

Specification for

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

ICS 25.160.10

Confirmed December 2011

Committees responsible for this British Standard

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

- Associated Offices Technical Committee
- British Gas plc
- British Non-ferrous Metals Federation
- British Nuclear Fuels Ltd.
- Electricity Association
- 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
- National Association of Plumbing, Heating and Mechanical Services Contractors
- Power Generation Contractors' Association (BEAMA Ltd.)
- Stainless Steel Fabricators' Association of Great Britain
- United Kingdom Atomic Energy Authority
- Welding Institute
- Welding Manufacturers' Association (BEAMA Ltd.)

This British Standard, having been prepared under the direction of the Welding Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 28 June 1991

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First published April 1961
Second edition October 1977
Third edition June 1991

The following BSI references relate to the work on this standard:
Committee reference WEE/21
Draft for comment 90/71692 DC

ISBN 0 580 19384 5

Amendments issued since publication

Amd. No.	Date	Text affected
9773	February 1998	Indicated by a sideline in the margin

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Foreword

This revision of this British Standard has been prepared under the direction of the Welding Standards Policy Committee. It embodies the technical developments that have taken place since the 1977 edition, which is superseded and withdrawn. On common aspects the standard has generally been aligned with BS 2633.

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).

It is recommended that carbon steels with a carbon content exceeding 0.25 % and all ferritic alloy steels be welded in accordance with BS 2633 irrespective of the operating conditions.

Purchasers ordering to this standard are advised to specify in their contracts that the manufacturer operates a quality system in compliance with the appropriate standard in the BS EN ISO 9000 series to assure themselves that pipework claimed to have been welded in accordance with BS 2971 consistently achieves the required level of quality.

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	Specification for 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 4204	Specification for flash welding of steel tubes for pressure applications
BS 4677	Specification for arc welding of austenitic stainless steel pipework for carrying fluids

Inspecting authority. For the purposes of this British Standard the term 'inspecting authority' refers to that competent independent body or association which verifies compliance with this standard.

Contracting parties. For the purposes of this British Standard, the term 'contracting parties' is intended to cover the purchaser, the manufacturer and the inspecting authority in any relevant combination according to the particular circumstances.

Pipe and tube. For the purposes of 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.

Pipework dimensions. Unless otherwise qualified, for the purposes of this British Standard 'pipe diameter' relates to the nominal value of the outside diameter and 'pipe thickness' relates to the nominal value of the wall thickness specified in the standard to which the pipe is ordered.

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.

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

Section 1. 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.

NOTE 1. For details of oxy-acetylene welding see BS 2640.

This standard is only applicable where there is adequate access available for welding and, when required, non-destructive testing.

NOTE 2. In cases of poor access, a mechanical connection could be used.

In addition to the definitive requirements, this standard 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 3. 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 at the contract stage 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 permanent backing rings are required (see 8.1).
- d) Whether all welds are to be heat-treated after welding (see 18.1).
- e) Whether completed welds are to be ground (see 32.1).
- f) The category required for non-destructive testing of butt joints (see 34.1).
- g) Whether a written welding procedure specification is required (see 39.1).
- h) Whether an approved welding procedure is required to be used (see 39.2).
- i) Whether welding procedure tests using pipe of specified diameter and thickness are required (see 39.3).

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 materials 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 joint preparation to be used (see clause 9).
- d) The precautions to be taken when design factors are such that the meeting of more than two welded seams cannot be avoided (see clause 10).
- e) The service conditions for which gusseted bends are to be used (see 21.1).
- f) Details of joint design and fabrication when the branch angle is less than 60° (see 23.1).
- g) The method and amount of inspection for partial penetration welds on structural attachments (see 28.2).
- h) The use and extent of non-destructive testing (see clause 33).
- i) The inspection and testing requirements for other than butt joints (see 34.2).
- j) The use of a joint preparation incorporating a wider root gap for making a repair weld (see 37.3(c)).

3 Parent metal

3.1 The parent metal for pipes (including those with a longitudinal or helical welded seam) and attachments shall be carbon or carbon-manganese steel containing not more than 0.25 % carbon. The materials selected shall be agreed between the contracting parties, taking account of their suitability for the service conditions (see 2.2(a)).

NOTE. Appendix B gives details of grades in British Standards for the type of steel given in 3.1 and nearest similar grades in ASTM and DIN standards for pipe.

3.2 When required by the purchaser, the manufacturer shall maintain records of the materials used during fabrication (see 2.1(b)).

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 or porosity shall be subject to agreement between the contracting parties (see **2.2(b)**).

4 Weld metal

4.1 Mechanical properties and chemical composition

The mechanical properties of the weld metal shall be suitable for the design requirements of the pipework system.

NOTE 1. In general, the requirements for yield strength should be at least equal to the minimum in the specification for the parent metal.

The chemical composition of the weld metal, including that from fusible inserts, shall be compatible with that of the parent material. The use of hydrogen-controlled weld metal shall be as given in **17.3**.

NOTE 2. The requirements of this clause are met by welding consumables of the types stated that comply with the following British Standards:

- covered electrodes for manual metal-arc welding with BS EN 499;
- filler materials for gas-shielded arc welding with BS EN 440;
- filler wire/flux combinations for submerged-arc welding with BS EN 756 and BS EN 760;
- tubular cored electrodes for arc welding with BS 7084.

As submerged-arc welding conditions can have a significant effect on the chemical composition of the weld metal, the welding conditions shall be controlled to ensure that the correct weld metal composition is consistently achieved.

