



Specification for Welding Earthmoving, Construction, and Agricultural Equipment



American Welding Society



AWS D14.3/D14.3M:2010
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Specification for Welding Earthmoving, Construction, and Agricultural Equipment

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Prepared by the
American Welding Society (AWS) D14 Committee on Machinery and Equipment
Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification provides standards for producing structural welds used in the manufacture and repair of earthmoving, construction, and agricultural equipment. Such equipment is defined as self-propelled, on- and off-highway machinery and associated implements. Manufacturer's responsibilities are presented as they relate to the welding practices that have been proven successful within the industry in the production of weldments on this equipment. Basic dimensional weld details are defined and interpreted for application throughout the document. Provisions are made to identify base metals used in these weldments. Procedures to ensure that they are welded with compatible, identifiable welding processes and consumables are included with consideration given to factors that affect weldability.



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Foreword

This foreword is not part of AWS D14.3/D14.3M:2010, *Specification for Welding Earthmoving, Construction, and Agricultural Equipment*, but is included for informational purposes only.

AWS first published the Specification for Welding Earthmoving and Construction Equipment in 1977 to provide a welding specification where none previously existed. By definition, the types of equipment covered by the specification are numerous and varied. Every effort was made to reflect the best welding practices employed by manufacturers within the industry and to incorporate all the various methods which have proven successful by individual manufacturers. This edition builds on these foundations to improve interpretation and effect implementation. Text, tables, and figures have been updated or clarified to reflect more recent developments and promote standardization.

Changes in this 6th edition of D14.3 include the following:

1. Updated requirements in Clause 7 for prequalified procedures using single wire SAW;
2. Updated Clauses 7 and 8 to reference AWS B2.1 as the primary source of requirements for procedure and performance qualifications and removed redundant information from this standard;
3. Clarified the qualification of individuals responsible for performance test evaluations as described in Clause 8;
4. Added some general statements to the Workmanship and Welding Quality Requirements in Clause 9.

Underlined areas in text, tables, or figures indicate changes from the previous edition. A vertical line in the margin next to a figure, equation, or other item indicates a revision of that item from the previous edition.

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Specification for Welding Earthmoving, Construction, and Agricultural Equipment

1. Scope and General Provisions

1.1 Scope

1.1.1 This specification applies to all structural welds used in the manufacture and repair of earthmoving, construction, and agricultural equipment.¹ It reflects the welding practices employed by manufacturers within the industry and incorporates various methods which have been proven successful by individual manufacturers. No restrictions are placed on the use of any welding process or procedure, provided the weld produced meets the qualification requirements of this specification. No attempt is made to limit or restrict the welding technology progression of earthmoving, construction, and/or agricultural equipment manufacturing and repair, nor should any such limitation be inferred. Design criteria for allowable stresses for the base and weld metal and the fatigue analysis for welded joints are not published in the specification. The user shall utilize AWS D14.4, *Specification for Welded Joints in Machinery and Equipment*, or appropriate engineering practices and principles for design criteria.

1.1.2 The Manufacturer's adherence to this specification shall include responsibility for the following:

- (1) welding, as defined in 1.1.1, in accordance with this specification;
- (2) producing welds as designated on drawings by appropriate symbols and notes, with sufficient detail to show joint preparation compatible with applied processes;
- (3) providing and using written welding procedure specifications (WPSs);
- (4) ensuring that qualified welders are used to make welds;
- (5) recording and maintaining results of all welder performance and procedure qualification tests;
- (6) controlling use of designated base metals and consumables;
- (7) inspecting the welds to the requirements of this specification;
- (8) ensuring a safe welding environment and safe welding practice;
- (9) having a quality system in place. The requirements of AWS B5.17, *Specification for the Qualification of Welding Fabricators* may be used as a guide in establishing this quality program. Accreditation of quality systems of welding fabricators may be obtained through the AWS Certified Welding Fabricator (CWF) or equivalent programs.

1.2 Units of Measure. This specification makes use of both the U.S. Customary Units and the International System of Units (SI). The measurements may not be exact equivalents; therefore each system must be used independently of the other without combining in any way. The specification with the designation D14.3 uses U.S. Customary Units. The specification D14.3M uses SI Units. The latter are shown in appropriate columns in tables and figures or within brackets [] when used in the text. Detailed dimensions on figures are in inches. A separate tabular form that relates the U.S. Customary Units with SI units may be used in tables and figures.

¹ For purposes of this specification, earthmoving, construction, and agricultural equipment are described as self-propelled, on and off-highway machinery and associated implements. Such products as crawlers, tractors, graders, loaders, off-highway trucks, power shovels, backhoes, mobile cranes, draglines, and similar equipment are considered to be included in this specification.

1.3 Safety. 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.

1.4 Symbols. Welding symbols shown on drawings shall be compatible with those shown in AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*. Special conditions or deviations shall be fully explained by added notes, details, or definitions.

2. Normative References

The following standards contain provisions which, through reference in this text, constitute 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 Standards²

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

AWS A3.0, *Standard Welding Terms and Definitions*

AWS A5.32/A5.32M, *Specification for Welding Shielding Gases*

AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*

AWS D14.4/D14.4M, *Specification for Welded Joints in Machinery and Equipment*

ASTM Standards³

ASTM E 92, *Test for Vickers Hardness of Metallic Materials*

ASTM E 140, *Standard Hardness Conversion Tables for Metals*

ISO Standards⁴

ISO 9016, *Destructive tests on welds in metallic materials—Impact tests—Test specimen location, notch orientation and examination*

3. Definitions

Terms used in this specification shall be in accordance with AWS A3.0, *Standard Welding Terms and Definitions*. Additional terms specific to this standard are defined in this clause.

consumables. Filler metals, fluxes, and shielding gases used in the welding process.

contract documents. Manufacturing documentation which may include manufacturing prints, purchase orders, or contracts.

effective weld areas

groove welds. The effective area is the effective weld length multiplied by the weld size. (See 4.2 for additional details.)

fillet welds. The effective area is the effective weld length multiplied by the effective throat. (See 4.3 for additional details.)

plug and slot welds. The effective area shall be the nominal area of the hole or slot in the plane of the faying surface.

² AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

³ ASTM International Standards are published by the American Society for Testing and Materials (ASTM), PO Box C700, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

⁴ ISO Standards are published by the International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland.

equipment modification. An alteration to machinery or equipment that changes the original design.

Engineer. The responsible technical authority.

qualification variable. A welding parameter whose change beyond the tolerances permitted by a standard requires requalification of a welding procedure, welder, or welding operator. (Formerly known as essential variable).

Manufacturer. The organization responsible for the performance of the work covered by this specification. This term includes contractors, subcontractors, fabricators, erectors, or any other organization making weldments intended to meet the requirements of this specification.

operator of automatic welding equipment. Welding personnel who operate equipment that requires only occasional or no observation and no manual adjustment of the controls.

Owner. The person, company, or agency that purchases the equipment.

pipng porosity. A form of porosity having a length greater than its width that lies approximately perpendicular to the weld face. When the porosity extends to the weld surface, it is frequently referred to as “pin holes.”

Qualified Person. A person who, by possession of a recognized degree or certificate of professional standing, or who, by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work.

repair. The restoration of machinery or equipment to meet its intended performance without changing the original design.

structural welds. Welds which carry the primary working loads during normal operations.

tack welder. A fitter, or someone under the direction of a fitter, who tack welds parts of a weldment to hold them in proper alignment until the final welds are made.

4. Basic Weld Detail

4.1 Weld Size Considerations. Individual weld pass sizes considerably less than plate thickness may result in inadequate heat input which can lead to cracking, loss of fracture toughness (degradation of impact properties), and lack of fusion. When final weld sizes (individual or multiple pass) smaller than 30% of plate thickness are to be used, the Engineer shall determine whether testing needs to be performed to ensure that the resulting welded joint properties are consistent with design and quality requirements.

4.2 Groove Welds

4.2.1 A complete-joint-penetration weld is a groove weld in which weld metal extends through the entire joint thickness. The size of a complete joint penetration groove weld shall be the thickness of the thinner part joined.

4.2.2 A partial-joint-penetration weld may be welded from one or both sides and has incomplete joint penetration. The size of a partial-joint-penetration groove weld shall be the joint penetration obtained.

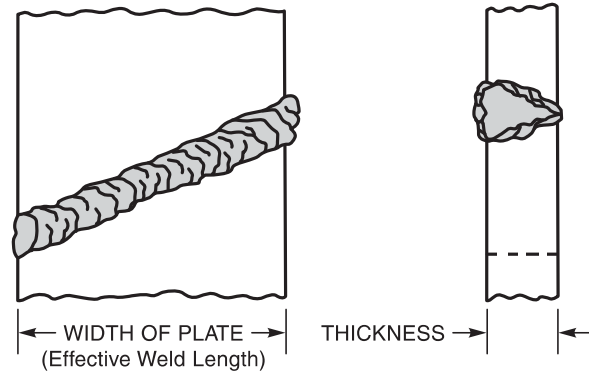
4.2.3 The effective length for any groove weld, square or skewed, shall be the width of the part joined (see Figure 1).

4.2.4 The effective weld area shall be the effective weld length multiplied by the weld size.

4.3 Fillet Welds

4.3.1 The effective throat for a fillet weld is defined as the minimum distance minus any convexity between the weld root and the face of a fillet weld (see Figures 2, 3, and 4). Design values based on joint penetration or effective throat, or both, which are beyond the root of the joint shall only be used when the values have been determined from a significant number of cross-sectioned samples which reflect the range of materials, material thicknesses, and welding conditions.

4.3.2 The length of a fillet weld shall be the overall length of the full-size fillet, including boxing.



THE DIRECTION OF THE WELD ACROSS THE PLATE IS OTHER THAN 90° TO THE LENGTH OF THE PLATE.

Figure 1—Skewed Groove Weld

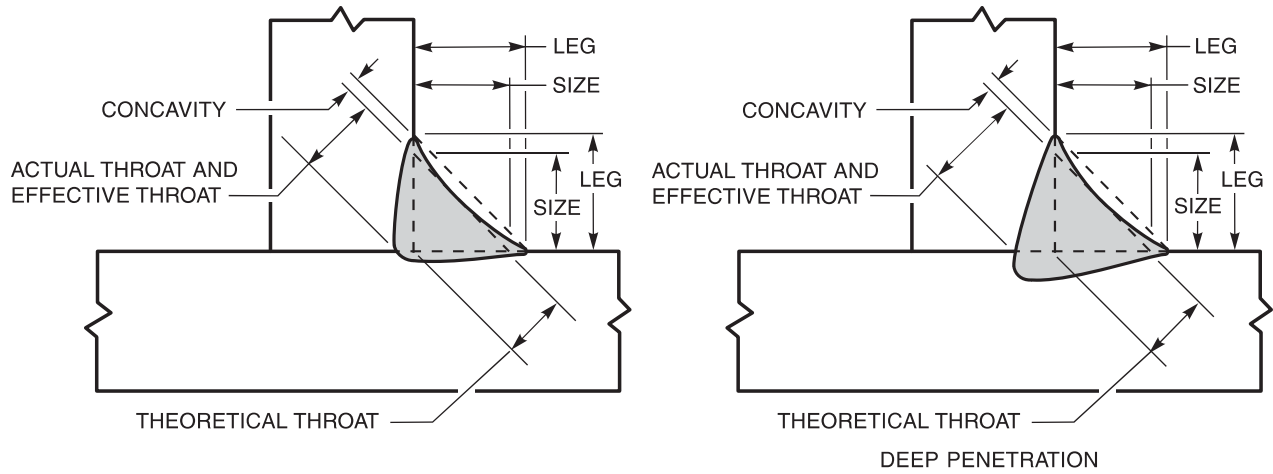


Figure 2—Concave Fillet Weld Profiles

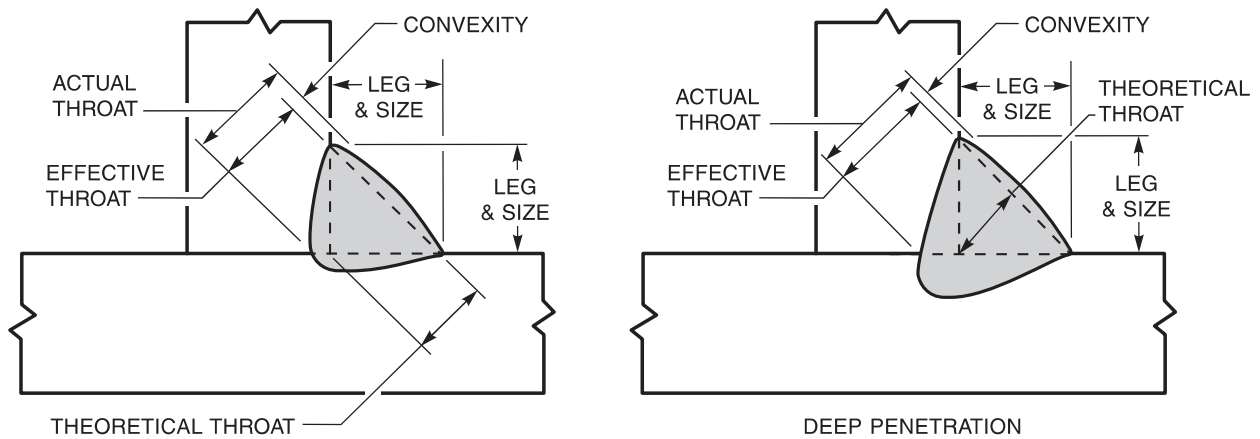


Figure 3—Convex Fillet Weld Profiles

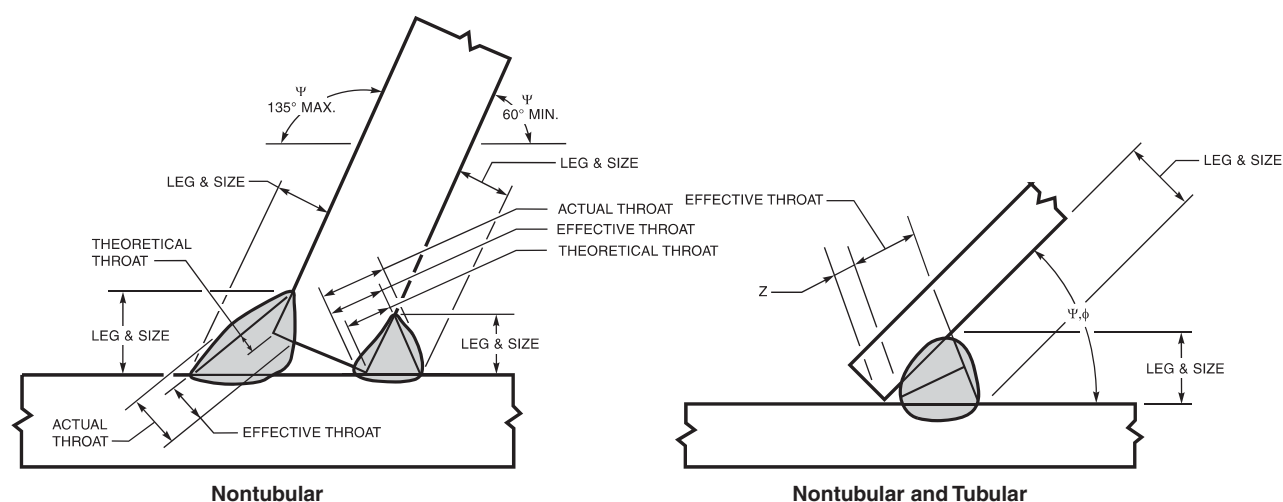


Figure 4—Skewed T-Joint

Table 1
Z Loss Dimension (Nontubular)

Dihedral Angle ψ	Position of Welding—V or OH			Position of Welding—H or F		
	Process	Z(in)	Z(mm)	Process	Z(in)	Z(mm)
$60^\circ > \psi \geq 45^\circ$	SMAW	1/8	3	SMAW	1/8	3
	FCAW-S	1/8	3	FCAW-S	0	0
	FCAW-G	1/8	3	FCAW-G	0	0
	GMAW	N/A	N/A	GMAW	0	0
$45^\circ > \psi \geq 30^\circ$	SMAW	1/4	6	SMAW	1/4	6
	FCAW-S	1/4	6	FCAW-S	1/8	3
	FCAW-G	3/8	10	FCAW-G	1/4	6
	GMAW	N/A	N/A	GMAW	1/4	6

4.3.3 The effective area shall be the effective weld length multiplied by the effective throat. Stress in a fillet weld shall be considered as applied to this effective area for any direction of applied load.

4.3.4 Fillet welds may be used in skewed T-Joints (Tee Joints) having a dihedral angle of not less than 60° nor more than 135° [see Figure 4 (Nontubular)]. Angles less than 60° may be used; however, such welds are considered to be partial joint penetration (PJP) groove welds [see Figure 4 (Nontubular and Tubular)].

4.3.5 When welding is required in an acute angle that is less than 60° but equal to or greater than 30° [Figure 4 (Nontubular and Tubular)], the effective throat shall be increased by the Z-loss allowance (Table 1 and Table 2). The contract documents shall specify the required effective throat. The shop drawings shall show the required leg dimensions to satisfy the required effective throat, increased by the Z-loss allowance in Tables 1 and 2.

4.4 Combinations of Groove and Fillet Welds. The effective throat for combinations of groove and fillet welds is the shortest distance from the root of the weld to the face of the fillet, less any convexity (see Figure 5).

4.5 Intermittent Welds

4.5.1 The length of any segment of an intermittent fillet weld shall not be less than four times the weld size. Welds less than 1/4 in [6 mm] size shall not be less than 1 in [25 mm] in length.

4.5.2 If intermittent fillet welds are used, welds should be located at each end of the joint.

Table 2
Z Loss Dimensions for Calculating Prequalified PJP T-, Y-,
and K-Tubular Connection Minimum Weld Sizes

Joint Included Angle ϕ	Position of Welding: V or OH			Position of Welding: H or F		
	Process	Z(in)	Z(mm)	Process	Z(in)	Z(mm)
$\phi \geq 60^\circ$	SMAW	0	0	SMAW	0	0
	FCAW-S	0	0	FCAW-S	0	0
	FCAW-G	0	0	FCAW-G	0	0
	GMAW	N/A	N/A	GMAW	0	0
	GMAW-S	0	0	GMAW-S	0	0
$60^\circ > \phi \geq 45^\circ$	SMAW	1/8	3	SMAW	1/8	3
	FCAW-S	1/8	3	FCAW-S	0	0
	FCAW-G	1/8	3	FCAW-G	0	0
	GMAW	N/A	N/A	GMAW	0	0
	GMAW-S	1/8	3	GMAW-S	1/8	3
$45^\circ > \phi \geq 30^\circ$	SMAW	1/4	6	SMAW	1/4	6
	FCAW-S	1/4	6	FCAW-S	1/8	3
	FCAW-G	3/8	10	FCAW-G	1/4	6
	GMAW	N/A	N/A	GMAW	1/4	6
	GMAW-S	3/8	10	GMAW-S	1/4	6

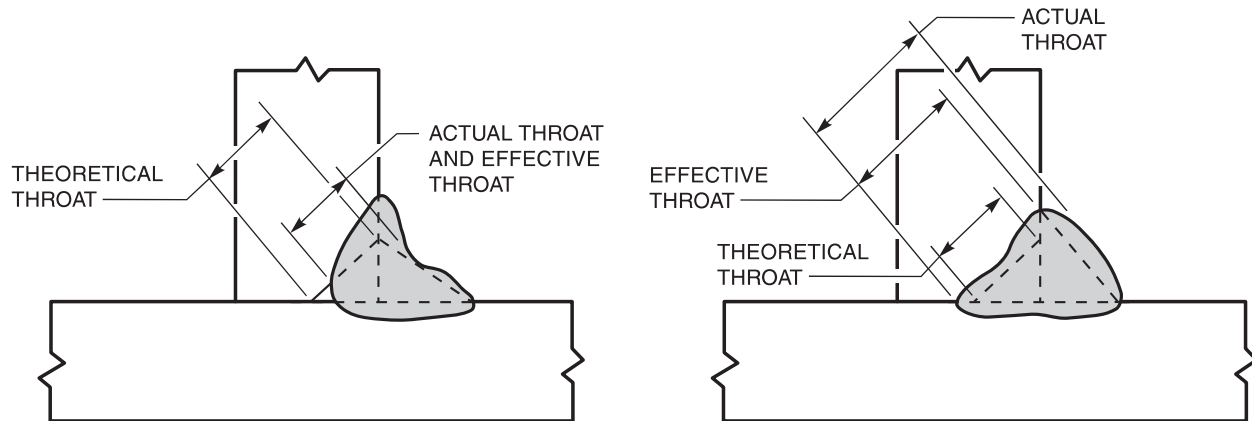


Figure 5—Combination of Bevel-Groove and Fillet Weld Profile

5. Base Metals

5.1 Structural Steels and Nonferrous Metals. Structural steel, steel castings and forgings, and nonferrous metals used in the weldments of earthmoving, construction, and agricultural equipment shall be identified by a specification. Specifications developed by the Manufacturer or commonly used industry-wide specifications developed by organizations such as ASTM International (ASTM), American Iron and Steel Institute (AISI), Society of Automotive Engineers (SAE), and American Foundrymen's Society (AFS) may be used.

5.2 Properties. Base metal specifications shall designate the chemical composition of the material to be used and shall include the mechanical properties and/or heat treatment of the material when required for proper identification. Base metals are expected to be compatible with the welding process and consumables recommended in this specification.

It is not the intent of this specification to restrict base metal selection, but to ensure weldability factors have been considered.

5.3 Weldability and Procedure Qualification. The weldability and procedure for welding base metals shall be established by qualification in accordance with the requirements of Clause 7, Welding Procedure Qualification.

6. Welding Processes and Consumables

6.1 Processes

6.1.1 All welding processes and methods recognized by AWS A3.0, *Standard Welding Terms and Definitions*, may be used in the construction, fabrication, and repair of earthmoving, construction, and agricultural equipment.

6.1.2 Processes which are not classified or recognized by AWS may be used, provided the Manufacturer can show evidence that the process used produces welds which meet the requirements of Clause 7, Welding Procedure Qualification.

6.2 Consumables

6.2.1 Consumables that meet the requirements of AWS filler metal specifications need not be tested by the user.

6.2.2 Consumables which are not classified in accordance with AWS A5 requirements may be used, provided the Manufacturer can show evidence that the consumables used will consistently produce welds which meet the requirements of Clause 7, Welding Procedure Qualification.

6.2.3 Consumables shall be protected and stored so that their characteristics or welding properties are not adversely affected. Consumable manufacturer's recommendations shall be applied. Annex C contains general practices for storage and the use of SMAW, FCAW, GMAW, and SAW consumables employed for application within the scope of this specification.

6.2.4 When a gas or gas mixture is used for shielding in any gas-shielded process, it shall meet the requirements of AWS A5.32/5.32M, *Specification for Welding Shielding Gases*.

7. Welding Procedure Qualification

7.1 Scope. Welding procedure qualification shall be performed per 7.1.1 to establish weldability with any particular combination of the qualification variables noted in 7.1.2.

7.1.1 Each Manufacturer shall be responsible for the choice of qualifying method, completing welding procedure qualification tests, and for recording of all tests supporting production welding. Welding procedure specifications shall be qualified using AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*, within the limits of 7.1 and the workmanship and quality requirements of Clause 9. Alternatively, welding procedure specifications may be qualified by one of the three methods addressed in 7.2.1. Records of the test results shall be retained by the Manufacturer, and shall be available for review for the length of time required by the contract.

7.1.2 All procedures to be used shall be prepared by the Manufacturer as written welding procedure specifications (WPSs) and shall include ranges for each of the qualification variables. Each of the following six variables, as established by procedure qualification, shall be part of the WPS:

- (1) base metal class (see Clause 5 and 7.5)
- (2) welding process
- (3) filler metal
- (4) joint design
- (5) welding conditions
- (6) position

Once qualified, any changes to a qualification variable outside the range specified in the WPS requires requalification. The Manufacturer shall be responsible for ensuring that such changes are consistent with the weld quality requirements of Clause 9, Workmanship and Welding Quality Requirements. Any changes shall be reflected in the WPS.

7.1.3 Alternative Welding Procedure Qualification Methods. As noted in 7.1.1, procedure qualification may also be achieved as noted below:

- (1) Method I—Prototype Testing,
- (2) Method II—Procedure Qualification Tests for Partial Joint Penetration Groove Welds, or
- (3) Method III—Prequalified Joint Procedure.

Welding procedures once qualified by any of the methods are considered qualified whenever the same set of six variables (see 7.1.3) is encountered. This permits the development of standard procedures by a manufacturer.

7.2 General Requirements

Standard Welding Procedure Specifications published by the AWS B2 Committee on Procedure and Performance Qualification are considered to be qualified in accordance with this specification.

7.2.1 Base Metal and Its Preparation. The base metal and its preparation for welding shall comply with the WPS. The test specimen required for all types of welded joints shall be such that the length of the weld and the dimensions of the base metal are sufficient for testing.

7.2.2 Position of Test Welds. All welds that will be encountered in actual construction shall be classified as being (1) flat, (2) horizontal, (3) vertical, or (4) overhead, in accordance with the definitions of welding positions given in Figures 6 and 7. Procedures qualified to Method I, Method II, and AWS B2.1/B2.1M, *Specification for Welding Performance and Procedure Qualification* shall be qualified in each position to be used.

7.2.2.1 Groove Welds

- (1) Position 1G (flat)—The test plates shall be placed in an approximately horizontal plane and the weld metal deposited from the upper side, as illustrated in Figure 8(A).
- (2) Position 2G (horizontal)—The test plates shall be placed in an approximately vertical plane with the welding groove approximately horizontal, as illustrated in Figure 8(B).
- (3) Position 3G (vertical)—The test plates shall be placed in an approximately vertical plane with the welding groove, approximately vertical, as illustrated in Figure 8(C).
- (4) Position 4G (overhead)—The test plates shall be placed in an approximately horizontal plane and the weld metal deposited from the underside, as illustrated in Figure 8(D).

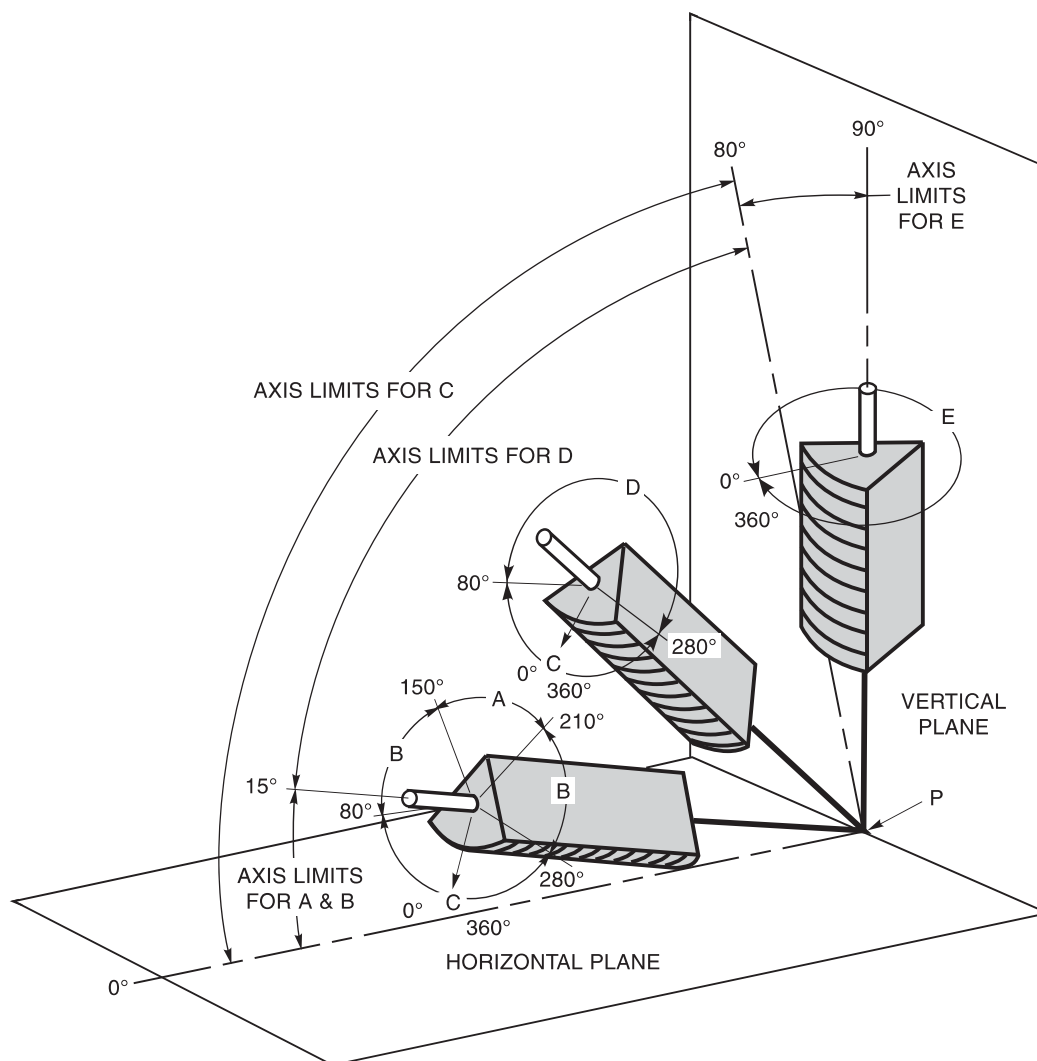
7.2.2.2 Fillet Welds

- (1) Position 1F (flat)—The test plates shall be placed so that each fillet weld is deposited with its axis approximately horizontal and its throat approximately vertical, as illustrated in Figure 9(A).
- (2) Position 2F (horizontal)—The test plates shall be placed so that each fillet weld is deposited on the upper side of the horizontal surface and against the vertical surface, as illustrated in Figure 9(B).
- (3) Position 3F (vertical)—Each fillet weld shall be made vertically, as illustrated in Figure 9(C).
- (4) Position 4F (overhead)—The test plates shall be placed so that each fillet weld is deposited on the underside of the horizontal surface and against the vertical surface, as illustrated in Figure 9(D).

