

ANSI/AWS B2.1-1-209-96
An American National Standard

**Standard
Welding Procedure
Specification (WPS) for**

**Gas Tungsten Arc Welding
Followed by Shielded Metal Arc Welding
of Carbon Steel (M-1/P-1/S-1, Group 1 or 2),
1/8 through 1-1/2 inch Thick, ER70S-2
and E7018, As-Welded
or PWHT Condition,
Primarily Pipe
Applications**



American Welding Society

Key Words — Welding Procedure Specification,
base metal, allowable joint designs,
filler metal, carbon steel, gas
tungsten arc welding, shielded metal
arc welding, manual welding

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Approved by
American National Standards Institute
June 7, 1996

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Prepared by
AWS Committee on Welding Qualification

Under the Direction of the
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

This standard contains the essential welding variables for carbon steel in the thickness range of 1/8 through 1-1/2 inch, using manual gas tungsten arc welding followed by shielded metal arc welding. It cites the base metals and operating conditions necessary to make the weldment, the filler metal specifications, and the allowable joint designs for fillet and groove welds. This WPS was developed primarily for pipe applications.



American Welding Society

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

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Foreword

(This Foreword is not a part of the ANSI/AWS B2.1-1-209-96, *Standard Welding Procedure Specification (WPS)*, but is included for information purposes only.)

The American Welding Society and the Welding Research Council have joined in a cooperative effort to generate standard welding procedures for industry. The need for pretested welding procedures that are supported by adequate test data and that satisfy the technical requirements for the commonly used construction codes and specifications has been expressed by many individuals and organizations. The purpose of a welding procedure qualification is to provide test data for assessing the properties of a weld joint.

This Welding Procedure Specification is an outgrowth of the coordinated work of the Welding Procedures Committee of WRC and the Committee on Welding Qualification of the AWS. The summaries of Procedure Qualification Records are available from the Welding Research Council, Room 1301, 345 E. 47 St., New York, NY 10017.

The welding terms used in this specification shall be interpreted in accordance with the definitions given in the latest edition of ANSI/AWS A3.0, *Standard Welding Terms and Definitions*. Welding symbols shall be those shown in the latest edition of ANSI/AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*.

The AWS Committee on Welding Qualification was formed in 1979 to provide welding standards concerning the subject of qualification. The primary document developed by this committee is AWS B2.1, *Standard for Welding Procedure and Performance Qualification*. This document established the foundation and framework for Standard Welding Procedure Specifications.

Comments on this publication will be most welcome. They should be addressed to the Secretary, AWS Committee on Welding Qualification, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

Standard Welding Procedure Specification (WPS)

Gas Tungsten Arc Welding Followed by Shielded Metal Arc Welding of Carbon Steel (M-1/P-1/S-1, Group 1 or 2), 1/8 through 1-1/2 inch Thick, ER70S-2 and E7018, As-Welded or PWHT Condition, Primarily Pipe Applications

Welding Research Council¹—Supporting PQR Numbers:

001002, 001007, 001010, 001013, 001014, 001015, 001017, 001024, 001038, 005031, 200266, 200267, 200268, 200269, 200270, 200272, 200273, 200274, 200275, 200530, 200531, 200532, 200534, 200535, 200625, 200626, 200627, 200628, 200629, 200630, 200631, 200632, 200633, 200634, 200635, 200636, 200637, 200638, 200639, 200708, 200709, 200710, 200711, 200712, 200713, 200728, 001A, 002A, 003B, 004A, 029A, 030A

Requirements for Application of Standard WPSs

Scope. The data to support this Standard Welding Procedure Specification (WPS) have been derived from the above listed Procedure Qualification Records (PQRs) which were reviewed and validated under the auspices of the Welding Research Council. This Standard WPS is not valid using conditions and variables outside the ranges listed. The American Welding Society considers that this Standard WPS presents information for producing an acceptable weld using the conditions and variables listed. The user needs a significant knowledge of welding and accepts full responsibility for the performance of the weld and for providing the engineering capability, qualified personnel, and proper equipment to implement this Standard WPS.

Application. This Standard WPS is to be used only as permitted by the applicable fabrication document(s) [such as code, specification, or contract document(s)]. The fabrication document(s) should specify the engineering requirements such as design, need for heat treatment, fabricating tolerances, quality control, and examination and tests applicable to the end product.

User's Responsibility. A Standard WPS does not replace or substitute for fabrication codes, specifica-

tions, contract requirements, or capability and judgment on the part of the user. A Standard WPS is to be used only as permitted by the applicable fabrication code, specification, or contract document.

