

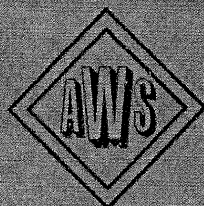
AWS B 3.0-77



TECHNICAL DEPT

American Welding Society
Standard

Welding Procedure and Performance Qualification



AMERICAN WELDING SOCIETY



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AWS B 3.0-77

**Welding
Procedure
and Performance
Qualification**

Superseding AWS B3.0-41

Prepared by
AWS Committee on Qualification

Under direction of
AWS Technical Activities Committee

Approved by
the AWS Board of Directors, March 22, 1977

AMERICAN WELDING SOCIETY, INC.

550 North LeJeune Road, Miami, FL 33135



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Foreword

In 1934, the American Welding Society appointed a committee to formulate a Standard Qualification Procedure which, it was hoped, would be adopted by all the major code writing bodies, thereby eliminating the wide discrepancies then existing between the qualification requirements of the various codes. This committee, known as the *Committee on Standard Qualification Procedure*, completed its first report in 1936 and issued two revisions, one in 1938 and one in 1941.

The provisions of the Standard Qualification Procedure were unique, originating "P-No." base metal groupings, etc., and were incorporated in the more important codes and specifications outside AWS, including those issued by American National Standards Institute (ANSI) and the American Society of Mechanical Engineers. This 1977 revision brings the B3.0 Standard up to date with regard to present materials and welding processes.

This is a general qualification standard for qualification of procedures and performance of welders and welding operators. It is intended for use in any welding situation where a specific product specification does not exist for the application. It is not intended to replace the qualification requirements of AWS or other recognized product codes and specifications.

Preface

The properties and quality of a welded joint will be determined by the specific joint welding procedure used and by the ability of the welder or welding operator to apply that procedure. Predictable results as to the properties and soundness of a joint can be secured only by adherence to a joint welding procedure that has been properly qualified. It cannot be expected that these predictable results will be obtained, even by careful and painstaking workmen, if poor material or inadequate or worn out equipment is used. Also, a properly qualified joint welding procedure will not result in the desired welded joint if the welders or welding operators have not been trained and are not properly supervised to be certain that all essential details of the specific welding procedure are followed. In addition, preparation of the coupons for testing must be done in a workmanlike manner to obtain proper and consistent test results.

In production welding there are two basic concerns which relate to successful application. These are (1) mechanical properties and composition, and (2) workmanship or quality. The mechanical properties of the weld metal, such as tensile strength, ductility, toughness, etc., and, in some cases, its composition will be determined by the joint welding procedure. The quality of the welded joint will be determined by the degree to which that weld metal is kept free of voids and inclusions and by its fusion to the base metal. Under a qualified joint welding procedure, these factors are the ones over which the welder or welding operator has control. It is therefore not necessary to test the welds in welder and welding operator qualification for mechanical properties. Having established that a given joint welding procedure is satisfactory, comparatively simple tests are adequate to determine the ability of an individual to make a sound weld using that welding procedure.

The requirements for qualifying a welding procedure are given in Section 4 and the method of qualifying welders and welding operators is given in Section 5.

There are several variables involved in any joint welding procedure. If predictable results are to be obtained, certain limitations must be placed upon those variables. Having fixed upon these limitations, it is necessary that some tolerance or degree of departure from a given limitation, as stated in a joint welding procedure specification, be recognized as permissible without requiring that a qualification of a revised procedure be made. Departures from a qualified joint welding procedure that might affect the predictable results are referred to as changes in essential variables. The essential variables in this standard are those items, listed under limitations of variables, which will affect the mechanical properties or chemical properties, or both, of the weldment. Similarly, variables in a welding operation, such as change in process, etc., that reflect on the welder's or welding operator's ability are listed under limitations of variables. If these limitations of variables are exceeded, a new procedure qualification is required.

The International System of Units (SI) used to express measurements in this document are rounded units converted from the U.S. customary units following them in parentheses. The U.S. customary units are the principal ones to be used at this time. The SI units are given to acquaint the reader with them. At some future time, the SI units will become the principal units and the U.S. customary units may be deleted. For additional information, refer to the latest edition of AWS 2.3, Metric Practice Guide for the Welding Industry.

Operations involving welding, cutting, brazing, and allied processes should conform with the recommended practices of ANSI Z49.1, Safety in Welding and Cutting, for the protection of welders and nearby personnel from injury and illness and for the protection of property from damage.

Personnel should be protected against exposure to noise generated in welding and cutting processes in accordance with paragraph 1910.95, Occupational Noise Exposure, of the Occupational Safety and Health Standards, Occupational Safety and Health Administration, U.S. Department of Labor.

Procedures involving the use of arc and gas welding, cutting, brazing, and allied processes should conform with the recommendations of ANSI Z49.2/NFPA 51B, Fire Prevention in the Use of Cutting and Welding Processes, for the protection of property from fire and explosion.

Comments or inquiries pertaining to this standard are welcome. They should be addressed to: Secretary, Committee on Qualification, American Welding Society, 550 North LeJeune Rd., Miami, FL, 33135.

Welding Procedure and Performance Qualification

Scope

This standard sets forth the requirements for the qualification of welding procedures, welders, and welding operators for joining ferrous and nonferrous metals and applicable combinations of these materials using the shielded metal arc, gas metal arc, gas tungsten arc, flux cored arc, electroslag, electrogas, submerged arc, plasma arc, and oxyfuel gas welding processes for groove and fillet welds.

The standard is intended for use in any welding situation where a specific product specification does not exist for the application. It is not intended to replace the qualification requirements of AWS or other recognized product codes and specifications.

1. General Provisions

1.1 Definitions. The welding terms used in this standard shall be interpreted in accordance with the definitions given in the latest edition of AWS A3.0, Welding Terms and Definitions.

The term "plate," when used in this standard, is intended to cover sheet also and "pipe" is intended to cover cylindrical tubing also, except where differentiated.

1.2 Responsibility

1.2.1 Welding Procedure Specification Qualification.

Each manufacturer or contractor is responsible for the welding done by his organization. He shall prepare detailed written welding procedure specifications, have the necessary test plates or pipes welded and mechanical tests performed, as specified herein, to assure the criteria of this standard are met, and he shall record this information on a form for welding procedure qualification. Typical forms for a welding procedure specification and a welding procedure qualification are in Appendix A.

The interchange of welding procedure qualifications within a multifaceted organization is permissible provided the parent company exerts direct technical control of welding within its satellite groups.

1.2.2 Performance Qualification. Each manufacturer or contractor shall be responsible for conducting the performance tests necessary to qualify the welders and welding operators who will apply these procedures. Evaluation of the test assemblies may be made by the manufacturer, contractor, or an outside agency. See 5.1 for additional

requirements. A typical form for a welder or welding operator performance qualification is in Appendix A.

1.2.3 Records. Each manufacturer or contractor shall maintain the applicable welding procedure specification records, welding procedure qualification records, and performance qualification records at the job site. These records shall be available to those authorized to inspect them.

1.3 Welding Processes. This standard is applicable to the following welding processes and methods:

- (1) Shielded metal arc welding (SMAW)
- (2) Gas metal arc welding (GMAW)
- (3) Gas tungsten arc welding (GTAW)
- (4) Flux cored arc welding (FCAW)
- (5) Electroslag welding (ESW)
- (6) Electrogas welding (GMAW-EG & FCAW-EG)
- (7) Submerged arc welding (SAW)
- (8) Plasma arc welding (PAW)
- (9) Oxyfuel gas welding (OFW).

2. Base Metals

2.1 General. The grouping of base metals by P Number in Table 2.1 has been made on the basis of mechanical properties and chemical composition. Qualification of a joint welding procedure using one base metal qualifies the procedure for use with all other base metals within the same P number. P1A and P1B, for example, will require separate qualification. The groupings do not imply that base metals may be indiscriminately substituted for a base metal which was used in the qualification test without consideration of their metallurgical compatibility.

Coated materials, such as terneplate and galvanized or painted materials, shall require separate qualification if the coating is not removed.

2.2 Categories. Table 2.1 lists base metals by their ASTM, ABS, or API specification number. Included are:

- (1) Ferrous metals (P1A through P11C)
- (2) Aluminum and aluminum alloys (P21 through P25)
- (3) Copper and copper base alloys (P31 through P35)
- (4) Nickel and nickel base alloys (P41 through P45)
- (5) Unalloyed titanium (P51 and P52).

2.3 Base metals not listed herein shall require qualification of each individual welding procedure to be used with that base metal.

3. Filler Metals

3.1 General. The grouping of filler metals in Tables 3.1A, 3.1B, 3.1C, and 3.1D has been made on the basis of chemical composition, mechanical, metallurgical, and welding characteristics. The electrodes in each F number group are sufficiently similar to justify extension of a joint welding procedure qualification test or a welder, welding operator, or performance qualification test performed with any electrode within the group to cover every other electrode in that group. Additional extensions are noted in Sections 4 and 5. Grouping reduces the number of qualification tests required. The groupings do not imply that any other filler metal in a group may be indiscriminately substituted in an application for that used in the original qualification test. Selection of the filler metal should be based on a careful consideration of the requirements of the application and the characteristics of the base metal involved.

3.2 Filler Metal Specifications

3.2.1 General. The following AWS specifications provide the detailed requirements and general applicability of the electrodes which have been grouped for procedure and performance qualification in Tables 3.1A, 3.1B, 3.1C, and 3.1D.

