

**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**



American Welding Society

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

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An American National Standard

Approved by
American National Standards Institute
April 15, 1993

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1/8 through 1-1/2 inch Thick, ER70S-2 and E7018
As-Welded or PWHT Condition**

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 plate and structural applications.



American Welding Society

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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 It must be reviewed every five years and if not revised, it must be either reapproved or withdrawn.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 B2.1-1-021-94, *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 specification 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, *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 are most welcome. They should be addressed to: Secretary, AWS Committee on Welding Qualification, American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 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

Welding Research Council¹—Supporting PQR Numbers:
001002, 001007, 001013, 001014, 001015, 001017, 001024,
001038, 200708, 200709, 200710, 200711, 001A, 002A, 003B,
004A, 029A, 030A, 107A, 108A, 109A, 113A, 114A, 115A

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 [such as code, specification, or contract document(s)]. The fabrication document 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 judgement. The user is responsible for the quality and performance of the final product in accordance with the provisions of the fabrication document.

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. These instructions shall not be less restrictive than provided in the Standard WPS.

Safety. Safety precautions shall conform to the latest edition of ANSI/ASC Z49.1, *Safety in Welding and Cutting*, 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
Diameter: Groove Welds: 1 in. minimum
Fillet Welds: all diameters

FILLER METALS

Filler Metal Specification:² ANSI/AWS A5.18 or ASME SFA 5.18 for GTAW,
ANSI/AWS A5.1 or ASME SFA 5.1 for SMAW
A Number 1, F Number 6 for GTAW, and
F Number 4 for SMAW
Classification: ER70S-2 for GTAW and E7018 for SMAW
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
GTAW not to exceed 50% of deposit for groove or 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 or carbon steel weld metal. Nonmetallic or nonfusing metal retainers are not permitted

POSITIONS

Permitted Positions: All
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 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 to meet the requirements of the fabrication document(s).

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GAS

Shielding Gas: Welding Grade Argon
Flow Rate: 15 to 25 ft³/h
Trailing Gas: None
Backing Gas: Optional; If used, backing gas shall be Argon.
Flow Rate: A typical flow rate of 5 to 15 ft³/h may be varied depending on component configuration
Shielding Gas Nozzle Size: 1/4 to 3/4 in. I.D.

TUNGSTEN ELECTRODES

Specification: ANSI/AWS A5.12 or ASME SFA 5.12
Classification: EWTh-2 or EWCe-2
Size: 1/16 through 1/8 in. diameter sharpened to a point

ELECTRICAL CHARACTERISTICS

Gas Tungsten Arc Welding			
Filler Metal		Current	
Classification	Dia. in.	Amperes ¹	Polarity
ER70S-2	1/16	60–100	DCEN (Straight)
ER70S-2	3/32	80–140	DCEN (Straight)
ER70S-2	1/8	100–160	DCEN (Straight)
Shielded Metal Arc Welding			
Filler Metal		Current	
Electrode ²	Dia. in.	Current/Amperes	Current/Polarity
E7018	3/32	70–110	DCEP (Reverse)
E7018	1/8	90–150	DCEP (Reverse)
E7018	5/32	120–190	DCEP (Reverse)
E7018	3/16 ³	170–280	DCEP (Reverse)

1. Values not to exceed the capacity of tungsten electrodes.
 2. The care and storage of electrodes shall be as recommended by the electrode manufacturer.
 3. 3/16 in. electrodes shall not be used in the vertical or overhead positions.

Pulsing Current: Not permitted

POSTWELD HEAT TREATMENT

Postweld Heat Treatment: Welds may either be as-welded or postweld heat treated at 1100 to 1200°F. 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.

Standard Welding Procedure Specification (WPS)

TECHNIQUE

Weave or Stringer Bead:	Either
Peening:	Not required; if used, proceed as directed by the fabrication document
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 Passes:	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

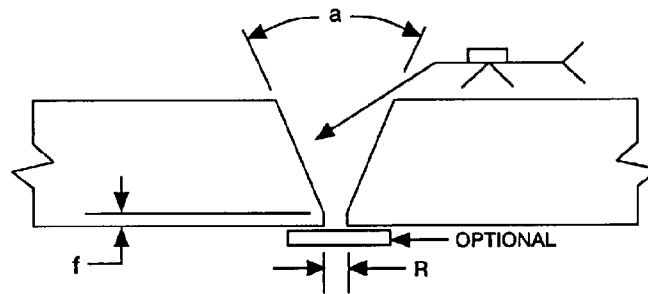
DATE _____ APPROVED BY _____ TITLE _____

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.

