


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



# **Specification for Welding Procedure and Performance Qualification**



**American Welding Society**

---



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

**Approved by the  
American National Standards Institute  
August 22, 2008**

# **Specification for Welding Procedure and Performance Qualification**

**5th Edition**

**Supersedes AWS B2.1:2005**

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 electro-gas 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.



**American Welding Society**

550 N.W. LeJeune Road, Miami, FL 33126

International Standard Book Number: 978-0-87171-512-8

American Welding Society

550 N.W. LeJeune Road, Miami, FL 33126

© 2009 by American Welding Society

All rights reserved

Printed in the United States of America

**Photocopy Rights.** No portion of this standard may be reproduced, stored in a retrieval system, or transmitted in any form, including mechanical, photocopying, recording, or otherwise, without the prior written permission of the copyright owner.

Authorization to photocopy items for internal, personal, or educational classroom use only or the internal, personal, or educational classroom use only of specific clients is granted by the American Welding Society provided that the appropriate fee is paid to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, tel: (978) 750-8400; Internet: <[www.copyright.com](http://www.copyright.com)>.

## Statement on the Use of American Welding Society Standards

All standards (codes, specifications, recommended practices, methods, classifications, and guides) of the American Welding Society (AWS) are voluntary consensus standards that have been developed in accordance with the rules of the American National Standards Institute (ANSI). When AWS American National Standards are either incorporated in, or made part of, documents that are included in federal or state laws and regulations, or the regulations of other governmental bodies, their provisions carry the full legal authority of the statute. In such cases, any changes in those AWS standards must be approved by the governmental body having statutory jurisdiction before they can become a part of those laws and regulations. In all cases, these standards carry the full legal authority of the contract or other document that invokes the AWS standards. Where this contractual relationship exists, changes in or deviations from requirements of an AWS standard must be by agreement between the contracting parties.

AWS American National Standards are developed through a consensus standards development process that brings together volunteers representing varied viewpoints and interests to achieve consensus. While the AWS administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in its standards.

AWS disclaims liability for any injury to persons or to property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this standard. AWS also makes no guarantee or warranty as to the accuracy or completeness of any information published herein.

In issuing and making this standard available, AWS is neither undertaking to render professional or other services for or on behalf of any person or entity, nor is AWS undertaking to perform any duty owed by any person or entity to someone else. Anyone using these documents should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. It is assumed that the use of this standard and its provisions are entrusted to appropriately qualified and competent personnel.

This standard may be superseded by the issuance of new editions. Users should ensure that they have the latest edition.

Publication of this standard does not authorize infringement of any patent or trade name. Users of this standard accept any and all liabilities for infringement of any patent or trade name items. AWS disclaims liability for the infringement of any patent or product trade name resulting from the use of this standard.

Finally, the AWS does not monitor, police, or enforce compliance with this standard, nor does it have the power to do so.

On occasion, text, tables, or figures are printed incorrectly, constituting errata. Such errata, when discovered, are posted on the AWS web page ([www.aws.org](http://www.aws.org)).

Official interpretations of any of the technical requirements of this standard may only be obtained by sending a request, in writing, to the appropriate technical committee. Such requests should be addressed to the American Welding Society, Attention: Managing Director, Technical Services Division, 550 N.W. LeJeune Road, Miami, FL 33126 (see Annex H). With regard to technical inquiries made concerning AWS standards, oral opinions on AWS standards may be rendered. These opinions are offered solely as a convenience to users of this standard, and they do not constitute professional advice. Such opinions represent only the personal opinions of the particular individuals giving them. These individuals do not speak on behalf of AWS, nor do these oral opinions constitute official or unofficial opinions or interpretations of AWS. In addition, oral opinions are informal and should not be used as a substitute for an official interpretation.

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.

This page is intentionally blank.

## Personnel

### AWS B2 Committee on Procedure and Performance Qualification

J. J. Fluckiger, Chair	<i>Idaho National Laboratory</i>
J. L. Cooley, 1st Vice Chair	<i>J. C. and Associates, Incorporated</i>
E. W. Beckman, 2nd Vice Chair	<i>International Training Institute</i>
S. Morales, Secretary	<i>American Welding Society</i>
L. P. Connor	<i>Consultant</i>
W. D. Doty	<i>Doty and Associates, Incorporated</i>
E. H. Gray	<i>U.S. Nuclear Regulatory Commission</i>
B. J. Hable	<i>Ford Motor Company</i>
M. Herrle	<i>Arise, Incorporated</i>
R. A. LaFave	<i>Elliott Company, Incorporated</i>
K. Y. Lee	<i>The Lincoln Electric Company</i>
K. M. McTague	<i>Factory Mutual</i>
A. S. Olivares	<i>HSB Global Standards</i>
J. F. Pike	<i>NASA Langley Research Center</i>
W. M. Ruof	<i>Bechtel Plant Machinery, Incorporated</i>
J. J. Sekely	<i>Welding Services, Incorporated</i>
M. R. Stone	<i>Canadian Welding Bureau</i>
G. M. Wisbrock	<i>Lockheed Martin Missiles and Fire Control (Retired)</i>
R. K. Wiswesser	<i>Welder Training and Testing Institute</i>

