



BS 2971:1977

UDC 621.644.2 : 669.146 : 621.791.753

Confirmed August 1982

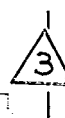
Specification for
**Class II arc welding of carbon steel pipework
for carrying fluids**

Spécification du soudage à l'arc de classe II des tuyauteries en acier
au carbone destinées au transport des liquides

Spezifikation für Lichtbogenschweißen der Klasse II für
Kohlenstoffstahl-Förderleitungen für Flüssigkeiten

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Foreword

This revision of BS 2971 is the first that has been undertaken since the standard was published in 1961 and it embodies the technical developments that have taken place since then. On common aspects the standard has generally been aligned with BS 2633.

As a result, there is a limitation on the parent metal to which this standard relates and it is recommended that carbon steels with a carbon content exceeding 0.25 % and all alloy steels be welded in accordance with the requirements of BS 2633 irrespective of the operating conditions. Because of its increased use for quality control purposes, non-destructive testing has been introduced as an optional requirement together with the allied acceptance levels. These levels are based on experience of what can be achieved commercially on class II work. Whilst no scientific basis is implied, it is known that such levels represent welds in pipework which have given satisfactory service life and therefore of a quality which may be regarded as class II.

The relevant application standard, where it exists, should specify whether class II welding of pipework is required, but the factors to be taken into account in coming to such a conclusion are the operating conditions of the pipework, the degree of inspection and the acceptance requirements. (See also appendix A.)

The following are companion standards to this standard:

- BS 2640 Class II oxy-acetylene welding of steel pipelines and pipe assemblies for carrying fluids
- BS 2633 Class I arc welding of ferritic steel pipework for carrying fluids
- BS 1821 Class I oxy-acetylene welding of steel pipelines and pipe assemblies for carrying fluids
- BS 4204 General requirements for the flash welding of steel pipes and tubes for pressure and other high duty applications
- BS 4677 Class I arc welding of austenitic stainless steel pipework for carrying fluids

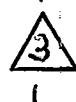
Inspecting authority. The term inspecting authority refers to that competent independent body or association which verifies compliance with this standard.

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 purposes 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.

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

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



British Standard Specification for

Class II arc welding of carbon steel pipework for carrying fluids

Section one. General

1. Scope

This British Standard specifies requirements for both shop and site class II arc welding of joints in carbon steel pipework intended to carry fluids. It covers manual, automatic or semi-automatic arc welding or combinations of these processes, but it also allows joints to be made with an oxy-acetylene root run without a backing ring by agreement between the contracting parties. (For details of oxy-acetylene welding see BS 2640.)

Attention is particularly drawn to appendix B which lists items for agreement between the contracting parties.

2. References

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

3. Parent metals

This standard relates to pipes and attachments made from carbon steel containing not more than 0.25 % carbon that comply with the requirements of



BS 1387

BS 3059 : Part 1–320

BS 3059 : Part 2–360 and 440

BS 3601–320, 360 and 410

BS 3602 : Part 1–360, 410, 460 and 490Nb

BS 3602 : Part 2–410 and 460

BS 3603–410LT50

BS 3606–320 and 440

The use of equivalent alternative steels to those complying with the above standards is permitted. The material used for pipes and fittings shall be fully suitable for the service conditions.

While the requirements and limitations 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 or porosity, shall be subject to agreement between the purchaser and the manufacturer.

4. Weld metal

Electrodes, filler wires, filler wire/flux combinations and fusible inserts shall produce carbon or carbon manganese weld metal that has mechanical properties suitable for the design requirement of the pipe system and at least equal to the minimum values stated in the specification for the parent metal.

The requirements of this clause are met by welding consumables of the types stated that comply with the requirements of the following British Standards:

Covered electrodes for manual metal-arc welding with BS 639

Filler materials for gas-shielded arc welding with BS 2901 : Part 1

Filler wire/flux combinations for submerged arc welding with BS 4165

5. Gases for shielding and purging

5.1 Shielding gases. One of the following gases or gas mixtures shall be used where appropriate and shall be of the quality stated.

(a) *Argon.* The gas shall comply with the requirements of BS 4365.

(b) *Argon/oxygen mixtures.* The mixture shall consist of argon complying with the requirements of BS 4365 with up to 5 % added oxygen complying with the requirements of BS 4364. The total impurities shall not exceed 0.075 %.

(c) *Argon/carbon dioxide mixtures.* The mixture shall consist of argon complying with the requirements of BS 4365 with up to 25 % added carbon dioxide complying with the requirements of BS 4105, type 1, with or without up to 5 % oxygen complying with the requirements of BS 4364.

