AWS B2.1/B2.1M:2026
An American National Standard

Specification for Welding Procedure and Performance Qualification

American Welding Society®

Approved American National Standard
ANSI

AWS B2.1/B2.1M:2026
An American National Standard

Approved by the
American National Standards Institute
December 15, 2025

Specification for Welding Procedure and Performance Qualification

8th Edition

Revises AWS B2.1/B2.1M:2021

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.

American Welding Society®

ISBN Print: 978-1-64322-430-5
ISBN PDF: 978-1-64322-431-2
©2026 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.

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 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 is entrusted to appropriately qualified and competent personnel.

This standard may be revised, corrected through publication of amendments or errata, or supplemented by publication of addenda. Information on the latest editions of AWS standards including amendments, errata, and addenda is posted on the AWS web page (www.aws.org). Users should ensure that they have the latest edition, amendments, errata, and addenda.

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.

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

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: Director, Standards Committee Operations, 8669 NW 36 St, #130, Miami, FL 33166 (see Annex I). 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 requested 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, 8669 NW 36 St, #130, Miami, FL 33166.

Personnel

AWS B2 Committee on Procedure and Performance Qualification

A. Anderson, Chair	*ITW—Miller Electric Manufacturing Company*
T. A. Davenport, Vice Chair	*PPCP Inc.*
M. E. Barrett, 2nd Vice Chair	*Westinghouse Electric Company*
J. Padron, Secretary	*American Welding Society*
J. Alston	*Jefferson Lab*
J. P. Bell	*Yates Construction*
D. T. Braun	*Southside Virginia Community College*
M. W. Bumgarner	*Bumgarner Consulting LLC*
H. R. Castner	*Retired*
M. C. Cook	*ACME Constructors, Inc.*
J. L. Cooley	*YMC Mechanical*
C. R. Cross	*The Lincoln Electric Company*
J. D. Farren	*Office of Naval Research*
B. T. Guy	*Illinois Tools Works*
M. Herrle	*Consultant*
P. Kumar	*Special Technical Services*
D. Mata	*Kiewit Nuclear Solutions*
L. D. Melendez	*TC Energy*
T. C. Mueller	*Synergistic Technical Solutions Ltd.*
J. L. Pasqua	*Salco Products*
F. M. Rice	*Tincher's Welding, LLC*
A. B. Rigato	*Pacific Northwest National Laboratory*
W. M. Ruof	*Bechtel Plant Machinery, Inc.*
J. J. Sekely	*Welding Services, Inc.*
M. L. Thomas	*Rocky Mountain Testing, LLC*
R. K. Wiswesser	*Welder Training and Testing Institute, Inc.*

Advisors to the AWS B2 Committee on Procedure and Performance Qualification

B. W. Beckman	*International Training Institute*
M. Bernasek	*C-Spec*
B. J. Hable	*Consultant*
K. Y. Lee	*DNV*
B. B. MacDonald	*Consultant*
T. A. Mihalik	*International Training Institute*
C. D. Morell	*QSAI*
A. W. Sindel	*TRC*
W. J. Sperko	*Sperko Engineering Services, Inc*
R. F. Waite	*Robert F. Waite, PE PC*
G. M. Wisbrock	*Consultant*

AWS B2B Subcommittee on Welding Qualification

T. A. Davenport, Chair	*PPCP Inc.*
M. C. Cook, Vice Chair	*ACME Constructors, Inc.*
J. Padron, Secretary	*American Welding Society*
J. Alston	*Jefferson Lab*
A. Anderson	*ITW—Miller Electric Manufacturing Company*
M. E. Barrett	*Westinghouse Electric Company*
J. P. Bell	*Yates Construction*
D. T. Braun	*Southside Virginia Community College*
M. W. Bumgarner	*Bumgarner Consulting LLC*
H. R. Castner	*Retired*
J. L. Cooley	*YMC Mechanical*
J. D. Farren	*Office of Naval Research*
J. Hernandez	*SBC Global*
T. C. Mueller	*Synergistic Technical Solutions Ltd.*
J. L. Pasqua	*Salco Products*
A. B. Rigato	*Pacific Northwest National Laboratory*
J. J. Sekely	*Welding Services, Inc.*
M. L. Thomas	*Rocky Mountain Testing, LLC*
R. K. Wiswesser	*Welder Training and Testing Institute, Inc.*

