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Guidance for arc welding of reinforcing steel

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Summary of pages

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31st January 2017. It was prepared by Technical Committee WEE/43, *Welding of steel for concrete reinforcement*. A list of organizations represented on this committee can be obtained on request to its secretary.

Test laboratory accreditation. Users of this British Standard are advised to consider the desirability of selecting test laboratories that are accredited to BS EN ISO/IEC 17025 by a national or international accreditation body.

Use of this document

As a guide, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

This standard has been prepared with the aim of clarifying the requirements and providing suitable guidance for the arc welding of carbon steel reinforcing bars produced in accordance with BS 4449 and BS 4482. This standard has been developed to reflect current best welding practice, standards and specifications.

This standard also gives recommendations and guidance on friction welding in Annex A.

This standard gives general guidance for the satisfactory production and control of the welding of steel reinforcement in accordance with the requirements of BS EN 1011-2, BS EN ISO 17660-1 and BS EN ISO 17660-2. In order to aid the specifier and manufacturer using these standards, additional informative guidance has been added, especially regarding the steps to be taken to avoid hydrogen cracking.

The procedures and test requirements contained in this standard apply to the assessment of the weld and its potential effect on the welded reinforcement but do not take into account design criteria, e.g. fatigue, that are the responsibility of the relevant application standard.

The preferred method of control of welding is under factory conditions. Construction site welding, if conducted, should be carried out under similar controlled conditions.

These and other products give the designer a broad range of options for specifying pre-assembled welded fabrications.

Reinforcing steel bars manufactured in accordance with the requirements of BS 4449 and BS 4482 are produced by a number of differing process routes, typically quenched and self-tempered, cold reduced and to a lesser extent micro-alloyed steel. In addition to this the profile of the reinforcement bar is ribbed and as such the welding of steel reinforcement requires a specific level of skill and job knowledge, both for the welder and the organization exercising control over the whole process, from purchasing of the steel to the eventual supply of the prefabricated item to the customer.

Whilst the specific requirements for the welding of steel reinforcement are set out in BS EN ISO 17660-1 and BS EN ISO 17660-2, this standard gives general guidance for the satisfactory production and control of welding and details some of the possible detrimental phenomena which might occur, with advice on the methods by which they can be avoided.

The recommendations in this standard are relevant to the metal arc welding processes, which are commonly used for the welding of reinforcing steels, although other welding processes may be used by agreement between the contracting parties.

1 Scope

This British Standard gives guidance for the metal arc welding of reinforcing steel bars produced in accordance with BS 4449 and BS 4482 and welded in accordance with the requirements of BS EN ISO 17660-1 and BS EN ISO 17660-2.

The welding of stainless reinforcing steels is not covered by this standard.

This British Standard can be used by clients, specifiers, construction companies and fabricators of welded steel reinforcement as a means of agreeing the technical requirements of welded steel reinforcement.

This standard applies to the welding of load bearing joints (structural and semi-structural) and non-load bearing joints, including prefabricated assemblies, produced either in a factory, workshop or in a site environment. It also applies to the welding of reinforcing steels to other steel components such as connection devices, inserts, and anchors.

This standard gives recommendations on the information to be included in the Project Specification and also covers the materials of construction, methods for the approval of welding procedures and welding, workmanship, inspection, testing and acceptance requirements for the welded joints. It can be used for all types of reinforced concrete structures designed for static loading conditions.

The recommendations in this standard can be introduced into a construction contract by a Project Specification.

This standard does not apply to factory production of welding fabric and lattice girders using multiple spot welding machines. Annex A addresses the requirements for the friction welding of steel products to reinforcement.