### Advisors to the AWS B2 Committee on Procedure and Performance Qualification

W. L. Ballis	<i>Consultant</i>
J. D. Duncan	<i>Consultant</i>
N. K. Kanaya	<i>BEAR Testing Laboratory</i>
B. B. MacDonald	<i>Consultant</i>
A. W. Sindel	<i>Alstom Power—USA</i>
C. E. Speader, Jr.	<i>Aristech Chemical Corporation</i>
W. J. Sperko	<i>Sperko Engineering Services</i>
R. F. Waite	<i>Consultant</i>

### AWS B2A Subcommittee on Brazing Qualification

J. L. Cooley, Chair	<i>J. C. and Associates, Incorporated</i>
S. Morales, Secretary	<i>American Welding Society</i>
J. J. Fluckiger	<i>Idaho National Laboratory</i>
L. Guimaraes	<i>National Automotive Corporation</i>
R. A. LaFave	<i>Elliott Company</i>
R. L. Peaslee	<i>Wall Colmonoy Corporation</i>
W. J. Sperko	<i>Sperko Engineering Services</i>
K. P. Thornberry	<i>Care Medical, Incorporated</i>
G. M. Wisbrock	<i>Lockheed Martin Missiles and Fire Control (Retired)</i>
R. K. Wiswesser	<i>Welder Training and Testing Institute</i>

**Advisors to the AWS B2A Subcommittee on Brazing Qualification**

W. D. Rupert	<i>Wolverine Joining Technologies</i>
J. J. Sekely	<i>Welding Services, Incorporated</i>
C. E. Spaeder	<i>Consultant</i>

**AWS B2B Subcommittee on Welding Qualification**

G. M. Wisbrock, Chair	<i>Lockheed Martin Missiles and Fire Control (Retired)</i>
S. Morales, Secretary	<i>American Welding Society</i>
E. W. Beckman	<i>International Training Institute</i>
L. P. Connor	<i>Consultant</i>
J. L. Cooley	<i>J. C. and Associates, Incorporated</i>
W. D. Doty	<i>Doty and Associates, Incorporated</i>
J. J. Fluckiger	<i>Idaho National Laboratory</i>
E. H. Gray	<i>U.S. Nuclear Regulatory Commission</i>
B. J. Hable	<i>Ford Motor Company</i>
K. Y. Lee	<i>The Lincoln Electric Company</i>
K. M. McTague	<i>Factory Mutual</i>
A. S. Olivares	<i>HSB Global Standards</i>
J. F. Pike	<i>NASA Langley Research Center</i>
J. J. Sekely	<i>Welding Services, Incorporated</i>
M. R. Stone	<i>Canadian Welding Bureau</i>
R. K. Wiswesser	<i>Welder Training and Testing Institute</i>

**Advisors to the AWS B2B Subcommittee on Welding Qualification**

W. L. Ballis	<i>Consultant</i>
J. D. Duncan	<i>Consultant</i>
N. K. Kanaya	<i>BEAR Testing Laboratory</i>
V. A. McCray	<i>ExxonMobil Research and Engineering Company</i>
A. W. Sindel	<i>Sindel and Associates</i>
W. J. Sperko	<i>Sperko Engineering Services</i>

**AWS B2C Subcommittee on Materials**

W. M. Ruof, Chair	<i>Bechtel Plant Machinery, Incorporated</i>
S. Morales, Secretary	<i>American Welding Society</i>
W. D. Doty	<i>Doty and Associates, Incorporated</i>
J. J. Fluckiger	<i>Idaho National Laboratory</i>
M. Herrle	<i>Arise, Incorporated</i>
R. A. LaFave	<i>Elliott Company, Incorporated</i>

**Advisors to the AWS B2C Subcommittee on Materials**

C. E. Cross	<i>Federal Institute for Material</i>
A. Donlevy	<i>International Titanium Association</i>
G. L. Hoback	<i>Haynes International</i>
B. Moore	<i>Spectrulite</i>
P. Pollak	<i>Aluminum Association</i>
A. P. Seidler	<i>Armco Steel</i>
A. W. Sindel	<i>Sindel and Associates</i>
C. E. Speader, Jr.	<i>Aristech Chemical Corporation</i>
L. T. Vernam	<i>AlcoTec Wire Corporation</i>
G. M. Wisbrock	<i>Lockheed Martin Missiles and Fire Control (Retired)</i>

