AWS B2.1/B2.1M:2009
An American National Standard

Specification for Welding Procedure and Performance Qualification

American Welding Society

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An American National Standard

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Specification for Welding Procedure and Performance Qualification

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Prepared by the
American Welding Society (AWS) B2 Committee on Procedure and Performance Qualification

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification provides the requirements for qualification of welding procedure specifications, welders, and welding operators for manual, semiautomatic, mechanized, and automatic welding. The welding processes included are electrogas welding, electron beam welding, electroslag welding, flux cored arc welding, gas metal arc welding, gas tungsten arc welding, laser beam welding, oxyfuel gas welding, plasma arc welding, shielded metal arc welding, stud arc welding, and submerged arc welding. Base metals, filler metals, qualification variables, welding designs, and testing requirements are also included.

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This standard is subject to revision at any time by the AWS B2 Committee on Procedure and Performance Qualification. It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn. Comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this standard are required and should be addressed to AWS Headquarters. Such comments will receive careful consideration by the AWS B2 Committee on Procedure and Performance Qualification and the author of the comments will be informed of the Committee's response to the comments. Guests are invited to attend all meetings of the AWS B2 Committee on Procedure and Performance Qualification to express their comments verbally. Procedures for appeal of an adverse decision concerning all such comments are provided in the Rules of Operation of the Technical Activities Committee. A copy of these Rules can be obtained from the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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Foreword

This foreword is not part of AWS B2.1/B2.1M:2009, *Specification for Welding Procedure and Performance Qualification*, but is included for informational purposes only.

The AWS B2 Committee on Procedure and Performance Qualification was formed in 1979. The first edition of B2.1, *Standard for Welding Procedure and Performance Qualification*, was published in 1984. This standard introduced the concept of Standard Welding Procedure Specifications (SWPSs) in addition to a set of rules for qualifying welding procedures, welders, and welding operators. The following edition, renamed B2.1:1998, *Specification for Welding Procedure and Performance Qualification*, was an extensive revision of B2.1-84. The Committee has published sixty-two Standard Welding Procedure Specifications; B2.2, *Standard for Brazing Procedure and Performance Qualification*; B2.3, *Specification for Soldering Procedure and Performance Qualification*; and B2.4, *Specification for Welding Procedure and Performance Qualification for Thermoplastics*.

AWS B2.1-84, *Standard for Welding Procedure and Performance Qualification*, was revised in 1998, 2000, and 2005.

This is the fifth edition of B2.1, *Specification for Welding Procedure and Performance Qualification*. This revision has undergone several modifications including incorporation of SI units; a major reformatting effort that has renumbered existing clauses, tables, figures, and annexes; the addition of new sample forms; and the deletion of any reference to "sheet metals." New welding and qualification variables and tighter restrictions have been made within 4.13 and 4.14. Table C.1 in Annex C, Filler Metal Groupings, has been updated to reflect revised filler metal specifications. Several new materials have been added in this edition within the Base Metal Groupings. Among the new additions are materials from Australian and New Zealand standards; a few new 10H materials, such as ASTM A 182, A 240, A 276, A 479, A 789, and A 790; and other adopted ASTM materials, including ASTM A 795, A 815, A 890, A 928, and A 995. In order to facilitate the adoption of new materials, the informative annex titled *Guidelines for Requesting Adoption of New Materials under the B2.1 Standard* has been added.

Underlined text in clauses, tables, or figures indicates an editorial or technical change from the 2005 edition. A vertical line in the margin also indicates a revision from the 2005 edition.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS B2 Committee on Procedure and Performance Qualification, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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Specification for Welding Procedure and Performance Qualification

1. Scope

This specification provides requirements for welding procedure and welding performance qualification. It is the intent that this specification be referenced by other documents, such as codes, specifications, contracts, and quality control or quality assurance manuals. Such documents are recognized in this specification as Referencing Documents. Requirements imposed by the Referencing Document supersede the requirements of this specification.

The requirements for the qualification of welding procedures are provided in Clause 4, Procedure Qualification. The requirements for the performance qualification of welders and welding operators are provided in Clause 5, Performance Qualification.

This specification also defines and establishes qualification variables. Qualification requirements are based on the premise that the Referencing Document will specify fabrication, design, base metal, filler metal, preheat, interpass temperature, postweld heat treatment, nondestructive examination, and test requirements applicable to the product. Welding procedure and performance qualifications which meet the requirements of other codes and specifications are acceptable, provided they also meet the requirements of this specification.