7.2.3 Impact Requirements. The Engineer is responsible for determining if notch toughness (crack arrest capability) requirements are applicable for any portion of the product design. If notch toughness requirements exist, the Manufacturer shall use AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification* for the qualification of welding procedures. Method I—Prototype Testing, except as allowed by SAE J1040 or ISO 3471, Method II—Partial Joint Penetration Groove Welds, and Method III—Prequalified Joint Procedures are not permitted for qualifying welding procedures to be used on products or components having notch toughness requirements. Refer to AWS B4.0 or B4.0M, *Standard Methods for Mechanical Testing of Welds* for specific requirements regarding notch toughness testing for welding procedure qualifications. Users of D14.3M should refer to ISO 9016, *Destructive tests on welds in metallic materials—Impact tests—Test specimen location, notch orientation and examination* for specific requirements regarding notch toughness testing for welding procedure qualifications.

7.2.4 Heat Input Limitations. Where heat input is determined to be critical to maintain base metal mechanical properties, the heat input limitation is to be recorded in the WPS. The formulas for calculating heat input from welding are listed in Table 3.

7.2.5 Welding shall comply in all respects to the Welding Procedure Specification (WPS).

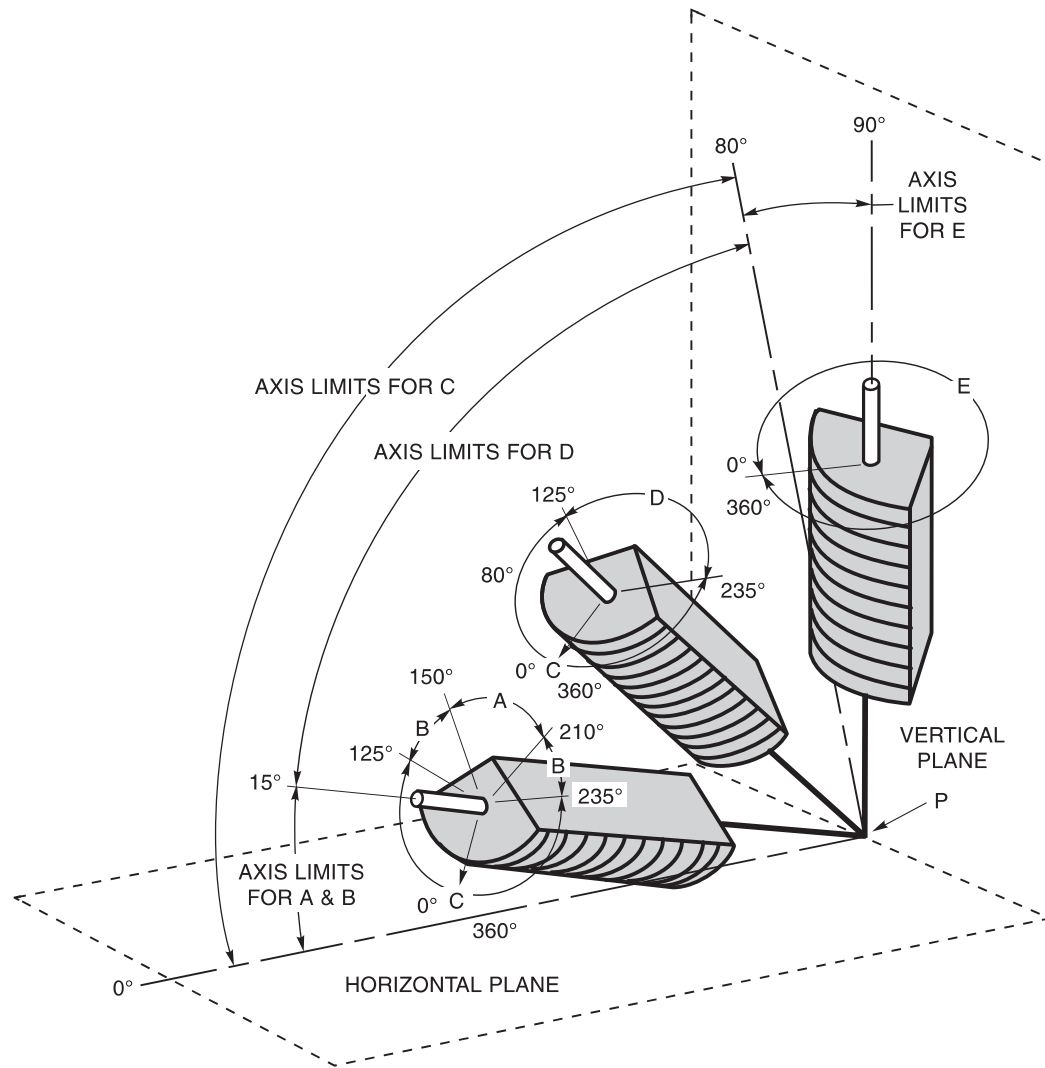


Tabulation of Positions of Groove Welds			
Position	Diagram Reference	Inclination of Axis	Rotation of Face
Flat	A	0° to 15°	150° to 210°
Horizontal	B	0° to 15°	80° to 150° 210° to 280°
Overhead	C	0° to 80°	0° to 80° 280° to 360°
Vertical	D	15° to 80°	80° to 280°
	E	80° to 90°	0° to 360°

Notes:

1. The horizontal reference plane is always taken to lie below the weld under consideration.
2. The inclination of axis is measured from the horizontal reference plane toward the vertical reference plane.
3. The angle of rotation of the face is determined by a line perpendicular to the theoretical face of the weld which passes through the axis of the weld. The reference position (0°) of rotation of the face invariably points in the direction opposite to that in which the axis angle increases. When looking at point P the angle of rotation of the face of the weld is measured in a clockwise direction from the reference position (0°).

Figure 6—Positions of Groove Welds



Tabulation of Positions of Fillet Welds			
Position	Diagram Reference	Inclination of Axis	Rotation of Face
Flat	A	0° to 15°	150° to 210°
Horizontal	B	0° to 15°	125° to 150° 210° to 235°
Overhead	C	0° to 80°	0° to 125° 235° to 360°
Vertical	D	15° to 80°	125° to 235°
	E	80° to 90°	0° to 360°

Figure 7—Positions of Fillet Welds

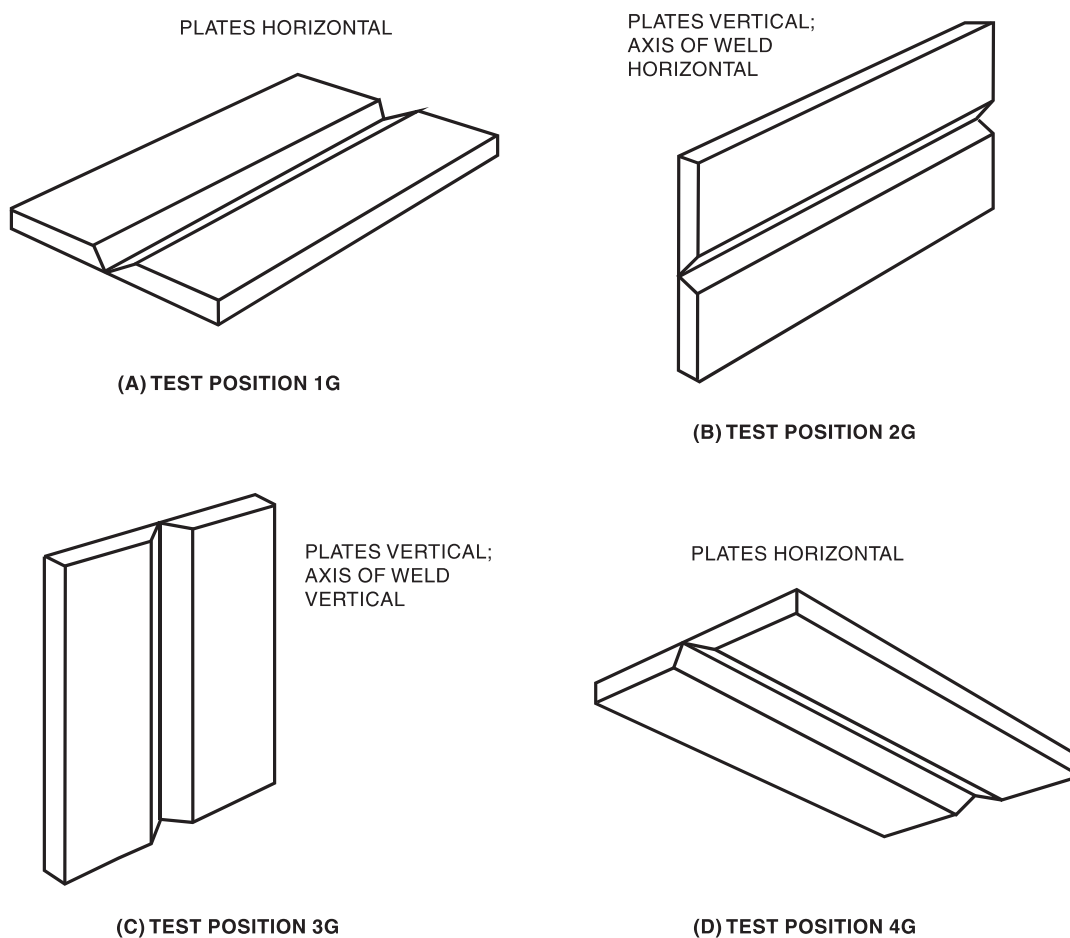


Figure 8—Positions of Test Plates for Groove Welds

**Table 3
Heat Input Calculations**

Units of Measure	Formula for Calculation
Joules per Inch (J/in)	$(\text{Amps} \times \text{Volts} \times 60) / \text{Travel Speed}^a$
Kilojoules per inch (kJ/in)	$(\text{Amps} \times \text{Volts} \times 60) / (\text{Travel Speed}^a \times 1000)$
Joules per millimeter (J/mm)	$(\text{Amps} \times \text{Volts} \times 60) / \text{Travel Speed}^b$
Kilojoules per meter (kJ/m)	$(\text{Amps} \times \text{Volts} \times 60) / (\text{Travel Speed}^c \times 1000)$

^a Travel speed measured in inches per minute.

^b Travel speed measured in millimeters per minute.

^c Travel speed measured in meters per minute.

7.3 Method I—Prototype Testing

7.3.1 Welding procedure specifications may be qualified under Method I by utilizing prototype structures or components that comply with the minimum performance criteria in a simulated service test or field test as described in 7.3.1.1 and 7.3.1.2.

7.3.1.1 Simulated service tests are tests of a welded assembly or a mockup of a welded joint tested in a simulated environment that represents the significant weld performance conditions for the application. Examples include required specification performance tests such as SAE criteria for rollover protection system (ROPS) and falling object protection

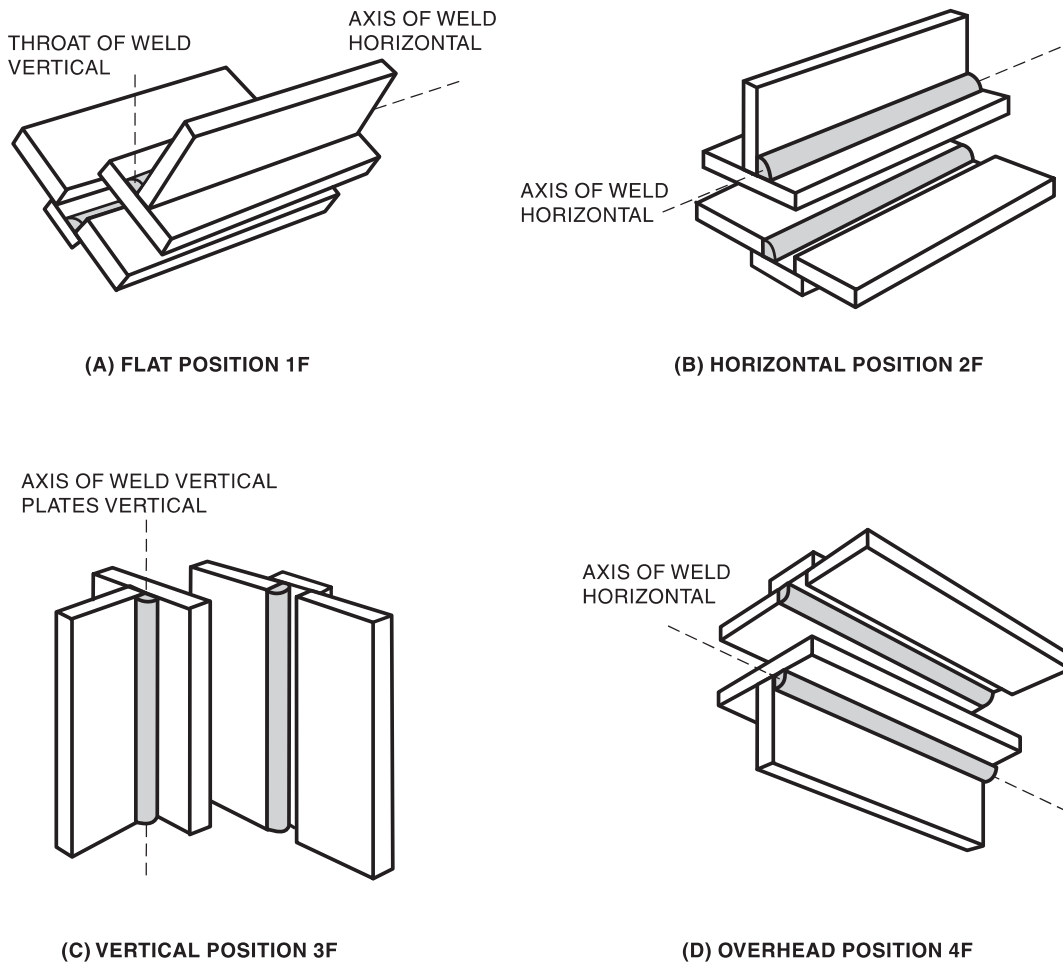


Figure 9—Positions of Test Plates for Fillet Welds

system (FOPS) structures, lift arm safety devices, steering frame locks, industrial power mower housings, etc. The simulated service test may include impact loading, loading in bending, static loading, or fatigue testing to duplicate the type of loading the joint will be subjected to in service.

7.3.1.2 A field test is a test of the welded assembly on a machine that is loaded and performing the work for which it was designed.

7.3.2 For simulated service or field tests, the following shall be documented and recorded:

7.3.2.1 The test assembly shall be welded using the intended WPS.

7.3.2.2 The weldment drawing to which the test part or assembly was made.

7.3.2.3 The material specifications of all items included in the assembly.

7.3.2.4 The WPS variables used to manufacture the test unit (see 7.1 and Annex B).

7.3.2.5 The type of loading applied, direction, and magnitude of forces (by calculation or instrumentation), frequency and total number of applications, or specific duration of the test.

7.3.2.6 The results of visual and nondestructive examination of all welds subjected to loading in the test.

7.3.2.7 The results of destructive tests of weldments.

7.3.3 The WPS employed for the test assembly shall be considered qualified provided:

7.3.3.1 Visual and any required nondestructive examinations, conducted prior to testing, meet the requirements of Clause 9, Workmanship and Welding Quality Requirements.

7.3.3.2 Specified examinations conducted after testing is complete ensure that performance criteria are met.

7.4 Method II—Procedure Qualification Test for Partial Joint Penetration Groove Welds

7.4.1 Partial Joint Penetration (PJP) Groove Welds. Welding procedure specifications for partial joint penetration groove welds may be qualified under Method II by welding a weld test plate using the groove design desired to be used in production. The test plate shall be cross-sectioned and macroetched to demonstrate that the designed weld characteristics are obtained in accordance with requirements of 9.5.1. The depth of groove need not exceed 1 in [25 mm].

7.4.2 Macroetch Test. A minimum of three specimens shall be etched with a suitable solution to give a clear definition of the weld. Guidelines for macroetch procedures may be found in the Annex of AWS B2.1/B2.1M, *Specification for Welding Performance and Procedure Qualification*.

7.4.3 Test Result Criteria for Partial Joint Penetration Groove Welds. The requirements for the test results shall be as follows:

- (1) **Visual Examination.** Visual examination shall meet the visual quality requirements of 9.5.1.
- (2) **Macroetch Tests.** The macroetched specimens shall be examined for defects, and if defects prohibited by Clause 9, Workmanship and Welding Quality Requirements, are found, the test shall be considered as failed. The qualification test weld shall show fusion through the specified weld size and shall be free from fusion defects.

7.4.4 Other Weld Configurations. Where the welding process does not lend itself to making basic groove or fillet welds, or both, because of the process (such as resistance welding, solid-state welding, and other processes) or because of the configuration (such as in plug, or slot welds), test pieces conforming to the actual production joint in size, mass, and material shall be made and sectioned to determine whether the procedure provides the specified minimum penetration, fusion, and weld profile. In addition, suitable mechanical tests of the welded joint shall be performed (tensile tests where applicable) when specified mechanical properties are required.

7.5 Method III—Prequalified Welding Procedure. Certain fundamental groove welded joints meeting all the requirements listed in 4.2 are designated as prequalified within the limitations shown in Annex A, Figures A.1 through A.6. Fillet welds meeting all the requirements listed for a specified joint in 4.3 and shown in Figure A.7 are also designated as prequalified. Prequalified groove welds and fillet welds may be used without performing welding procedure qualification tests, provided the conditions documented on the written WPS are capable of satisfying the requirements of 9.5.1, 9.5.5, and 9.5.6. WPS's that meet the aforementioned requirements of this clause shall be identified on the WPS as prequalified and are exempt from the qualification testing required by Methods I, II and AWS B2.1/B2.1M, *Specification for Welding Performance and Procedure Qualification*. All prequalified WPSs shall be written. For a WPS to be prequalified, conformance with all the applicable requirements of Method III shall be required. WPSs that do not conform to the requirements of Method III may be qualified by test in conformance with Methods I, II or AWS B2.1/B2.1M, *Specification for Welding Performance and Procedure Qualification*. The use of a prequalified welding procedure shall not exempt the Manufacturer from using sound judgment in determining the suitability of application of these welding procedures.

7.5.1 The welding process used shall be one of the following processes, or a combination of these processes:

- (1) shielded metal arc welding (SMAW) (see 7.5.5)
- (2) submerged arc welding (SAW) (see 7.5.6 and 7.5.7)
- (3) gas metal arc welding (GMAW),⁵ and gas metal arc welding—pulsed (GMAW-P)⁵ (see 7.5.8)
- (4) flux cored arc welding (FCAW) (see 7.5.8)

7.5.2 Base metal, filler metal, preheat, and interpass temperature requirements shall meet the following:

- (1) Steels listed in Table 2 or defined in Table 3 are prequalified for welding, provided the preheat and interpass temperatures used are no lower than those listed in Table 6.
- (2) Steels listed in AWS B2.1/B2.1M, *Specification for Welding Performance and Procedure Qualification* that have the same M number and group number as those steels identified in Table 4 or defined in Table 5 are also

⁵ GMAW and GMAW-P may be used in prequalified welding procedures provided that the average current and voltage are sufficient to promote the spray or globular modes of metal transfer. Prequalification does not apply to short circuiting transfer (GMAW-S).

considered prequalified, provided the preheat and interpass temperatures used are no lower than those listed in Table 6.

- (3) Prequalified steels are divided into five weldability classes for the purpose of specifying the minimum preheat and interpass welding temperatures. Table 4 lists typical steel specifications which are in each of the classes.
- (4) The weldability classification for steels not listed in Table 4 may be determined by comparison to the limitations within the classes as listed in Table 5. These limitations are the following:
 - (a) yield strength range
 - (b) maximum carbon equivalent
 - (c) maximum limit for individual alloying element
- (5) The Class for a steel grade not listed in Table 4 shall be determined by placing the steel in the highest possible classification of Table 5 without exceeding the limitations of yield strength, carbon equivalent, and alloying elements. When a steel grade does not fit in a single classification due to disagreement with the listed values, procedure qualification is required.
- (6) The WPS for a prequalified welding procedure shall include the specification of minimum preheat and interpass temperature for the welding process, class of steel, and thickness to be welded in accordance with the requirements of Table 4.
- (7) Table 7 (U.S. Customary Units) and Table 7M (SI Units) list prequalified filler metals for complete-joint-penetration groove welds when the design requires that the filler metal shall equal the tensile strength of the base steel. For welds which, by design, do not require filler metals with a tensile strength equal to the base metal, lower strength filler metal may be specified. Selection of filler material and parameters used should conform to the filler metal manufacturer's recommendations.

7.5.3 The WPS for the prequalified welding procedure shall meet the applicable requirements given in 7.5.5, 7.5.6, 7.5.7, and 7.5.8. Any changes to a prequalified welding procedure specification outside the applicable limits of 7.5 shall require qualification by Methods I, II, or AWS B2.1/B2.1M. *Specification for Welding Performance and Procedure Qualification.*

7.5.4 Workmanship and Weld Quality Requirements. Applicable requirements of Clause 9, Workmanship and Welding Quality Requirements, shall be met.

7.5.5 Prequalified Procedures for Manual Shielded Metal Arc Welding (SMAW)

7.5.5.1 The work shall be positioned for flat position welding whenever practicable.

7.5.5.2 The classification and size of electrode, arc voltage, and amperage shall be suited to the thickness of the material, type of material, type of groove, welding positions, and other circumstances pertaining to the work.

7.5.5.3 The maximum size of electrodes shall be as follows:

Table 4^a
Weldability Classification—Typical Steel Products

Class I	AISI/SAE 1005, 1006, 1008, 1010, 1012, 1016, 1017, 1018, 1020 ASTM A 366, A 569; SAE J-525
Class II	AISI/SAE 1021, 1025, 1026; ASTM A 36, A 53 Grade B, A 53 Grade F, A 106, A 131, ^b A 139, A 500, A 501, A 516, A 524, A 529, A 570 Grades 30, 33, 36, 40, 45, 50 and 55, A 606
Class III	ASTM A 242, A 441, A 500 Grade C, A 537 Class 1 and 3, A 572 Grades 42 and 50, A 588, ^c A 607 Grades 45 and 50, A 618, A 633 Grades A, B, C, D and E API 5LX Grade 42; ABS Grades AH, DH and EH
Class IV	ASTM A 572 Grades 60 and 65, A 607 Grades 60 and 70, A 656 Grades 50, 60, 70 and 80, A 715 Grades 50, 60, 70 and 80
Class V	ASTM A 514 ^d and A 517 ^e

^a See 7.5.2

^b Except ASTM A 131 Gr. AH, DH, and EH.

^c Except ASTM A 588 Gr. G.

^d Except ASTM A 514 Gr. E, P, and Q.

^e Except ASTM A 517 Gr. E, P, and Q.

Table 5
Weldability Classification^a

	Structural Carbon Steel		High-Strength Low Alloy Steels		Quench and Tempered Steels
	Class I	Class II	Class III ^b	Class IV ^b	Class V
Yield Strength, ksi ^c	30–46	35–55	40–45	50–80	90–100
Yield Strength, MPa ^c	205–315	240–380	275–380	345–550	620–690
Maximum CE ^d	0.38	0.48	0.63	—	0.74
Maximum Chemical Limits ^e					
Carbon	0.23	0.30	0.24	—	0.22
Manganese	0.90	1.35	1.65	—	1.50
Phosphorus	0.04	0.04	0.04	—	0.04
Sulfur	0.05	0.05	0.05	—	0.05
Silicon	0.60	0.60	0.90	—	0.90
Nickel	—	—	1.25	—	1.50
Chromium	—	—	1.00	—	2.00
Molybdenum	—	—	0.25	—	0.65
Vanadium ^{f, g}	—	—	0.10 ^{f, g}	—	0.08 ^g
Titanium	—	—	0.07	—	0.10
Zirconium	—	—	0.15	—	0.15
Niobium (Columbium) ^f	—	—	0.04 ^f	—	—
Copper	—	—	1.00	—	0.50
Boron	—	—	—	—	0.006

^a Use the highest classification allowed by yield strength of base metal, calculated CE value, and typical chemical composition.

^b Only ASTM A 572, A 607, A 656, and A 715 (alloyed with some combination of niobium, vanadium, and nitrogen) are prequalified under Class IV. No nitrogen containing steel other than A 572, A 607, A 656, and A 715 are prequalified under Class III.

^c Minimum yield strengths are generally values published by the producer, or in the case where values are not published, then the value that is used for design purposes.

^d Carbon Equivalent, CE. The maximum CE values shown are based on the maximum composition limits of the materials, plus the check tolerance; therefore, caution must be used when the maximum limits are approached.

Reference: IIW Formula for CE for Carbon and Low Alloy Steels is:

$$CE = C + Mn/6 + (Cu + Ni)/15 + (Cr + Mo + V)/5$$

^e In weight %.

^f Maximum for the sum of niobium + vanadium = 0.10.

^g When welds are to be thermally stress relieved, the deposited weld metal shall not exceed 0.05 vanadium.

- (1) 5/16 in [8 mm] for all welds made in the flat position, except root passes;
- (2) 1/4 in [6.4 mm] for horizontal fillet welds;
- (3) 1/4 in [6.4 mm] for root passes of fillet welds made in the flat position and of groove welds made in the flat position with backing, and with root opening of 1/4 in [6 mm] or more;
- (4) 5/32 in [4.0 mm] for welds made with EXX14 and low-hydrogen electrodes in the vertical and overhead positions;
- (5) 3/16 in [4.8 mm] for root passes of groove welds and for all other welds not included under 7.5.5.3(1), 7.5.5.3(2), 7.5.5.3(3), and 7.5.5.3(4).

7.5.5.4 The minimum size of a root pass shall be sufficient to prevent cracking.

7.5.5.5 The maximum thickness of layers subsequent to the root pass of fillet welds and of all layers of groove welds shall be the following:

- (1) 1/4 in [6 mm] for root passes of groove welds;
- (2) 1/8 in [3 mm] for subsequent layers of welds made in the flat position;
- (3) 3/16 in [5 mm] for subsequent layers of welds made in the vertical, overhead, and horizontal positions.

