British Standard

BRITISH STANDARD

BS 4677:1984

Including Amendment No. 1 (not issued separately) and Amendment No. 2

Specification for

Arc welding of austenitic stainless steel pipework for carrying fluids

ICS 25.160.10

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Welding Standards Committee (WEE/-) to Technical Committee WEE/21 upon which the following bodies were represented:

Associated Offices Technical Committee
British Gas Corporation
British Non-ferrous Metals Federation
British Steel Industry
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
Health and Safety Executive
Heating and Ventilating Contractors' Association
Institute of Refrigeration
Institution of Gas Engineers
Institution of Mechanical Engineers
Joint Industry Board for Plumbing Mechanical Engineering Services in England and Wales
Power Generation Association (BEAMA Ltd.)
Stainless Steel Fabricators' Association of Great Britain
United Kingdom Atomic Energy Authority
Water-tube Boilermakers' Association
Welding Institute
Welding Manufacturers' Association (BEAMA Ltd.)
Coopted member

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Contents

Foreword

This revision of this British Standard has been prepared under the direction of the Welding Standards Committee. It embodies the technical developments that have taken place since the first edition was published in 1971. On common aspects the standard has been aligned with BS 2633. BS 4677:1971 is withdrawn.

It should be appreciated that the welding or post-weld heat treatment of austenitic stainless steel pipework can cause discoloration or oxidation of pipe surfaces. If these effects are not acceptable for the finished product then it is a matter for agreement between the contracting parties to have the welded pipes cleaned after welding.

The following are companion standards to this standard:

BS 1821, *Specification for class I oxy-acetylene welding of ferritic steel pipework for carrying fluids.*

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

BS 2640, *Specification for class II oxy-acetylene welding of carbon steel pipework for carrying fluids.*

BS 2971, *Specification for class II arc welding of carbon steel pipework for carrying fluids.*

BS 4204, *Specification for flash welding of steel tubes for pressure applications.*

Inspecting authority. The term "inspecting authority" refers to that competent independent body or association which verifies compliance with this standard.

Pipe and tube. In this British Standard the word "pipe", alone or in combination, is used to mean "pipe" or "tube", although these terms are often used for different categories of product by different industries.

Pipe dimensions. Unless otherwise qualified, for the purpose of this British Standard "pipe diameter" relates to the specified value of the outside diameter and "pipe thickness" relates to the specified value of the wall thickness of the pipe in the as supplied condition.

At the time of publication of this British Standard, no corresponding international standard exists.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 42, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

This British Standard specifies requirements for both shop and site arc welding, using manual, semi-automatic, automatic and mechanized welding processes or combinations of these, of joints in austenitic stainless steel pipework intended to carry fluids.

In addition to the definitive requirements, it also requires the items detailed in clause **2** to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

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

2 Information and requirements to be agreed and to be documented

2.1 Information to be supplied by the purchaser

The following information to be supplied by the purchaser shall be fully documented. Both the definitive requirements specified throughout the standard and the documented items shall be satisfied before a claim of compliance with the standard can be made and verified.

a) The application standard to be used if any.

b) Whether records of materials used during fabrication are required (see **3.2**).

c) Whether special procedure tests are required for transition joints (see clause **22**).

d) Whether completed welds are to be ground (see **39.1**).

e) Lower limits on bore protrusion when required (see **39.4**).

f) The percentage of each welder's production of butt joints to be radiographed when more than 10 % is required (see **40.1.1**).

g) Whether liquid penetrant testing is required [see **40.3** b)].

h) Alternative fault limitations when required (see **41.2**).

i) Whether welding procedure tests using pipe of specified diameter and thickness are required (see **45.2**).

2.2 Requirements to be agreed

The following items to be agreed between the contracting parties, which are specified in the clauses referred to, shall be fully documented. Both the definitive requirements specified throughout the standard and the following documented items shall be satisfied before a claim of compliance with the standard can be made and verified.

a) The material to be used for pipes and attachments (see **3.1**).

b) The precautions in inspection and welding procedure required when welding cast parts (see **3.3**).

c) The use of weld metal having a different composition to that of the parent metal (see **5.1**).

d) The need for ferrite control (see **5.1**).

e) The metal for permanent backing rings if other than of similar composition to the pipe [see **9.1** b)].

f) The use of copper backing rings (see **9.3**).

g) The precautions to be taken when design factors preclude the avoidance of certain circumstances relating to the proximity of welds (see **11.3**).

h) Details of any post-weld heat treatment when there is no application standard [see **20.1** b)].

i) The method of attaching thermocouples (see **21.4**).

j) The service conditions for which segmental bends are to be used (see **25.1**).

k) The method and amount of inspection for partial penetration welds on structural attachments (see **35.2**).

l) The inspection and testing requirements for other than butt joints (see **40.1.2**).

m) The radiographic technique to be used (see **40.2**).

n) The use of a method other than liquid penetrant testing to check the building-up of the base of a groove for making a repair weld [see **43.3** b)].

o) The use of a joint preparation incorporating a wider root gap for making a repair weld [see **43.3** c)].

3 Parent metal

3.1 The parent metal for pipes (including those with a longitudinal or helical welded seam) and attachments shall be one of the types of steel listed in Table 1. The material selected shall be agreed between the contracting parties, taking account of its suitability for the service conditions.

NOTE 1 Austenitic stainless steel pipework may be specified for a wide range of duties, and the correct grade of steel should be chosen, depending on the duty involved. Factors to be considered include the nature of the fluid to be handled and the operating temperature.

NOTE 2 Appendix A gives details of grades in British Standards for the types of steel listed in Table 1.

Table 1 — Parent metals

Types of steel
18 Cr 10 Ni
18 Cr 12 Ni, low carbon
18 Cr 12 Ni, Ti stabilized
18 Cr 12 Ni, Nb stabilized
18 Cr 12 Ni 2½ Mo
18 Cr 12 Ni 2½ Mo, Ti stabilized
18 Cr 12 Ni 2½ Mo, low carbon
18 Cr 12 Ni 3½ Mo
15 Cr 10 Ni 6 Mn Nb V
25 Cr 20 Ni

3.2 When required by the purchaser, the manufacturer shall maintain records of the materials used during fabrication.

3.3 While the requirements of this standard apply also to the welding of cast parts, additional precautions in inspection and welding procedure that may be necessary to deal with the presence of non-metallic inclusions, alloy segregations or porosity, shall be subject to agreement between the contracting parties.

4 Condition of pipes before welding

Unless otherwise stated in any relevant application standard or unless the welded pipework is to be solution heat treated, pipes shall be in the solution heat treated condition before welding.

5 Weld metal

5.1 Chemical composition

Weld metal, including that from fusible inserts, having a different chemical composition to that of the parent material shall only be used by agreement between the contracting parties. When the need for ferrite control is agreed between the contracting parties, the delta ferrite content of the weld metal shall be determined as part of the welding procedure test.

NOTE 1 In the case of autogenous welding, the composition of the parent metals may have to be modified to ensure control of delta ferrite.

NOTE 2 Guidance on suitable types of weld metal is given in Appendix B.

NOTE 3 When high temperature creep rupture properties are important, care should be taken to ensure that the high temperature mechanical properties of the weld metal fulfil design requirements.

5.2 Submerged arc welding consumables

Electrode wire/flux combinations shall be such that the chemical composition of the weld metal complies with BS 5465.

Since welding conditions have a significant effect on the chemical composition of the weld metal, the required composition shall be established under test conditions similar to those to be used on the actual fabrication. The welding conditions shall be controlled to ensure consistent weld metal composition, especially where the alloying elements are contained in the flux.

5.3 Storage and handling

Electrodes, filler wires and rods, and fluxes shall be stored and handled so as to avoid damage or deterioration to them and to the containers in which they are transported. Electrodes, filler wires and rods, and fluxes that show signs of damage or deterioration shall not be used.

6 Gases for shielding and purging

6.1 Shielding gases

Where appropriate, gases or gas mixtures of the following quality shall be used.

a) *Argon,* complying with BS EN 439.

b) *Argon/oxygen mixtures,* consisting of argon, with up to 5 % added oxygen and complying with BS EN 439.

c) *Argon/carbon dioxide mixtures,* consisting of argon, with up to 20 % added carbon dioxide, with or without up to 5 % oxygen and complying with BS EN 439.

d) *Argon/hydrogen mixtures,* consisting of argon, with up to 5 % added hydrogen and complying with BS EN 439.

e) *Helium,* complying with BS EN 439.

f) *Other gases or gas mixtures* that have been proved to be satisfactory as a result of procedure approval tests.

6.2 Gases for back purging

For purging the back of a weld during welding, argon, argon/hydrogen mixtures or helium of the quality specified in **6.1** or one of the following gases shall be used.

a) *Nitrogen,* complying with BS EN 439.

b) *Nitrogen/hydrogen mixtures,* consisting of nitrogen with up to 5 % hydrogen and complying with BS EN 439.

7 Equipment

Welding plant, instruments, cables and accessories shall comply with the appropriate Parts of BS 638. Their capacity shall be adequate for the welding procedure proposed and subsequently to be approved.

The installation, operation and maintenance shall be effected by competent persons in accordance with the appropriate safety recommendations. All electrical equipment used in connection with the welding operation shall be adequately earthed.

Adequate means of measuring current shall be available either as part of the welding plant or by the provision of a portable ammeter. In the case of semi-automatic, automatic and mechanized welding, means shall be provided for measuring the arc voltage since this may exert considerable influence on the form, composition and soundness (e.g. porosity) of the weld. When using a gas-shielded welding process, means of measuring the gas flow shall be provided.

Where necessary, staging and protection from the weather shall be provided to enable the welding operation to be performed properly.

8 Welding processes

8.1 Complete welds

Welds shall be made by one of the following welding processes or by a combination of those processes:

manual metal-arc welding

MIG welding

metal active-gas welding

TIG welding

submerged-arc welding

flux cored or coated welding with or without gas-shielding

8.2 Root runs

Methods of making the initial root run in butt joints by the various welding processes shall be as given in Table 2.

9 Backing rings

9.1 Permanent backing rings

When permanent backing rings are permitted the rings shall be one of the types shown in Figure 1. The gap between the outside diameter of the backing ring and the bore of the pipe end shall not exceed 0.4 mm.

Backing rings fitting tightly into machined recesses with square or sharp corners or of such a shape as to restrict longitudinal contraction (Figure 2) shall not be used as they increase the tendency to basal crack formation. Permanent backing rings shall be of a metal either:

a) of similar composition to that of the pipe; or

b) agreed between the contracting parties.

9.2 Steel temporary backing rings

Steel temporary backing rings (e.g. see Figure 3) shall be of similar composition to the pipe.

9.3 Copper backing rings

Removable copper backing rings shall only be used by agreement between the purchaser and the manufacturer, since there is a danger of copper pick-up in the weld metal and heat-affected zone.

9.4 Temporary non-metal backing rings

Temporary non-metal backing rings shall be of non-combustible materials and shall be completely removed after completion of welding.

10 Joint preparation

Joint preparations shall be as shown in the approved welding procedure.

NOTE Typical joint preparations are given in Appendix C.

11 Proximity of welds

11.1 The design of joints shall be such as to provide adequate access for the deposition of weld metal to meet the requirements of this standard.

11.2 The toes of adjacent butt welds shall whenever possible be no closer than four times the nominal thickness of the pipe.

11.3 If design factors preclude the avoidance of the circumstances given in the following notes 1 and 2, then appropriate precautions shall be taken which shall be agreed between the contracting parties.

NOTE 1 Joints where more than two welded seams meet should be avoided.

NOTE 2 Attachments of non-pressure parts by welds which cross existing main welds or for which the minimum nominal distance between the toe of the attachment weld and the toe of existing main welds or branch welds is less than the smaller of twice the thickness of the pressure part or 40 mm, should be avoided (see Figure 4).

If such welds cannot be avoided, they should cross the main weld completely rather than stop abruptly near the main or branch weld in order to avoid stress concentrations in these areas.

Table 2 — Methods of making root runs in butt joints

Welding processes	Type of joint
Manual metal-arc welding	With permanent or temporary[a] backing ring or unbacked
MIG welding Metal active-gas welding	With permanent or temporary[a] backing ring or unbacked with purge[b]
TIG welding a) With fusible insert b) Without fusible insert but using filler wire c) Fusing root without using either fusible insert or filler wire	Unbacked with purge
Submerged-arc welding Flux cored or coated welding with or without gas-shielding	With permanent or temporary[a] backing ring

[a] The use of temporary backing rings is dependent upon access for their removal on completion of the weld; see also clause **9**.
[b] By agreement between the contracting parties flux applied to the back of the weld preparation may replace back purging; see also clause **14**.