Advisors to the AWS B2B Committee on Welding Qualification

B. W. Beckman	*International Training Institute*
M. Bernasek	*C-Spec*
B. J. Hable	*Consultant*
K. Y. Lee	*DNV*
A.S. Luby	*Moraine Park Technical College*
T. A. Mihalik	*International Training Institute*
C. D. Morell	*QSAI*
A. W. Sindel	*TRC*
W. J. Sperko	*Sperko Engineering Services, Inc*
G. Trepus	*Boeing Research and Technology*
G. M. Wisbrock, Jr.	*Consultant*

AWS B2C Subcommittee on Materials

M. Bernasek, Chair	*C-Spec*
J. Padron, Secretary	*American Welding Society*
A. Anderson	*ITW—Miller Electric Manufacturing Company*
J. L. Cooley	*YMC Mechanical*
J. D. Farren	*Office of Naval Research*
M. F. Herrle	*Arise*
A. B. Rigato	*Pacific Northwest National Laboratory*
W. M. Ruof	*Bechtel Plant Machinery, Inc.*

Advisors to the AWS B2C Committee on Materials

C. E. Cross	*Los Alamos National Laboratory*
A. Donlevy	*International Titanium Association*
B. J. Hable	*Consultant*
P. Pollak	*Pollak & Associates*
L. T. Vernam	*AlcoTec Wire Corporation*
G. M. Wisbrock, Jr.	*Consultant*

Foreword

This foreword is not part of this standard 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 numerous 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, 2005, 2009, 2014, and 2021.

This is the eighth edition of B2.1, *Specification for Welding Procedure and Performance Qualification*.

A vertical line in the margin or underlined text in clauses, tables, or figures indicates an editorial or technical change from the 2021 edition; vertical lines denote omissions, and underlining denotes new information.

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, 8669 NW 36 St, # 130, Miami, FL 33166.

Table of Contents

Page No.

Personnel v
Foreword vii
List of Tables xi
List of Figures xi
List of Forms xii

1. General Requirements 1
1.1 Scope 1
1.2 Units of Measure 2
1.3 Safety 2

2. Normative References 2

3. Terms and Definitions 3

4. Procedure Qualification 5
4.1 General 5
4.2 Standard Welding Procedure Specifications 5
4.3 Welding Procedures Qualified by Employer 7
4.4 Evaluation of Test Coupons 8
4.5 Qualification Thickness Limitations 9
4.6 Special Test Coupon Acceptance Criteria 11
4.7 Pipe and Plate Groove Test Coupons and Acceptance Criteria 11
4.8 Fillet Test Coupons and Acceptance Criteria 13
4.9 Cladding Test Coupons and Acceptance Criteria 15
4.10 Hardfacing Test Coupons and Acceptance Criteria 18
4.11 Stud Welds and Acceptance Criteria 19
4.12 Test Coupons Less than 1/16 in [1.5 mm] Acceptance Criteria 20
4.13 Welding Procedure Specification Data 22
4.14 Procedure Qualification Variables 24
4.15 Additional Procedure Qualification Variables for Hybrid Welding 33

5. Performance Qualification 35
5.1 General 35
5.2 Qualification by Standard Test 37
5.3 Qualification by Workmanship Test 37
5.4 Test Coupons 37
5.5 Examination Procedures and Acceptance Criteria 47
5.6 Performance Qualification Variables 49