Base metals and filler metals have been grouped into categories that will minimize the number of qualification tests required. Substitution of one base metal or filler metal for another, even when within the allowable rules, should only be made after an evaluation of the material's suitability for its intended use. For some materials, additional tests may be appropriate to verify the material's suitability. Materials not listed require separate qualification.

This specification is intended for use with the following welding processes:

EBW = Electron Beam Welding
EGW = Electrogas Welding
ESW = Electroslag Welding
FCAW = Flux Cored Arc Welding
GMAW = Gas Metal Arc Welding
GTAW = Gas Tungsten Arc Welding
LBW = Laser Beam Welding
OFW = Oxyfuel Gas Welding
PAW = Plasma Arc Welding
SAW = Submerged Arc Welding
SMAW = Shielded Metal Arc Welding
SW = Stud Arc Welding

Employers shall be responsible for the welding performed by their organization, including the use of qualified welding procedures, qualified welders, and qualified welding operators. The welding procedure may be an AWS Standard Welding Procedure Specification (SWPS) published by the American Welding Society, or it shall be qualified by the Employer as required under the rules of Clause 4, Procedure Qualification. It is the Employer's responsibility to assure that Welding Procedure Specifications (WPSs) meet all requirements of the Referencing Document.

When not otherwise specified by the Referencing Document, the edition of this specification to be used should be established in accordance with the following:

(1) Editions may be used at any time after the effective date of issue.

(2) Latest edition of this document should be used for new contracts.

(3) Editions established by contract date may be used during the entire term of the contract, or the provisions of later editions may be used when agreed upon by the contracting parties.

This standard makes use of both U.S. Customary Units and the International System of Units (SI). The latter are shown within brackets [ ] or in appropriate columns in tables and figures. The measurements may not be exact equivalents; therefore, each system must be used independently.

Safety and health issues and concerns are beyond the scope of this standard and therefore are not fully addressed herein. Safety and health information is available from other sources, including but not limited to, ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, and applicable federal, state, and local regulations. Additionally, the cautionary notes contained in the Material Safety Data Sheets (MSDSs) supplied by the material supplier should be part of each Employer's safety program. Further safety information is available in the *Safety and Health Facts Sheets* published by the American Welding Society.

It is the responsibility of the Employer to establish appropriate safety and health practices and to determine the applicability of any regulatory limitations prior to welding.

2. Normative References

The following standards contain provisions which, through reference in this text, constitute mandatory provisions of this AWS standard. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

AWS Documents:[1]

(1) AWS A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*;

(2) AWS B4.0, *Standard Methods for Mechanical Testing of Welds*;

(3) AWS D1.4/D1.4M, *Structural Welding Code—Reinforcing Steel*; and

(4) AWS D11.2, *Guide for Welding Iron Casting*.

Other Documents:

(5) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*;[2]

(6) ASME *Boiler and Pressure Vessel Code*, Section V;[3]

(7) ASME *Boiler and Pressure Vessel Code*, Section IX; and

(8) ASTM E 165, *Standard Test Method for Liquid Penetrant Examination*.[4]

3. Terms and Definitions

AWS A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*, provides the basis for terms and definitions used herein. However, the following terms and definitions are included below to accommodate usage specific to this document.

A-Number. A designation used to classify ferrous weld metal for procedure qualification based upon chemical composition (see Annex C).

Employer. The contractor or manufacturer that adopts this specification for welding procedure and performance qualification. Closely related companies, including those with different names, for which effective control of welding is as one organization, shall be considered as one Employer.

F-Number. A designation used to group welding filler metal for procedure and performance qualifications (see Annex C).

fracture toughness. A mechanical property of materials exhibiting its ability to contain a crack and resist fracture as determined by any of the following tests: Charpy V-notch, dynamic tear, plane-strain fracture toughness, and drop-weight nil-ductility transition temperature.

interpass temperature. In a multipass weld, the minimum (preheat) or maximum metal temperature immediately prior to applying the second or all subsequent passes.

M-Number. A designation used to group base metals for procedure and performance qualifications consistent with the P-Number and S-Number designations established by the ASME *Boiler and Pressure Vessel Code*, Section IX, but which also incorporate materials not recognized or used under ASME rules (see Annex D).

pipe. Used generally to refer to pipe and tube.

plate. Used to refer to rolled, extruded, or forged products other than pipe and tube.

[1] AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.
[2] ANSI Z49.1 is published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.
[3] ASME standards are published by the American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10016-5990.
[4] ASTM International standards are published by the American Society of Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.