

ANSI/AWS B2.1-1-027-95
An American National Standard

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

**Self-Shielded Flux Cored
Arc Welding of Carbon Steel
(M-1/P-1/S-1, Group 1 or 2),
1/8 through 3/4 inch Thick,
E71T-11, As-Welded
Condition**



American Welding Society

Key Words — Welding Procedure Specification,
base metal, allowable joint designs,
filler metal, carbon steel, semi-
automatic, self-shielded flux
cored arc welding

ANSI/AWS B2.1-1-027-95
An American National Standard

Approved by
American National Standards Institute
July 24, 1995

Standard Welding Procedure
Specification (WPS)
Self-Shielded Flux Cored Arc Welding of
Carbon Steel (M-1/P-1/S-1, Group 1 or 2)
1/8 through 3/4 inch Thick, E71T-11
As-Welded Condition

Prepared by
AWS Committee on Procedure and Performance 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 3/4 inch, using semiautomatic, self-shielded flux cored 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 is intended primarily for plate and structural applications.



American Welding Society

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

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This standard is subject to revision at any time by the AWS Welding Qualification Committee. It must be reviewed every five years and if not revised, it must be either reapproved or withdrawn.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 Welding Qualification Committee 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 Welding Qualification Committee 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, Florida 33126.

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Foreword

(This Foreword is not a part of the ANSI/AWS B2.1-1-027-95, *Standard Welding Procedure Specification*, 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 Welding Procedures Committee has provided the test data documented on Procedure Qualification Records, which are available from the Welding Research Council.

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, *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, *Specification 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: Secretary, AWS Committee on Welding Qualification, American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33126.

Official interpretations of any of the technical requirements of this standard may be obtained by sending a request, in writing, to the Managing Director of Technical Services, American Welding Society. A formal reply will be issued after it has been reviewed by the appropriate personnel following established procedures.

Standard Welding Procedure Specification (WPS)

Self-Shielded Flux Cored Arc Welding of Carbon Steel (M-1/P-1/S-1, Group 1 or 2), 1/8 through 3/4 inch Thick, E71T-11, As-Welded Condition

Welding Research Council¹—Supporting PQR Numbers:
007014, 007015, 007016, 200015, 200293, 200295, 200296, 200431, 200432,
200433, 200434, 200600, 200601, 200602, 200603, 200608, 200609, 200610,
200731, 200732, 200733, 200787, 200790, 200791, 200794, 200796

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 Welding Procedure Specification.

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 or PWHT applications.

WELDING PROCESSES

Welding Processes: FCAW-S (Flux Cored Arc Welding, Self-Shielded)
Method of Application: Semiautomatic

BASE METALS

Base Metal Classification: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 3/4 in. for groove welds,
1/8 in. minimum for fillet welds
Diameter: Groove Welds: 4 in. minimum
Fillet Welds: all diameters

FILLER METALS

Filler Metal Specification:² ANSI/AWS A5.20 or ASME SFA 5.20
A Number 1, F Number 6
Classification: E71T-11
Deposit Thickness Range: 3/4 in. maximum plus reinforcement for groove welds,
1/8 in. through 3/4 in. fillet weld size for fillet welds
Supplementary Filler Metal: Not permitted
Supplementary Power: Not permitted

JOINT DESIGNS

Joint Designs: See Figure 1
Backing: When required by Figure 1
Backing Material:² Carbon Steel, M-1, P-1, or S-1, Group 1, 2, or 3. Nonmetallic or nonfusing metal retainers are not permitted

POSITIONS

Permitted Positions: All
Vertical Progression: Either uphill or downhill

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 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 or 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), or by the Electrode Manufacturer.

Standard Welding Procedure Specification (WPS)

POSTWELD HEAT TREATMENT

Postweld Heat Treatment: None (Not qualified for PWHT applications)

ELECTRICAL CHARACTERISTICS

ELECTRODE		VOLTAGE	CURRENT		Wire Feed Speed (ipm)
Classification	Dia. in.	Volts	Amperes	Polarity	
E71T-11	1/16	18-21	150-190	DCEN (Straight)	90-110
E71T-11	0.068	18-21	150-190	DCEN (Straight)	90-110
E71T-11	5/64	16-21	145-300	DCEN (Straight)	50-140
E71T-11	3/32	16-22	190-325	DCEN (Straight)	50-120

Pulsing Current: Not permitted

Contact Tube to Work Distance: 3/4 in. $\pm$ 1/4 in.

