

AWS D3.6M:1999
An American National Standard

Specification for Underwater Welding



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Key Words— Underwater welding, dry spot welding, habitat welding, one atmosphere welding, wet welding, hyperbaric welding

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Specification for Underwater Welding

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Prepared by
AWS Committee on Welding in Marine Construction
Subcommittee on Underwater Welding

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

This specification covers the requirements for welding structures or components under the surface of water. It includes welding in both dry and wet environments. Sections 1 through 6 constitute the general requirements for underwater welding while sections 7 through 10 contain the special requirements applicable to four individual classes of weld:

- Class A**—Comparable to above-water welding
- Class B**—For less critical applications
- Class C**—Where load bearing is not a primary consideration
- Class O**—To meet the requirements of another designated code or specification



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Foreword

(This Foreword is not a part of AWS D3.6M:1999, *Specification for Underwater Welding*, but is included for information only.)

In 1975, the AWS Committee on Marine Construction requested the Subcommittee on Underwater Welding to establish a standard reflecting state-of-the-art technology relative to underwater welding. The first edition of the specification was published in 1983, with subsequent editions issued in 1989 and 1993.

This current edition is presented in the same format as the 1993 edition except that the SI units of measure are the standard. The U.S. Customary Units are approximate and for information only. Sections 1 through 6 constitute the general requirements applicable to all classes of underwater welds. Sections 7 through 10 contain unique requirements applicable to each class.

Initially applied as a means of temporary repair for damaged steel-hulled vessels, underwater welding has evolved into an accepted method of construction and repair of engineered structures. Recent applications include engineered repair and alteration of off-shore structures, submerged marine pipelines, underwater port facilities and nuclear power plant components.

There are five basic methods of underwater welding currently in use:

- (1) Welding in a pressure vessel in which the pressure is reduced to approximately one atmosphere, independent of depth. (Dry welding at one atmosphere)
- (2) Welding at ambient pressure in a large chamber from which water has been displaced in an atmosphere such that the welder/diver does not work in diving equipment. (Dry welding in a habitat)
- (3) Welding at ambient pressure in a simple open-bottomed dry chamber that accommodates, as a minimum, the head and shoulders of the welder/diver in full diving equipment. (Dry chamber welding)
- (4) Welding at ambient pressure in a small, transparent, gas-filled enclosure with the welder/diver outside in the water. (Dry spot welding)
- (5) Welding at ambient pressure with the welder/diver in the water without any mechanical barrier between the water and the welding arc. (Wet welding)

No sharp distinction exists between these methods; intermediate degrees of weldment and welder protection from the water are in use. Metal-transfer characteristics, solidification behavior, weld appearance, mechanical properties, and other characteristics can vary with pressure, and each method of welding may differ from its usual behavior with conventional surface welding. Special quality requirements and inspection procedures must be established for underwater welds because of the altered environment and accessibility. This document is intended to define the important variables associated with underwater welding and to describe welding and inspection procedures so that work of a known quality level can be conveniently specified.

Four weld classes (A, B, C, and O) are specified herein. They encompass the range of quality and properties currently produced by application of the various methods. Each weld class defines a set of criteria for weldment properties that must be established during qualification, and a set of weld soundness requirements that are to be verified during construction. Welds in each class must meet all the criteria specified for that class. This specification does not address the selection of the class that meets the service requirements of a particular application. The selection of the class of weld to be provided is to be prescribed by the customer.

Comments and suggestions for the improvement of this standard are welcome. They should be addressed to the Secretary, Subcommittee on Underwater Welding, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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

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Specification for Underwater Welding

1. General Provisions

1.1 Scope

This specification covers underwater welding in both dry and wet environments. Operations required at the surface related to and in support of underwater welding are within the scope of this document, but welding above the surface is not. All provisions of this document apply equally to new construction and to modification and repair of existing structures underwater.

1.2 References

It shall be the responsibility of the Customer to specify the appropriate editions of the standards referenced in this specification. The following documents are incorporated by reference:

ANSI/AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Testing*
 ANSI/AWS A3.0, *Standard Method for Standard Welding Terms and Definitions*
 ANSI/AWS B4.0, *Mechanical Testing of Welds*
 ANSI/AWS D1.1, *Structural Welding Code—Steel*
 API RP2X, *Recommended Practice for Ultrasonic and Magnetic Examination of Offshore Structural Fabrication and Guidelines for Qualification of Technicians*
 ASTM A 370, *Standard Methods and Definitions for Mechanical Testing of Steel Products*
 ASTM E 92, *Test Method for Vickers Hardness of Metallic Materials*
 ASTM E 164, *Standard Practice for Ultrasonic Contact Examination of Weldments*
 ASTM E 165, *Standard Test Method for Liquid Penetrant Examination*
 ASTM E 309, *Standard Practice for Eddy-Current Examination of Steel Tubular Products using Magnetic Saturation*
 ASTM E 340, *Standard Test Method for Macroetching Metals and Alloys*

ASTM E 426, *Standard Practice for Electromagnetic (Eddy-Current) Examination of Seamless and Welded Tubular Products Austenitic Stainless Steel and Similar Alloys*

ASTM E 709, *Guide for Magnetic Particle Examination*
 ASTM E 1219, *Standard Test Method for Fluorescent Liquid Penetrant Examination Using the Solvent-Removable Process*

ASTM E 1220, *Standard Test Method for Visible Liquid Penetrant Examination Using the Solvent-Removable Process*

ASTM E 1416, *Standard Test Method for Radioscopic Examination of Weldments*

ASTM E 1444, *Standard Practice for Magnetic Particle Examination*

ISO 148, *Steel—Charpy Impact Test (V-Notch)*

ISO 3452, *Non-destructive Testing—Penetrant Inspection—General Principles*

ISO 4136, *Fusion Welded Butt Joints in Steel—Transverse Tensile Test*

ISO 4969, *Steel—Macroscopic Examination by Etching with Strong Mineral Acids*

ISO 6892, *Metallic Materials—Tensile Testing at Ambient Temperature*

ISO 6947, *Welds—Working Positions—Definitions of Angles of Slope and Rotation*

ISO 9304, *Seamless and Welded (Except Submerged Arc Welded) Steel Tubes for Pressure Purposes—Eddy Current Testing for the Detection of Imperfections*

ISO/DIS 9015.2, *Welding—Welded Joints in Metallic Materials—Hardness Testing*

ISO/DIS 9016.2, *Welding—Welded Joints in Metallic Materials—Specimen Location and Notch Orientation for Impact Tests*

QW-470, *Etching Processes and Reagents (ASME B&PV Code Section IX)*

SNT-TC-1A, American Society for Nondestructive Testing, *Recommended Practice*

1.3 Purpose

This specification addresses fabrication and quality standards for underwater welding. This document may be used in conjunction with other applicable codes or specifications for design, construction, or repair.

1.4 Application

1.4.1 All references to the need for approval shall be interpreted to mean approval by a duly designated person acting for and in behalf of the Customer on all matters within the scope of this specification. The Customer may designate an engineer, inspector or other(s) to act in the Customer's behalf to assure that the requirements of this specification are fulfilled. The Customer should specify the authority of the authorized representatives. Hereinafter, the term *Customer* shall be used to mean the party contracting for the work or the authorized representative.

1.4.2 In this specification, the term "shall" indicates a mandatory requirement and has the significance of excluding the idea of discretion. The word "should" indicates a nonmandatory recommended practice. The word "may" implies no obligation and expresses liberty or permission.

1.4.3 For **Class O** welds (see 2.1.7 and 5.6), conflicts between referenced documents and this document shall be brought to the attention of the Customer for disposition. In general, the referenced documents may take precedence in matters not affected by the underwater environment. However, this document shall take precedence in matters related to the underwater welding environment and working conditions.

1.5 Base Metals

1.5.1 The base metals presently included under this specification are carbon, low alloy, and austenitic stainless steels commonly used in the fabrication of steel structures. The weldability of the steel and the procedures for welding it shall be established by qualification. Each procedure is qualified based on the carbon content, carbon equivalent, and strength of the base metal to be welded in production. Production welding on base metal of carbon equivalent or strength above that qualified shall require requalification of the procedure. (Carbon equivalent shall not be applicable to austenitic stainless steel base metals.)

1.5.2 This specification may be used for welding of other base metals. In such cases, applicability of specific requirements shall be determined by the Customer.

1.6 Welding Process

1.6.1 Gas metal arc welding (GMAW), gas tungsten arc welding (GTAW), flux cored arc welding (FCAW), plasma arc welding (PAW), and shielded metal arc welding (SMAW) are the principal joining processes addressed by this specification. These processes may be used, provided the welding procedure is qualified in accordance with all applicable requirements of this document.

1.6.2 Other welding processes may be used at the discretion of the Customer, provided the applicable qualification requirements of this specification are met.

1.7 Definitions

The welding terms used in this specification shall be interpreted in accordance with the definitions given in the latest edition of ANSI/AWS A3.0, *Standard Welding Terms and Definitions*, supplemented by Annex B of this document (AWS D3.6M).

1.8 Welding and NDE Symbols

Welding and examination symbols shall be those shown in ANSI/AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*. Special conditions shall be fully explained by added notes or details.

1.9 Safety and Health

This document is not a safety standard and does not establish specific performance requirements for safety issues or procedures associated with diving or underwater welding. However, Annex D provides some guidance relative to safety in underwater welding and cutting. Additional pertinent welding safety information can be found in the documents referenced in Annex E. In addition, manufacturer's safety literature on equipment and materials, as well as other pertinent documents, should be considered. Each contractor must determine independently whether the safety precautions contained in the referenced publications are adequate.

1.10 Standard Units of Measure

The values stated in SI units are to be regarded as the standard. United States Customary Units, shown parenthetically, may be approximate and are for information.

2. Classification and Design of Welded Connections

2.1 Classification of Welds

2.1.1 A *weld* class specifies a level of serviceability and a set of required properties, as defined by mechanical tests, surface appearance, and nondestructive examination requirements, to which welds of a given class must conform.

2.1.2 In any solicitation for work, contract, or bid, the Customer shall specify each weld class and any supplementary requirements for the proposed work. All welds produced in accordance with this specification shall be made in accordance with a qualified welding procedure and shall meet the general requirements applicable to all weld classes specified in sections 1 through 6 and the unique requirements for one or more of the weld classes specified in this section. Each designated weld must meet all the requirements for the weld class specified.

2.1.3 Toughness and hardness of weldments that are made underwater may be significantly different from those properties of similar weldments made above the surface. The Customer may specify supplemental requirements for any class of weld.

2.1.4 Class A Welds. Class A underwater welds are intended to be suitable for applications and design stresses comparable to their conventional surface welding counterparts by virtue of specifying comparable properties and testing requirements. The unique requirements for **Class A** welds are specified in section 7. Additional requirements may be appropriate for critical applications, and should be agreed to in advance and specified in the contract document.

2.1.5 Class B Welds. Class B underwater welds are intended for less critical applications where lower ductility, moderate porosity, and other limited discontinuities can be tolerated. The unique requirements for **Class B** welds are specified in section 8. The suitability of a **Class B** weld for a particular application should be evaluated on a "Fitness for Purpose" basis.

2.1.6 Class C Welds. Class C underwater welds need only satisfy lesser requirements than class A, B, and O and are intended for applications where the load-bearing function is not a primary consideration. The unique requirements for **Class C** welds are specified in section 9. Selection of a **Class C** weld shall include a determination that its use will not impair the integrity of the primary structure by creating fracture-initiation sites.

2.1.7 Class O Welds. Class O underwater welds must meet the requirements of some designated code or specification, as well as additional requirements, defined herein, to cope with the underwater welding environment and working conditions. The unique requirements for **Class O** welds are specified in section 10. The Customer shall specify the standard that applies to this class of weld.

2.2 Design

This specification does not address design considerations such as arrangement of parts or stress calculations. The Customer shall determine the service conditions, the required performance level, and the appropriate design stress level. The Customer shall specify the weld class, inspection method, and acceptance criteria.

3. Workmanship

3.1 General

All welds produced in accordance with this specification shall be examined using the criteria specified for the particular weld class. This requirement is met when the results of all required examinations are submitted to and accepted by the Customer.

3.2 Base Metal Preparation

3.2.1 Corrosion pits or other discontinuities that would adversely affect the integrity of the weld shall be repaired. When repair by welding is required, the welding procedure shall be qualified to the specification requirements of **5. Qualification** for the weld class specified. The repair procedure shall be submitted to the Customer for approval before weld repair begins. The surfaces to be welded and the surfaces adjacent to the weld shall be free from scale, paint, marine growth, or other foreign matter.