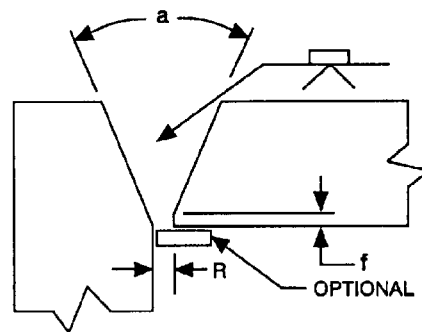
For tubular products, see Joints 1, 2, 6 and 7. In addition, joints having groove designs resulting from end preparations conforming with the latest edition of ANSI/ASME B16.25, *Butt Welding Ends*, are also allowable for application with this WPS.



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

WITHOUT BACKING
 $a = 60^\circ$ MIN.
 $R = 1/8$ in., $+1/16 - 1/16$
 $f = 1/16$ in. MAX.

JOINT 1



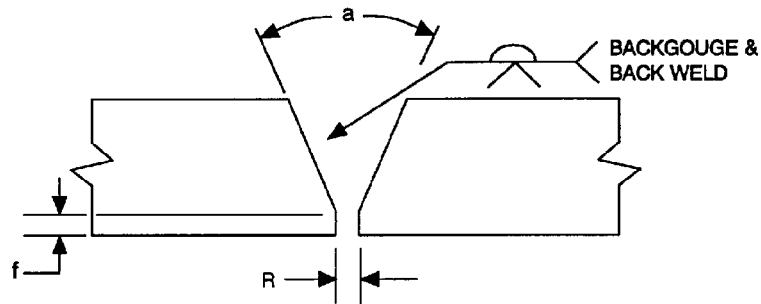
WITH BACKING
 $a = 45^\circ$ MIN.
 $R = 1/4$ in., $+1/4 - 1/16$
 $f = R/2$

WITHOUT BACKING
 $a = 60^\circ$ MIN.
 $R = 1/8$ in., $+1/16 - 1/16$
 $f = 1/16$ in. MAX.

JOINT 2

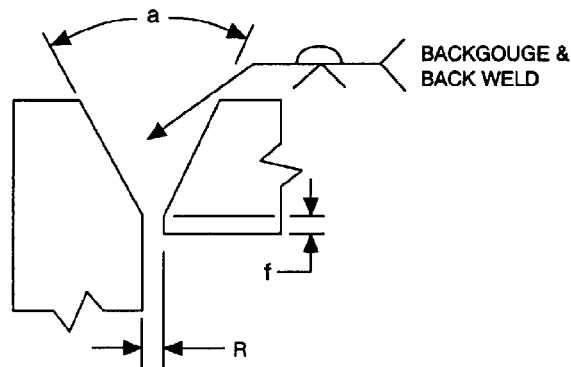
Figure 1—Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



$a = 60^\circ \text{ MIN.}$
 $R = 1/8 \text{ in., } +1/16-1/8$
 $f = \text{NOT LIMITED}$

JOINT 3

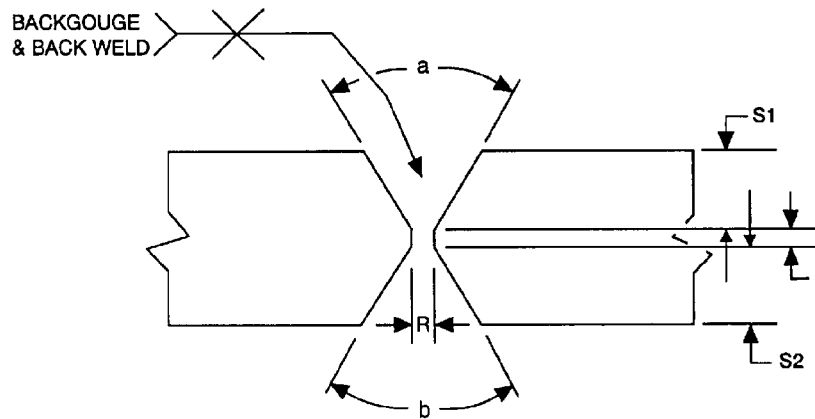


$a = 60^\circ \text{ MIN.}$
 $R = 1/8 \text{ in., } +1/16-1/8$
 $f = \text{NOT LIMITED}$