The ability to produce production welds having properties suitable for the application depends upon supplementing the Standard WPS with appropriate performance qualification tests and sound engineering judgment. The user is responsible for the quality and performance of the final product in accordance with the provisions of the fabrication document(s).

Supplementary Instructions. To adapt this Standard WPS to a specific application, a user may issue supplementary instructions. Such instructions may consist of tighter fit-up tolerances, higher minimum preheat temperature or any other instructions necessary to produce a weldment that meets the requirements of the fabrication document(s). These instructions shall not be less restrictive than provided in the Standard WPS.

Safety. Safety precautions shall conform to the latest edition of ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society.

This specification may involve hazardous materials, operations, and equipment. The specification does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to establish appropriate safety and health practices. The user should determine the applicability of any regulatory limitations prior to use.

1. Welding Research Council, 345 East 47th Street, New York, NY 10017.

Standard Welding Procedure Specification (WPS)

LIMITATIONS

This procedure is not qualified for Notch Toughness applications.

WELDING PROCESSES

Welding Processes: GTAW (Gas Tungsten Arc Welding) followed by SMAW (Shielded Metal Arc Welding)
Method of Application: Manual

BASE METALS

Base Metal:² Carbon Steel, M-1, P-1, or S-1, Group 1 or 2 to M-1, P-1, or S-1, Group 1 or 2
Thickness Range: 1/8 in. through 1-1/2 in. for groove welds,
1/8 in. minimum for fillet welds
Pipe Diameter: All diameters

FILLER METALS

Filler Metal Specification:² ANSI/AWS A5.18 or ASME SFA 5.18 for Filler Rod,
ANSI/AWS A5.1 or ASME SFA 5.1 for Electrode
A Number 1, F Number 6 for GTAW, and F Number 4 for SMAW
Classification: ER70S-2 and E7018
Deposit Thickness Range: 1-1/2 in. maximum plus reinforcement for groove welds,
1/8 in. through 1-1/2 in. fillet weld size for fillet welds
Consumable Inserts: Not permitted

JOINT DESIGNS

Joint Designs: See Figure 1
Backing: Not required for GTAW, required for SMAW
Backing Material:² Carbon Steel, M-1, P-1, or S-1, Group 1, 2, or 3 or weld metal of similar chemical analysis. Nonmetallic or nonfusing metal retainers are not permitted

POSITIONS

Permitted Positions: All, except as noted
Vertical Progression: Uphill

PREHEAT AND INTERPASS TEMPERATURES

Preheat Temperature:³ 50°F Minimum
Interpass Temperature:³ 50°F Minimum, 500°F Maximum
Preheat Maintenance: Continuous or special heating is not required

2. M, P, and S numbers for base metal and F and A numbers for filler metal and weld metal respectively, are as detailed in AWS B2.1 and ASME *Boiler and Pressure Vessel Code*, Section IX.

3. Preheat and interpass temperatures must be sufficient to prevent crack formation. Temperatures above the minimum shown may be required for highly restrained welds or by the fabrication document(s).

Standard Welding Procedure Specification (WPS)

GAS

Torch Shielding Gas:	Welding Grade Argon
Flow Rate:	12 to 25 ft ³ /h
Root Shielding Gas:	Optional; If used, root shielding gas shall be Welding Grade Argon
Flow Rate:	A typical flow rate of 5 to 15 ft ³ /h may be varied depending on component configuration
Trailing Gas:	None
Torch Gas Nozzle Size:	1/4 to 3/4 in. inside diameter

TUNGSTEN ELECTRODES

Type:	ANSI/AWS A5.12 or ASME SFA 5.12, EWTh-2, EWCe-2, or EWLa-1
Size:	0.060 through 0.125 in. diameter sharpened to a blunt point