3.2.2 Ferrous Filler Metals

- A5.1 Specification for Mild Steel Covered Arc-Welding Electrodes
- A5.2 Specification for Iron and Steel Gas-Welding Rods
- A5.4 Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes
- A5.5 Specification for Low-Alloy Steel Covered Arc-Welding Electrodes
- A5.9 Specification for Corrosion Resisting Chromium and Chromium-Nickel Steel Welding Rods and Bare Electrodes
- A5.15 Specification for Welding Rods and Covered Electrodes for Welding Cast Iron
- A5.17 Specification for Bare Carbon Steel Electrodes and Fluxes for Submerged Arc Welding
- A5.18 Specification for Mild Steel Electrodes for Gas Metal Arc Welding
- A5.20 Specification for Mild Steel Electrodes for Flux Cored Arc Welding
- A5.22 Specification for Flux Cored Corrosion Resisting Chromium and Chromium-Nickel Steel Electrodes
- A5.23 Specification for Bare Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding.

3.2.3 Nonferrous Filler Metals

- A5.3 Specification for Aluminum and Aluminum Alloy Arc Welding Electrodes
- A5.6 Specification for Copper and Copper-Alloy Covered Electrodes
- A5.7 Specification for Copper and Copper-Alloy Bare Welding Rods and Electrodes

- A5.10 Specification for Aluminum and Aluminum Alloy Welding Rods and Bare Electrodes
- A5.11 Specification for Nickel and Nickel Alloy Covered Welding Electrodes
- A5.13 Specification for Surfacing Welding Rods and Electrodes
- A5.14 Specification for Nickel and Nickel Alloy Bare Welding Rods and Electrodes
- A5.16 Specification for Titanium and Titanium-Alloy Bare Welding Rods and Electrodes.

3.2.4 Nonconsumable Electrodes

- A5.12 Specification for Tungsten Arc-Welding Electrodes.

4. Joint Welding Procedure Qualification

4.1 Test Positions

4.1.1 Test Positions for Groove Welds. Groove welds may be made in test material oriented in any of the positions shown in Fig. 4.1.1.1 or Fig. 4.1.1.2 and as described in the following paragraphs. An angular deviation of plus or minus 15 degrees from the specified horizontal and vertical planes and an angular deviation of plus or minus 5 degrees from the specified inclined plane are permitted during qualification test welding. Refer to Fig. 4.1.1 for definitions of welding positions which are thereby qualified. A groove weld does not qualify a fillet weld.

4.1.1.1 Plate Positions

4.1.1.1.1 Flat Position 1G. Plate in a horizontal plane with the weld metal deposited from above. Refer to Fig. 4.1.1.1(A).

4.1.1.1.2 Horizontal Position 2G. Plate in a vertical plane with the axis of the weld horizontal. Refer to Fig. 4.1.1.1(B).

4.1.1.1.3 Vertical Position 3G. Plate in a vertical plane with the axis of the weld vertical. Refer to Fig. 4.1.1.1(C).

4.1.1.1.4 Overhead Position 4G. Plate in a horizontal plane with the weld metal deposited from underneath. Refer to Fig. 4.1.1.1(D).

4.1.1.2 Pipe Positions

4.1.1.2.1 Flat Position 1G. Pipe with its axis horizontal and rolled during welding so that the weld metal is deposited from above. Refer to Fig. 4.1.1.2(A).

4.1.1.2.2 Horizontal Position 2G. Pipe with its axis vertical and the axis of the weld in a horizontal plane. Pipe shall not be rotated during welding. Refer to Fig. 4.1.1.2(B).

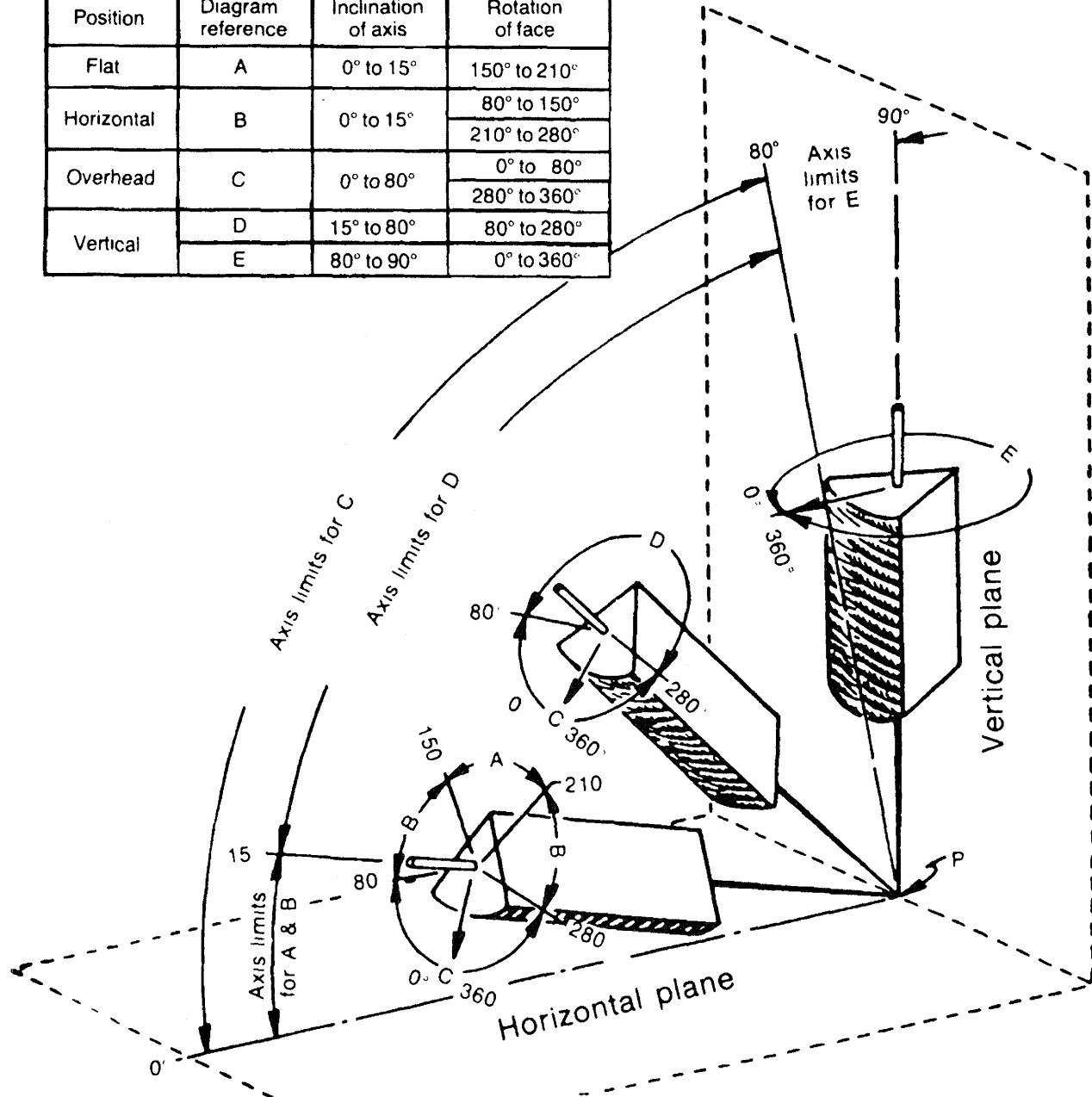
4.1.1.2.3 Multiple Positions 5G. Pipe with its axis horizontal and with the welding groove in a vertical plane. Welding shall be done without rotating the pipe. Refer to Fig. 4.1.1.2(C).

4.1.1.2.4 Multiple Positions 6G. Pipe with its axis inclined at 45 degrees to horizontal. Welding shall be done without rotating the pipe. Refer to Fig. 4.1.1.2(D).

4.1.1.2.5 Position 6GR. (Test for complete joint penetration groove welds of tubular T-, K-, and Y-connections). The test pipe shall be inclined at 45 degrees.



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 taken to lie always below the weld under consideration.
2. Inclination of axis is measured from the horizontal reference plane toward the vertical.
3. Angle of rotation of face is determined by a line perpendicular to the theoretical face of the weld and 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. The angle of rotation of the face of weld is measured in a clockwise direction from this reference position (0°) when looking at point P.

Fig. 4.1.1—Positions of groove welds

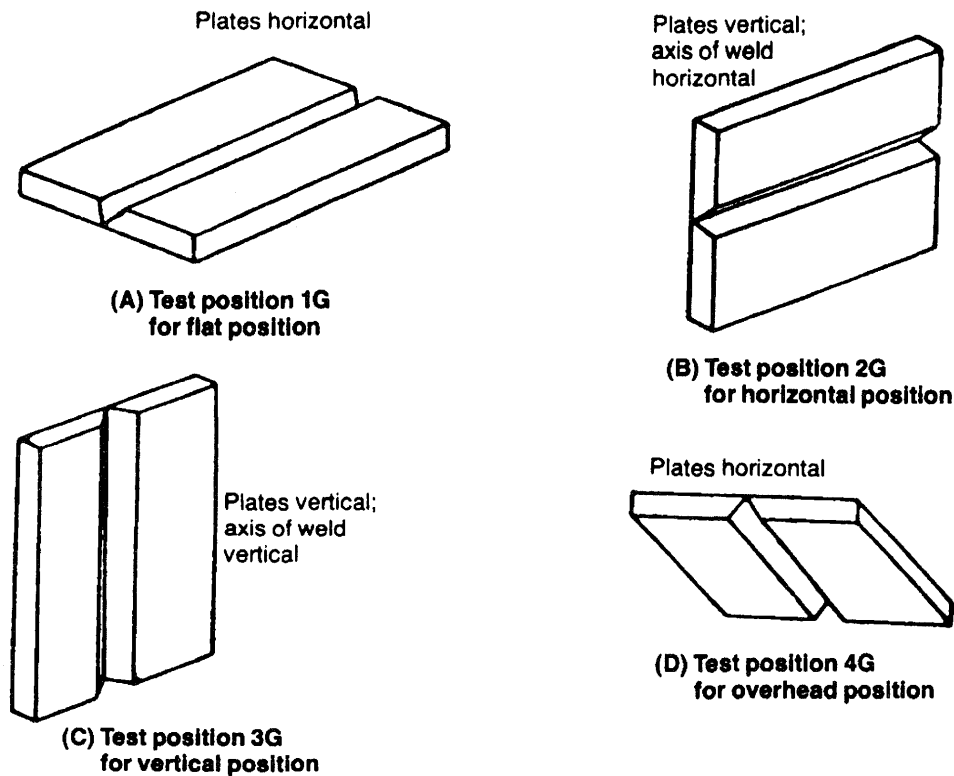


Fig. 4.1.1.1 — Positions of test plates for groove welds

with the horizontal. The pipe or tube is not rotated during welding. Refer to Fig. 4.1.1.2 (E).