3.2.2 In the repair of excessive discontinuities observed on cut edges, such as entrapped slag, refractory inclusions, deoxidation products, porosity, or blow holes, the amount of metal removed shall be the minimum necessary to eliminate the discontinuity, unless otherwise specified in the repair procedure.

3.2.3 Laminations in plate edges may, with the approval of the Customer, be repaired by welding. The repair shall include complete removal of the lamination or removal of metal to a distance equal to the lesser of half of the base-metal thickness or 10 mm (3/8 in.) from the original prepared edge, using a method described in the approved repair procedure. Welding shall be performed with procedures qualified for production welding or with procedures qualified specifically for the repair. The Customer shall be notified before repair commences.

3.3 Assembly

3.3.1 Dry Welding

3.3.1.1 Tolerances for the weld preparation and joint fit-up shall be developed during welding procedure qual-

ification. Alternatively, the tolerances given on Figure 3.1 may be applied to groove welds. In either case, the qualified welding procedure shall define the limits.

Where irregularities prevent alignment or fit-up to limits identified in the qualified welding procedure, alternative methods may be used to achieve the limits, subject to the Customer's approval. Welding procedures utilized to achieve acceptable fit shall be qualified under the rules of this specification.

When the joint includes a backing bar, the separation between faying surfaces of butt joints landing on a backing shall not exceed 1.5 mm (1/16 in.). Where irregularities prevent alignment or fit-up to limits qualified in the welding procedure, the methods used to meet those limits shall be subject to the Customer's approval. Welding procedures required to achieve the correct fit are also required to be qualified under the rules of this specification.

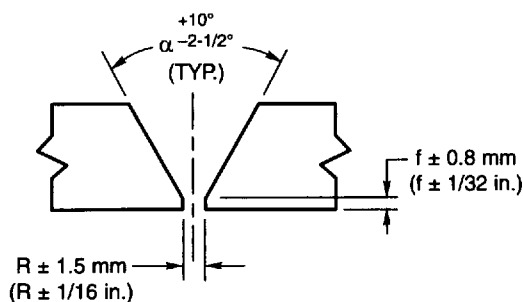
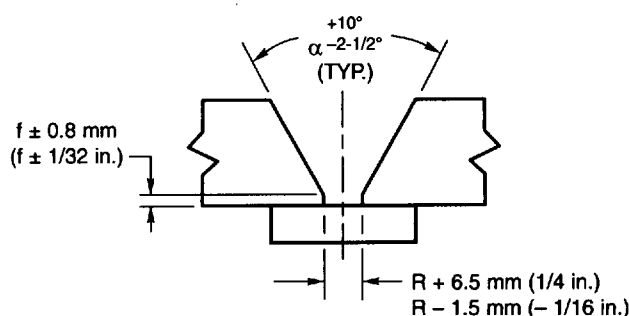
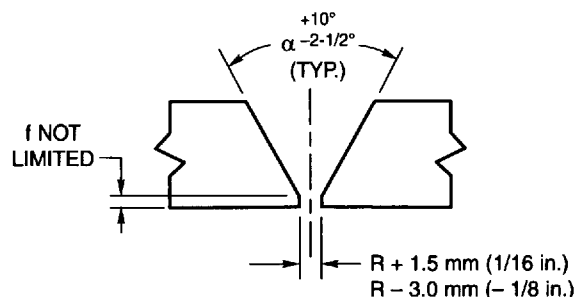
3.3.1.2 The parts to be joined by fillet welds shall be brought into as close contact as practical. The root opening shall not exceed the maximum permitted by the qualified welding procedure. If the root opening cannot be closed to meet this tolerance, a suitable compensating technique approved by the Customer shall be required. Any increase in the size of the root opening beyond 1.5 mm (1/16 in.) shall require that the leg of the fillet weld be increased by a similar amount.

3.3.2 Wet Welding. Joint assembly tolerances shall be developed during welding procedure qualification. The assembly and fit-up tolerances shall be defined in the qualified welding procedure and approved by the Customer prior to the start of production welding.

3.4 Confirmation Weld

Unless otherwise specified by the Customer, the requirements of 3.4.1, 3.4.2, 3.4.3, and 3.4.4 apply.

3.4.1 General. Prior to production underwater welding, a confirmation weld test shall be satisfactorily completed. The confirmation weld shall be satisfactorily completed

(A) GROOVE WELD WITHOUT BACKING—
NOT BACKGOUGED(B) GROOVE WELD WITH BACKING—
NOT BACKGOUGED(C) GROOVE WELD WITHOUT BACKING—
BACKGOUGED**Notes:**

α — groove angle

R — root opening

f — root face

The groove configurations shown are for illustration only.

Figure 3.1—Tolerances in Assembly of Groove Weld Butt Joints—Dry Welding

at the job site and at the depth at which production welding will take place. At least one confirmation weld, excluding automated welding, shall be satisfactorily completed for each welding system to be used during production. The confirmation test weld shall be a fillet break weld conforming to the requirements of section 5.11.7 except that the length shall be a minimum of 200 mm (8 in.). Unless otherwise specified by the Customer, the requirements of 3.4.2, 3.4.3, and 3.4.4 apply.

3.4.2 Base Metals. The base metal for the confirmation weld should be 10 mm (3/8 in.) minimum thickness and carbon equivalent within 0.05 of the maximum CE of the base metal welded in production.

3.4.3 Position. Where the production weld is to be made in only one welding position, the confirmation weld shall be made in that position. Where welding in more than one position is necessary, the confirmation weld shall be

made in the position in production in which the majority of welding will be done or as directed by the Customer.

3.4.4 Examination Requirements. Each confirmation weld shall undergo visual inspection and fillet break testing, except that Class C welds require only visual examination. Macroetch testing shall not be required. The test plate may be cut into smaller sections by any convenient means (e.g., oxygen-acetylene) to facilitate breaking. However, cutting shall not interfere with evaluation of the root pass start and stop. Acceptance criteria shall be as specified in sections 7, 8, 9, or 10 for the class of weld.

3.5 Dimensional Tolerances

The sizes and lengths of welds shall not be smaller than those specified. Fillet weld sizes shall not exceed

the specified sizes by more than 25 percent or 3 mm (1/8 in.), whichever is greater. The lengths of the weld shall not exceed the specified length by more than 25 mm (1 in.) or 15 percent, whichever is greater, without the Customer's approval. The location of welds shall not be changed without the approval of the Customer.

3.6 Weld Profiles

All welds must be neat and workmanlike in appearance and shall, as a minimum, meet the visual acceptance criteria for weld profiles as defined in Part III of sections 7 through 10 for **Class A** through **O** welds, respectively.

3.7 Tack Welds and Temporary Welds

3.7.1 All tack welds incorporated in the final weld shall be subject to the same qualification requirements and acceptance criteria as the final welds.

3.7.2 The location and dimensions of temporary welds shall be subject to prior approval by the Customer. Temporary welds, including tack welds that are not incorporated in the final weld, shall be removed, unless otherwise permitted by the Customer. Removal of temporary welds shall be accomplished using a procedure that does not cause damage to the base metal. Temporary welds not removed shall conform to the requirements of this specification for the class of weld selected.

3.8 Repairs

3.8.1 The removal of weld metal or portions of the base metal shall be done by a method approved by the Customer, and in such a manner that the remaining weld metal or base metal is not damaged. The surfaces shall be restored to a suitable condition before rewelding.

3.8.2 Flaws may be removed by grinding. The base-metal thickness shall not be reduced below the required minimum thickness. If the required minimum base-metal

thickness is violated, the thickness shall be restored by welding, using a qualified procedure.

3.8.3 Prior approval shall be obtained from the Customer for all corrections. The repaired or replaced weld shall be reinspected using the technique and acceptance criteria as originally specified.

3.8.4 The correction shall be in accordance with the original welding procedure or with a procedure prepared specifically for the repair, and qualified in accordance with this specification.

3.9 Peening

The root layer shall not be peened. Peening of subsequent beads shall be permitted only with prior approval of the Customer. Care shall be taken to prevent slag entrapment, overlap, or cracking of the welds. The cap or toe of a finished weld may be peened with a blunt instrument, when approved by the Customer, but such peening shall be preceded by all required nondestructive examination and followed by an additional examination using magnetic particle methods.

3.10 Arc Strikes

Arc strikes outside the area of permanent welds should be avoided on any base metal. Cracks or blemishes caused by arc strikes shall be ground to a smooth contour under the restrictions stated in 3.8.2.

3.11 Weld Cleaning

After completion of a weld, the weldment surfaces shall be cleaned and prepared such that surface finish conditions will not interfere with inspections or nondestructive examinations to be employed. Excessive slag and spatter shall be removed from the weld and adjacent base metal. Surface discontinuities which could mask weld defects shall be removed.

4. Technique

4.1 Filler Metal

4.1.1 After filler metals are removed from their original package, they shall be protected or stored so that their characteristics and welding properties are not adversely affected. Surface storage conditions shall conform to the filler metal manufacturer's recommended practice, or an alternate written procedure shall be submitted to the Customer for approval.

4.1.2 There shall be no addition or deletion of electrode coatings (e.g., waterproofing) from those used during welding procedure qualification.

4.1.3 Methods of underwater transport and storage of filler metals shall be specified in the welding procedure.

4.2 Measurement of Variable Conditions

Effective means of verifying variables (such as welding current, arc voltage, and shielding gas composition and flow rate) should be provided at the location underwater where the welding is to be performed. If not measured at the weld location, provisions shall be made to ensure that compensation has been made for the effects of the leads, ambient pressure, and other operating conditions. Records of welding variables to be maintained during production shall be as specified by the Customer.

4.3 Weld Temperature Control

Where weld temperature control is utilized during procedure qualification, the procedure qualification record shall state the required temperature range and the time at temperature. The method used for temperature measurement and control and the maximum and minimum heating and cooling rates at temperatures exceeding 260°C (500°F) shall be specified.

5. Qualification

Part I *General Requirements*

5.1 Approved Procedure

5.1.1 Procedure Specification. All welding shall be performed in accordance with a Welding Procedure Specification (WPS) which meets the requirements of this section. The WPS employed shall be qualified prior to production welding in accordance with the requirements of this section. Satisfactory evidence that the procedure has been qualified shall be submitted to the Customer in the form of a Procedure Qualification Record (PQR) supporting the WPS and approved by the Customer prior to any production welding.

5.1.2 Procedure Qualification. A welding procedure specification shall be qualified by testing weldments produced under actual or simulated site conditions. The test welds shall demonstrate that a joint of required integrity can be made within the essential variables of the procedure specification. The specific tests required for each weld class are identified in Part I of sections 7 through 10 for Class A through O welds, respectively.

5.2 Previous Qualification

The Customer may accept evidence of previous qualification, provided all the requirements of this specification are met.

5.3 Performance Qualification

All persons performing any welding shall be qualified for a given weld class in accordance with this section. Satisfactory evidence that the requirements are met shall be submitted to and approved by the Customer prior to any production welding.

Welders qualified to deposit Class A welds are also qualified to deposit Class B and Class C welds. Welders qualified to deposit Class B welds are also qualified to deposit Class C welds.

5.4 Qualification Responsibility

Each Contractor shall be responsible for the qualification of welding procedures and welders employed in performing work to this specification and shall conduct the tests required to accomplish these qualifications. Satisfactory evidence that the procedure and welders have been qualified shall be submitted to and approved by the Customer prior to production welding.

Part II *Procedure Qualification*

5.5 Limitation of Variables

5.5.1 Essential and Nonessential Variables. Each welding variable described in 5.6 shall be designated as either an essential or nonessential variable for each process.

5.5.2 Limitations on Essential and Nonessential Variables. Changes in essential variables beyond the limits specified in Table 5.1 (Dry Welding Variables) and 5.2 (Wet Welding Variables), require development and qualification of a separate procedure or revision and requalification of an existing welding procedure. The qualified ranges of essential variables are those used during the procedure qualification test. Changes may be made in the nonessential variables without requalification of the procedure. This may be documented by revising or amending the original Welding Procedure Specification (WPS) or by preparing a new WPS.