**AWS B2D Subcommittee on Standard Welding Procedure Specifications**

J. J. Sekely, Chair	<i>Welding Services, Incorporated</i>
S. Morales, Secretary	<i>American Welding Society</i>
L. P. Connor	<i>Consultant</i>
W. D. Doty	<i>Doty and Associates, Incorporated</i>
J. J. Fluckiger	<i>Idaho National Laboratory</i>
K. M. McTague	<i>Factory Mutual</i>
W. M. Ruof	<i>Bechtel Plant Machinery, Incorporated</i>

**Advisor to the AWS B2D Subcommittee on Standard Welding Procedure Specifications**

G. M. Wisbrock	<i>Lockheed Martin Missiles and Fire Control (Retired)</i>
----------------	--

**AWS B2E Subcommittee on Soldering Qualification**

E. W. Beckman, Chair	<i>International Training Institute</i>
S. Morales, Secretary	<i>American Welding Society</i>
J. L. Cooley	<i>J. C. and Associates, Incorporated</i>
J. J. Fluckiger	<i>Idaho National Laboratory</i>
E. H. Gray	<i>U.S. Nuclear Regulatory Commission</i>
P. T. Vianco	<i>Sandia National Laboratories</i>

**Advisors to the AWS B2E Subcommittee on Soldering Qualification**

G. M. Wisbrock	<i>Lockheed Martin Missiles and Fire Control</i>
R. Zahner	<i>A Zahner Company</i>

**AWS B2F Subcommittee on Plastic Welding Qualification**

L. T. Hutton, Chair	<i>ARKEMA, Incorporated</i>
R. Hanselka, Vice Chair	<i>Advanced Industrial Design</i>
S. P. Hedrick, Secretary	<i>American Welding Society</i>
K. Argasinki	<i>Solvay Solexis</i>
R. Basile	<i>AB Plastics, Incorporated</i>
M. Callahan	<i>Local 290</i>
D. Chandler	<i>Engiplast, Incorporated</i>
J. Craig	<i>McElroy Manufacturing, Incorporated</i>
P. Demchko	<i>Solvay Solexis</i>
J. J. Fluckiger	<i>Idaho National Laboratory</i>
S. M. Gardiner	<i>IPS Corporation</i>
D. P. Glavin	<i>Steamfitters Local Union 449</i>
G. Hopkins	<i>Plastek Werks, Incorporated</i>
J. Leary	<i>Asahi American, Incorporated</i>
B. B. MacDonald	<i>Consultant</i>
P. F. Martin	<i>United Association</i>
C. L. Parker	<i>Lubrizol Advanced Materials, Incorporated</i>
G. Sample	<i>George Fischer</i>
J. Sciadini	<i>Tech South, Incorporated</i>
K. C. Thomas	<i>Quadrant EPP</i>
M. J. Troughton	<i>TWI</i>
D. Ziegler	<i>Wegener North America, Incorporated</i>
P. Zitkus	<i>Wegener Welding</i>

**Advisors to the AWS B2F Subcommittee on Plastic Welding Qualification**

J. Hessel	<i>Hessel Ingenieurtechnik GmbH</i>
R. James	<i>International Training Institute</i>
A. Lopez	<i>Dow Chemical</i>
G. M. Wisbrock	<i>Lockheed Martin Missiles and Fire Control (Retired)</i>

## 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.

This page is intentionally blank.