4.1.2 Test Positions for Fillet Welds. Fillet welds may be made in test material oriented in any of the positions shown in Fig. 4.1.2.1 and as described in the following paragraphs. An angular deviation of plus or minus 15 degrees from the specified horizontal and vertical planes is permitted during welding. Refer to Fig. 4.1.2 for definitions of welding positions.

4.1.2.1 Plate Positions

4.1.2.1.1 Flat Position 1F. Plates so placed that the weld is deposited with its axis horizontal and its throat vertical. Refer to Fig. 4.1.2.1(A).

4.1.2.1.2 Horizontal Position 2F. Plates so placed that the weld is deposited with its axis horizontal on the upper side of the horizontal surface and against the vertical surface. Refer to Fig. 4.1.2.1(B).

4.1.2.1.3 Vertical Position 3F. Plates so placed that the weld is deposited with its axis vertical. Refer to Fig. 4.1.2.1(C).

4.1.2.1.4 Overhead Position 4F. Plates so placed that the weld is deposited with its axis horizontal on the underside of the horizontal surface and against the vertical surface. Refer to Fig. 4.1.2.1(D).

4.1.2.2 Pipe Positions

4.1.2.2.1 Flat Position 1F. Pipe with its axis inclined at 45 degrees to horizontal and rotated during welding so that the weld metal is deposited from above and at the point of deposition; the axis of the weld is horizontal and the throat vertical. Refer to Fig. 4.1.2.2(A).

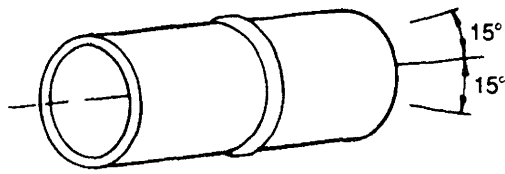
4.1.2.2.2 Horizontal Position 2F and 2FR

(1) Position 2F pipe with its axis vertical so that the weld is deposited on the upper side of the horizontal surface and against the vertical surface. The axis of the weld will be horizontal and the pipe is not to be rotated during welding. Refer to Fig. 4.1.2.2(B).

(2) Position 2FR pipe with its axis horizontal and the axis of the deposited weld in the vertical plane. The pipe is rotated during welding. Refer to Fig. 4.1.2.2(C).

4.1.2.2.3 Overhead Position 4F. Pipe with its axis vertical so that the weld is deposited on the underside of the horizontal surface and against the vertical surface. The axis of the weld will be horizontal and the pipe is not to be rotated during welding. Refer to Fig. 4.1.2.2(D).

4.1.2.2.4 Multiple Position 5F. Pipe with its axis horizontal and the axis of the deposited weld in the vertical plane. The pipe is not rotated during welding. Refer to Fig. 4.1.2.2(E).

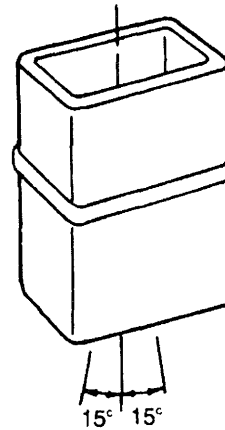
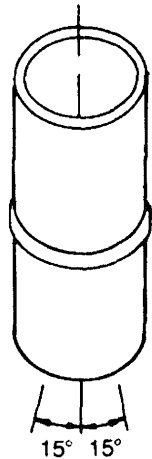


Pipe horizontal and rotated.
Weld flat ($\pm 15^\circ$) Deposit
filler metal at or near the top

**(A) Test position 1G
for flat position**

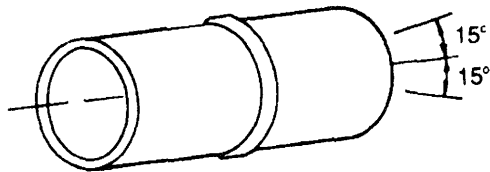
Pipe or tube vertical and
not rotated during welding.
Weld horizontal ($\pm 15^\circ$).

**(B) Test position 2G
for horizontal position**



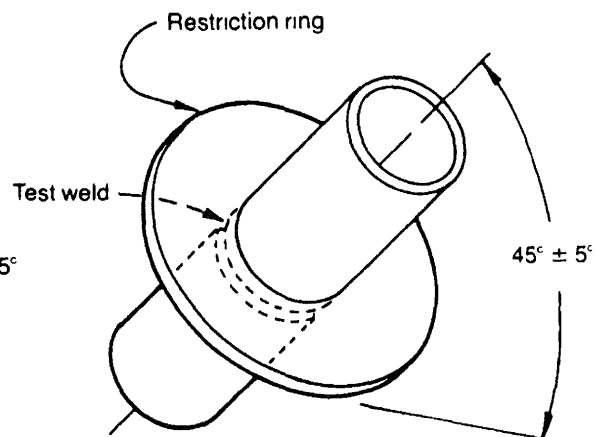
Pipe or tube horizontal fixed ($\pm 15^\circ$). Weld flat, vertical, overhead.

**(C) Test position 5G
for multiple position**



Pipe inclined fixed ($45^\circ \pm 5^\circ$) and not rotated during welding.