11.4 All intersections of welds made to this standard shall be non-destructively tested (see section 8).

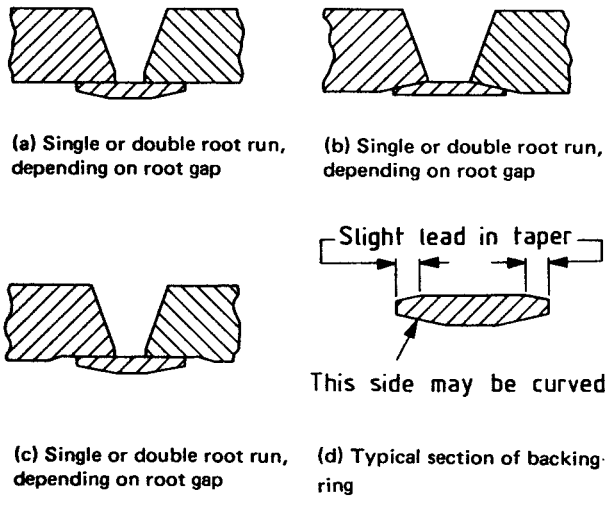


Figure 1 — Permissible types of permanent backing ring

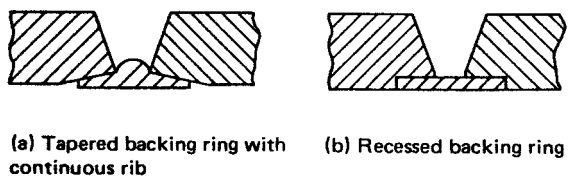


Figure 2 — Types of backing ring not permissible

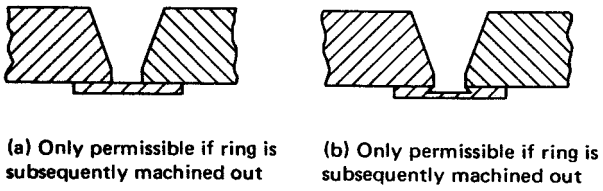


Figure 3 — Permissible types of temporary backing ring

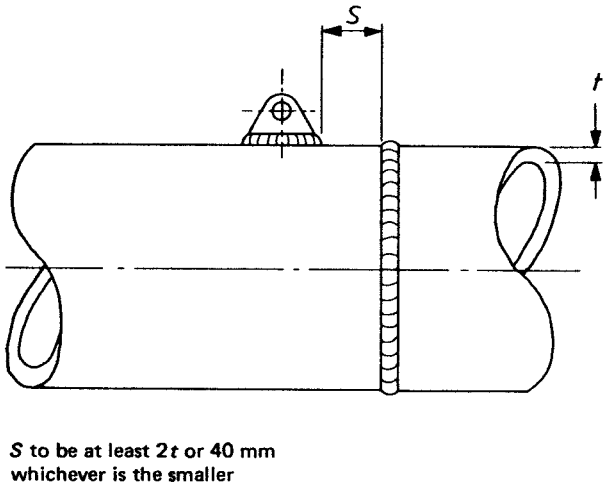


Figure 4 — Example of proximity of attachment weld

12 Fusion faces

The fusion faces and the adjacent material shall be free from moisture, scale, paint, grease or other foreign matter immediately prior to welding.

13 Assembly for welding

To maintain the specified alignment (see Table 3) and gap, where used, during welding, the parts to be welded shall be securely held in position by mechanical means, welded-on bridge pieces, or tack welding.

When bridge pieces are used they shall be of austenitic stainless steel, or of ferritic steel whose fusion faces have been "buttered" with austenitic stainless steel weld metal. Austenitic stainless steel weld metal shall be used for welding all bridge pieces.

NOTE The specified dimensions of the root gap are the dimensions after tack welding. It is appreciated that there may be difficulty in complying strictly with the specified requirements for the root gap. Slight modifications imposed by practical considerations may be permitted by agreement between the contracting parties.

Hot setting to achieve alignment shall only be carried out under controlled conditions.

Electrodes or filler materials used for tack welding shall be of the same type and class as, and of a size not larger than, those to be used for completing the first run of weld metal.

Particular attention shall be paid to the quality of tack welds which shall be deposited by approved welders. The throat thickness of tack welds shall be similar to that of the initial root run. Where necessary, the extremities of these tack welds shall be dressed by grinding or chipping to facilitate proper fusion when they are incorporated in the root run. All cracked tack welds shall be completely removed.

Where welded-on bridge pieces are used, the pipe surfaces shall not be left in a damaged condition after the bridge pieces are removed. All welded-on bridge pieces shall be removed and the welded area ground flush and liquid penetrant tested before applying any post-weld heat treatment, which shall embrace the area occupied by the bridge pieces.

14 Purging

When back purging all air shall be removed by the admission of a volume of purging gas at least six times the volume of air being displaced, in order to prevent oxidation of the penetration bead.

15 Damage to parent metal

While arc strikes are to be avoided, all accidental arc strikes shall be ground smooth and liquid penetrant tested. A piece of scrap austenitic stainless steel plate clamped to the pipe near the weld shall be used for dabbing the electrode where such a procedure is necessary for removing slag from the tip or to facilitate the starting of the arc.

NOTE 1 It is recommended that electrode holders be of the fully insulated type.

Precautions shall be taken to avoid contact of the pipe with incompatible materials.

NOTE 2 Under certain circumstances, liquid metal embrittlement could result from contamination by some non-ferrous metals or their alloys. Certain types of austenitic stainless steel may be attacked by chlorides and therefore care is needed to ensure that materials such as identification tapes or penetrants are as free as practicable from chlorides.

16 Inter-run cleaning

Each run of weld metal shall be clean before a further run is applied, particular attention being paid to the junctions between the weld metal and the fusion faces. Brushes used in cleaning shall be of stainless steel wire.

NOTE For certain applications "iron free" grinding wheels may be necessary.

Brushes and grinding wheels shall have only been used on austenitic steel. When grinding is used, care shall be taken to avoid overheating the material due to the grinding action. Visible defects such as cracks, cavities and other deposition faults shall be removed before deposition of further weld metal.

17 Cold pull

Where the effects of thermal expansion in service are to be counteracted by "cold pull" during erection of the pipe assembly, the "cold pull" shall be maintained during welding, and any subsequent heat treatment and cooling.

Before applying "cold pull" to a joint, all other joints in the pipe assembly shall have been welded, subjected to any post-weld heat treatment, inspected and accepted.

18 Pre-heating

Any pre-heating shall be in accordance with the details given in the approved welding procedure.

NOTE In general, pre-heating is not required for the welding of materials covered by this standard. Special circumstances might occur, however, where the thickness, mass or rigidity of the part to be welded may necessitate pre-heating up to 125 °C.

19 Continuity of welding

Irrespective of the type of steel, root runs shall be made without interruption, except for the changing of electrodes or to allow the welder to re-position himself.

20 Heat treatment after welding

20.1 Any post-weld heat treatment shall be either:

a) in accordance with the application standard[1)]; or

b) in the absence of an application standard, as agreed between the contracting parties.

NOTE Factors to be taken into account in deciding the need for and the type of heat treatment to be used include the grade of stainless steel, the degree of cold working during fabrication and the service conditions under which the pipework is to operate.

20.2 Heat treatment shall be carried out by one of the following methods, care being taken to ensure that the minimum stipulated temperature is achieved through the thickness of the pipe:

a) heating in a stationary industrial furnace;

b) local heating:

1) portable muffle furnace;

2) induction coils;

3) resistance heating.

Manually-operated gas torches shall not be used.

NOTE Alternative methods of heating may be used provided that the reproducibility of the technique can be demonstrated to the satisfaction of the purchaser and it can be shown that the method is metallurgically acceptable for the steel involved. When solution heat treatment is used, care should be taken to minimize the risk of distortion and sagging.

21 Temperature measurement

21.1 General

Pre-heating, interpass and post-weld heat treatment temperatures, when specified, shall be checked during the period of their application and all post-weld heat treatment conditions shall be recorded.

21.2 Pre-heating and interpass temperature

Temperature indicating paints or crayons, thermometers, thermocouples or pyrometers shall be used to check pre-heating and interpass temperatures.

NOTE Temperature indicating paints or crayons will not indicate by how much the minimum temperature is exceeded. Some types will not show, once the temperature has been reached, that this temperature is being maintained. In these cases the paint or crayon has to be re-applied if continued temperature observations are to be made.

When thermocouples are used they shall be located in positions within 40 mm from the outside edge of the fusion faces.

21.3 Post-weld heat treatment temperature

Thermocouples shall be used for recording post-weld heat treatment temperatures. They shall be disposed so as to give a true measure of the joint temperature and where local post-weld heat treatment is used they shall be located so as to indicate the temperature at significant points on the weld.

21.4 Thermocouple attachment

Thermocouples shall be in metallic contact with the parts being heated and attached by a method agreed between the contracting parties, e.g. capacitor discharge welding.

21.5 Thermocouple junctions

Thermocouple junctions and wires shall be protected from flame impingement. To prevent direct radiation from the heating elements on the hot junction when electrical resistance heating is used, thermocouples shall be covered with thermal insulation.

22 Transition joints between dissimilar metals

Several welding processes are suitable for making transition joints between dissimilar metals but each shall be subject to procedure test approval. When special service conditions require special procedure tests, the need for them shall be specified by the purchaser in the enquiry and order.

NOTE 1 Transition joints may be made as separate items and welded to components so that all subsequent welds are between like materials.

The interior and exterior surfaces shall, where necessary, be machined to facilitate inspection.

NOTE 2 For welding joints between ferritic steel and austenitic stainless steel, guidance is given in Appendix D.

[1)] For example BS 1113.

Section 2. Butt joints[2)]

23 General

Section 1 of this standard details the basic procedure requirements with which all welded joints between pipes and fittings shall comply. These basic requirements are supplemented by the specific requirements detailed in this section 2. Both section 1 and section 2 of this standard shall be applied in determining the full procedure requirements.

24 All types of butt joint

24.1 Matching of bores

It is preferred that, for welding purposes, the bores of the ends of adjacent pipes match exactly, but in any case they shall not differ at any diameter by more than the amounts given in Table 3, whilst the alignment shall be within the limits stated in the table.

NOTE 1 It is recognized that the ends of pipes and welding fittings will be supplied to standard tolerances and may not match, especially if placed together at random. Additional workmanship may therefore be required to ensure the alignment specified in Table 3.

The welding of pipe joints in accordance with this standard shall include the proper matching by the welding contractor of the pipe ends at each joint, if necessary, before welding.

Matching shall be effected by selection, drifting, machining or the use of a suitable expander. When either bore expanding or reducing is done hot it shall be carried out at 950 °C to 1 150 °C. This shall be done before any final solution heat treatment. Temperatures shall be checked by one of the methods given in **21.2**.

When cold expanding is used the change in bore diameter shall not exceed 5 %, and it shall be followed, if necessary, by heat treatment to make the material suitable for the intended service conditions.

NOTE 2 Cold expanding is not normally applied.

Wherever the thickness is reduced by drifting, machining or expanding, the thickness at every point in the circumference clear of the weld preparation shall be not less than the design thickness for the particular pipe. Any machining on the inside of the pipe shall run out smoothly into the bore at a taper not steeper than 1 in 4.

NOTE 3 If the maximum permissible amount of machining is insufficient to match the ends, drifting should be employed, but a combination of drifting or expanding with machining within the permitted limits may also be used.

24.2 Preparation of pipe ends

The ends shall be prepared by machining, grinding or arc-plasma cutting or by powder cutting with subsequent machining or grinding (see clause **16** regarding grinding wheels).

NOTE Typical joint preparations for pipe ends are shown in Figure 8 to Figure 11 (see also clause **10**).

The joint preparation shall be concentric with the bore of the pipe within the tolerance limits for the root face.

For pipes which are intended to be in axial alignment the plane of the ends shall be square with the axis of the pipe. For pipes which are intentionally out of axial alignment, the plane of the joint shall bisect the angle between adjacent pipes.

25 Segmental bends

25.1 General

The service conditions for which segmental bends are to be used shall be the subject of agreement between the contracting parties except where an application standard permits the use of such bends.

25.2 Preparation

The preparation of each segment for a segmental bend shall be done by cutting the pipe end to the correct angle, followed by the weld preparation as specified in **24.2**. The planes of the ends of the separate pieces of pipe prepared for welding to form a segmental bend shall all be inclined at the same angle to the axis of the piece.

The width of a segment at the throat of a bend measured at the outside diameter of the pipe shall be not less than 16.5 mm. For right angle bends of radius equal to the bore of the pipe, the dimensions of the segments shall be as shown in Figure 5, with only two cuts being necessary for pipe not exceeding 88.9 mm outside diameter.

To prepare the segment for welding, all spatter, oxide and ragged edges shall be removed from the prepared edge and the bore of the pipes, the correct gap shall be set and the segment tacked in position.

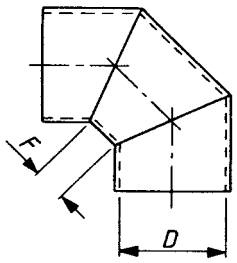
25.3 Welding procedure

All welds in a segmental bend shall be treated as butt welds and the requirements of clauses **13**, **23** and **24.2** shall apply.

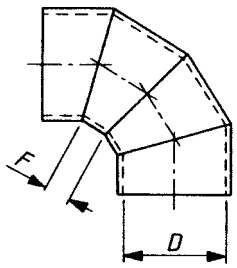
[2)] In this section the term "pipe" is intended to cover pipes and fittings (e.g. welding neck flanges, forged tees, welding elbows).