Mode of Metal Transfer: Globular or Spray Transfer Mode

TECHNIQUE

Weave or Stringer Bead: Either

Peening: Not required; if used, proceed as permitted by the fabrication document(s)

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

Gouging: Mechanical or thermal

Single or Multiple Pass: Either

Maximum Bead Thickness: 1/4 in.

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 _____

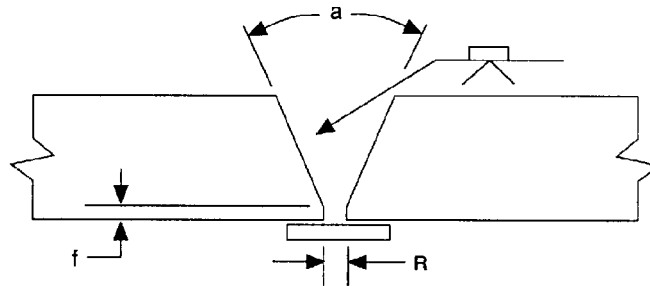
DATE _____ APPROVED BY _____ TITLE _____

Standard Welding Procedure Specification (WPS)

FILLET WELDS: All Joints

GROOVE WELDS: See Joints 1 through 17. Joints having prequalified joint details permitted by the latest edition of ANSI/AWS D1.1, *Structural Welding Code—Steel* are also permitted.

For tubular products, see Joints 1, 2, 6 and 7. In addition, joints having groove designs resulting from end preparations conforming with the latest edition of ANSI/ASME B16.25, *Butt Welding Ends*, are also allowable for application with this WPS.



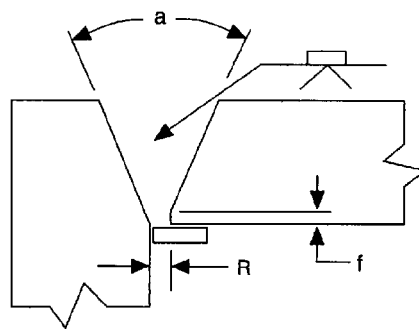
STRUCTURAL PRODUCTS

$a = 45^\circ$ MIN.
 $R = 1/4$ in., $+1/4 -1/16$
 $f = R/2$ MAX.

TUBULAR PRODUCTS

$a = 60^\circ$ MIN.
 $R = 3/16$ in., $+1/4 -1/16$
 $f = R/2$ MAX.

JOINT 1



STRUCTURAL PRODUCTS

$a = 45^\circ$ MIN.
 $R = 1/4$ in., $+1/4 -1/16$
 $f = R/2$ MAX.

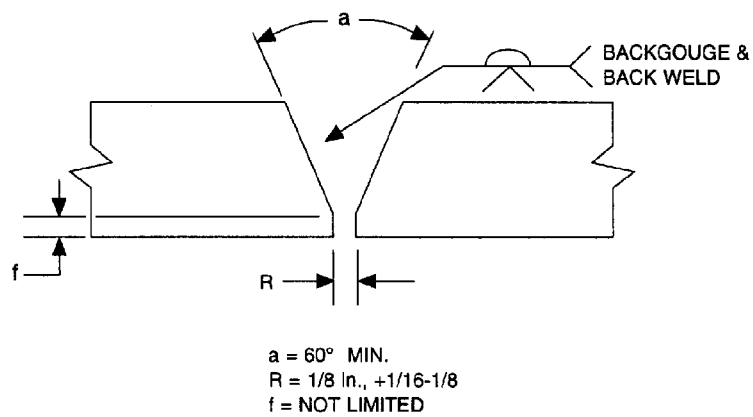
TUBULAR PRODUCTS

$a = 60^\circ$ MIN.
 $R = 3/16$ in., $+1/4 -1/16$
 $f = R/2$ MAX.