Table 6
Minimum Preheat and Interpass Temperatures^{a, b, c, d}

Thickness of Thickest Part at Point of Welding	Welding Process													
	SMAW with other than Low Hydrogen Electrodes				SMAW with Low Hydrogen Electrodes, SAW, GMAW, or FCAW				SMAW with Low Hydrogen Electrodes, SAW with Carbon or Alloy Steel Electrodes, Neutral or Active Flux, GMAW, or FCAW				SAW with Carbon Steel Electrodes and Alloy Flux	
	Steel Class													
	Class I		Class II		Class I		Classes II and III		Class IV		Class V		Class V	
	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Through 3/4 incl.	50	10	50	10	50	10	50	10	50	10	50	10	50	10
Over 3/4 to 1 1/2	50	10	150	65	50	10	50	10	150	65	125	50	200	95
Over 1 1/2 to 2 1/2	50	10	225	105	50	10	150	65	225	105	175	80	300	150
Over 2 1/2	200	95	300	150	150	65	225	105	300	150	225	105	400	205

^a When the base metal is below the temperature listed for the welding process being used and the thickness of material being welded, it shall be preheated (except as otherwise provided) in such a manner that the surfaces of the parts on which weld metal is being deposited are at or above the specified minimum temperature for a distance equal to the thickness of the part being welded, but not less than 3 in [75 mm], both laterally and in advance of the welding. Preheat and interpass temperatures shall be sufficient to prevent crack formation. Temperatures above the minimum shown may be required for highly restrained welds. For quenched and tempered steel, the maximum preheat and interpass temperature should not exceed 400°F [205°C] for thickness up to 1-1/2 in [38 mm], inclusive and 450°F [230°C] for greater thickness. When welding quenched and tempered steel, heat input should not exceed the steel producer's recommendations.

^b In joints involving combinations of base metals, preheat shall be as specified for the higher strength steel being welded.

^c In some instances the minimum preheat and interpass temperature for a particular steel may be conservative. The user may use Method II—Procedure Qualification Tests to qualify a welding procedure without preheat or with a lower preheat than specified in Table 6.

^d Alternate minimum preheats may be used as developed by using AWS D14.8M:2009/ISO/TR 17844, *Standard Methods for the Avoidance of Cold Cracks*.

Table 7
Filler Metal Requirements^{a, b} for Prequalified Complete-Joint-Penetration Groove Welds

Welding Process				
Base Metal ^b	SMAW	SAW	GMAW	FCAW
Class I and Class II	AWS A5.1 E60XX or E70XX E7018M AWS A5.5 E70XX-X ^c	AWS A5.17 F(S)6XX-E(C)XXX or F(S)7XX-E(C)XXX AWS A5.23 F(S)7XX-E(C)XX-XX ^c	AWS A5.18 ER70S-X or E70C-XX ^d [Except E70C-GS(X)]	AWS A5.20 E6XT-X(M) or E7XT-X(M) (Except -2, -3, -10, -13, -14, or -GS) AWS A5.29 E7XTX-X(M) ^c E6XTX-X
Class III	AWS A5.1 E70XX ^c E7018M AWS A5.5 E70XX-X ^{c, e}	AWS A5.17 F(S)7XX-E(C)XXX AWS A5.23 F(S)7XX-E(C)XX-XX ^c	AWS A5.18 ER70S-X or E70C-XX ^d [Except E70C-GS(X)]	AWS A5.20 E7XT-X(M) (Except -2, -3, -10, -13, -14, or -GS) AWS A5.29 E7XTX-X(M) ^c
Class IV	AWS A5.5 E80XX-X ^{c, e} E90XX-X ^{c, e} E9018M	AWS A5.23 F(S)8XX-E(C)XX-XX ^c F(S)9XX-E(C)XX-XX ^c	AWS A5.28 ER80S-XXX or ER80C-XXX ^{c, d} ER90S-XXX or ER90C-XXX ^{c, d}	AWS A5.29 E8XTX-X(M) ^c E9XTX-X(M) ^c
Class V	AWS A5.5 E110XX-X ^{c, e} E11018M	AWS A5.23 F(S)11XX-E(C)XX-XX ^c	AWS A5.28 ER110S-XXX or E110C-XXX ^{c, d}	AWS A5.29 E11XTX-X(M) ^c

^a In joints involving base metals of different yield points or strengths, filler metals applicable to the lower strength base metal may be used.

^b Filler metal of a lower or higher strength may be used where specified by design.

^c Filler metals of alloy groups B3, B3L, B4, B4L, B5, B5L, B6, B6L, B7, B7L, B8, B8L, or B9 in AWS A5.5/A5.5M, A5.23/A5.23M, A5.28/A5.28M, or A5.29/A5.29M are not prequalified for use in the as-welded condition.

^d Metal cored welding electrode is prequalified for thicknesses up to and including 1 in [25 mm] maximum. Thicknesses exceeding 1 in [25 mm] require qualification by Method I, Method II, or AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*.

^e Low hydrogen classifications only.

7.5.5.6 The maximum size fillet weld which may be made in one pass shall be the following:

- (1) 3/8 in [10 mm] in the flat position;
- (2) 5/16 in [8 mm] in horizontal or overhead positions;
- (3) 1/2 in [13 mm] in the vertical position.

7.5.5.7 The progression for welding in a vertical position for all passes shall be upwards. Undercut may be repaired vertically downwards when preheat is in accordance with Table 6.

7.5.5.8 Complete-joint-penetration groove welds made without the use of backing shall be backgouged to sound metal before welding is started from the other (opposite) side of the joint.

7.5.6 Prequalified Procedures for Submerged Arc Welding (SAW) with Single Electrode

7.5.6.1 SAW, except for fillet welds, shall be performed in the flat position $\pm 15^\circ$. Fillet welds may be made in either the flat or horizontal position, except that single-pass fillet welds made in the horizontal position shall not exceed 5/16 in [8 mm].

7.5.6.2 The thickness of weld layers, except root and surface layers, shall not exceed 1/4 in [6 mm]. A multiple-pass, split-layer technique shall be used when the root opening is 1/2 in [13 mm] or greater. The split-layer technique shall also be used in making multiple-pass welds when the width of the layer exceeds 5/8 in [16 mm].

Table 7M
Filler Metal Requirements^{a, b} for Prequalified Complete-Joint-Penetration Groove Welds

Welding Process				
Base Metal ^b	SMAW	SAW	GMAW	FCAW
Class I and Class II	AWS A5.1M E43XX or E49XX E4918M AWS A5.5M E49XX-X ^c	AWS A5.17M F(S)43XX-E(C)XXX or F(S)49XX-E(C)XXX AWS A5.23M F(S)49XX-E(C)XX-XX ^c	AWS A5.18M ER49S-X or 49C-XX ^d [Except E49C-GS(X)]	AWS A5.20M E43XT-X(M) or E49XT- X(M) (Except -2, -3, -10, -13, -14, or -GS) AWS A5.29M E49XTX-X(M) ^c E43XTX-X
Class III	AWS A5.1M E49XX ^c E4918M AWS A5.5M E49XX-X ^{c, e}	AWS A5.17M F(S)49XX-E(C)XXX AWS A5.23M F(S)49XX-E(C)XX-XX ^c	AWS A5.18M ER49S-X or E49C-XX ^d [Except E49C-GS(X)]	AWS A5.20M E49XT-X(M) (Except -2, -3, -10, -13, -14, or -GS) AWS A5.29M E49XTX-X(M) ^c
Class IV	AWS A5.5M E55XX-X ^{c, e} E62XX-X ^{c, e} E6218M	AWS A5.23M F(S)55XX-E(C)XX-XX ^c F(S)62XX-E(C)XX-XX ^c	AWS A5.28M E55S-XXX or ER55C-XXX ^{c, d} ER62S-XXX or ER62C-XXX ^{c, d}	AWS A5.29M E55XTX-X(M) ^c E62XTX-X(M) ^c
Class V	AWS A5.5M E76XX-X ^{c, e} E7618M	AWS A5.23M F(S)76XX-E(C)XX-XX ^c	AWS A5.28M ER76S-XXX or E76C-XXX ^{c, d}	AWS A5.29M E76XTX-X(M) ^c

^a In joints involving base metals of different yield points or strengths, filler metals applicable to the lower strength base metal may be used.

^b Filler metal of a lower or higher strength may be used where specified by design.

^c Filler metals of alloy groups B3, B3L, B4, B4L, B5, B5L, B6, B6L, B7, B7L, B8, B8L, or B9 in AWS A5.5/A5.5M, A5.23/A5.23M, A5.28/A5.28M, or A5.29/A5.29M are not prequalified for use in the as-welded condition.

^d Metal cored welding electrode is prequalified for thicknesses up to and including 1 in [25 mm] maximum. Thicknesses exceeding 1 in [25 mm] require qualification by Method I, Method II, or AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*.

^e Low hydrogen classifications only.

7.5.6.3 The welding current, arc voltage, and speed of travel shall be such that each pass will have complete fusion with the adjacent base metal and weld metal, and will have no overlap or undercutting.

7.5.6.4 The maximum welding current and thickness of weld layers may exceed the limitations given in 7.5.6.1, 7.5.6.2, and 7.5.6.3, provided the Manufacturer can demonstrate by nondestructive examination or macroetch examination of sample welds that sound welds are produced.

7.5.6.5 Preheat and interpass temperatures for single electrode SAW shall be in accordance with Table 6. Preheat and interpass temperatures may be established for single-pass groove or fillet welds, for combinations of metals being welded, and for the heat input involved which are sufficient to reduce the hardness in the heat-affected zones of the base metal to less than 225 Vickers hardness number for steel having a minimum specified tensile strength not exceeding 60 000 psi [415 MPa]. Heat-affected zone hardness may not exceed 280 Vickers hardness number for steel having a specified tensile strength greater than 60 000 psi [415 MPa], but not exceeding 70 000 psi [485 MPa].

Note: The Vickers hardness number shall be determined in conformance with ASTM E 92. If another method of hardness is to be used, the equivalent hardness number shall be determined from ASTM E 140, and testing shall be performed according to the applicable ASTM standard.

7.5.6.6 No reduction of the preheat requirements of Table 6 shall be permitted for fillet welds 3/8 in [10 mm] and under in size.

7.5.6.7 Backing may be used for flux retention and to prevent melt-through for fillet welds and the roots of partial-joint-penetration welds.

7.5.7 Prequalified Procedures for Submerged Arc Welding (SAW) with Multiple Electrodes

7.5.7.1 Submerged Arc Welding (SAW) with multiple electrodes, except for fillet welds, shall be made in the flat position $\pm 15^\circ$. Fillet welds may be made in either the flat or horizontal position, except that single-pass multiple-arc fillet welds made in the horizontal position shall not exceed 1/2 in [13 mm].

7.5.7.2 The thickness of weld layers is not limited. Either single or multiple electrodes may be used in making the root pass of a groove weld. Backing or root faces shall be of adequate thickness to prevent melt-through. Multiple electrodes shall be displaced laterally, or a split-layer technique shall be used to ensure adequate corner fusion when the width of a surface in a groove of which a layer of weld metal is to be deposited exceeds 1/2 in [13 mm]. A split-layer technique with electrodes in tandem shall be employed when the width of a previously deposited layer exceeds 1 in [25 mm] and only two electrodes are used.

7.5.7.3 The welding current, arc voltage, speed of travel, and relative location of electrodes shall be such that each pass will have complete fusion with the adjacent base metal and weld metal, and there will be no depressions, overlap, or unacceptable undercutting at the toe of the weld. Unacceptable concavity of initial passes shall be avoided to prevent cracking in roots of joints under restraint.

7.5.7.4 Multiple-arc welds may also be made in the root of the groove joints and for fillet welds using a combination of gas metal arc followed by multiple submerged arcs. The gas metal arc welding (GMAW) shall conform to the requirements of 7.5.8. The spacing between the GMAW head and the first following SAW head shall not exceed 15 in [380 mm].

7.5.7.5 Preheat and interpass temperatures for multiple electrode SAW shall be in accordance with Table 6. Preheat and interpass temperatures may be established for single-pass groove or fillet welds, for combinations of metals being welded, and for the heat input involved which are sufficient to reduce the hardness in the heat-affected zones of the base metal to less than 225 Vickers hardness number for steel having a minimum specified tensile strength not exceeding 60 000 psi [415 MPa]. Heat-affected zone hardness may not exceed 280 Vickers hardness number for steel having a specified tensile strength greater than 60 000 psi [415 MPa], but not exceeding 70 000 psi [485 MPa].

Note: The Vickers hardness number shall be determined in conformance with ASTM E 92. If another method of hardness is to be used, the equivalent hardness number shall be determined from ASTM E 140, and testing shall be performed according to the applicable ASTM standard.

7.5.7.6 No reduction of the preheat requirements of Table 6 shall be permitted for fillet welds 3/8 in [10 mm] and under in size.

7.5.7.7 Backing may be used for flux retention and to prevent melt-through for fillet welds and the roots of partial-joint-penetration welds.

7.5.8 Prequalified Procedures for Gas Metal Arc Welding (GMAW and GMAW-P) and Flux Cored Arc Welding (FCAW)

7.5.8.1 The following requirements are essential when using either the gas metal arc or flux cored arc process for prequalified procedures that are exempt from qualification testing:

- (1) The welding parameters shall be such that each pass will have complete fusion with adjacent base metal and weld metal, and there will not be overlap, porosity, or undercutting.
- (2) Complete-joint-penetration groove welds made without the use of backing shall be backgouged to sound metal before welding is started from the second side.
- (3) Backing may be used to prevent melt-through for fillet welds and the roots of partial-joint-penetration welds.
- (4) Welding with external gas shielding shall not be done in a draft or wind that diverts the shielding gas from the weld pool.
- (5) The progression for welding in a vertical position for all passes shall be upwards. Undercut may be repaired vertically downwards when preheat is in accordance with Table 6.
- (6) Electrode extension (contact tip to work distance) shall be listed in the WPS and shall be in accordance with the electrode manufacturer's recommendations.

8. Welding Personnel Qualification

8.1 Scope. The qualification tests described herein are especially designed to determine the ability of the welding personnel to produce sound welds.

It is not necessarily intended that the welder performance qualification tests be used as a guide for welding during actual construction. The latter shall be performed in accordance with the requirements of the welding procedure specification. This clause is organized into four distinct parts as follows:

1. Welder Qualification (see 8.3)
 - (a) Method A, Performance Qualification by Standard Test
 - (b) Method B, Performance Qualification by Workmanship and Production Samples
2. Welding Operator Qualification (see 8.4)
3. Operator of Automatic Welding Equipment Qualification (see 8.5)
4. Tack Welder Qualification (see 8.6)

8.2 General. The Manufacturer shall be responsible for the choice of welding personnel qualification methods and maintaining the records of all tests demonstrating the ability of welding personnel to produce sound welds.

Certified welders meeting the requirements of AWS QC7, *Standard for the Certification of Welders*, that have been tested in a Accredited Test Facility and have maintained their certification are considered qualified to D14.3/D14.3M within the limitations of 8.2.2.

Welders who are not certified by AWS QC7, *Standard for the Certification of Welders*, may be qualified by the Manufacturer, or by an independent testing facility under the supervision of the Manufacturer.

Radiographic or ultrasonic examination may be used in lieu of bend tests for welding personnel qualification. The user is cautioned that procedure and technique will affect results. The user shall be responsible for ensuring that test results reflect a quality level equal to or surpassing the minimum weld quality requirements of 9.5.2.

Welding personnel qualified to AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*, AWS D14.4/D14.4M, *Specification for Welded Joints in Machinery and Equipment*, AWS D1.1/D1.1M, *Structural Welding Code—Steel*, ASME Section IX, *Boiler and Pressure Vessel Code*, or other standards acceptable to the Manufacturer may be considered qualified within the limits of 8.2.2.

8.2.2 Limitation of Variables. The limitations of variables shall be in accordance with AWS B2.1/B2.1M, *Specification for Performance and Procedure Qualification* with the following exceptions:

8.2.2.1 Welding personnel shall be qualified for each welding process used separately (e.g., SMAW, GMAW, FCAW, SAW, etc.). Significant differences exist between the various modes of operation within these welding process categories, as in FCAW with or without gas shielding, GMAW in spray, short-circuiting transfer, or GMAW-P.⁶ Therefore, separate qualification tests are required for each of these modes of operation.

8.2.2.2 Positions for which welding personnel are qualified by the weld test position are listed in Table 8.

8.3 Welder Qualification

8.3.1 Method A—Welder Performance Qualification by Standard Test. A welder's ability to produce a sound weld shall be qualified in accordance with AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*, subject to the limits of 8.2.2, using a welding procedure specification qualified in accordance with this standard.

8.3.2 Method B—Welder Performance Qualification by Workmanship and Production Samples. Method B consists of two parts for qualification: Workmanship Sample and Production Sample.

8.3.2.1 Workmanship Sample. A workmanship sample that is similar to the production weld and represents the required degree of manipulative ability (see Figures 10, 11, and 12) shall be made. The type and number of samples to be

⁶ Requalification is not required when switching from GMAW to GMAW-P and vice versa when the average current and voltage are sufficient to promote the spray or globular modes of metal transfer.

Table 8
Welding Personnel Qualification—Type and Position Limitations

Type of Welding and Position of Qualification Test	Welding Position Qualified ^{a, b}		
	Weld Position	Groove	Fillet
Groove	1G	F	F, H
	2G	F, H	F, H
	3G	F, V	F, H, V
	4G	F, OH	F, H, OH
Fillet	1F		F
	2F		F, H
	3F		F, H, V
	4F		F, H, OH

^a Positions of welding: F = flat, H = horizontal, V = vertical, OH = overhead (see Figures 6, 7, 8, and 9).

^b For welding personnel qualification test positions not listed above (i.e., 5G and 6G) in Table 8, refer to AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*.

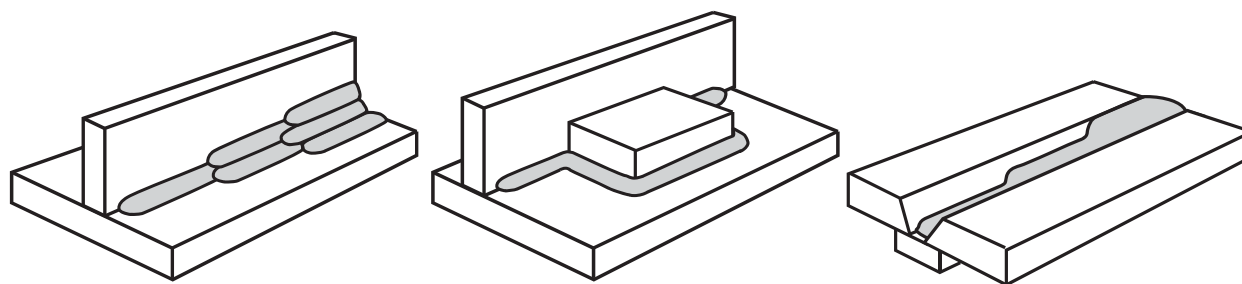


Figure 10—Example 1 of Workmanship Sample

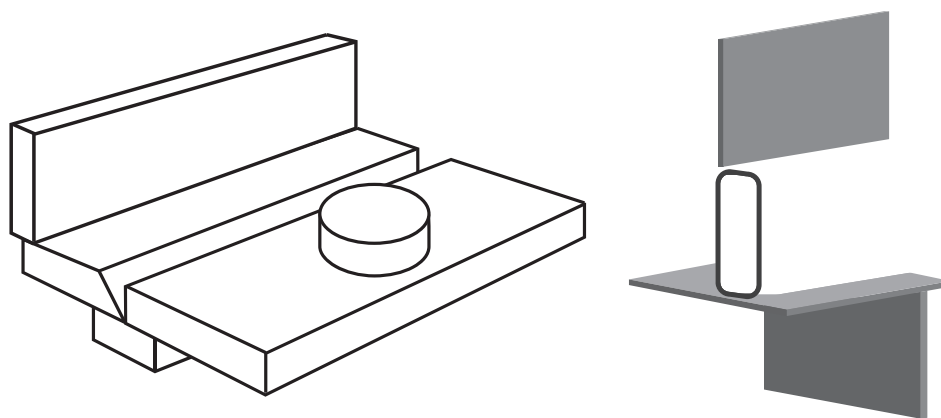


Figure 11—Example 2 of Workmanship Sample

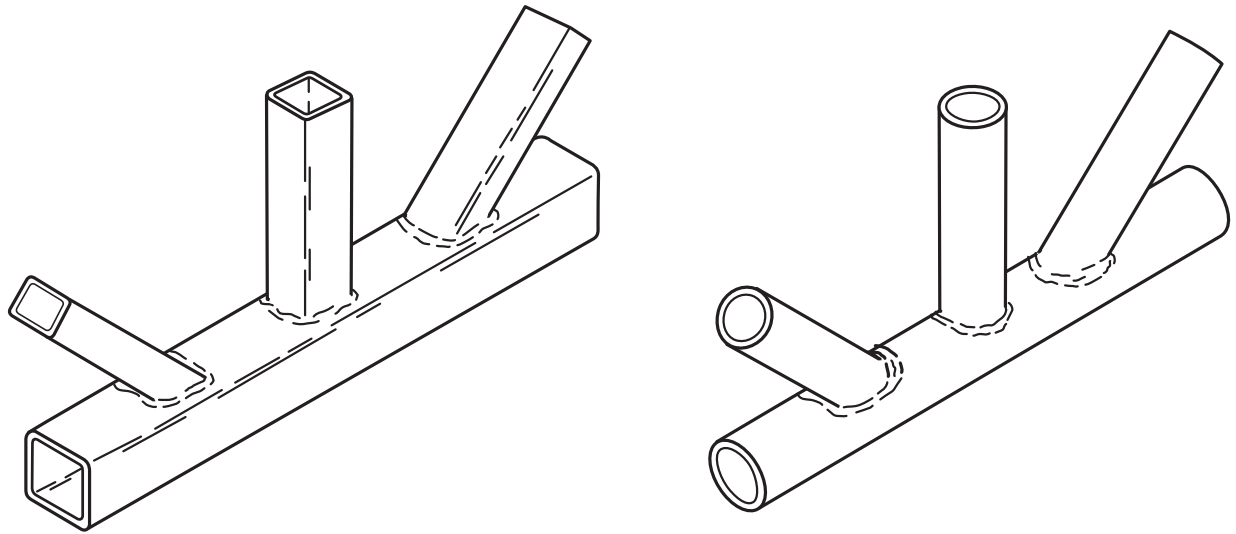


Figure 12—Example 3 of Workmanship Sample

made shall be determined by the Manufacturer to represent the type of work the welder will be performing. The samples shall be tested using visual inspection, appropriate sectioning, and etching of the sample, and shall meet the requirements of Clause 9, Workmanship and Weld Quality Requirements. Testing shall be witnessed, evaluated, and recorded by a CWI or qualified personnel.

8.3.2.2 Production Sample. The capability of the welder to satisfactorily perform production welding shall be determined after a tryout at the job station only after successful completion of the workmanship sample. Qualification shall be achieved when the welder produces a typical production part that meets the quality requirements of this specification, as witnessed, evaluated, and recorded by a CWI or qualified individual.

8.3.3 Retests—Welder Qualification Methods A and B. A retest may be allowed if a welder fails to meet the requirements of one or more test welds under the following conditions:

- (1) An immediate retest may be made which shall consist of two test welds of each type failed. All test specimens shall meet all the requirements for such welds.
- (2) A retest may be made, provided there is evidence that the welder has had further training or practice. In this case, a complete retest shall be made.

8.3.4 Period of Effectiveness—Welder Qualification Methods A and B. The welder qualification shall remain in effect indefinitely unless:

- (1) The welder is not engaged in a given process of welding for which the welder is qualified for a period exceeding six months. Requalification for (1) in 8.3.3 is permitted and shall follow the requirements of AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification* for requalification.
- (2) There is reason to question the welder's ability. The welder must retest each qualification for which his ability was questioned.

8.3.5 Records—Welder Qualification Methods A and B. Records of the test results and continued performance shall be kept by the Manufacturer and shall be available as required by the contract [see 8.3.4(1)].

8.4 Welding Operator Qualification

8.4.1 Welding Operator Qualification Tests. The qualification test for welding operators shall consist of welding a test assembly which meets the following requirements:

- (1) Complete-joint-penetration groove weld selected from Figure A.3 for submerged arc welding.

- (2) Complete-joint-penetration groove weld selected from Figure A.5 for gas metal arc or flux cored arc welding.
- (3) Welding in accordance with the requirements of the welding procedure specification.
- (4) Suitable test pieces conforming to the actual production joint in size, mass, and materials shall be made if the welding process does not lend itself to making basic groove welds, or the welded joints covered by the welding procedure specification do not comply with Figures A.3 through A.7.
- (5) Tests shall be witnessed, evaluated, and recorded by a CWI or a qualified person.

8.4.2 Macroetch specimens shall be prepared from the welded test assembly by sectioning through the weld in at least two locations, and by polishing and etching with a suitable solution to give a clear definition of weld.

8.4.3 Test Results Required. The welded test assembly shall meet the visual requirements of 9.5.1.

8.4.3.1 The macroetched specimens shall be examined for defects, and if defects prohibited by Clause 9, Workmanship and Welding Quality Requirements, are found, the test shall be considered as failed. The weld shall show fusion to the root and shall be free from fusion defects. Convexity and concavity of fillet welds shall not exceed the limits specified in Clause 9, Workmanship and Welding Quality Requirements, and both legs of the fillet shall be equal within 1/8 in [3 mm].

8.4.4 Retests. A retest may be allowed if a welding operator fails to meet the requirements of one or more test welds under the following conditions:

- (1) An immediate retest may be made which shall consist of two test welds of each type failed. All test specimens shall meet all the requirements for such welds.
- (2) A retest may be made, provided there is evidence that the welder has had further training or practice. In this case, a complete retest shall be made.

8.4.5 Period of Effectiveness. The welding operator qualification shall remain in effect indefinitely unless the following:

- (1) The welding operator is not engaged in a given process of welding for which the welder is qualified for a period exceeding six months. Requalification for (1) in 8.4.4 is permitted and shall follow the requirements of AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification* for requalification.
- (2) There is reason to question the welding operator's ability. The welding operator must retest each qualification for which his ability was questioned.

8.4.6 Records. Records of the test results and continued performance shall be kept by the Manufacturer and shall be available as required by the contract [see 8.3.4(1)].

8.5 Operators of Automatic Welding Equipment. The Manufacturer shall be responsible for determining the qualification requirements of personnel who operate equipment that requires only occasional or no observation and no manual adjustment of the controls.

8.6 Qualification of Tack Welders

8.6.1 Limitation of Variables. The following rules (in addition to those found in 8.2.2) shall apply for the qualification of a tack welder.

8.6.1.1 A tack welder qualified for shielded metal arc welding with an electrode listed in AWS B2.1/B2.1M/B2.1 M Table, *Specification for Welding Performance and Procedure Qualification* (Grouping of Welding Electrodes and Rods for Qualification) shall be considered qualified to tack weld with any other electrode in the same group designation.

8.6.1.2 A tack welder shall be qualified by one test plate made in each position in which the tack welder is to tack weld (flat, horizontal, vertical up, vertical down, and overhead); (see Figures 7, 8, and 9). A tack welder qualified in the vertical-up position for a particular process shall also be considered qualified in the flat and horizontal positions for that process. Qualification in the overhead position shall also be considered qualified for the flat position for the same process (see Table 8).

8.6.2 Test Specimens—Number, Type, and Preparation. The tack welder shall make a 1/4 in [6 mm] maximum-size weld approximately 2 in [50 mm] long on the fillet weld break specimen as shown in Figure 13.

