

Specification for

Metal arc welding of steel for concrete reinforcement

Committees responsible for this British Standard

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- British Reinforcement Manufacturers Association
- British Steel Industry
- Concrete Society
- Department of Transport
- Federation of Civil Engineering Contractors
- High Yield Bar Development Association
- Institution of Structural Engineers
- UK Certification Authority Reinforcing Steels
- Welding Institute
- Welding Manufacturers Association

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Foreword

This British Standard has been prepared under the direction of the Welding Standards Policy Committee.

In using some other, more general, welding process standards, it was found that there were certain difficulties in applying these to reinforcing steels and it was decided to produce a standard devoted specifically to these.

It should be emphasized that the procedures and testing contained in this standard apply solely to assessing the weld and do not take into account design criteria, e.g. fatigue, that are more properly the responsibility of the application standard.

It has been assumed in the drafting of this 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 24, 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.

1 Scope

This British Standard specifies requirements for materials of construction, methods for the approval of welding procedures and welders, workmanship and inspection requirements for the joining, by metal-arc welding, of reinforcing steel for concrete structures.

It is intended for use in the welding of reinforcing steel complying with BS 4449 and BS 4482 but also applies to the welding of steel connection devices, inserts, anchors and anchor details, including prefabricated assemblies required in reinforced concrete and precast concrete constructions, in the fabrication shop and in the field.

In addition to the definitive requirements, it also requires the items detailed in clause 3 to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

The welding processes covered by this British Standard are manual metal-arc welding, gas-shielded welding with solid or flux-cored wires and non-shielded welding, using either a bare wire or cored electrode.

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

2 Definitions

For the purposes of this British Standard the following definitions apply. For other relevant terms the definitions in BS 499-1 apply.

2.1 bar

a steel product of plain round or deformed profile, including a rod or wire of steel

2.2 hot rolled bar

a bar that complies with the requirements of BS 4449

2.3 cold worked bar

a bar that complies with the requirements of BS 4449

2.4 cold reduced wire

wire that complies with the requirements of BS 4482

2.5 deformed bar or wire

bar or wire that is so shaped that its bond with concrete is increased, the degree of deformation being as defined in BS 4449 or BS 4482, as relevant

2.6 size (nominal size, d)

the diameter of a circle with an area equal to the effective cross-sectional area of the bar, rod or wire

2.7 yield stress

the stress measured during the tensile test when the extension is a specified percentage increase in the gauge length

2.8 structural joint

a joint designed to support loads during service

NOTE For example butt joints between bars, or joints between bars and anchorage plates.

2.9 tack weld

a weld used to hold together assemblies of reinforcing bars

2.10 flare-bevel fillet weld

a weld between the curved surface of a reinforcing bar and the flat surface of a plate section (See Figure 1(a).)

2.11 flare-vee fillet weld

a weld between the curved surfaces of two adjacent parallel bars (See Figure 1(b).)

2.12 butt joint

a joint between two bars, having their axes in alignment, joined to each other by a butt weld, the cross section of the bars being welded (See Figure 2.)

2.13 splice joint

a joint between two bars having their axes in alignment, the bars being attached by fillet welds to a common splice member, the cross section of the bars being unwelded (See Figure 3.)

2.14 splice member

a plate, angle, section, sleeve or bar used as a link between two bars in a joint, the two bars being welded separately to the link instead of directly to each other (See Figure 3.)

2.15 lap joint

a connection between two overlapping bars (see Figure 4 and Figure 5.)

2.16**cruciform joint**

a joint between two bars, having their axes at right angles, joined to each other by a fillet weld, the cross section of the bars being unwelded (see Figure 6)

3 Information and requirements to be agreed and to be documented**3.1 Information to be supplied by the client**

The following information to be supplied by the client 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, where this exists, together with any supplementary requirements.
- b) Whether written welding procedures are required (see 11.9).
- c) Whether welding procedure approval testing is required (see clauses 5 and 12).
- d) Quality assurance requirements.

3.2 Information to be supplied by either of the contracting parties

The following information, to be supplied by either of the contracting parties, shall be fully documented and the origin of the information shall be stated.

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) Specification of the parent metal and of the required weld metal together with welded joint properties and details of any backing material.
- b) Locations, dimensions and details, i.e. form of joint, gaps between parts etc. of all welds.

NOTE When symbols are used for standard weld forms, they should comply with BS 499-2.

3.3 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 documented items shall be satisfied before a claim of compliance with the standard can be made and verified.