(d) *Argon/hydrogen mixtures.* The mixture shall consist of argon complying with the requirements of BS 4365 with up to 10 % added hydrogen complying with the requirements of BS 3906, type 2, for use when a higher arc voltage is required.

(e) *Carbon dioxide.* The gas shall comply with the requirements of BS 4105, type 1.

(f) *Other gases or gas mixtures.* The use of other gases or gas mixtures is permissible provided that they have proved to be satisfactory as a result of procedure approval tests.

5.2 Gases for back purging. For purging the back of a weld during welding, argon, argon/hydrogen mixtures or helium of the quality specified in 5.1 or one of the following gases shall be used.

(a) *Nitrogen.* The gas shall comply with the requirements of BS 4366, type 1.

(b) *Nitrogen/hydrogen mixtures.* The mixture shall consist of nitrogen complying with the requirements of BS 4366, type 1, with up to 15 % added hydrogen complying with the requirements of BS 3906, type 2.

When back purging it is essential that 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.

6. Equipment

6.1 Welding plant, instruments, cables and accessories shall comply with the requirements of the appropriate British Standard where available (see, for example, BS 638 and BS 679). Their capacity shall be adequate for the welding procedure proposed and subsequently to be approved. The contractor shall maintain all welding plant and ancillary equipment in good working order.

NOTE. The attention of the contractor is drawn to the advice on safety precautions contained in the Health and Safety at Work booklet No. 38 'Electric arc welding' issued by the Health and Safety Executive and published by HMSO.

6.2 All electrical plant used in connection with the welding operation shall be adequately earthed.

6.3 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 automatic and semi-automatic 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.

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

7. Welding processes

7.1 Complete welds. Welds shall be made by one of the welding processes permitted under clause 1 or by a combination of those processes.

7.2 Root runs. Methods of making the initial root run in butt joints by the various welding processes shall be as given in table 1.

8. Backing rings

8.1 Permanent backing rings. When permanent backing rings are permitted the gap between the outside diameter of the backing ring and bore of the pipe end shall not exceed 1 mm.

Backing rings fitting tightly into machined recesses with square or sharp corners, or of such a shape as to restrict longitudinal contraction are not permissible as they increase the tendency to basal crack formation.

It is permitted that a machined backing ring be split to allow it to spring against the internal surface of the pipe. The gap between the ends of a split ring, when fitted, shall not exceed 3 mm.

8.2 Material for permanent or temporary backing rings. Backing rings shall be of carbon steel up to 0.25 C provided that the sulphur and phosphorus contents do not exceed 0.050 % each (a high or segregated sulphur content in the backing ring may produce defects at or in the root run).

9. Alternative joint preparation

Joint preparations differing from those shown in this standard shall be permitted by agreement between the contracting parties.

10. Proximity of welds

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.

Joints where more than two welded seams meet should be avoided. If the design cannot avoid this, then appropriate precautions shall be taken which shall be agreed between the manufacturer, the purchaser and the inspecting authority.

11. Fusion faces

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

Certain proprietary protective coatings are specially formulated with the intention that they should not interfere with subsequent welding. The use of such coatings is not excluded by the requirements of this clause, but if so required by the purchaser the manufacturer shall demonstrate by means of specimen welds that the coating does not affect the quality of the weld.

Table 1. Methods of making root runs in butt joints*

Welding process	Type of joint
Manual metal-arc welding MIG-welding Active-gas metal-arc welding	With permanent or temporary† backing ring or unbacked
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
Submerged arc welding Flux cored or coated welding with or without shielding gas	With permanent or temporary† backing ring

*For making an oxy-acetylene root run without a backing ring, by agreement between the contracting parties, see BS 2640.

†The use of temporary backing rings is dependent upon access for their removal on completion of the weld; see also clause 8.

12. Assembly for welding

To maintain the specified alignment and gap, where used, during welding (see table 2 and figures 1 to 7), the parts to be welded shall be securely held in position by mechanical means, welded-on bridge pieces or by tack welding.

The specified dimensions of the 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 purchaser and the manufacturer.

The pre-heating requirements given in clause 16 shall be applied and maintained during tack welding and the welding-on of bridge pieces or other attachments.

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.

Attention shall be paid to the quality of tack welds. 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.

When used, clamps for aligning pipes shall not be removed until at least half the root run has been completed and is uniformly distributed round the circumference of the joint.

Where welded-on bridge pieces are used, the pipe surfaces shall not be left in a damaged condition after the bridge pieces are removed.

13. Damage to parent metal by arc strikes

Arc strikes away from the fusion faces should be avoided. It is recommended that electrode holders be of the fully insulated type.

