comply with the requirements of one of the following British Standards:

BS 3601. Steel pipes and tubes for pressure purposes. Carbon steel: ordinary duties.

BS 3602. Steel pipes and tubes for pressure purposes. Carbon steel: high duties.

BS 3604. Steel pipes and tubes for pressure purposes. Low and medium alloy steel.

BS 1387. Steel tubes and tubulars for screwing to BS 21 pipe threads.

1.5.2 Pipe fittings. Pipe fittings shall comply with the requirements of one of the following British Standards:

BS 3799. Forged steel pipe fittings, screwed and socket-welding for the petroleum industry.

BS 1740. Wrought pipe fittings, iron and steel (screwed B.S.P. thread).

BS 1965. Butt-welding pipe fittings for pressure purposes.
Part 1. Carbon steel.
Part 2. Austenitic stainless steel.

1.5.3 Castings (iron and steel). Castings shall comply with the requirements of one of the following British Standards:

(1) *Iron castings*

Iron castings shall have properties at least equal to those of BS 1452, 'Grey iron castings', Grade 14

(2) *Carbon and alloy steel castings*

BS 3100–592. Carbon steel castings for general engineering purposes.

BS 1504–161. Carbon steel castings (for parts under pressure).

BS 1504–622. 2¼% chromium, 1% molybdenum steel castings.

1.5.4 Flanges and bolts. Materials for flanges and bolts shall comply with the requirements in BS 10, 'Flanges and bolting for pipes, valves and fittings'.

2. DESIGN REQUIREMENTS

2.1 MAXIMUM PERMISSIBLE DESIGN PRESSURES, TEMPERATURES AND STRESSES

The pressure and temperature limits within which pipes and pipe fittings of various materials are permitted to be used and maximum design stress values are given in Table 1 (see also Appendix E).

NOTE. *Design criteria.* The design stress values specified in Table 1 have been derived using the factors given in Appendix E. In the range where stress to rupture in 100 000 hours is the design criterion, the design factor of 1·6 results in an available life in excess of 100 000 hours and which is appropriate for the majority of piping installations covered by this standard.

Where the available life of a piping installation is predetermined, by agreement between the purchaser, manufacturer and inspecting authority, design stress values may be derived using the following design factors on the mean stress to rupture in 100 000 hours for design temperatures of 1000°F and above for the materials indicated:

Material	Permitted design factor for available life		
	Up to 150 000 hours	Over 150 000 hours Up to 200 000 hours	Over 200 000 hours Up to 250 000 hours
2¼ Cr 1 Mo Steel 622·27	1·5	1·6	1·8
2¼ Cr 1 Mo Steel 622·31	1·5	1·6	1·8
½ Cr ½ Mo ¼ V Steel 660	1·5	1·6	1·8

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2.2 THICKNESS OF WROUGHT STEEL STRAIGHT PIPES

The minimum thickness of straight pipes shall be determined as follows.

Where the outside diameter is the basis for calculation:

$$t_t = \frac{p\,D}{2fe + p} \qquad (1)$$

Where the bore is the basis for calculation:

$$t_t = \frac{p\,d}{2fe - p} \qquad (1A)$$

where (see 1.2).

t_t = minimum thickness in inches.
p = design pressure, in pounds-force per square inch.
D = outside diameter of pipe, in inches.
d = inside diameter of pipe, in inches.
f = maximum permissible design stress in pounds-force per square inch as specified in Table 1.
e = 1·0 for seamless and for electric resistance welded steel pipes.
e = 0·95 for electric fusion welded steel pipes to BS 3602* on which the weld is fully radiographed and on which the relevant tests are carried out on every 250 ft.
e = 0·90 for welded steel pipes to BS 3601† other than electric resistance welded pipes.

* BS 3602, 'Steel pipes and tubes for pressure purposes. Carbon steel: high duties'.
† BS 3601, 'Steel pipes and tubes for pressure purposes. Carbon steel: ordinary duties'.

NOTE. The value of t_t is the minimum thickness for straight pipes and provision must be made for any minus tolerances. Manufacturing considerations may make it necessary for pipes thicker than this minimum to be used.

2.3 WROUGHT STEEL BENT PIPES

2.3.1 Thickness of bends. The minimum thickness (t_b) of a straight pipe from which a pipe bent to a radius in accordance with Table 2 is to be made shall be determined from equation (2) or equation (3), except where it can be demonstrated that the use of a thickness less than t_b would not reduce the thickness below t_t at any point after bending.

For pipes 8⅝ in outside diameter and below, and for pipes above 8⅝ in outside diameter bent to the radii specified in Table 2, Column 2:

$$t_b = 1{\cdot}125 t_t \qquad (2)$$

For pipes above 8⅝ in outside diameter, where t_t is 1¼ in or more, bent to the radii specified in Table 2, Column 3:

$$t_b = 1{\cdot}10 t_t \qquad (3)$$

NOTE. The value of t_b is the minimum thickness and provision must be made for minus tolerances. Manufacturing considerations may make it necessary for pipes thicker than this minimum to be used.

2.3.2 Radii of bends

2.3.2.1 Pipes of the thickness determined as in 2.3.1 shall not be bent to radii less than those given in Table 2. Where smaller radii are necessary further allowance shall be made for thinning at the back of the bend except where it can be demonstrated that the use of t_b will not reduce the thickness below t_t at any point after bending.

2.3.2.2 There is a minimum thickness for each size of pipe, dependent on bending procedure, below which the allowance for thinning will be exceeded, and in such cases the radius given in Table 2 shall be increased where necessary to ensure that the thickness is not below t_t at any point after bending.

2.3.2.3 For the minimum radii of bends of Steel 35 and of alloy steels, which are cold bent without subsequent heat treatment, reference shall be made to 3.2.