Table 5.1
Welding Variables

Dry Welding by Shielded Metal Arc, Gas Metal Arc, Flux Cored Arc, Gas Tungsten Arc, and Plasma Arc Welding Processes

A. Variables Common to All Welding Processes

1. Joints

- | | |
|--|--------------|
| (a) Fillet weld to groove weld | Essential |
| (b) Multiple pass fillet weld to single pass fillet weld and vice versa | Essential |
| (c) Omission of backing | Essential |
| (d) A backing thickness change of 1.5 mm (1/16 in.) or 25%, whichever is greater | Essential |
| (e) Groove shape: a decrease in included angle, a decrease in root opening, or an increase in root face beyond the range specified in 5.9.3 | Essential |
| (f) Groove weld to multiple pass fillet weld, subject to paragraph 5.9.2 | Nonessential |
| (g) Fillet Weld Size: For single pass fillet welding procedure qualification, the production weld size (leg length) shall be 1.5S where S is the size of the qualification weld and smaller. For multiple pass fillet welding procedure qualification, the production weld size shall be the qualification size or larger. | Essential |

2. Base Metal

- | | |
|--|-----------|
| (a) Thickness: For groove welding procedure qualification with a test plate or pipe thickness, t, the maximum production thickness shall be 1.5t. The minimum production plate or pipe thickness shall be 0.50t. Qualification on two different thicknesses of plate or pipe also qualifies all intermediate thicknesses | Essential |
| (b) A change in chemical composition beyond the limits of 5.6.1 except for carbon equivalent. | Essential |
| (c) An increase in specified minimum tensile strength beyond the greater of (a) the all-weld-metal tensile strength, or (b) the tensile strength measured in the transverse tension test | Essential |

3. Filler Metal

- | | |
|---|-----------|
| (a) Filler metal classification or type | Essential |
| (b) Procedure for underwater transport and storage, including (but not limited to) change from internally pressurized to unpressurized transfer containers. | Essential |
| (c) Addition or deletion of supplementary coatings | Essential |
| (d) An increase in exposure time of filler metal in the qualification depth atmosphere | Essential |

4. Position

- | | |
|---|-----------|
| (a) Any change beyond that qualified in Table 4 | Essential |
|---|-----------|

5. Weldment Temperature

- | | |
|--|-----------|
| (a) A decrease in preheat or interpass temperature | Essential |
| (b) A decrease in postweld heat treatment temperature or time at postweld heat treatment temperature | Essential |

6. Electrical Characteristics

- | | |
|---|-----------|
| (a) Welding current type (direct current electrode positive, direct current electrode negative, pulsed current, and others) | Essential |
| (b) Type of power source (constant current, constant voltage) | Essential |
| (c) Welding current | Essential |
| (d) Arc voltage | Essential |

7. Technique

- | | |
|--|--------------|
| (a) Stringer bead to weave and vice versa | Essential |
| (b) Progression up or down | Essential |
| (c) Deletion of temper bead | Essential |
| (d) Decrease in accessibility or visibility from change in dimensions of shroud or components | Essential |
| (e) Change in travel speed or electrode run length | Essential |
| (f) Welding method (manual, semiautomatic, automatic) | Essential |
| (g) Joint cleaning | Essential |
| (h) Addition or elimination of peening | Essential |
| (i) Addition of temper bead | Nonessential |
| (j) Progression direction for the initial pass on joints welded from both sides where the root pass is backgouged to sound weld metal prior to welding the second side | Nonessential |

(Continued)

Table 5.1 (Continued)

8. Environment	
(a) Change in depth beyond that allowed in 5.6.2	Essential
(b) Back side dry to wet	Essential
(c) Change in background gas composition or type or oxygen partial pressure beyond that associated with the depth allowance in 5.6.2	Essential
(d) Back side wet to dry	Nonessential
B. Shielded Metal Arc Welding	
3. Filler Metal	
(a) Manufacturer	Essential
(b) Manufacturer's trade name	Essential
(c) In root, hot, and cap passes, a change in electrode diameter (standard size)	Essential
(d) In fill passes, use of an electrode with a diameter not used during overall qualification	Essential
6. Electrical Characteristics	
(a) Welding current exceeding +15% of the maximum, or -15% of the minimum of that qualified	Essential
(b) Arc voltage exceeding +15% of the maximum or -15% of the minimum of that qualified	Essential
C. Gas Metal Arc Welding	
3. Filler Metal	
(a) Manufacturer	Nonessential
(b) Manufacturer's trade name, for ERXXS-G(X) or EXXC-G(X) (AWS A5.18 or A5.28)	Essential
(c) Manufacturer's trade name, except classification ERXXS-G	Nonessential
(d) Diameter	Essential
6. Electrical Characteristics	
(a) Welding current exceeding +10% of the maximum, or -10% of the minimum of that qualified	Essential
(b) Arc voltage exceeding +7% of the maximum, or -7% of the minimum of that qualified	Essential
(c) Mode of metal transfer (spray, globular, short-circuiting)	Essential
9. Shielding Gas	
(a) Nominal percentage composition	Essential
(b) Flow rate changes exceeding +25% of the maximum, or -25% of the minimum of that qualified	Essential
(c) Nozzle orifice diameter (size change)	Essential
D. Flux Cored Arc Welding	
3. Filler Metal	
(a) Manufacturer	Essential
(b) Manufacturer's trade name (even if both meet the same AWS Classification)	Essential
(c) Diameter	Essential
6. Electrical Characteristics	
(a) Welding current exceeding +10% of the maximum, or -10% of the minimum of that qualified	Essential
(b) Arc voltage exceeding +7% of the maximum, or -7% of the minimum of that qualified	Essential
(c) Mode of metal transfer (spray, globular)	Essential
9. Shielding Gas	
(a) Addition, or deletion or change in gas	Essential
(b) Flow rate change exceeding +25% of the maximum, or -10% of the minimum of that qualified	Essential
(c) Nozzle orifice diameter (size change)	Essential
E. Gas Tungsten Arc and Plasma Arc Welding	
3. Filler Metal	
(a) Manufacturer	Essential
(b) Manufacturer's trade name (even if both meet the same AWS Classification)	Essential
(c) Diameter	Essential

(Continued)

Table 5.1 (Continued)

6. Electrical Characteristics	
(a) Welding current exceeding +10% of the maximum, or -10% of the minimum of that qualified	Essential
(b) Arc Voltage exceeding +7% of the maximum or -7% of the minimum of that qualified	Essential
(c) Arc initiation method	Nonessential
(d) Electrode (non-consumable) type	Nonessential
(e) Electrode (non-consumable) size	Nonessential
9. Shielding Gas	
(a) Gas nominal percentage composition (shielding and orifice)	Essential
(b) Flow rate change exceeding +25% of the maximum, or -10% of the minimum of that qualified	Essential
(c) Nozzle orifice diameter (size change)	Essential

**Table 5.2
Welding Variables****Wet Welding by Shielded Metal Arc or Flux Cored Arc Welding****A. Variables Common to All Welding Processes****1. Joints**

(a) Fillet weld to groove weld	Essential
(b) Multiple pass fillet weld to single pass fillet weld and vice versa	Essential
(c) Omission of backing	Essential
(d) Groove shape: a decrease in included angle, a decrease in root opening, or an increase in root face beyond the range qualified (refer to 5.9.4)	Essential
(e) Groove weld to multiple pass fillet weld subject to paragraph 5.9.2	Nonessential
(f) Fillet weld size: For single pass fillet welding procedure qualification, the maximum production weld size (leg length) shall be 1.0S and the minimum production weld size shall be 0.5S, where S is the leg length of the qualification weld. For multiple pass fillet welding procedure qualification, maximum production weld size (leg length) shall be 1.5S, and the minimum production weld size shall be 0.5S, where S is the leg length of the qualification weld.	Essential

2. Base Metal

(a) Thickness: For groove welding procedure, qualification with a test plate or pipe thickness, t , the maximum production plate or pipe thickness shall be 1.5 t . The minimum production plate or pipe wall thickness shall be 0.5 t . However, if the production weld thickness is 6 mm (1/4 in.) or less, the test weld shall be the same thickness	Essential
(b) An increase in carbon equivalent or percent carbon of the steel above that qualified (not applicable to austenitic stainless steel)	Essential
(c) An increase in the specified minimum tensile strength beyond that qualified	Essential
(d) A change in chemical composition beyond that qualified in 5.6.1	Essential

3. Filler Metal

(a) Manufacturer	Essential
(b) Manufacturer's trade name (even if both meet the same Filler Metal Classification)	Essential
(c) Diameter	Essential
(d) Methods of underwater transport or storage	Essential
(e) Addition, deletion, or change of supplementary coatings or waterproofing	Essential
(f) An increase in exposure time of filler metal in the qualification depth atmosphere	Essential

4. Position

(a) Any change beyond that qualified in Table 5.4	Essential
---	-----------

5. Weldment Temperature

(a) A change in any heat treatment	Essential
------------------------------------	-----------

(Continued)

Table 5.2 (Continued)

6. Electrical Characteristics		
(a) Welding current type (direct current electrode positive, direct current electrode negative, pulsed current, and others)		Essential
(b) Type of power source (constant current, constant voltage)		Essential
(c) Welding current exceeding +10% of the maximum, or -10% of the minimum of that qualified		Essential
(d) Arc voltage exceeding +10% of the maximum, or -10% of the minimum of that qualified		Essential
7. Technique		
(a) Stringer bead to weave or vice versa		Essential
(b) Progression from up or down or vice versa		Essential
(c) Deletion of temper bead		Essential
(d) Change in weld bead sequence		Essential
(e) Travel speed or electrode run length beyond the range qualified		Essential
(f) Joint cleaning		Essential
(g) Addition, deletion, or change in any type of barrier to restrict water access during welding or cooling		Essential
(h) Addition of temper bead		Nonessential
(i) Progression direction for the root pass on double welded joints where second side is back gouged to sound metal		Nonessential
8. Environment		
(a) Change in depth beyond that allowed in 5.6.2		Essential
(b) Back side dry to wet if material thickness is 6 mm (1/4 in.) or greater		Essential
(c) Back side dry to wet and vice versa if material thickness is less than 6 mm (1/4 in.)		
(d) Pressure differential between back and front side of weld greater than that qualified		Essential
(e) Water current		Nonessential
(f) Salinity (salt water to fresh water and vice versa)		Nonessential

5.5.3 Electrical Measurement Accuracy. Electrical measurements made under qualification and production conditions will involve different levels of accuracy. Accordingly, the electrical ranges discussed in this specification are considered nominal values.

5.6 Procedure Qualification Variables

Variables for welding procedure qualification are listed in Tables 5.1 and 5.2, and described in the following sections. In general, for **Class O** welds, the referenced documents take precedence. However, this document shall take precedence in regard to essential variables and the extent of nondestructive and destructive examination.

5.6.1 Requirements for Base Metals

5.6.1.1 The chemical composition and carbon equivalent (if applicable) of procedure qualification test plates shall be determined by chemical analysis.

5.6.1.2 The chemical compositions of all base metals to be welded in production shall be known or determined in accordance with any of the following methods.

(1) **Specification Limits**—The chemical composition of the metal may be based on the maximum values permitted by the applicable specification(s) if it can be demonstrated that all heats of the metals to be welded in production were produced in accordance with the referenced specification(s).

(2) **Mill Test Reports**—The chemical composition of the metal may be based on the maximum values from ranges provided by the supplier for the heats of metal to be welded in production.

(3) **Analysis Using Standard Test Methods**—the chemical composition of the metal may be based on the actual values as determined from analyses performed in accordance with ISO or ASTM standard test methods for each heat of material to be welded in production.

(4) **Historical Data**—The chemical composition of the metal may, with Customer approval, be estimated based on the highest values from historical data, provided it can be demonstrated that the historical data is representative of all the metals to be welded in production.

5.6.1.3 The carbon equivalent of carbon and low-alloy steels used for welding procedure qualification shall not be less than the carbon equivalent of the steel to be

welded in production, as determined by the following formula:

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (\text{Eq. 1})$$

When only carbon and manganese are known, the following alternative formula may be used:

$$CE = C + \frac{Mn}{6} + 0.05 \quad (\text{Eq. 2})$$

The values for the elements in the above formulas are expressed in weight percent. Other methods of determining the carbon equivalent may be used if permitted by the Customer.

5.6.1.4 Procedure qualification testing shall be performed on material with chemical composition and mechanical properties (e.g., equivalent material specification and grades) as close as practical to the production metal, but in no case with a carbon content less than the metal to be welded in production.

5.6.2 Depth Range

5.6.2.1 Welding procedure qualification depth limitations shall be in accordance with Table 5.3.

5.6.2.2 For all welding, qualification at two depths qualifies for any depth between the two.

5.6.2.3 The effects of wave action when welding at shallow depths should be considered.

5.7 Types of Tests

The welded test assemblies required to qualify a welding procedure are described in Part I of sections 7 through 10 for **Class A** through **O** welds, respectively. The assemblies shall be welded with the procedure that is to be qualified, and shall satisfy all the test requirements for the weld class.

5.8 Position of Test Welds

Welding positions for groove and fillet welds are defined in ISO-6947 or ANSI/AWS A3.0. (Figures 5.1 and 5.2 reflect AWS A3.0 requirements)

5.8.1 Welding position is an essential variable. Production positions qualified by specific test positions are listed in Table 5.4.