14. Inter-run cleaning

Each run of weld metal shall be cleaned before a further run is applied, particular attention being paid to the junctions between the weld metal and the fusion faces. Visible defects such as cracks, cavities and other deposition faults shall be removed before deposition of further weld metal.

15. 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 pre-heating (where applicable), welding, any post-weld 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.

16. Pre-heating for cutting and welding

16.1 General. No thermal cutting, welding or tack welding shall be carried out when the temperature of the parent material within 150 mm of the joint or cut is less than 5 °C.

16.2 Pre-heating for cutting. Pre-heating for thermal cutting is unnecessary unless the temperature of the parent metal is less than 5 °C.

16.3 Pre-heating for welding. When welding material of a thickness* greater than 20 mm with non-hydrogen controlled weld metal or of a thickness* greater than 30 mm with hydrogen controlled weld metal†, a minimum pre-heating temperature of 100 °C shall be used, unless welding procedures have proved that different conditions are acceptable.

16.4 Methods. The procedure used for applying pre-heat shall ensure a satisfactory temperature distribution around and through the joint to be welded and shall not interfere with access for welding. To check that the pre-heating temperature distribution through the pipe is satisfactory, particularly when thick material is involved and/or heating is from the outside only, it is recommended that temperature measurements be made at the root of the joint. Where pre-heating is applied manually by gas torches, care shall be taken to ensure an even distribution of heat. Excessive local heating of the pipe surface shall be avoided. For details of temperature measurement see BS 2633.

17. Heat treatment after welding

17.1 General. It is advisable for the purchaser in all cases to inform the manufacturer of the use to which the pipework will be put. Post-weld heat treatment is not required for thicknesses up to and including 30 mm, unless the purchaser states in the enquiry and order that all welds are to be heat treated.

17.2 Heat treatment conditions. When post-weld heat treatment is required the soaking temperature shall be within the range 580 °C to 620 °C and the time at temperature shall be 2.5 min per millimetre of thickness with a minimum of 30 min, for both furnace and local heat treatment.

For further details of heat treatment conditions and temperature measurement see BS 2633.

18. Inspection

The purchaser or his representative shall have access, at all reasonable times, to those parts of the works or site engaged on the preparation, fabrication and testing of the pipe assemblies which he has ordered.

Section two. Butt joints

19. General

Section one 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 two. Both sections one and two of this standard shall be applied in determining the full procedure requirements.

20. All types of butt joint

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

*The greatest component thickness at the joint.

†Hydrogen controlled weld metal as defined in BS 639 contains not more than 15 ml of diffusible hydrogen per 100 g of deposited metal when determined by the method given in that standard.

Table 2. Sizing and alignment

Bore	Maximum permissible difference in internal diameter		Maximum out of alignment at the bore	
	with backing ring	without backing ring	with backing ring	without backing ring
mm	mm	mm	mm	mm
Up to and including 150	1.6	3.0	1.6	2.5
Over 150	2.5	5.0	2.5	3.0

20.1 Matching of bores. The bores of the ends of adjacent pipes shall preferably, for welding purposes, match exactly, but in any case shall not differ at any diameter by more than the amounts given in table 2, whilst the alignment shall be within the limits stated in that table.

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 given in table 2.

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

Matching shall be effected by selection, drifting, machining or by the use of a suitable expander. When drifting or expanding hot, the pipe shall be heated to a temperature within the range 900 °C to 975 °C or alternatively to a temperature within the range 500 °C to 620 °C.

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. 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 be used if desired.

20.2 Preparation of pipe ends. Typical acceptable joint preparations for pipe ends are shown in figures 1 to 7 (see also clause 9). The ends shall be prepared by machining, grinding or machine gas cutting or by hand flame cutting with subsequent filing or grinding if necessary.

NOTE. A feather edge may arise at some parts of the circumference due to the ovality of the pipe.

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.

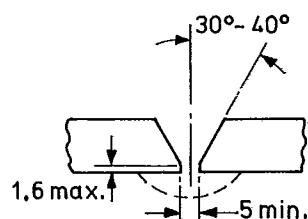


Figure 1. Single-V for use with backing ring (pipes up to and including 12.5 thick)