2.3.2.4 For pipes rolled to a specified bore, the minimum bending radii and corresponding thinning allowance shall be that applicable to the nearest outside diameter listed in Table 2 greater than that resulting from the specified bore plus $2t_b$.

2.4 GUSSETED BENDS

Where gusseted bends are used these shall be in accordance with:

BS 2633‡ for pressures and temperatures not exceeding 300 lbf/in² and 500°F (260°C), or

BS 2971§ within the pressure and temperature limitations specified for Class II.

‡ BS 2633, 'Class I arc welding of ferritic steel pipework for carrying fluids'.

2.5 THICKNESS OF CAST STEEL STRAIGHT PIPES AND BENDS

The minimum thickness of cast steel straight pipes and bends shall be determined from equation (4) but in no case shall the minimum thickness be less than ⅜ in.

$$t_t = \frac{Fpd}{2f - p} \qquad (4)$$

where (see 1.2)

t_t = minimum thickness, in inches.
p = design pressure, in pounds-force per square inch.
d = bore of pipe, in inches.
f = maximum permissible design stress, in pounds-force per square inch as specified in Table 1 for the equivalent grade and properties of wrought steel.
F = 1·4 except that, for those parts shown to be sound by radiography or by ultrasonic testing, F shall be 1.1.

NOTE. It is emphasized that the thickness derived from equation (4) applies only to straight pipes and bends. Where there is any departure from these forms the design must receive special consideration.

§ BS 2971, 'Class II metal-arc welding of steel pipelines and pipe assemblies for carrying fluids'.

TABLE 1. MAXIMUM PERMISSIBLE DESIGN PRESSURES

Material	Pipe standard	Method of manufacture	Steel grade	Maximum permissible design pressure lbf/in²	Maximum permissible design temperature	Values of f lbf/in²					
						120 (49)	200 (93)	300 (149)	400 (204)	500 (260)	600 (316)
Carbon steel	BS 3601	HFS, CDS, ERW and BW	22	300	500°F (260°C)	18 300	16 900	15 500	13 700	12 100	
		EFW and SFW	26			18 800	17 800	16 700	15 500	14 300	
		HFS, CDS and ERW	27			22 400	20 400	17 900	16 400	14 800	
Carbon steel	BS 3602	HFS, CDS and ERW	23	No restrictions	900°F (482°C)	18 900	17 800	16 400	15 900	14 700	12 700
		HFS, CDS and ERW	27			22 400	20 400	17 900	17 200	15 800	13 600
		EFW	28B*			22 400	19 600	18 600	17 700	15 700	13 800
		HFS and CDS	35			28 000	24 600	20 200	19 000	18 100	17 300
Alloy steel 1 Cr ½ Mo	BS 3604	HF and CD	620	No restrictions	1050°F (566°C)	21 000	20 400	19 600	18 800	16 500	14 200
2¼ Cr 1 Mo		HF and CD	622·27		1100°F (593°C)	21 000	18 900	16 200	13 800	13 400	12 900
2¼ Cr 1 Mo		HF and CD	622·31			23 800	23 300	22 700	22 200	21 100	20 200
½ Cr ½ Mo ¼ V		HF and CD	660		1070°F (577°C)	24 900	23 900	22 700	22 200	21 100	20 200
Cast iron				Feed: 200 Blow down (excluding fittings): 150		3000 up to and including 430°F (221°C)					
				Steam (fittings only): 190	430°F (221°C)						

NOTE. For austenitic steels, see Appendix F.
* Made from plate in accordance with BS 1501, 151 and 161: Grade 28B up to and including 1¼ in thick.

TEMPERATURES AND VALUES OF f FOR STRAIGHTS, BENDS OR FITTINGS

for design temperatures in °F (°C) not exceeding:†

700 (371)	750 (399)	800 (427)	850 (454)	900 (482)	925 (496)	950 (510)	975 (524)	1000 (538)	1010 (543)	1020 (549)	1030 (554)	1040 (560)	1050 (566)	1060 (571)	1070 (577)	1080 (582)	1090 (588)	1100 (593)
11 200	10 700	10 400	7 800	4 800														
12 800	12 500	11 300	7 800	4 800														
13 200	13 000	12 400	8 400	5 000														
16 700																		
13 300	13 200	13 000	12 900	12 700	12 600	11 100	8 150	5 950	5 250	4 650	4 100	3 600	3 150					
12 300	12 100	11 900	11 700	11 500	11 400	11 200	11 100	9 150	8 400	7 700	7 050	6 450	5 850	5 300	4 850	4 450‡	4 050‡	3 700‡
19 200	18 600	18 200	17 700	17 200	15 900	15 400	11 100	9 150	8 400	7 700	7 050	6 450	5 850	5 300	4 850	4 450‡	4 050‡	3 700‡
19 200	18 600	18 200	17 700	17 200	17 000	14 700	11 900	9 500	8 700	7 950	7 250	6 650	6 100	5 600	5 200			

† Intermediate values may be obtained by linear interpolation.
‡ At these temperatures the effects of scaling become significant and due allowance should be made for this.

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TABLE 2. MINIMUM BENDING RADII FOR PIPES OF THICKNESS DETERMINED IN 2.3.2

1	2	3
Outside diameter	Radii measured to centreline of pipe	
	$t_b = 1{\cdot}125t_t$ all thicknesses	$t_b = 1{\cdot}1t_t$ $t_b = 1\frac{3}{8}$ in or above
in	in	in
1 1/16	2½	
1 11/32	3	
1 11/16	4	
1 29/32	4½	
2⅜	6	
3	7½	
3½	9	
4	10½	
4½	12	
5	14	
5½	15	
6	17	
6⅝	18	
7	23	
7⅝	25	
8⅝	28	
9⅝	32	45
10¾	40	50
11¾	44	55
12¾	48	60
14	59	70
16	68	80
18	80	90

NOTE. There is a practical minimum thickness for each size below which larger radii must be used.