JOINT 4

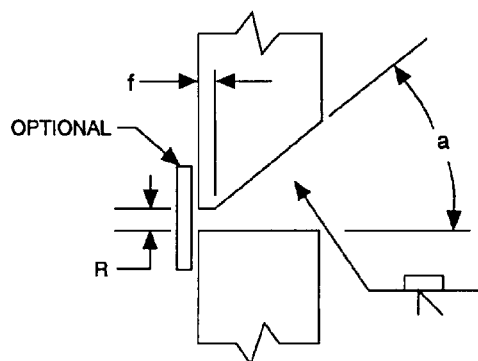
Figure 1 (continued)—Allowable Joint Designs

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



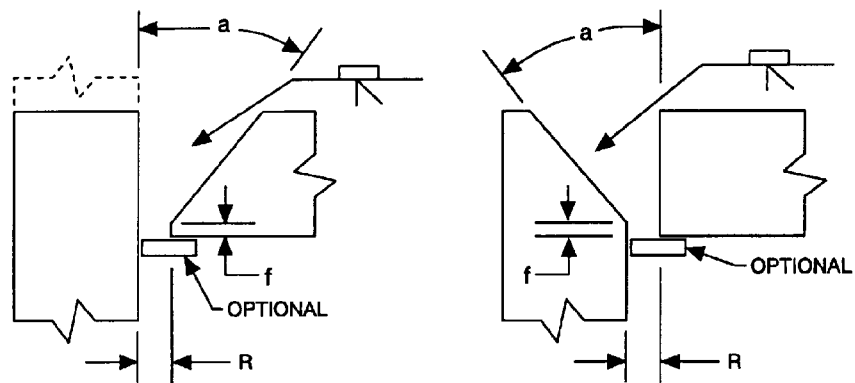
WITH BACKING
 $a = 45^\circ$ MIN.
 $R = 1/4$ in., $+1/4-1/16$
 $f = R/2$

WITHOUT BACKING
 $a = 60^\circ$ MIN.
 $R = 1/8$ in., $+1/16-1/16$
 $f = 1/16$ in. MAX.

JOINT 6

Figure 1 (continued)—Allowable Joint Designs

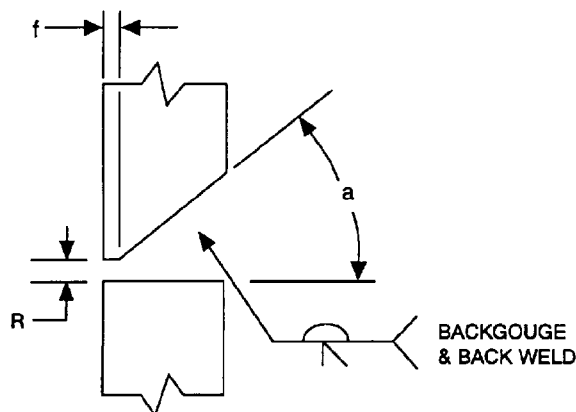
Standard Welding Procedure Specification (WPS)



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

WITHOUT BACKING
 $a = 60^\circ$ MIN.
 $R = 1/8$ in., $+1/16$ - $1/16$
 $f = 1/16$ in. MAX.