- a) The method and extent of inspection and testing and the quality requirements in the absence of a relevant application standard (see clause 7).

b) Approval and testing of welding procedures including any to be undertaken by an independent testing laboratory or authority (see clause 5).

c) Approval and testing of welders including any to be undertaken by an independent authority (see clause 6).

d) Selection of metal arc welding consumables (see 9.1 and 9.2).

e) Whether the requirements for preheating temperatures apply (see 11.2.1).

f) Acceptance levels for minor local imperfections revealed by macro-etch tests (see 12.3.6).

4 Materials**4.1 Parent metal**

The parent metal shall comply with the requirements for chemical composition and mechanical properties given in BS 4449 or BS 4482 as relevant.

4.2 Backing material

Steel backing material to be fused in the welding process shall have a carbon equivalent and sulphur and phosphorus levels not greater than that specified for the parent metal.

5 Approval and testing of welding procedures

If so required by the client, the contractor shall carry out the relevant testing procedures according to the type of welding process employed (see clause 12).

6 Approval and testing of welders

The contractor shall satisfy the client that the welders are suitable for the work upon which they will be employed by complying with the requirements of clause 13.

7 Inspection and testing**7.1 General**

The method and extent of inspection and testing shall be in accordance with the relevant application standard where it exists.

If no application standard exists, the method and extent of inspection and testing shall be agreed between the contracting parties (see 3.3).

NOTE 1 Inspection methods may be visual, including dye penetrant examination or magnetic particle inspection and may include radiography.

NOTE 2 Because of the risk of delayed cracking, a period of at least 48 h is recommended before inspection is made of as-welded fabrications. Whatever period is used it should be stated in the inspection records.

7.2 Quality of welds

The quality of the welded joints shall meet the acceptance levels for visual examination in Table 7 and, if required, the acceptance levels for non-destructive testing given in Table 8.

8 Metal arc welding equipment

8.1 Equipment

Welding power sources, instruments, cables and accessories shall comply with the requirements of the appropriate Parts of BS 638. The capacity of the welding power source and ancillary equipment shall be adequate for the welding procedure to be used and shall be maintained in good working order.

All electrical plant used in connection with the welding operation shall be correctly earthed. The welding return lead from the work shall be of appropriate cross section and shall be correctly connected and earthed.

NOTE Attention is drawn to the advice on safety precautions contained in the Health and Safety at Work Guidance Note PM 64 "Electric safety in arc welding" issued by the Health and Safety Executive and published by HM Stationery Office and to BS 638-6 and BS 638-7.

8.2 Instrumentation

Means of measuring the 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 welding, means shall be provided for measuring the arc voltage, current and/or wire feed speed.

Where drying ovens are required, they shall be provided with means of measuring the oven temperature.

9 Metal arc welding consumables

9.1 Manual metal-arc welding

Electrodes shall comply with BS 639 and shall be selected having regard to the particular application, i.e. joint design, welding position and the properties required to meet service conditions [see 3.2 a)].

9.2 Gas-shielded welding

9.2.1 Filler rods and wires. Where a solid metal filler rod or wire is used with a gas-shielded process, it shall comply with BS 2901-1 and shall be selected having regard to the particular application, i.e. joint design, welding position and the properties required to meet service conditions [see 3.2 a)].

Cored electrodes, when used with the appropriate shielding gas or gas mixture, shall comply with BS 7084 and shall be selected having regard to the particular application, i.e. joint design, welding position and the properties required to meet service conditions [see 3.2 a)].

9.2.2 Shielding gases. When a gas or gas mixture is used, it shall be of the following quality, as appropriate:

- a) carbon dioxide complying with type 1 specified in BS 4105;
- b) gas mixtures of carbon dioxide and argon that have been proved to be satisfactory as a result of either documented experience or procedure approval tests.

9.3 Non-shielded welding

Electrodes for non-shielded semi-automatic arc welding, which are usually of the cored type, shall be selected having regard to the particular application, i.e. joint design, welding position and the properties required to meet service conditions [see 3.2 a)].

9.4 Storage and handling

9.4.1 General. All consumables shall be stored and handled with care and in accordance with the manufacturer's recommendations. Electrodes, filler wires and rods and fluxes that show signs of damage or deterioration shall not be used.

NOTE Examples of damage or deterioration include cracked or flaked coatings on covered electrodes, rusty or dirty electrode wires and wires with flaked or damaged copper coatings.

9.4.2 Covered electrodes. Electrodes shall be stored in their original containers in a dry, preferably heated place adequately protected from the effects of the weather and in accordance with the manufacturer's recommendations. When special protection or other treatment during storage or immediately prior to use is recommended by the electrode manufacturer, they shall be treated in accordance with the conditions detailed by the manufacturer.