2.6 THICKNESS OF CAST IRON STRAIGHT PIPES AND BENDS FOR FEED AND BLOW-DOWN

The thickness of cast iron straight pipes and bends shall be determined from equation (5) and shall be not less than those shown in Table 3.

$$t_t = \frac{pD}{2f} + 0{\cdot}015D + 0{\cdot}25 \qquad (5)$$

where (see 1.2)

t_t = minimum thickness in inches.
p = design pressure, in pounds-force per square inch
D = outside diameter of pipe, in inches.
f = 3000 pounds-force per square inch.

TABLE 3. MINIMUM THICKNESS OF CAST IRON STRAIGHT PIPES AND BENDS FOR FEED AND BLOW-DOWN

Bore (d)	Minimum thickness for design pressures of			
	Feed and blow-down pipes			Feed pipes only
	Up to and including 50 lbf/in²	Over 50 up to and including 100 lbf/in²	Over 100 up to and including 150 lbf/in²	Over 150 up to and including 200 lbf/in²
in	in	in	in	in
2		0·34	0·36	0·39
2½		0·35	0·38	0·41
3		0·37	0·40	0·44
3½		0·39	0·42	0·47
4		0·40	0·45	0·49
4½		0·42	0·47	0·52
5		0·44	0·49	0·55
6		0·47	0·53	0·60
7		0·51	0·58	0·65
8		0·54	0·62	0·72
9		0·57	0·66	0·76
10		0·61	0·71	0·81
11	0·53	0·64	0·75	0·87
12	0·56	0·68	0·79	0·92

NOTE. It is emphasized that these thicknesses apply to straight pipes and bends. Where there is any departure from these forms, the design should receive special consideration.

2.7 JOINTS

The flanges and bolts for ordinary bolted flange joints shall be in accordance with BS 10*. Special joints and special types of flanges may be used provided they are shown to be suitable for the design conditions.

Butt welded joints between abutting pipe ends shall comply with the requirements given in 3.3.

Socket weld joints may be used with carbon steel pipes not exceeding 2⅜ in outside diameter for design temperatures not exceeding 700°F (371°C). The procedure to be observed in welding and heat-treating these welds shall be in accordance with the requirements for lap and T joints (fillet welds) in BS 2633†.

Socket weld couplings and fittings shall comply generally with the dimensional requirements of BS 3799‡ with such modifications as may be necessary to suit the outside diameter and the thickness of the pipe. Couplings and fittings for use with pipes of carbon steel 23 and 27 shall be of carbon steel complying with BS 3799. Couplings and fittings for use with pipes of carbon steel 35 shall be of steel similar to the pipes.

Screwed and socketed joints to BS 1387§ and screwed wrought steel fittings to BS 1740* are permitted within the limits given in Table 4.

* BS 10, 'Flanges and bolting for pipes, valves and fittings'.
† BS 2633, 'Class I arc welding of ferritic steel pipework for carrying fluids'.
‡ BS 3799, 'Forged steel pipe fittings, screwed and socket-welding for the petroleum industry'.
§ BS 1387, 'Steel tubes and tubulars suitable for screwing to BS 21 pipe threads'.

TABLE 4. MAXIMUM PERMISSIBLE PRESSURES AND TEMPERATURES FOR SCREWED JOINTS (EXCLUDING SCREWED-ON FLANGES)

(*see 3.5.4*)

Nominal bore	Maximum permissible pressure	Maximum permissible temperature
in	lbf/in²	°F (°C)
Up to and including 1	175	500 (260)
Over 1 up to and including 1½	150	500 (260)
Over 1½ up to and including 3	125	500 (260)
Over 3 up to and including 4	100	500 (260)

2.8 BRANCHES

2.8.1 Branches shall not be welded to any main at an angle less than 60°.

2.8.2 External reinforcement. If the thickness of the main or branches of a branch piece is less than that given by equation (6) below, adequate external reinforcement shall be provided. Such reinforcement may be multiple radial plates of 'horseshoe' form, collars or other approved reinforcement applied to or around the junction between branch and main. Gusset plates attached longitudinally to the surfaces of either pipe shall not be used.

2.8.3 Thickness where no external reinforcement is provided. Where more than one branch is attached to a pipe the opening of each branch shall be projected perpendicularly on the axis of the main and the distance between each pair of those projections measured. If the distance so measured between two branches is less than the sum of their bores, the two branches are deemed to affect each other; if this distance is equal to or greater than the sum of their bores, the two branches are deemed not to affect each other.

In calculating the reinforcement required, each branch is to be considered in turn together with all the branches by which it is affected. Figs. 2 to 5 show typical examples.

2.8.3.1 *A branch not affected by any other branch.* Where no external reinforcement is to be applied to a branch piece the thickness of the branch shall be determined from equation (6).

$$t_m = \frac{pD}{2fex + p} \qquad (6)$$

where (see 1.2)

t_m = minimum thickness of the branch in inches.
p = design pressure in pounds-force per square inch.
D = outside diameter of branch in inches.
f = allowable design stress in pounds-force per square inch as specified in Table 1.
e = factor given in 2.2.
x = $1 - B(1 - 0{\cdot}7 \sin \gamma)$ (see nomogram in Fig. 1). (7)
B = ratio of bore of branch to bore of main.
γ = angle between branch and main in degrees.

* BS 1740, 'Wrought pipe fittings, iron and steel (screwed B.S.P. thread)'.

NOTE. The value of t_m derived from equation (6) is the minimum thickness and further provision must be made for the minus tolerance.

No reinforcement is required if

$$B \leq \frac{\gamma}{\gamma + 90} \qquad (8)$$

2.8.3.2 *A branch affected by one or more other branches.* Determine the 'x' values for each branch alone from equation (7). Let x be the value for the branch under consideration and x_a, x_b, etc., the values for the other branches.

$$\text{Then } x_1 = 1 - C(1 - x_a) \qquad (9)$$
$$x_2 = 1 - C(1 - x_b)$$
etc.

where C is a factor the value of which is to be taken from Table 5.