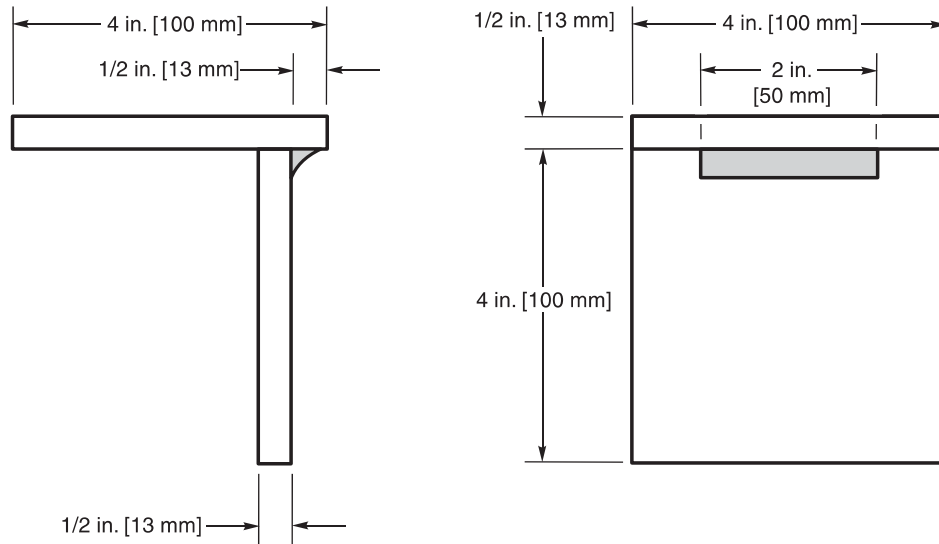


Figure 13—Fillet Weld Break Specimen—Tack Welder Qualification

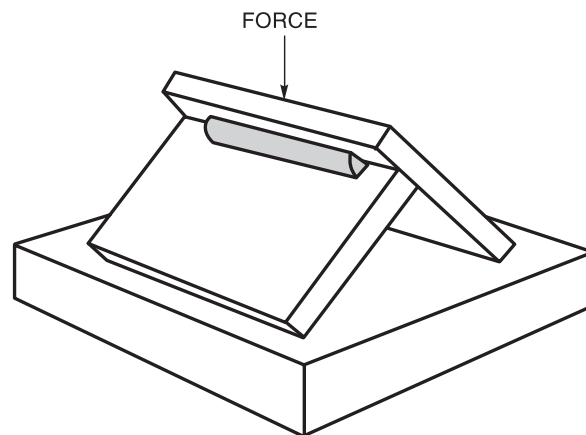


Figure 14—Method of Rupturing Specimen—Tack Welder Qualification

8.6.3 Method of Testing Specimen. A force shall be applied to the specimen as shown in Figure 14 until rupture occurs. The force may be applied by any convenient means.

8.6.4 Test Results Required

8.6.4.1 The tack weld shall present a reasonably uniform appearance and shall be free of cracks, excessive overlap, and undercut. There shall be no porosity visible on the surface of the weld.

8.6.4.2 The fractured surface of the tack weld shall show fusion to the root, but not necessarily beyond, and shall exhibit complete fusion to the base metal without any inclusions or porosity larger than 3/32 in [2.4 mm] in the greatest dimension.

8.6.4.3 A tack welder who passes the fillet weld break test shall be eligible to tack weld all types of joints for the process and in the positions in which the tack welder has qualified.

8.6.5 Retests. The tack welder may make one retest without additional training in case of failure to pass the above test.

8.6.6 Period of Effectiveness. The tack welder qualification shall remain in effect indefinitely in the position and with the processes for which the tack welder is qualified unless there is some specific reason to question the tack welder's

ability. In such case, the tack welder shall be required to demonstrate the ability to make sound tack welds by again passing the prescribed tack welding test.

8.6.7 Records. Records of the test results shall be kept by the Manufacturer as required by the contract.

9. Workmanship and Welding Quality Requirements

9.1 Scope. This clause presents quality and workmanship levels which are expected to be normally attainable within this industry. General or specific applications and designs may allow levels different than those listed here. Such differences, when specified and documented, may be applied.

9.2 General Requirements

9.2.1 All requirements of this clause shall be satisfied in the production and inspection of welded assemblies covered under this specification.

9.2.2 Welding shall not be done when the temperature of the part to be welded is lower than that specified on the engineering drawing or welding procedure specification, nor shall welding be done when the weldment is exposed to high winds, drafts, or moisture. The temperature of the part, when not specified, shall not be lower than 50°F [10°C]. Winds or drafts must be limited to avoid affecting gas shielding with appropriate processes. In addition, winds and drafts shall also be limited to avoid excessive cooling rates which may affect properties of the weld and heat-affected zone.

9.2.3 Welding variables shall be in conformance with the requirements of the applicable written WPS that has been qualified to the requirements of Clause 7. All welders, welding operators, operators of automatic welding equipment, and tack welders shall be instructed in the proper use of the applicable WPS, and the applicable WPS shall be followed during the performance of welding.

9.2.4 All welders, welding operators, operators of automatic welding equipment, and tack welders employed to weld under the requirements of this specification shall have been qualified by the methods specified in Clause 8. Each welder, welding operator, operator of automatic welding equipment or tack welder shall only perform welding within the limitation of variables to which they are currently qualified.

9.3 Preparation of Materials

9.3.1 Joint edges shall be uniform and free from fins, notches, tears, cracks, and other irregularities that will adversely affect the quality or strength of the weld or member. The welding surface shall also be free from moisture, loose or thick scale, slag, heavy rust or oxidation, grease, or other foreign material that will adversely affect quality or strength of the weld.

9.3.2 Surfaces within 1/2 in [13 mm] of any weld location shall be free from material that will prevent proper welding.

9.3.3 Mechanical or thermal processes may be used for weld joint preparation. The resulting surfaces shall be reasonably smooth for welding. Users of D14.3 may use AWS C4.1, *Surface Roughness Guide for Oxygen Cut Surfaces*, as a guide for thermal cut surfaces. Users of D14.3M may use AWS C4.6M(ISO9013:2002), *Thermal Cutting—Classifications of Thermal Cuts—Geometric Product Specification and Quality Tolerances*, as a guide for thermal cut surfaces. Caution shall be taken when oxyfuel gas cutting or gouging is used on any structural weldment where stresses due to adverse heating conditions may be considered detrimental to the end product. The gouged or cut surfaces may require grinding to remove a carburized layer resulting from these operations. Exercising care in the use of the gouging or cutting process may produce surfaces which are usable without subsequent preparation.

9.4 Assembly

9.4.1 Fillet Welds

9.4.1.1 The parts to be joined by fillet welds shall be brought into as close contact as practicable. The gap between parts shall normally not exceed 1/8 in [3 mm], except in cases involving plates 3 in [75 mm] or greater in thickness or structural shapes when, after straightening and in assembly, the gap cannot be closed sufficiently to meet this tolerance.

9.4.1.2 The separation between faying surfaces of lap joints shall not exceed 1/16 in [1.6 mm].

9.4.1.3 Corrective action, such as increasing weld size to avoid loss of effective throat, shall be taken for gaps in excess of 1/16 in [1.6 mm] unless allowance for such gaps is permitted in the design criteria.

9.4.2 Groove Welds

9.4.2.1 Dimensions of the cross section of groove joints shall not vary from those shown on the detail drawing by more than the workmanship tolerance listed in Table 9.

9.4.2.2 Root openings wider than the thickness of the thinner member, may be built up by welding to acceptable dimensions prior to the joining of the parts by welding.

9.4.3 Use of Fillers. The use of fillers to correct a gap condition is prohibited, except when specified on the detail drawing.

9.5 Quality of Welds

9.5.1 General Requirements. The quality of welds shall be determined by visual inspection and nondestructive examination (NDE), if so specified. When nondestructive examination is required, it shall be performed according to methods developed by the Manufacturer or in accordance with provisions of AWS D14.4/D14.4M, *Specification for Welded Joints in Machinery and Equipment*. All final welds shall be cleaned for inspection.

9.5.1.1 All weld lengths and sizes shall conform to the requirements shown on the drawing.

9.5.1.2 All craters shall be filled to at least 85% of the full cross section of the welds and shall terminate where required by the drawing.

9.5.1.3 There shall be no cracks in the weld or adjacent base metal surfaces.

9.5.1.4 The sum of diameters of visual or surface porosity, including piping porosity, shall not exceed 3/8 in [10 mm] in any 4 in [100 mm] length of weld and shall not exceed 3/4 in [20 mm] in any 12 in [300 mm] length of weld, with no single void exceeding 3/32 in [2.4 mm] in diameter.

9.5.1.5 Weld overlap (a condition where the weld toe transition angle is less than 90 degrees) is not permitted for any high static load or high cycle fatigue application. For all other applications, weld overlap shall not extend more than 1/32 in [0.8 mm] beyond the fusion line of the weld in any cross-section, as shown in Figure 3 and Figure 4, when measured with a 0.001 in [0.025 mm] feeler gage before painting. The length affected by overlap shall total no more than 1/2 in [13 mm] in 12 in [300 mm] of continuous weld and no more than 1/4 in [6 mm] in any weld having a specified length of 6 in [150 mm] or less.

9.5.1.6 Undercut shall not exceed the following:

- (1) In primary load bearing members, undercut shall be no more than 0.01 in [0.25 mm] deep when the weld is transverse to tensile stress. These welds shall be identified by the Engineer on the contract documents.
- (2) In all other cases, undercut shall not exceed the following:
 - (a) Material thickness to and including 1/4 in [6 mm]—10% of material thickness.
 - (b) Material thicknesses greater than 1/4 in [6 mm]—1/32 in [1 mm]. In addition, 1/16 in [1.6 mm] undercut depth up to 1 in [25 mm] continuous length in any 12 in [300 mm] weld length is permissible; the accumulative length is not to exceed 1.5 in [38 mm] in the same 12 in [300 mm] length.

Table 9
Workmanship Tolerances for Groove Welds

	Root Not Backgouged ^a	Root Backgouged
Root Face of Joint	+1/8 in [3 mm] -1/16 in [1.6 mm]	Not Limited
Root Opening of Joints without Steel Backing	+1/8 in [3 mm] -1/16 in [1.6 mm]	±1/8 in [3 mm]
Root Opening of Joints with Steel Backing	+1/4 in [6 mm] -1/16 in [1.6 mm]	Not Applicable
Groove Angle of Joint	+10° -5°	+10° -5°

^a Backgouging forms a bevel or groove on the other side of a partially welded joint to ensure complete penetration upon subsequent welding from that side.

9.5.1.7 The subsurface quality of the welds as determined by radiographic examination, ultrasonic examination, or destructive sectioning and testing shall meet the following minimum acceptance criteria:

- (1) Underbead cracks are not permissible.
- (2) Planar-type discontinuities (lack of fusion, slag inclusions, or fissures) are permissible to 25% of specified weld size, or less than 25% of joint penetration in height or width. The length of an individual discontinuity, or the sum of the discontinuities, shall not exceed 10% of the weld length for up to 7 in [180 mm] of weld.
- (3) Three dimensional-type discontinuities are permissible in discontinuous distribution, provided the largest dimension of any single discontinuity does not exceed the following:
 - (a) 20% of the weld size or joint penetration for welds 3/8 in [10 mm] and below;
 - (b) 15% of the weld size or joint penetration for welds over 3/8 in [10 mm].

The sum total of the largest dimensions shall not exceed 3/8 in [10 mm] in any linear inch [25 mm] of weld, nor in 10% of the weld length.

9.5.2 Radiographic and Ultrasonic Requirements. Test result requirements for radiographic and ultrasonic examination, when required, shall be those specified in 9.5.1.

9.5.3 Magnetic Particle and Liquid Penetrant Requirements. Test result requirements for magnetic particle and liquid penetrant testing, when required, shall be those specified in 9.5.1.

9.5.4 Tack Welds

9.5.4.1 Tack welds, regardless of whether they are incorporated into the final weldment or not, are subject to the same quality requirements as the final weld.

9.5.4.2 When the termination locations of tack welds are required, they shall be specified on the drawing.

9.5.4.3 Multiple-pass tack welds shall have cascaded ends.

9.5.5 Fillet Welds

9.5.5.1 All fillet welds shall be of desirable or acceptable types as shown in Figures 15(A) and (B).

9.5.5.2 Fillet weld leg size shall conform to the following tolerances based on a measurement of fused leg length:

- (1) weld sizes under 3/8 in [10 mm]:
 - +1/8 in [3 mm]
 - 1/32 in [1 mm]
- (2) weld sizes 3/8 in [10 mm] and over:
 - +1/8 in [3 mm]
 - 1/16 in [1.6 mm]

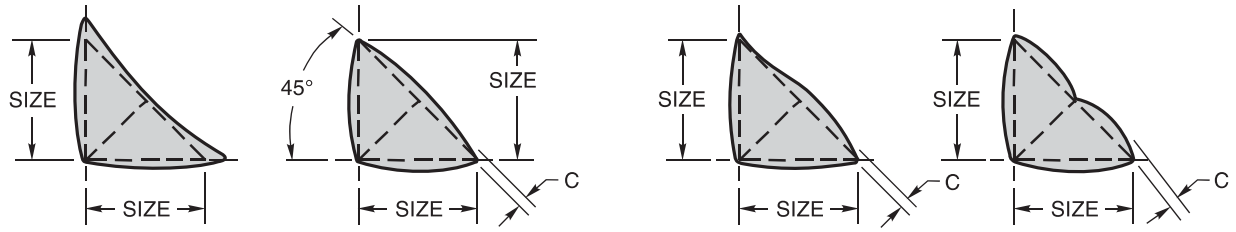
The average weld size of a given length of weld shall not be less than the weld size specified on the engineering drawing. The average weld size is determined by the average of leg length measurements obtained at 3 in [75 mm] intervals along the weld length. For welds below 3 in [75 mm] in length, the above-mentioned tolerances are applied directly. For welds exceeding these tolerances, see 9.6.6 and 9.6.7.

9.5.6 Groove Welds. Groove welds in butt joints shall preferably be made with slight weld reinforcement, unless otherwise specified, and shall have no defects such as those shown in Figure 15(E). The height of weld reinforcement shall not exceed 1/8 in [3 mm] for a joint or weld sizes up to and including 2 in [50 mm]. The weld reinforcement of weld size over 2 in [50 mm] shall not exceed 3/16 in [5 mm], as shown in Figure 15(D).

9.6 Repair of Weld Defects

9.6.1 All repair welding shall be performed in conformance to the welding requirements of this specification and the WPS for the welded joint involved.

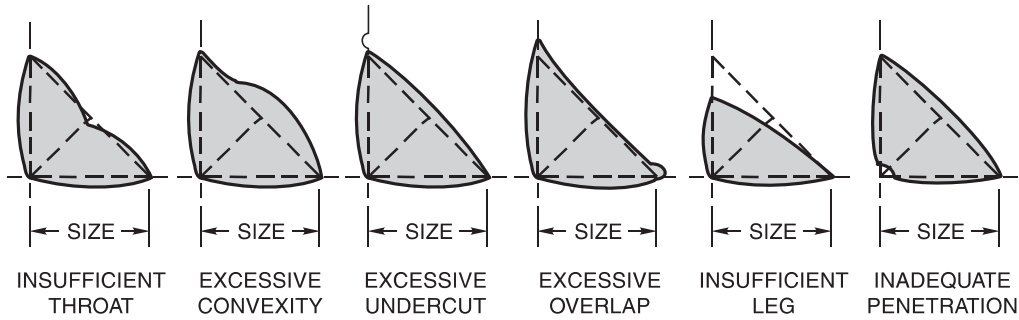
9.6.2 Underfilled Craters. Underfilled craters shall be rewelded and filled to at least 85% of the full cross-section of the weld size.



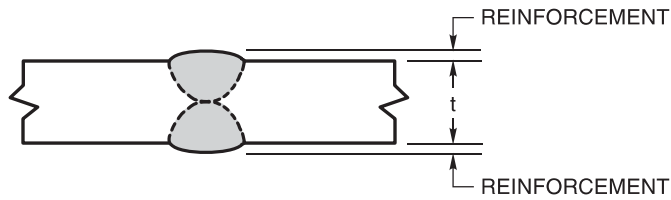
NOTE: CONVEXITY C SHALL NOT EXCEED 0.1 TIMES ACTUAL LEG SIZE, OR THE LONGER LEG IN THE CASE OF AN UNEQUAL LEG FILLET WELD. PLUS 0.06 In [2 mm].

(A) DESIRABLE FILLET WELD PROFILES

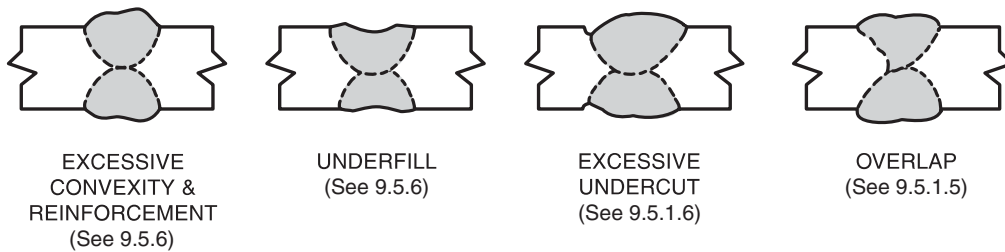
(B) ACCEPTABLE FILLET WELD PROFILES



(C) UNACCEPTABLE FILLET WELD PROFILES



(D) ACCEPTABLE GROOVE WELD PROFILE



(E) UNACCEPTABLE GROOVE WELD PROFILE

Figure 15—Acceptable and Unacceptable Weld Profiles

9.6.3 Cracks, Porosity, and Planar Discontinuities. Cracks, porosity, and planar-type discontinuities deemed to be unacceptable in accordance with the established acceptance criteria (see 9.5.1.7) shall be completely removed by appropriate means. The areas from which these discontinuities are removed shall be inspected by an approved NDE method, such as magnetic particle or penetrant testing, to ensure complete removal of the discontinuity prior to repair welding.

9.6.4 Undercut. Unacceptable undercut shall be filled with weld metal or, if strength will not be adversely affected, blended out by appropriate means.

9.6.5 Overlap. Unacceptable overlap shall be removed by appropriate means. Additional weld metal may be added after removal of the overlap condition in order to restore the specified weld size and shape.

9.6.6 Undersize Welds. Undersize welds shall be repaired to size by depositing additional weld metal as required.

9.6.7 Oversize Welds. Oversize welds shall be reduced to specified size by appropriate means only when they will cause interference with other parts, or will otherwise produce an adverse effect upon the weldment.

9.6.8 The area of repaired work shall be reinspected.

9.7 Cleaning. Slag shall be cleaned from all welds prior to inspection.

9.8 Dimensional Tolerance. The dimensions of welded structural members shall be within the tolerance of the general specifications governing the work.

10. Inspection

10.1 The Manufacturer shall provide a CWI or a Qualified Person to ensure that all fabrication by welding is performed in accordance with this specification.

10.2 When nondestructive examination (NDE) is required, it shall be performed according to methods developed by the Manufacturer or in accordance with provisions of AWS D14.4/D14.4M, *Specification for Welded Joints in Machinery and Equipment*. Inspection practices and controlling methods shall be used which ensure the following:

10.2.1 Welding Procedures comply with Clause 7, Welding Procedure Qualification.

10.2.2 Welding personnel are qualified in accordance with Clause 8, Welding Personnel Qualification, and they are observed at specified intervals to make certain that the workmanship requirements of Clause 9, Workmanship and Welding Quality Requirements, are maintained.

10.3 Inspection procedures and personnel involved in NDE and evaluation (including visual examination) shall be qualified to determine weld quality levels in compliance with Clause 9, Workmanship and Welding Quality Requirements.

10.4 Weld quality shall comply with or be corrected to conform to the provisions of Clause 9, Workmanship and Welding Quality Requirements.

10.5 When the quality performance of welding personnel is found to be consistently below the requirements of this specification, that person shall be requalified to the requirements of Clause 8, Welding Personnel Qualification.

11. Field Repair and Modification

11.1 This specification recognizes eventual need for field repairs as a result of normal wear and tear or accident. Each repair and any related modification shall be the responsibility of the equipment owner and the person or agency performing the work. The original manufacturer shall be contacted, if possible, to ensure that any repair or modification maintains the original design requirement. Modifications that change the designed intent of the equipment without documented consent from the original manufacturer shall be the responsibility of the owner and the person or agency performing the work.

A modification or repair can also be a change or correction by the Manufacturer to a new or existing model after shipment. In this case, the Manufacturer shall furnish drawings, procedures, or instructions necessary for the modification or repair.

The Owner, Manufacturer, or Manufacturer's representative should appoint an Engineer or other Qualified Person (see definitions in Clause 3) who is responsible for the field execution of the repair or modification.

11.2 Specific instruction provided shall indicate (by outline diagrams or other means) those areas and materials which require specific welding procedures and techniques necessary to ensure weldability (e.g., preheat, postheat, filler metals, etc.).

11.3 Recommended practices for preheat to supplement generalized welding instructions are listed in Table 6.

11.4 All field repair welding shall be performed by personnel qualified to perform welding in the basic welding positions as may be necessary.

11.5 A recommended resource for understanding weldability for repair on existing structures is AWS D1.7, *Guide for Strengthening and Repairing Existing Structures*.

Annex A (Normative)

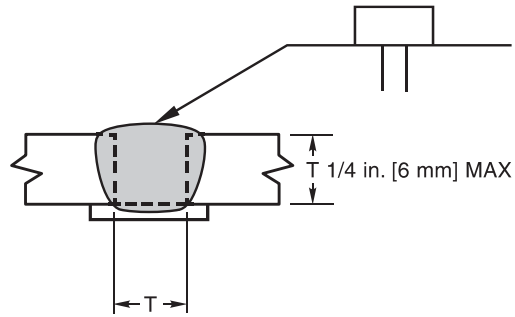
Prequalified Weld Joints

This annex is part of AWS D14.3/D14.3M:2010, *Specification for Welding Earthmoving, Construction, and Agricultural Equipment*, and includes mandatory elements for use with this standard.

Legend for Annex A	
Symbols for Joint Types	
Symbol	Joint Type
B	Butt
C	Corner
T	T-joint
BC	Butt or Corner
TC	T or Corner
BTC	Butt, T, or Corner
Symbols for Base Metal Thickness and Penetration	
L	Limited Thickness—Complete Joint Penetration
U	Unlimited Thickness—Complete Joint Penetration
P	Partial Joint Penetration
Symbols for Weld Types	
1	Square-Groove
2	Single-V-Groove
3	Double-V-Groove
4	Single-Bevel-Groove
5	Double-Bevel-Groove
6	Single-U-Groove
7	Double-U-Groove
8	Single-J-Groove
9	Double-J-Groove
Symbols for Welding Processes if not SMAW	
S	Submerged Arc Welding (SAW)
G	Gas Metal Arc Welding (GMAW)
F	Flux Cored Arc Welding (FCAW)

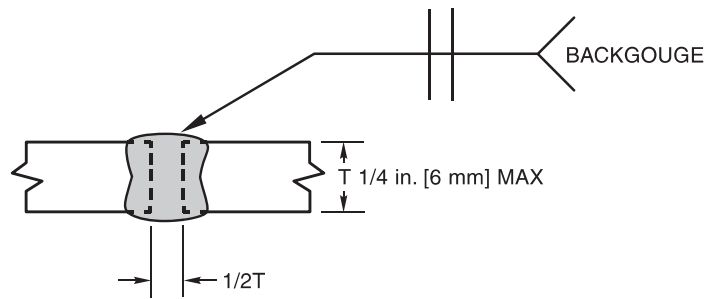
Note: Small or lower case letters, e.g., a, b, c, etc., are used as symbols to differentiate between variations from a basic joint geometry with root opening closing to zero for joints that are designated by the same weld symbol. Alphabetical progression is confined within each joint penetration category, complete (L & U) and partial (P), for each welding process.

Square-Groove Weld (1)
Butt Joint (B)
Limited Thickness (L)



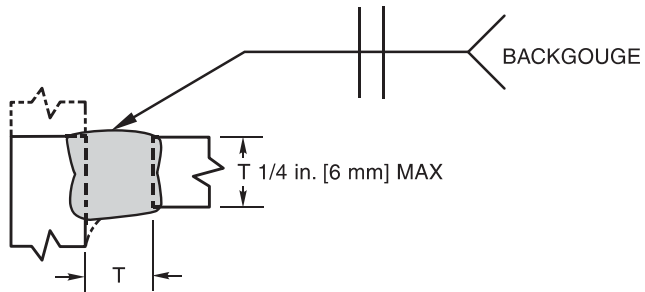
B-L1a

Square-Groove Weld (1)
Butt Joint (B)
Limited Thickness (L)



B-L1b

Square-Groove Weld (1)
T-Joint (T)
Corner Joint (C)
Limited Thickness (L)



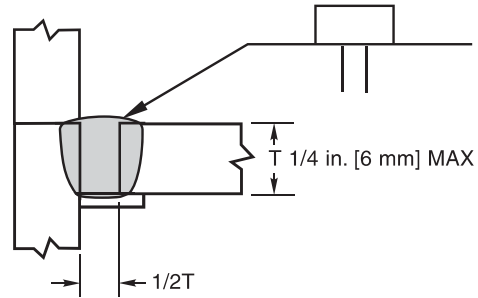
TC-L1a

Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to $T/4$ but need not exceed $3/8$ in [10 mm].

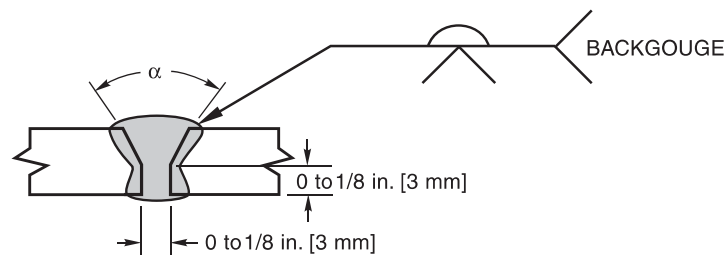
**Figure A.1—Prequalified Complete-Joint-Penetration Weld Joints—
Shielded Metal Arc Welding**

Square-Groove Weld (1)
T-Joint (T)
Corner Joint (C)
Limited Thickness (L)



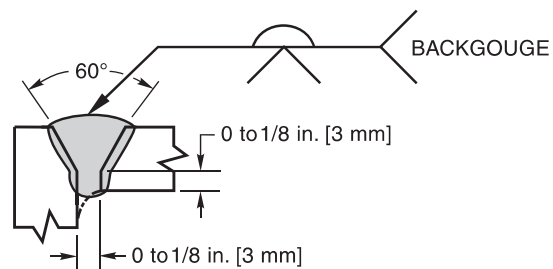
TC-L1b

Single-V-Groove Weld (2)
Butt Joint (B)
Unlimited Thickness (U)



B-U2

Single-V-Groove Weld (2)
Corner Joint (C)
Unlimited Thickness (U)



C-U2

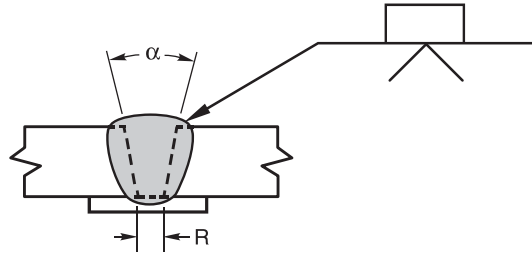
Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to $T/4$ but need not exceed $3/8$ in [10 mm].

**Figure A.1 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
Shielded Metal Arc Welding**

Single-V-Groove Weld (2)
Butt Joint (B)
Unlimited Thickness (L)

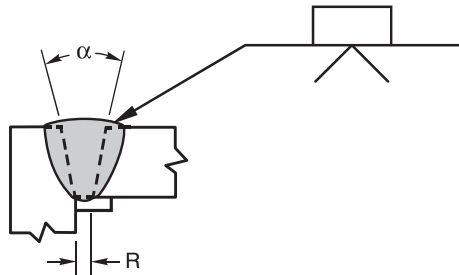
Limitations for Joints B-U2a		
α	R in. [mm]	Permitted Positions
45°	1/4 [6]	All Positions
30°	3/8 [10]	Flat and Overhead
20°	1/2 [13]	Flat and Overhead



B-U2a

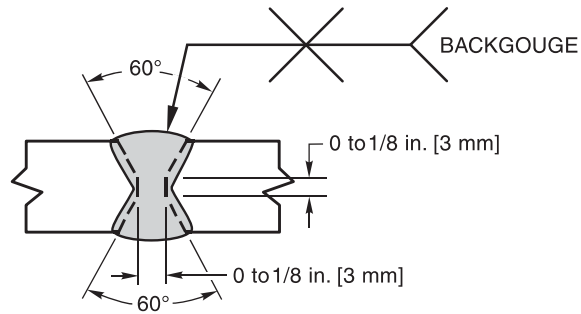
Single-V-Groove Weld (2)
Corner Joint (C)
Unlimited Thickness (U)

Limitations for Joints C-U2a		
α	R in. [mm]	Permitted Positions
45°	1/4 [6]	All Positions
30°	3/8 [10]	Flat and Overhead
20°	1/2 [13]	Flat and Overhead



C-U2a

Double-V-Groove Weld (3)
Butt Joint (B)
Unlimited Thickness (U)



B-U3

(Should be limited to base metal thickness $\geq 5/8$ in. [16mm].)