This standard gives general guidance on joints between reinforcing steels and other steel components. It only includes more detailed information on the most commonly used joints.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 4449:2005+A3:2016, *Steel for the reinforcement of concrete – Weldable reinforcing steel – Bar, coil and decoiled product – Specification*

BS 4482, *Steel wire for the reinforcement of concrete products – Specification*

BS EN 1011-2:2001, *Welding – Recommendations for welding of metallic materials – Part 2: Arc welding of ferritic steels*

BS EN 10020:2000, *Definition and classification of grades of steel*

BS EN ISO 2553, *Welding and allied processes – Symbolic representation of drawings – Welded joints*

BS EN ISO 3834-2, *Quality requirements for fusion welding of metallic materials – Comprehensive quality requirements*

BS EN ISO 4063:2010, *Welding and allied processes – Nomenclature of processes and reference numbers*

BS EN ISO 5817, *Welding – Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) – Quality levels for imperfections*

BS EN ISO 9015-1, *Destructive tests on welds in metallic materials – Hardness testing – Part 1: Hardness test on arc welded joints*

BS EN ISO 9606-1:2013, *Qualification testing of welders – Fusion Welding – Part 1: Steels*

BS EN ISO 13916, *Welding – Guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature*

BS EN ISO 14731:2006, *Welding coordination – Tasks and responsibilities*

BS EN ISO 15613:2004, *Specification and qualification of welding procedures for metallic materials – Qualification based on pre-production welding test*

BS EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials – Welding procedure test – Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys*

BS EN ISO 15620, *Welding – Friction welding of metallic materials*

BS EN ISO 15630-1, *Steel for the reinforcement and prestressing of concrete – Test methods – Part 1: Reinforcing bars, wire rod and wire*

BS EN ISO 15630-2, *Steel for the reinforcement and prestressing of concrete – Test methods – Part 2: Welded fabric*

BS EN ISO 17639, *Destructive tests on welds in metallic materials – Macroscopic and microscopic examination of welds*

BS EN ISO 17660-1, *Welding – Welding of reinforcing steel – Part 1: Load-bearing welded joints*

BS EN ISO 17660-2, *Welding – Welding of reinforcing steel – Part 2: Non load-bearing welded joints*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1.1 company welding coordinator

person or persons responsible for ensuring that welding is performed in accordance with the defined welding conditions, procedures and practices

3.1.2 customer

individual, or company, placing the contract with the manufacturer

3.1.3 factory

suitably enclosed rigid structure, consisting of a solid floor, walls and ceilings and constructed from recognized construction materials, providing a weatherproof envelope for the assembled products being welded so as to protect them from deleterious environmental factors such as wind, rain and snow

3.1.4 load bearing welded joint

welded joint for the transmission of specified loads between reinforcing steel bars, or between a reinforcing steel bar and other steel products

NOTE There are two types of load bearing welded joints in pre-assembled welded fabrications: semi-structural joints and structural joints.

3.1.5 manufacturer

enterprise carrying out the welding works within workshops or on site

3.1.6 non-load bearing welded joint

welded joint whose strength is not taken into account in the design of the reinforced concrete structure

NOTE 1 These welds are also referred to as locational welds.

NOTE 2 The purpose of these joints is normally only to keep the reinforcing components in place during fabrication, transport and concreting.

3.1.7 responsible welding coordinator

person or persons responsible for defining the welding conditions, procedures and practices

3.1.8 semi-structural joint

joint designed to support loads during transport and placement at the construction site to ensure safe handling, lifting, transport and use of the fabricated structure

3.1.9 shear factor S_f

relationship between the shear force of a cruciform joint and the nominal yield strength multiplied by the nominal cross-sectional area of the loaded bar

3.1.10 site welding

welding that takes place without a structure to provide a weatherproof envelope

NOTE In these instances of unprotected welding, extreme care needs to be taken to ensure that the ambient conditions are conducive to welding.

3.1.11 structural joint

joint designed to support loads during service

3.1.12 workshop

rigid structure that is capable of providing a weatherproof envelope for both welder and welds so as to protect them from deleterious environmental factors such as wind, rain and snow

NOTE The weatherproof envelope would also be expected to protect the piece, parts and stock used to manufacture the welded structure.

3.2 Symbols and abbreviations

For the purposes of this British Standard, the following symbols and abbreviations in Table 1 apply.