# Table of Contents

	Page No.
<i>Personnel</i> .....	v
<i>Foreword</i> .....	ix
<i>List of Tables</i> .....	xii
<i>List of Figures</i> .....	xii
<i>List of Forms</i> .....	xiii
<b>1. Scope</b> .....	1
<b>2. Normative References</b> .....	2
<b>3. Terms and Definitions</b> .....	2
<b>4. Procedure Qualification</b> .....	4
4.1 General .....	4
4.2 Standard Welding Procedure Specifications .....	4
4.3 Welding Procedures Qualified by Employer .....	6
4.4 Evaluation of Test Weldments .....	7
4.5 Qualification Thickness Limitations .....	7
4.6 Special Test Weldment Acceptance Criteria .....	10
4.7 Pipe and Plate Groove Test Weldments and Acceptance Criteria .....	10
4.8 Fillet Test Weldments and Acceptance Criteria .....	11
4.9 Cladding Test Weldment and Acceptance Criteria .....	12
4.10 Hardfacing Test Weldment and Acceptance Criteria .....	13
4.11 Stud Welds and Acceptance Criteria .....	14
4.12 <u>Test Weldments less than 1/16 in [1.5 mm]</u> Acceptance Criteria .....	18
4.13 Welding Procedure Specification Data .....	21
4.14 Procedure Qualification Variables .....	23
<b>5. Performance Qualification</b> .....	29
5.1 General .....	29
5.2 Qualification by Standard Test .....	31
5.3 Qualification by Workmanship Test .....	31
5.4 Test Weldments .....	32
5.5 Examination Procedures and Acceptance Criteria .....	32
5.6 Performance Qualification Variables .....	35
<i>Annexes</i> .....	45
<u>Cross Reference for Renumbered Annexes from the 2005 Code to the 2009 Code</u> .....	46
<u>Annex A (Normative)—Basis for Establishing a Standard Welding Procedure Specification (SWPS)</u> .....	47
<u>Annex B (Normative)—Illustrations—Weld Position, Test Specimens, and Text Fixtures</u> .....	49
<u>Annex C (Normative)—Filler Metal Grouping</u> .....	69
<u>Annex D (Normative)—Base Metal Grouping</u> .....	73
<u>Annex E (Normative)—Radiographic Examination Procedure</u> .....	261
<u>Annex F (Informative)—Sample Forms</u> .....	265
<u>Annex G (Informative)—Macroetch Procedure</u> .....	273
<u>Annex H (Informative)—Guidelines for the Preparation of Technical Inquiries</u> .....	275
<u>Annex I (Informative)—Guidelines for Requesting Adoption of New Materials Under the AWS B2.1 Standard</u> .....	277
List of AWS Documents on Welding Procedure and Performance Qualification .....	279

## List of Tables

Table	Page No.
<u>4.1</u> Test Methods Required for Procedure Qualification .....	8
<u>4.2</u> Thickness and Size Limitations for Fillet Welds for Procedure Qualification .....	8
<u>4.3</u> Thickness Limitations of Plate and Pipe for Groove Welds for Procedure Qualification .....	9
<u>4.4</u> Thickness Limitations for Cladding and Hardfacing for Procedure Qualification .....	9
<u>4.5</u> Minimum Shear Strength for Aluminum Fillet Welds .....	16
<u>4.6</u> Minimum Tensile Load Requirements for Aluminum Stud Welds .....	18
<u>4.7</u> Minimum Torque Requirements for Steel Stud Welds .....	19
<u>4.8</u> Minimum Torque Requirements for Aluminum Stud Welds .....	19
<u>5.1</u> Examination Requirements for Performance Qualification .....	30
<u>5.2</u> Number of Bend Tests for Performance Qualification .....	31
<u>5.3</u> Allowable Base Metals for Performance Qualification .....	34
<u>5.4</u> Allowable Filler Metals for Performance Qualification .....	34
<u>5.5</u> Position Limitations for Performance Tests .....	36
<u>5.6</u> Limitations for Performance Qualification on Groove Welds in Pipe and Tube .....	44
<u>5.7</u> Limitations for Performance Qualification in Plate Groove Welds .....	44
<u>5.8</u> Limitations for Performance Qualification in Pipe Fillet Welds .....	44
<u>C.1</u> Grouping of Welding Electrodes and Rods for Qualification .....	70
<u>C.2</u> Classification of Ferrous Weld Metal for Procedure Qualification .....	72
<u>D.1</u> Listing of Base Metal Specifications—Ferrous Alloys .....	74
<u>D.1</u> Listing of Base Metal Specifications—Nonferrous Alloys .....	112
<u>D.2</u> M-Number Listing of Base Metals—Ferrous Alloys .....	136
<u>D.2</u> M-Number Listing of Base Metals—Nonferrous Alloys .....	201
<u>D.3</u> Listing of Base Metal Specifications—Iron Castings .....	259
<u>E.1</u> Acceptable Linear Discontinuities for Radiographic Examination .....	262
<u>E.2</u> Acceptable Rounded Discontinuities for Radiographic Examination .....	262