Table 3 — Bore difference and alignment

Bore		Processes other than TIG welding		TIG welding, close butt welds		TIG welding with root gap
Over	Up to and including	With backing ring	Without backing ring	With fusible insert or without filler wire	With filler wire	
Maximum permissible difference in bore						
mm	mm	mm	mm	mm	mm	mm
—	100	0.4	0.8	0.4	0.8	0.8
100	300	0.4	1.6	0.4	0.8	1.6
300	—	0.8	2.5	—	1.2	2.5
Maximum out of alignment at the bore						
—	100	0.4	0.8	0.4	0.8	0.8
100	300	0.4	1.6	0.4	0.8	1.6
300	—	0.8	1.6	—	0.8	1.6



2 cuts, 1*D* radius



3 cuts, 1*D* radius

Inside diameter, *D*	Outside diameter	*F*
mm	mm	mm
50	60.3	16.5
65	76.1	22.5
75	88.9	25.0

Inside diameter, *D*	Outside diameter	*F*
mm	mm	mm
90	101.6	21.0
100	114.3	23.0
115	127.0	28.0
125	139.7	29.5
150	165.1	36.0
150	168.3	35.5
180	193.7	44.5
200	219.1	48.5
230	244.5	57.5
250	273.0	61.0
300	323.9	74.0
—	355.6	95.0
—	406.4	109.0

Figure 5 — Segmental bends

Section 3. Branches and small bore connections

26 General

Section 1 of this standard details the basic procedure requirements with which all welded joints between pipes and fittings shall comply. For branches or small bore connections that are made from pipe, tube or bar, the basic requirements are supplemented by the specific requirements detailed in this section 3. Both section 1 and section 3 of this standard shall be applied in determining the full procedure requirements.

NOTE It is preferable that branches and small bore connections be welded at the works.

27 Branches

27.1 Angle of branch

In view of the additional difficulty involved in making a satisfactory joint at the intersection of two pipes not at right angles, for branch pipes sloping away from a main, a right angle branch and a bend to give the required slope shall be used wherever possible.

Where a sloping branch has to be connected directly to the main, the angle between the centre line of the main and that of the branch shall whenever possible be not less than 60°. Where the angle is unavoidably less than 60°, special consideration shall be given to joint design and fabrication.

NOTE The difficulty of making a weld at the acute crotch position might make special precautions necessary to ensure a sound weld at that position.

27.2 Spacing of branches

Spacing of branches on the main pipe and the lengths of flanged branches shall be such that there is adequate access for satisfactory welding (see also clause **11**).

27.3 Joint preparation

Branch connections and branch openings in the main pipe shall be cut by machining, powder cutting or arc-plasma cutting. To remove any roughness the cut edges shall then be dressed by chipping, filing or grinding.

NOTE 1 Typical edge shapes are shown in Figure 12 to Figure 17 (see also clause **10**).

NOTE 2 When using the powder injection method of cutting holes in main pipes for branches, there is a possibility of iron contamination inside the pipe which could, for example, affect corrosion resistance. This area should be inspected and cleaned as necessary.

27.4 Welding procedure

27.4.1 *Gap.* The gap where specified shall be maintained during deposition of the first run (see clause **13**).

27.4.2 *Internal root runs.* When, in order to satisfy the requirements of section 8, it is necessary to apply an internal root run, access for the manual metal-arc welding of such an internal weld shall be considered possible:

a) where the main is 450 mm bore or larger, irrespective of branch length; or

b) where the main is less than 450 mm bore, and the branch length (face of branch to flank of joint) does not exceed the bore of the branch.

NOTE Using other welding processes it may be possible to weld in the bore of branches which have a length greater than that given in b).

28 Small bore connections

When the bore of the branch is 50 mm or less the guidance given in **C.3** shall be taken into account.

NOTE Typical forms of small bore connections are illustrated in Figure 18. (See clause **3** regarding materials and clause **5** on deposited weld metal.)

Section 4. Socket-welding fittings

29 General

Section 1 of this standard details the basic procedure requirements with which all welded joints between pipes and fittings shall comply. These basic requirements are supplemented by the specific requirements detailed in this section 4. Both section 1 and section 4 of this standard shall be applied in determining the full procedure requirements.

30 Socket joint details

Forged socket-welding fittings shall be used within the limitations in the appropriate application standard.

NOTE A socket joint is formed when the end of a pipe enters the socket end of a socket-welding fitting and the pipe and socket are joined by means of a fillet weld. Socket joints should not be used where corrosion resistance is important.

Preparation and assembly of the joint for welding shall be such as to ensure that the pipe end is axially square to the base of the fitting and that there is a gap of approximately 1.6 mm between the pipe end and the base of the fitting (see Figure 6). To achieve this gap, the pipe end shall first be fully inserted and the outside surface of the pipe marked in line with the end face of the socket. The pipe shall then be withdrawn approximately 1.6 mm before welding. The diametral clearance between the outside diameter of the pipe and the bore of the fitting shall not exceed 0.8 mm.

The fillet weld leg lengths for socket joints shall be at least T by $1.25T$, where T is the nominal pipe thickness (see Figure 6). For pipe of nominal thickness 3 mm or less, care shall be taken so that there is no over-heating or burn-through of the pipe (see clauses **46** and **48**).

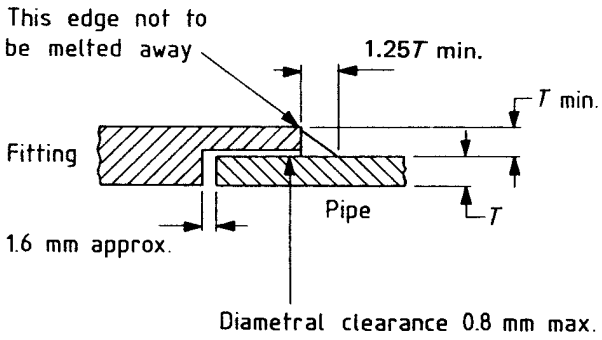


Figure 6 — Socket joint details

Section 5. Reinforcement of welded branch connections (compensation)

31 General

Section 1 of this standard details the basic procedure requirements with which all welded joints between pipes and fittings shall comply. These basic requirements are supplemented by the specific requirements detailed in this section 5. Both section 1 and section 5 of this standard shall be applied in determining the full procedure requirements.

The need to fit reinforcement to a branch connection shall be determined by reference to the appropriate application standard.

The preparation, assembly and welding of reinforcements shall comply with the procedure requirements applicable to the type of steel involved and shall be in accordance with the relevant clauses of this standard.

32 Preparation and assembly

The edges of the reinforcement shall be prepared to shape by machining, grinding or arc-plasma cutting, or by powder cutting with subsequent machining or grinding (see clause **16** regarding grinding wheels).

The reinforcement shall be assembled and securely held in position on the main and/or branch by tack welds. Tack welds shall be of sound quality. Any tack weld found to be cracked shall be removed completely and replaced by a tack weld of sound quality (see also clause **13**).

33 Welding procedure

Electrodes or filler materials shall be suitable for welding the pipe to which the reinforcement is attached.

There shall be complete fusion between the weld metal, pipe and reinforcement.

Section 6. Structural attachments

34 General

Section 1 of this standard details the basic procedure requirements with which all welded joints between pipes and fittings shall comply. These basic requirements are supplemented by the specific requirements detailed in this section 6. Both section 1 and section 6 of this standard shall be applied in determining the full procedure requirements.

Attachments to pressure parts that are primarily designed as load carrying members shall comply with this section.

NOTE For the design of attachments the relevant application standard should be consulted.

35 Welding procedure

35.1 Each run of weld metal shall be clean and free from scale before the next run is deposited. To ensure full penetration in a double sided weld, the under surface of the root run shall be removed, by chipping, grinding or air arc or arc-plasma gouging followed by grinding to give a clean metallic surface, before welding from the other side is commenced.

35.2 II partial penetration welds are used, the form of the preparation shall be specified on the drawings. The method and amount of inspection shall be agreed between the contracting parties.

35.3 I or pipe of nominal thickness 3 mm or less, care shall be taken so that there is no over-heating or burn-through of the pipe (see clauses **46** and **48**).

When welding procedure test indicates that severe oxidation in the bore is likely to occur, e.g. with thin tubes of high heat input welding processes, the procedure shall be modulated to minimize the risk.

Section 7. Flanges

36 General

Section 1 of this standard details the basic procedure requirements with which all welded joints between pipes and fittings shall comply. These basic requirements are supplemented by the specific requirements detailed in this section 7. Both section 1 and section 7 of this standard shall be applied in determining the full procedure requirements.

37 Welding neck flanges

The procedure to be applied for the welding of welding neck flanges (see Figure 7) shall be the same as for normal butt welds, for which the requirements of section 2 shall apply.

38 Plate flanges

38.1 Fit

The flange shall be a loose fit on the pipe but the clearance between the outside diameter of the pipe and bore of the flange shall not exceed 3.0 mm at any point and the sum of the clearances on any diameter shall not exceed 5.0 mm.

NOTE The flange should be substantially concentric with the pipe.

38.2 Preparation

Flanges shall be prepared for welding by machining, grinding or arc-plasma cutting, or by powder cutting with subsequent machining or grinding (see clause **16** regarding grinding wheels).

NOTE Typical weld preparations of plate flanges are shown in Figure 19 to Figure 27.

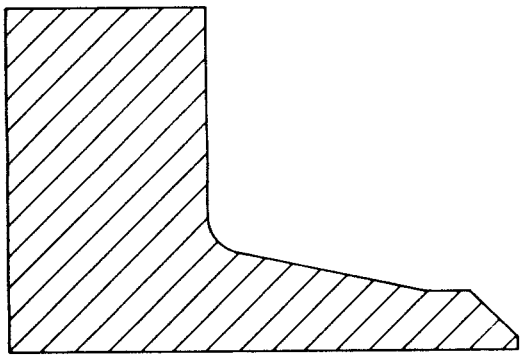


Figure 7 — Welding neck flange

Section 8. Inspection

39 Requirements for visual examination of completed welds

39.1 General

All welds shall be visually examined on the outside surface and, where practicable, in the bore (with the aid of optical instruments if necessary) and shall show the features detailed in **39.2**, **39.3**, **39.4**, **39.5** and **39.6**.

Visually detectable imperfections shall be assessed in accordance with clause **41**.

If the purchaser requires completed welds to be ground, this shall be stated in the enquiry and order.

39.2 Profile of external surface

Weld metal shall be properly fused with the parent metal without significant undercutting or overlapping at the toes of the weld; slight intermittent undercut shall be permitted provided that it does not form a sharp notch and that it meets the following requirements.

The toes of undressed welds shall blend smoothly and gradually into the parent metal and the depth of any local undercut shall be in accordance with the appropriate values given in Table 5.

The toes of dressed welds shall be free from undercut or other depressions and the depth of underflushing shall be in accordance with the appropriate values given in Table 5.

External weld reinforcement shall be in accordance with the appropriate values given in Table 5 and shall be substantially symmetrical about the centre line of the joint. In all cases it shall be of smooth contour blending smoothly at the toes with the parent metal.

NOTE The shape of the reinforcement may vary according to the type of filler metal used, the welding technique and the welding position.

The surface of the weld shall be free from porosity and loose or excessive scale. Any crater pipes and surface cavities shall be in accordance with the appropriate values given in Table 5.

39.3 Smoothness of undressed welds

The stop and start of each run of weld shall merge smoothly, and shall show no pronounced hump or crater in the weld surface.

39.4 Penetration bead in unbacked welds

The weld shall fuse the pipe at the root without protruding excessively into the bore of the pipe. The maximum penetration of the root bead into the bore shall be as specified in Table 4, although an occasional local slight excess of penetration is permitted.

If the purchaser requires limits on protrusion lower than specified in Table 4, this shall be stated in the enquiry and order.

39.5 Root concavity

If there is complete root fusion, root concavity (or sinkage) at the bore shall be acceptable provided that:

a) the bore surface of the joint is of smooth contour;

b) the depth of root concavity is not greater than that given in Table 5;

c) the thickness of the weld is not less than the pipe thickness.

39.6 Profile of root bead

The root bead or any concavity shall merge smoothly into the adjacent surfaces.