The thickness of each branch, irrespective of the ratio of the bore of the branch to that of the main, shall then be determined from equation (10).

$$t_m = \frac{pD}{2fex(x_1 x_2 x_3 \ldots) + p} \qquad (10)$$

TABLE 5. FACTOR C

(Intermediate values by linear interpolation)

$\frac{L}{d_m + d_n}$	C
1 or greater	0
0·9	0·10
0·8	0·34
0·7	0·66
0·6	0·80
0·5	0·90
0·4	0·94
0·3	0·97
0·2	0·98
0·1	0·99
0	1

L = distance between projections of branch bores, d_m and d_n, where the subscripts m and n represent the branch numbers under consideration (see Figs. 2 to 5).

2.8.3.3 *Length of branch reinforcement.* The additional thickness of the branch required by equation (6) or (10) for reinforcement shall extend for a distance not less than the bore of the branch measured from the outside diameter of the main along the centreline of the branch.

2.8.3.4 *Mains* (see Figs. 2 to 5). The thickness of a main carrying a branch shall be determined as for the branch except that the symbols 'D' and 'e' shall apply to the main.

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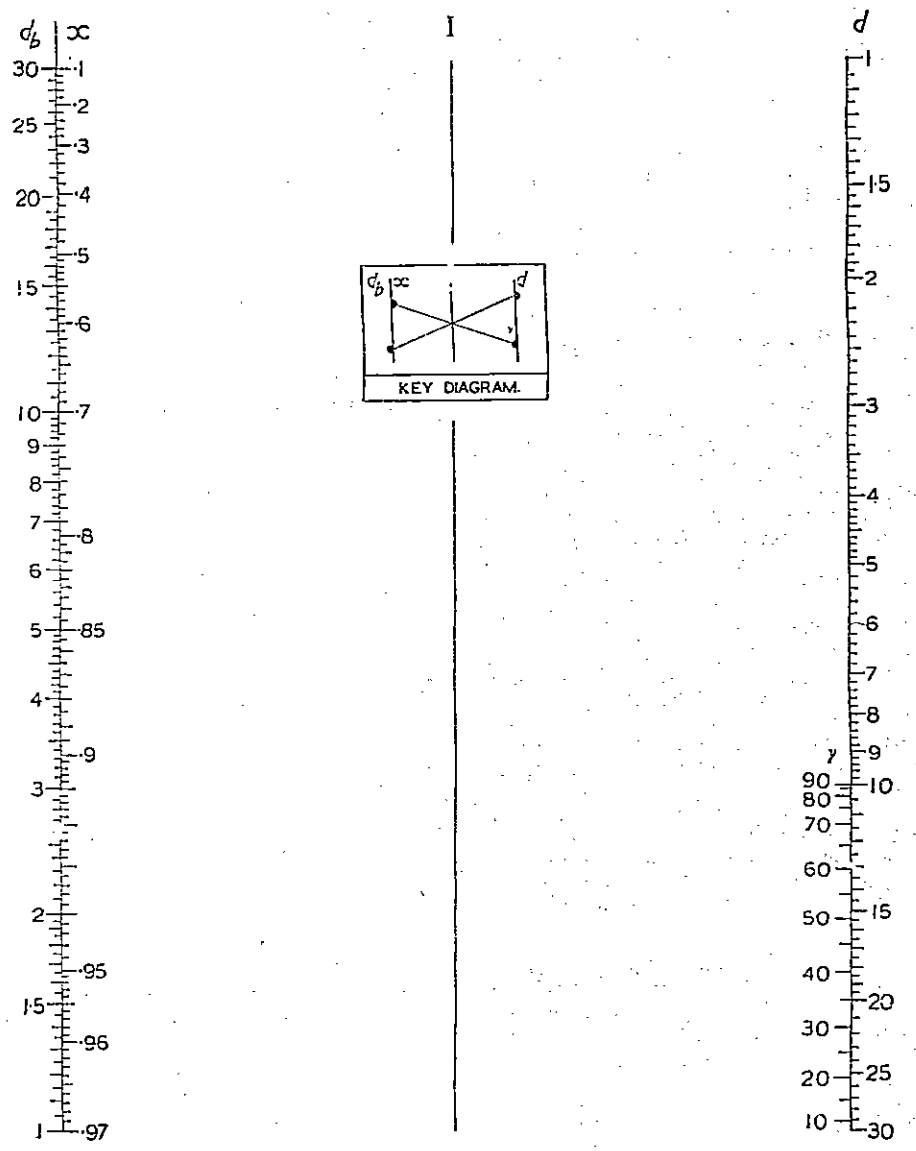
The thickness of a main carrying more than one branch shall be the greatest of the thicknesses of the main calculated in connection with each branch separately.

The additional thickness of a main for branch reinforcement shall extend over the length covered by the branch or group of interacting branches and beyond it on each side for a distance not less than the bore of the main.