Table 1 **Symbols and abbreviations** (1 of 2)

Symbol	Description	Unit
A_n	nominal cross-sectional area of the bar	mm ²
A_{gt}	percentage total elongation at maximum force	%
a	weld throat thickness	mm
C_{eq}	carbon equivalent value	%
D	nominal diameter of the welded bar	mm
d	thickness of steel components	mm
d_{max}	nominal diameter of the largest bar size in the welded joint	mm
d_{min}	nominal diameter of the smallest bar size in the welded joint	mm
l	length of weld	mm
R_e	specified characteristic yield strength of the reinforcing steel bar	N/mm ²

Table 1 Symbols and abbreviations (2 of 2)

R_m	nominal tensile strength of the reinforcing steel bar	N/mm ²
F_s	shear force	kN
S_f	shear factor	—
t	time	—
w	weld width	mm
WPQR	welding procedure qualification record	—
WPS	welding procedure specification	—

NOTE 1 If R_m is not specified for the parent metal, the value of R_m is to be taken as the specified characteristic yield strength R_e of the bar multiplied by the specified characteristic R_m/R_e ratio.

NOTE 2 Other symbols and abbreviated terms should be as specified in BS EN ISO 17660-1 and BS EN ISO 17660-2.

4 Information required by the manufacturer – Project specification

It is the responsibility of the customer to provide appropriate information for the intended works.

The following items, agreed between the contracting parties, should be fully documented. If not specified by the customer, they should be stated by the manufacturer.

- Specification of the parent metal and of the required weld metal together with welded joint properties and details of any backing material.
- Locations, dimensions and details, i.e. form of joint, gaps between parts etc. of all welds.
- Examiner responsible for qualification of weld test procedures (see Note 1).
- Examiner responsible for qualification and testing of welders (see Note 1).
- The method and extent of inspection and testing and the quality requirements (see Clause 9).
- The project specification should clearly identify if there is a design requirement, including temporary works design, and who is responsible for the design.
- Agreed weld quality acceptance levels (see 7.4).
- Quality management system requirements.
- Whether third party approval is required by the customer.

NOTE Testing of welding procedures and welders can be undertaken by an independent testing laboratory or authority (see Clause 7). Users of this British Standard are advised to consider the desirability of selecting test laboratories that are accredited to BS EN ISO/IEC 17025 by a national or international accreditation body.

Other additions and deviations may be agreed between the contracting parties.

When symbols are used for standard weld forms, they should conform to BS EN ISO 2553 and BS EN ISO 4063.

In the event of a conflict in specified requirements, the Project Specification takes precedence over other documents.

5 Materials – Parent materials

5.1 Reinforcing steels

Reinforcing steels should conform to the requirements of BS 4449 or BS 4482.

5.2 Other steel components

Other steel components should have carbon equivalent, sulphur and phosphorus levels not greater than those specified in 7.1 of BS 4449:2005+A3 and in BS 4482 for the reinforcing steel being welded. Other steel components may include hot rolled products of structural steels in accordance with BS EN 10025.

5.3 Material test certificates

All the steels being welded should have a material test certificate available which should include the carbon equivalent value (C_{eq}) and the manufacturing process route.

5.4 Welding consumables

5.4.1 General

Welding consumables should be designated in accordance with the relevant product standard. Consumables should be selected with regard to the particular application, e.g. joint design, welding position and the properties required to meet the service conditions. Any special recommendations given by the manufacturer/supplier should be observed.

Many welding consumables are now required to be CE marked and relevant documentation should be verified before use of materials.

5.4.2 Supply, storage and handling

All consumables should be stored and handled with care and in accordance with the relevant standards and/or the manufacturer's/supplier's recommendations.

All covered electrodes, wire electrodes, rods and fluxes, etc. as well as their packaging, which show signs of damage or deterioration should not be used.

NOTE Examples of damage or deterioration are cracked or flaked coatings on covered electrodes, rusty or dirty wire electrodes and wire with flaked or damaged protective coatings.

Consumables returned to the stores should be treated in accordance with the manufacturer's/supplier's recommendations before re-issue.

6 Workmanship – Welding processes and joints

6.1 Welding processes

The welding processes covered by this standard are listed in Table 2. Other welding processes may be used by agreement between the contracting parties.

Table 2 List of most common welding processes

Welding process – Ref No. from BS EN ISO 4063	Term
111	metal-arc welding with covered electrode (MMA)
131	metal-arc inert gas welding (MIG welding)
135	metal-arc active gas welding (MAG welding)