ELECTRICAL CHARACTERISTICS

GROOVE WELDS				
Filler Metal			Current	
Layer	Classification ¹	Dia. (in.)	Amperes ²	Polarity
Root ³	ER70S-2	1/16	60–100	DCEN (Straight)
Root ³	ER70S-2	3/32	80–140	DCEN (Straight)
Root ³	ER70S-2	1/8	100–160	DCEN (Straight)
Fill	E7018	3/32	70–100	DCEP (Reverse)
Fill	E7018	1/8	115–165	DCEP (Reverse)
Fill	E7018	5/32	150–220	DCEP (Reverse)
Fill	E7018	3/16 ⁵	200–275	DCEP (Reverse)
FILLET WELDS AND GROOVE WELDS ON BACKING RINGS ⁴				
Filler Metal			Current	
Layer	Classification ¹	Dia. (in.)	Amperes ²	Polarity
Root or Fill	ER70S-2	1/16	60–100	DCEN (Straight)
Root or Fill	ER70S-2	3/32	80–140	DCEN (Straight)
Root or Fill	ER70S-2	1/8	100–160	DCEN (Straight)
Root or Fill	E7018	3/32	70–100	DCEP (Reverse)
Root or Fill	E7018	1/8	115–165	DCEP (Reverse)
Fill	E7018	5/32	150–220	DCEP (Reverse)
Fill	E7018	3/16 ⁵	200–275	DCEP (Reverse)

1. The care and storage of electrodes shall be as recommended by the electrode manufacturer to ensure that the low-hydrogen characteristics are maintained.
2. Values not to exceed capacity of tungsten electrodes.
3. An additional layer is optional.
4. Backing rings may be used when permitted by the fabrication document(s).
5. Flat and Horizontal positions only.

Pulsing Current: Not permitted

Standard Welding Procedure Specification (WPS)

POSTWELD HEAT TREATMENT (PWHT)

Postweld Heat Treatment: Welds may either be as-welded or postweld heat treated at 1100 to 1200°F or as required by the fabrication document(s). If heat treated, the heat treatment time shall be 1 hour per inch of thickness (15 minutes minimum) unless otherwise noted in the fabrication document(s).

TECHNIQUE

Weave or Stringer Bead: Either
Peening: Not permitted
Initial Cleaning: Chemical or mechanical; joint shall be dry prior to welding
Interpass Cleaning: Mechanical only
Backgouging: Mechanical or thermal when required by Figure 1
Single or Multiple Passes: Either. All pressure retaining welds shall be a minimum of two passes
Maximum Bead Thickness: 1/4 in.
Repair: Defects in welds shall be removed by mechanical or thermal methods. The repair cavity may differ in contour and dimension from a normal joint preparation and may present different restraint conditions. Repair of base metal defects shall be in accordance with the requirements of the fabrication document(s)

COMPANY NAME _____

In the name of the Company stated above, I accept full responsibility for the application of this Standard WPS for use with:

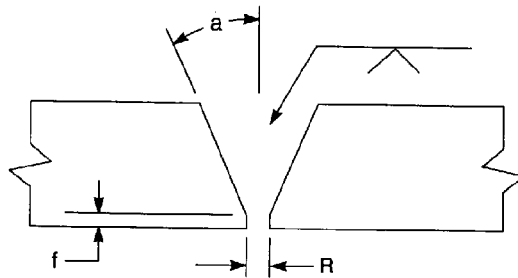
Fabrication Document(s): (such as Code, Specification, or Contract Document) Dated _____

DATE _____ APPROVED BY _____ TITLE _____

Standard Welding Procedure Specification (WPS)

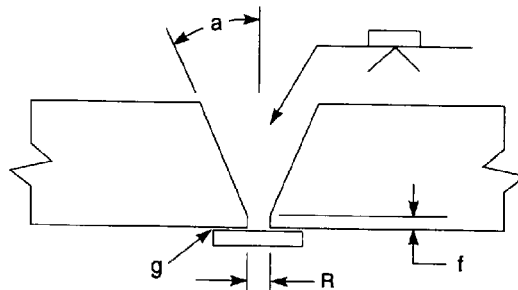
FILLET WELDS: All Joints

GROOVE WELDS: For pipe and tubular products, see Joints 1 through 7. In addition, joints having groove designs resulting from end preparations conforming with ASME/ANSI B16.25, *Butt Welding Ends*, and prequalified joint details for complete joint penetration groove welded joints permitted by ANSI/AWS D1.1, *Structural Welding Code — Steel*, are also allowable for application with this WPS.



$a = 30^\circ, +10^\circ, -0^\circ$
 $f = 1/16 \text{ in.} \pm 1/32 \text{ in.}$
 $R = 1/8 \text{ in.} \pm 1/16 \text{ in.}$
 I.D. MISMATCH = 1/16 in. MAX.