Table 4 — Penetration of root bead

Nominal size of pipe	Max. penetration in bore	Max. restriction in bore
	mm	mm
Less than 12 mm	1.0	1.5
12 mm up to but not including 25 mm	1.5	2.0
25 mm up to but not including 50 mm	2.5	3.0
50 mm up to but not including 100 mm	3.0	5.0
100 mm and larger	3.0	6.0

Table 5 — Defect limits

Defect type	Defect limits			
	For pipe up to and including 2.9 mm thick (*T*)	**For pipe over 2.9 mm up to and including 4.5 mm thick (*T*)**	**For pipe over 4.5 mm up to and including 6.3 mm thick (*T*)**	**For pipe over 6.3 mm thick (*T*)**
Undercut (depth) (undressed welds)	10 % *T* max. (see **39.2**)	10 % *T* max. (see **39.2**)	Smaller of 10 % *T* or 0.5 mm max. (see **39.2**)	0.5 mm max. (see **39.2**)
Underflushing (dressed welds)	10 % *T* max. (see **39.2**)	10 % *T* max. (see **39.2**)	10 % *T* max. (see **39.2**)	0.8 mm max. (see **39.2**)
Reinforcement height	1.5 mm min. 2.5 mm max. (see **39.2**)	1.5 mm min. 3.0 mm max. (see **39.2**)	1.5 mm min. 5.0 mm max. (see **39.2**)	1.5 mm min. 5.0 mm max. (see **39.2**)
Misalignment	See **24.1** and Table 3	See **24.1** and Table 3	See **24.1** and Table 3	See **24.1** and Table 3
Root protrusion	See **39.4** and Table 4	See **39.4** and Table 4	See **39.4** and Table 4	See **39.4** and Table 4
Root concavity	0.8 mm max. (see **39.5**)	1.2 mm max. (see **39.5**)	1.2 mm max. (see **39.5**)	1.5 mm max. (see **39.5**)
Crater pipes and surface cavities	Length 3.0 mm max. Height 20 % *T* max.	Length 4.0 mm max. Height 20 % *T* max.	Length 5.0 mm max. Height 20 % *T* max.	Length 6.0 mm max. Height 1.5 mm max.
Cracks	Not permitted	Not permitted	Not permitted	Not permitted
Lack of root penetration	Length 3.0 mm max.[a] Height 20 % *T* max.	Length 6.0 mm max.[a] Height 20 % *T* max.	Length 10.0 mm max.[a] Height 1.2 mm max.	Length 10.0 mm max.[a] Height 1.2 mm max.
Lack of root fusion	Length 3.0 mm max.[a] Height 20 % *T* max.	Length 6.0 mm max.[a] Height 20 % *T* max.	Length 10.0 mm max.[a] Height 1.2 mm max.	Length 10.0 mm max.[a] Height 1.2 mm max.
Lack of side fusion	Length 3.0 mm max.[a] Height 20 % *T* max.	Length 6.0 mm max.[a] Height 20 % *T* max.	Length 10.0 mm max.[a] Height 1.2 mm max.	Length 12.0 mm max.[a] Height 1.6 mm max.
Lack of inter-run fusion	Length 3.0 mm max.[a] Height 20 % *T* max.	Length 6.0 mm max.[a] Height 20 % *T* max.	Length 10.0 mm max.[a] Height 1.2 mm max.	Length 12.0 mm max.[a] Height 1.6 mm max.
Wormholes	Length 3.0 mm max.[a] Height 20 % *T* max.	Length 6.0 mm max.[a] Height 20 % *T* max.	Length 10.0 mm max.[a] Height 1.2 mm max.	Length 12.0 mm max.[a] Height 1.6 mm max.
Porosity (isolated)	0.8 mm max.	1.2 mm max.	1.6 mm max.	2.5 mm max.
Porosity (scattered)	Aggregate length of pores 3.0 mm max. in any 25 mm length of weld[b]	Aggregate length of pores 5.0 mm max. in any 25 mm length of weld[b]	Aggregate length of pores 6.0 mm max. in any 25 mm length of weld[b]	Aggregate length of pores 8.0 mm max. in any 25 mm length of weld[b]
Porosity (localized) (e.g. stop/start porosity)	Total area of porosity 1.5 mm^2 max.[c] in any 6.0 mm dia.	Total area of porosity 2.0 mm^2 max.[d] in any 6.0 mm dia.	Total area of porosity 2.0 mm^2 max.[d] in any 6.0 mm dia.	Total area of porosity 3.0 mm^2 max.[e] in any 10.0 mm dia.
Slag inclusions	Length 3.0 mm max. Height 20 % *T* max.[b]	Length 6.0 mm max. Height 20 % *T* max.[b]	Length 12.0 mm max. Height 1.2 mm max.[b]	Length 15.0 mm max. Height 1.6 mm max.[b]
Tungsten inclusions (isolated)	0.8 mm max.	1.2 mm max.	1.6 mm max.	2.5 mm max.
Tungsten inclusions (scattered)	Aggregate length of inclusions 3.0 mm max. in any 25 mm length of weld[b]	Aggregate length of inclusions 5.0 mm max. in any 25 mm length of weld[b]	Aggregate length of inclusions 6.0 mm max. in any 25 mm length of weld[b]	Aggregate length of inclusions 8.0 mm max. in any 25 mm length of weld[b]

NOTE "Length" is measured with respect to the long axis of the weld, i.e. circumferentially.

"Height" is measured with respect to the actual throat thickness of the weld, i.e. radially.

[a] Adjacent defects with combined lengths greater than that permitted for isolated defects are to be separated by a distance not less than six times the length of the longer defect. The presence of this defect generally disposed around the weld is cause for rejection.

[b] Adjacent defects with combined sizes greater than that permitted for isolated defects are to be separated by a distance not less than four times the size of the longer defect. Defects generally disposed around the weld are to be investigated.

[c] Porosity of total area 1.5 mm^2 is approximately equivalent to the area of three pores 0.8 mm in diameter.

[d] Porosity of total area 2.0 mm^2 is approximately equivalent to the area of four pores 0.8 mm in diameter.

[e] Porosity of total area 3.0 mm^2 is approximately equivalent to the area of six pores 0.8 mm in diameter.

40 Non-destructive testing

40.1 General

40.1.1 The quality of pressure-containing welds shall be assessed by radiographic examination in accordance with clause **41**. At least 10 % of each welder's production of butt joints in accordance with section 2, selected at random, shall be subjected to full radiographic examination, although a higher minimum percentage shall be used when this is specified by the relevant application standard or by the purchaser. The weld profile and surface shall be suitable for radiographic examination; this might entail dressing the weld.

NOTE Although no British Standard exists for the method, ultrasonic examination is sometimes applicable to welds in austenitic stainless steel. Under optimum conditions it can detect planar defects such as lack of fusion, which are not always revealed by radiography, and coarse porosity, but interpretation can be complicated by the effect of the metallurgical structure. Where it can be demonstrated that the use of ultrasonic examination is satisfactory, it may be used as an alternative or in addition to radiography by agreement between the contracting parties.

40.1.2 The inspection and testing requirements for other than butt joints in accordance with section 2 shall be agreed between the contracting parties.

40.2 Radiographic examination of butt joints

The radiographic technique employed shall be one of the following from BS 2910, as agreed between the contracting parties:

technique numbers 1, 4, 7, 10, 13 and 16.

NOTE For guidance on the radiographic sensitivity that can be obtained using wire-type and step/hole-type image quality indicators, see Appendix E.

40.3 Liquid penetrant testing

Liquid penetrant testing shall be carried out when it is either:

a) specified in an application standard; or

b) is required by the purchaser.

NOTE For liquid penetrant testing it may be necessary to dress the surface of the weld.

40.4 Re-examination

When random radiographic examination reveals unacceptable defects in a weld, at least two further welds in the group represented by this weld shall be examined by the same method. The examination shall cover not less than one-third of the circumference of pipes of less than 168.3 mm outside diameter and not less than 300 mm of the circumference of larger pipes, the location being selected by the inspector. If the examination of these further welds in the group reveals no unacceptable defects, the defects in the first weld shall be repaired and re-examined by the original method. If the repair is satisfactory, the group of welds shall be accepted.

If the examination of either of the further welds in the group reveals unacceptable defects, each weld in the group shall be examined by the same method over its complete circumference. Unacceptable defects shall be repaired and then re-examined by the original method.

41 Fault limitations

41.1 Any *one* of the types of defect that does not comply with any of the relevant limits given in Table 5 shall be sufficient cause for rejection, unless alternative limits are specified by the purchaser in accordance with **41.2**.

NOTE 1 The effects of weld faults on the service performance of a joint are influenced by the location and disposition of the faults; in general those located in the body of the weld are less serious than those in the root, a factor that should be borne in mind by the inspector when considering the rejection of joints that appear to be borderline in quality as assessed by the fault limitations specified.

NOTE 2 Multiple-type faults contained within the same weld, either superimposed or interposed, which are individually acceptable as isolated imperfections should be considered collectively by the inspector when assessing the weld quality.

NOTE 3 As an alternative to the defect limits given in Table 5, the technique of Engineering Critical Assessment may be used to derive other values by agreement between the contracting parties (see PD 6493).

41.2 When the service conditions of the pipework are such that some or all of the defect limits given in Table 5 are inappropriate, alternative limits shall be specified by the purchaser in the enquiry and order (see also notes 1, 2 and 3 in **41.1**).

NOTE The dimensional limitations of faults specified in Table 5 are intended to ensure a quality of welding that may be regarded as suitable generally for austenitic stainless steel pipework. Service conditions may exist, however, that require a higher standard, for example those involving crevice corrosion or cyclic stressing which may lead to fatigue and for which relatively fault-free weld roots are desirable. On the other hand, for certain applications like the brewing and food industries where stresses may be low, larger mid-wall defects than specified in Table 5 may be quite acceptable yet smaller root defects unacceptable simply because of bacterial contamination in service.

Section 9. Rectification of faulty welds

42 Removal of faults

Where welds fail to comply wholly or in part with section 8 all unacceptable defects shall be removed.

NOTE 1 The technique of Engineering Critical Assessment may be used by agreement between the contracting parties to determine whether a defect needs to be removed (see PD 6493).

Defects shall be removed by chipping, grinding, machining or thermal cutting or by thermal gouging (including air-arc gouging), followed by grinding or machining.

Major repairs involve:

a) cutting through the weld; or

b) cutting out a length of pipe containing the weld (see clause **11**); or

c) removing weld metal down to the backing ring (where used).

A cut through a weld as in a) or through the pipe as in b) shall be made by machine thermal cutting, guided hand thermal cutting, saw cutting or by machine cutting. Following thermal cutting, fusion faces shall be prepared by grinding or machining such that a smooth surface free from serrations is obtained.

NOTE 2 When thermal cutting is used it may be necessary to take special steps to compensate for any loss of length that may occur.

43 Preparation for re-welding

43.1 General

Any repair to a weld shall be reported to the inspecting authority. If the repair is made as a consequence of non-destructive testing, the records relating to the original defects shall be made available.

43.2 Partial removal of weld

The cut out portion shall be sufficiently deep and long to remove the defect. The exposed surfaces shall then be subjected to liquid penetrant testing. At the ends and sides of the cut there shall be a gradual taper from the base of the cut to the surface of the weld metal. The width and profile of cut shall be such as will give adequate access for re-welding.

The removal of the last 6.0 mm of weld metal down to a backing ring shall be carried out only by grinding.

NOTE When the root of the weld is accessible from the bore of the pipe, a repair may be made from that position (see **27.4.2**).

43.3 Complete removal of weld

Where a cut has been made through a faulty weld and there has been no serious loss of pipe length, the weld preparation shall be re-made in accordance with the appropriate section of this standard.

Where it is necessary to compensate for loss of pipe length, this shall be done:

a) by inserting a new length of pipe and preparing the two joints in accordance with section 2; or

b) by building up the base of the groove with suitable weld metal; if this method is used liquid penetrant testing or some other method of non-destructive testing agreed between the contracting parties shall be applied after building-up; or

c) by adopting a joint preparation incorporating a wider root gap, provided agreement between the contracting parties is obtained on the use of this method.

44 Re-welding

Before re-welding, the weld metal and welding procedure shall have been approved by the inspecting authority or the purchaser.

A repaired weld shall be subjected, as a minimum requirement, to the same testing and inspection requirements as the original weld. Repairs involving fully austenitic weld metal shall be given special consideration and testing.

Section 10. Welding procedure approval

45 General

45.1 Welding shall be controlled by reference to BS EN 288 as defined below.

All welding shall be performed in accordance with the welding procedure specification or other work instruction written in accordance with BS EN 288-2. These welding procedure specifications shall be substantiated by a welding procedure test, either:

a) in accordance with BS EN 288-3; or

b) a pre-existing weld procedure test performed to BS 4870-1 previously acceptable to an examiner or test body except that the range of approval of this test shall be in accordance with the ranges in BS EN 288-3.

Existing procedures to BS 4870-1 shall be considered technically equivalent to BS EN 288-3 when similar types of test have been carried out. Thus, the bend tests in BS 4870-1 shall be considered equivalent to those in BS EN 288-3 even though the exact number and bend angle differ. Similarly, visual, radiographic, ultrasonic, surface crack detection, transverse tensile, hardness, macro-examination and impact tests shall be considered equivalent.

Where BS EN 288-3 calls for a type of test to be performed and this has not been carried out on the pre-existing BS 4870-1 procedure qualifications test, additional testing, as described in clause **0** of BS EN 288-3 shall be carried out. For example, if impact tests have not been carried out on the BS 4870-1 test piece, it is only necessary to do an additional set of impact tests on a test piece made in accordance with BS EN 288-3.

NOTE It is recommended that welding procedure tests carried out in accordance with this clause and witnessed by an examiner or test body should be accepted by other examiners or test bodies provided that all the provisions have been fulfilled.

45.2 When, for certain operating conditions, the purchaser requires that welding procedure tests employ pipe of specified diameter and thickness, such a requirement shall be stated on the enquiry and order.

46 Attachments to thin pipes and branch welds

46.1 Attachments to thin pipes

When attachment welds are to be made to pipes equal to or less than 5 mm wall thickness, a test shall be made using a typical weld detail to determine that burn-through does not occur. The test weld shall be made on pipe of contract thickness and the minimum approved thickness shall be that thickness welded.

NOTE The approval may apply to other contracts.

46.2 Branch welds

Branch weld tests shall be performed in accordance with BS EN 288-3.

NOTE This may need to be supplemented by a butt weld test piece to obtain relevant mechanical data.

Section 11. Welder approval

47 General

47.1 Approval testing of welders shall be carried out in accordance with BS EN 287-1. Welders who previously held approvals to BS 4871-1 shall be considered to be approved to work with the following provisos.

a) The range of approval of the welder shall be in accordance with BS EN 287-1.

b) Welder approval tests to BS 4871-1 shall be considered technically equivalent to BS EN 287-1, except that for all MIG/MAG welding, bend tests shall be carried out. If bend tests for these processes have not been carried out during the original test, reapproval to BS EN 287-1 shall be performed.

c) The prolongation of a BS 4871-1 approval test, if required, shall be made at six-monthly intervals by the employer/manufacturer, in accordance with **10.1** of BS EN 287-1:1992 for the period of two years from the date of effect of BS EN 287-1, i.e. from 1 May 1992.

d) The prolongation of BS 4871-1 approval test in excess of the initial 2 years from 1 May 1992 shall be made in accordance with **10.2** of BS EN 287-1:1992 in conjunction with an examiner or test body.