In order to ensure that the weld metal deposited by hydrogen-controlled electrodes contains a maximum diffusible hydrogen content of 15 mL/100 g, determined by the methods specified in BS 6693-2 the drying or baking conditions indicated by the electrode manufacturer shall be followed.

Electrodes shall be removed from their original containers before drying or baking. After removal from the oven, the electrodes shall be protected from the exposure to conditions conducive to moisture absorption.

NOTE 1 In order to provide this protection, it may be necessary for welders to be issued with electrodes in quivers or sealed containers.

Electrodes returned to stores shall be treated in accordance with the electrode manufacturer's recommendations before re-issue.

NOTE 2 If electrodes have been exposed to poor storage conditions or it is suspected that they have become damp, the advice of the manufacturer should be sought before use.

10 Welded connections

10.1 General

For the transmission of loads reinforcing bars shall be joined together by butt, splice, lap or cruciform joints.

Where reinforcing steel is to be joined to steel plate, rolled sections or hollow sections by butt or fillet welds, the welding shall comply with this standard and, where relevant, with BS 5135.

10.2 Butt joints

Butt joints shall have full penetration butt welds and the consumables shall be chosen so that the tensile strength of the weld shall be at least as high as the specified tensile strength of the reinforcing bar.

NOTE Suitable end preparations are shown in Figure 2.

10.3 Splice joints

The splice member shall be plate, bar, angle, tube or any shape approved by the client.

Reinforcing bars shall be joined to plate or angle sections by flare bevel fillet welds and, when the splice member is a short length of bar, flare vee fillet welds shall be used (see Figure 3).

NOTE Flare bevel and flare vee fillet welds may be single or double, and splice joints made with short lengths of bars may include one or two bars. The splice joint shown in Figure 3 (c) incorporates two splice bars.

10.4 Lap joints

Lap joints shall be made with flare vee fillet welds (see Figure 4).

NOTE 1 The use of double fillet welds rather than single fillet welds will minimize bar overlap.

NOTE 2 It is recommended that, in the case of lap welds, the ends of the weld should be started and finished on the surface of one of the bars, i.e. away from the gap between the bars (see Figure 5).

10.5 Cruciform joints

Cruciform joints shall be made with flare vee fillet welds which can be intermittent or continuous (see Figure 6).

Procedure tests shall be carried out to determine what length and size of weld is required to produce joints of a given strength.

10.6 Tack welds (locational)

Tack welds to join reinforcing bars together for locational purposes prior to concreting, although essentially non load bearing, shall comply with Appendix A.

10.7 Preparation for welding

The surfaces to be welded shall be free from characteristics that would affect the quality of the weld:

- a) cracks, notches or other irregularities that can be shown to interfere with the deposition of the weld or be the cause of defects, and;
- b) loose or heavy scale, moisture, rust, oil or grease or other foreign material.

The ends of reinforcing bars to be joined by butt welds shall be prepared by mechanical means e.g. by sawing or by grinding (see Figure 2).

10.8 Assembly

Bars shall be held in the correct position until completion of welding. Each joint shall have clearance and access for the production of a sound weld.

The misalignment of bars to be joined by a direct butt weld shall be not greater than 10 % of their size or 3 mm whichever is the lesser.

Bars to be connected by means of lap joints shall be brought into mutual contact.

Before any tack welds are deposited the bars shall be preheated if necessary and the temperatures used shall be those given in Table 1 and Table 2.

Tack welds for lap joints shall be cleaned free of slag before the final weld is made.

In butt joints that are to be welded from both sides the root of the first side welded shall be ground or gouged to clean metal from the second side before depositing weld metal on that side.

10.9 Weld design

10.9.1 Weld metal strength. Electrodes shall be selected that will deposit weld metal with a yield stress comparable to the characteristic strength of the bar to be welded.

For design purposes the yield strength of the weld shall be taken as being equivalent to the characteristic strength of the reinforcing bar.

In the case of shear loading the yield stress in shear shall be taken as:

- a) 115 N/mm^2 for weld metal with a yield stress of less than 410 N/mm^2 or
- b) 160 N/mm^2 for weld metal with a yield stress of 410 N/mm^2 or more.

10.9.2 Joint design and strength. Butt joints shall be formed by complete penetration butt welds.

NOTE 1 With correctly selected consumables the strength of the weld will be not less than the specified tensile strength of the bar.

Splice joints and lap joints shall be formed by flare-bevel or flare-vee fillet welds.