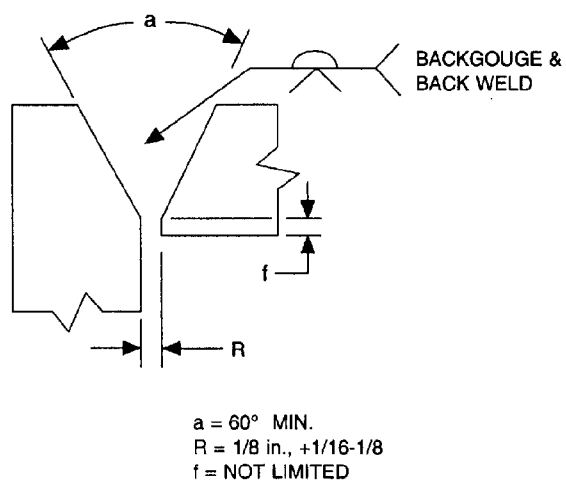
JOINT 2

Figure 1—Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



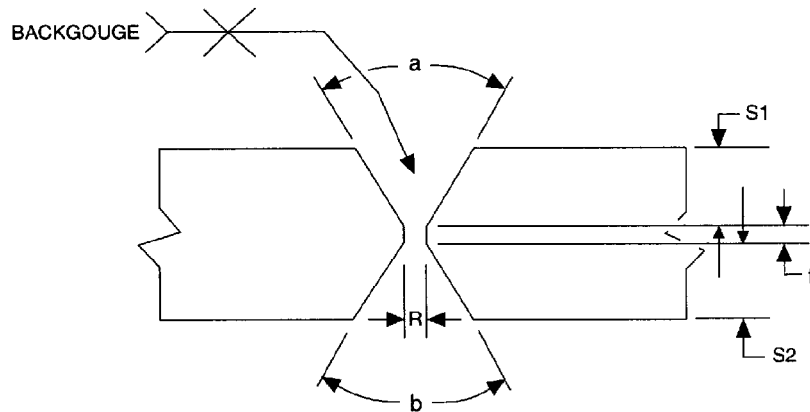
JOINT 3



JOINT 4

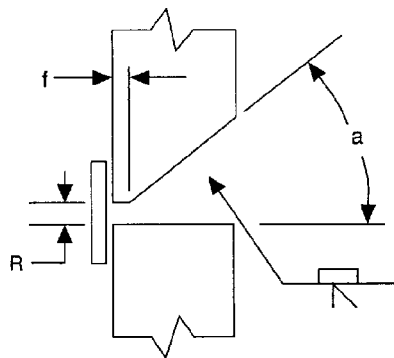
Figure 1 (continued)—Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



a AND $b = 60^\circ$ MIN.
 $R = 1/8$ in., $+1/16$ - $1/8$
 $f =$ NOT LIMITED
 $S1 =$ NOT LIMITED
 $S2 =$ NOT LIMITED

JOINT 5



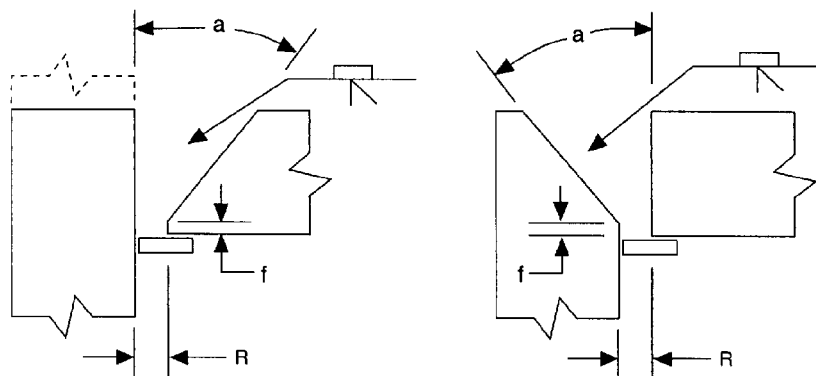
STRUCTURAL PRODUCTS
 $a = 45^\circ$ MIN.
 $R = 1/4$ in., $+1/4$ - $1/16$
 $f = R/2$ MAX.

TUBULAR PRODUCTS
 $a = 60^\circ$ MIN.
 $R = 3/16$ in., $+1/4$ - $1/16$
 $f = R/2$ MAX.

JOINT 6

Figure 1 (continued)—Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



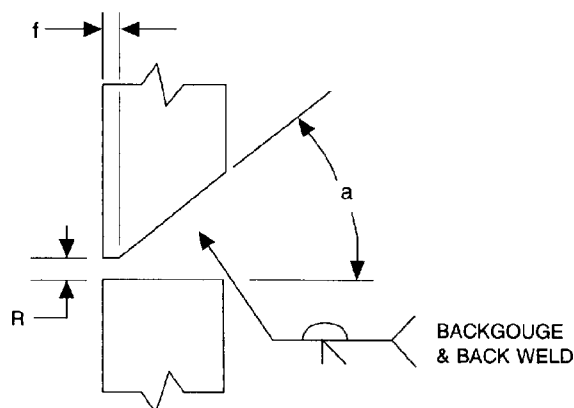
STRUCTURAL PRODUCTS

$a = 45^\circ$ MIN.
 $R = 1/4$ in., $+1/4 - 1/16$
 $f = R/2$ MAX.