4.2 Storage and handling

Electrodes, filler wires and rods, and fluxes shall be stored and handled in accordance with the manufacturer's recommendations 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.

5 Gases for shielding and purging

5.1 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) *Carbon dioxide*, 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.

NOTE. Certain gases are heavier than air and therefore precautions should be taken to ensure adequate ventilation and extraction for all welding processes.

5.2 Gases for back purging

For purging the back of a weld during welding, argon, argon/hydrogen mixtures or helium as specified in **6.1** 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.

6 Equipment

Welding plant, instruments, cables and accessories shall comply with the appropriate Parts of BS 638, BS EN 50078, BS EN 60974-11 and BS EN 60974-12. Their capacity shall be adequate for the welding procedure proposed to be used.

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.

NOTE. Attention is drawn to the advice on safety precautions contained in Guidance Note PM 64 'Arc welding electrical safety' issued by the Health and Safety Executive and published by HM Stationery Office.¹⁾

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.

¹⁾ Available from The Stationery Office, 49 High Holborn, London WC1 for personal callers, or by post from The Stationery Office, PO Box 276, London SW8 5DT.

7 Welding processes

7.1 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
- tubular cored arc welding with or without gas-shielding.

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.

Table 1. Methods of making initial root runs in butt joints¹⁾	
Welding processes	Type of joint
Manual metal-arc welding MIG welding Metal active-gas welding Tubular cored arc welding with or without gas-shielding	With temporary ²⁾ or permanent (if permitted, see 8.1) backing ring or unbacked without purge
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	Backed or unbacked with or without purge
Submerged-arc welding	With temporary ²⁾ or permanent (if permitted, see 8.1) backing ring
¹⁾ By agreement between the contracting parties, joints in certain materials may be made with an oxy-acetylene root run without a backing ring (see BS 2640). ²⁾ The use of temporary backing rings is dependent upon access for their removal on completion of the weld (see also clause 8).	

8 Backing rings

8.1 Permanent steel backing rings

When permanent steel backing rings are permitted by the application standard or are required by the purchaser (see 2.1(c)), 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, shall not be used as they increase the tendency to weld root crack formation.

When a machined backing ring is split to allow it to spring against the internal surface of the pipe, the gap between the ends of the split ring, after fitting, shall not exceed 3 mm.

8.2 Material for permanent or temporary steel 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.

NOTE. A high or segregated sulphur content in the backing ring may produce flaws at or in the root run.

9 Joint preparations

Joint preparations shall be agreed between the contracting parties (see 2.2(c)).

NOTE. Typical joint preparations are given in appendix C.

10 Proximity of welds

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

If design factors are such that the meeting of more than two welded seams cannot be avoided, then appropriate precautions shall be taken which shall be agreed between the contracting parties (see 2.2(d)).

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.

NOTE. 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 should demonstrate their acceptability by means of specimen welds (see BS 6084).

12 Assembly for welding

To maintain the specified alignment and gap, where used, during welding (see 20.1), the parts to be welded shall be securely held in position by mechanical means, welded-on bridge pieces or by tack welding.

NOTE. The dimension of the root gap is the dimension 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.

The preheating requirements given in clause 17 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 Purging

When back purging, air shall be removed in the vicinity of the weld by the admission of a sufficient volume of purging gas such that oxidation of the penetration bead is prevented.

14 Damage to parent metal by arc strikes

While arc strikes are to be avoided, any that do occur shall be assessed and when necessary shall be either ground smooth or filled to restore the metal thickness. A piece of scrap 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.

NOTE 2. Stray arcing between the work and either the welding earth return lead or any part at earth potential can be avoided by a firm earth connection (see clause 6).

15 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. Visible flaws such as cracks, cavities and other deposition faults shall be removed before deposition of further weld metal.

16 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 preheating (where applicable; see clause 17), 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.

17 Preheating for cutting and welding

17.1 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.

17.2 Preheating for cutting

Preheating for thermal cutting shall be applied when the temperature of the parent metal is less than 5 °C.

17.3 Preheating for welding

When welding material of a thickness¹⁾ greater than 20 mm with non-hydrogen controlled weld metal, or of a thickness¹⁾ greater than 30 mm with hydrogen controlled weld metal²⁾, a minimum preheating temperature of 100 °C shall be used, unless welding procedures have proved that different conditions are acceptable.

17.4 Methods

Preheating shall be applied by one of the following means, the choice being dependent on local conditions:

- a) gas rings, gas radiant panels or muffle furnaces;
- b) electric resistance heaters;
- c) induction heating;
- d) oxy-acetylene or other gas torches.

¹⁾ The greatest component thickness at the joint.

²⁾ Hydrogen controlled weld metal as defined in BS EN 499 contains not more than 15 ml of diffusible hydrogen per 100 g of deposited metal when determined by the method given in BS 6693 : Part 2.

The procedure used shall ensure a satisfactory temperature distribution around and through the joint to be welded and shall not interfere with access for welding.

NOTE. To check that the preheating 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. For details of temperature measurement, see BS 2633.

Where preheating 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.

18 Heat treatment after welding

18.1 General

Post-weld heat treatment shall not be required for pipe or weld-throat thicknesses up to and including 35 mm, unless the purchaser states in the enquiry and order that all welds are to be heat treated (see 2.1(d)).

NOTE. It is advisable for the purchaser in all cases to inform the manufacturer of the use to which the pipework will be put.

18.2 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 this temperature shall be 2.5 min per millimetre of thickness with a minimum of 30 min, for both furnace and local heat treatment.

Other relevant details of heat treatment conditions and temperature measurement shall be in accordance with BS 2633.