JOINT 7

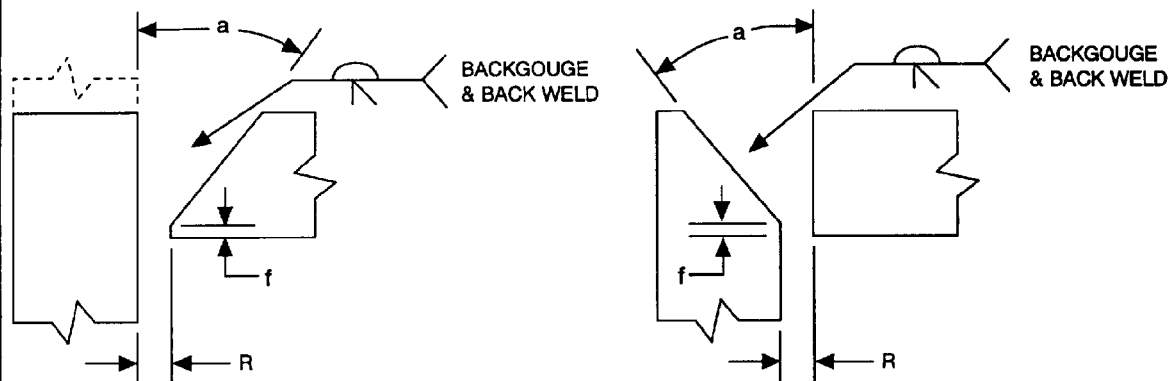


$a = 45^\circ$ MIN.
 $R = 1/8$ in., $+1/16$ - $1/8$
 $f =$ NOT LIMITED

JOINT 8

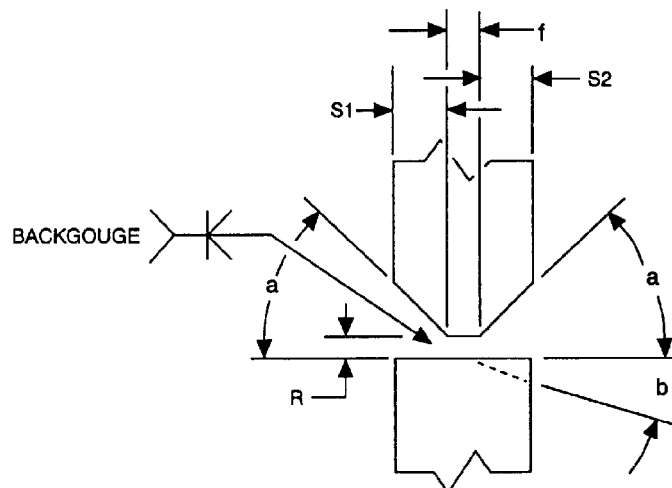
Figure 1 (continued)—Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



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

JOINT 9

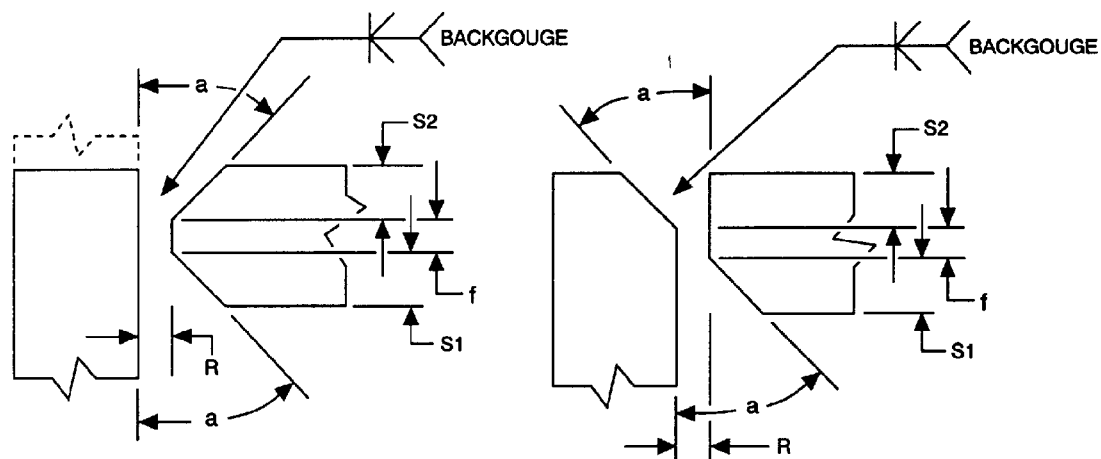


$a = 45^\circ \text{ MIN.}$
 $b = 15^\circ \text{ MAX.}$
 $R = 1/8 \text{ in., } +1/16-1/16$
 $f = \text{NOT LIMITED}$
 $S1 = \text{NOT LIMITED}$
 $S2 = \text{NOT LIMITED}$