TUBULAR PRODUCTS

$a = 60^\circ$ MIN.
 $R = 3/16$ in., $+1/4 - 1/16$
 $f = R/2$ MAX.

JOINT 7

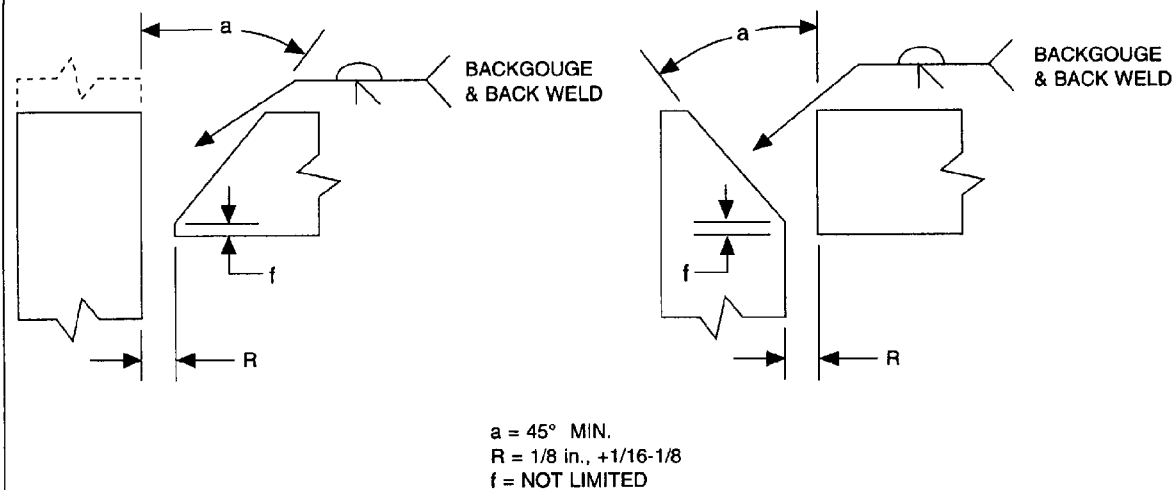


$a = 45^\circ$ MIN.
 $R = 1/8$ in., $+1/16 - 1/8$
 $f = \text{NOT LIMITED}$

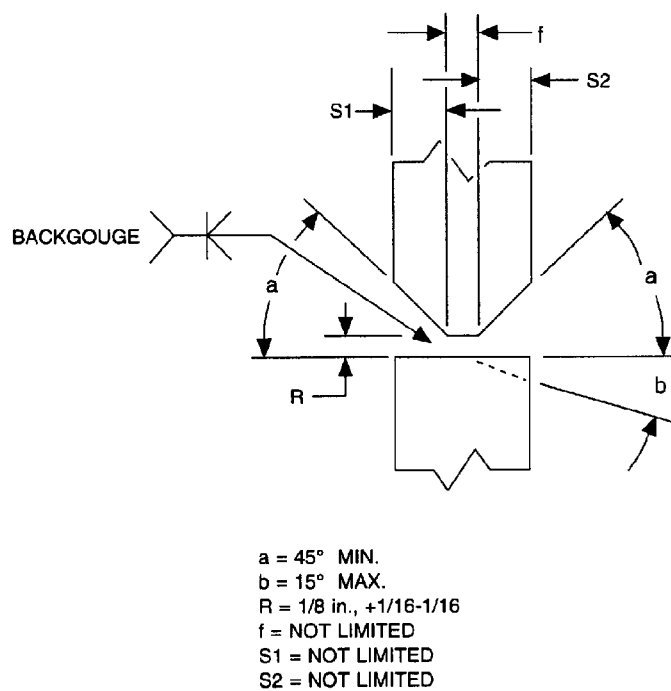
JOINT 8

Figure 1 (continued)—Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



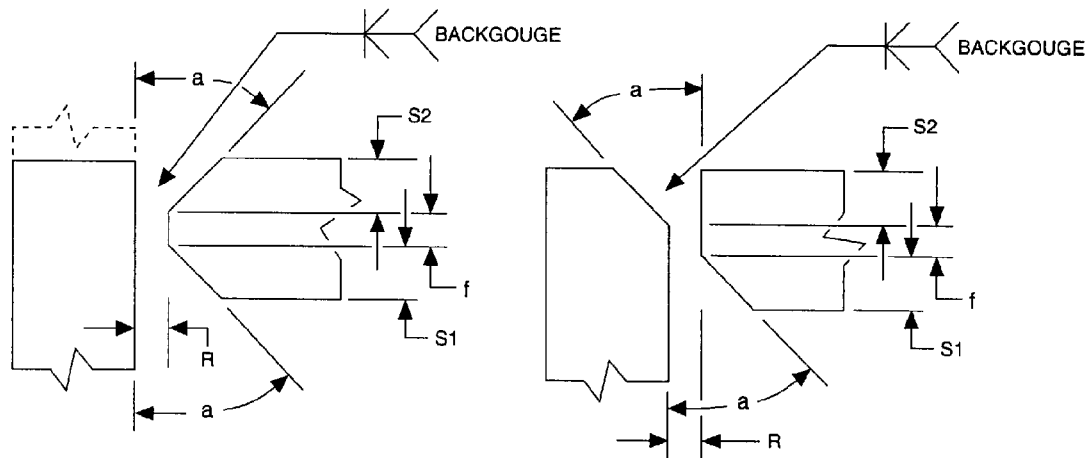
JOINT 9



JOINT 10

