

Specification and approval of welding procedures for metallic materials

Part 1. General rules for fusion welding

The European Standard EN 288 : Part 1 : 1992 has the status of a British Standard

Descriptif et qualification d'un mode
opérateur de soudage sur les matériaux
métalliques
Partie 1. Règles générales; soudage par fusion

Anforderung und Anerkennung von
Schweißverfahren für metallische Werkstoffe
Teil 1. Allgemeine Regeln für das
Schmelzschweißen

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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 1 May 1992

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The following BSI references relate to the work on this standard:
Committee reference WEE/36
Draft for comment 89/70001 DC

ISBN 0 580 20433 2

Amendments issued since publication

Amd. No.	Date	Text affected

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National foreword

This British Standard has been prepared under the direction of the Welding Standards Policy Committee and is the English language version of EN 288 'Specification and approval of welding procedures for metallic materials — Part 1 : General rules for fusion welding', published by the European Committee for Standardization (CEN).

EN 288-1 was produced as a result of international discussion in which the UK took an active part.

National appendix NA gives the constitution of the committee responsible for UK participation in the preparation of this standard.

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 288-1

February 1992

UDC 621.791.75(083.1)

Descriptors: Welding, welded joints, procedure, approval, definitions, generalities

English version

Specification and approval of welding procedures for
metallic materials —
Part 1: General rules for fusion welding

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Europäisches Komitee für Normung

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Ref. No. EN 288-1 : 1992 E

Foreword

This standard has been prepared by Working Group 1 Specification and approval of welding procedures for metallic materials of CEN/TC 121 Welding.

For this standard, ISO/TC 44/SC10 N 175 was considered and used as a basis. However, alterations were necessary due to the consideration of experience and updated knowledge.

This standard consists of various parts. The already finalized parts of this standard are listed in clause 2.

More parts are being prepared by CEN/TC 121 and the contents of these are described briefly in Annex A of this part.

In accordance with the Common CEN/CENELEC Rules, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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0 Introduction

Welding procedure specifications are needed in order to provide a well defined basis for planning of the welding operations and for quality control during welding. Welding is considered a special process in the terminology of standards for quality systems. Standards for quality systems usually require that special processes shall be carried out in accordance with written procedure specifications.

Part 2 of this standard defines a format for the welding procedure specifications for arc welding of metallic materials, which is considered to fulfill the requirements in current standards for quality systems as regards procedure specifications.

Preparation of a welding procedure specification provides the necessary basis for, but does not in itself ensure that the welds fulfill the requirements. Some deviations, notably imperfections and distortions, can be evaluated by non-destructive methods on the finished product.

Metallurgical deviations constitute a special problem, however, because non-destructive evaluation of the mechanical properties is impossible at the present level on non-destructive technology. This has resulted in the establishment of a set of rules for approval of the welding procedure prior to the release of the specification to actual production. Part 1 of this standard defines these rules.

1 Scope

This standard defines general rules for the specification and approval of welding procedures for metallic materials. This standard also refers to several other standards as regards detailed rules for specific applications.

It is assumed that the welding procedure specifications are used in production by competent welders, approved in accordance with the relevant part of EN 287.

This standard presupposes production by conventional welding equipment under direct control of the welder. This standard may not be sufficient for fully automatic or robotic welding, without direct human control ("intelligent welding system").

This standard applies when approval of the welding procedure is required e.g. by either contract, standards, rules or legal requirements.

The use of a particular method of approval of a welding procedure is often a mandatory requirement of an application standard. In the absence of such a requirement the method of approval shall be agreed between the contracting parties at the enquiry or at the order stage.

2 Normative references

This standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

- | | |
|----------------|---|
| EN 287-1, | Approval testing of welders – Fusion welding – Part 1: Steels |
| EN 287-2, | Approval testing of welders – Fusion welding – Part 2: Aluminium and aluminium alloys |
| EN 288-2, | Specification and approval of welding procedures for metallic materials – Part 2: Welding procedure specification for arc welding |
| EN 288-3, | Specification and approval of welding procedures for metallic materials – Part 3: Welding procedure tests for the arc welding of steels |
| EN 288-4, | Specification and approval of welding procedures for metallic materials – Part 4: Welding procedure tests for the arc welding of aluminium and its alloys |
| EN 26520, | Classification of imperfections in metallic fusion welds, with explanations |
| ISO 857:1990, | Welding, brazing and soldering processes – Vocabulary |
| ISO 4063:1990, | Welding brazing, soldering and braze welding of metals – Nomenclature of processes and reference numbers for symbolic representation on drawings |

3 Definitions

3.1 Welding procedure

A specified course of action to be followed in making a weld, including reference to materials, preparation, preheating (if necessary), method and control of welding and post-weld heat treatment (if relevant), and necessary equipment to be used.