The welder who satisfactorily completes the welding procedure test shall thereby be approved in those procedures without undergoing welder approval tests except for fillet welds where the extra tests required by BS EN 287-1 (two macros or test piece fracture) shall be completed.

NOTE It is recommended that welder approval tests carried out in accordance with this clause and witnessed by an examiner or test body should be accepted by other examiners or test bodies provided that all the provisions have been fulfilled.

47.2 Tungsten inclusions shall be assessed in accordance with Table 5.

48 Attachments to thin pipes

Welders to be engaged in welding attachments to pipes equal to or less than 5 mm wall thickness shall demonstrate their ability. The test weld shall be made on pipe of contract thickness and the minimum thickness shall be the thickness welded.

Appendix A Grades of steel in British Standards

Table 6 gives details of grades in British Standards for the types of steel listed in Table 1. Materials for flanges are given in BS 1560-2.

Table 6 — Grades of steel in British Standards

Types of steel	Grades in British Standards for pipes	
	BS 3605-1 and BS 3605-2	BS 3059-2
18 Cr 10 Ni	304S31 304S51	304S51
18 Cr 12 Ni, low carbon	304S11	—
18 Cr 12 Ni, Ti stabilized	321S31 321S51	321S51
18 Cr 12 Ni, Nb stabilized	347S31 347S51	347S51
18 Cr 12 Ni 2½ Mo	316S31 315S52	316S51
18 Cr 12 Ni 2½ Mo, Ti stabilized	—	—
18 Cr 12 Ni 2½ Mo, low carbon	316S13 316S11	—
18 Cr 12 Ni 3½ Mo	—	—
15 Cr 10 Ni 6 Mn Nb V	—	215S15
25 Cr 20 Ni	—	—

Appendix B Guidance on suitable types of weld metal

Guidance on suitable types of weld metal for welding similar austenitic stainless steels and dissimilar steels is given in Table 7 and Table 8 respectively. British Standard designations for the types of weld metal given in these tables are stated in Table 9.

Table 7 — Guidance on types of weld metal for welding similar austenitic stainless steel
(see also Table 9)

Types of steel	Types of weld metal (deposit analysis)	Remarks
18 Cr 10 Ni	A, C, D	
18 Cr 12 Ni, low carbon	B, C	Low carbon weld metal of matching composition is essential where 18 Cr 12 Ni low carbon steel has been chosen for corrosion resistance and Type C weld metal would be unacceptable.
18 Cr 12 Ni, Ti stabilized 18 Cr 12 Ni, Nb stabilized	C F	Welds in excess of 25 mm thickness should be made with Type F weld metal, if service permits, to reduce hot cracking tendencies. If Type C weld metal is required for welds over 25 mm thick, special precautions should be taken.
18 Cr 12 Ni 2½ Mo	D	
18 Cr 12 Ni 2½ Mo, Ti stabilized	F	
18 Cr 12 Ni 2½ Mo, low carbon	E, F	Low carbon weld metal of matching composition is essential where 18 Cr 12 Ni 2½ Mo low carbon steel has been chosen for corrosion resistance and Type F weld metal would be unacceptable.
18 Cr 12 Ni 3½ Mo	G	
15 Cr 10 Ni 6 Mn Nb V	R	A complex high temperature creep resistant material. Welding should be carried out using weld metal of nearly matching composition.
25 Cr 20 Ni	K, L	Tendency to cracking in multi-layer welds under severe restraint. Use stabilized version, Type L, to minimize hot cracking or for high corrosion resistance.

Table 8 — Guidance on types of weld metal for welding dissimilar steels (see also Table 9)

Types of steel	18 Cr 12 Ni, low carbon (note 3)	18 Cr 12 Ni, Ti stabilized	18 Cr 12 Ni, Nb stabilized	18 Cr 12 Ni 2½ Mo	18 Cr 12 Ni 2½ Mo, Ti stabilized	18 Cr 12 Ni 2½ Mo, low carbon (not 3)	18 Cr 12 Ni 3½ Mo	15 Cr 10 Ni 6 Mn Nb V	25 Cr 20 Ni	Carbon and low alloy steel
18 Cr 10 Ni	A, C, D	A, C, D	A, C, D,	A, C, D	A, C, D	A, C, D	A, C, D	—	A, C, D, K	K, D, H, J, M, N
18 Cr 12 Ni, low carbon (note 3)		B, C	C, B	C, B, D	B, E, F, C	B, E, C	B, D, C	—	A, K, C	K, D, H, J, M, N
18 Cr 12 Ni, Ti stabilized			C	C, D	C, F	C, E	C, D	—	C, K	K, D, H, J, M, N
18 Cr 12 Ni, Nb stabilized				C, D	C, F	C, E	C, D	—	C, K	K, D, H, J, M, N
18 Cr 12 Ni 2½ Mo					D	D	D	M, N, P, Q	D, K	K, D, H, J, M, N
18 Cr 12 Ni 2½ Mo, Ti stabilized						E, F	F, G	—	F, K	K, F, H, J
18 Cr 12 Ni 2½ Mo, low carbon (note 3)							G, E, F	—	E, F, K	K,F, H, M, N
18 Cr 12 Ni 3½ Mo								—	G, K	K, G, H
15 Cr 10 Ni 6 Mn Nb V									M, N, Q	M, Q
25 Cr 20 Ni										H, K

NOTE 1 Differing grades of austenitic steel may be welded together without undue difficulty. However, many combinations of steel types may give rise to service difficulties in corrosive or high temperature applications. Mixing of materials should, therefore, be avoided wherever possible.

NOTE 2 The difficulties of mixed materials are accentuated when one of the materials is a carbon or low alloy steel. Attention should therefore be given to the careful siting of "mixed" welds at the design stage. High nickel weld metal may be used for transition joints.

NOTE 3 The combination of low carbon grades with unstabilized grades is not recommended. The combination of low carbon grades with Ti or Nb stabilized grades is recommended only for non-corrosive duties, or where tests have shown that adequate resistance to intergranular corrosion is achieved right across the weld zone.

Table 9 — Types of weld metal given as guidance in Table 7 and Table 8 and British Standard electrode and filler metal designations where they exist

Type of weld metal	BS 2926 composition code	BS 2901-2 and BS 2901-5 designation
A 19-9	19.9	308S96
B 19-9, L	19.9.L	308S92
C 19-9, Nb	19.9.Nb	347S96
D 19-12-Mo	19.12.3	316S96
E 19-12-Mo, L	19.12.2.L 19.12.3.L	316S92
F 19-12-Mo, Nb	19.12.3.Nb	318S96
G 19-13-Mo	19.13.4	317S96
H 23-12	23.12	309S94
J 23-12-Mo	23.12.2	—
K 25-20	25.20	310S94
L 25-20-Nb	25.20.Nb	313S94
M Nickel base 18 to 22 Cr	—	NA 35
N Nickel base 14 to 17 Cr	—	NA 39
P Nickel base 13 to 17 Cr 5 to 9.5 Mo	—	—
Q 17-8-2 Mo[a]	17.8.2	—
R 16 Cr 7 Ni 5 Mn Nb V	—	—

[a] Used as an alternative to 19-12-Mo. Exhibits good all round mechanical properties and generally possesses a reduced tendency for intermetallic embrittlement at elevated temperatures compared to 19-12-Mo.

Appendix C Typical joint preparations

C.1 Typical butt joint preparations are shown in Figure 8 to Figure 11.

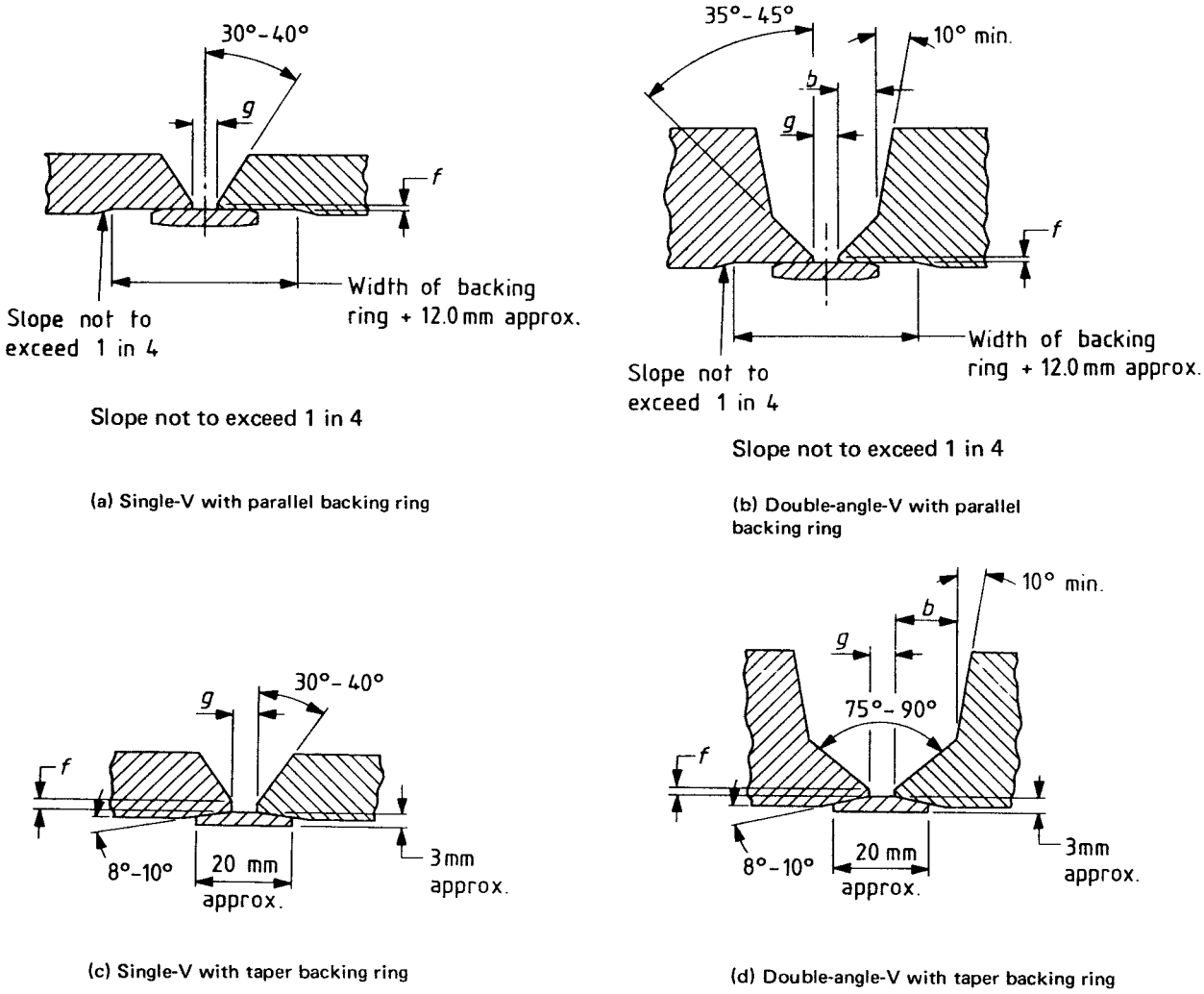
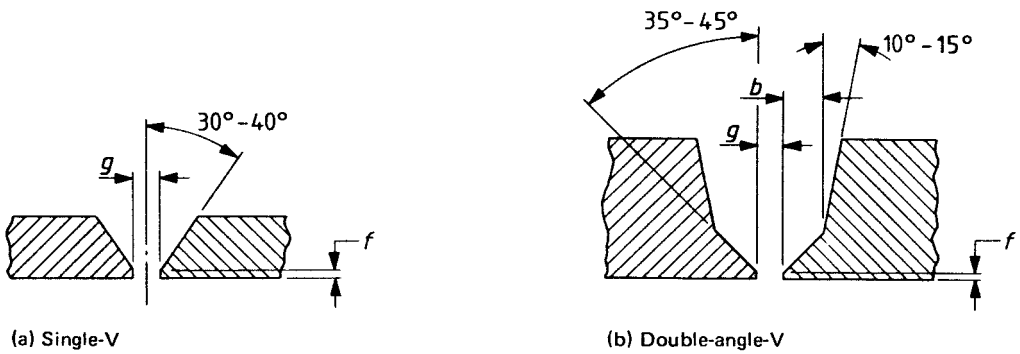


Figure	Pipe thickness		*g* (min.)	*f*	*b*
	Over	Up to and including			
	mm	mm	mm	mm	mm
(a)	—	20	5.0[a]	0.8 to 2.5	—
(b)	20	—	5.0[a]	0.8 to 2.5	6.0
(c)	—	20	5.0	0.8 max.	—
(d)	20	—	5.0	0.8 max.	6.0 min.

[a] This dimension may be reduced to 4.0 mm minimum for joints in vertical pipes.