5.8.2 After a groove weld procedure for plate has been qualified in one position, a smaller test plate and fewer tests are required to qualify additional positions. The “first position” and “additional position” test plates are identified in Part I of sections 7 and 8 for **Class A** and **B** welds, respectively. The Customer shall determine which position shall be used for the first position (i.e., larger test plate).

5.8.3 After a groove weld procedure for pipe has been qualified in one position, additional positions may be qualified by making similar welds that are tested as identified in Part I of sections 7 and 8 for **Class A** and **B** welds, respectively. Each procedure shall be tested in the manner indicated in 5.8.5.

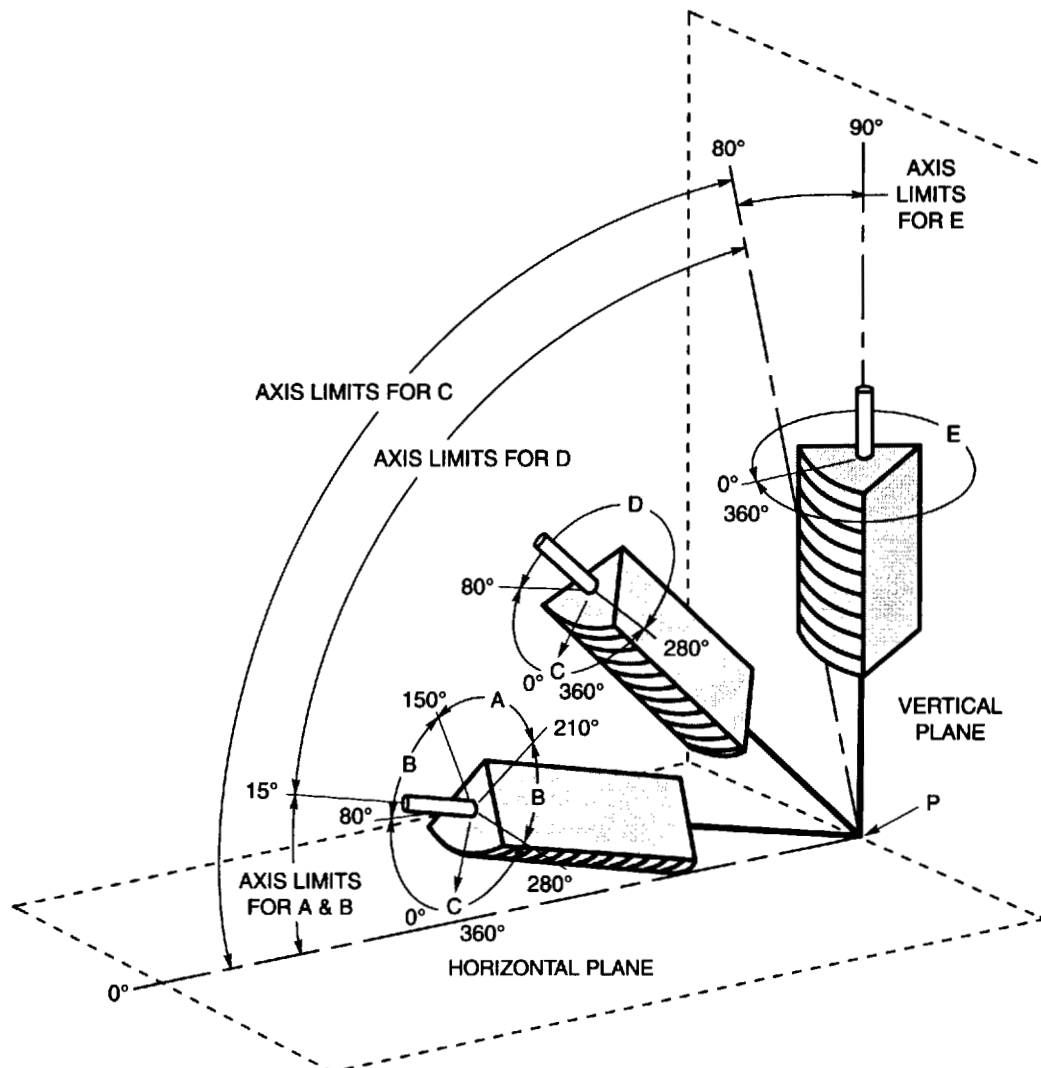
Table 5.3
Depth Limitations for Qualification Welding

Type of Welding	Depth of Production Welding	Max. Depth Qualified	Min. Depth Qualified
Dry welding	All	X plus 10 m (33 ft)	X minus 10 m (33 ft) or 0.2X, whichever is greater
Wet welding with carbon or low-alloy steel filler metal	Greater than 3 m (10 ft)	X plus 10 m (33 ft)	X minus 10 m (33 ft) or 0.2X, whichever is greater
	Equal to or less than 3 m (10 ft)	X plus 10 m (33 ft)	X
Wet welding with austenitic stainless steel filler metal	All	X plus 3 m (10 ft)	X minus 10 m (33 ft) or 0.2X, whichever is greater
Wet welding with other filler metals	All	X	X minus 10 m (33 ft) or 0.2X, whichever is greater

General Notes:

1. X is qualification test depth.
2. For the maximum depth qualified, depth shall be measured from the lower extremity of the test weldment with a tolerance of plus or minus 230 mm (9 in.).
3. For the minimum depth qualified, depth shall be measured from the upper extremity of the test weldment with a tolerance of plus or minus 230 mm (9 in.).

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 5.1—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°

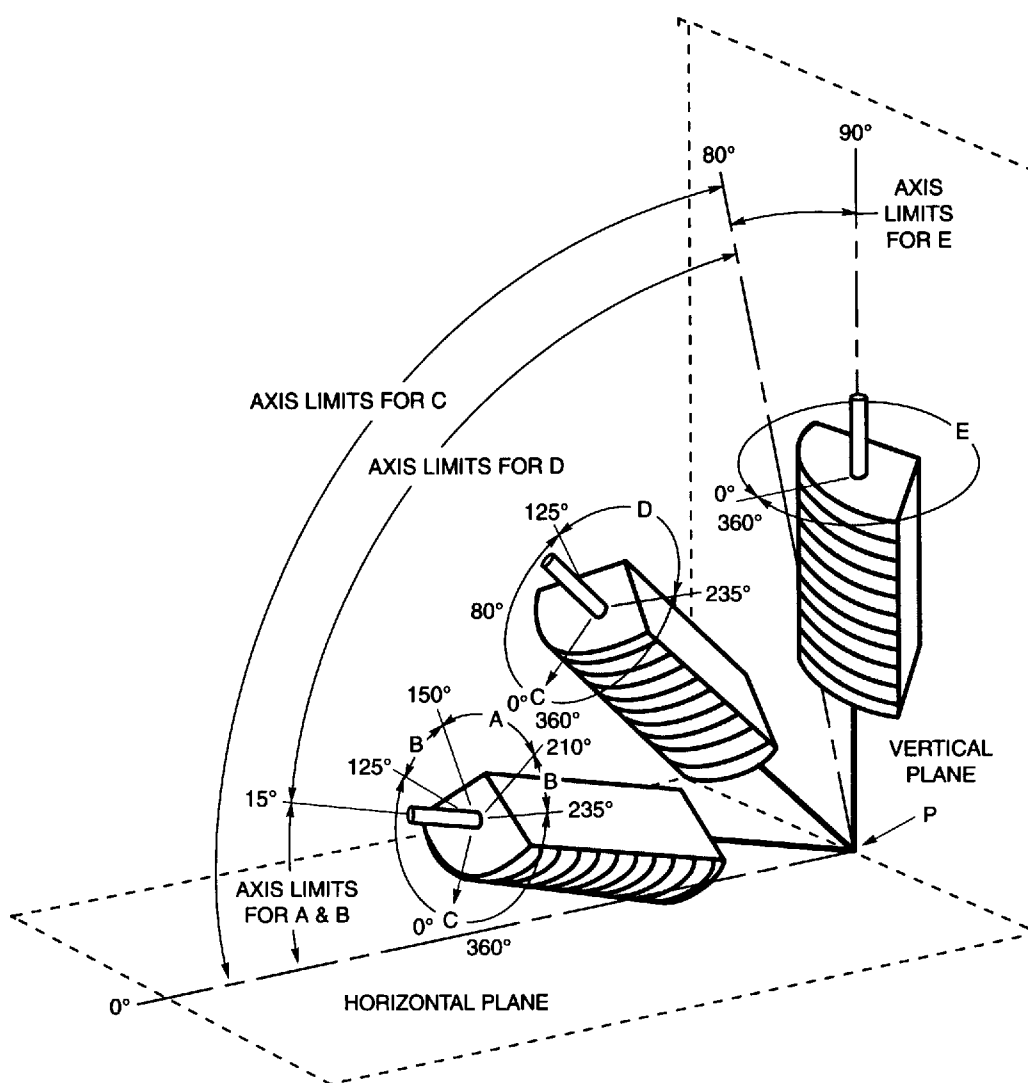


Figure 5.2—Positions of Fillet Welds

Table 5.4
Procedure Qualification—Type and Position Limitations

Qualification Test		Type of Weld and Position of Welding Qualified ⁽⁴⁾			
		Plate ⁽¹⁾		Pipe ⁽¹⁾	
Weld	Plate or Pipe Positions ⁽⁵⁾	Groove	Fillet	Groove	Fillet ⁽³⁾
Plate-groove	PA (1G)	F	F		F
	PC (2G)	H	H	H	H
	PG (3G)	V down	V down		
	PF (3G)	V up	V up		
	PE (4G)	OH	OH		
Plate-fillet	PA (1F)		F		
	PB (2F)		H		
	PG (3F)		V down		
	PF (3F)		V up		
	PD (4F)		OH		
Pipe-groove	PA (1G)	F	F	F	F
	PC (2G)	H	H	H	H
	PG (5G)	V down	V down	F, V, OH	F, V, OH
	PF (5G)	V up	V up	F, V, OH	F, V, OH
	H-, J-L045 (6G) ⁽²⁾	F, H, V, OH ⁽²⁾	F, H, V, OH	F, H, V, OH ⁽²⁾	F, H, V, OH ⁽²⁾
	H-, J-L045 Restricted (6GR)	All	All	All	All
Pipe-fillet	PA (1F)		F		F
	PB (2F)		H		H
	PB 2FR		H		H
	PD (4F)		OH		OH
	PG (5F)		V down		All
	PF (5F)		V up		All

Notes:

1. Plate qualifies for welding pipe or tubing over 610 mm (24 in.) in diameter.
2. Qualifies for fillet and groove welds in all positions except for complete joint penetration groove welding of T-, Y-, and K-connections.
3. See 5.9.2 and Part I of sections 7 through 10 for requirements.
4. Positions of welding: F = flat, H = horizontal, V = vertical, OH = overhead.
5. Positions as defined in 5.8.

5.8.4 Plate Groove Welds. In making the tests to qualify groove welds, test plates shall be welded in the following positions (illustrated in Figure 5.3):

5.8.4.1 Position PA (1G) Flat. The plates are placed in an approximately horizontal plane and the weld metal is deposited from the upper side. See Figure 5.3(A).

5.8.4.2 Position PC (2G) Horizontal. The plates are placed in an approximately vertical plane with the groove approximately horizontal. See Figure 5.3(B).

5.8.4.3 Position PG (3G down) or PF (3G Up). The plates are placed in an approximately vertical plane with the groove approximately vertical. See Figure 5.3(C).

5.8.4.4 Position PE (4G) Overhead. The plates are placed in an approximately horizontal plane, and the weld metal is deposited from the under side. See Figure 5.3(D).

5.8.5 Pipe Groove Welds. In making the tests to qualify groove welds, the positions shall be as indicated below (illustrated in Figure 5.4):

5.8.5.1 Position PA (1G) Pipe Horizontal Rolled. The pipe shall be placed with its axis horizontal and the groove in an approximately vertical plane. The pipe shall be rotated during welding, so the weld metal is deposited from the upper side. See Figure 5.4(A).

5.8.5.2 Position PC (2G) Pipe Vertical. The pipe shall be placed with its axis vertical and the welding groove approximately horizontal. The pipe shall not be rotated during welding. See Figure 5.4(B).