**(D) Test position 6G
for multiple position**



**(E) Test position 6GR
(T, K, or Y connections)
for multiple position**

Fig. 4.1.1.2—Positions of test pipes for groove welds

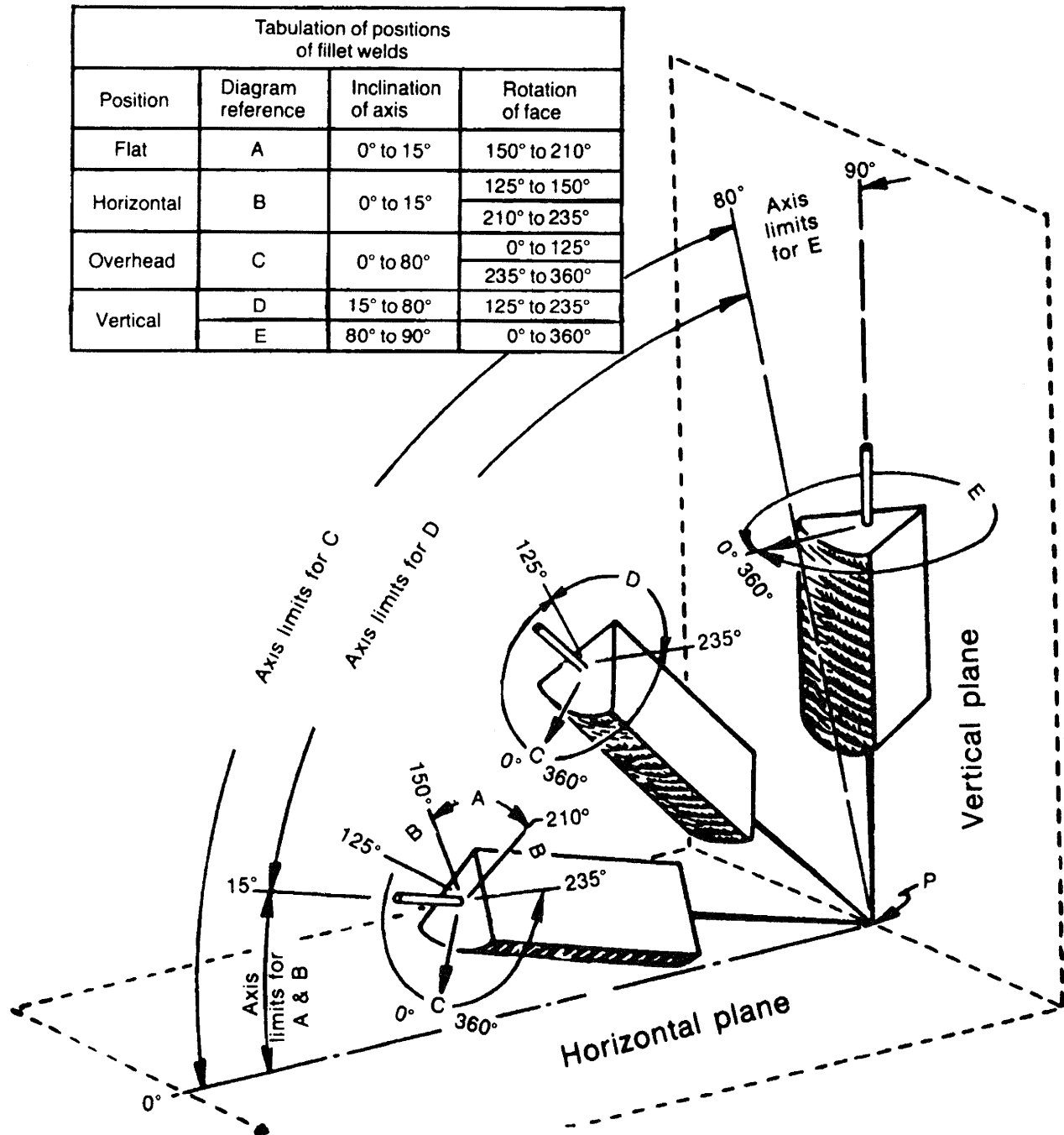


Fig. 4.1.2—Positions of fillet welds

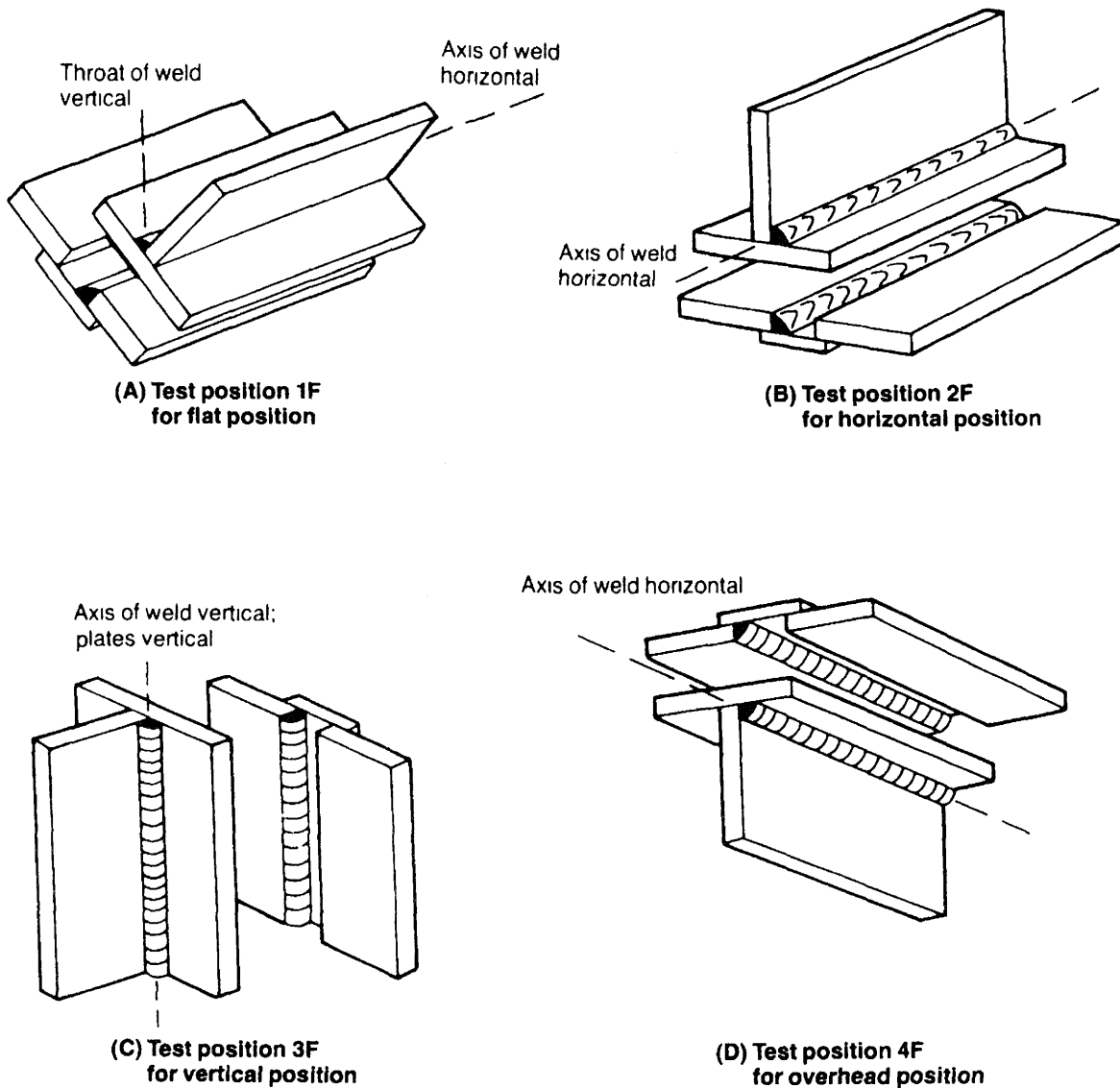


Fig. 4.1.2.1 — Positions of test plates for fillet welds

4.2 Limitations of Variables

4.2.1 General Requirements

4.2.1.1 Those variables that will affect the mechanical properties or chemical properties or both are considered essential variables and must be controlled within the limits prescribed for the process. In preparing a welding procedure specification, the manufacturer, fabricator, contractor, or installer shall show specific values for the essential variables that are to be observed during qualification. When qualified, the essential variables are established and the procedure may be utilized within the limits hereinafter established. Changes in any essential variable, exceeding the prescribed limits, will require a new procedure incorporating the necessary change. The new procedure must then be qualified as required for the initial procedure.

4.2.1.2 Joint welding procedure specifications incorporating a combination of two or more welding processes in a single joint shall include the essential variables that apply to each process and which shall be observed during the use of each respective process. Changes exceeding the limitations for the essential variables of any one or more processes shall require establishment of a new procedure, incorporating the changes, and qualification of the new procedure.

4.2.1.3 Variables not listed are not considered essential for the specific process. However, their omission is not to be considered an indication that such variables should be ignored.

4.2.1.4 The ranges allowed in the limitations of variables are based on the individual values actually used in qualification of the welding procedure.

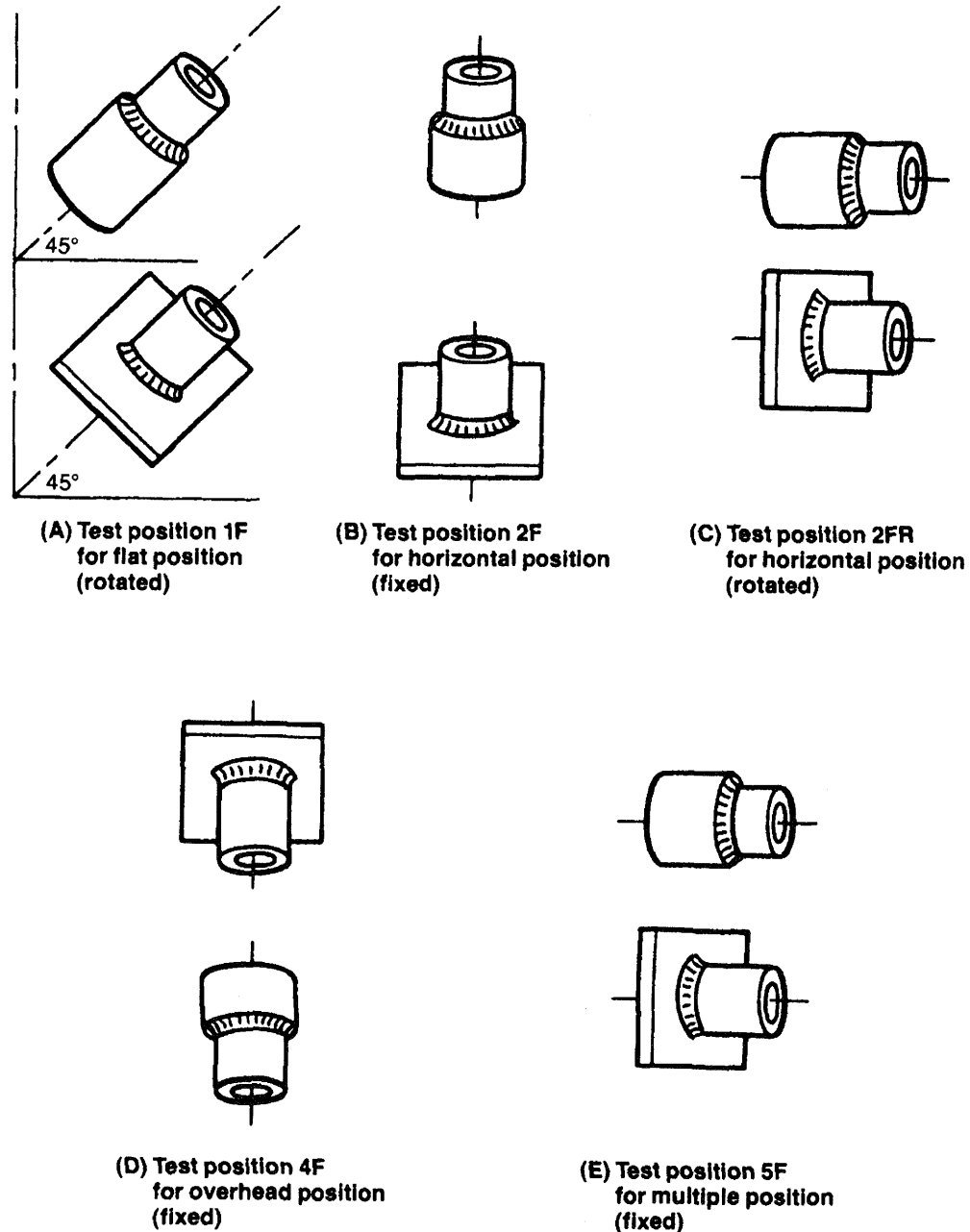


Fig. 4.1.2.2—Positions of test pipes for fillet welds

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4.2.1.5 Where a combination of two or more welding processes is used to complete a weld, the essential variables for each process shall apply to that portion of the weld in which the process is used. Where two or more welding processes are used in a single joint, the thickness of weld metal deposited by each process shall be as specified in the joint welding procedure specification. The thickness (of weld metal) qualified shall be as specified in the limitations of variables which shall apply severally to the weld deposited by each process.

4.2.2 Limitations of Variables by Process. The variables listed in 4.2.2 shall be considered essential variables of a joint welding procedure. Any change exceeding the limitations thereof shall require a new procedure incorporating those changes and qualification of that procedure.