Figure 8 — Typical butt joint preparations for use with metal-arc welding, with backing ring for single or double root run

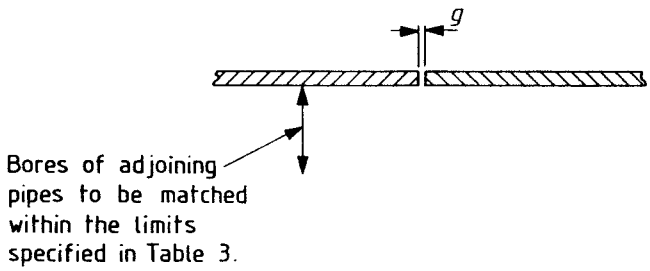


(a) Single-V (b) Double-angle-V

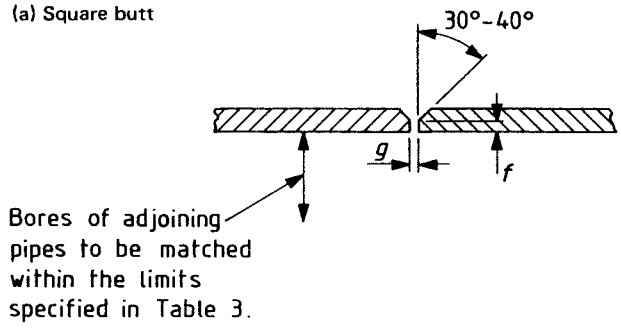
Figure	Pipe thickness		g^a	f	b
	Over	Up to and including			
	mm	mm	mm	mm	mm
(a)	—	20	1.6 to 4.0	1.6 ± 0.8	—
(b)	20	—	2.5 to 4.0	1.6 ± 0.8	6.0

[a] The actual gap will vary according to the welding process and welding position used (see also clause **13**).

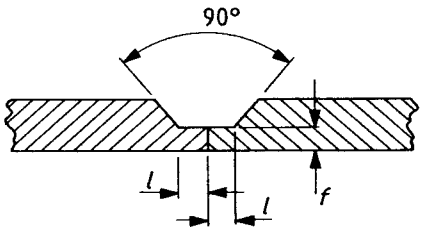
Figure 9 — Typical butt joint preparations for use with metal-arc welding, without backing ring



(a) Square butt



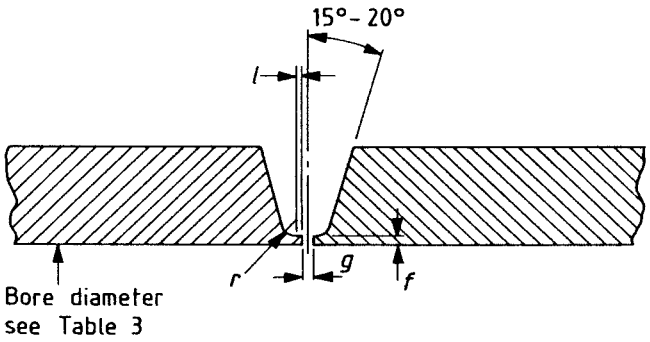
(b) Single-V



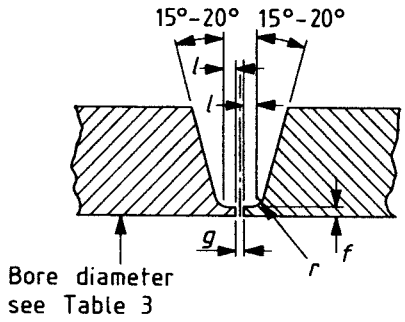
(c) Single-V with lands

Figure	Pipe thickness		*g*	*f*	*l*
	Over	Up to and including			
	mm	mm	mm	mm	mm
(a)	—	2.3	0 + 1.6	—	—
(b)	2.3	6.3	0 + 1.6	1.6	—
(c)	3.2	6.3	0	2.5	3.0

Figure 10 — Typical butt joint preparations for use with manual TIG welding, with or without filler wire



(a)

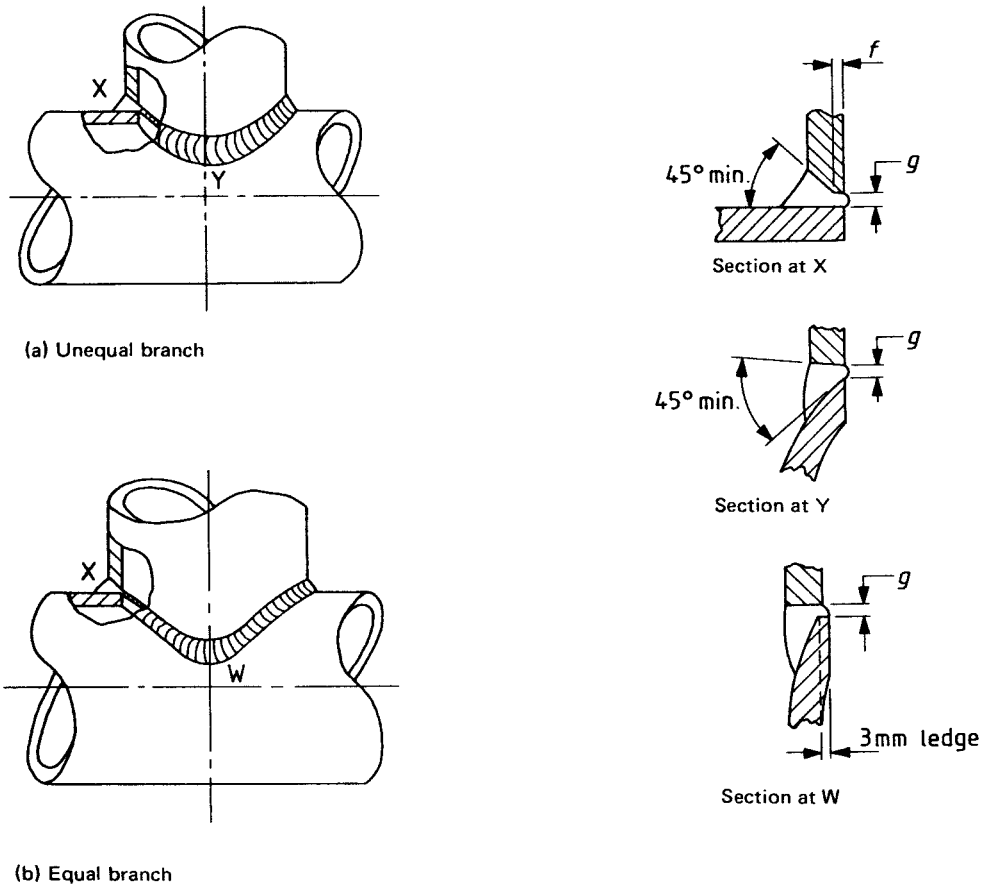


(b)

Figure	*g*			*f*	*l*	*r*
	Without filler wire or insert	Using filler wire	Using fusible insert			
		mm		mm	mm	mm
(a)	0	0.8 to 1.6	To suit type and make of	1.2 to 2.5	0.8 to 1.6	3.0 to 5.0
(b)	0	0.8 to 1.6	fusible insert used	1.0 to 2.5	5.0	1.6

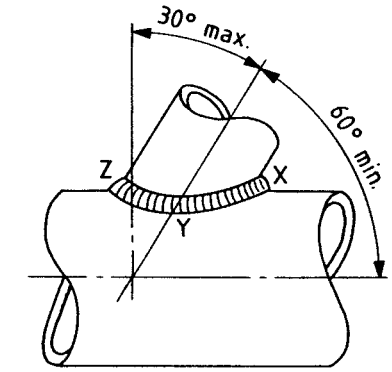
Figure 11 — Typical butt joint preparations for use with TIG welding for the root run, with or without filler wire, or with fusible insert

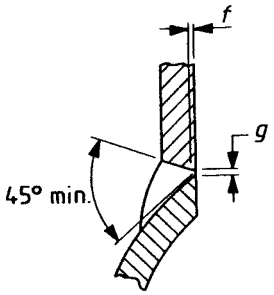
C.2 Typical edge shapes for branch connections are shown in Figure 12 to Figure 17.



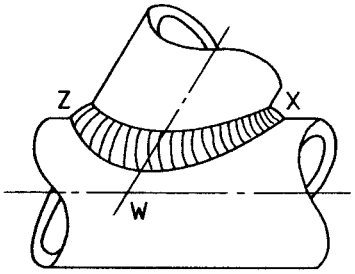
g	*f*
mm	mm
2.5 ± 0.8	1.6 ± 0.8

Figure 12 — Typical preparation and assembly of set-on right angle branches without backing

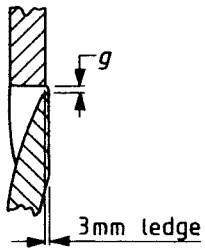




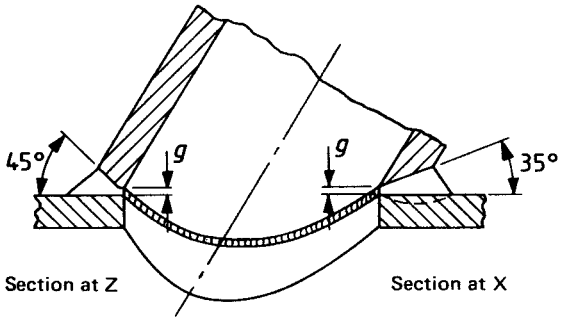
Section at Y



(b) Equal branch



Section at W



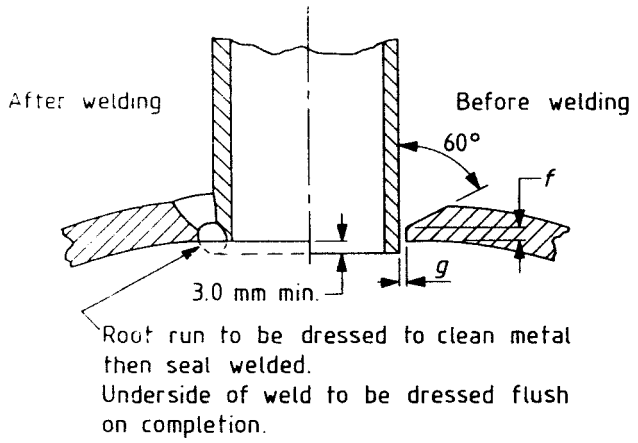
Alternative profile. Main pipe ground locally to improve access.

Section at Z

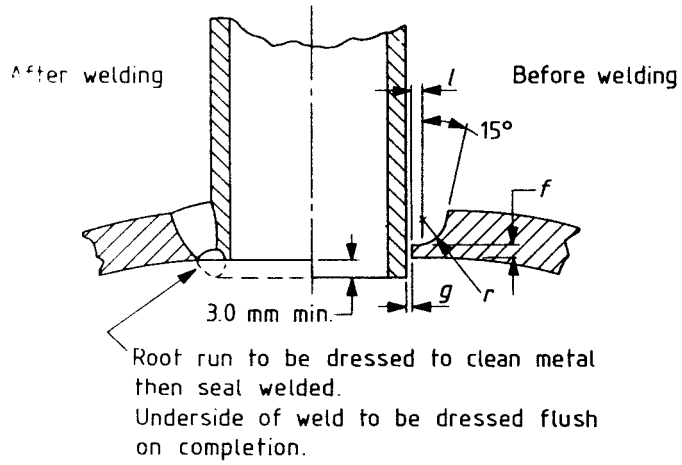
Section at X

g	*f*
mm	mm
2.5 ± 0.8	1.6 ± 0.8

Figure 13 — Typical preparation and assembly of set-on sloping branches without backing



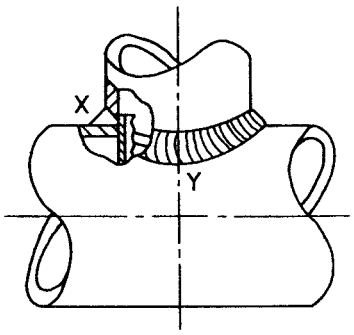
(a) Single-bevel preparation



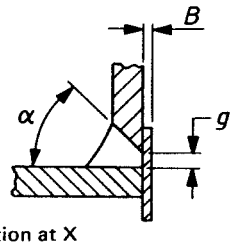
(b) Single-J preparation

Figure	g	f (max.)	l	r
	mm	mm	mm	mm
(a)	0.8	2.5	—	—
(b)	0.8	3.0	3.0	5.0

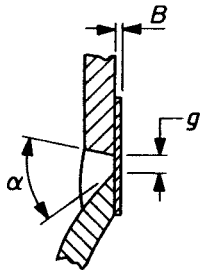
Figure 14 — Typical preparation and assembly of set-in branches (access from inside pipe)