5.8.5.3 Position PG (5G down) or PF (5G up) Pipe Horizontal Fixed. The pipe shall be placed with its axis horizontal and the groove in an approximately vertical

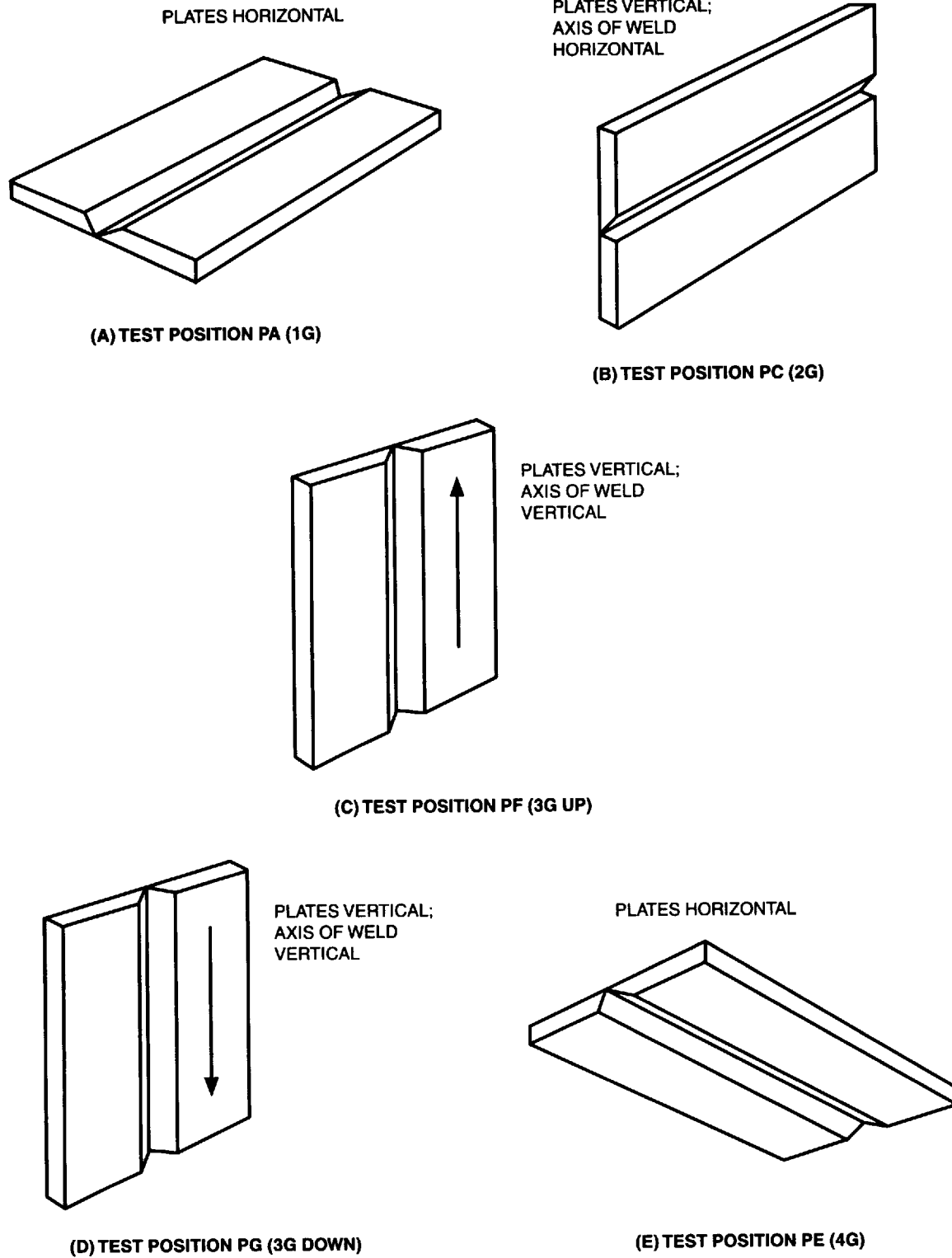


Figure 5.3—Positions of Test Plates for Groove Welds

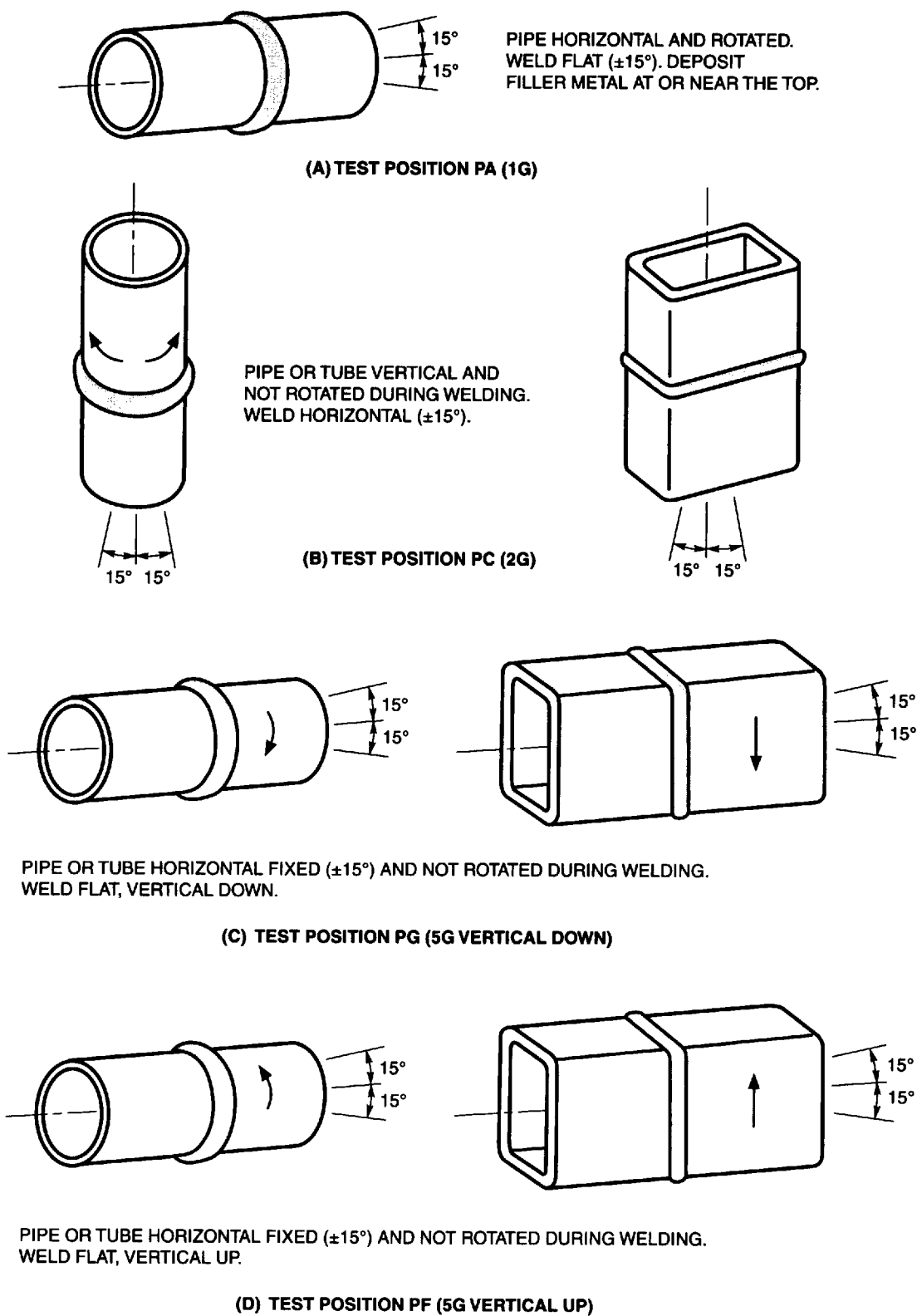


Figure 5.4—Positions of Test Pipe or Tubing for Groove Welds

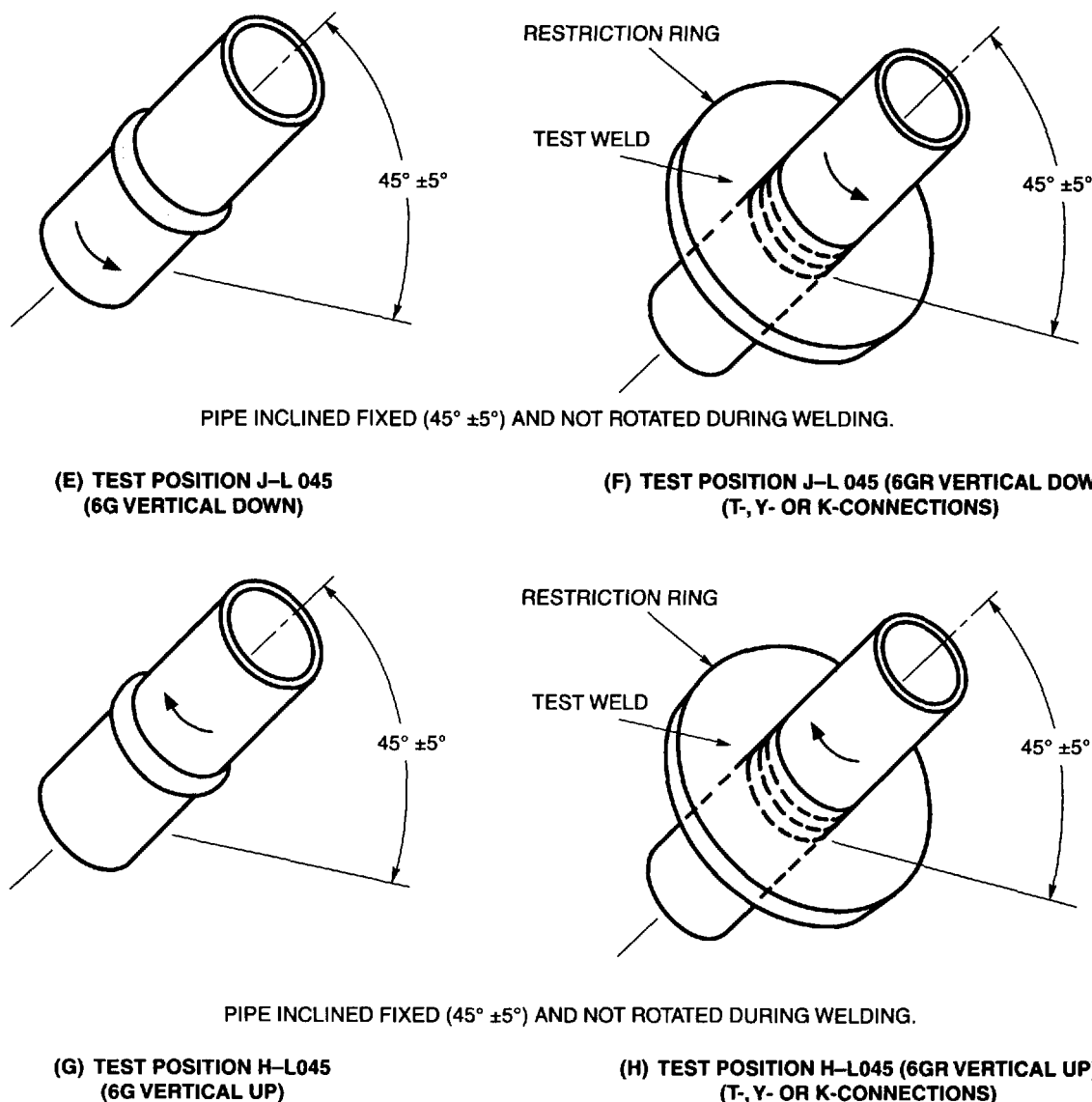


Figure 5.4 (Continued)—Positions of Test Pipe or Tubing for Groove Welds

plane. The pipe shall not be rotated during welding. See Figure 5.4(C).

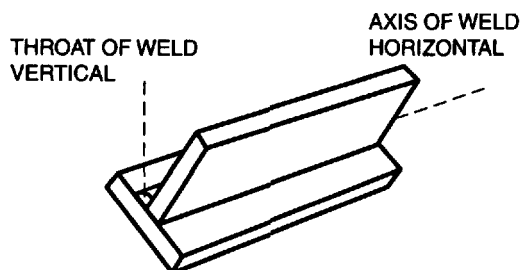
5.8.5.4 Position H-, J-L 045 (6G down) or H-L 045 (6G up) Pipe Inclined Fixed. The pipe shall be inclined at 45 degrees with the horizontal. The pipe shall not be rotated during welding. See Figure 5.4(E and G).

5.8.5.5 Position H-, J-L 045 Restricted (6GR). Test for complete joint penetration groove welds of tubular T, Y-, and K-connections—The pipe shall be inclined at 45 degrees with the horizontal. The pipe (or tube) shall not be rotated during welding. See Figure 5.4(E), and Figures 7.4, 8.4.