2.8.4 Appendix C gives worked examples of reinforcement.

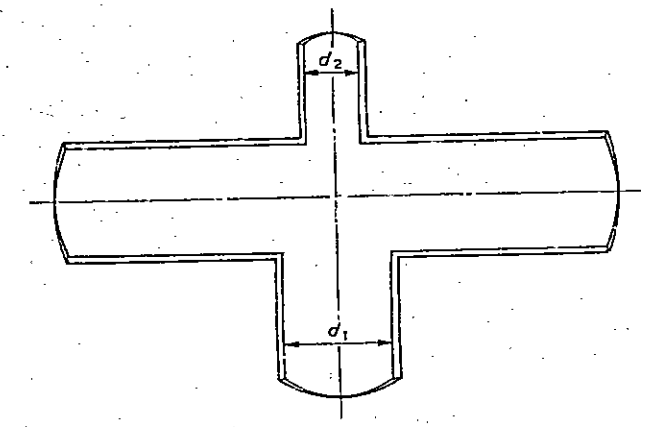


The factor x is given by the formula

$$x = 1 - \frac{d_b}{d}(1 - 0{\cdot}7 \sin \gamma)$$

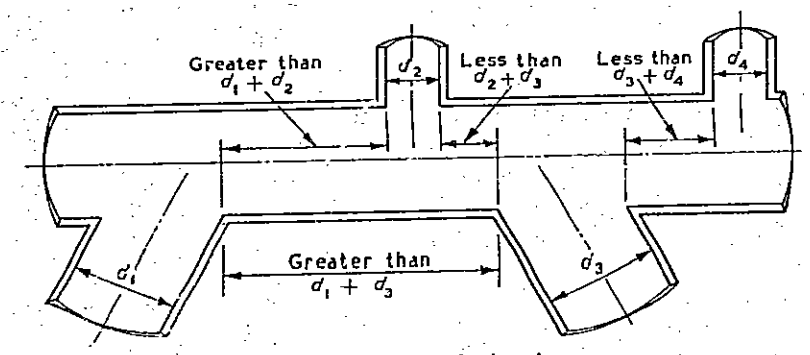
where d_b = bore of branch, d = bore of main, γ = angle between axes of main and branch.

Fig. 1. Nomogram. Reinforcement of branch pieces



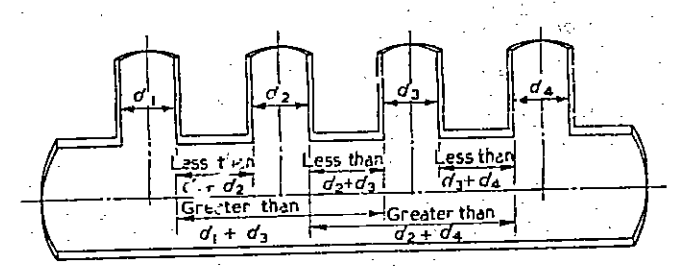
d_1 and d_2 form a pair affecting each other

Fig. 2



d_1 is unaffected by the other branches
d_2 is affected by d_3
d_3 is affected by d_2 and d_4
d_4 is affected by d_3

Fig. 3



d_1 is affected by d_2
d_4 is affected by d_3
d_2 is affected by d_1 and d_3
d_3 is affected by d_2 and d_4

Fig. 4

(For calculations see Appendix C)

Figs. 2 to 5. Typical branch pieces

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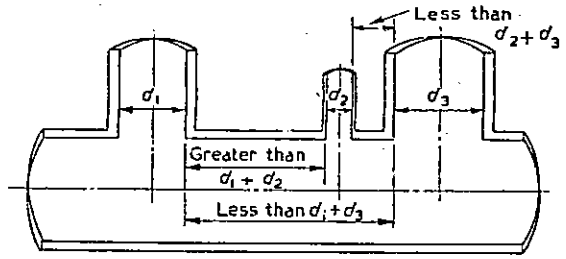

d_1 is affected by d_3
d_2 is affected by d_3
d_3 is affected by d_1 and d_2

Fig. 5

(For calculations see Appendix C)

Figs. 2 to 5 (*continued*). Typical branch pieces

2.9 EXPANSION ALLOWANCE

The allowance for expansion per 100 ft of piping at various temperature ranges shall be as given in Table 6. (For coefficients of expansion see Appendix A.)

2.10 SAFETY VALVE DISCHARGE PIPING

The safety valve discharge pipes shall comply with the requirements specified in BS 759*. Where a slip or expansion joint is used, such joint shall be properly anchored. The discharge pipes shall be as short and straight as possible and drained to prevent the accumulation of water within them.

2.11 FLEXIBILITY

2.11.1 The pipes shall be arranged so that the system is sufficiently flexible to absorb the whole of its own expansion and that of the connecting equipment without exceeding the requirements specified in 2.11.2.

The pipe dimensions used in flexibility calculations shall be the mean thickness and outside diameter D (or bore d) as defined in 1.2. For tubes rolled to a standard outside diameter (D) with a bilateral tolerance on thickness the mean thickness shall be taken as t as defined in 1.2. For tubes rolled to a specified bore (d) with a unilateral plus tolerance on thickness, the mean thickness shall be taken as the specified minimum thickness plus 50% of the tolerance. Where practicable, the requisite flexibility shall be provided in the layout of the pipes. Where lack of space or other considerations prohibit the use of this method, expansion pieces or corrugated pipes may be used provided that the limitations imposed by maximum design pressure, drainage etc., are taken into account.

For further information concerning expansion pieces and general recommendations for dealing with system flexibility see Appendix D.

The pipes may be pre-stressed for the purposes of reducing expansion stress under working conditions, by leaving gaps at appropriate points and pulling up cold during erection. Anchors shall be designed and installed to ensure that there is no slipping or twisting of the pipes and care shall be taken that the gaps are correctly set. After the pipes have been pulled together the joint faces shall be correctly positioned and the pipes shall be in proper alignment. Credit may then be taken for the reduction in expansion stress under working conditions, when calculating the total stress in accordance with 2.11.2.

Where creep conditions apply (see Appendix D) the amount of cold pull shall not be less than 85% of the total calculated expansion of the system and preferably shall be equal to the total calculated expansion of the system.

2.11.2 At any point in the pipes and under any operating conditions within the limits of the design pressure and temperature the arithmetical sum of the equivalent stress (f_e) due to expansion or cold pull, the longitudinal pressure stress and the longitudinal stress due to deadweight and any other causes shall not exceed the appropriate value of f specified in Table 1. The provisions of 2.11.4 to 2.11.6 shall also be taken into account.