JOINT 1

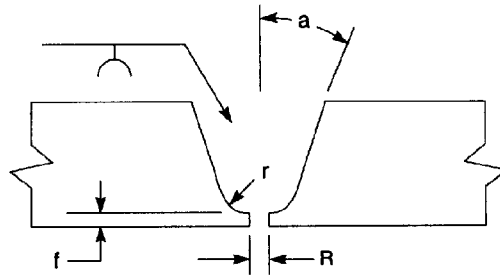


$a = 30^\circ, +10^\circ, -0^\circ$
 $f = 1/16 \text{ in.} \pm 1/32 \text{ in.}$
 $g = 1/16 \text{ in. MAX.}$
 $R = 3/16 \text{ in.} \pm 1/16 \text{ in.}$
 I.D. MISMATCH = 1/16 in. MAX.

JOINT 2

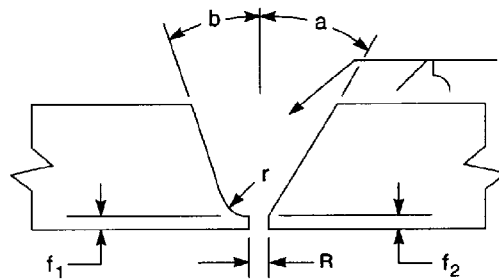
Figure 1—Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



$a = 22-1/2^\circ \pm 2-1/2^\circ$
 $f = 1/16 \text{ in.} \pm 1/32 \text{ in.}$
 $r = 1/8 \text{ in. TO } 3/16 \text{ in. RADIUS}$
 $R = 1/16 \text{ in., } +1/16 \text{ in., } -1/32 \text{ in.}$
 I.D. MISMATCH = $1/16 \text{ in. MAX.}$

JOINT 3

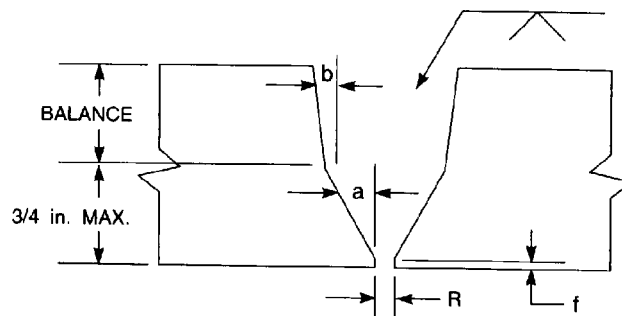


$a = 30^\circ, +10^\circ, -0^\circ$
 $b = 22-1/2^\circ \pm 2-1/2^\circ$
 $f_1 = 1/16 \text{ in., } +1/16 \text{ in., } -1/32 \text{ in.}$
 $f_2 = 1/16 \text{ in., } +1/16 \text{ in., } -1/32 \text{ in.}$
 $r = 1/8 \text{ in. TO } 3/16 \text{ in. RADIUS}$
 $R = 3/32 \text{ in.} \pm 1/32 \text{ in.}$
 I.D. MISMATCH = $1/16 \text{ in. MAX.}$

JOINT 4

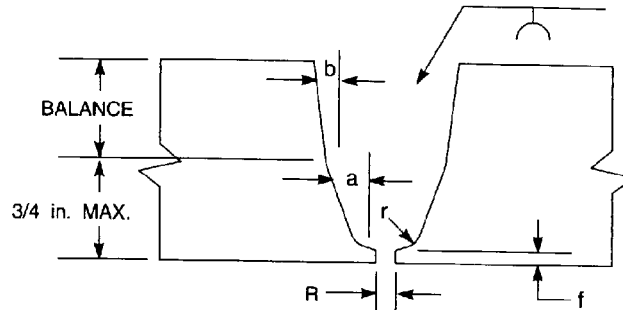
Figure 1 (continued) — Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



$a = 30^\circ + 10^\circ, - 0^\circ$
 $b = 10^\circ + 5^\circ, - 0^\circ$
 $f = 0 \text{ in. TO } 1/16 \text{ in.}$
 $R = 1/8 \text{ in., } \pm 1/16 \text{ in.}$
 I.D. MISMATCH = $1/16 \text{ in. MAX.}$

JOINT 5

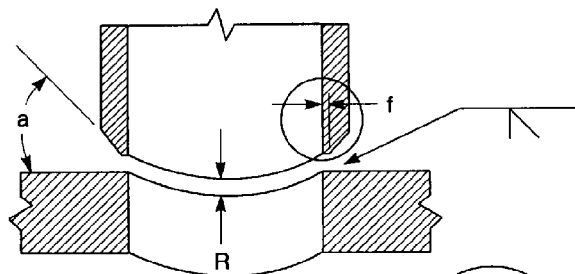


$a = 22\text{-}1/2^\circ \pm 2\text{-}1/2^\circ$
 $b = 10^\circ + 5^\circ, - 0^\circ$
 $f = 1/16 \text{ in., } \pm 1/32 \text{ in.}$
 $r = 1/8 \text{ in. TO } 3/16 \text{ in. RADIUS}$
 $R = 1/16 \text{ in., } \pm 1/16 \text{ in.}$
 I.D. MISMATCH = $1/16 \text{ in. MAX.}$