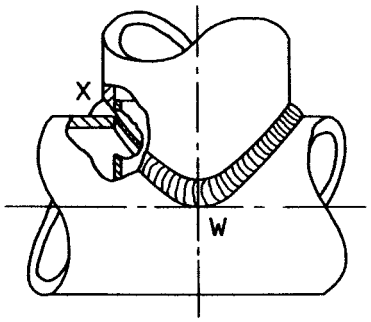
(a) Unequal branch



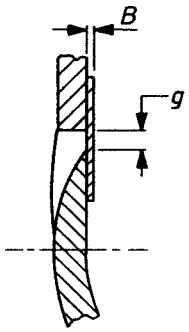
Section at X



Section at Y



(b) Equal branch



Section at W

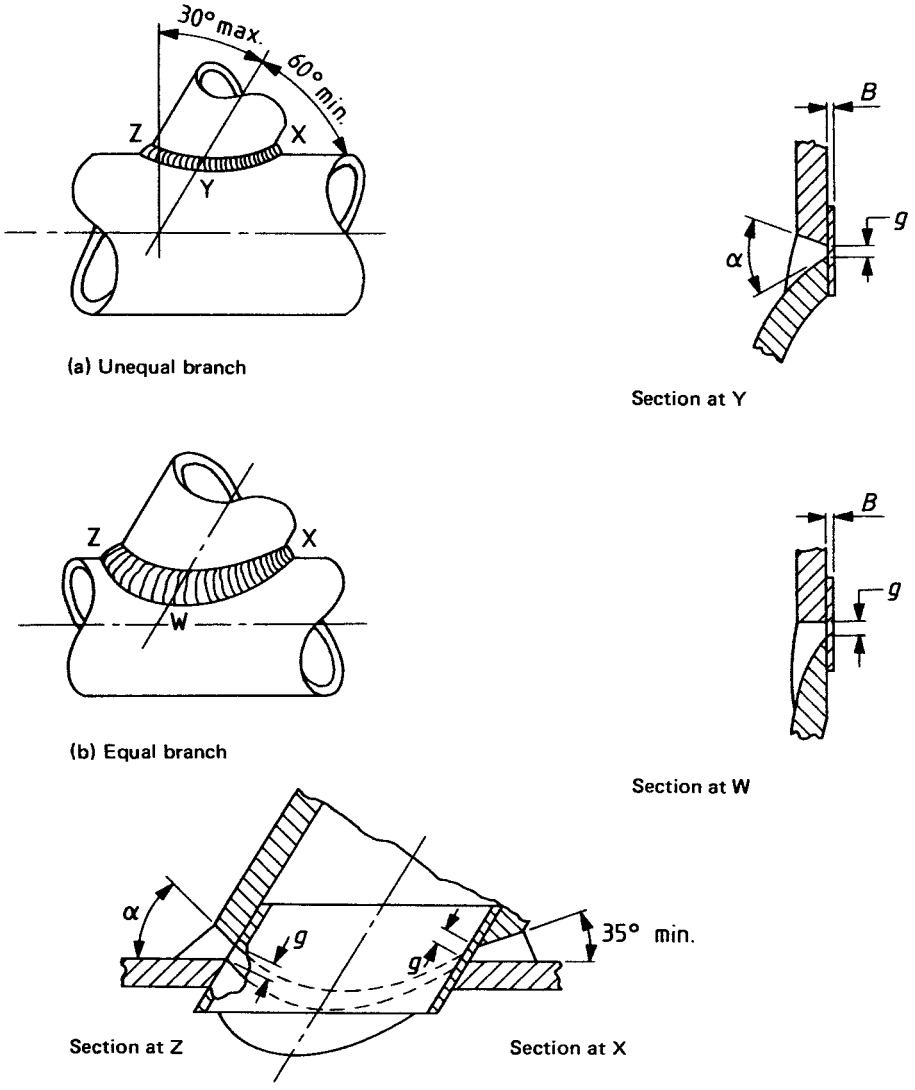
α	g	B
	mm	mm
15° to 20°	8.0 to 10.0	3.0 to 5.0

NOTE 1 Root run in each corner in all cases. The backing ring is to be removed after welding.

NOTE 2 A recessed backing ring may be necessary in some cases.

NOTE 3 A collapsible copper sleeve may be used as an alternative to a backing ring (see **9.3**).

Figure 15 — Typical preparation and assembly of set-on right angle branches with temporary backing



α	g	B
	mm	mm
15° to 20°	8.0 to 10.0	3.0 to 5.0

NOTE 1 Root run in each corner in all cases. The backing ring is to be removed after welding.

NOTE 2 A recessed backing ring may be necessary in some cases.

NOTE 3 A collapsible copper sleeve may be used as an alternative to a backing ring (see **9.3**).

Figure 16 — Typical preparation and assembly of set-on sloping branches with temporary backing

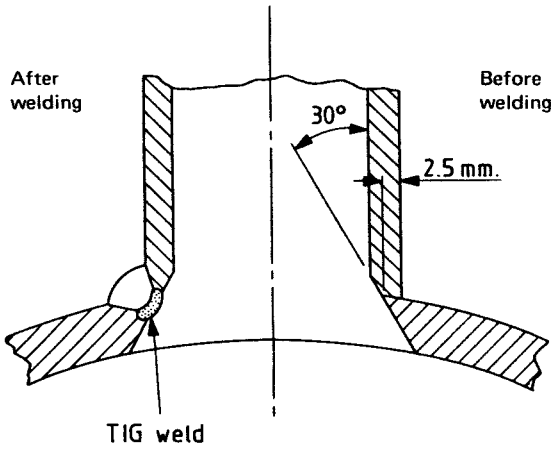


Figure 17 — Typical set-on connection

C.3 Typical forms of small bore connections are shown in Figure 18 and guidance on their use is given below.

Figure 18(a). This type of connection is made from forged or rolled bar and is bored to finished or tapping size after welding. It is suitable for all sizes of main pipe.

Figure 18(b). This type of connection is made from screwed sockets, couplings or tube shaped to suit the bore of the main pipe.

It is recommended that this type of connection should only be used where it is located near the open end of a pipe and only on pipes of such bore as will allow access for the removal of any excess penetration of weld metal at the root of the weld by grinding, filing or machining.

Figure 18(c). This type of connection is made from tube, or half couplings or equivalent, and is suitable for all sizes of main pipe. It is bored to finished or tapping size after welding and to remove the root penetration of the weld.

Figure 18(d). This small bore branch connection is only suitable where the main pipe has a bore at least five times the bore of the branch. A flat is machined on the outside of the main pipe to receive the prepared end of the branch.

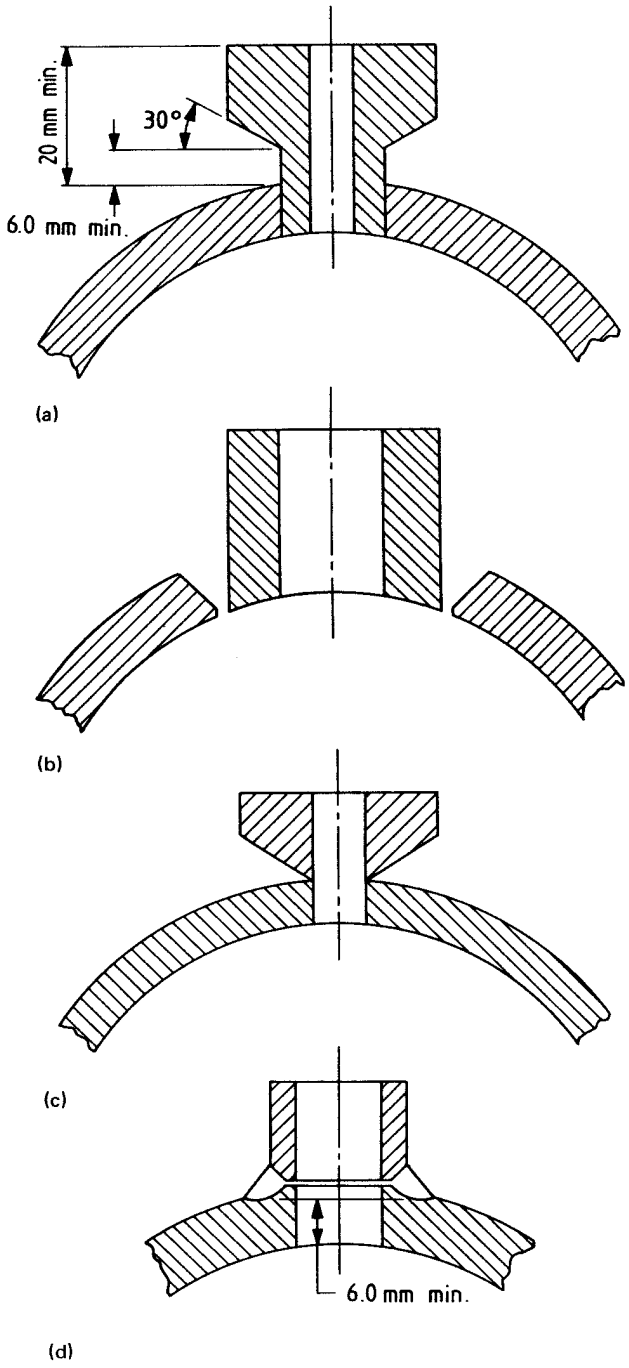
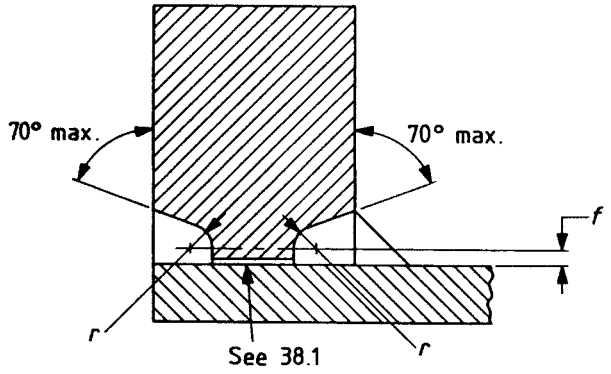


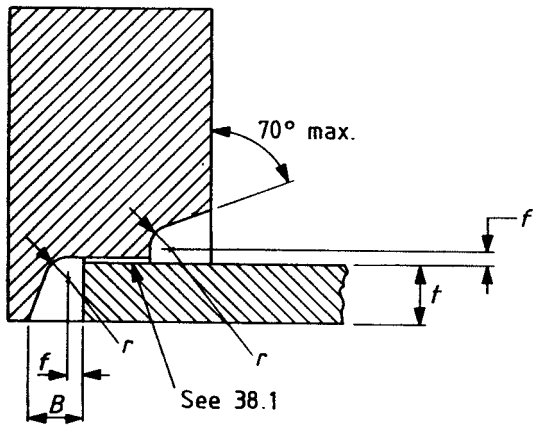
Figure 18 — Typical small bore connections

C.4 Typical weld preparations for plate flanges are shown in Figure 19 to Figure 27.



f = 3.0 mm
r = 5.0 mm min.

Figure 19 — Typical "face and back" welded-on flange

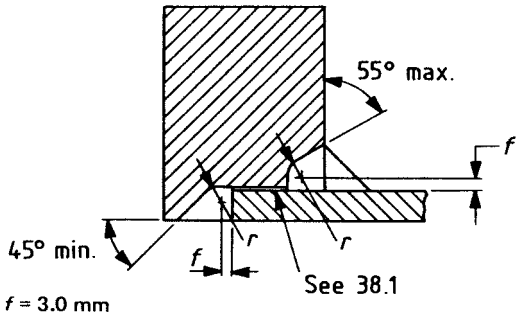


This preparation is limited to pipes having a bore of not less than 75 mm.

B =
- = 8.0 mm min. where t is not more than 8.0 mm.
- = (t – 1.6 mm) where t is over 8.0 mm up to and including 14.2 mm.
- = (t – 3.0 mm) where t is over 14.2 mm up to and including 22.2 mm.
- = (t – 6.0 mm) where t is over 22.2 mm.

f = 3.0 mm
r = 5.0 mm min.

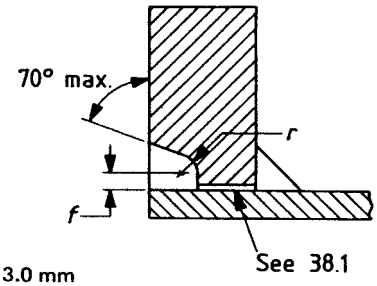
Figure 20 — Typical "bore and back" welded-on flange



f = 3.0 mm
r = 5.0 mm min.

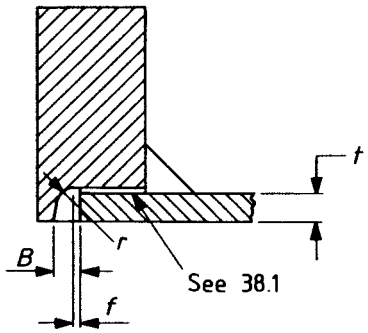
This preparation is limited to pipes having a bore of not less than 75 mm.

Figure 21 — Typical "bore and back" welded-on flange for positional welding



f = 3.0 mm
r = 5.0 mm min.

Figure 22 — Typical "face and fillet" welded-on flange

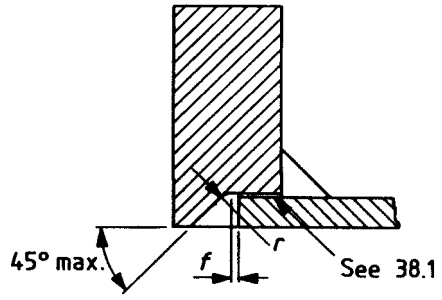


This preparation is limited to pipes having a bore of not less than 75 mm.

B = 8.0 mm minimum where t is not more than 8.0 mm.
= (t – 1.6 mm) where t is over 8.0 mm up to and including 14.2 mm.
= (t – 3.0 mm) where t is over 14.2 mm up to and including 22.2 mm.
= (t – 6.0 mm) where t is over 22.2 mm.

f = 3.0 mm
r = 5.0 mm min.

Figure 23 — Typical "bore and fillet" welded-on flange



This preparation is limited to pipes having a bore of not less than 75 mm.