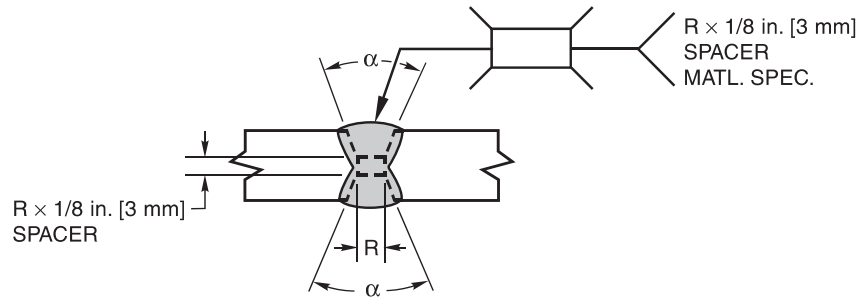
Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].

**Figure A.1 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
Shielded Metal Arc Welding**

Double-V-Groove Weld (3)
Butt Joint (B)
Unlimited Thickness (L)

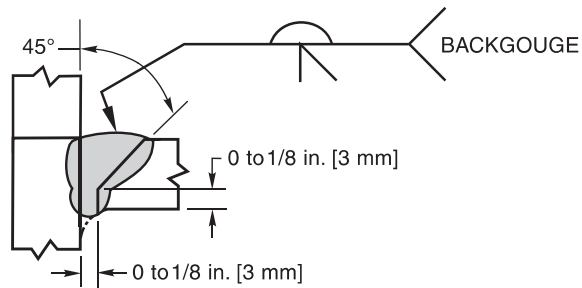
Limitations for Joints B-U3a		
α	R in. [mm]	Permitted Positions
45°	1/4 [6]	All Positions
30°	3/8 [10]	Flat and Overhead
20°	1/2 [13]	



B-U3a

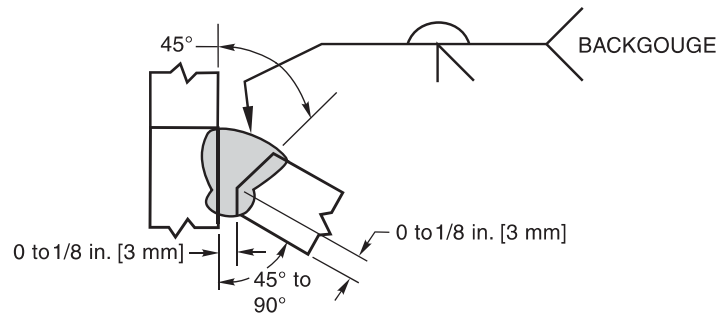
(Should be limited to base metal thickness $\geq 5/8$ in. [16mm].)

Single-Bevel-Groove Weld (4)
T-Joint (T)
Corner Joint (C)
Unlimited Thickness (U)



TC-U4

Single-Bevel-Groove Weld (4)
T-Joint (T)—Skew
Corner Joint (C)—Skew
Unlimited Thickness (U)



TC-U4a

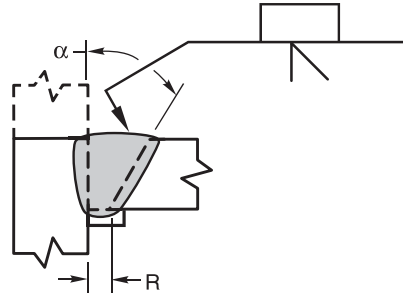
Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].

**Figure A.1 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
Shielded Metal Arc Welding**

Square-Bevel-Groove Weld (4)
 T-Joint (T)
 Corner Joint (C)
 Unlimited Thickness (U)

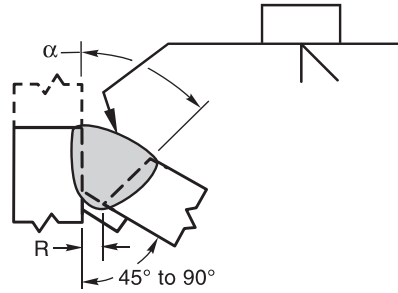
Limitations for Joints TC-U4b		
α	R in. [mm]	Permitted Positions
45°	1/4 [6]	All Positions
30°	3/8 [10]	Flat and Overhead



TC-U4b

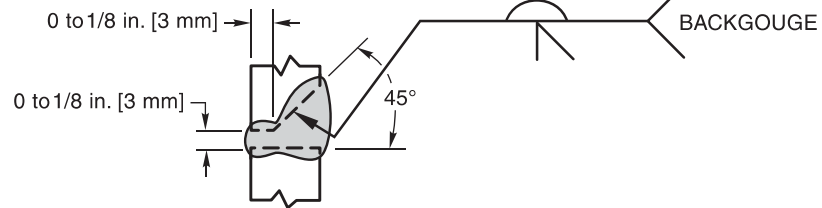
Single-Bevel-Groove Weld (4)
 T-Joint (T)—Skew
 Corner Joint (C)—Skew
 Limited Thickness (U)

Limitations for Joints B-U2a		
α	R in. [mm]	Permitted Positions
45°	1/4 [6]	All Positions
30°	3/8 [10]	Flat and Overhead



TC-U4c

Single-Bevel-Groove Weld (4)
 Butt Joint (B)
 Unlimited Thickness (U)



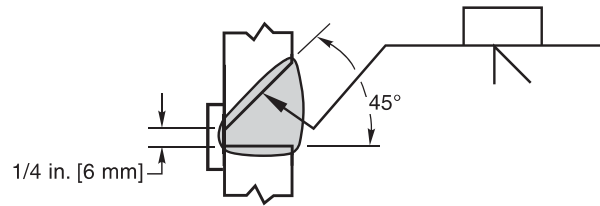
B-U4

Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].

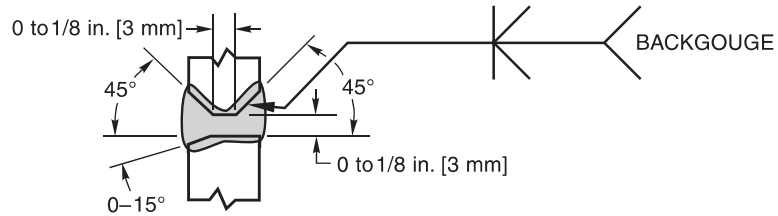
**Figure A.1 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
 Shielded Metal Arc Welding**

Single-Bevel-Groove Weld (4)
Butt Joint (B)
Unlimited Thickness (U)



B-U4a

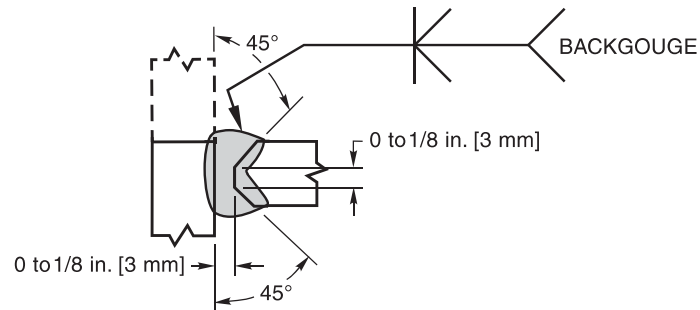
Double-Bevel-Groove Weld (5)
Butt Joint (B)
Unlimited Thickness (U)



B-U5

(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

Double-Bevel-Groove Weld (5)
T-Joint (T)
Corner Joint (C)
Unlimited Thickness (U)



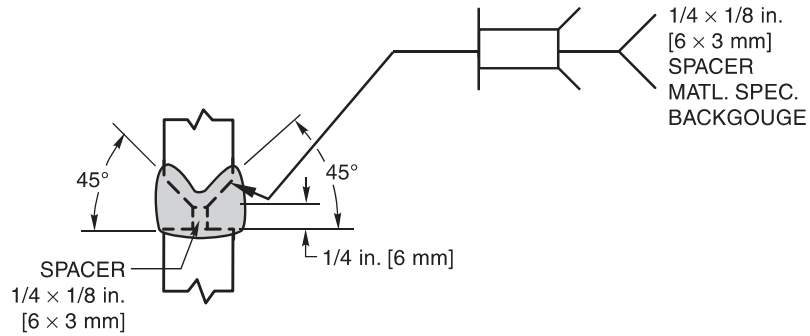
TC-U5

Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].

Figure A.1 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—Shielded Metal Arc Welding

Double-Bevel-Groove Weld (5)
Butt Joint (B)
Unlimited Thickness (U)

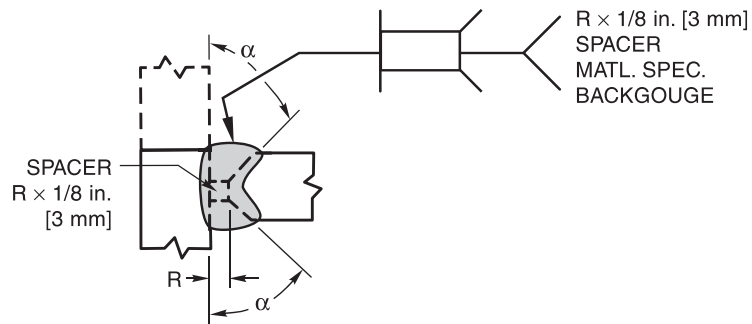


B-U5a

(Should be Limited to Base Metal Thickness $\geq 5/8$ in. [16 mm].)

Double-Bevel-Groove Weld (5)
T-Joint (T)—Skew
Corner Joint (C)—Skew
Unlimited Thickness (U)

Limitations for Joints TC-U5b		
α	R in. [mm]	Permitted Positions
45°	1/4 [6]	All Positions
30°	3/8 [10]	Flat and Overhead

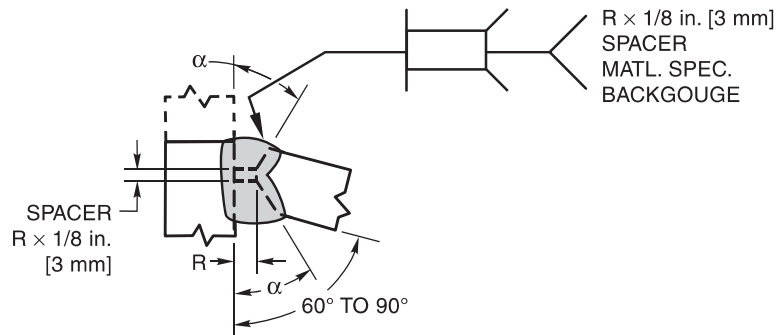


TC-U5b

(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

Double-Bevel-Groove Weld (5)
T-Joint (T)—Skew
Corner Joint (C)—Skew
Unlimited Thickness (U)

Limitations for Joints B-U5c		
α	R in. [mm]	Permitted Positions
45°	1/4 [6]	All Positions
30°	3/8 [10]	Flat and Overhead



TC-U5c

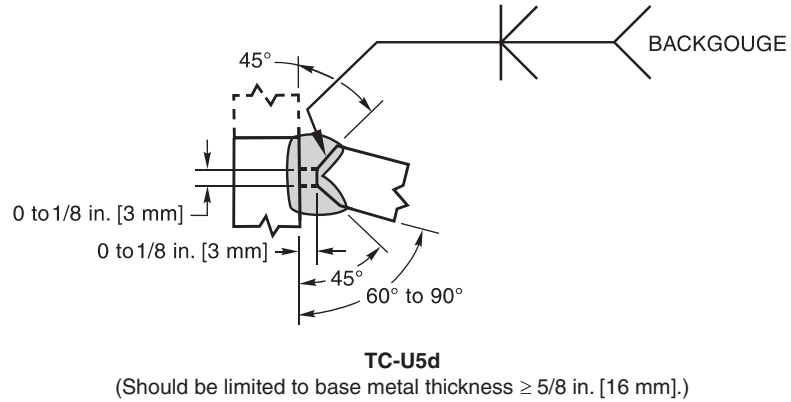
(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].

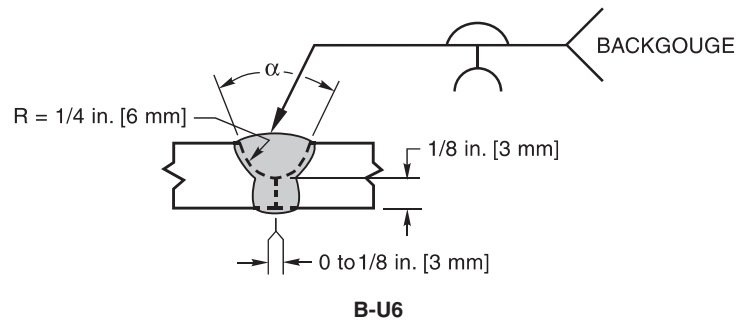
**Figure A.1 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
Shielded Metal Arc Welding**

Double-Bevel-Groove Weld (5)
 T-Joint (T)—Skew
 Corner Joint (C)—Skew
 Unlimited Thickness (U)



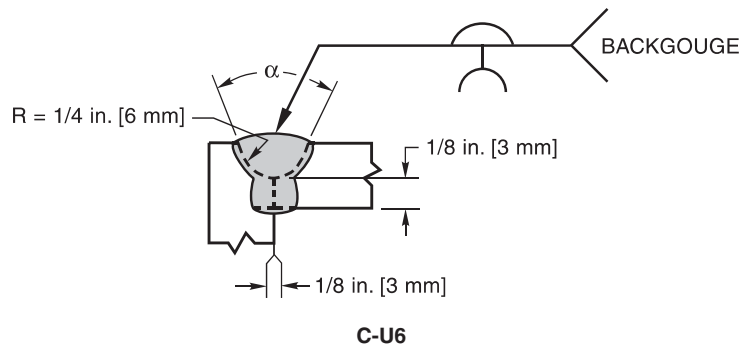
Single-U-Groove Weld (6)
 Butt Joint (B)
 Corner Joint (C)
 Unlimited Thickness (U)

Limitation for Joints	
B-U6	
α	Permitted Positions
45°	All Positions
20°	Flat and Overhead



Single-U-Groove Weld (6)
 Corner Joint (C)
 Unlimited Thickness (U)

Limitation for Joints	
C-U6	
α	Permitted Positions
45°	All Positions
20°	Flat and Overhead



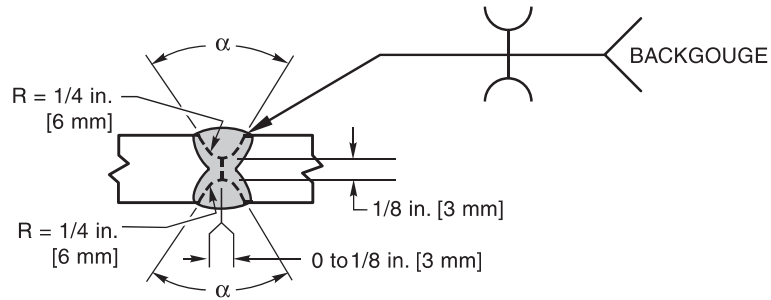
Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to $T/4$ but need not exceed $3/8$ in [10 mm].

**Figure A.1 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
 Shielded Metal Arc Welding**

Double-U-Groove Weld (7)
Butt Joint (B)
Unlimited Thickness (U)

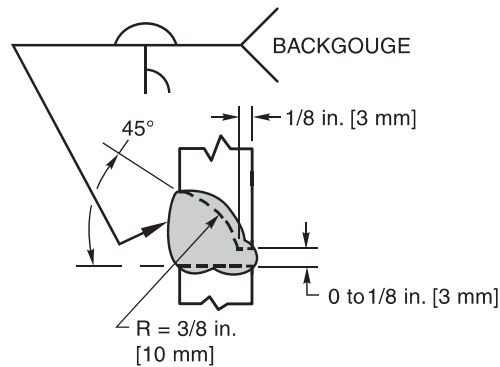
Limitation for Joints B-U7	
α	Permitted Positions
45°	All Positions
20°	Flat and Overhead



B-U7

(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

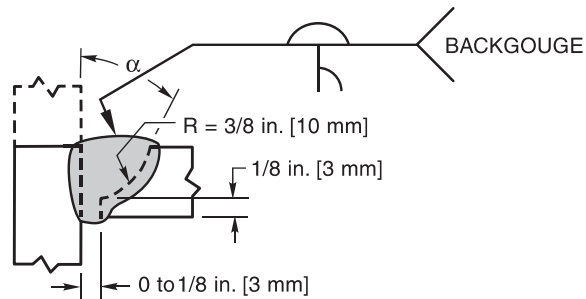
Single-J-Groove Weld (8)
Butt Joint (B)
Unlimited Thickness (U)



B-U8

Single-J-Groove Weld (8)
T-Joint (B)
Corner Joint (C)
Unlimited Thickness (U)

Limitation for Joints TC-U8a	
α	Permitted Positions
45°	All Positions
30°	Flat and Overhead



TC-U8a

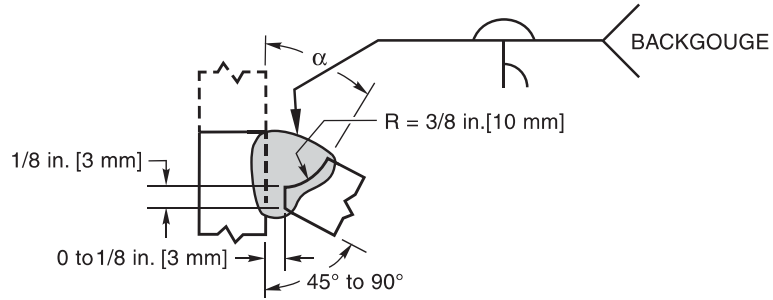
Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to $T/4$ but need not exceed $3/8$ in [10 mm].

Figure A.1 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—Shielded Metal Arc Welding

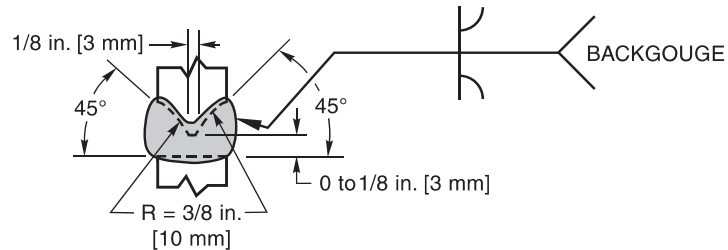
Single-J-Groove Weld (8)
 T-Joint (T)—Skew
 Corner Joint (C)—Skew
 Unlimited Thickness (U)

Limitation for Joints TC-U8b	
α	Permitted Positions
45°	All Positions
30°	Flat and Overhead



TC-U8b

Double-J-Groove Weld (9)
 Butt Joint (B)
 Unlimited Thickness (U)

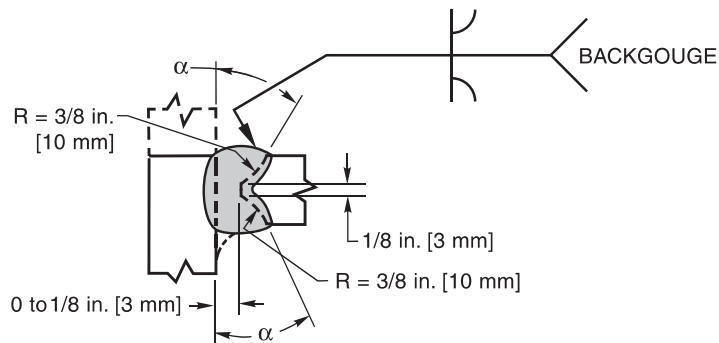


B-U9

(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

Double-J-Groove Weld (9)
 T-Joint (T)
 Corner Joint (C)
 Unlimited Thickness (U)

Limitation for Joints TC-U9a	
α	Permitted Positions
45°	All Positions
30°	Flat and Overhead



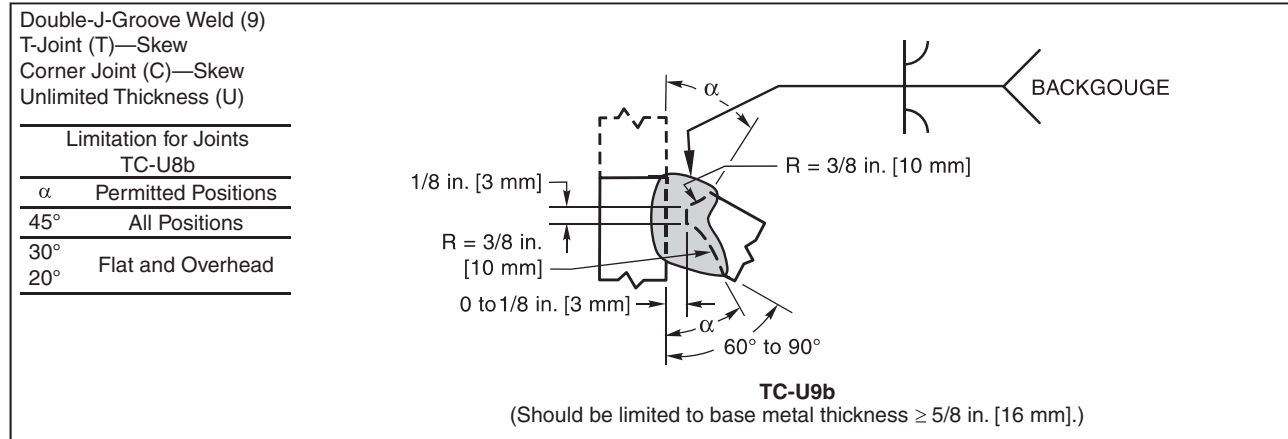
TC-U9a

(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to $T/4$ but need not exceed $3/8$ in [10 mm].

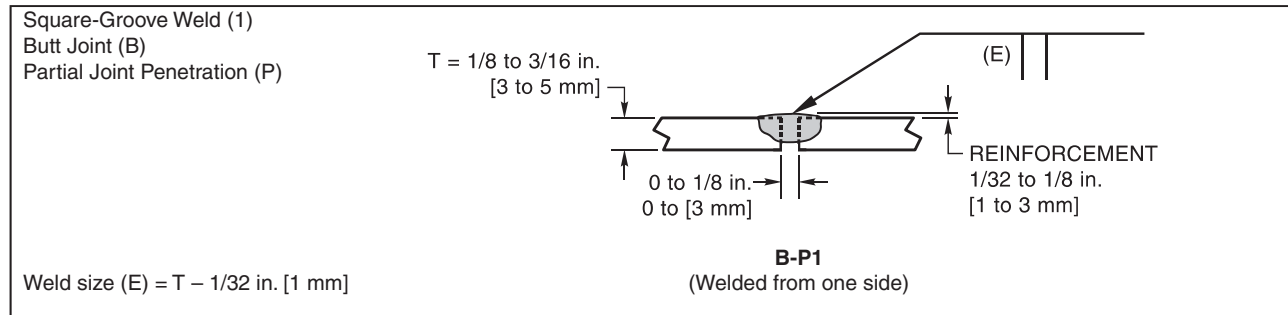
**Figure A.1 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
Shielded Metal Arc Welding**



Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 8 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].

**Figure A.1 (Continued)—Prequalified Complete-Joint-Penetration
Weld Joints—Shielded Metal Arc Welding**



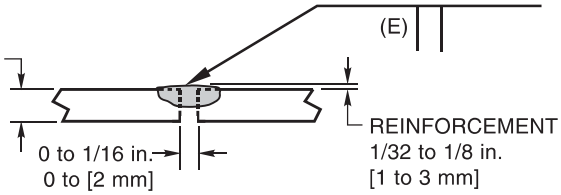
Note: See Table 9 for workmanship tolerances.

**Figure A.2—Prequalified Partial-Joint-Penetration Weld Joints—
Shielded Metal Arc Welding**

Square-Groove Weld (1)
Butt Joint (B)
Partial Joint Penetration (P)

$$\text{WELD SIZE (E)} = \frac{T}{2}$$

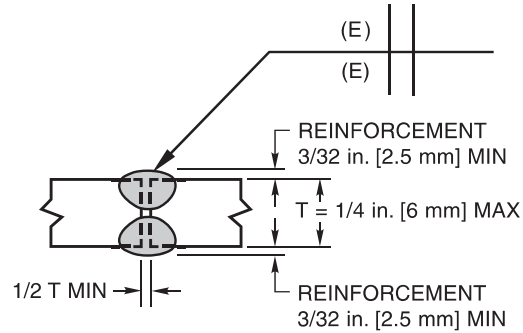
$$T = > 3/16 \text{ to } 1/4 \text{ in.} \\ [> 5 \text{ to } 6 \text{ mm}]$$



B-P1a

Square-Groove Weld (1)
Butt Joint (B)
Partial Joint Penetration (P)

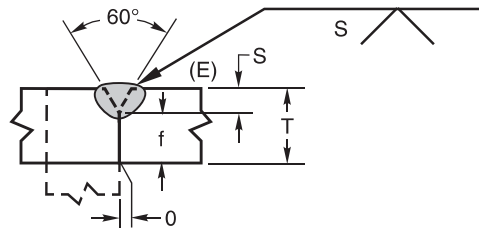
$$\text{WELD SIZE (E)} = T/2 - 1/32 \text{ in. [1 mm]} \\ \text{TOTAL WELD SIZE (E}_T\text{)} = (\text{E Side 1} + \text{E Side 2})$$



B-P1b

Single-V-Groove Weld (2)
Butt Joint (B)
Corner Joint (C)
Partial Joint Penetration (P)

$$\text{WELD SIZE (E)} = S$$

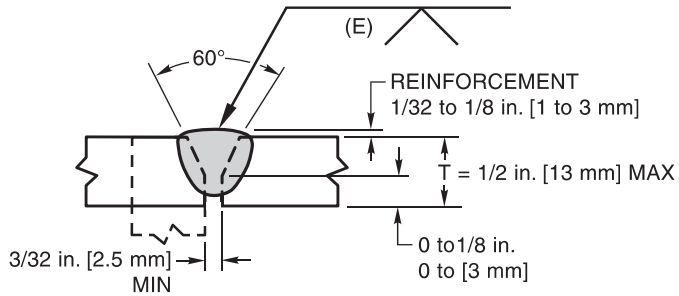
BC-P2^a

^a Minimum root face (f) shall be 1/8 in [3 mm] when specified.

Note: See Table 9 for workmanship tolerances.

**Figure A.2 (Continued)—Prequalified Partial-Joint-Penetration Weld Joints—
Shielded Metal Arc Welding**

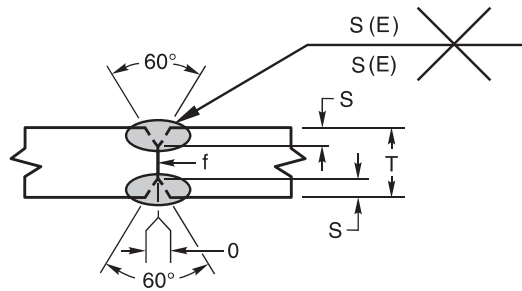
Single-V-Groove Weld (2)
Butt Joint (B)
Corner Joint (C)
Partial Joint Penetration (P)



WELD SIZE (E) = $T - 1/32$ in. [1 mm]

BC-P2a

Double-V-Groove Weld (3)
Butt Joint (B)
Partial Joint Penetration (P)

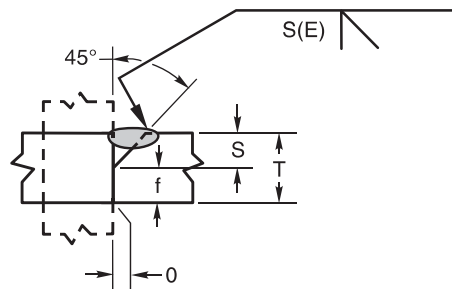


WELD SIZE (E) = S

TOTAL WELD SIZE (E_T) = (E) Side 1 + (E) Side 2

B-P3^a

Single-Bevel-Groove Weld (4)
Butt Joint (B)
T-Joint (T)
Corner Joint (C)
Partial Joint Penetration (P)



WELD SIZE (E) = $S - 1/8$ in. [3 mm]

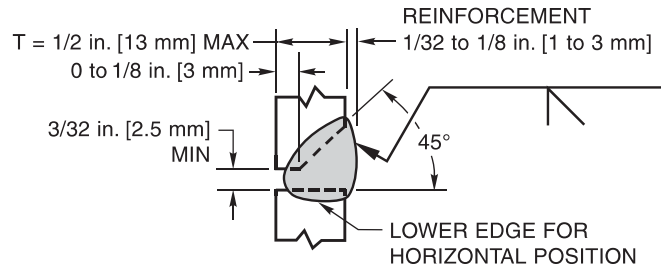
BTC-P4^a

^a Minimum root face (f) shall be 1/8 in [3 mm] when specified.