3.2 Welding processes

For the welding processes the nomenclature and definitions given in ISO 857 are followed in this standard. The numbering system for welding processes in ISO 4063 is adhered to.

3.3 Preliminary welding procedure specification (pWPS)

A tentative welding procedure specification, which is assumed to be adequate by the manufacturer, but which has not been approved. Welding of test pieces needed for approval of a welding procedure specification has to be carried out on the basis of a preliminary welding procedure specification (pWPS).

3.4 Welding procedure specification (WPS)

A document providing in detail the required variables for a specific application to assure repeatability.

3.5 Work instruction

Simplified specification of the welding procedure, suitable for direct application in the workshop.

3.6 Approved welding procedure specification

A specification for which the welding procedure has been approved in accordance with the rules of this standard.

3.7 Welding procedure approval record (WPAR)

A record comprising all relevant data from the welding of a test piece needed for approval of a welding procedure specification as well as all results from the testing of the test weld.

NOTE 1: One or more welding procedure approval records may be needed in order to approve one welding procedure specification, and one welding procedure approval record may, in certain cases, provide approval for more than one welding procedure specification.

NOTE 2: WPAR was formerly designated as WPQR.

3.8 Previous welding experience

When it can be shown by authenticated test data that the manufacturer's established production welding procedures have been capable of consistently producing welds of acceptable quality over a period of time.

3.9 Approved welding consumable

A welding consumable or consumable combination tested and certified by an independent examiner or test body.

3.10 Welding procedure test

The making and testing of a welded joint, representative of the one to be used in production, in order to prove the feasibility of a welding procedure.

3.11 Standard welding procedure

A welding procedure tested and certified by an independent examiner or test body which may then be made available to any manufacturer.

3.12 Pre-production welding test

A welding test having the same function as a welding procedure test, but based on a non-standard test piece, simulating the production conditions.

3.13 Welding consumables

Materials consumed in the making of a weld, including filler metals, fluxes and gases.

3.14 Welding variable

3.14.1 Essential variable

A variable which influences the mechanical and/or metallurgical properties of the welded joint.

3.14.2 Additional variable

A variable which does not influence the mechanical and/or metallurgical properties of the welded joint.

3.15 Range of approval

The extent of approval for an essential variable.

3.16 Parent metal

3.16.1 Standard material

Parent metal of a defined chemical composition, mechanical properties, heat treatment etc., produced and delivered according to a standard or similar comprehensive specification.

3.16.2 Group of standard materials

A defined number of similar standard materials.

3.16.3 Batch of standard materials

Parent metals of the same chemical composition, mechanical properties, heat treatment etc., delivered as a unit from a single manufacturer (e.g. steel mill). The batch is limited to a single charge.

3.17 Test piece

The welded assembly which is used in the approval test.

3.18 Test specimen

The part or portion cut from the test piece in order to perform a specified destructive test.

3.19 Test

A series of operations which will include the making of a welded test piece and subsequent non-destructive and/or destructive testing and reporting of results.

3.20 Homogeneous assembly

An assembly in which the weld metal and parent metal have no significant differences in mechanical properties and/or chemical composition.

NOTE: An assembly made of similar parent metals without filler metal is considered homogeneous.

3.21 Heterogeneous assembly

An assembly in which the weld metal and parent metal have significant differences in mechanical properties and/or chemical composition.

3.22 Dissimilar metal joint

An assembly in which the parent metals have significant differences in mechanical properties and/or chemical composition.

3.23 Imperfection

A discontinuity in the weld or a deviation from the intended geometry. Imperfections include e.g.: Cracks, lack of penetration, porosity, slag inclusions.

NOTE: EN 26520 contains a comprehensive list of imperfections.

3.24 Metallurgical deviation

Changes in the mechanical properties and/or metallurgical structure of the weld metal or heat affected zones compared to the properties of the parent metal.

NOTE: Metallurgical changes include: Reduced strength, reduced ductility, reduced fracture toughness etc... in the weld metal and heat affected zones. The metallurgical changes are caused by the temperature variations during welding combined with the resulting chemical composition and structure of the weld metal.