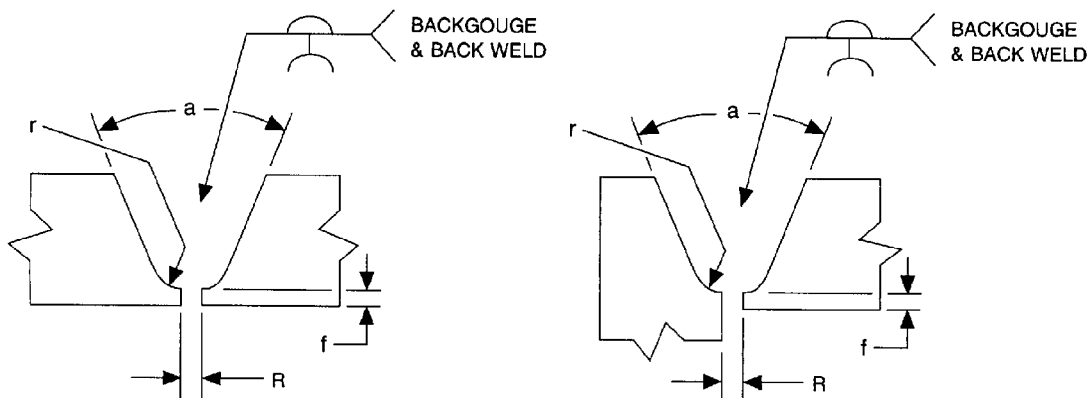
Figure 1 (continued)—Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



$a = 45^\circ \text{ MIN.}$
 $R = 1/8 \text{ in., } +1/16-1/8$
 $f = \text{NOT LIMITED}$
 $S1 = \text{NOT LIMITED}$
 $S2 = \text{NOT LIMITED}$

JOINT 11

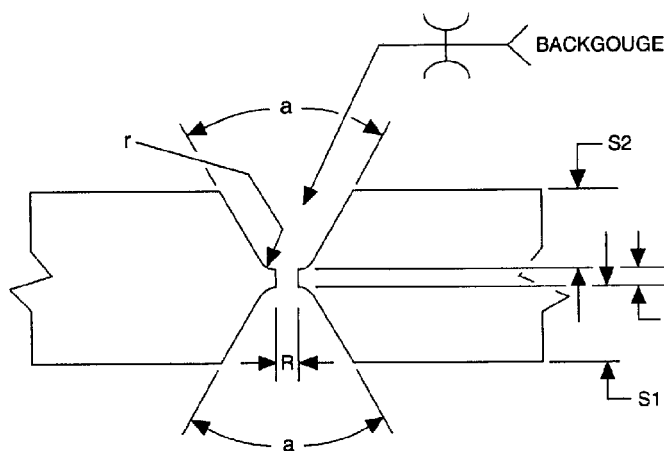


$a = 45^\circ \text{ MIN.}$
 $R = 1/8 \text{ in., } +1/16-1/8$
 $f = \text{NOT LIMITED}$
 $r = 1/4 \text{ in., } +1/8-0$