4.2.2.1 Shielded Metal Arc Welding (SMAW)

*(1) A change in base metal from one P number grouping to another P number grouping.

(2) A change in the base metal thickness for single pass welding beyond the range of 0.75t to 1.5t for test plate of 1.60 mm (0.063 in.) or less and 0.5t to 1.25t for thicker than 1.60 mm (0.063 in.). For multiple pass welding, 0.5t to 2t for test plate under 25.4 mm (1 in.) in thickness and 0.5t to unlimited for test plate 25.4 mm (1 in.) or over in thickness, where t is the thickness of the material used for procedure qualification.

*(3) A decrease of 14° C (25° F) or more in the minimum specified preheat or interpass temperature used in the procedure qualification.

*(4) A change increasing the maximum preheat or interpass temperature when specified for metallurgical considerations.

*(5) A change in the postweld heat treating temperature range and aggregate time at temperature beyond that specified.

(6) Filler metal:

(a) An increase in specified filler metal strength classification exceeding 69 MPa (10 000 psi) nominal.

(b) A decrease in filler metal strength classification.

(c) A change from one F number to any other F number.

*(d) A change in weld deposit from one A number to any other A number.

(7) A decrease of more than one standard size of filler metal diameter or an increase in standard filler metal diameter.

(8) A change in the welding position (refer to 4.1).

(9) A change in dimensions of the welding groove exceeding the following:

(a) Root opening: with backing + 6.4 mm (1/4 in.), - 1.6 mm (1/16 in.); without backing, $\pm$ 1.6 mm (1/16 in.).

*(b) Root face: $\pm$ 20 percent when back gouging is not used.

(c) Groove angle: + 20 degrees, - 5 degrees.

*(d) Groove radius: + 3.2 mm (1/8 in.), - 0.

(10) The omission of or change in the type of backing.

*(11) The omission of back gouging.

*(12) A change from single pass weld to multiple pass weld or vice versa.

(13) For a specified joint configuration and thickness, any change in the number of passes exceeding 25 percent unless the change is proportional to a change in groove area.

(14) A change in the second side root treatment of double welded joints (joints welded from two sides):

(a) A change from a mechanical method to a thermal method.

(b) A change in thermal method of preparation.

(c) Any increase in the remaining root face height.

(15) A change in welding current or electrode melting rate of more than 15 percent provided the change does not result in heat input outside the recommendation of the base metal producer or currents outside the range recommended by the electrode manufacturer.

(16) In vertical position welding, any change in the direction of progression of welding.

4.2.2.2 Gas Metal Arc Welding (GMAW)

(1) A change in feed rate of filler metal additions exceeding 20 percent.

(2) A change in the number of electrodes.

(3) A change in specified electrode extension exceeding 6.4 mm (1/4 in.).

(4) A change of more than 12.7 mm (1/2 in.) in the specified longitudinal spacing of electrodes.

(5) A change of more than 10 percent or 1.6 mm (1/16 in.), whichever is greater, in the specified lateral spacing of electrodes.

(6) In machine or automatic welding, any change in travel speed exceeding 10 percent.

(7) In machine or automatic welding, the addition or omission of oscillation or change in oscillation amplitude or frequency exceeding 10 percent.

(8) A change in shielding gas nominal composition.

(9) An increase of 25 percent or more or a decrease of 10 percent or more in the rate of flow of the shielding gas.

*(10) A change in base metal from one P number grouping to another P number grouping.

(11) A change in the base metal thickness for single pass welding beyond the range of 0.75t to 1.5t for test plates of 1.60 mm (0.063 in.) or less and 0.5t to 1.25t for thicker than 1.60 mm (0.063 in.). For multiple pass welding, 0.5t to 2t for test plates under 25.4 mm (1 in.) in thickness and 0.5t to unlimited for test plates 25.4 mm (1 in.)

1. Measurements are given in SI units and U.S. customary units in parentheses. The U.S. customary units are the principal units to be used. See the explanation in the preface.

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2.

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2.

or over in thickness, where t is the thickness of the material used for procedure qualification.

*(12) A decrease of 14° C (25° F) or more in the minimum specified preheat or interpass temperature used in the procedure qualification.

*(13) A change increasing the maximum preheat or interpass temperature when specified for metallurgical considerations.

*(14) A change in the postweld heat treating temperature and aggregate time at temperature beyond that specified.

(15) Filler metal:

(a) An increase in specified filler metal strength classification exceeding 69 MPa (10 000 psi).

(b) A decrease in filler metal strength classification.

(c) A change from one F number to any other F number.

*(d) A change in weld deposit from one A number to any other A number.

(16) A decrease of more than one standard size of filler metal diameter or an increase in standard filler metal diameter.

(17) Addition or omission of filler metal from a source other than the electrode.

(18) A change in the form or type of filler metal additions (e.g., wire to powder).

(19) A change in the welding position (refer to 4.1).

(20) A change in dimensions of the welding groove exceeding the following:

(a) Root opening: with backing, + 6.4 mm (1/4 in.), - 1.6 mm (1/16 in.); without backing, $\pm$ 1.6 mm (1/16 in.).

*(b) Root face: $\pm$ 20 percent when back gouging is not used.

(c) Groove angle: + 20 degrees, - 5 degrees.

*(d) Groove radius: + 3.2 mm (1/8 in.), - 0.

(21) The omission of or change in the type of weld backing or any change in backing gas nominal composition.

*(22) The omission of back gouging.

*(23) A change from single pass weld to multiple pass weld or vice versa.

(24) For a specified joint configuration and thickness, any change in the number of passes exceeding 25 percent unless the change is proportional to a change in groove area.

(25) A change in second side root treatment of double welded joints (joints welded from two sides):

(a) A change from a mechanical method to a thermal method.

(b) Any change in thermal method of preparation.

(c) Any increase in the remaining root face height.

(26) A change from alternating current to direct

current or vice versa, or a change in polarity for direct current.

(27) A change in welding current or electrode melting rate of more than 10 percent. A change of less than 10 percent must not result in heat input exceeding the recommendation of the base metal producer.

(28) A change of more than 2 V in arc voltage above or below the specified mean arc voltage. A change of less than 2 V must not result in heat input exceeding the recommendations of the base metal producer.

(29) The addition or omission of current pulsation or changes in pulse times or amplitudes exceeding 10 percent.

(30) A change from forehand to backhand welding or vice versa.

(31) In vertical welding, any change in the direction of progression of welding.

4.2.2.3 Gas Tungsten Arc Welding (GTAW)

(1) A change in tungsten electrode type, nominal size or end preparation.

(2) A change in the number of electrodes.

(3) A change of more than 12.7 mm (1/2 in.) in the specified longitudinal spacing of electrodes.

(4) A change of more than 10 percent or 1.6 mm (1/16 in.), whichever is greater, in the specified lateral spacing of electrodes.

(5) A change in travel speed exceeding 10 percent.

(6) A change in shielding gas nominal composition.

(7) An increase of 25 percent or more or a decrease of 10 percent or more in the rate of flow of the shielding gas.

(8) Additional limitations of variables for machine and automatic welding:

(a) Any change in arc voltage exceeding 1 V

(b) Any change in amperage exceeding 5 percent

(c) A change in upslope or downslope time program

(d) Addition or omission of magnetic fields for the control of the arc plasma

(e) A change in filler wire feed rate exceeding 10 percent

(f) A change in the filler wire size exceeding one nominal diameter

(g) A change from automatic voltage controlled head to manually positioned head

(h) The addition or omission of oscillation or change in oscillation amplitude exceeding 10 percent or 1.6 mm (1/16 in.), whichever is greater, or oscillation frequency exceeding 20 percent.

(9) A change from an autogenous weld to one made with filler wire and vice versa.

*(10) A change in base metal from one P number grouping to another P number grouping.

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2.



(11) A change in the base metal thickness for single pass welding beyond the range of 0.75t to 1.5t for test plates of 1.60 mm (0.063 in.) or less and 0.5t to 1.25t for thicker than 1.60 mm (0.063 in.). For multiple pass welding, 0.5t to 2t for test plates under 25.4 mm (1 in.) in thickness and 0.5t to unlimited for test plates 25.4 mm (1 in.) or over in thickness, where t is the thickness of the material used for procedure qualification.

*(12) A decrease of 14° C (25° F) or more in the minimum specified preheat or interpass temperature used in the joint welding procedure qualification.

*(13) A change increasing the maximum preheat or interpass temperature when specified for metallurgical considerations.

*(14) A change in the postweld heat treating temperature range and aggregate time at temperature beyond that specified.

(15) Filler metal:

(a) An increase in specified filler metal strength classification exceeding 69 MPa (10 000 psi) nominal

(b) A decrease in filler metal strength classification

(c) A change from one F number to any other F number

*(d) A change in weld deposit from one A number to any other A number.

(16) A decrease of more than one standard size of filler metal diameter or an increase in standard filler metal diameter.

(17) Change in the welding position (refer to 4.1).

(18) A change in dimensions of the welding groove exceeding the following:

(a) Root opening: with backing, + 6.4 mm (1/4 in.), - 1.6 mm (1/16 in.); without backing, ± 1.6 mm (1/16 in.)

*(b) Root face: ± 20 percent when back gouging is not used

(c) Groove angle: + 20 degrees, - 5 degrees

*(d) Groove radius: + 3.2 mm (1/8 in.), - 0.

(19) The omission of or change in the type of backing. For single welded joints, addition or omission of consumable insert or change in shape or size of insert.

*(20) The omission of back gouging

*(21) A change from single pass weld to multiple pass weld or vice versa.

(22) For a specified joint configuration and thickness, any change in the number of passes exceeding 25 percent unless the change is proportional to a change in groove area.