Localized stresses not specifically allowed for in the calculation, such as circumferential bending stress or stress concentrations produced by changes of section, should be kept to a reasonable minimum.

2.11.3 Where a pipe is subject to combined bending and torsion the equivalent bending stress (f_e) shall be determined from equation (11).

$$f_e = \sqrt{f_b^2 + 4f_t^2} \qquad (11)$$

where f_e = equivalent stress,
f_b = resultant flexural bending stress,
f_t = torsional stress.

2.11.4 When a steam pipe system is cold the arithmetical sum of the equivalent stress (f_e) due to cold pull and the longitudinal stress due to deadweight and any other causes shall not exceed the value of f specified in Table 1 for design temperatures up to and including 120°F (49°C).

2.11.5 When a feed pipe or other system may be required to operate under the design pressure at ambient temperature the arithmetical sum of the equivalent stress (f_e) due to cold pull, the longitudinal pressure stress and the longitudinal stress due to deadweight or any other causes shall not exceed the value of f specified in Table 1 for design temperatures up to and including 120°F (49°C).

2.11.6 When a hydraulic test is applied to a completed system (see 4.2) the arithmetical sum of the equivalent stress (f_e) due to cold pull, the longitudinal stress due to the hydraulic test pressure and the longitudinal stress due to deadweight and any other causes shall not exceed 1·2 times the value of f specified in Table 1 for design temperatures up to and including 120°F (49°C). The requirements specified in 2.11.4 or 2.11.5 shall apply when the system is not under test.

2.11.7 In addition to the requirements specified in 2.11.1 the pipes shall be arranged so that the system is sufficiently flexible to ensure that the end reactions, under any operating conditions either hot or cold within the limits of the design temperature and pressure, do not overload the connected equipment. Maximum values for the forces and moments due to expansion or cold pull and unsupported deadweight, which may be applied to the connected equipment, shall be agreed between the purchaser and the manufacturer.

2.12 DRAINAGE

2.12.1 Every precaution shall be taken in the layout of steam pipework to prevent the formation of water during operation or when shut down. Provision shall be made for water, whether formed continuously or occasionally, to be removed from the system without, as far as is practicable, being allowed to come into contact with metal at a higher temperature.

Where practicable, a suitable fall shall be provided in the pipework in the direction of flow of steam to ensure that the water flows towards the drainage point.

2.12.2 Small pipes such as gauge connections, which might act as reflux condensers, shall be arranged to ensure that any condensate which is formed will be re-evaporated before it can enter the larger and hotter pipe. This may be done by nesting the smaller pipe against the larger under the lagging or the provision of perforated internal pipe suitably arranged within an annulus branch.

2.12.3 Steam pipework shall be provided with adequate draining points wherever water can collect under working conditions. Such provision shall take the form of drain pockets which shall be connected to steam traps, or other suitable apparatus which will ensure the prompt discharge of water from the system. It is recommended that a bypass be fitted to each steam trap. The water shall be handled by equipment which can easily be replaced. Hand drains shall be provided at all other points at which water can collect in any portion of the pipework, due to valve leakage or other causes, when shut down or when warming up prior to use.

2.12.4 Where entrained water is likely to cause damage, separators shall be installed. Such separators shall be fitted with means for drainage.

2.12.5 Drain branches shall be provided with a shut-off cock or valve adjacent to the pipe to be drained, and, where connected to a common drain pipe, a non-return valve shall be fitted between each drain branch and the common drain.

2.13 PIPEWORK SUPPORTS

All pipework shall be adequately supported under test and working conditions. The supports shall permit free movement for expansion and contraction and shall, as far as possible, not damage the insulation. It is desirable that points of support should, as far as practicable, be arranged adjacent to the pipe joints. Slings are in general preferable to roller supports which should be used only where necessary.

TABLE 6. EXPANSION ALLOWANCE

Temperature range		Expansion (inches per 100 ft)	
°F	°C	Carbon and low alloy steels	Cast iron
60– 250	16–121	1·56	1·25
60– 300	16–149	1·99	1·58
60– 350	16–177	2·43	1·91
60– 400	16–204	2·89	2·24
60– 450	16–232	3·35	
60– 500	16–260	3·83	
60– 550	16–288	4·31	
60– 600	16–316	4·81	
60– 650	16–343	5·31	
60– 700	16–371	5·83	
60– 750	16–399	6·36	
60– 800	16–427	6·89	
60– 850	16–454	7·44	
60– 900	16–482	7·99	
60– 925	16–496	8·28	
60– 950	16–510	8·57	
60– 975	16–524	8·86	
60–1000	16–538	9·14	
60–1010	16–543	9·25	
60–1020	16–549	9·37	
60–1030	16–554	9·50	
60–1040	16–560	9·61	
60–1050	16–566	9·72	
60–1060	16–571	9·84	
60–1070	16–577	9·96	
60–1080	16–582	10·08	
60–1090	16–588	10·24	
60–1100	16–593	10·34	

BS 759, * Valves, gauges and other safety fittings for application to boilers and to piping installations for and in connection with boilers '.

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3. CONSTRUCTION AND WORKMANSHIP

3.1 GENERAL

Contamination of the surfaces of the pipes by corrosive or other detrimental substances, particularly by non-ferrous metals and sulphur, shall be avoided; for example during heating adequate measures shall be taken to prevent sulphur pick up. Filling sand, if used, shall be inert and no paint, labels or tools containing lead, copper, zinc or tin shall be used.

It is essential that alloy steel pipes, when cold shall not be subjected to impact or hammer blows likely to cause local damage. Every precaution shall be taken to avoid such occurrences in handling and during all operations on the pipes. Care shall be taken in manipulation to avoid the formation of notches or other sharp changes of contour likely to cause stress concentration.