JOINT 12

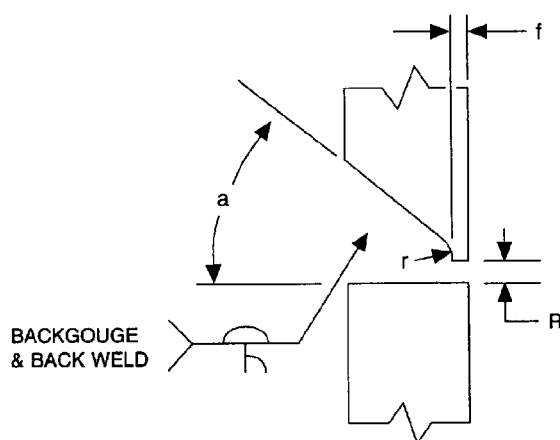
Figure 1 (continued)—Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



$a = 45^\circ \text{ MIN.}$
 $R = 1/8 \text{ in., } +1/16-1/8$
 $f = \text{NOT LIMITED}$
 $r = 1/4 \text{ in., } +1/16-1/16$
 $S1 = \text{NOT LIMITED}$
 $S2 = \text{NOT LIMITED}$

JOINT 13

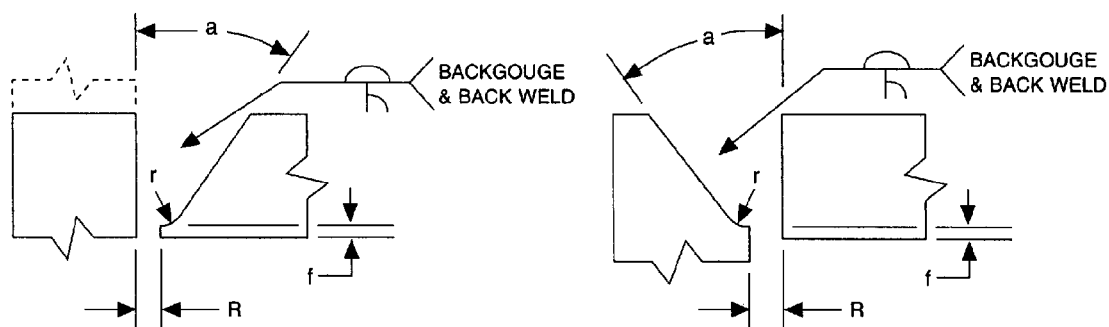


$a = 45^\circ \text{ MIN.}$
 $R = 1/8 \text{ in., } +1/16-1/8$
 $f = \text{NOT LIMITED}$
 $r = 3/8 \text{ in., } +1/16-1/16$

JOINT 14

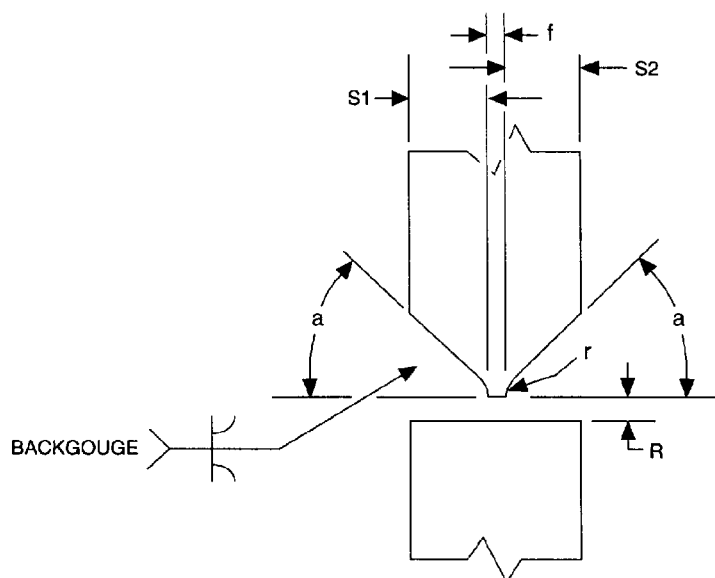
Figure 1 (continued)—Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