Annexes 51
Annex A (Normative)—Illustrations—Weld Position, Test Specimens, and Text Fixtures 53
Annex B (Normative)—Filler Metal Grouping 73
Annex C (Normative)—Base Metal Grouping 77
Annex D (Normative)—Radiographic Examination Procedure 215
Annex E (Normative)—Wire-Additive Material Manufacturing 219
Annex F (Informative)—Basis for Establishing a Standard Welding Procedure Specification (SWPS) 225

Annex G (Informative)—Sample Forms 227
Annex H (Informative)—Macroetch Procedure 233
Annex I (Informative)—Requesting an Official Interpretation on an AWS Standard 237
Annex J (Informative)—Guidelines for Requesting Adoption of New Materials Under the AWS B2.1 Standard . . . 239

List of AWS Documents on Welding Procedure and Performance Qualification. 243

List of Tables

Table		Page No.
4.1	Test Methods Required for Procedure Qualification	9
4.2	Thickness and Size Limitations for Fillet Welds for Procedure Qualification	9
4.3	Thickness Limitations of Plate and Pipe for Groove Welds for Procedure Qualification	10
4.4	Thickness Limitations for Cladding and Hardfacing for Procedure Qualification	10
4.5	Minimum Shear Strength for Aluminum Fillet Welds	17
4.6	Minimum Tensile Load Requirements for Aluminum Stud Welds	19
4.7	Minimum Torque Requirements for Steel Stud Welds	20
4.8	Minimum Torque Requirements for Aluminum Stud Welds	21
5.1	Examination Requirements for Performance Qualification	36
5.2	Number of Bend Tests for Performance Qualification	39
5.3	Allowable Base Metals for Performance Qualification	39
5.4	Allowable Filler Metals for Performance Qualification	40
5.5	Position Limitations for Performance Tests	42
5.6	Limitations for Performance Qualification on Groove Welds in Pipe and Tube	50
5.7	Limitations for Performance Qualification in Plate Groove Welds	50
5.8	Limitations for Performance Qualification in Pipe Fillet Welds	50
B.1	Grouping of Welding Electrodes and Rods for Qualification	74
B.2	Classification of Ferrous Weld Metal for Procedure Qualification	76
C.1	Listing of Base Metal Specifications—Ferrous Alloys	78
C.1	Listing of Base Metal Specifications—Nonferrous Alloys	116
C.2	M-Number Listing of Base Metals—Ferrous Alloys	137
C.2	M-Number Listing of Base Metals—Nonferrous Alloys	170
C.3	Listing of Base Metal Specifications—Iron Castings	198
C.4	Listing of Base Metal Specifications for Standard Welding Procedure Specifications for Naval Applications—Ferrous Alloys	200
D.1	Acceptable Linear Discontinuities for Radiographic Examination	216
D.2	Acceptable Rounded Discontinuities for Radiographic Examination	216
E.1	Variables for Wire-Additive Material Manufacturing WPS and PQR	220
E.2	Wire-Additive Material Manufacturing Qualification Layer Width Limits	221

List of Figures

Figure		Page No.
4.1	Welding Procedure Selection Criteria	6
4.2	Location of Groove Weld Test Specimens—Pipe	11
4.3	Location of Test Specimens for Welded Box Tubing	12
4.4	Location of Tension, Longitudinal Bend, and Fracture Toughness Test Specimens—Plate	13
4.5	Location of Tension, Fracture Toughness, and Transverse Bend Test Specimens—Plate	14
4.6	Location of Fillet Weld Shear Test and Macroetch Specimens	15
4.7	Fillet Weld Break Test and Macroetch Specimens for Procedure Qualification	16