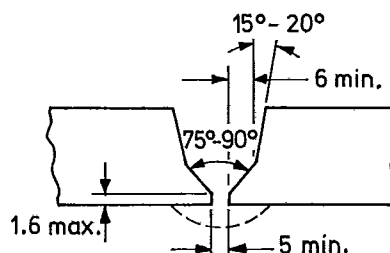
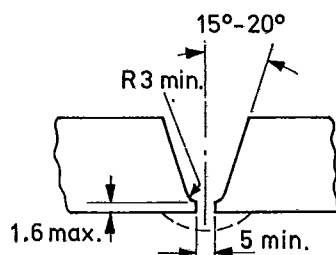
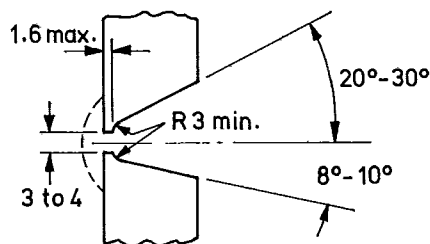


Figure 2. Double angle-V for use with backing ring (pipes over 12.5 thick)



(a) Normal preparation



(b) Permissible alternative preparation for vertical or nearly vertical pipe

Figure 3. Single-U for use with backing ring (pipes over 12.5 thick)

All dimensions in millimetres.

Figures 1 to 3. Typical butt joint preparations for use with backing rings

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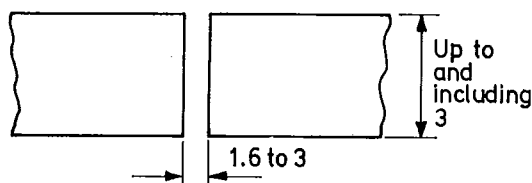


Figure 4. Square butt

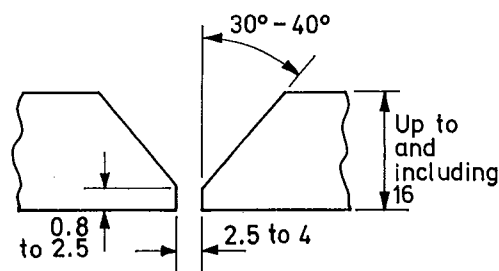


Figure 5. Single-V with root face

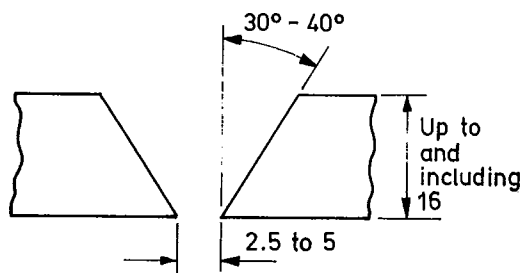


Figure 6. Single-V without root face for use with special welding technique

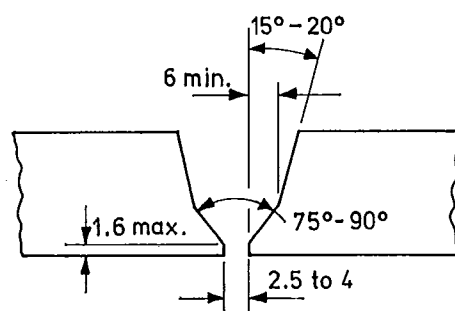


Figure 7. Double angle-V for pipes over 12.5 thick

All dimensions in millimetres.

Figures 4 to 7. Typical butt joint preparations for use without backing rings

21. Gusseted bends

21.1 General. The service conditions for which gusseted bends may be used shall be the subject of agreement between the purchaser, the manufacturer and the inspecting authority, except where an application standard permits the use of such bends.

Gusseted bends are of the following types.

- (a) *Segmental*: separate pieces of pipe cut at an angle and welded together.
- (b) *Cut-and-shut*: wedge shaped pieces cut from one side of a pipe, the pipe pulled round until the cut edges come to the correct welding position and then welded.

21.2 Preparation

21.2.1 General. The preparation of any gusset for any gusseted bend shall be done by cutting the pipe end to the correct angle followed by the weld preparation as specified in 20.2.

To prepare the gussets 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 gussets tacked in position.

21.2.2 Segmental bends. The planes of 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 change of angle of the centreline at each cut shall not exceed approximately 30° except that right angle bends of radius equal to the nominal bore of the pipe made from pipe not exceeding 88.9 mm outside diameter may be made with a minimum of two cuts (see figure 8).

For segmental right angle bends of radius equal to the nominal bore of the pipe, the dimensions of the segments at the throat of the bend shall be as shown in figure 8. In no case shall the width of the segment at the throat of the bend measured at the outside diameter of the pipe be less than 16.5 mm.

21.2.3 Cut-and-shut bends. A cut-and-shut bend shall have the angle of cut equally disposed about a line at right angles to the axis of the pipe. (See figure 9.)

21.3 Welding procedure. A weld in a gusseted bend shall be treated as a butt weld and the requirements of clauses 12 and 19 and 20.2 shall apply.