Figure 24 — Typical "bore and fillet" welded-on flange for positional welding

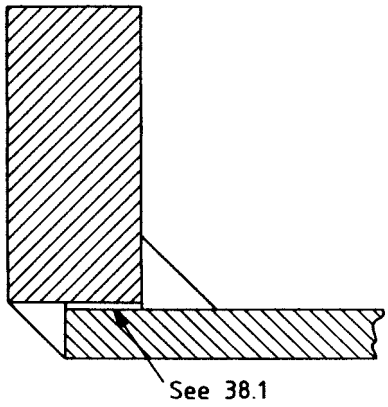


Figure 25 — Typical "slip on" welded-on flange

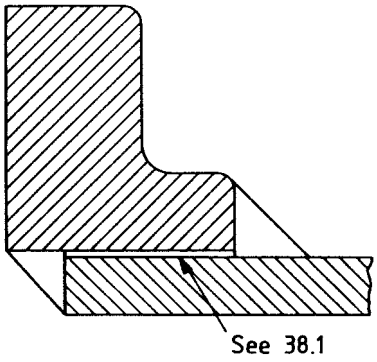


Figure 26 — Typical "slip on" hubbed welded-on flange

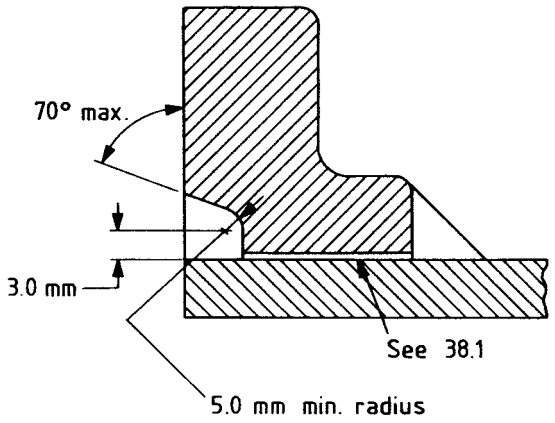


Figure 27 — Typical "face and fillet" hubbed welded-on flange

Appendix D Guidance on welding transition joints between ferritic steel and austenitic stainless steel

D.1 Introduction

D.1.1 Where it is necessary in a pipework system to join different types of steel, this can be successfully achieved by the use of a welded joint. Careful consideration of all design factors, e.g. design strength, corrosion behaviour and fatigue resistance, should be used to decide the location of transition joints.

D.1.2 Generally, no special weld preparations are required and welds can be made using the pre-heating conditions for the ferritic alloy. Welds have been successfully made in pipe of thicknesses from 3 mm to 80 mm and all diameters. Special welding tests may be necessary to demonstrate the successful manufacture and use of a transition joint for any particular application.

D.1.3 A range of filler metals is available and unless special operating conditions are required, such as high temperature strength or low temperature toughness, the normal welding procedure tests in accordance with BS 4870-1 are adequate to demonstrate the acceptability of any particular material combination. Some special consideration may have to be given to the performance of weld metal/heat-affected zone interfaces when bend tests as required by BS 4870-1 are carried out, as a failure in these tests may not be indicative of any weakness in the use of the joint in service. The weld metal/heat-affected zone interfaces may also require careful consideration if the joint is intended for high temperature service, since some weakening may occur due to either sensitization to intergranular failure or loss of alloying elements causing loss of mechanical strength. The designer should examine whether additional tests are necessary to substantiate operation in service.

D.1.4 For all transition joints the designer should also evaluate the need for and temperature of any post-weld heat treatment, as they may also have an effect on the long term reliability of such joints.

D.1.5 The inspection and testing of austenitic stainless/ferritic steel joints may also require individual procedures both in manufacture and service because not all available methods of non-destructive testing will be suitable for use on such weldments.

D.2 Materials

Parent metals are those covered by clause **3** and BS 2633.

D.3 Methods of making transition joints

D.3.1 *Normal butt joint*

A weld preparation of conventional type is filled with austenitic stainless steel or nickel base alloy weld metal. The austenitic stainless steel weld metal should preferably be of an over-alloyed type such as 23 Cr 12 Ni to allow for dilution rather than a grade matching the stainless steel parent material.

D.3.2 ***Buttered preparation***

When it is necessary to prevent carbon migration from the ferritic material, it is usual to butter the preparation with nickel base weld metal and then re-prepare the fusion faces for welding.

Alternatively the butter layer can be of a niobium stabilized austenitic stainless steel or a very low carbon version of the ferritic parent material.

D.3.3 ***Transition inserts***

D.3.3.1 *Ungraded.* In certain high temperature situations instead of a single joint between the two parent metals it may be considered advisable to introduce an insert of compatible material, usually austenitic stainless steel or nickel base alloy, with a coefficient of expansion between that of the two parent metals. Two transition welds would be required. The transition joint can be prefabricated with cuff extensions prior to insertion in the final assembly.

D.3.3.2 *Graded.* Proprietary insert sections are available, produced by consumable remelting of composite electrodes, where material matching one of the parent metals changes throughout its length to material matching the other parent metal. In addition to being better able to withstand the effects of thermal gradients, this type of joint allows welds in matching materials and is suitable for creep and non-creep conditions. The minimum length of insert should take account of inspection requirements and possible local post-weld heat treatment.

D.4 Joint preparation

Joint preparations should be based on those given in Appendix C or BS 2633.

D.5 Weld metal

D.5.1 ***Non-creep service conditions***

For a transition weld joining a ferritic material, other than 3½ Ni and 9 Ni, to austenitic stainless steel, weld metal such as produced by electrodes complying with class **23.12** of BS 2926 or wire complying with type 309S94 of BS 2901-2 is recommended or nickel base alloy weld metal such as from wires complying with type NA 35 or NA 43 of BS 2901-5. For 3½ Ni and 9 Ni to austenitic stainless materials, nickel base alloy weld metal is recommended. When nickel base alloy weld metal is used for buttering, the fill-up should also be with nickel base alloy.

D.5.2 ***Creep service conditions***

Nickel base alloy weld metal such as from wires complying with type NA 35 or NA 43 of BS 2901-5 is recommended. This does not preclude the use of austenitic stainless steel weld metal providing sufficient evidence of suitability for service conditions is available. Nickel base alloy weld metal should be acceptable at both ends of ungraded inserts.

D.6 Selection and control of welding processes

TIG welding and manual metal-arc welding may be readily adopted for nickel base alloy or austenitic consumables of both types. Submerged-arc welding may be adopted providing the ferritic parent metal is first buttered with weld metal of the 23 Cr 12 Ni type using TIG welding or manual metal-arc welding. Nickel base alloys are not recommended for use with submerged-arc welding.

Other processes may be used provided there is sufficient evidence for their adoption.

D.7 Purging

Purging should be in accordance with clause **14** or BS 2633.

D.8 Pre-heating, interpass temperature and post-weld heat treatment

D.8.1 ***Pre-heating***

Generally, pre-heating should be in accordance with BS 2633 for the ferritic parent material. However, because the low diffusion rate of hydrogen in austenitic stainless and nickel base weld metal reduces hydrogen concentration in the ferritic
heat-affected zone, a lower temperature may be acceptable.

D.8.2 ***Post-weld heat treatment***

Generally, when it is necessary to temper the heat-affected zone of the ferritic material, the requirements of BS 2633 should be met. However, metallurgical damage to the austenitic stainless steel could result from such a heat treatment unless the ferritic side of the joint is post-weld heat treated separately; this can be achieved by the use of an insert or buttering.

D.9 Further metallurgical considerations

D.9.1 *Carbon migration*

Weakening of the ferritic side of the joint can occur due to carbon diffusion during welding, post-weld heat treatment or operation in the creep range (see **D.3.2**).

D.9.2 *Dilution problems*

High dilution (above 30 %) of filler materials by parent metals is undesirable when either austenitic or nickel alloy consumables are used.

If the dilution is known, the Schaefler diagram or the Delong diagram may be used to determine the constitution of the weld metal when austenitic stainless consumables are used. A weld metal consisting of austenite with 5 % to 10 % delta-ferrite will generally give satisfactory results.

For dilutions of less than 30 %, consumables of the 23 Cr 12 Ni or nickel alloy types would normally produce acceptable weld metal compositions.

Root runs, where dilution is likely to be most severe, should not be made without filler wire or a consumable insert unless the whole root area is to be removed before the joint is put into service.

D.10 Non-destructive testing

D.10.1 *Surface inspection*

Liquid penetrant testing is suitable for surface examination of austenitic stainless/ferritic steel joints.

NOTE Austenitic stainless steel is not ferro-magnetic, therefore magnetic particle testing is not suitable.

D.10.2 *Volumetric testing*

D.10.2.1 Radiography may be used but care is necessary in the application of the technique to allow for different absorption characteristics of the various materials.

In addition, interpretation of radiographs may be complicated by the diffraction patterns occasionally generated by austenitic stainless and nickel base weld metals.

D.10.2.2 Ultrasonic examination of transition joints is possible but attenuation and beam deflection can influence signals to such an extent that misleading information is given. Procedures should be proven on joints made to the same manufacturing procedure and similar geometry to the production joints.

D.11 General comments and recommendations

D.11.1 Branch welds between austenitic stainless and ferritic steels are not recommended.

D.11.2 Ferritic steel attachments to austenitic stainless steel pipes operating in the creep range are not recommended.

D.11.3 Attachment welds between dissimilar steels should receive the same consideration as butt welds.

D.11.4 Joint alignment for welding should preferably be achieved without the use of welded bridge pieces, particularly where high alloy ferritic steels are involved. Where this is not possible it may be advisable to make special bridge pieces enabling ferritic to ferritic steel welds to be made on one side of the joint and austenitic stainless to austenitic stainless steel to be made on the other side (see clause **13**).

D.11.5 Root runs should preferably be made by TIG welding using filler wire or a consumable insert.

D.11.6 When it is necessary to remove the root area to achieve the desired quality, a machining allowance will be required.

D.11.7 Transition joints between austenitic stainless and ferritic steel pipes should preferably be made as a sub-item which can be welded, machined, post-weld heat treated when required, and fully inspected before final assembly welds are made in like materials.

Appendix E Image quality indicator sensitivities

Table 10 — Image quality indicator sensitivities (types I and II)

Section A More critical techniques			Section B Normal techniques		
Specimen thickness	Image quality Indicator sensitivity		Specimen thickness	Image quality indicator sensitivity	
	Wire type	Step/hole type		Wire type	Step/hole type
mm	%	%	mm	%	%
3	2.4	5.1	3	—	—
6	1.6	3.6	6	—	—
12.5	1.4	3.0	12.5	2.4	4.6
25	1.2	2.5	25	1.7	3.0
40	1.1	2.1	40	1.5	2.5
50	1.0	1.8	50	1.3	2.2
75	0.9	1.6	75	1.1	2.0
100	0.8	1.4	100	1.0	1.8
150	0.7	1.3	150	0.9	1.8

NOTE Image quality indicator sensitivity does not necessarily represent flaw sensitivity. There is a relationship but this depends on factors such as the nature and orientation of the flaw.

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Publications referred to

BS 638, *Arc welding power sources, equipment and accessories.*
BS 1113, *Water-tube steam generating plant (including super-heaters, reheaters and steel tube economizers).*
BS 1560, *Circular flanges for pipes, valves and fittings (Class designated).*
BS 1560-3, *Steel, cast iron and copper alloy flanges.*
BS 1560-3.1, *Specification for steel flanges.*
BS 1640, *Steel butt-welding pipe fittings for the petroleum industry.*
BS 1640-4, *Wrought and cast austenitic chromium-nickel steel fittings.*
BS 1821, *Specification for class I oxy-acetylene welding of ferritic steel pipework for carrying fluids*[3)].
BS 2633, *Class I arc welding of ferritic steel pipework for carrying fluids.*
BS 2640, *Specification for class II oxy-acetylene welding of carbon steel pipework for carrying fluids* [3)].
BS 2901, *Filler rods and wires for gas-shielded arc welding.*
BS 2901-2, *Austenitic stainless steels.*
BS 2901-5, *Nickel and nickel alloys.*
BS 2910, *Methods for radiographic examination of fusion welded circumferential butt joints in steel pipes.*
BS 2926, *Chromium-nickel austenitic and chromium steel electrodes for manual metal-arc welding.*
BS 2971, *Specification for class II arc welding of carbon steel pipework for carrying fluids*[3)].
BS 3059, *Specification for steel boiler and superheater tubes.*
BS 3059-2, *Carbon, alloy and austenitic stainless steel tubes with specified elevated temperature properties.*
BS 3605, *Austenitic stainless steel pipes and tubes for pressure purposes.*
BS 3605-1, *Specification for seamless tubes.*
BS 3605-2, *Specification for longitudinally welded tubes.*
BS 3971, *Specification for image quality indicators for industrial radiography (including guidance on their use).*

BS 4204, *Specification for flash welding of steel tubes for pressure applications*[3)].

BS 4870, *Approval testing of welding procedures.*
BS 4870-1, *Fusion welding of steel (withdrawn).*
BS 4871, *Approval testing of welders working to approved welding procedures.*
BS 4871-1, *Fusion welding of steel (withdrawn).*
BS EN 287-1, *Approval testing of welders for fusion welding — Part 1 Steels.*
BS EN 288-2, *Specification and approval of welding procedures for metallic materials — Part 2 Welding procedures specification for arc welding.*
BS EN 288-3, *Specification and approval of welding procedures for metallic materials — Part 3 Welding procedure tests for the arc welding of steels.*
BS EN 349, *Welding consumables — Shielding gases for arc welding and cutting.*

[3)] Referred to in the foreword only.

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