(23) A change in second side root treatment of double welded joints (joints welded from two sides):

(a) A change from a mechanical method to a thermal method

(b) Any change in thermal method

(c) Any increase in the remaining root face height.

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2

(24) A change from alternating current to direct current or vice versa, or a change in polarity for direct current.

(25) A change in welding current of more than 15 percent. A change of less than 15 percent must not result in heat input exceeding the recommendation of the base metal producer.

(26) A change of more than 2 V in arc voltage above or below the specified mean arc voltage. A change of less than 2 V must not result in heat input exceeding the recommendations of the base metal producer.

(27) The addition or omission of current pulsation or changes in pulse times or amplitudes exceeding 15 percent.

(28) A change from forehand to backhand welding or vice versa.

(29) In vertical position welding, any change in the direction of progression of welding.

4.2.2.4 Flux Cored Arc Welding (FCAW)

(1) A change in feed rate of metal additions exceeding 20 percent.

(2) A change in the number of electrodes.

(3) A change in specified electrode extension exceeding 9.5 mm (3/8 in.).

(4) A change of more than 12.7 mm (1/2 in.) in the specified longitudinal spacing of electrodes.

(5) A change of more than 10 percent or 1.6 mm (1/16 in.), whichever is greater, in the specified lateral spacing of electrodes.

(6) In machine or automatic welding, any change in travel speed exceeding 10 percent.

(7) In machine or automatic welding, the addition or omission of oscillation or change in oscillation amplitude or frequency exceeding 10 percent.

(8) A change in shielding gas nominal composition.

(9) An increase of 25 percent or more or a decrease of 10 percent or more in the rate of flow of the shielding gas.

*(10) A change in base metal from one P number grouping to another P number grouping.

(11) A change in the base metal thickness for single pass welding beyond the range of 0.75t to 1.5t for test plates of 1.60 mm (0.063 in.) or less and 0.5t to 1.25t for thicker than 1.60 mm (0.063 in.). For multiple pass welding, 0.5t to 2t for test plates under 25.4 mm (1 in.) in thickness and 0.5t to unlimited for test plates 25.4 mm (1 in.) or over in thickness, where t is the thickness of the material used for procedure qualification.

*(12) A decrease of 14° C (25° F) or more in the minimum specified preheat or interpass temperature used in the procedure qualification.

(13) A change increasing the maximum preheat or interpass temperature when specified for metallurgical considerations.

*(14) A change in the postweld heat treating tem-

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2



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perature range and aggregate time at temperature beyond that specified.

(15) Filler metal:

(a) An increase in specified filler metal strength classification exceeding 69 MPa (10 000 psi) nominal

(b) A decrease in filler metal strength classification

(c) A change from one F number to any other F number

* (d) A change in weld deposit from one A number to any other A number.

(16) A decrease of more than one standard size of filler metal diameter or an increase in standard filler metal diameter.

(17) Addition or omission of filler metal from a source other than the electrode.

(18) A change in the form or type of filler metal additions (e.g., wire to powder).

(19) A change in the welding position (refer to 4.1).

(20) A change in dimensions of the welding groove exceeding the following:

(a) Root opening: with backing, 6.4 mm (1/4 in.), - 1.6 mm (1/16 in.); without backing, $\pm$ 1.6 mm (1/16 in.)

* (b) Root face: $\pm$ 20 percent when back gouging is not used

(c) Groove angle: + 20 degrees, - 5 degrees

* (d) Groove radius: + 3.2 mm (1/8 in.), - 0.

(21) The omission of or change in the type of weld backing or any change in backing gas nominal composition.

* (22) The omission of back gouging.

* (23) A change from single pass weld to multiple pass weld or vice versa.

(24) For a specified joint configuration and thickness, any change in the number of passes exceeding 25 percent unless the change is proportional to a change in groove area.

(25) A change in second side root treatment of double welded joints (joints welded from two sides):

(a) A change from a mechanical method to a thermal method

(b) Any change in thermal method of preparation

(c) Any increase in the remaining root face height.

(26) A change from alternating current to direct current or vice versa, or a change in polarity for direct current.

(27) A change in welding current or electrode melting rate of more than 15 percent. A change of less than 15 percent must not result in heat input exceeding the recommendation of the base metal producer.

(28) A change of more than 10 percent in arc voltage above or below the specified mean arc voltage. A change of less than 10 percent must not result in heat

input exceeding the recommendations of the base metal producer.

(29) A change from forehand to backhand welding or vice versa.

(30) In vertical welding, any change in the direction of progression of welding.

4.2.2.5 Electroslag Welding (ESW)

(1) A change in the number of electrodes.

(2) A change in vertical travel speed exceeding 20 percent.

(3) A change in filler metal oscillation traverse speed exceeding 254 mm/min (10 ipm).

(4) A change in filler metal oscillation traverse dwell exceeding two seconds.

(5) A change in filler metal oscillation length affecting proximity of filler metal to the molding shoes by more than 6.4 mm (1/4 in.).

* (6) A change in base metal from one P number grouping to another P number grouping.

(7) A change in the base metal thickness beyond the range of 0.5t to 1.1t, where t is the thickness of the material used for procedure qualification.

* (8) A decrease of 14° C (25° F) or more in the minimum specified preheat or interpass temperature used in the procedure qualification.

* (9) A change increasing the maximum preheat temperature when specified for metallurgical considerations.

* (10) A change in the postweld heat treating temperature range and aggregate time at temperature beyond that specified.

* (11) A change in weld deposit from one A number to another A number.

(12) A change of more than one standard size of filler metal diameter.

(13) A change in consumable guide tube composition from (a) one having 0.30 percent carbon or less to one having over 0.30 percent carbon, or vice versa, or (b) a mild or low alloy steel to a high alloy steel or vice versa.

(14) A change in the consumable guide cross-sectional area exceeding 30 percent.

(15) A change in the flux system (cored electrode to magnetic electrode, to flux covered consumable guide, to externally added flux, etc.).

(16) A change in the nominal chemical composition of the flux.

(17) A change in the joint axis position from vertical by more than 10 degrees.

(18) A change in dimensions of the welding groove exceeding the following:

(a) Root opening: + 6.4 mm (1/4 in.), - 1.6 mm (1/16 in.)

* (b) Root face: $\pm$ 20 percent

(c) Groove angle: $\pm$ 10 degrees

* (d) Groove radius: + 3.2 mm (1/8 in.), - 0.

(19) The omission of or change in the type

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2.

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2.



of weld backing, including a reduction in any cross-sectional dimension or area of solid nonfusing shoes, either fixed or movable, exceeding 25 percent.

*(20) The omission of back gouging.

*(21) A change from single pass weld to multiple pass weld or vice versa.

(22) A change in second side root treatment of double welded joints (joints welded from two sides):

(a) A change from a mechanical method to a thermal method

(b) A change in thermal method of preparation

(c) An increase in the remaining root face height.

(23) A change from alternating current to direct current or vice versa, or a change in polarity for direct current.

(24) A change in welding current exceeding 20 percent or electrode melting rate exceeding 10 percent. A change in welding current of less than 20 percent, or a change in electrode melting rate of less than 10 percent, must not result in heat input exceeding the recommendation of the base metal producer.

(25) A change of more than 10 percent in arc voltage above or below the specified mean arc voltage. A change of less than 10 percent must not result in heat input exceeding the recommendations of the base metal producer, except that any changes within the starting or finishing sumps are permissible provided the sumps are removed after welding.

4.2.2.6 Electrode Gas Welding (GMAW-EG & FCAW-EG)

(1) A change in the number of electrodes.

(2) A change in vertical travel speed exceeding 20 percent.

(3) A change in filler metal oscillation traverse speed exceeding 254 mm/min (10 ipm).

(4) A change in filler metal oscillation traverse dwell exceeding two seconds.

(5) A change in filler metal oscillation length affecting proximity of filler metal to the molding shoes by more than 3.2 mm (1/8 in.).

(6) A change in shielding gas nominal composition.

(7) An increase of 25 percent or more or a decrease of 10 percent or more in the rate of flow of the shielding gas.

*(8) A change in base metal from one P number grouping to another P number grouping.

(9) A change in the base metal thickness beyond the range of 0.5t to 1.1t, where t is the thickness of the material used for procedure qualification.

*(10) A decrease of 14° C (25° F) or more in the minimum specified preheat or interpass temperature used in the procedure qualification.

*(11) A change increasing the maximum preheat

temperature when specified for metallurgical considerations.

*(12) A change in the postweld heat treating temperature range and aggregate time at temperature beyond that specified.

*(13) A change in weld deposit from one A number to any other A number.

(14) A change of more than one standard size of filler metal diameter.

(15) A change in flux system (cored electrode to magnetic electrode, etc.).

(16) A change in the joint axis position from vertical by more than 10 degrees.

(17) A change in dimensions of the welding groove exceeding the following:

(a) Root opening: + 6.4 mm (1/4 in.), - 1.6 mm (1/16 in.)

*(b) Root face: ± 20 percent

(c) Groove angle: ± 10 degrees

*(d) Groove radius: + 3.2 mm (1/8 in.), - 0.

(18) The omission of or change in the type of weld backing, including a reduction in any cross-sectional dimension or area of solid nonfusing shoes, either fixed or movable, exceeding 25 percent. Any change in backing gas nominal composition.

*(19) The omission of back gouging.

*(20) A change from single pass weld to multiple pass weld or vice versa.

(21) A change in second side root treatment of double welded joints (joints welded from two sides):

(a) A change from a mechanical method to a thermal method

(b) Any change in thermal method of preparation

(c) An increase in the remaining root face height.

(22) A change from alternating current to direct current or vice versa, or a change in polarity for direct current.

(23) A change in welding current or electrode melting rate of more than 15 percent. A change of less than 15 percent must not result in heat input exceeding the recommendation of the base metal producer.