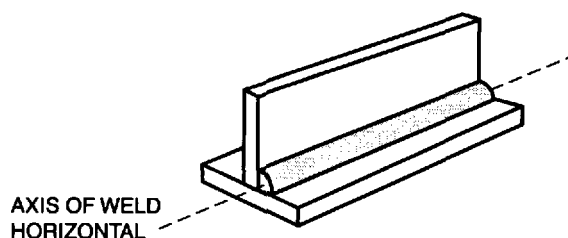
5.8.6 Plate Fillet Welds. In making the tests to qualify fillet welds, the test plate positions shall be as indicated below (illustrated in Figure 5.5):

5.8.6.1 Position PA (1F) Flat. The plates are placed such that each fillet weld is deposited with its axis approximately horizontal and its throat approximately vertical. See Figure 5.5(A).

5.8.6.2 Position PB (2F) Horizontal. The plates are placed such that each fillet weld is deposited on the upper side of a horizontal surface and against a vertical surface. See Figure 5.5(B).



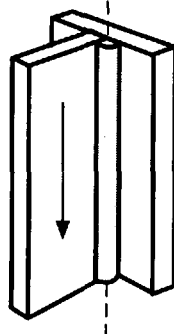
(A) TEST POSITION PA (1F)



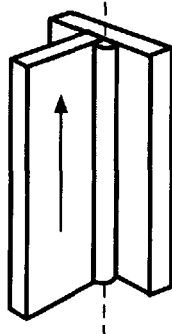
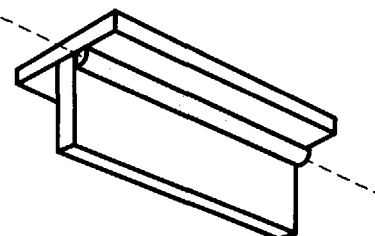
(B) TEST POSITION PB (2F)

NOTE: ONE PLATE MUST BE HORIZONTAL

AXIS OF WELD VERTICAL

(C) TEST POSITION PG
(3F DOWN)

AXIS OF WELD VERTICAL

(D) TEST POSITION PF
(3F UP)AXIS OF WELD
HORIZONTAL

NOTE: ONE PLATE MUST BE HORIZONTAL

(E) TEST POSITION PD (4F)

Figure 5.5—Positions of Test Plates for Fillet Welds

5.8.6.3 Position PG (3F Down) or PF (3F Up) Vertical. The plates are placed such that each fillet weld is deposited with its axis approximately vertical. See Figure 5.5(C).

5.8.6.4 Position PD (4F) Overhead. The plates are placed such that each fillet weld is deposited on the underside of a horizontal surface and against a vertical surface. See Figure 5.5(D).

5.8.7 Pipe Fillet Welds. In making tests to qualify fillet welds, test pipes shall be welded in the positions indicated below (illustrated in Figure 5.6):

5.8.7.1 Position PA (1F) Flat. The assembly shall be placed with the pipe axis inclined at 45 degrees to hori-

zontal and rotated during welding; the weld metal shall be deposited from above and at the highest point of rotation of the joint. The axis of the weld at that point shall be horizontal and the throat vertical. Refer to Figure 5.6(A).

5.8.7.2 Position PB (2F) Horizontal. The assembly shall be placed with the pipe axis vertical so that the weld is deposited on the upper side of a horizontal surface and against a vertical surface. The axis of the weld shall be horizontal, and the pipe shall not be rotated during welding. Refer to Figure 5.6(B).

5.8.7.3 Position PB (2FR) Horizontal Rotated. The assembly shall be placed with the pipe axis horizontal

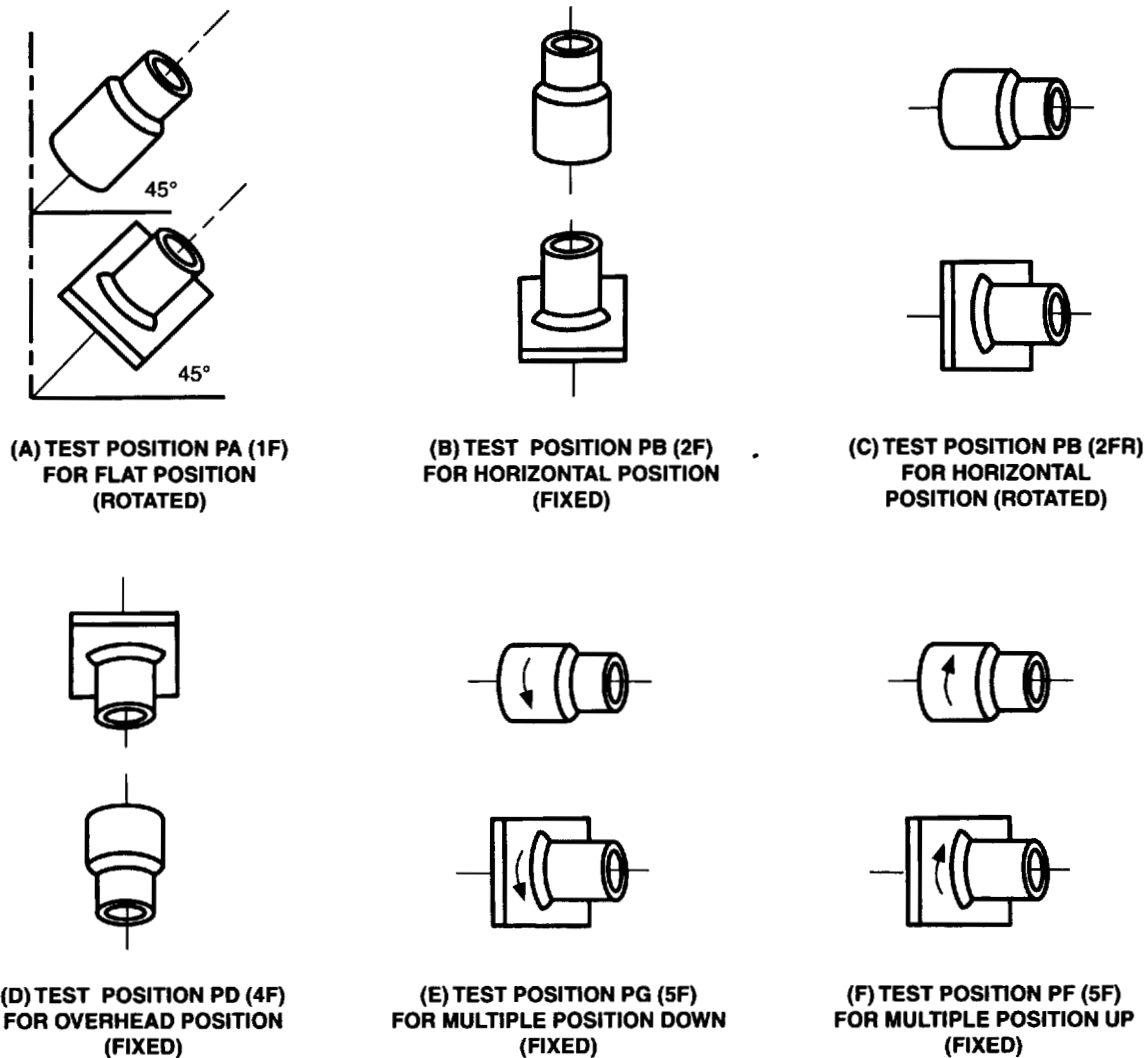


Figure 5.6—Positions of Test Pipes for Fillet Welds

and rotated during welding. The weld metal shall be deposited at the highest point of rotation of the pipe, on the upside of a horizontal surface and against a vertical surface. Refer to Figure 5.6(C).

5.8.7.4 Position PD (4F) Overhead. The assembly shall be placed with the pipe axis vertical so that the weld is deposited on the underside of a horizontal surface and against a vertical surface. The axis of the weld shall be horizontal, and the pipe shall not be rotated during welding. Refer to Figure 5.6(D).

5.8.7.5 Position PG (5F down) or PF (5F up) Multiple Positions. The assembly shall be placed with the pipe axis horizontal and the axis of the deposited weld in

a vertical plane. The pipe shall not be rotated during welding. Refer to Figure 5.6(E).

5.9 Joint Configuration

5.9.1 Joint configuration shall be an essential variable for welding procedure specifications. (Refer to Tables 5.1 and 5.2.)

5.9.2 A procedure qualified to perform groove welds shall be qualified to perform multiple-pass fillet welds. Single-pass fillet welds are not qualified by groove weld qualification.

5.9.3 Tolerances for the weld preparation and joint fit-up for dry welding may be developed during weld procedure qualification.

5.9.4 Joint assembly tolerances for wet welding shall be developed during welding procedure qualification and identified on the welding procedure specification.

5.10 Test Specimens: Number and Type

The number and type of test specimens required for procedure qualification to test the first position and additional positions, as required by 5.8, for one process are summarized in Part I of sections 7 through 10 for **Class A** through **O** welds, respectively. Specimens shall be removed and tested in accordance with 5.11. Test results shall be in accordance with Part I of sections 7 through 10, as applicable.

5.11 Preparation and Testing of Specimens

Test assemblies and specimens shall be prepared in accordance with the requirements of Part I of sections 7 through 10 for **Class A** through **O** welds, respectively. In addition, the following requirements shall apply:

5.11.1 Reduced-Section Tension Specimens. Specimens shall be prepared to the dimensions shown in Figure 5.7. Before testing, the least width and corresponding thickness of the reduced section shall be measured. The specimen shall be tested to rupture under tensile load, and the maximum load shall be determined. The tensile strength shall be obtained by dividing the maximum load by the cross-sectional area.

5.11.2 Macroetch Test. Specimens shall be removed as shown in Figure 5.8, 5.9, 7.1, 7.2, 8.1, or 8.2 as applicable. The cross-section surfaces cut from the test weld for macroscopic examination shall be prepared with a surface finish appropriate for macroetching. A suitable etching solution shall be used to give a clear definition of the weld metal and the heat-affected zone. (Refer to ISO 4969 or ASTM E 340.)

5.11.3 Root, Face, and Side Bend Specimens. Transverse bend specimens, 10 mm (3/8 in.) thick, shall be prepared in accordance with Figures 5.10 or 5.11. Specimens may be machine cut or oxyfuel gas cut from the test plates. If they are oxyfuel gas cut, an additional 3 mm (1/8 in.) of metal shall be included on both sides of the rough-cut sample. The sample shall be machined or ground to the final dimensions. Each specimen shall

be bent a full 180 degrees in a guided bend test jig having the contour dimensions shown in Figure 5.12. Bend radius shall be as specified in Part I of sections 7 through 10 for **Class A** through **O** welds, respectively.

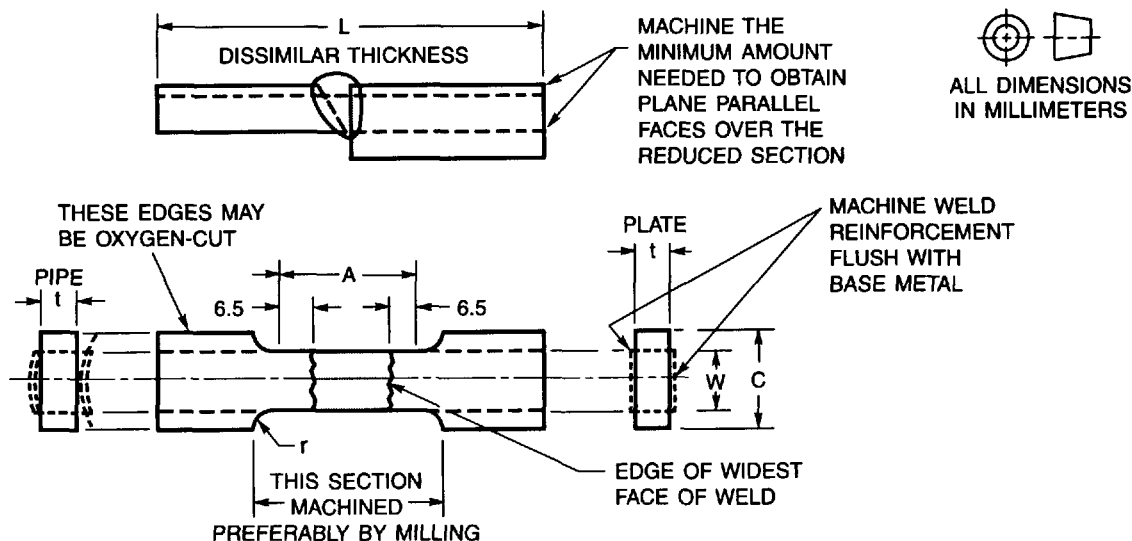
5.11.3.1 Any convenient means may be used to move the plunger member of the guided bend test jig, Figure 5.12, with relation to the die member. The specimen shall be placed on the die member of the jig with the weld at midspan. Facebend specimens shall be placed with the face of the weld toward the die member and rootbend specimens with the root of the weld toward the die member. Side bend specimens shall be placed with that side showing the greater number of discontinuities, if any, toward the die member.