4.8 Location of Cladding Test Specimens 17
4.9 Location of Hardfacing Test Specimens 18
4.10 Rotating Tool Design Characteristics (FSW) 33
5.1 Selection of Performance Qualification Method—Workmanship Test or Standard Test 36
5.2 Typical Workmanship Test Coupons 38
5.3 Location of 1G, 2G, 5G, and 6G Bend Specimens—Pipe Groove Test Coupon 40
5.4 Location of Bend Specimens—Combined Pipe Positions 2G and 5G 41
5.5 Location of Bend Specimens for Box Tube 43
5.6 Location of Transverse Bend Specimens—Plate Groove Test Coupon 43
5.7 Location of Longitudinal Bend Specimens—Plate Groove Test Coupon 44
5.8 Location of Fillet Test Specimens—Plate 44
5.9 Location of Fillet Test Specimens—Alternate Test Coupon—Plate 45
5.10 Location of Fillet Test Specimens—Pipe 45
5.11 Location of Fillet Test Specimens—Alternate Weld—Pipe 46
5.12 Location of Cladding Specimens—Plate 46
5.13 Location of Test Specimen—Hardfacing Test Coupon—Plate 47
A.1A Welding Test Positions—Groove, Cladding, and Hardfacing Welds 55
A.1B Limits of Welding Positions—Groove, Cladding, and Hardfacing Welds 56
A.1C Welding Test Positions—Fillet Welds 57
A.1D Limits of Welding Positions—Fillet Welds 58
A.1E Welding Positions—Stud Welds 59
A.2A Transverse Face and Root Bend Specimens 60
A.2B Longitudinal Face and Root Bend Specimens 61
A.2C Transverse Side Bend Specimens 61
A.3A Reduced Section Tension Specimen—Rectangular 62
A.3B Reduced Section Tension Specimen—Round 63
A.3C Alternate Tension Specimen for Pipe 3 in [76 mm] O.D. or Less 63
A.3D Alternate Tension Specimen for Pipe 2 in [51 mm] O.D. or Less 64
A.4A Weld Cladding Side Bend Specimen 65
A.4B Weld Cladding and Hardfacing Chemical Analysis Specimens 65
A.5A Guided Bend Fixture—Bottom Ejecting Type 66
A.5B Guided Bend Fixture—Bottom Type 67
A.5C Guided Bend Fixture—Wrap-Around 68
A.5D Stud Weld Bend Test Fixture 69
A.5E Stud Weld Torque Test Fixture 70
A.5F Stud Weld Tension Test Fixture 71
D.1 Rounded Indication Charts for Radiographic Examination 217
E.1 Layer Width (W) > 1/2 in [13 mm] Procedure Qualification 223
E.2 Layer Width (W) ≤1/2 in [13 mm] Procedure Qualification 224

List of Forms

Form **Page No.**

G.1 Example of a Performance Qualification Test Record 228
G.2 Example of a Welding Procedure Specification 229
G.3 Example of a Procedure Qualification Record 230

Specification for Welding Procedure and Performance Qualification

1. General Requirements

1.1 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 (PWHT), 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 = Arc Stud 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.

1.2 Units of Measure. 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.

1.3 Safety. Safety and health issues and concerns are beyond the scope of this standard; some safety and health information is provided, but such issues are not fully addressed herein.

Safety and health information is available from the following sources:

American Welding Society:

(1) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*

(2) AWS Safety and Health Fact Sheets

(3) Other safety and health information on the AWS website

Material or Equipment Manufacturers:

(1) Safety Data Sheets supplied by materials manufacturers

(2) Operating Manuals supplied by equipment manufacturers

Applicable Regulatory Agencies

Work performed in accordance with this standard may involve the use of materials that have been deemed hazardous, and may involve operations or equipment that may cause injury or death. This standard does not purport to address all safety and health risks that may be encountered. The user of this standard should establish an appropriate safety program to address such risks as well as to meet applicable regulatory requirements. ANSI Z49.1 should be considered when developing the safety program.

2. Normative References

The documents listed below are referenced within this publication and are mandatory to the extent specified herein. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments or revisions of the publications may not apply since the relevant requirements may have changed.