3.25 Manufacturer

The person or organisation which is responsible for the welding production (welding workshop).

3.26 Welder

A person who performs the welding.

NOTE: A collective term used for both manual welders and welding operators.

3.27 Manual welder

A welder who holds and manipulates the electrode holder, welding gun, torch or blowpipe by hand.

3.28 Welding operator

A welder who operates welding equipment with partly mechanized relative movement between the electrode holder, welding gun, torch or blowpipe and the workpiece.

3.29 Examiner or test body

A person or organisation appointed by the contracting parties to verify compliance with the applicable standard.

3.30 Supplier of consumables

The company which manufactures or supplies the consumables.

4 Specification of welding procedures

All welding operations shall be adequately planned prior to production: the planning shall provide WPS's for all welded joints. The WPS shall comply with Part 2 of this standard. The specification level shall be compatible with the chosen method of approval.

WPS shall be classified as pWPS until approved in accordance with the rules of this standard.

The manufacturer may, in addition to the WPS, prepare detailed work instructions etc., to be used during the actual production. Work instructions are not mandatory, unless required by the manufacturer. If prepared, the work instructions shall:

- be prepared on the basis of an approved WPS;
- define values for the welding process to be used by the welder for all essential variables under direct control by the welder. The values may be given as machine settings, provided there is a well defined correspondence between machine settings and the values of the essential and additional variables defined in the WPS.

5 Approval of welding procedures

5.1 General

5.1.1 Methods for approval

This standard defines a number of methods for approval of welding procedures. Each method of approval has certain limits of application as regards welding process, parent metal and consumables (if used). Limitations for the application of the various methods of approval are stated in this standard and in subsequent parts of this standard.

Each WPS shall be approved by only one method. The use of a particular method of approval of a welding procedure is often a mandatory requirement of an application standard. In the absence of such a requirement the method of approval shall be agreed between the contracting parties at the enquiry or at the order stage.

The annex provides some guidelines for the application of each method of approval. Approval shall be obtained by one of the following types of documentation:

- previous welding experience – See 5.2.
- approved welding consumables – See 5.3.
- welding procedure tests – See 5.4.
- standard welding procedure – See 5.5.
- pre-production welding test – See 5.6.

5.1.2 Application

The manufacturer shall prepare a pWPS in accordance with the rules in clause 4. The workshop shall ensure that the pWPS is applicable for the actual production, using experience from previous productions and the general fund of knowledge of welding technology. Subsequently, the pWPS shall be approved by one of the methods stated in 5.1.1.

If the approval involves welding of test pieces, then the test pieces shall be welded in accordance with the pWPS.

All welding procedures shall be approved prior to actual production welding.

5.1.3 Supervision

When approval is obtained by a welding procedure test or pre-production welding test, all activities including preparation and assembly related to welding, inspection and testing of the test pieces shall be verified by the examiner or test body.

5.2 Approval by previous welding experience

A manufacturer may have a WPS approved by referring to previous experience on condition that he can prove by appropriate authentic documentation of an independent nature that he has previously satisfactorily welded the type of joint and materials in question.

The permissible range for a WPS, approved by reference to previous experience, shall be limited to the standard material(s), welding process(es), consumable(s) and ranges of essential variables, for which adequate previous experience can be documented.

NOTE: Further information and technical details which specify the requirements for approval testing using previous welding experience will be identified in a subsequent part of EN 288.

5.3 Approval by use of approved welding consumables

Some materials do not deteriorate significantly in the heat affected zones, provided heat inputs are kept within specified limits. For such materials, a WPS shall be considered approved on the condition that the welding consumables are approved and that all essential variables are within the range for which the approval is valid.

Approval by the use of approved welding consumables shall be restricted to arc welding processes, using filler metals.

All activities related to welding, testing and inspection of test pieces shall be the responsibility of an independent examiner or test body. The examiner or test body shall state the permitted range of approval with regards to essential variables for the approved welding consumables.

NOTE: Further information and technical details which specify the requirements for approval testing using approved welding consumables will be identified in a subsequent part of EN 288.

5.4 Approval by welding procedure tests

Welding procedure tests shall be carried out in accordance with this standard – see e.g. Parts 3 and 4.

5.5 Approval by a standard welding procedure

A WPS prepared by a manufacturer is approved, if the ranges for all variables are within the range permitted by a standard welding procedure.