The plunger shall force the specimen into the die until the specimen assumes a U-shape. The weld and heat-affected zones shall be centered and shall be completely within the bent portion of the specimen after testing.

5.11.3.2 When using the alternate wraparound jig, Figure 5.12 (B), the specimen shall be firmly clamped on one end so that there is no sliding of the specimen during the bending operation. The weld and heat-affected zones shall be completely in the bent portion of the specimen after testing. Test specimens shall not be removed from the jig until the outer roll has been moved 180 degrees from the starting point. Bend specimens shall be positioned with respect to the fixed pin of diameter A in the same manner as with the plunger member of Figure 5.12(A).

5.11.4 All-Weld-Metal Tension Test. An all-weld-metal tension test specimen shall be prepared as shown in Figures 5.13 or 5.14. If approved by the Customer, the specimen may be machined from the procedure test weld. For hydrogen release, the sample may be aged at 95°–105°C (200°–220°F) for approximately 10 hours prior to testing. The test specimen shall be tested in accordance with ISO 6892 or ANSI/AWS B4.0.

5.11.5 Charpy Impact Tests. The location and orientation of Charpy V-notch impact specimens are to be as shown in Figure 5.13. Charpy V-notch specimens shall be machined in accordance with ISO/DIS 9016.2 or ASTM A 370. For groove weld qualifications, three Charpy V-notch impact specimens shall be machined from the weld metal and three from the heat-affected zone in accordance with Figure 5.15. For qualification of fillet welds, three Charpy V-notch impact specimens shall be machined from the weld metal only. Specimen preparation and testing shall be in accordance with ISO 148 or ASTM A 370. The test temperature shall be the minimum design service temperature, unless a lower test temperature is specified by the Customer.

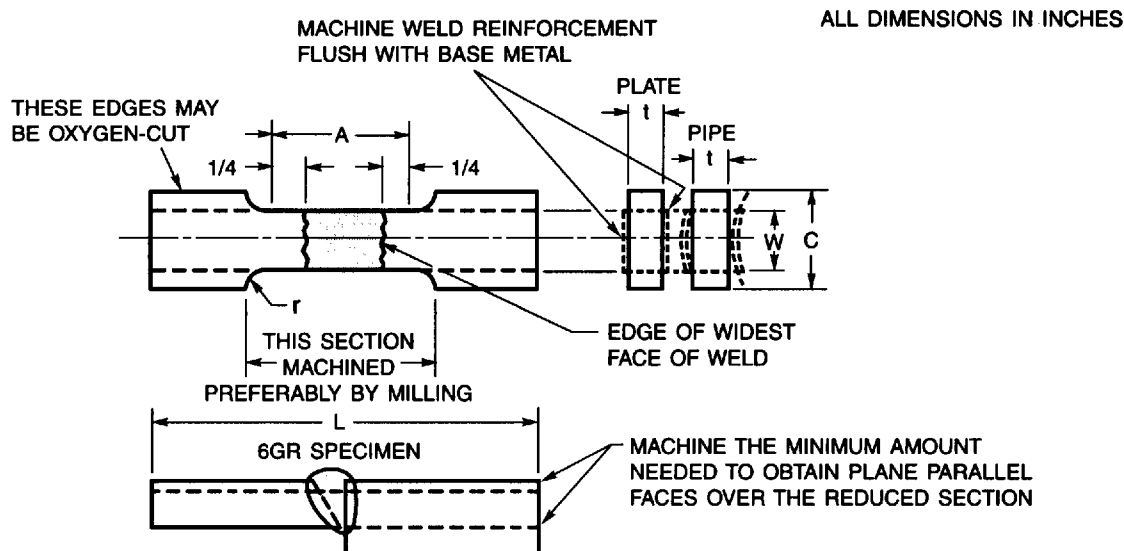


	Dimensions in mm			
	Test Plate		Test Pipe	
	$T_p \leq 40$ mm	$T_p \geq 40$	Less than 150 mm (nominal)	150 mm (nominal) and Greater
A—Length of reduced section	Widest face of weld + 12, 60 min.		Widest face of weld + 12, 60 min.	
L—Overall length, min (Note 2)	As required by testing equipment		As required by testing equipment	
W—Width of reduced section (Notes 3, 4)	20	20	12	20
C—Width of grip section (Notes 4, 5)	W + 12 min.	W + 12 min.	W + 12 min.	W + 12 min.
t—Specimen thickness (Note 6)	T_p	T_p/n (Note 6)	Maximum possible with plane parallel faces within length A	
r—Radius of fillet, min	35	35	25	25

Notes:

1. Metric specimens may be produced in accordance with ISO 4136.
2. It is desirable, if possible, to make the length of the grip section large enough to allow the specimen to extend into the grips a distance equal to two-thirds or more of the length of the grips.
3. The ends of the reduced section shall not differ in width by more than 0.1 mm. Also, there may be a gradual decrease in width from the ends to the center, but the width of either end shall not be more than 0.4 mm larger than the width at the center.
4. Narrower widths (W and C) may be used when necessary. In such cases, the width of the reduced section should be as large as the width of the material being tested permits. If the width of the material is less than W, the sides may be parallel throughout the length of the specimen.
5. For standard plate-type specimens, the ends of the specimen shall be symmetrical with the centerline of the reduced section within 6.5 mm.
6. For plates over 40 mm thick, specimens may be cut into "n" approximately equal strips. Each strip shall be at least 20 mm thick. The test results of each strip shall meet the minimum requirements.

Figure 5.7—Reduced Section Tension Specimens

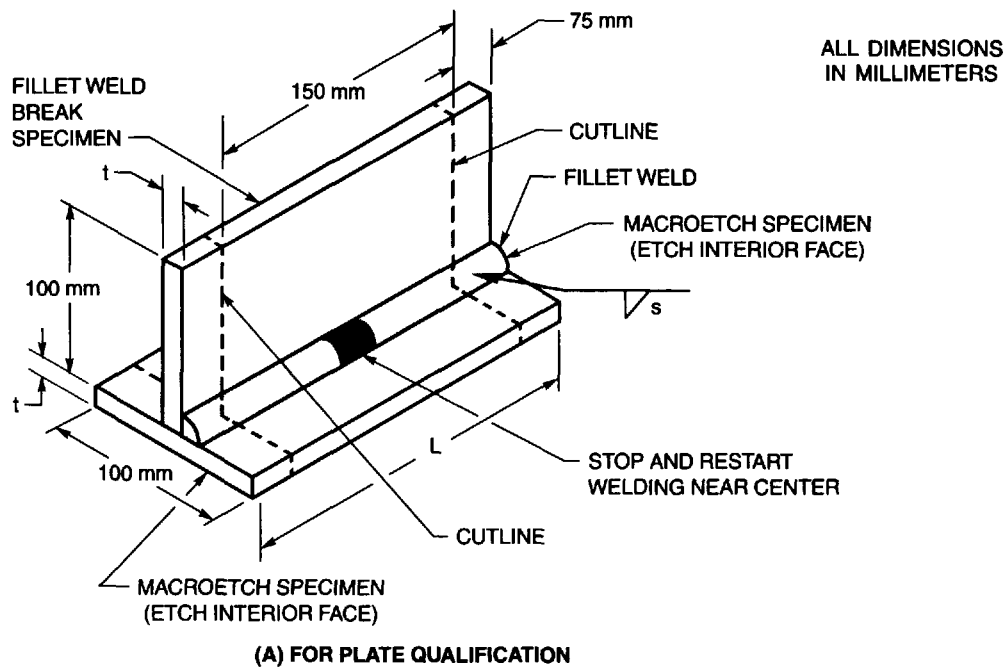


	Dimensions in inches	
	Test Plate	Test Pipe
	$T_p \leq 1\text{-}1/2$ in.	$T_p > 1\text{-}1/2$ in.
A—Length of reduced section	Widest face of weld + $1/2$ in., 2- $1/4$ min.	Widest face of weld + $1/2$ in., 2- $1/4$ min.
L—Overall length, min (Note 2)	As required by testing equipment	As required by testing equipment
W—Width of reduced section (Notes 3, 4)	$3/4$ in. min.	$3/4$ in. min.
C—Width of grip section (Notes 4, 5)	$W + 1/2$ in. min.	$W + 1/2$ in. min.
t—Specimen thickness (Note 6)	T_p	T_p/n (Note 6)
r—Radius of fillet, min	$1/2$	$1/2$

Notes:

1. T_p = Nominal Thickness of the Plate.
2. It is desirable, if possible, to make the length of the grip section large enough to allow the specimen to extend into the grips a distance equal to two-thirds or more of the length of the grips.
3. The ends of the reduced section shall not differ in width by more than 0.004 in. Also, there may be a gradual decrease in width from the ends to the center, but the width of either end shall not be more than 0.015 in. larger than the width at the center.
4. Narrower widths (W and C) may be used when necessary. In such cases, the width of the reduced section should be as large as the width of the material being tested permits. If the width of the material is less than W , the sides may be parallel throughout the length of the specimen.
5. For standard plate-type specimens, the ends of the specimen shall be symmetrical with the centerline of the reduced section within 0.25 in.
6. For plates over 1- $1/2$ in. thick, specimens may be cut into "n" approximately equal strips. Each strip shall be at least $3/4$ in. thick. The test results of each strip shall meet the minimum requirements.

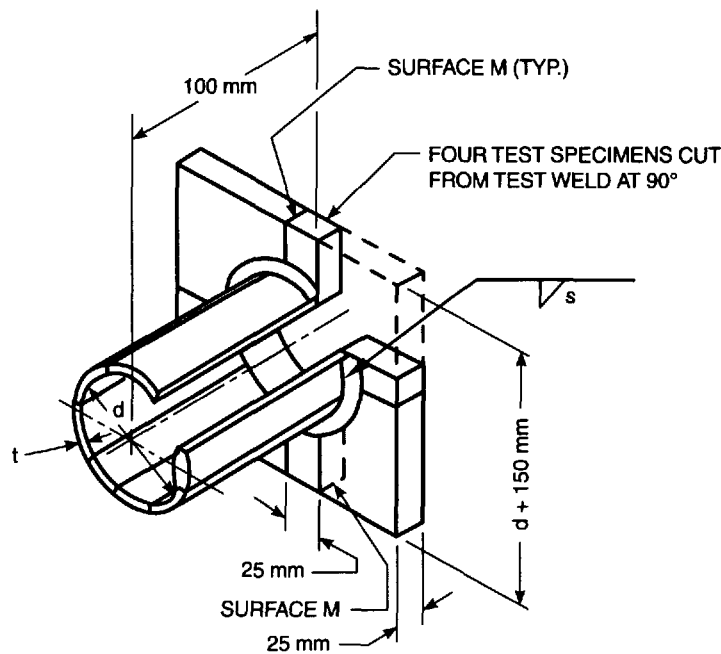
Figure 5.7A—Reduced Section Tension Specimens



(A) FOR PLATE QUALIFICATION

Notes:

1. t in accordance with Tables 5.1 [Item A.2(a)], and 5.2 [Item A.2(a)]. As a minimum, $t = s + 3$ mm.
2. L —equal to 300 mm min. for welder performance qualification and for welding procedure qualification.
3. Fillet weld break specimen may be cut in sections to facilitate breaking.