American Welding Society (AWS) standards:

AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*;

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

AWS A5.32M/A5.32, *Welding Consumables—Gases and Gas Mixtures for Fusion Welding and Allied Processes;*

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

AWS D1.4/D1.4M, *Structural Welding Code—Reinforcing Steel*;

AWS D11.2, *Guide for Welding Iron Castings*; and

ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processe*s;

American Society of Mechanical Engineers (ASME) standards:

ASME *Boiler and Pressure Vessel Code*, Section V; and

ASME *Boiler and Pressure Vessel Code*, Section IX;

American Society for Testing and Materials (ASTM) standard:

ASTM E165, *Standard Test Method for Liquid Penetrant Examination.*

3. Terms and Definitions

AWS A3.0M/A3.0 *Standard Terms and Definitions* 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.

bracketed qualification. A procedure qualification performed by preparing test coupons using combinations of high and low values of specified variables to establish the upper and lower bounds for the range of qualification for those variables.

circumferential weld. A fillet or groove weld in a complete circular path of less than 24 in [610 mm] diameter.

control method *(FSW).* The manner of monitoring and controlling the position of the rotating tool with respect to the weld joint during the friction stir welding process.

control method, force *(FSW).* A control method that uses a force set point, such as plunge force or travel force, to control the tool position. Under the force control method, the plunge depth or travel speed can vary, within a specified range, during welding.

control method, position *(FSW).* A control method that uses a set plunge position relative to the plate surface to control the tool position. Under the position control method, the plunge force can vary, within a specified range, during welding.

control method, travel *(FSW).* A control method that uses a set travel speed to control the tool position. Under the travel control method, the travel force can vary, within a specified range, during welding.

corresponding material specification. The documented material specification (e.g., ASTM A516, Grade 70, or API 5L Grade X60) that weld metal properties will be evaluated against.

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.

fracture toughness. A mechanical property of materials exhibiting their ability to resist crack propagation as determined by any of the following tests, including but not limited to: Charpy V-notch, dynamic tear, plane-strain fracture toughness, and drop-weight nil-ductility transition temperature.

integrated backing. Base metal that supports or contains the weld puddle during its deposition and remains as part of the completed weldment.

M-Number. A designation used to group base metals for procedure and performance qualifications consistent with the P-Number designation 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 C).

pipe. Used generally to refer to pipe and tube.

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

process separation, *hybrid welding.* The distance between each welding process as specified in the WPS.

process sequence, *hybrid welding.* The order of each welding process with respect to the direction of travel.

qualification variable. See **performance qualification variable and procedure qualification variable**.

Qualifier. The Employer, organization, or individual responsible for conducting and supervising qualification testing.

radial weld. A fillet or groove weld that is not a complete circle between two faying surfaces having rounded portions with a radius of less than 12 in [305 mm].

Referencing Document. The fabrication code, specification, contract document, or internal document such as quality control or quality assurance manuals that invokes this specification.

root shielding gas. A shielding gas used to provide a protective atmosphere to the root surface (opposite from the welding side) of the weld.

Standard Welding Procedure Specification (SWPS). A welding procedure specification qualified according to the requirements of AWS B2.1/B2.1M, approved by AWS, and made available for production welding by companies or individuals other than those performing the qualification test.

test coupon. A weldment used for procedure or performance qualification testing.

test specimen. A sample of a test coupon subjected to testing.

test specimen blank. The section removed from a test coupon from which the test specimen is prepared.

torch shielding gas. Protective gas emanating from the torch, used to prevent or reduce atmospheric contamination.

trailing gas. A gas used to produce a protective atmosphere that extends beyond the weld pool in the direction opposite of travel.

welding grade argon. Argon with a purity of 99.99% minimum (see AWS A5.32).

welding variable. Any controllable detail of a welding procedure which is required to be addressed on the welding procedure specification (WPS).

wire-additive material manufacturing. The deposition of weld metal using a welding process and wire filler metal to create a new component either separately or joined to an existing component.