3.2 HEAT TREATMENT AND FINAL CONDITION

3.2.1 Heat treatment. All pipes of carbon steel 35 or of alloy steel shall be heat-treated as follows:

Carbon steel 35:	normalized.
1 Cr, ½ Mo, steel 620:	normalized. Tempering may also be carried out.
2¼ Cr, 1 Mo, steel 622·27:	annealed and cooled, at an average rate of not less than 30 degC per hour, down to 600°C. If the cooling rate has exceeded 100 degC per hour the material shall be tempered.
2¼ Cr, 1 Mo, steel 622·31:	normalized and tempered.
½ Cr, ½ Mo, ¼V, steel 660:	normalized and tempered.

3.2.1.1 Pipes of the above materials which have been heated for manipulating operations, other than welding or thermal cutting, or have been cold bent to a radius less than 3½*D* (see Note) shall be heat-treated as specified above after these operations have been carried out.

3.2.1.2 Pipes of the above materials which are to be cold bent to a radius of 3½*D* or greater and which are heat-treated as specified above before bending do not require re-heat treatment after bending.

NOTE. For pipes 9⅝ in outside diameter and below, the minimum bending radii specified in Table 2 are less than 3½*D*.

3.2.1.3 The temperatures for the heat treatments specified above shall be as specified in Table 7. In order to ensure uniform soaking, the temperatures for normalizing or annealing shall be maintained for a time proportionate to the thickness of the pipe at a rate of not less than 30 minutes per inch of maximum thickness, followed by cooling in still air. Any minor correction of distortion due to heat treatment may be done at a temperature below 660°C without requiring further heat treatment.

3.2.2 Final condition of pipes. Before erection as part of a pipework installation all pipes of carbon steel 35 or of alloy steel, whether straights or manipulated pipes, shall be in the heat-treated condition specified in 3.2.1 and where there is subsequent welding, the welds shall be heat-treated in accordance with 3.3.

3.3 WELDING

3.3.1 The preparation for welding, the requirements for pre-heating and heat treatment and the procedure to be observed in pre-heating, gas cutting, welding and heat treatment of welds shall be in accordance with the requirements of the following standards as appropriate:

BS 2633.	Class I arc welding of ferritic steel pipework for carrying fluids.
BS 2971.	Class II metal-arc welding of steel pipelines and pipe assemblies for carrying fluids.
BS 1821.	Class I oxy-acetylene welding of steel pipelines and pipe assemblies for carrying fluids.
BS 2640.	Class II oxy-acetylene welding of steel pipelines and pipe assemblies for carrying fluids.

TABLE 7. HEAT TREATMENT OF COMPLETED PIPES

Material	Heat treatment temperature in °C			
	Normalized	Normalized and tempered		Annealed
		Normalized	Tempered	
Carbon steel 35	850/880	—	—	—
1 Cr ½ Mo Steel 620	900/960	900/960	630/660	—
2¼ Cr 1 Mo Steel 622·27	—	—	—	900/960*
2¼ Cr 1 Mo Steel 622·31	—	900/960	650/750†	—
½ Cr ½ Mo ¼ V Steel 660	—	950/1000	650/710	—

* The average rate of cooling after annealing shall be not less than 30degC per hour. If the cooling rate exceeds 100 degC per hour the pipes shall be subsequently tempered between 660°C and 690°C.
† If tempering is carried out above 720°C the period above this temperature shall not exceed 30 minutes.

NOTE. The preparation and heat treatment requirements for flange welds are specified in greater detail in 3.5.

Class I welding shall be used for steam services exceeding 250 lbf/in² or 425°F (218°C) and for feed services exceeding 350 lbf/in² or 400°F (204°C).

3.3.2 Permitted welding processes are:

(1) Oxy-acetylene welding.

(2) Manual metal-arc welding.
Electrodes shall comply with one of the following British Standards:

BS 639. Covered electrodes for the manual metal-arc welding of mild steel and medium-tensile steel.

BS 2493. Molybdenum and chromium-molybdenum low alloy steel electrodes for manual metal-arc welding.

(3) Inert-gas arc welding:

a. TIG-welding (inert-gas tungsten-arc welding)
or *b.* MIG-welding (inert-gas metal-arc welding).

(4) CO_2 welding or CO_2 flux welding.

(5) Submerged-arc welding.

3.4 ATTACHMENT OF BRANCHES

Branches, bosses, and drain pockets shall be welded to the pipes and the welding shall comply with the requirements specified in 3.3.

3.5 ATTACHMENT OF FLANGES
(see Figs. 6 to 14)

3.5.1 General. Flanges shall be secured to the pipes by welding or by screwing.

3.5.2 Welded-on flanges. Where flanges are welded on the welding processes listed in 3.3 are applicable as follows:

(1) *Type 1 flanges* shall be welded by process (2), (3) or (5) in 3.3.2 unless the material is carbon steel or 1% Cr ½% Mo steel where process (1) or (4) may also be used.

(2) *Types 2, 3, 3A, 4, 5, 5A and 6 flanges* shall be welded by process (2), (3), (4) or (5) in 3.3.2.

(3) *Type 7 flanges* shall be welded by process (1) in 3.3.2.

The preparation of the welds shall be as illustrated in Figs. 6 to 14.

NOTE. Oxy-acetylene welding is permitted only for Types 1 and 7 flanges.

The flange shall not be a tight fit on the pipe. The maximum clearance between the bore of the flange and the outside diameter of the pipe shall be ⅛ in at any point, and the sum of the clearances diametrically opposite shall not exceed 3/16 in.

3.5.2.1 The design conditions for each type are as follows:

Type 1, 2, 3 and 3A flanges for all design pressure and temperature conditions.

Type 4, 5 and 5A flanges for the temperature-pressure ratings specified in BS 10* for flange tables up to and including Table R at temperatures not exceeding 800°F (427°C).