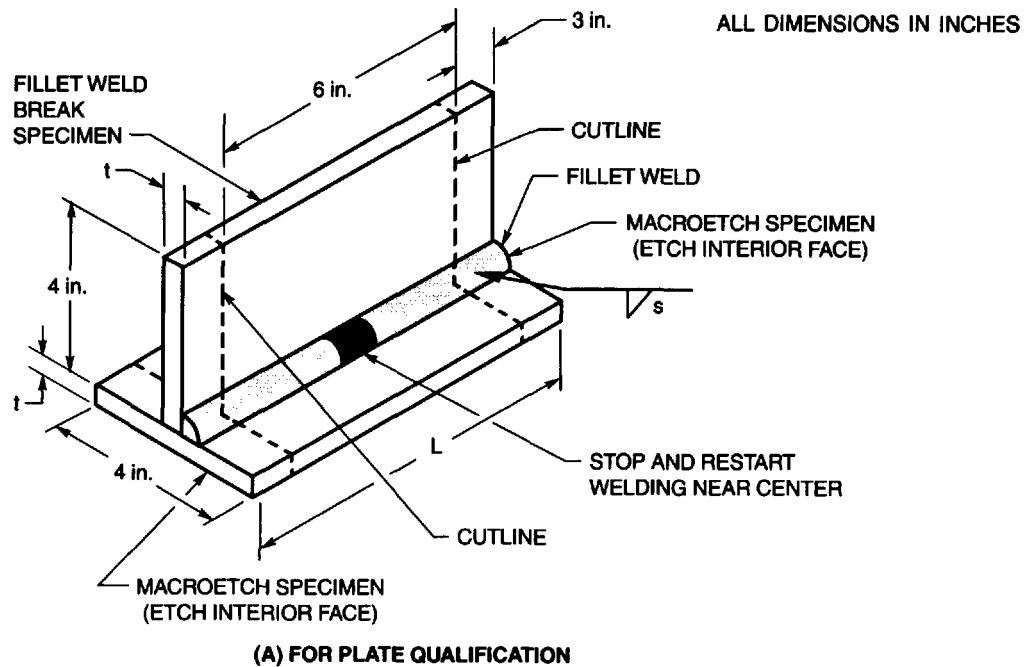


(B) FOR PIPE QUALIFICATION

Notes:

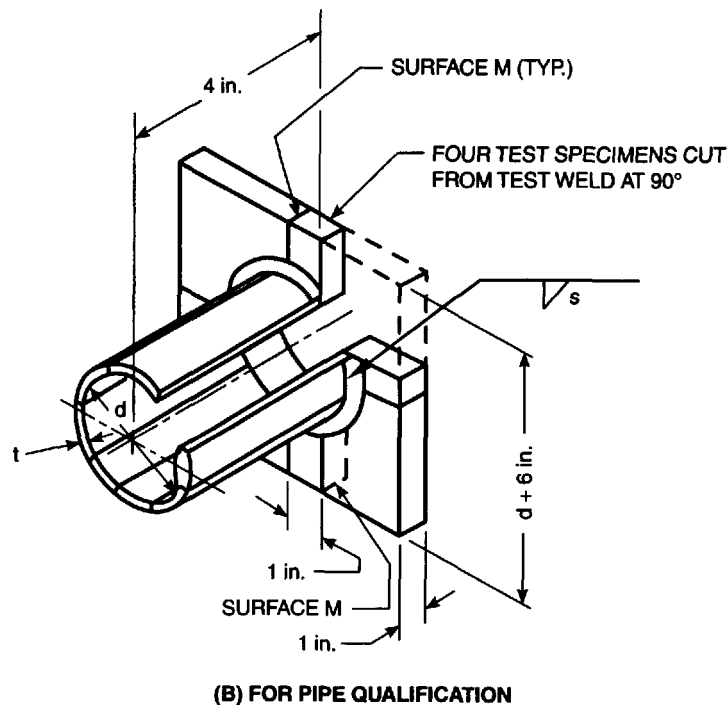
1. Diameter of d selected from Table 5.6 to qualify for production pipe sizes (welder qualification only).
2. Thicknesses t in accordance with Tables 5.1 [Item A.2(a)] and 5.2 [Item A.2(a)] for procedure qualification and Section 5, Part III for performance qualification. As a minimum, $t = s + 3$ mm.
3. Surfaces M to be examined for macroetch test. Hardness tests, when required, shall be made on the specimen from the six o'clock position.

Figure 5.8—Fillet Weld Break and Macroetch Test Specimens



Notes:

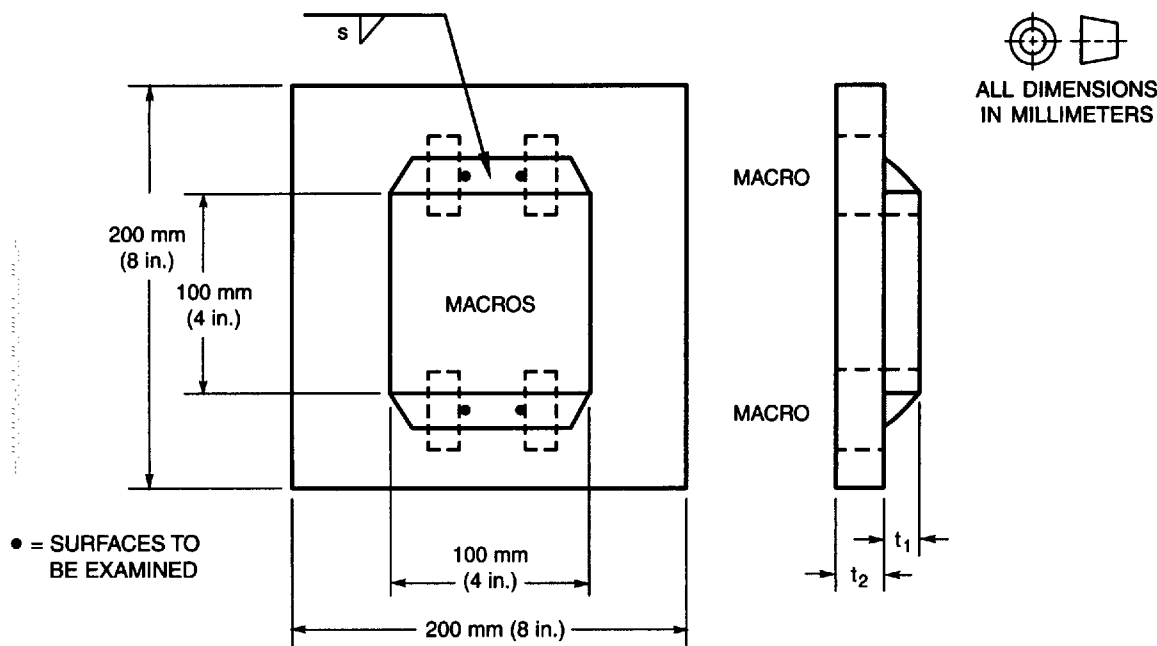
1. t in accordance with Tables 5.1 [Item A.2(a)], and 5.2 [Item A.2(a)]. As a minimum, $t = s + 1/8$ in.
2. L —equal to 12 in. min. for welded performance qualification and for welding procedure qualification.
3. Fillet weld break specimen may be cut in sections to facilitate breaking.



Notes:

1. Diameter of d selected from Table 5.6 to qualify for production pipe sizes (welder qualification only).
2. Thickness in accordance with Tables 5.1 [Item A.2(a)] and 5.2 [Item A.2(a)] for procedure qualification and Section 5, Part III for performance qualification. As a minimum, $t = s + 1/8$ in.
3. Surfaces M to be examined for macroetch test. Hardness tests, when required, shall be made on the specimen from the six o'clock position.

Figure 5.8A—Fillet Weld Break and Macroetch Test Specimens



NOTE: THICKNESS t_1 AND t_2 ARE TO BE IN ACCORDANCE WITH TABLES 5.1 AND 5.2 FOR PROCEDURE QUALIFICATION AND SECTION 5, PART III FOR PERFORMANCE QUALIFICATION.

Figure 5.9—Lap Joint Fillet Macroetch Test Assembly and Specimen Location

When the average value of the three specimens equals or exceeds the minimum value permitted for a single specimen and the value for more than one specimen is below the required average value, or when the value for one specimen is below the minimum value permitted for a single specimen, a retest of three additional specimens shall be made. The value for each of these retest specimens shall equal or exceed the required average value.

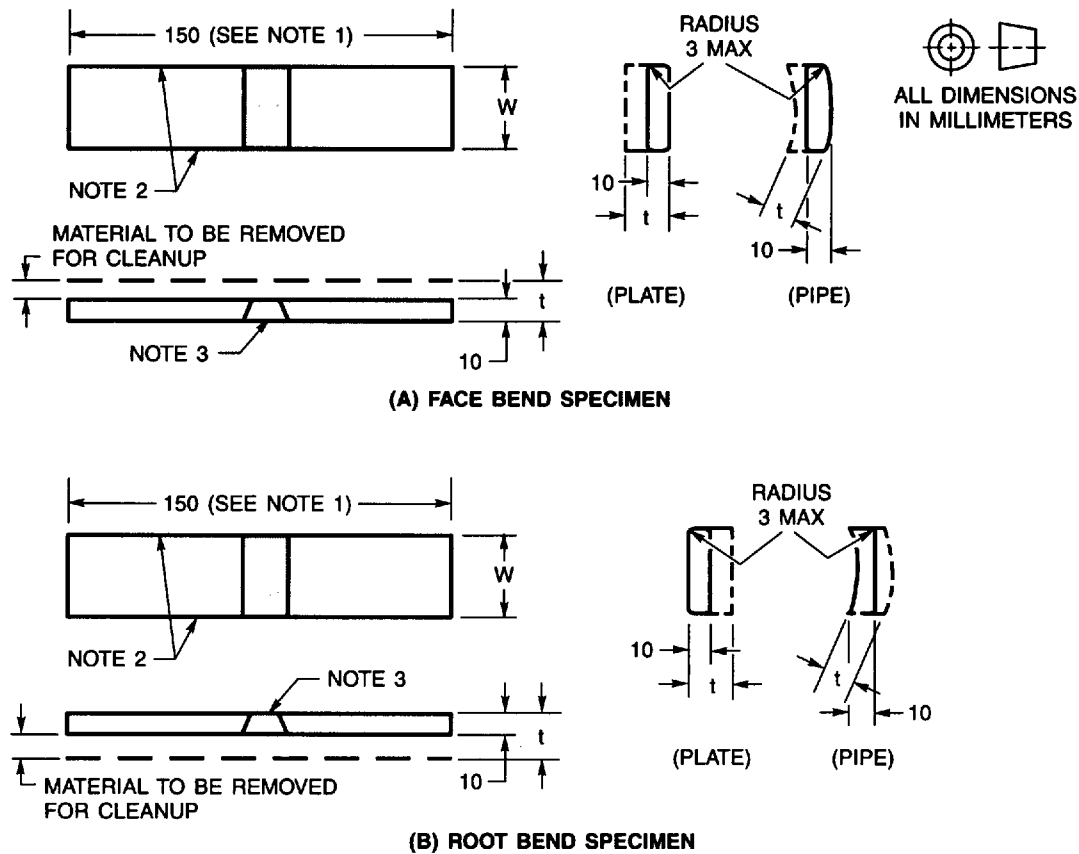
5.11.6 Hardness Test. The specimens used for macroetch and hardness test shall be prepared in accordance with ISO/DIS 9015.2 or ASTM E 92. The location of indentations shall be as shown in ISO/DIS 9015.2 or as specified by the Customer.

5.11.7 Fillet-Weld-Break Test. The coupon prepared for the fillet-weld-break test shall conform to Figure 5.8(A) for plate, and 5.8(B) for pipe qualifications. The entire length of the fillet weld shall be examined visually. For plate, one fillet weld break specimen approximately 150 mm (6 in.) long, and for pipe, four (4) specimens [each containing approximately 25 mm (1 in.) of weld] shall be tested. The specimens shall be loaded in such a way that the root of the weld is in tension until the specimen fractures or bends flat upon itself.

5.11.8 Fillet-Weld-Shear Strength Test. The specimen prepared for the fillet-weld-shear strength testing shall conform to Figures 5.16, 5.17, or 5.18. The specimen type and welding position are to be specified by the Customer. Position of welding may have a significant effect on the properties of the weld, and the Customer should take this into consideration in design and in selection of the first and other positions during procedure qualification.

Before testing, the average throat and length of the test weld shall be measured. The throat of the fillet weld is the distance from the root of the joint preparation to the face of the weld, minus any convexity, disregarding any root penetration. The specimen shall be ruptured under tensile load, and the maximum load shall be determined. The cross-sectional area shall be obtained by multiplying the average throat of the weld by the length. The shear strength shall be obtained by dividing the maximum load by the cross-sectional area.

5.11.9 Bridge Bend Test. The weld test coupons shall be made as shown in Figure 5.19. The coupons shall be bent with the weld bead in tension. Bending shall proceed until a minimum angle of 20 degrees has been developed in the coupon on either side of the bead. The test will pass if no cracks have opened up in either the weld or heat-affected zone. The specimen is unacceptable if a crack is detected.



Dimensions	
Test Weldment	Test Specimen Width, (W) mm
Plate	40
Test Pipe smaller than 150 mm (nominal)	25
Test Pipe 150 mm (nominal) or greater	40

- Notes:
1. A longer specimen length may be necessary when using a wraparound-type bending fixture or when testing bends with greater than 3T bend radius. A longer specimen will be necessary for testing Class B welds with a 6T bend radius.
 2. These edges may be oxygen cut and may or may not be machined.
 3. The weld reinforcement and backing, if any, shall be removed flush with the surface of the specimen. If a recessed backing is used, this surface may be machined to a depth not exceeding the depth of the recess to remove the backing; in such cases, the thickness of the finished specimen shall be that specified above. Cut surfaces shall be smooth and parallel.

Figure 5.10—Face- and Root-Bend Specimens