A standard welding procedure shall be prepared and approved by an independent examiner or test body. The independent examiner or test body shall verify the preparation of a pWPS, welding of test pieces, testing and inspection, and preparation of a final WPS in accordance with this standard for procedure testing.

However, special attention shall be paid to proper specification of essential welding variables so as to make the approved WPS independent of any particular make of welding machine or any particular conditions during welding of the test pieces. When approved by the examiner or test body, the final WPS becomes a standard welding procedure which may then be made available to any manufacturer.

NOTE: Further information and technical details which specify the requirements for approval testing using a standard welding procedure will be identified in a subsequent part of EN 288.

5.6 Approval by a pre-production welding test

Approval by a pre-production welding test may be used where the shape and dimensions of required test pieces (e.g. those in 6.2 of part 3) do not adequately represent the joint to be welded, e.g. attachment weld to thin pipe.

In such cases, one or more special test pieces shall be made to simulate the production joint in all essential features, e.g. dimensions, restraint, heat sink effects. The test shall be carried out prior and under the conditions to be used in production.

Inspection and testing of the test piece shall be carried out as far as possible within the requirements of this standard e.g. Parts 3 and 4, but this testing may need to be supplemented or replaced by special tests according to the nature of the joint in question and shall be agreed by the examiner or test body.

A satisfactory pre-production welding test approves any WPS essentially similar to that used in the test.

NOTE: Further information and technical details which specify the requirements for approval testing using a standard welding procedure will be identified in a subsequent part of EN 288.

Annex A

(informative)

Guidelines for the application and the subsequent choice of method of approval

A large number of national standards for specification and approval of welding procedures are in existence. Although of a similar nature, the requirements differ in many details. The present set of standards (Part 1 and subsequent parts) provides an European, standardized system for specification and approval of welding procedures. The European system should comply with the principles of most of the national standards and should permit a gradual transfer to a truly European system.

Approval by reference to previous welding experience (see 5.2) has a number of applications. Only welding procedures known from experience to be reliable should be used in such cases.

Approval by use of an approved welding consumable (see 5.3) has been used for many years by some branches of industry. Approval of the welding consumables is carried out according to national schemes pending the establishment of European certification schemes.

Approval by welding procedure tests (see 5.4) is standardized in a large number of national standards and widely used in many countries. A procedure test may be a rather expensive type of approval. A procedure test is needed whenever the properties of the material in the weld metal and heat affected zones are critical for the application.

Approval by reference to a standard welding procedure (see 5.5) presently is used to a rather limited extent; it is covered only by few national rules. This type of approval is attractive, because it has the potential of lowering the costs related to approval for the individual manufacturer.

National schemes for standard welding procedures are presently being developed in several countries. The present set of European standards should be compatible with such national schemes.

Approval by pre-production welding test (see 5.6) is rarely mentioned in national standards. It is, however, needed for special welding procedures.

Approval by a pre-production test is the only reliable method of approval for some welding procedures, of which the resulting properties of the weld strongly depend on certain conditions such as; component, special restraint conditions, heat sinks etc., which cannot be reproduced by standardized test pieces.

NOTE 1: Testing of test pieces or complete products may be carried out during actual production as part of a statistical quality control programme, based on destructive testing. Such production testing should not be used as a substitute for pre-production testing and a requirement for pre-production testing should not be taken to entail production testing.

NOTE 2: In many cases feasibility tests are performed prior to production even though the welding procedure is approved. Examples are run-in tests of new welding machines and tests of an established (and approved) welding procedure in an unusual joint or position. Test pieces welded during feasibility tests usually are examined and tested for imperfections only. Reference to this standard should not be interpreted as a requirement for any feasibility testing and a requirement for approval of the welding procedure by pre-production test.

National appendix NA (informative)

The United Kingdom participation in the preparation of this European Standard was entrusted by the Welding Standards Policy Committee (WEE/-) to Technical Committee WEE/36, upon which the following bodies were represented:

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Associated Offices Technical Committee
Association of Consulting Scientists
British Constructional Steelwork Association Ltd.
British Gas plc
British Nuclear Fuels plc
British Railways Board
British Steel Industry
Electricity Industry in United Kingdom
Engineering Equipment and Materials Users' Association
General, Municipal, Boilermakers' and Allied Trades Union
Health and Safety Executive
Lloyd's Register of Shipping
Ministry of Defence
Power Generation Contractors' Association (BEAMA Ltd.)
Process Plant Association
Railway Industry Association of Great Britain
Stainless Steel Fabricators' Association of Great Britain
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