JOINT 10

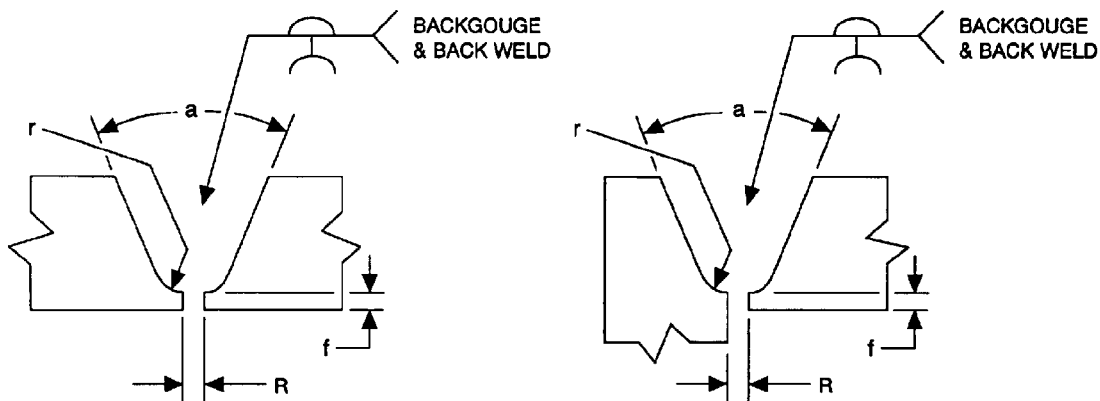
Figure 1 (continued)—Allowable Joint Designs