$a = 45^\circ \text{ MIN.}$
 $R = 1/8 \text{ in., } +1/16-1/8$
 $f = \text{NOT LIMITED}$
 $r = 3/8 \text{ in., } +1/16-1/16$

JOINT 15

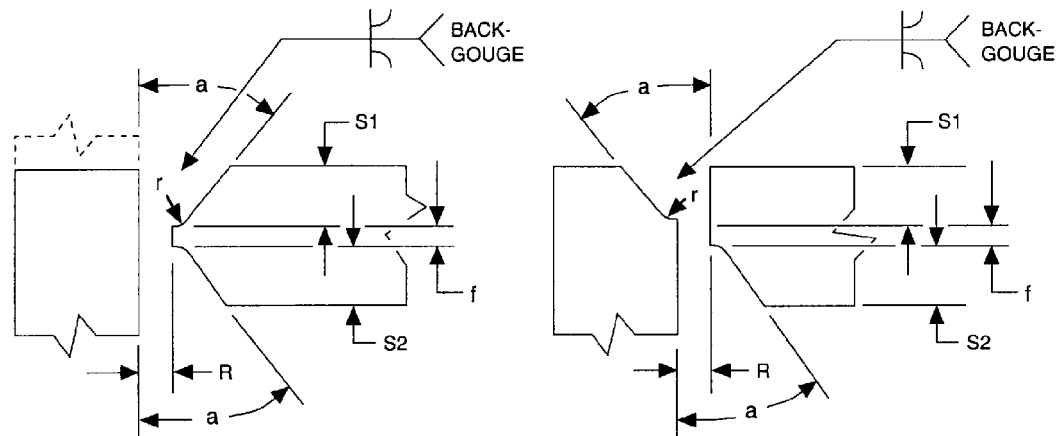


$a = 45^\circ \text{ MIN.}$
 $R = 1/8 \text{ in., } +1/16-1/8$
 $r = 3/8 \text{ in., } +1/16-1/16$
 $f = \text{NOT LIMITED}$
 $S1 \text{ AND } S2 = \text{NOT LIMITED}$

JOINT 16

Figure 1 (continued)—Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



$a = 45^\circ \text{ MIN.}$
 $R = 1/8 \text{ in., } +1/16-1/8$
 $r = 3/8 \text{ in., } +1/16-1/16$

$f = \text{NOT LIMITED}$
 $S1 = \text{NOT LIMITED}$
 $S2 = \text{NOT LIMITED}$

JOINT 17

Figure 1 (continued)—Allowable Joint Designs

Metric Conversions

in.	mm	°F	°C
1/16	1.6	50	10
5/64	2.0	500	260
3/32	2.4		
1/8	3.2		
3/16	4.8		
1/4	6.4		
3/4	19		
4	100		

AWS Welding Procedure and Performance Qualification Documents

AWS Designation	Title
B2.1-84	Standard for Welding Procedure and Performance Qualification
B2.1.001-90	Standard Welding Procedure Specification for Shielded Metal Arc Welding of Carbon Steel, (M-1/P-1, Group 1 or 2), 3/16 through 7/8 inch in the As-Welded Condition, with or without Backing
B2.1.002-90	Standard Welding Procedure Specification for Gas Tungsten Arc Welding of Carbon Steel, (M-1/P-1, Group 1 or 2), 3/16 through 7/8 inch in the As-Welded Condition, with or without Backing
B2.1.003-90	Standard Welding Procedure Specification for Gas Metal Arc Welding of Galvanized Steel, 10 through 18 Gage, in the As-Welded Condition, with or without Backing
B2.1.004-90	Standard Welding Procedure Specification for Gas Metal Arc Welding of Carbon Steel, (M-1, Group 1), 10 through 18 Gage, in the As-Welded Condition, with or without Backing
B2.1.005-90	Standard Welding Procedure Specification for Gas Metal Arc Welding of Austenitic Stainless Steel, (M-8 or P-8), 10 through 18 Gage, in the As-Welded Condition, with or without Backing
B2.1.006-90	Standard Welding Procedure Specification for Gas Metal Arc Welding of Carbon Steel to Austenitic Stainless Steel, (M-1 to M-8 or P-8), 10 through 18 Gage, in the As-Welded Condition, with or without Backing
B2.1.007-90	Standard Welding Procedure Specification for Gas Tungsten Arc Welding of Galvanized Steel, 10 through 18 Gage, in the As-Welded Condition, with or without Backing
B2.1.008-90	Standard Welding Procedure Specification for Gas Tungsten Arc Welding of Carbon Steel, (M-1, Group 1), 10 through 18 Gage, in the As-Welded Condition, with or without Backing
B2.1.009-90	Standard Welding Procedure Specification for Gas Tungsten Arc Welding of Austenitic Stainless Steel, (M-8/P-8), 10 through 18 Gage, in the As-Welded Condition, with or without Backing
B2.1.010-90	Standard Welding Procedure Specification for Gas Tungsten Arc Welding of Carbon Steel to Austenitic Stainless Steel, (M-1 to M-8 or P-8), 10 through 18 Gage, in the As-Welded Condition, with or without Backing
B2.1.011-91	Standard Welding Procedure Specification for Shielded Metal Arc Welding of Galvanized Steel, 10 through 18 Gauge, in the As-Welded Condition, with or without Backing
B2.1.012-91	Standard Welding Procedure Specification for Shielded Metal Arc Welding of Carbon Steel, (M-1, Group 1), 10 through 18 Gauge, in the As-Welded Condition, with or without Backing
B2.1.013-91	Standard Welding Procedure Specification for Shielded Metal Arc Welding of Austenitic Stainless Steel, (M-8 or P-8), 10 through 18 Gauge, in the As-Welded Condition, with or without Backing
B2.1.014-91	Standard Welding Procedure Specification for Shielded Metal Arc Welding of Carbon Steel to Austenitic Stainless Steel, (M-1 to M-8 or P-8), 10 through 18 Gauge, in the As-Welded Condition, with or without Backing