(24) A change of more than 10 percent in arc voltage above or below the specified mean arc voltage. A change of less than 10 percent must not result in heat input exceeding the recommendations of the base metal producer.

4.2.2.7 Submerged Arc Welding (SAW)

(1) A change in feed rate of welding electrodes exceeding 20 percent.

(2) A change in the number of electrodes.

(3) A change in specified electrode extension exceeding 9.5 mm (3/8 in.).

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2.

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2.

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(4) A change of more than 12.7 mm (1/2 in.) in the specified longitudinal spacing of electrodes.

(5) A change of more than 10 percent or 1.6 mm (1/16 in.), whichever is greater, in the specified lateral spacing of electrodes.

(6) A change of more than 15 percent above or below the specified mean travel speed.

*(7) A change in base metal from one P number grouping to another P number grouping.

(8) A change in the base metal thickness for single pass welding beyond the range of 0.75t to 1.5t for test plates of 1.60 mm (0.063 in.) or less and 0.5t to 1.25t for thicker than 1.60 mm (0.063 in.). For multiple pass welding, 0.5t to 2t for test plates under 25.4 mm (1 in.) in thickness and 0.5t to unlimited for test plates 25.4 mm (1 in.) or over in thickness, where t is the thickness of the material used for procedure qualification.

*(9) A decrease of 14° C (25° F) or more in the minimum specified preheat or interpass temperature used in the procedure qualification.

*(10) A change increasing the maximum preheat or interpass temperature when specified for metallurgical considerations.

*(11) A change in the postweld heat treating temperature range and aggregate time at temperature beyond that specified.

(12) A change increasing the minimum specified deposited weld metal strength level; e.g., 552 to 621 MPa (80 000 to 90 000 psi) but not vice versa.

(13) A decrease of more than one standard size of filler metal diameter or an increase in standard filler metal diameter. For welding with an alloy flux, any change in standard diameter of filler metal.²

(14) Addition or omission of filler metal from a source other than the electrode.

(15) A change in the form or type of filler material additions or amounts exceeding 20 percent.

*(16) A change in weld deposit from one A number to any other A number.

(17) A change in electrode and flux combination not covered by AWS Specification A5.17 or A5.23.

(18) A change in the welding position (refer to 4.1).

(19) A change in dimensions of the welding groove exceeding the following:

(a) Root opening: with backing, + 6.4 mm (1/4 in.), - 1.6 mm (1/16 in.); without backing, ± 1.6 mm (1/16 in.)

*(b) Root face: ± 20 percent when back gouging is not used

(c) Groove angle: + 20 degrees, - 5 degrees

*(d) Groove radius: + 3.2 mm (1/8 in.), - 0.

(20) The omission of or change in the type of backing.

(21) The omission of back gouging.

(22) A change from single pass weld to multiple pass weld or vice versa.

(23) For a specified joint configuration and thickness, any change in the number of passes exceeding 25 percent unless the change is proportional to a change in groove area.

(24) A change in second side root treatment of double welded joints (joints welded from two sides):

(a) A change from a mechanical method to a thermal method

(b) Any change in thermal method of preparation

(c) Any increase in the remaining root face height.

(25) A change in type of current (ac or dc) or a change in polarity.

(26) A change in welding current of more than 10 percent. A change of less than 10 percent must not result in heat input exceeding the recommendation of the base metal producer.

(27) A change of more than 15 percent in arc voltage above or below the specified mean arc voltage. A change of less than 15 percent must not result in heat input exceeding the recommendations of the base metal producer.

4.2.2.8 Plasma Arc Welding (PAW)

(1) A change in tungsten electrode type, size or end preparation.

(2) In machine or automatic welding, the addition or omission of oscillation or change in oscillation amplitude or frequency exceeding 10 percent.

(3) A change in shielding or plasma gas nominal composition.

(4) An increase or decrease in the rate of gas flow of:

(a) ± 10 percent in plasma gas

(b) + 25 percent, - 10 percent in shielding or backing gas.

(5) Additional limitations of variables for machine and automatic welding:

(a) The omission or addition of upslope or downslope control, or both, of either current or gas flow

(b) Addition or omission of magnetic fields for the control of arc plasma

(c) For circumferential welding, a change from fixed head to traveling head or vice versa

(d) Any change in travel speed exceeding 5 percent.

(6) A change in nominal torch orifice size.

(7) A change in nominal distance between electrode and torch orifice.

(8) A change from an autogenous weld to one made with filler wire and vice versa.

² An alloy flux is a flux upon which the alloy content of the weld is largely dependent

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2.

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2.



* (9) A change in base metal from one P number grouping to another P number grouping.

(10) A change in the base metal thickness for single pass welding beyond the range of 0.75t to 1.5t for test plates of 1.60 mm (0.063 in.) or less and 0.5t to 1.25t for thicker than 1.60 mm (0.063 in.). For single pass welding employing the keyhole technique, the maximum thickness welded in production shall not exceed the thickness of the test piece. For multiple pass welding, 0.5t to 2t for test plates under 25.4 mm (1 in.) in thickness and 0.5t to unlimited for test plates 25.4 mm (1 in.) or over in thickness, where t is the thickness of the material used for procedure qualification.

(11) A decrease of 14° C (25° F) or more in the minimum specified preheat or interpass temperature used in the procedure qualification.

(12) A change increasing the maximum preheat or interpass temperature when specified for metallurgical considerations.

* (13) Any change in the postweld heat treating temperature range and aggregate time at temperature beyond that specified.

(14) Filler metal:

(a) An increase in specified filler metal strength classification exceeding 69 MPa (10 000 psi) nominal

(b) A decrease in filler metal strength classification

(c) A change from one F number to any other F number

* (d) A change in weld deposit from one A number to any other A number.

(15) A decrease of more than one standard size of filler metal diameter or an increase in standard filler metal diameter.

(16) A change in welding position (refer to 4.1).

(17) A change in dimensions of the welding groove exceeding the following:

(a) Root opening: with backing, + 6.4 mm (1/4 in.), - 1.6 mm (1/16 in.); without backing, $\pm$ 1.6 mm (1/16 in.)

* (b) Root face: $\pm$ 20 percent when back gouging is not used

(c) Groove angle: + 20 degrees, - 5 degrees

* (d) Groove radius: + 3.2 mm (1/8 in.), - 0.

(18) The omission of or change in the type of weld backing; for single welded joints, addition or omission of consumable insert or change in shape or size of insert; any change in backing gas nominal composition.

* (19) The omission of back gouging.

* (20) A change from single pass weld to multiple pass weld or vice versa.

(21) For a specified joint configuration and thickness, any change in the number of passes exceeding 25 percent unless the change is proportional to a change in groove area.

(22) For second side preparation of double welded joints (welds made from two sides):

(a) A change from a mechanical method to a thermal method

(b) A change in thermal method of preparation

(c) An increase in the remaining root face height.

(23) A change from alternating current to direct current or vice versa, or a change in polarity for direct current.

(24) A change in welding current or electrode melting rate of more than 10 percent. A change of less than 10 percent must not result in heat input exceeding the recommendation of the base metal producer.

(25) A change of more than 2 V in arc voltage above or below the specified mean arc voltage. A change of less than 2 V must not result in heat input exceeding the recommendations of the base metal producer.

(26) The addition or omission of current pulsation or changes in pulse frequency or amplitude.

(27) A change from forehand to backhand welding or vice versa.

(28) In vertical welding, any change in the direction of progression of welding.

4.2.2.9 Oxyfuel Gas Welding (OFW)

(1) A change from the fuel gas qualified to any other fuel gas.

(2) A change from oxyfuel gas to air fuel gas welding.

(3) A change in tip size.

(4) A change from autogenous weld to one made with filler wire and vice versa.

(5) A change in base metal from one P number grouping to another P number grouping.

(6) A change in the base metal thickness for single pass welding beyond the range of 0.75t to 1.5t for test plates of 1.60 mm (0.063 in.) or less and 0.5t to 1.25t for thicker than 1.60 mm (0.063 in.). For multiple pass welding, 0.5t to 2t where t is the thickness of the material used for procedure qualification.

* (7) A decrease of 14° C (25° F) or more in the minimum specified preheat or interpass temperature used in the procedure qualification.

* (8) A change increasing the maximum preheat or interpass temperature when specified for metallurgical considerations.

* (9) A change in the postweld heat treating temperature range and aggregate time at temperature beyond that specified.

(10) A change in weld metal strength exceeding 69 MPa (10 000 psi) nominal.

(11) A decrease of more than one standard size of filler metal diameter or an increase in standard filler metal diameter.

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2.

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2.

*(12) A change in weld deposit from one A number to any other A number.

(13) The addition, omission, or change in the type or nominal composition of the flux.

(14) A change in the welding position (refer to 4.1).

(15) A change in dimensions of the welding groove exceeding the following:

(a) Root opening: ± 1.6 mm (1/16 in.)

*(b) Root face: ± 20 percent when back gouging is not used

(c) Groove angle: ± 5 degrees

*(d) Groove radius: $+ 3.2$ mm (1/8 in.), $- 0$.

*(16) The omission of back gouging.

*(17) A change from single pass weld to multiple pass weld or vice versa.

(18) For a specified joint configuration and thickness, any change in the number of passes exceeding 25 percent unless the change is proportional to a change in groove area.

(19) A change from forehand to backhand welding or vice versa.

(20) In vertical welding, any change in the direction of progression of welding.

(21) A change in the type of flame: neutral, oxidizing, or reducing (or carburizing).

4.3 Tests

4.3.1 General

4.3.1.1 Each welding procedure shall be qualified by making weld tests. The types of tests outlined below are to determine the mechanical properties, soundness, and appearance of welded joints made under a given procedure specification. (More comprehensive information on test methods and specimen preparation may be found in AWS B4.0, Standard Methods for Mechanical Testing of Welds.)