Note: See Table 9 for workmanship tolerances.

**Figure A.2 (Continued)—Prequalified Partial-Joint-Penetration Weld Joints—
Shielded Metal Arc Welding**

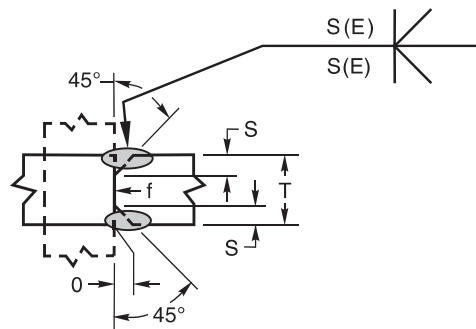
Single-Bevel-Groove Weld (4)
Butt Joint (B)
Partial Joint Penetration (P)



B-P4a

WELD SIZE (E) = $T - 1/32$ in. [1 mm]

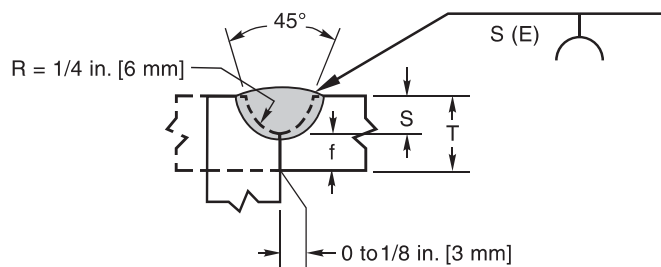
Double-Bevel-Groove Weld (5)
Butt Joint (B)
T-Joint (T)
Corner Joint (C)
Partial Joint Penetration (P)



BTC-P5^a

WELD SIZE (E) = $S - 1/8$ in. [3 mm]
TOTAL WELD SIZE (E_T) = (E) Side 1 + (E) Side 2

Single-U-Groove Weld (6)
Butt Joint (B)
Corner Joint (C)
Partial Joint Penetration (P)



BC-P6^a

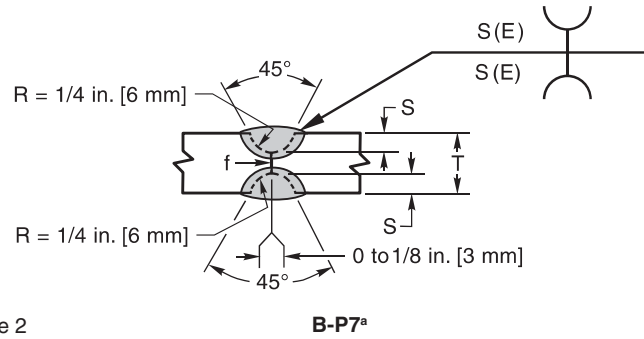
WELD SIZE (E) = S

^a Minimum root face (f) shall be 1/8 in [3 mm] when specified.

Note: See Table 9 for workmanship tolerances.

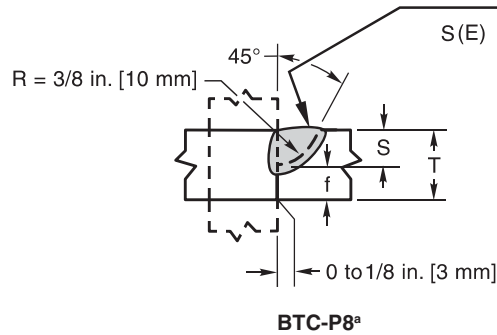
**Figure A.2 (Continued)—Prequalified Partial-Joint-Penetration Weld Joints—
Shielded Metal Arc Welding**

Double-U-Groove Weld (7)
Butt Joint (B)
Partial Joint Penetration (P)



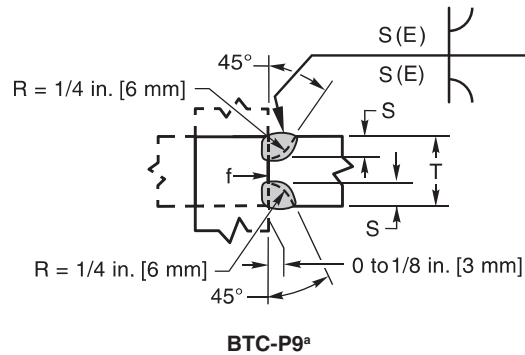
WELD SIZE (E) = S
TOTAL WELD SIZE (E_T) = (E) Side 1 + (E) Side 2

Single-J-Groove Weld (8)
Butt Joint (B)
T-Joint (T)
Corner Joint (C)
Partial Joint Penetration (P)



WELD SIZE (E) = S

Double-J-Groove Weld (9)
Butt Joint (B)
T-Joint (T)
Corner Joint (C)
Partial Joint Penetration (P)

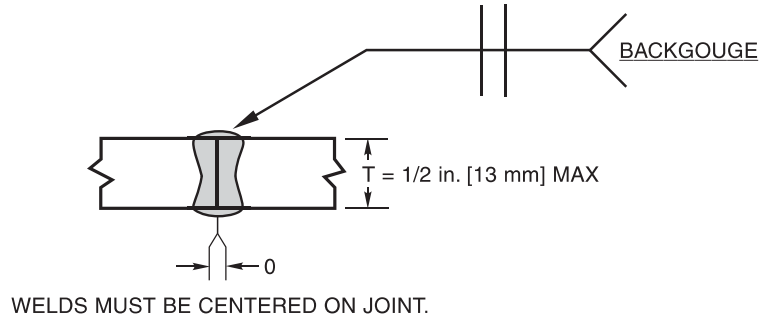


WELD SIZE (E) = S
TOTAL WELD SIZE (E_T) = (E) Side 1 + (E) Side 2

^a Minimum root face (f) shall be 1/8 in [3 mm] when specified.
Note: See Table 9 for workmanship tolerances.

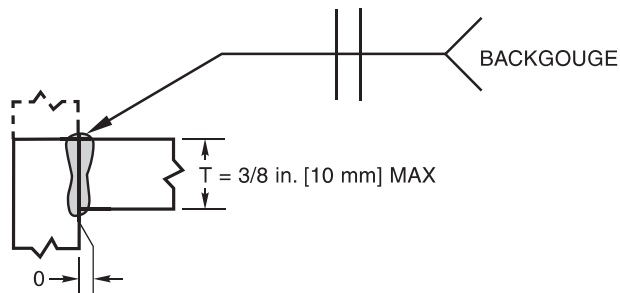
**Figure A.2 (Continued)—Prequalified Partial-Joint-Penetration Weld Joints—
Shielded Metal Arc Welding**

Square-Groove Weld (1)
Butt Joint (B)
Limited Thickness (L)



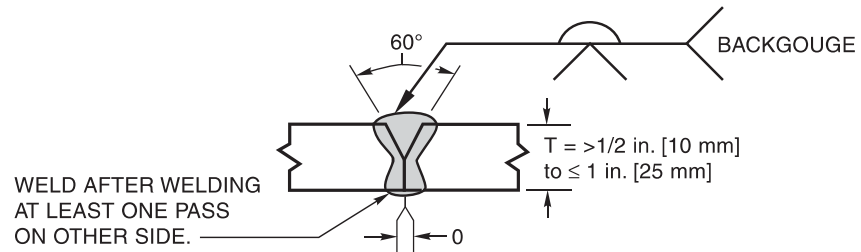
B-L1-S

Square-Groove Weld (1)
T-Joint (T)
Corner Joint (C)
Limited Thickness (L)



TC-L1-S

Single-V-Groove Weld (2)
Butt Joint (B)
Limited Thickness (L)



B-L2-S

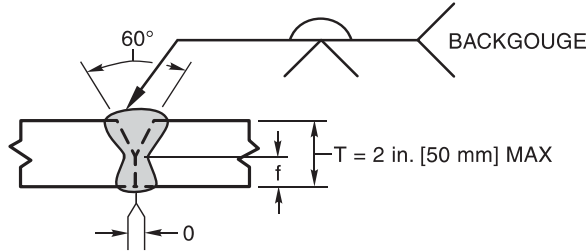
Notes:

1. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to $T/4$ but need not exceed $3/8$ in [10 mm].
2. See Table 9 for workmanship tolerances.
3. Gouge the roots of joints without backing before welding the other side.

**Figure A.3—Prequalified Complete-Joint-Penetration Weld Joints—
Submerged Arc Welding**

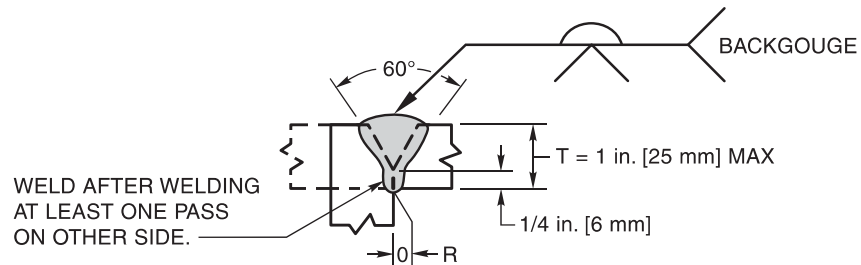
Single-V-Groove Weld (2)
Butt Joint (B)
Limited Thickness (L)

T	f
in. [mm]	in. [mm]
> 1/4 to ≤ 1	1/4 [6]
> 6 to ≤ 25	
> to ≤ 1-1/2	1/2 [13]
> 25 to ≤ 38	
> 1-1/2 to ≤ 2	5/8 [16]
> 38 to ≤ 50	



B-L2a-S

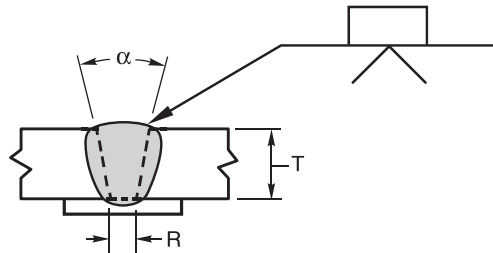
Single-V-Groove Weld (2)
Butt Joint (B)
Corner Joint (C)
Limited Thickness (L)



BC-L2b-S

Single-V-Groove Weld (2)
Butt Joint (B)
Limited Thickness (L)
Unlimited Thickness (U)

Limitations for Joints			
Joint	α	R in. [mm]	Maximum Thickness (T) in. [mm]
B-L2c-S	30°	1/4 [6]	1/2 [13]
B-U2a-S	20°	5/8 [16]	Unlimited



B-L2c-S and B-U2a-S

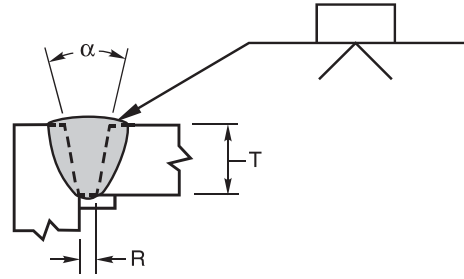
Notes:

1. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].
2. See Table 9 for workmanship tolerances.
3. Gouge the roots of joints without backing before welding the other side.

**Figure A.3 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
Submerged Arc Welding**

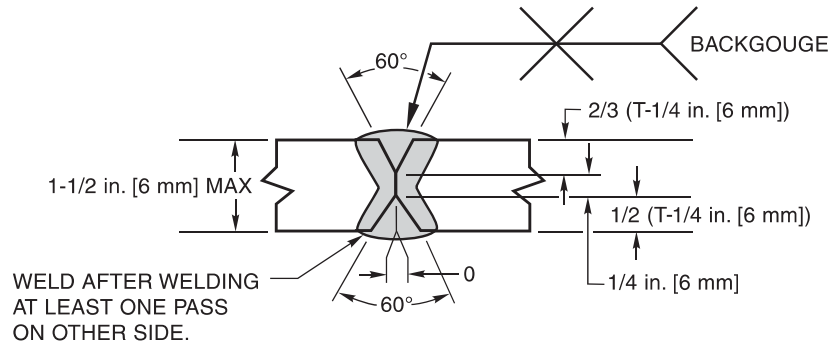
Single-V-Groove Weld (2)
Butt Joint (B)
Limited Thickness (L)
Unlimited Thickness (U)

Limitations for Joints			
Joint	α	R in. [mm]	Maximum Thickness (T) in. [mm]
C-L2c-S	30°	1/4 [6]	1/2 [13]
C-U2a-S	20°	5/8 [16]	Unlimited



C-L2c-S and C-U2a-S

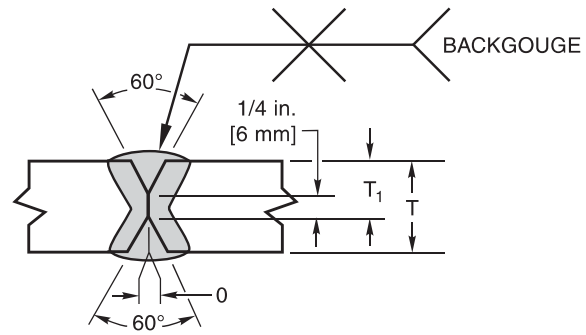
Double-V-Groove Weld (3)
Butt Joint (B)
Limited Thickness (L)



B-L3-S

Double-V-Groove Weld (3)
Butt Joint (B)
Unlimited Thickness (U)

INCHES		MILLIMETERS	
T	T ₁	T	T ₁
Over 2 to 2-1/2	1-3/8	Over 50 to 65	35
Over 2-1/2 to 3	1-3/4	Over 65 to 75	45
Over 3 to 3-5/8	2-1/8	Over 75 to 92	55
Over 3-5/8 to 4	2-3/8	Over 92 to 100	60
Over 4 to 4-3/4	2-3/4	Over 100 to 120	70
Over 4-3/4 to 5-1/2	3-1/4	Over 120 to 140	83
Over 5-1/2 to 6-1/4	3-3/4	Over 140 to 160	95
For T > 6-1/4 or T < 2		For T > 160 or T < 50	
T ₁ = 2/3 (T - 1/4)		T ₁ = 2/3 (T - 6)	



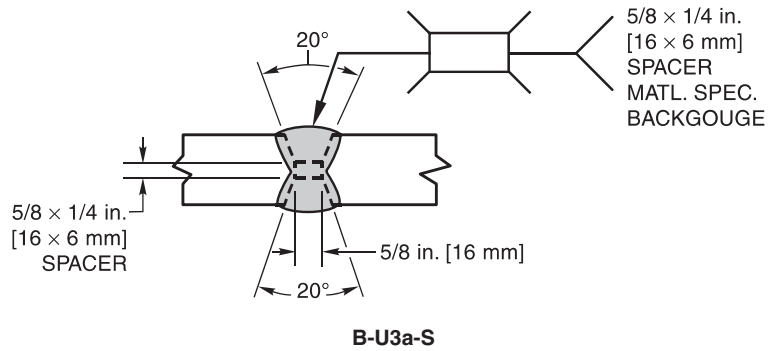
B-U3-S

Notes:

1. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].
2. See Table 9 for workmanship tolerances.
3. Gouge the roots of joints without backing before welding the other side.

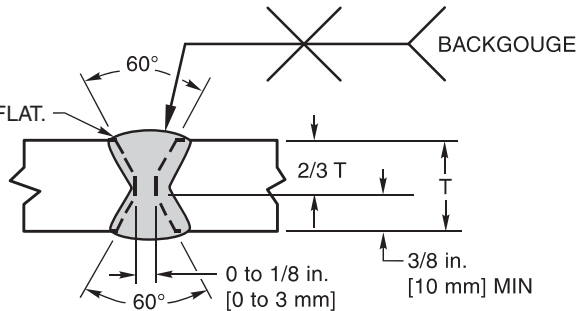
Figure A.3 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—Submerged Arc Welding

Double-V-Groove Weld (3)
Butt Joint (B)
Unlimited Thickness (U)



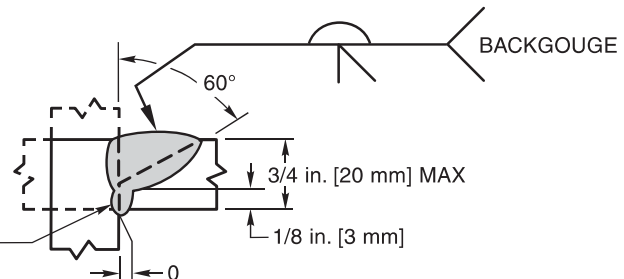
Double-V-Groove Weld (3)
Butt Joint (B)
Unlimited Thickness (U)

SINGLE OR MULTIPLE PASS
SUBMERGED ARC WELD IN FLAT.
POSITION AFTER SMAW
WELDING IS COMPLETED
IN THE OVERHEAD
POSITION WITH LOW
HYDROGEN ELECTRODES.



Single-Bevel-Groove Weld (4)
Butt Joint (B)
T-Joint (T)
Corner Joint (C)
Limited Thickness (L)

SHIELDED METAL ARC OR
SUBMERGED ARC BACKING
FILLET WELDS.



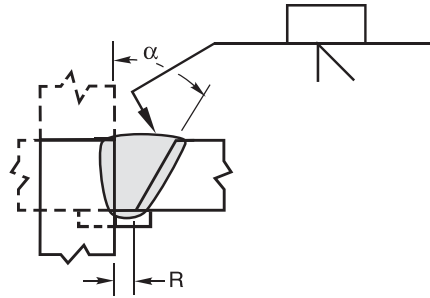
Notes:

1. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to $T/4$ but need not exceed $3/8$ in [10 mm].
2. See Table 9 for workmanship tolerances.
3. Gouge the roots of joints without backing before welding the other side.

**Figure A.3 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
Submerged Arc Welding**

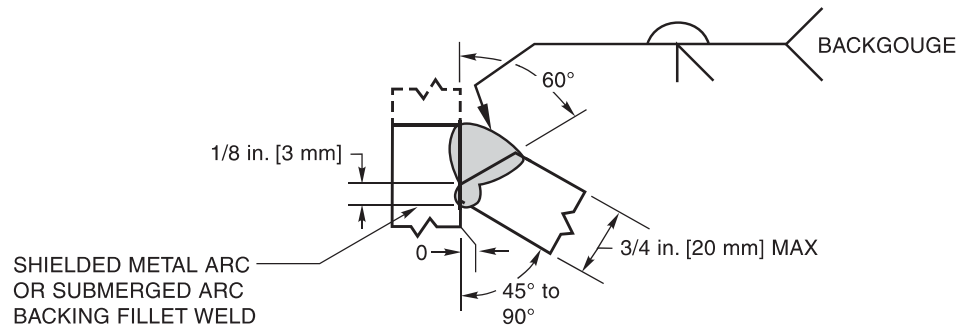
Single-Bevel-Groove Weld (4)
 Butt Joint (B)
 T-Joint (T)—Skew
 Corner Joint (C)
 Unlimited Thickness (U)

α	R in. [mm]
45°	1/4 [6]
30°	3/8 [10]



BTC-U4a-S

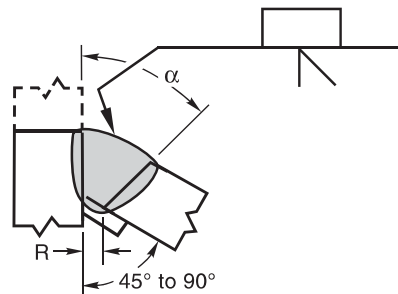
Single-Bevel-Groove Weld (4)
 T-Joint (T)—Skew
 Corner Joint (C)—Skew
 Limited Thickness (L)



TC-L4b-S

Single-Bevel-Groove Weld (4)
 T-Joint (T)—Skew
 Corner Joint (C)—Skew
 Unlimited Thickness (U)

α	R in. [mm]
45°	1/4 [6]
30°	3/8 [10]



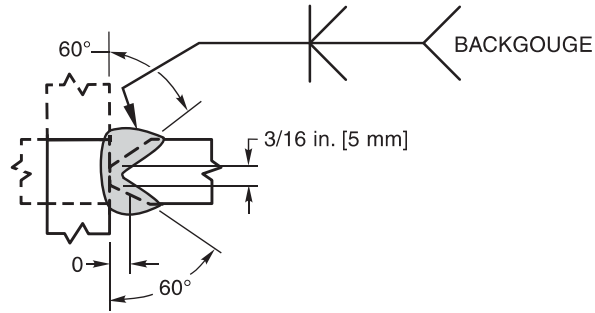
TC-U4c-S

Notes:

1. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].
2. See Table 9 for workmanship tolerances.
3. Gouge the roots of joints without backing before welding the other side.

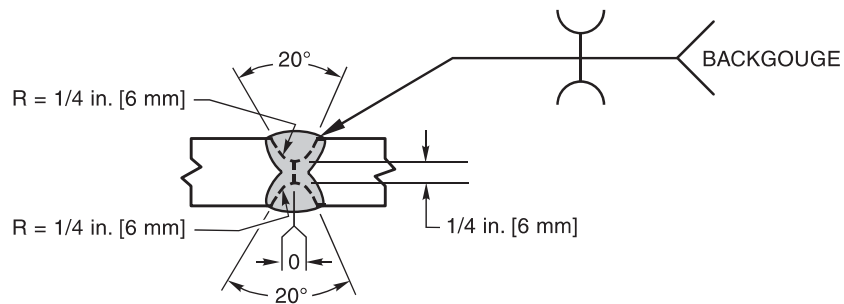
**Figure A.3 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
 Submerged Arc Welding**

Double-Bevel-Groove Weld (5)
 Butt Joint (B)
 T-Joint (T)
 Corner Joint (C)
 Unlimited Thickness (U)



BTC-U5-S

Double-Bevel-Groove Weld (7)
 Butt Joint (B)
 Unlimited Thickness (U)



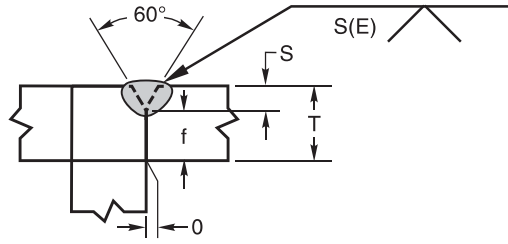
B-U7-S

Notes:

1. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].
2. See Table 9 for workmanship tolerances.
3. Gouge the roots of joints without backing before welding the other side.

**Figure A.3 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
 Submerged Arc Welding**

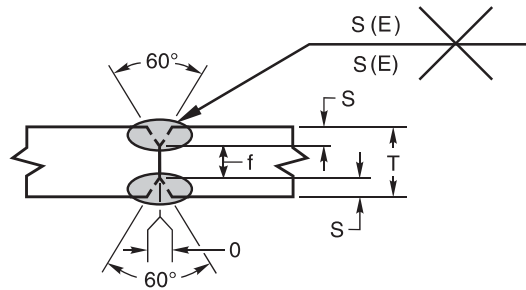
Single-V-Groove Weld (2)
Butt Joint (B)
Corner Joint (C)
Partial Joint Penetration (P)



WELD SIZE (E) = S

B-P2-S^a

Double-V-Groove Weld (3)
Butt Joint (B)
Partial Joint Penetration (P)

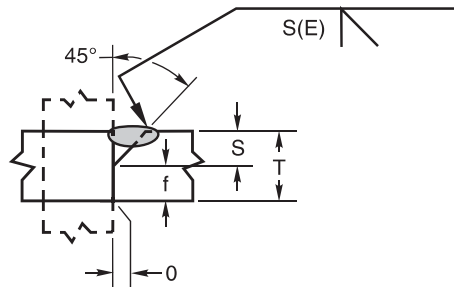


WELD SIZE (E) = S

TOTAL WELD SIZE (E_T) = (E) Side 1 + (E) Side 2

B-P3-S^a

Single-Bevel-Groove Weld (4)
Butt Joint (B)
T-Joint (T)
Corner Joint (C)
Partial Joint Penetration (P)



WELD SIZE (E) = S - 1/8 in. [3mm]

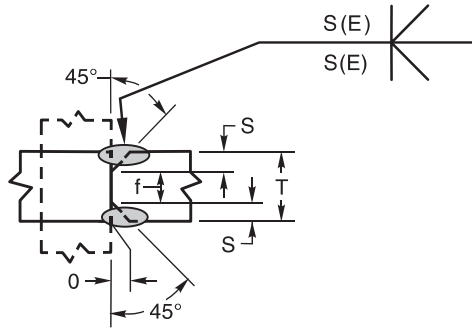
BTC-P4-S^a

^a Minimum root face (f) shall be 1/8 in [3 mm].

Note: See Table 9 for workmanship tolerances.

**Figure A.4—Prequalified Partial-Joint-Penetration Weld Joints—
Submerged Arc Welding**

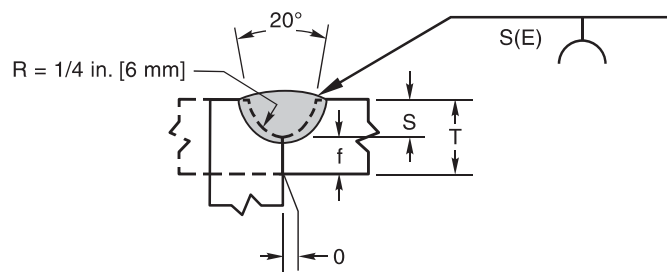
Double-Bevel-Groove Weld (5)
 Butt Joint (B)
 T-Joint (T)
 Corner Joint (C)
 Partial Joint Penetration (P)



WELD SIZE (E) = $S - 1/8$ in. [3 mm]
 TOTAL WELD SIZE (E_T) = (E) Side 1 + (E) Side 2

BTC-P5-S^a

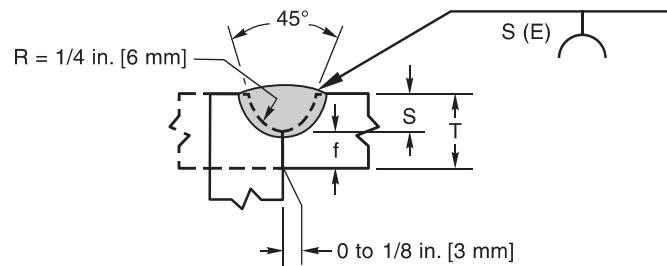
Single-U-Groove Weld (6)
 Butt Joint (B)
 Corner Joint (C)
 Partial Joint Penetration (P)



WELD SIZE (E) = S

BTC-P6-S^b

Single-U-Groove Weld (6)
 Butt Joint (B)
 Corner Joint (C)
 Partial Joint Penetration (P)



WELD SIZE (E) = S

BTC-P6b-S^b

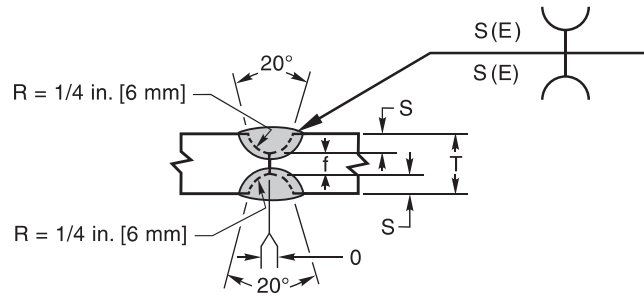
^a Minimum root face (f) shall be 1/8 in [3 mm].

^b Minimum root face (f) shall be 1/4 in [6 mm].

Note: See Table 9 for workmanship tolerances.