Type 6 flange for the temperature-pressure ratings specified in BS 10* for flange tables up to and including Table J at temperatures not exceeding 800°F (427°C).

Type 7 flange for the temperature-pressure ratings specified in BS 10* for flange tables up to and including Table H at temperatures not exceeding 750°F (399°C), except that Type 7 flanges shall not be used on pipes over 6 in nominal bore.

3.5.2.2 For size limitations on the use of flanges see Notes to the flange illustrations.

3.5.3 Heat treatment after welding

Types 1, 2, 3, 3A, 4, 5 and 5A carbon steel flanges (steels 23 and 27) welded on by process (2), (3) and (4) in 3.3.2 shall have the welds stress-relieved where the design depth of the weld recess is ¾ in or greater.

All welds joining flanges to pipes of carbon steel 35 or of alloy steel shall be stress-relieved.

Types 1 flanges welded by process (1) and Type 7 flanges shall have the welds normalized where they fall within the scope of BS 1821†.

3.5.4 Screwed-on flanges

Where flanges are secured by screwing the screw thread shall be in accordance with BS 21‡. The threads on the pipe and in the flange shall be arranged to end at a point just inside the back or boss of the flange. After the flange has been screwed on, the pipe shall be expanded into the flange by a roller expander. Such screwed and expanded flanges may be used for steam for a maximum design pressure of 450 lbf/in² and a maximum design temperature of 700°F (371°C), and for feed for a maximum design pressure of 700 lbf/in².

* BS 10, 'Flanges and bolting for pipes, valves and fittings'.
† BS 1821, 'Clause I oxy-acetylene welding of steel pipelines and pipe assemblies for carrying fluids'.
‡ BS 21, 'Pipe threads'.

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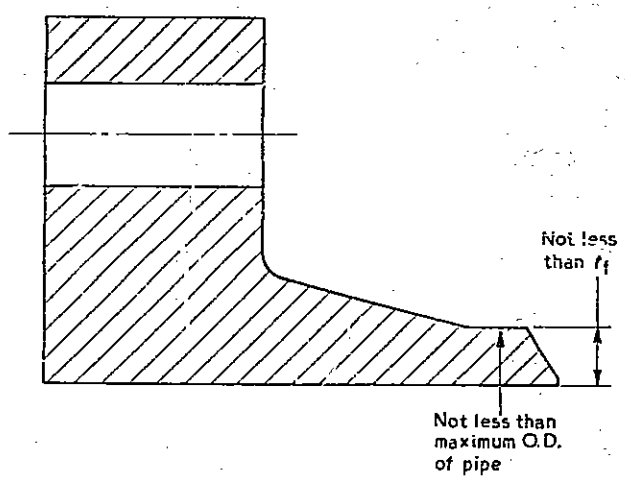


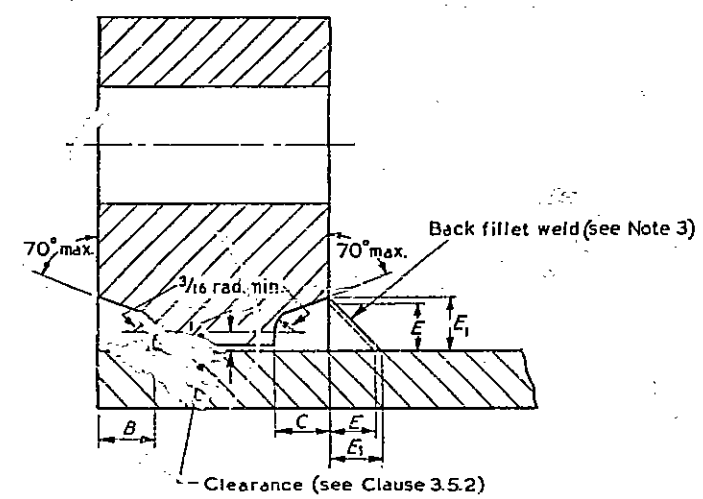
NOTE 1. Preparation and assembly for welding shall be in accordance with:

BS 2633. 'Class I arc welding of ferritic pipework for carrying fluids'.
BS 2971. 'Class II metal-arc welding of steel pipelines and pipe assemblies for carrying fluids'.
BS 1821. 'Class I oxy-acetylene welding of steel pipelines and pipe assemblies for carrying fluids'.
BS 2640. 'Class II oxy-acetylene welding of steel pipelines and pipe assemblies for carrying fluids'.

NOTE 2. t_f is the calculated pipe thickness in accordance with 2.2.

NOTE 3. This flange is suitable for all design pressure and temperature conditions (see 3.5.2.1).

Fig. 6. Type 1 'Welding neck' flange



Dimension	Steel	Design basis	
B	Carbon excl. steel 35	t_f	but not less than 3/16
	Alloy incl. steel 35	$2t_f$	
C	Carbon excl. steel 35	t_f	but not less than: ¼ for pipes ½ and ¾ bore; ⅜ for pipes 1 to 1½ bore; ⅜ for pipes 2 bore and over
	Alloy incl. steel 35	$2t_f$	
E	Carbon excl. steel 35	t_f but not less than ¾	
E_1	Alloy incl. steel 35	Height of weld recess	

NOTE 1. Dimensions B and C are minima after machining flange to final thickness.

NOTE 2. t_f is calculated pipe thickness (see 2.2).

NOTE 3. The outer surface of the weld must lie wholly outside the position indicated by the dotted line, or full line, whichever is applicable.

NOTE 4. The use of this type of attachment with alloy steel pipes for sizes above 6 in outside diameter shall be subject to agreement between the purchaser and the manufacturer.

NOTE 5. This flange is suitable for all design pressure and temperature conditions (see 3.5.2.1).

All dimensions are in inches

Fig. 7. Type 2. 'Face and back' welded on flange
(for metal-arc welding)

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