B2.1.015-91	Standard Welding Procedure Specification for Gas Tungsten Arc Welding of Aluminum, (M-22 or P-22), 10 through 18 Gauge, in the As-Welded Condition, with or without Backing
B2.1-1-016-94	Standard Welding Procedure Specification for 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, E7018, As-Welded or PWHT Condition
B2.1-1-017-94	Standard Welding Procedure Specification for 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, E6010, As-Welded or PWHT Condition
B2.1-1-018-94	Standard Welding Procedure Specification for Self-Shielded Flux Cored Arc Welding of Carbon Steel (M-1/P-1/S-1, Group 1 or 2), 1/8 through 1-1/2 inch Thick, E71T-8, As-Welded Condition
B2.1-1-019-94	Standard Welding Procedure Specification for CO ₂ Shielded Flux Cored Arc Welding of Carbon Steel (M-1/P-1/S-1, Group 1 or 2), 1/8 through 1-1/2 inch Thick, E70T-1 and E71T-1, As-Welded Condition
B2.1-1-020-94	Standard Welding Procedure Specification for 75% Ar/25% CO ₂ Shielded Flux Cored Arc Welding of Carbon Steel (M-1/P-1/S-1, Group 1 or 2), 1/8 through 1-1/2 inch Thick, E70T-1 and E71T-1, As-Welded or PWHT Condition
B2.1-1-021-94	Standard Welding Procedure Specification 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
B2.1-1-022-94	Standard Welding Procedure Specification for 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, E6010 (Vertical Uphill) Followed by E7018, As-Welded or PWHT Condition
B2.1-8-023-94	Standard Welding Procedure Specification for Shielded Metal Arc Welding of Austenitic Stainless Steel (M-8/P-8/S-8, Group 1), 1/8 through 1-1/2 inch Thick, As-Welded Condition
B2.1-8-024-94	Standard Welding Procedure Specification for Gas Tungsten Arc Welding of Austenitic Stainless Steel (M-8/P-8/S-8, Group 1), 1/8 through 1-1/2 inch Thick, As-Welded Condition
B2.1-8-025-94	Standard Welding Procedure Specification for Gas Tungsten Arc Welding Followed by Shielded Metal Arc Welding of Austenitic Stainless Steel (M-8/P-8/S-8, Group 1), 1/8 through 1-1/2 inch Thick, As-Welded Condition
B2.1-1-026-94	Standard Welding Procedure Specification for 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, E6010 (Vertical Downhill) Followed by E7018, As-Welded or PWHT Condition
B2.1-1-027-95	Standard Welding Procedure Specification for Self-Shielded Flux Cored Arc Welding of Carbon Steel (M-1/P-1/S-1, Group 1 or 2), 1/8 through 3/4 inch Thick, E71T-11, As-Welded Condition

For ordering information, contact the Order Department, American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33126. Phone: 1-800-334-9353.