**Figure A.4 (Continued)—Prequalified Partial-Joint-Penetration Weld Joints—
 Submerged Arc Welding**

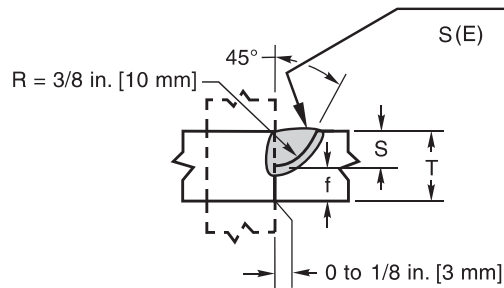
Double-U-Groove Weld (7)
Butt Joint (B)
Partial Joint Penetration (P)



WELD SIZE (E) = S
TOTAL WELD SIZE (E_r) = (E) Side 1 + (E) Side 2

BTC-P7-S^a

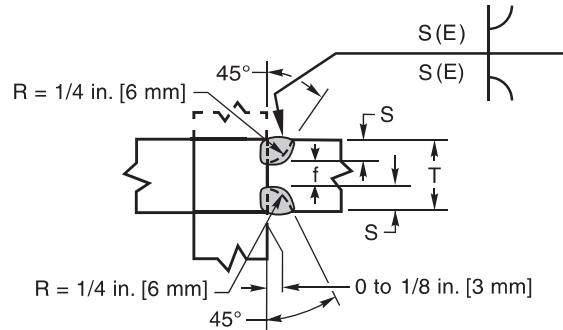
Single-J-Groove Weld (8)
Butt Joint (B)
T-Joint (T)
Corner Joint (C)
Partial Joint Penetration (P)



WELD SIZE (E) = S

BTC-P8-S^a

Double-J-Groove Weld (9)
Butt Joint (B)
T-Joint (T)
Corner Joint (C)
Partial Joint Penetration (P)



WELD SIZE (E) = S
TOTAL WELD SIZE (E_r) = (E) Side 1 + (E) Side 2

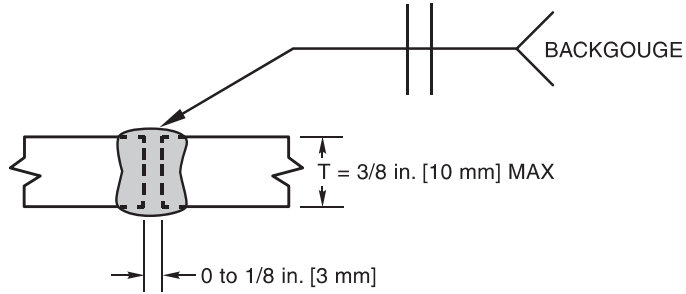
BTC-P9-S^a

^a Minimum root face (f) shall be 1/4 in [6 mm].

Note: See Table 9 for workmanship tolerances.

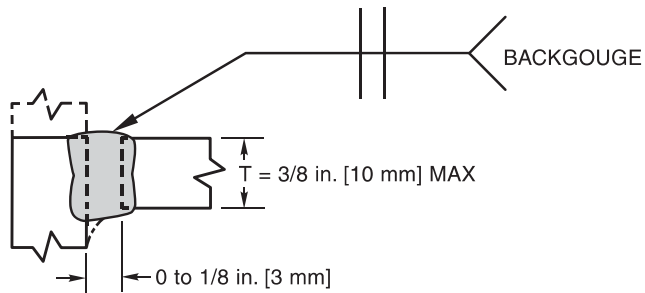
Figure A.4 (Continued)—Prequalified Partial-Joint-Penetration Weld Joints—Submerged Arc Welding

Square-Groove Weld (1)
Butt Joint (B)
Limited Thickness (L)



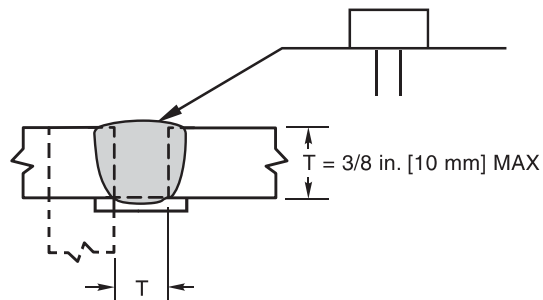
B-L1-GF

Square-Groove Weld (1)
T-Joint (T)
Corner Joint (C)
Limited Thickness (L)



TC-L1-GF

Square-Groove Weld (1)
Butt Joint (B)
Corner Joint (C)
Limited Thickness (L)



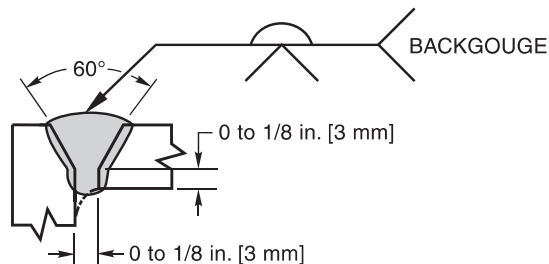
BC-L1a-GF

Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to $T/4$ but need not exceed $3/8$ in [10 mm].
4. Not prequalified for gas metal arc welding using short-circuiting transfer or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.

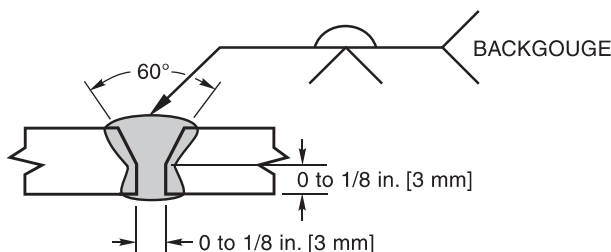
**Figure A.5—Prequalified Complete-Joint-Penetration Weld Joints—
Gas Metal and Flux Cored Arc Welding**

Single-V-Groove Weld (2)
 Corner Joint (C)
 Unlimited Thickness (L)



C-U2-GF

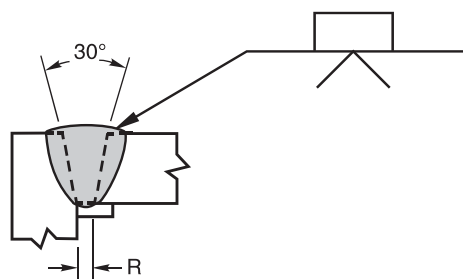
Single-V-Groove Weld (2)
 Butt-Joint (B)
 Unlimited Thickness (L)



B-U2-GF

Single-V-Groove Weld (2)
 Corner Joint (C)
 Unlimited Thickness (L)

Limitations for Joints C-U2a-GF		
Shielding	Positions ^a	R in. [mm]
Gas	F, V, & O	3/16 [5]
No Gas	F only	3/8 [10]
	V & O only	1/4 [6]



C-U2a-GF

^a F = Flat, V = Vertical, O = Overhead

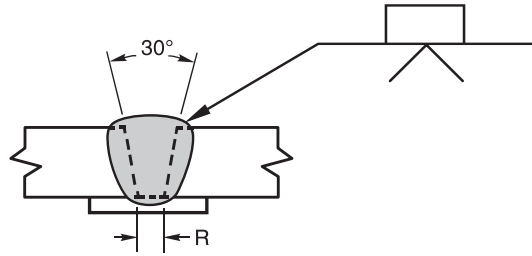
Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].
4. Not prequalified for gas metal arc welding using short-circuiting transfer or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.

**Figure A.5 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
 Gas Metal and Flux Cored Arc Welding**

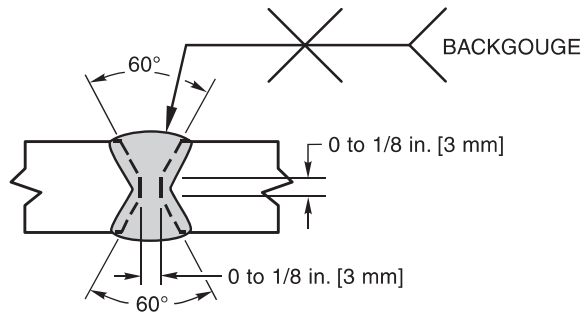
Single-V-Groove Weld (2)
Butt Joint (B)
Unlimited Thickness (U)

Limitations for Joints B-U2a-GF		
Shielding	Positions ^a	R in. [mm]
Gas	F, V, & O	3/16 [5]
No Gas	Flat only	3/8 [10]
	V & O only	1/4 [6]



B-U2a-GF

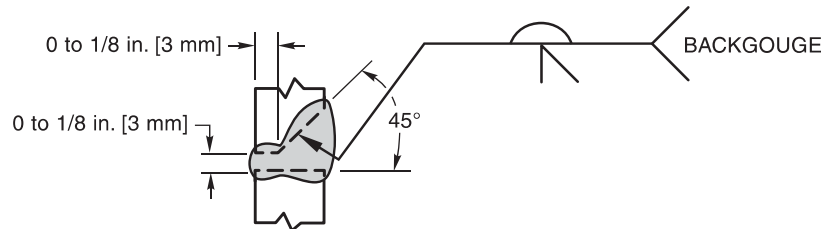
Double-V-Groove Weld (3)
Butt Joint (B)
Unlimited Thickness (U)



B-U3-GF

(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

Single-Bevel-Groove Weld (4)
Butt Joint (B)
Unlimited Thickness (U)



B-U4-GF

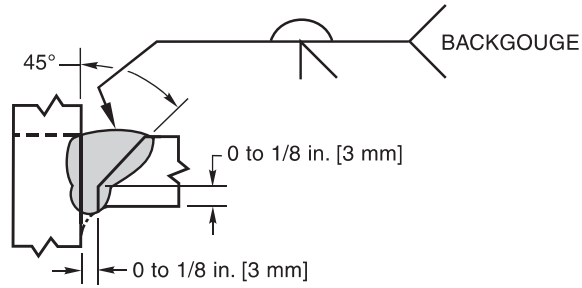
^a F = Flat, V = Vertical, O = Overhead

Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].
4. Not prequalified for gas metal arc welding using short-circuiting transfer or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.

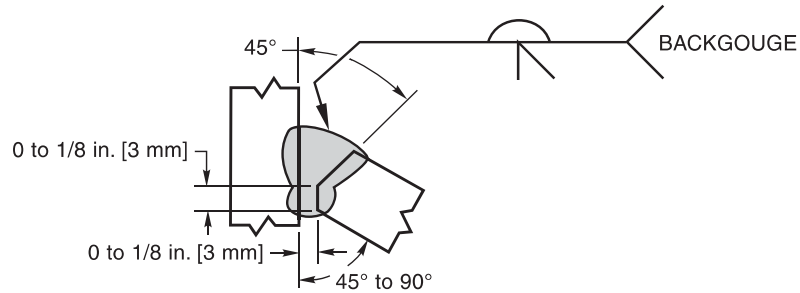
**Figure A.5 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
Gas Metal and Flux Cored Arc Welding**

Single-Bevel-Groove Weld (4)
 T-Joint (T)
 Corner Joint (C)
 Unlimited Thickness (U)



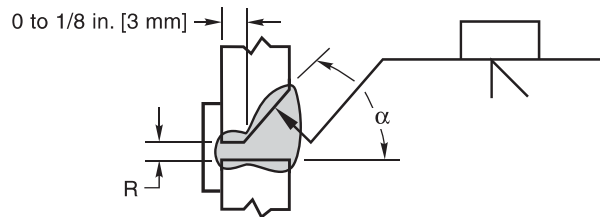
TC-U4-GF

Single-Bevel-Groove Weld (4)
 T-Joint (T)—Skew
 Corner Joint (C)—Skew
 Unlimited Thickness (U)



TC-U4a-GF

Single-Bevel-Groove Weld (4)
 Butt Joint (B)
 Unlimited Thickness (U)



B-U4b-GF

Limitations for Joints B-U4b-GF			
		R	
Shielding	Positions	α	in. [mm]
Gas	All	30°	3/16 [5]
No Gas	Flat only	30°	3/8 [10]
	All	45°	1/4 [6]

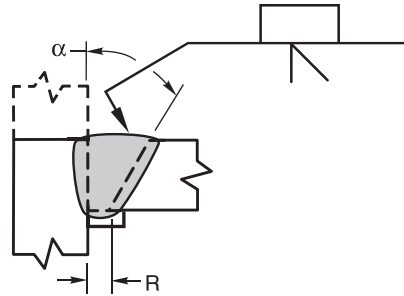
Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].
4. Not prequalified for gas metal arc welding using short-circuiting transfer or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.
5. Min 30° for plate thickness up to and including 1/2 in (13 mm).
 Min 45° for plate thickness greater than 1/2 in (13 mm).

**Figure A.5 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
 Gas Metal and Flux Cored Arc Welding**

Single-Bevel-Groove Weld (4)
 T-Joint (T)
 Corner Joint (C)
 Unlimited Thickness (U)

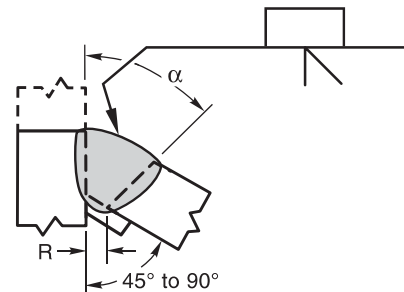
Limitations for Joints TC-U4c-GF				
Shielding	Positions	α	R	
			in. [mm]	
Gas	All	30°	3/16 [5]	
No Gas	Flat only	30°	3/8 [10]	
	All	45°	1/4 [6]	



TC-U4c-GF

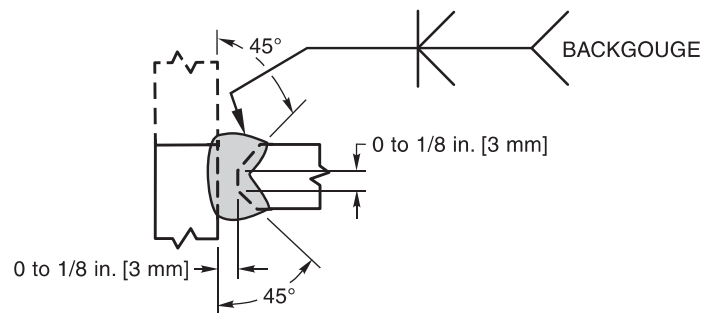
Single-Bevel-Groove Weld (4)
 T-Joint (T)—Skew
 Corner Joint (C)—Skew
 Unlimited Thickness (U)

Limitations for Joints TC-U4d-GF				
Shielding	Positions	α	R	
			in. [mm]	
Gas	All	30°	3/16 [5]	
No Gas	Flat only	30°	3/8 [10]	
	All	45°	1/4 [6]	



TC-U4d-GF

Double-Bevel-Groove Weld (5)
 T-Joint (T)
 Corner Joint (C)
 Unlimited Thickness (U)



TC-U5-GF

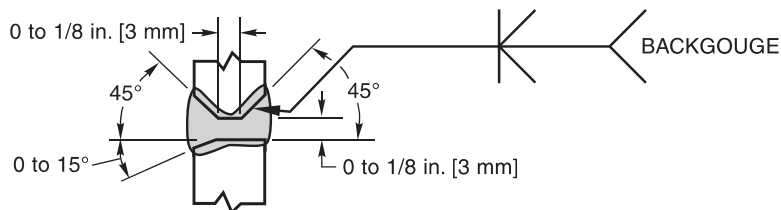
(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].
4. Not prequalified for gas metal arc welding using short-circuiting transfer or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.

**Figure A.5 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
 Gas Metal and Flux Cored Arc Welding**

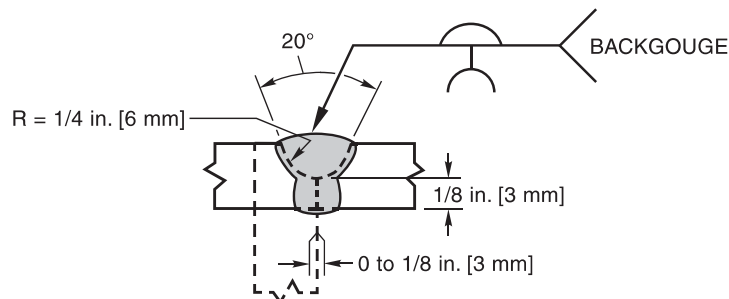
Double-Bevel-Groove Weld (5)
Butt Joint (B)
Unlimited Thickness (U)



B-U5-GF

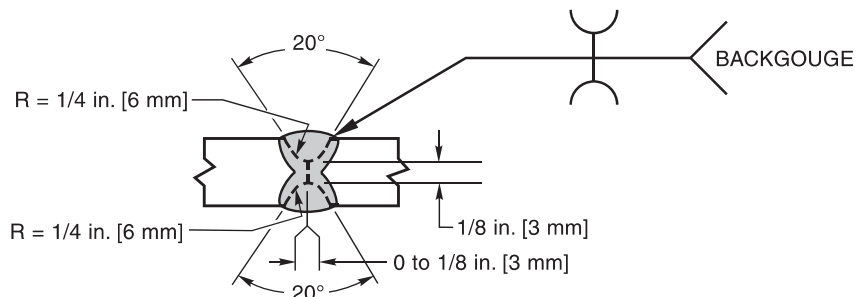
(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

Single-U-Groove Weld (6)
Butt Joint (B)
Corner Joint (C)
Unlimited Thickness (U)



BC-U6-GF

Double-U-Groove Weld (7)
Butt Joint (B)
Unlimited Thickness (U)



B-U7-GF

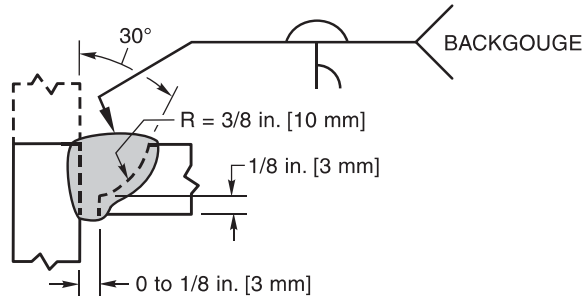
(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to $T/4$ but need not exceed $3/8$ in [10 mm].
4. Not prequalified for gas metal arc welding using short-circuiting transfer or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.

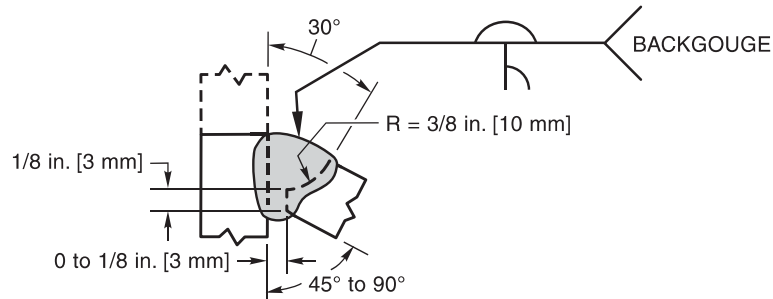
**Figure A.5 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
Gas Metal and Flux Cored Arc Welding**

Single-J-Groove Weld (8)
T-Joint (T)
Corner Joint (C)
Unlimited Thickness (U)



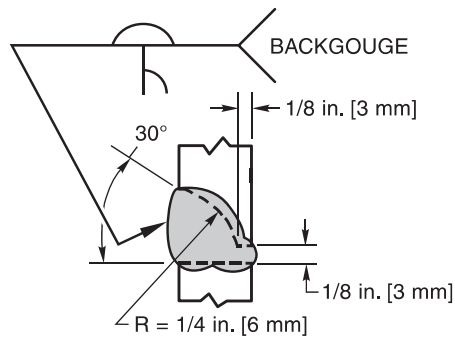
TC-U8-GF

Single-J-Groove Weld (8)
T-Joint (T)—Skew
Corner Joint (C)—Skew
Unlimited Thickness (U)



TC-U8a-GF

Single-J-Groove Weld (8)
Butt Joint (B)
Unlimited Thickness (U)



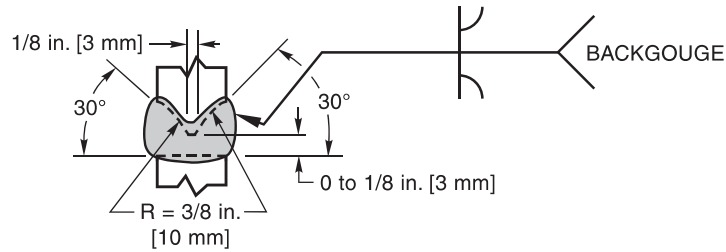
B-U8b-GF

Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].
4. Not prequalified for gas metal arc welding using short-circuiting transfer or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.

**Figure A.5 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
Gas Metal and Flux Cored Arc Welding**

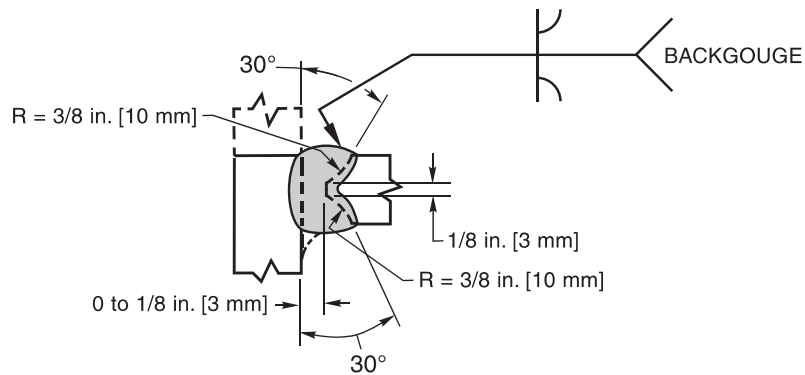
Double-J-Groove Weld (9)
Butt Joint (B)
Unlimited Thickness (U)



B-U9-GF

(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

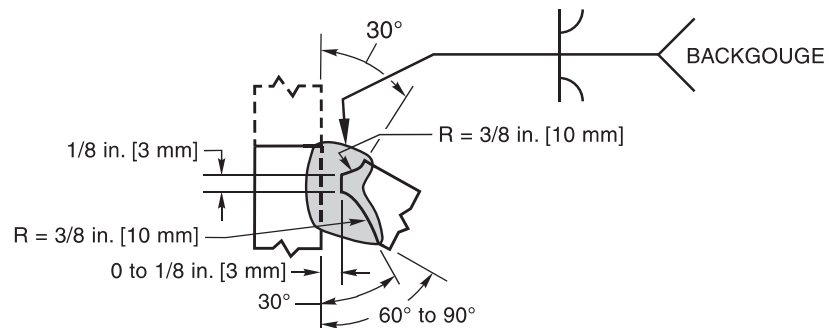
Double-J-Groove Weld (9)
T-Joint (T)
Corner Joint (C)
Unlimited Thickness (U)



TC-U9a-GF

(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

Double-J-Groove Weld (9)
T-Joint (T)—Skew
Corner Joint (C)—Skew
Unlimited Thickness (U)



TC-U9b-GF

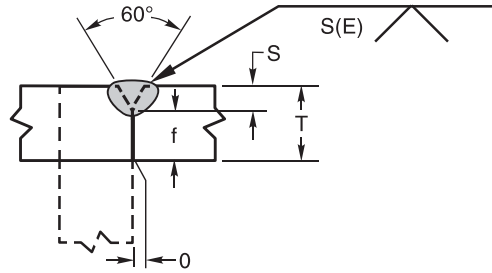
(Should be limited to base metal thickness $\geq 5/8$ in. [16 mm].)

Notes:

1. Gouge the roots of joints without backing before welding the other side.
2. See Table 9 for workmanship tolerances.
3. If fillet welds are used to reinforce groove welds in T-joints and corner joints, they shall be equal to T/4 but need not exceed 3/8 in [10 mm].
4. Not prequalified for gas metal arc welding using short-circuiting transfer or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.

**Figure A.5 (Continued)—Prequalified Complete-Joint-Penetration Weld Joints—
Gas Metal and Flux Cored Arc Welding**

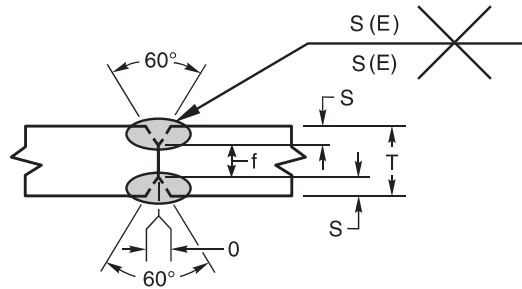
Single-V-Groove Weld (2)
Butt Joint (B)
Corner Joint (C)
Partial Joint Penetration (P)



WELD SIZE (E) = S

BC-P2-GF^a

Double-V-Groove Weld (3)
Butt Joint (B)
Partial Joint Penetration (P)

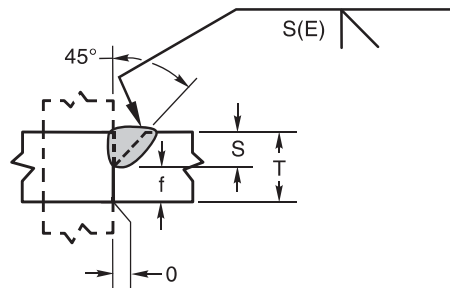


WELD SIZE (E) = S

TOTAL WELD SIZE (E_T) = (E) Side 1 + (E) Side 2

BC-P3-GF^a

Single-Bevel-Groove Weld (4)
Butt Joint (B)
T-Joint (T)
Corner Joint (C)
Partial Joint Penetration (P)



WELD SIZE (E) = S for Flat and Horizontal Positions
and when $t < \frac{1}{2}$ in. (13 mm)

WELD SIZE (E) = S - 1/8 in. [3 mm] for Vertical and
Overhead Positions

BTC-P4-GF^a

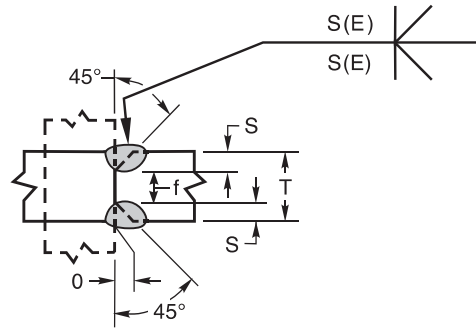
^a Minimum root face (f) shall be 1/4 in [6 mm].

Notes:

1. See Table 9 for workmanship tolerances.
2. Not prequalified for gas metal arc welding using short-circuiting transfer or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.

Figure A.6—Prequalified Partial-Joint-Penetration Weld Joints—Gas Metal and Flux Cored Arc Welding

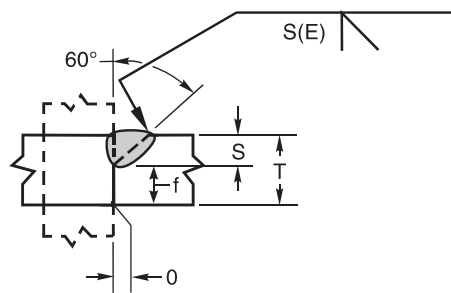
Double-Bevel-Groove Weld (5)
Butt Joint (B)
T-Joint (B)
Corner Joint (C)
Partial Joint Penetration (P)



WELD SIZE (E) = S for Flat and Horizontal Positions
WELD SIZE (E) = S - 1/8 in. [3 mm] for Vertical and Overhead Positions
TOTAL WELD SIZE (E_T) = (E) Side 1 + (E) Side 2

BTC-P5-GF^a

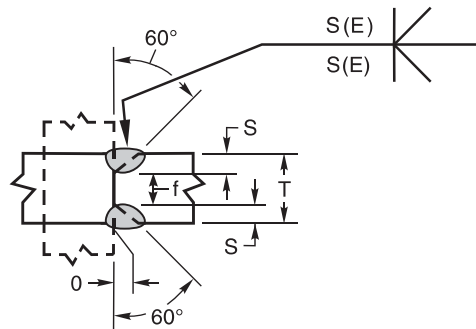
Single-Bevel-Groove Weld (4)
Butt Joint (B)
T-Joint (B)
Corner Joint (C)
Partial Joint Penetration (P)



WELD SIZE (E) = S

BTC-P4b-GF

Double-Bevel-Groove Weld (5)
Butt Joint (B)
T-Joint (T)
Corner Joint (C)
Partial Joint Penetration (P)



WELD SIZE (E) = S
TOTAL WELD SIZE (E_T) = (E) Side 1 + (E) Side 2

BTC-P5b-GF

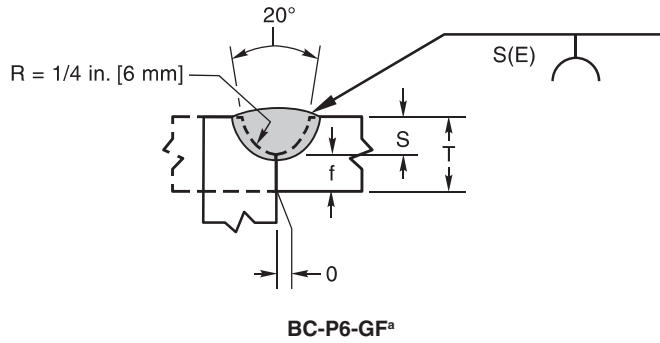
^a Minimum root face (f) shall be 1/4 in [6 mm].