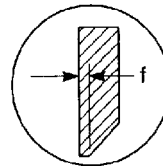
JOINT 6

Figure 1 (continued) — Allowable Joint Designs

Standard Welding Procedure Specification (WPS)

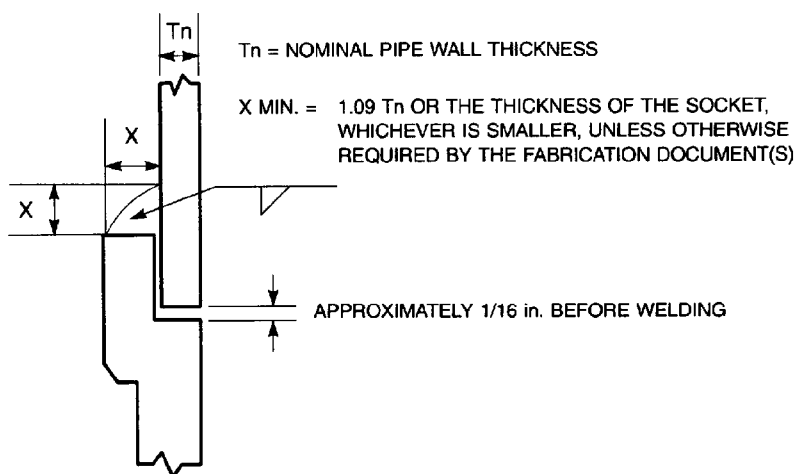


$a = 45^\circ \pm 5^\circ$
 $R = 1/8 \text{ in.} \pm 1/32 \text{ in.}$
 $f = 0 \text{ TO } 1/16 \text{ in.}$
 I.D. MISMATCH = $1/8 \text{ in. MAX.}$



TYPICAL BRANCH CONNECTION

JOINT 7

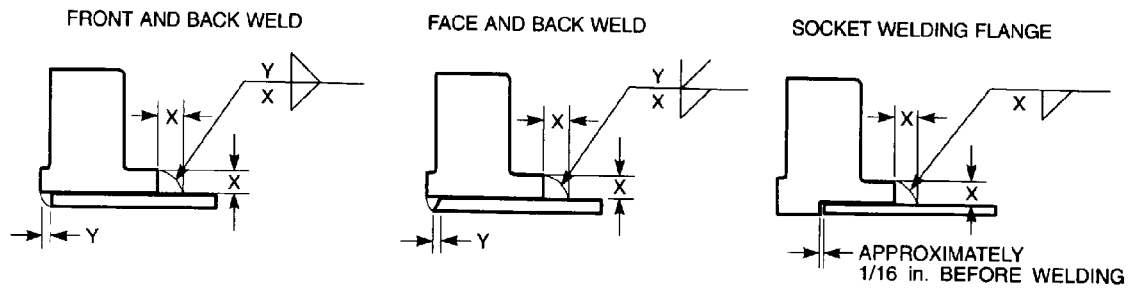


RECOMMENDED WELDING DIMENSIONS FOR SOCKET WELDING COMPONENTS OTHER THAN FLANGES

JOINT 8

Figure 1 (continued) — Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



X MIN. = $1.4 T_n$ OR THE THICKNESS OF THE HUB, WHICHEVER IS SMALLER, UNLESS OTHERWISE REQUIRED BY THE FABRICATION DOCUMENT(S)
 Y MIN. = T_n OR $1/4$ in., WHICHEVER IS SMALLER, UNLESS OTHERWISE REQUIRED BY THE FABRICATION DOCUMENT(S)
 T_n = NOMINAL PIPE WALL THICKNESS

RECOMMENDED WELDING DIMENSIONS FOR FLANGES

JOINT 9

Standard Welding Procedure Specification (WPS)

Metric Conversions

in.	mm	°F	°C	ft ³ /h	L/min
1/32	0.8	50	10	5	2.4
0.060	1.5	500	260	12	5.7
1/16	1.6	1100	595	15	7.1
3/32	2.4	1200	650	25	11.9
0.125	3.2				
1/8	3.2				
3/16	4.8				
1/4	6.4				
3/4	19.0				
1	25.4				
1-1/2	38.0				