## List of Figures

Figure	Page No.
<u>4.1</u> Welding Procedure Selection Criteria .....	5
<u>4.2</u> Location of Groove Weld Test Specimens—Pipe .....	11
<u>4.3</u> Location of Test Specimens for Welded Box Tubing .....	12
<u>4.4</u> Location of Tension, Longitudinal Bend, and <u>Fracture</u> Toughness Specimens— <u>Plate</u> .....	13
<u>4.5</u> Location of Tension, <u>Fracture</u> Toughness, and Transverse Bend Specimens— <u>Plate</u> .....	14
<u>4.6</u> Location of Fillet Weld Shear Test and Macroetch Specimens .....	15
<u>4.7</u> Fillet Weld Break Test and Macroetch Specimens for Procedure Qualification .....	16
<u>4.8</u> Location of Cladding Test Specimens .....	17
<u>4.9</u> Location of Hardfacing Test Specimens .....	17
<u>5.1</u> Selection of Performance Qualification Method—Workmanship Test or Standard Test .....	30
<u>5.2</u> Typical Workmanship Test Weldments .....	33
<u>5.3</u> Location of 1G, 2G, 5G, and 6G Bend Specimens—Pipe Groove Weldment .....	37
<u>5.4</u> Location of Bend Specimens—Combined Pipe Positions 2G and 5G .....	38

<b>Figure</b>	<b>Page No.</b>
<u>5.5</u> Location of Bend Specimens for Box Tube.....	39
<u>5.6</u> Location of Transverse Bend Specimens—Plate Groove Weldment.....	39
<u>5.7</u> Location of Longitudinal Bend Specimens—Plate Groove Test Weldment.....	40
<u>5.8</u> Location of Fillet Test Specimens—Plate.....	40
<u>5.9</u> Location of Fillet Test Specimens—Alternate Weldment—Plate .....	41
<u>5.10</u> Location of Fillet Test Specimens—Pipe .....	41
<u>5.11</u> Location of Fillet Test Specimens—Alternate Weld—Pipe .....	42
<u>5.12</u> Location of Cladding Specimens—Plate .....	42
<u>5.13</u> Location of Test Specimen—Hardfacing Test Weldment—Plate.....	43
<u>B.1A</u> Welding Test Positions—Groove, Cladding, and Hardfacing Welds.....	51
<u>B.1B</u> Limits of Welding Positions—Groove, Cladding, and Hardfacing Welds .....	52
<u>B.1C</u> Welding Test Positions—Fillet Welds .....	53
<u>B.1D</u> Limits of Welding Positions—Fillet Welds .....	54
<u>B.1E</u> Welding Positions—Stud Welds .....	55
<u>B.2A</u> Transverse Face and Root Bend Specimens .....	56
<u>B.2B</u> Longitudinal Face and Root Bend Specimens .....	57
<u>B.2C</u> Transverse Side Bend Specimens .....	57
<u>B.3A</u> Reduced Section Tension Specimen—Rectangular.....	58
<u>B.3B</u> Reduced Section Tension Specimen—Round .....	59
<u>B.3C</u> Alternate Tension Specimen for Pipe 3 in [76 mm] O.D. or Less .....	59
<u>B.3D</u> Alternate Tension Specimen for Pipe 2 in [51 mm] O.D. or Less .....	60
<u>B.4A</u> Weld Cladding Side Bend Specimens.....	61
<u>B.4B</u> Weld Cladding and Hardfacing Chemical Analysis Specimens .....	61
<u>B.5A</u> Guided Bend Fixture—Bottom Ejecting Type .....	62
<u>B.5B</u> Guided Bend Fixture—Bottom Type .....	63
<u>B.5C</u> Guided Bend Fixture—Wrap-Around .....	64
<u>B.5D</u> Stud Weld Bend Test Fixture .....	65
<u>B.5E</u> Stud Weld Torque Test Fixture .....	66
<u>B.5F</u> Stud Weld Tension Test Fixture .....	67
<u>E.1</u> Rounded Indication Charts for Radiographic Examination.....	263

## List of Forms

<b>Form</b>	<b>Page No.</b>
<u>F.1</u> Example of a Performance Qualification Test Record.....	266
<u>F.2</u> Example of a Welding Procedure Specification .....	267
<u>F.3</u> Example of a Procedure Qualification Record .....	269
<u>F.4</u> Example of a Welding Procedure Specification and a Procedure Qualification Record for Stud Welding.....	271
<u>F.5</u> Example of a Welding Procedure Specification and a Procedure Qualification Record for Electroslag and Electrogas Welding .....	272

This page is intentionally blank.

# 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 = Electroslag 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:<sup>1</sup>

(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*;<sup>2</sup>

(6) ASME *Boiler and Pressure Vessel Code, Section V*;<sup>3</sup>

<sup>1</sup> AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

<sup>2</sup> ANSI Z49.1 is published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

<sup>3</sup> ASME standards are published by the American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10016-5990.

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

(8) ASTM E 165, *Standard Test Method for Liquid Penetrant Examination*.<sup>4</sup>

## 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.

<sup>4</sup> ASTM International standards are published by the American Society of Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.