Notes:

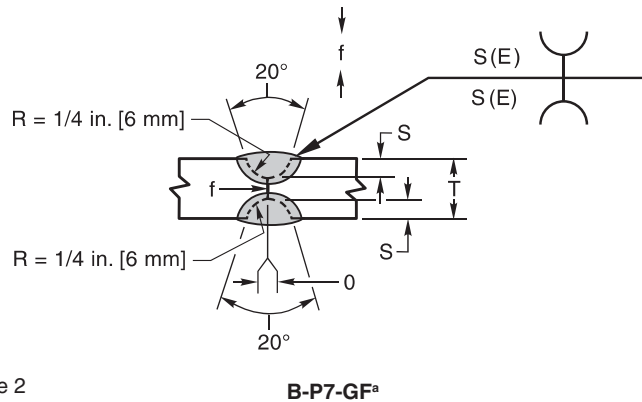
1. See Table 9 for workmanship tolerances.
2. Not prequalified for gas metal arc welding using short-circuiting transfer or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.

**Figure A.6 (Continued)—Prequalified Partial-Joint-Penetration Weld Joints—
Gas Metal and Flux Cored Arc Welding**

Single-U-Groove Weld (6)
Butt Joint (B)
Corner Joint (C)
Partial Joint Penetration (P)

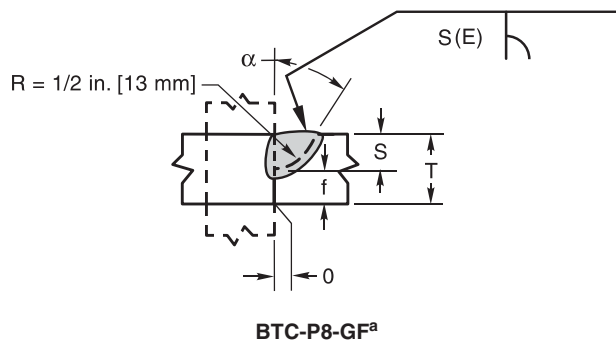


Double-U-Groove Weld (7)
Butt Joint (B)
Partial Joint Penetration (P)



Single-J-Groove Weld (8)
Butt Joint (B)
T-Joint (T)
Corner Joint (C)
Partial Joint Penetration (P)

Joint	α
B-P8-GF	20°
C-P8-GF	20°
T-P8-GF	45°



^a Minimum root face (f) shall be 1/8 in. [3 mm]

Notes:

1. See Table 9 for workmanship tolerances.
2. Not prequalified for gas metal arc welding using short-circuiting transfer or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.

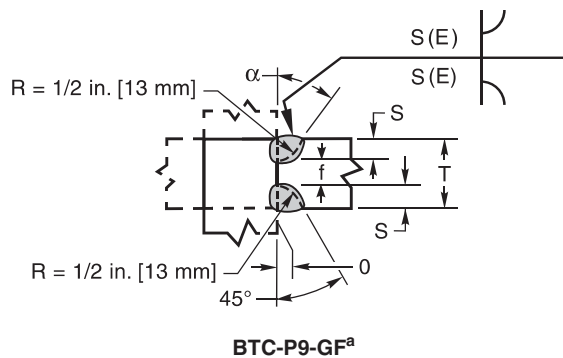
**Figure A.6 (Continued)—Prequalified Partial-Joint-Penetration Weld Joints—
Gas Metal and Flux Cored Arc Welding**

Double-J-Groove Weld (9)
 Butt Joint (B)
 T-Joint (T)
 Corner Joint (C)
 Partial Joint Penetration (P)

Joint	α
B-P9-GF	20°
C-P9-GF	20°
T-P9-GF	45°

WELD SIZE (E) = S

TOTAL WELD SIZE (E_T) = (E) Side 1 + (E) Side 2

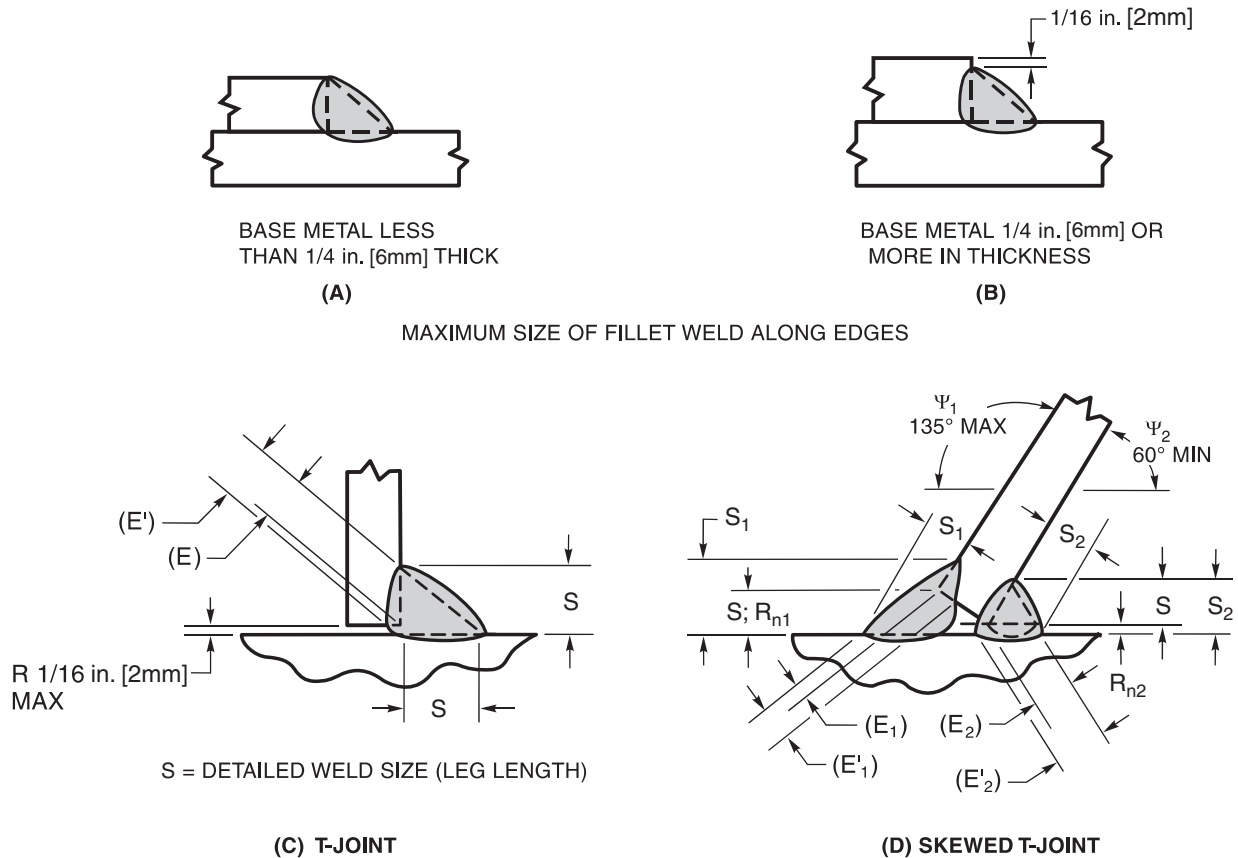


^a Minimum root face (f) shall be 1/8 in. [3 mm]

Notes:

1. See Table 9 for workmanship tolerances.
2. Not prequalified for gas metal arc welding using short-circuiting transfer or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.

**Figure A.6 (Continued)—Prequalified Partial-Joint-Penetration Weld Joints—
 Gas Metal and Flux Cored Arc Welding**



Notes:

1. Not prequalified for gas metal arc welding using the short-circuiting transfer mode or the pulsed arc welding mode when the average current and voltage are insufficient to promote the spray or globular metal transfer modes.
2. Maximum detailed size along edges shall be equal to the base metal thickness when it is less than 1/4 in [6 mm]; see sketch (A). For base metals 1/4 in [6 mm] and over, the maximum size shall be 1/16 in [2 mm] less than the base metal thickness; see sketch (B).
3. The minimum weld size that can be specified shall be 3/16 in [5 mm] for T up to and including 1/2 in [13 mm], and 1/4 in [6 mm] for T over 1/2 in [13 mm] up to and including 3/4 in [20 mm], where T is the thickness of the thinner member being joined.
4. The root opening (R or R_{n1}) shall not exceed 1/16 in [2 mm].
5. (E), (E₁), (E₂), and (E_n), which are the effective throats, are dependent on the magnitude of the root opening (R or R_{n1}). For qualification of joints with root opening greater than 1/16 in [2 mm], see 9.4.1.3.

Figure A.7—Details for Prequalified Fillet Welds of Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW), Submerged Arc Welding (SAW), and Flux Cored Arc Welding (FCAW).

Annex B (Informative)

Suggested Welding Procedure Specification and Qualification Test Record Forms

This annex is not part of AWS D14.3/D14.3M:2010, *Specification for Welding Earthmoving, Construction, and Agricultural Equipment*, but is included for informational purposes only.

See AWS B2.1/B2.1M, *Specification for Welding Performance and Procedure Qualification* for welding procedure and welder performance qualification forms.

It is suggested that this information be recorded on these forms or similar forms prepared by the user. Variations of these forms to meet the user's needs are permissible.

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Annex C (Informative)

Recommended Practices for Storage and Treatment of Electrodes and Fluxes

This annex is not part of AWS D14.3/D14.3M:2010, *Specification for Welding Earthmoving, Construction, and Agricultural Equipment*, but is included for informational purposes only.

Note: When available, the consumable manufacturer's specific requirements for storage, atmospheric exposure and reconditioning should be applied. When the consumable manufacturer's specifications are not available, the following guidelines may be used.

C1. SMAW Electrodes

C1.1 Storage Conditions

1. Low Hydrogen Electrodes. All electrodes having low hydrogen coverings conforming to AWS A5.1/A5.1M and AWS A5.5/A5.5M should be purchased in hermetically sealed containers or should be baked by the user in accordance with B1.3 prior to use. Immediately after opening the hermetically sealed container, electrodes should be stored in ovens held at a temperature of at least 250°F [120°C]. Electrodes should be rebaked no more than once. Electrodes that have been wet should not be used.

2. Non-Low Hydrogen Electrodes. Electrodes in unopened cans or cartons retain the proper moisture content indefinitely when stored in good condition. If exposed to humid air for long periods of time, electrodes from opened container may pick up enough moisture to affect operating characteristics or weld quality. If moisture appears to be a problem, discard the affected electrodes. Store electrodes from freshly opened containers in a dry environment. Cellulosic coverings for E6010 and E6011 electrodes need moisture levels of 3% to 7% for proper operation; therefore, storage or conditioning above ambient temperature may dry them too much and adversely affect their operation.

C1.2 Approved Low Hydrogen Electrode Atmospheric Time Periods. After hermetically sealed containers are opened or after electrodes are removed from baking or storage ovens, the electrode exposure to the atmosphere should not exceed the values shown for the specific electrode classification (see Tables C.1 and C.2) with optional supplemental designators, where applicable. Electrodes exposed to the atmosphere for periods less than those shown may be returned to a holding oven maintained at 250°F [120°C] min; after a minimum hold period of four hours at the specified minimum temperature, the electrodes may be reissued.

C1.3 Reconditioning of Low Hydrogen Electrodes. Electrodes exposed to the atmosphere for periods, greater than those permitted above should be reconditioned as follows:

- (1) All electrodes having low-hydrogen coverings conforming to AWS A5.1/A5.1M should be baked for at least one hour at temperatures between 500°F [260°C] and 800°F [430°C], or
- (2) All electrodes having low-hydrogen coverings conforming to AWS A5.5/A5.5M should be baked for at least one hour at temperatures between 700°F [370°C] and 800°F [430°C].

C1.4 Reconditioning of Non-Low Hydrogen Electrodes. Non-low hydrogen electrodes should be reconditioned according to the consumable manufacturer's specifications or discarded.

Table C.1
Electrodes Covered by AWS A5.1/A5.1M, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*

Electrode Designation		Maximum Exposure Time (hours)
<u>A5.1</u>	<u>A5.1M</u>	
E70XX	<u>E49XX</u>	4
E70XXR ^a	<u>E49XXR^a</u>	9
E70XXHZR ^a	<u>E49XXHZR^a</u>	9
E7018M	<u>E4918M</u>	9

^a The optional supplemental designator, R, designates a low hydrogen electrode which has been tested for covering moisture content after exposure to a moist environment for 9 hours and has met the maximum level permitted in AWS A5.1/A5.1M

Table C.2
Electrodes Covered by AWS A5.5/A5.5M, *Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*

Electrode Designation		Maximum Exposure Time (hours)
<u>A5.1</u>	<u>A5.1M</u>	
E70XX-X	<u>E49XX-X</u>	4
E70XX-X-R ^a	<u>E49XX-X-R^a</u>	9
E70XX-X-HZR ^a	<u>E49XX-X-HZR^a</u>	9
E80XX-X	<u>E55XX-X</u>	2
E80XX-X-R ^a	<u>E55XX-X-R^a</u>	9
E80XX-X-HZR ^a	<u>E55XX-X-HZR^a</u>	9
E90XX-X	<u>E62XX-X</u>	1
E90XX-X-R ^a	<u>E52XX-X-R^a</u>	9
E90XX-X-HZR ^a	<u>E52XX-X-HZR^a</u>	9
E100XX-X	<u>E69XX-X</u>	1/2
E100XX-X-R ^a	<u>E69XX-X-R^a</u>	9
E100XX-X-HZR ^a	<u>E69XX-X-HZR^a</u>	9
E110XX-X	<u>E76XX-X</u>	1/2
E110XX-X-R ^a	<u>E76XX-X-R^a</u>	9
E110XX-X-HZR ^a	<u>E76XX-X-HZR^a</u>	9

^a The optional supplemental designator, R, designates a low hydrogen electrode which has been tested for covering moisture content after exposure to a moist environment for 9 hours and has met the maximum level permitted in AWS A5.5/A5.5M, *Specification for Low Alloy Steel Electrodes for Shielded Metal Arc Welding*.

C2. FCAW and Metal Core Electrodes

C2.1 Electrode Packaging. Electrodes for FCAW and Metal Core welding should be received in moisture-resistant packages that are undamaged. They should be protected against contamination and injury during shipment and storage. Electrode packages should remain effectively sealed against moisture until the electrode is required for use. When removed from protective packaging and installed on machines, care should be taken to protect the electrodes and coatings, if present, from deterioration or damage. No one should modify or lubricate an electrode after manufacture for any reason except that drying may be permitted when recommended by the consumable manufacturer.

C2.2 Electrode Storage. When welding is to be suspended for more than 24 hours, electrode spools or coils should be removed from the machines and stored in airtight coverings or placed in a storage or drying oven maintained at a

temperature of 250°F [120°C] to 300°F [150°C] or as recommended by the consumable manufacturer. Electrodes on spools or coils not consumed within 48 hours of accumulated exposure outside sealed or heated storage should be redried as described in B2.3. Electrodes should be identified to facilitate monitoring of total atmospheric exposure time.

C2.3 Drying Temperatures. Only when approved by the consumable manufacturer, FCAW and Metal Core electrodes on metal supports may be baked once as specified by the consumable manufacturer to restore their condition. If the electrode or the electrode support is damaged by baking, the electrode should not be used. For electrodes in bulk storage packaging, follow the consumable manufacturer's recommendations for exposure and storage.

C3. Solid Wire Electrodes

C3.1 Electrode Care and Storage. Wire should be kept clean and care should be taken to keep wire from being contaminated with rust, oil, moisture, grinding dust, or other materials present in the work environment. When idle, the wire should be kept in its original plastic wrapping and/or shipping container. When a spool of wire is in place on a wire feeder, it should be covered with a protective covering when not used for prolonged periods of time.

C4. Submerged Arc Welding Flux

C4.1 Condition of Flux. Flux used for SAW should be dry and free of contamination from dirt, mill scale, or other foreign material. All flux should be purchased in packages that can be stored, under normal conditions, for at least six months without such storage affecting its welding characteristics or weld properties. Flux from damaged packages should be reconditioned according to consumable manufacturer's specifications or discarded. Flux should be placed in the dispensing system immediately upon opening a package, or if used from an opened package, the top 1 in [25 mm] should be discarded. Flux that has been wet should not be used.

C4.2 Flux Reclamation. SAW flux that has not been melted during the welding operation may be reused after recovery by vacuuming, catch pans, sweeping, or other means. The welding fabricator should have a system for collecting unmelted flux, adding new flux, and welding with the mixture of these two, such that the flux composition and particle size distribution at the weld puddle are relatively constant.

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Annex D⁷ (Informative)

Roadmap for Welding Procedure Specification (WPS) Development

This annex is not part of AWS D14.3/D14.3M:2010, *Specification for Welding Earthmoving, Construction, and Agricultural Equipment*, but is included for informational purposes only.

Table D.1 provides a guide to the user for decisions required in the preparation of a Welding Procedure Specification (WPS) and the applicable AWS Standard references describing each of the variables or options. Use of this Annex does not remove the responsibility of the Manufacturer to assure that the WPS meets all the requirements of Specification D14.3.

Table D.1
Roadmap for Development of Welding Procedure Specifications (WPS)

WPS Variable or Option ^a	AWS Standard	Location
1. Qualification Method		
a. Prototype Qualification	D14.3/D14.3M:2010	7.3
b. Procedure Qualification Tests	D14.3/D14.3M:2010	7.4
c. Prequalified Joint Procedures	D14.3/D14.3M:2010	7.5
2. Base Material		
a. Specification and Grade	D14.3/D14.3M:2010	Clause 5 ^b
b. Class	D14.3/D14.3M:2010	Table 5 ^b
c. M-No. and Group No.	B2.1/B2.1M:2009	4.13.2(1)
d. Thickness	D14.3/D14.3M:2010	Table 4.3
e. Diameter	B2.1/B2.1M:2009	4.13.2(3)
3. Welding Process		
a. Process	D14.3/D14.3M:2010	6.1 ^b
b. Technique	B2.1/B2.1M:2009	4.13.9(11)
4. Welding Consumables		
a. Specification Number	D14.3/D14.3M:2010	6.2 ^b
b. F-No. and A-No.	B2.1/B2.1M:2009	4.13.3(1)
c. Classification	D14.3/D14.3M:2010	6.2.2 ^b
d. Size/Diameter	B2.1/B2.1M:2009	4.13.3(3)
e. Shielding Gas Composition and Flow	D14.3/D14.3M:2010	6.2.4
f. Trailing Gas Composition and Flow	B2.1/B2.1M:2009	4.13.7
g. Purge Gas Composition and Flow	B2.1/B2.1M:2009	4.13.7
h. Flux	B2.1/B2.1M:2009	4.13.3(4)
5. Joint Design		
a. Joint Type	D14.3/D14.3M:2010	Clause 4 ^b
b. Joint Preparation	B2.1/B2.1M:2009	4.13.1
c. Cleaning	B2.1/B2.1M:2009	4.13.9(5)

⁷ Paragraph references are to the dated reference of the standard at the time of publication. The user is encouraged to use the most current revision of the reference even if the paragraph number has changed.

WPS Variable or Option ^a	AWS Standard	Location
6. Welding Conditions		
a. Current Type	B2.1/B2.1M:2009	4.13.8(1)
b. Amperage	B2.1/B2.1M:2009	4.13.8(1)
c. Voltage	B2.1/B2.1M:2009	4.13.8(2)
d. Travel Speed	B2.1/B2.1M:2009	4.13.9(12)
e. Heat Input	D14.3/D14.3M:2010	7.2.5 + Table 3
f. Bead Width	B2.1/B2.1M:2009	4.13.9(11)
g. Preheat	D14.3/D14.3M:2010	Table 6 ^b
h. Interpass Temperature	D14.3/D14.3M:2010	Table 6 ^b
i. Post Heat and PWHT	B2.1/B2.1M:2009	4.13.6
j. Backgouging	B2.1/B2.1M:2009	4.13.1(2)
k. Contact Tube to Work	B2.1/B2.1M:2009	4.13.9(4)
l. Single or Multiple Arc	B2.1/B2.1M:2009	4.13.9(2)
m. Orifice or Cup Size	D14.3/D14.3M:2010	Form B1
n. Other General Welding Variables	B2.1/B2.1M:2009	4.13.9
7. Position		
a. Position	D14.3/D14.3M:2010	7.2.3 ^b
b. Progression	D14.3/D14.3M:2010	7.5 ^b

^a Record the information on form F.2 (see AWS B2.1/B2.1M:2009, Annex F) or equivalent form.

^b Refer to AWS B2.1/B2.1M:2009, *Specification for Welding Procedure and Performance Qualification*, Subclause 4.13, for WPS data.

Annex E (Informative)

Guidelines for the Preparation of Technical Inquiries

This annex is not part of AWS D14.3/D14.3M:2010, *Specification for Welding Earthmoving, Construction, and Agricultural Equipment*, but is included for informational purposes only.

E1. Introduction

The American Welding Society (AWS) Board of Directors has adopted a policy whereby all official interpretations of AWS standards are handled in a formal manner. Under this policy, all interpretations are made by the committee that is responsible for the standard. Official communication concerning an interpretation is directed through the AWS staff member who works with that committee. The policy requires that all requests for an interpretation be submitted in writing. Such requests will be handled as expeditiously as possible, but due to the complexity of the work and the procedures that must be followed, some interpretations may require considerable time.

E2. Procedure

All inquiries shall be directed to:

Managing Director
Technical Services Division
American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126

All inquiries shall contain the name, address, and affiliation of the inquirer, and they shall provide enough information for the committee to understand the point of concern in the inquiry. When the point is not clearly defined, the inquiry will be returned for clarification. For efficient handling, all inquiries should be typewritten and in the format specified below.

E2.1 Scope. Each inquiry shall address one single provision of the standard unless the point of the inquiry involves two or more interrelated provisions. The provision(s) shall be identified in the scope of the inquiry along with the edition of the standard that contains the provision(s) the inquirer is addressing.

E2.2 Purpose of the Inquiry. The purpose of the inquiry shall be stated in this portion of the inquiry. The purpose can be to obtain an interpretation of a standard's requirement or to request the revision of a particular provision in the standard.

E2.3 Content of the Inquiry. The inquiry should be concise, yet complete, to enable the committee to understand the point of the inquiry. Sketches should be used whenever appropriate, and all paragraphs, figures, and tables (or annex) that bear on the inquiry shall be cited. If the point of the inquiry is to obtain a revision of the standard, the inquiry shall provide technical justification for that revision.

E2.4 Proposed Reply. The inquirer should, as a proposed reply, state an interpretation of the provision that is the point of the inquiry or provide the wording for a proposed revision, if this is what the inquirer seeks.

E3. Interpretation of Provisions of the Standard

Interpretations of provisions of the standard are made by the relevant AWS technical committee. The secretary of the committee refers all inquiries to the chair of the particular subcommittee that has jurisdiction over the portion of the standard addressed by the inquiry. The subcommittee reviews the inquiry and the proposed reply to determine what the response to the inquiry should be. Following the subcommittee's development of the response, the inquiry and the response are presented to the entire committee for review and approval. Upon approval by the committee, the interpretation is an official interpretation of the Society, and the secretary transmits the response to the inquirer and to the *Welding Journal* for publication.

E4. Publication of Interpretations

All official interpretations will appear in the *Welding Journal* and will be posted on the AWS web site.

E5. Telephone Inquiries

Telephone inquiries to AWS Headquarters concerning AWS standards should be limited to questions of a general nature or to matters directly related to the use of the standard. The *AWS Board Policy Manual* requires that all AWS staff members respond to a telephone request for an official interpretation of any AWS standard with the information that such an interpretation can be obtained only through a written request. Headquarters staff cannot provide consulting services. However, the staff can refer a caller to any of those consultants whose names are on file at AWS Headquarters.

E6. AWS Technical Committees

The activities of AWS technical committees regarding interpretations are limited strictly to the interpretation of provisions of standards prepared by the committees or to consideration of revisions to existing provisions on the basis of new data or technology. Neither AWS staff nor the committees are in a position to offer interpretive or consulting services on (1) specific engineering problems, (2) requirements of standards applied to fabrications outside the scope of the document, or (3) points not specifically covered by the standard. In such cases, the inquirer should seek assistance from a competent engineer experienced in the particular field of interest.

Annex F (Informative)

Informative References

This annex is not part of AWS D14.3/D14.3M:2010, *Specification for Welding Earthmoving, Construction, and Agricultural Equipment*, but is included for informational purposes only.

AWS Documents⁸

AWS A1.1, *Metric Practice Guide for the Welding Industry*
 AWS A5.01M/A5.01, *Filler Metal Procurement Guidelines*
 AWS A5.1/A5.1M, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*
 AWS A5.5/A5.5M, *Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*
 AWS A5.17/A5.17M, *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*
 AWS A5.18/A5.18M, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*
 AWS A5.20/A5.20M, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*
 AWS A5.23/A5.23M, *Specification for Low Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*
 AWS A5.28/A5.28M, *Specification for Low Alloy Steel Filler Metals for Gas Shielded Arc Welding*
 AWS A5.29/A5.29M, *Specification for Low Alloy Steel Electrodes for Flux Cored Arc Welding*
 AWS A5.32/A5.32M, *Specification for Welding Shielding Gases*
 AWS B5.1, *Specification for the Qualification of Welding Inspectors*
 AWS B5.17, *Specification for the Qualification of Welding Fabricators*
 AWS C4.1, *Surface Roughness Guide for Oxygen Cut Surfaces*
 AWS C4.6M (ISO9013:2002):200X, *Thermal Cutting—Classification of Thermal Cuts—Geometric Product Specification and Quality Tolerances*
 AWS D1.1/D1.1M, *Structural Welding Code—Steel*
 AWS D1.7/D1.7M, *Guide for Strengthening and Repairing Existing Structures*
 AWS F4.1, *Recommended Safe Practices for Preparation for Welding and Cutting of Containers and Piping*
 AWS QC1, *Standard for AWS Certification of Welding Inspectors*
 AWS QC4, *Standard for Accreditation of Test Facilities*
 AWS QC7, *Standard for the Certification of Welders*
 AWS QC17, *Standard for Accreditation for Welding Fabricators for AWS Certified Welding Fabricating Program*

ANSI Documents⁹

ANSI Z49.1, *Safety in Welding and Cutting and Allied Processes*
 ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*

ASME Standards¹⁰

ASME Section IX, *Boiler and Pressure Vessel Code*

⁸ Published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

⁹ Published by the American National Standards Institute, 11 W 42nd St, 13th Floor, New York, NY 10036.

¹⁰ ASME standards are published by the American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10017.

ISO Standards¹¹

ISO 3471, *Earth-moving machinery—Roll-over protective structures—Laboratory tests and performance requirements*

SAE Documents¹²

SAE-J1116, *Categories of Off-Road Self-Propelled Work Machines*

SAE J1040, *Performance Criteria for Rollover Protective Structures (ROPS) for Construction, Earthmoving, Forestry, and Mining Machines*

¹¹ ISO standards are published by the International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland.

¹² Published by the Society of Automotive Engineers International, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

List of AWS Documents on Machinery and Equipment

Designation	Title
D14.1/D14.1M	<i>Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment</i>
D14.3/D14.3M	<i>Specification for Welding Earthmoving, Construction, and Agricultural Equipment</i>
D14.4/D14.4M	<i>Specification for Welded Joints in Machinery and Equipment</i>
D14.5/ <u>D14.5M</u>	<i>Specification for Welding of Presses and Press Components</i>
D14.6/D14.6M	<i>Specification for Welding of Rotating Elements of Equipment</i>
D14.7/D14.7M	<i>Recommended Practices for Surfacing and Reconditioning of Industrial Mill Rolls</i>
<u>D14.8M</u>	<i><u>Standard Methods for the Avoidance of Cold Cracks</u></i>

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