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

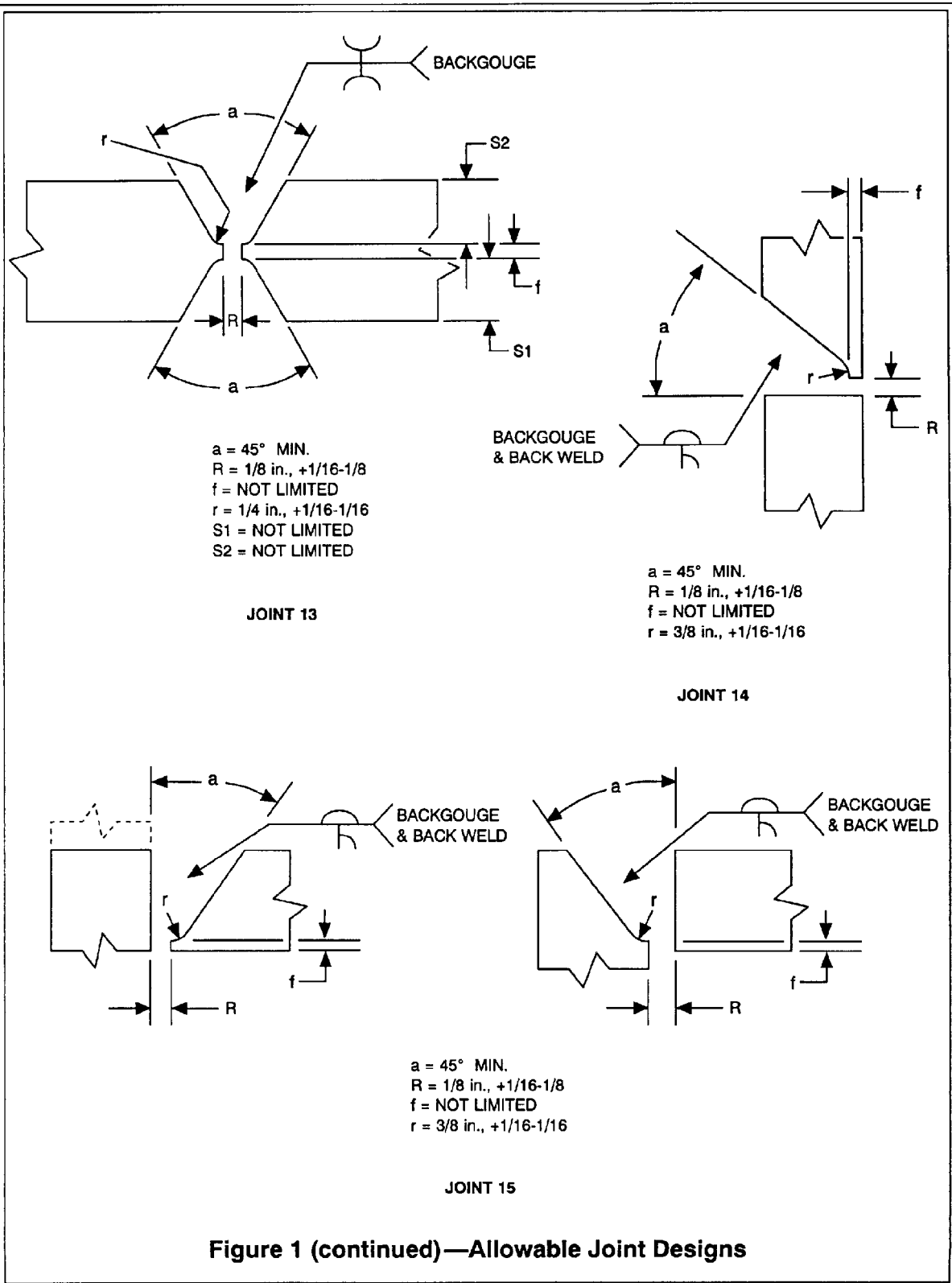


$a = 45^\circ \text{ MIN.}$
 $R = 1/8 \text{ in., } +1/16-1/8$
 $f = \text{NOT LIMITED}$
 $r = 1/4 \text{ in., } +1/8-0$

JOINT 12

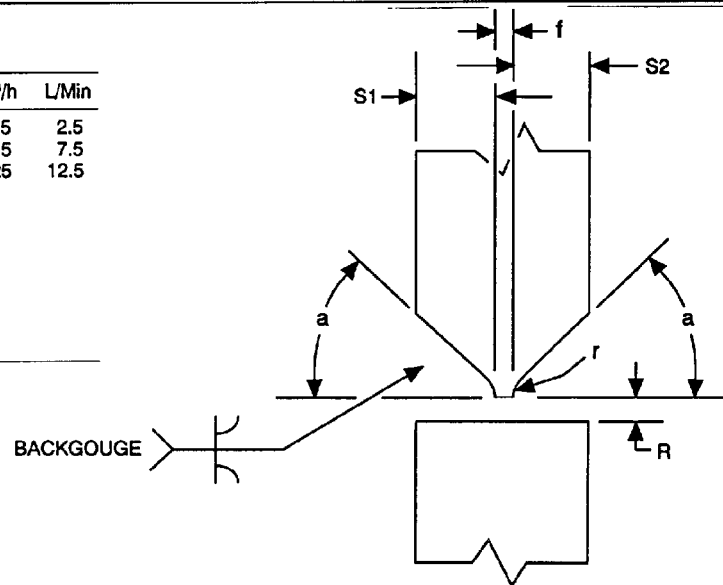
Figure 1 (continued)—Allowable Joint Designs

Standard Welding Procedure Specification (WPS)



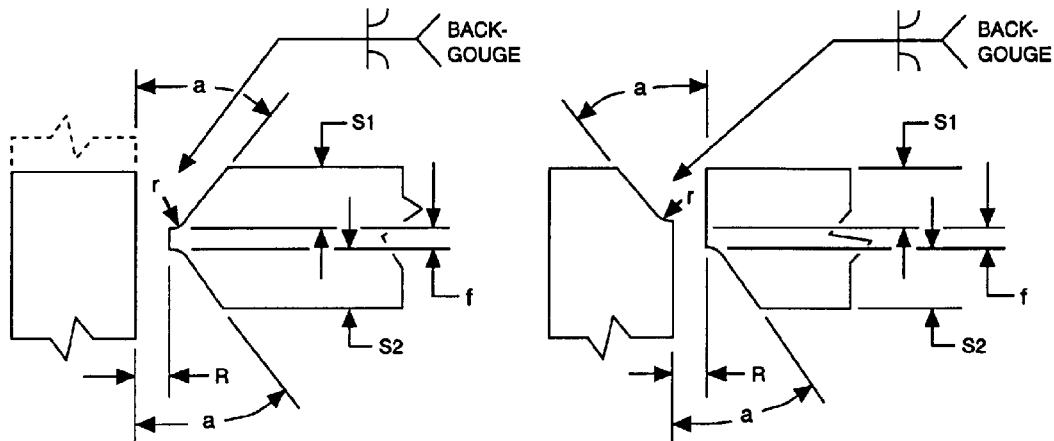
Standard Welding Procedure Specification (WPS)

Metric Conversions					
in.	mm	°F	°C	ft ³ /h	L/Min
0.045	1.1	50	10	5	2.5
0.052	1.3	500	260	15	7.5
1/16	1.6			25	12.5
5/64	2.0				
1/8	3.2				
3/16	4.8				
1/4	6.4				
1/2	13				
3/4	19				
1-1/2	38				
4	100				



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

JOINT 16



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

JOINT 17

Figure 1 (continued)—Allowable Joint Designs