4.3.1.2 The specific tests to be employed in qualification of joint welding procedures are described below. Use of additional nondestructive testing is optional. It is strongly recommended that joint welding procedure qualification tests be subjected to the same type and level of nondestructive test as will be required for the production welds on which the procedure is to be employed. The test methods and acceptance requirements described in the following paragraphs are minimum requirements. Other methods and additional acceptance criteria are a matter of agreement between the contractor and purchaser.

4.3.1.3 Test plate and pipe sizes shall be sufficiently large to enable removal of the test specimens required in 4.3.2.

4.3.2 Tests Required and Description of Specimens and Tests

4.3.2.1 Groove Welds. For all but cast iron, refer to Table 4.3.2.1 for the type and number of test specimens required to qualify a groove welding procedure. The test assemblies and order of removal of specimens are shown

in Figs. 4.3.2.1A, B, C, D, and E. Bend tests shall be made in a jig having the contour shown in Fig. 4.3.2.1 F1, F2, or F3. For cast iron only, the test assembly, number of tests, test specimens and test acceptance criteria are shown in Fig. 4.3.2.1G.

4.3.2.1.1 Reduced Section Tension Test for Tensile Strength. Tension test specimens for plate and pipe shall conform to Fig. 4.3.2.1.1A. Pipe 76.2 mm (3 in.) or less may be tension tested in full section in place of reduced section specimens. Two tension specimens are required conforming to Fig. 4.3.2.1.1B. The method of mounting the specimens for testing is also shown in this figure.

4.3.2.1.2 Side-Bend Test for Soundness. Side-bend specimens shall conform to Fig. 4.3.2.1.2.

4.3.2.1.3 Face-Bend Test for Soundness. Face-bend specimens shall conform to Fig. 4.3.2.1.3.

4.3.2.1.4 Root-Bend Test for Soundness. Root-bend specimens shall conform to Fig. 4.3.2.1.3.

4.3.2.1.5 Visual Test for Appearance and Soundness. Each sample weld shall be inspected as follows:

(1) Prior to assembly of the test pieces—to assure that the proper materials are being used, that the parts have been cleaned, and that the joint preparation is correct.

(2) After fit-up—to check the joint clearances.

(3) After welding has been completed (including any postheating)—to detect any surface defects.

4.3.2.2 Fillet Welds. One test weld shall be made to conform to Fig. 4.1.2.2 or 4.3.2.2A. Where a range of fillet weld sizes is to be used in construction, one test shall be made with the maximum size single pass fillet weld and one test shall be made with the minimum size multiple pass fillet weld.

4.3.2.2.1 Macroetch Test for Soundness

(1) For plate, macroetch tests shall be made on each test weld. Three macroetch specimens shall be cut as shown in Fig. 4.3.2.2A and one end of each specimen shall be macroetched.

(2) For pipe-to-pipe specimens and pipe-to-plate specimens, the test assemblies shall be quartered as shown in Fig. 4.3.2.2B. One face of each quarter shall be polished and macroetched.

4.3.2.2.2 Visual Test for Appearance and Soundness. The entire length of fillet welds shall be visually examined.

4.3.3 Acceptance Criteria

4.3.3.1 Reduced Section Tension Test and Full Section Pipe Test. The tensile strength shall not be less than the minimum specified tensile strength of the base metal to be used in construction. The tensile specimen may fail in the base metal, the heat-affected zone, or in the weld deposit. For welds between base metals of different specified minimum tensile strengths, the specimens shall have a tensile strength not less than the metal with the lowest strength.

4.3.3.2 Side-, Face-, and Root-Bend Tests. The guided-bend specimens shall have no open discontinuities exceeding 3.2 mm (1/8 in.) measured in any direction on

*An asterisk indicates those essential variables which are common to all the welding processes listed under 4.2.2.

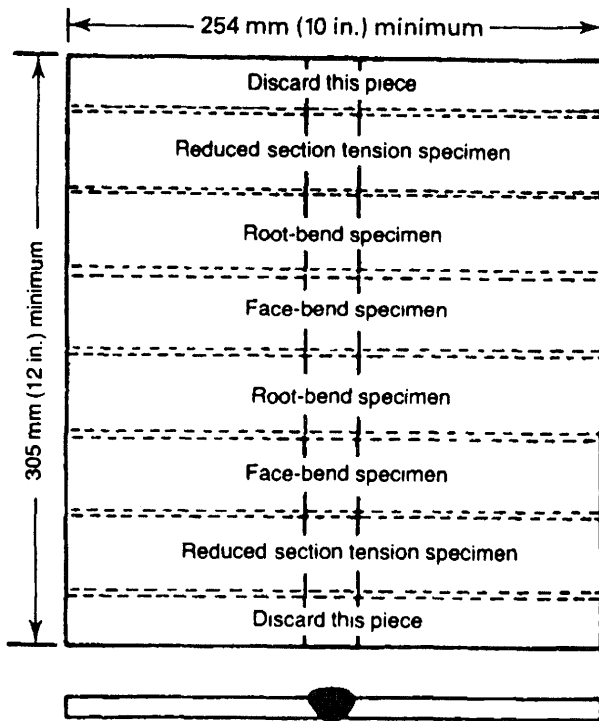


Fig. 4.3.2.1A—Plates 1.6 mm (1/16 in.) to 19 mm (3/4 in.)—procedure qualification

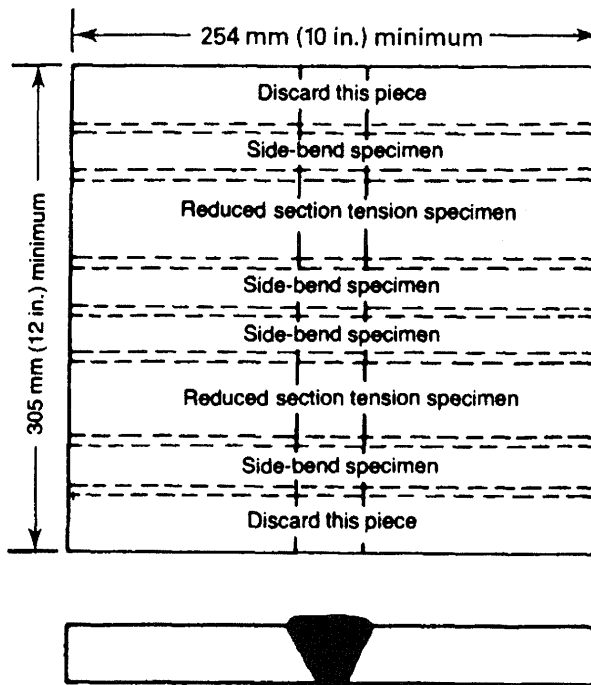


Fig. 4.3.2.1B—Plates over 19 mm (3/4 in.) and alternate 9.5 mm (3/8 in.) to 19 mm (3/4 in.)—procedure qualification

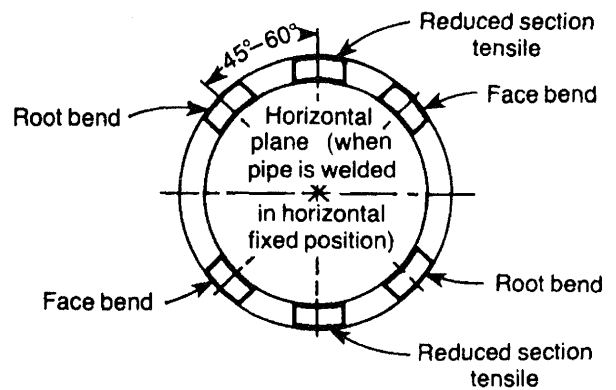


Fig. 4.3.2.1C—Pipes 1.6 mm (1/16 in.) to 19 mm (3/4 in.)—procedure qualification

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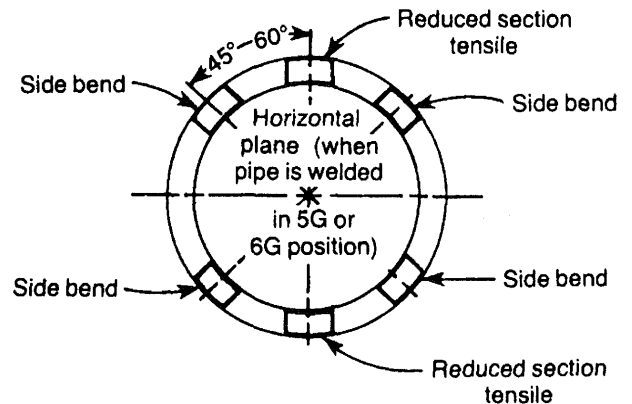


Fig. 4.3.2.1D—Pipes alternate over 9.5 mm (3/8 in.) to 19 mm (3/4 in.)—procedure qualification

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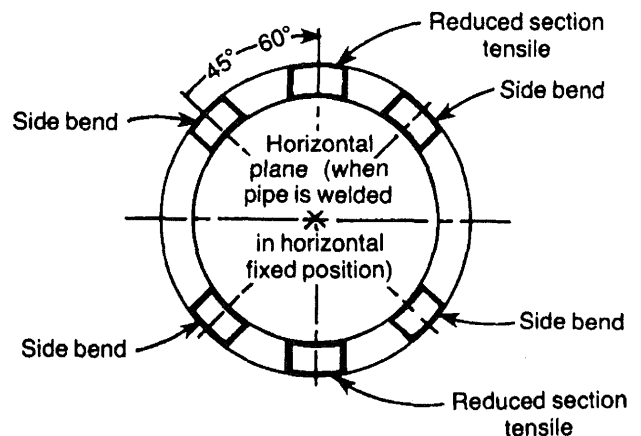
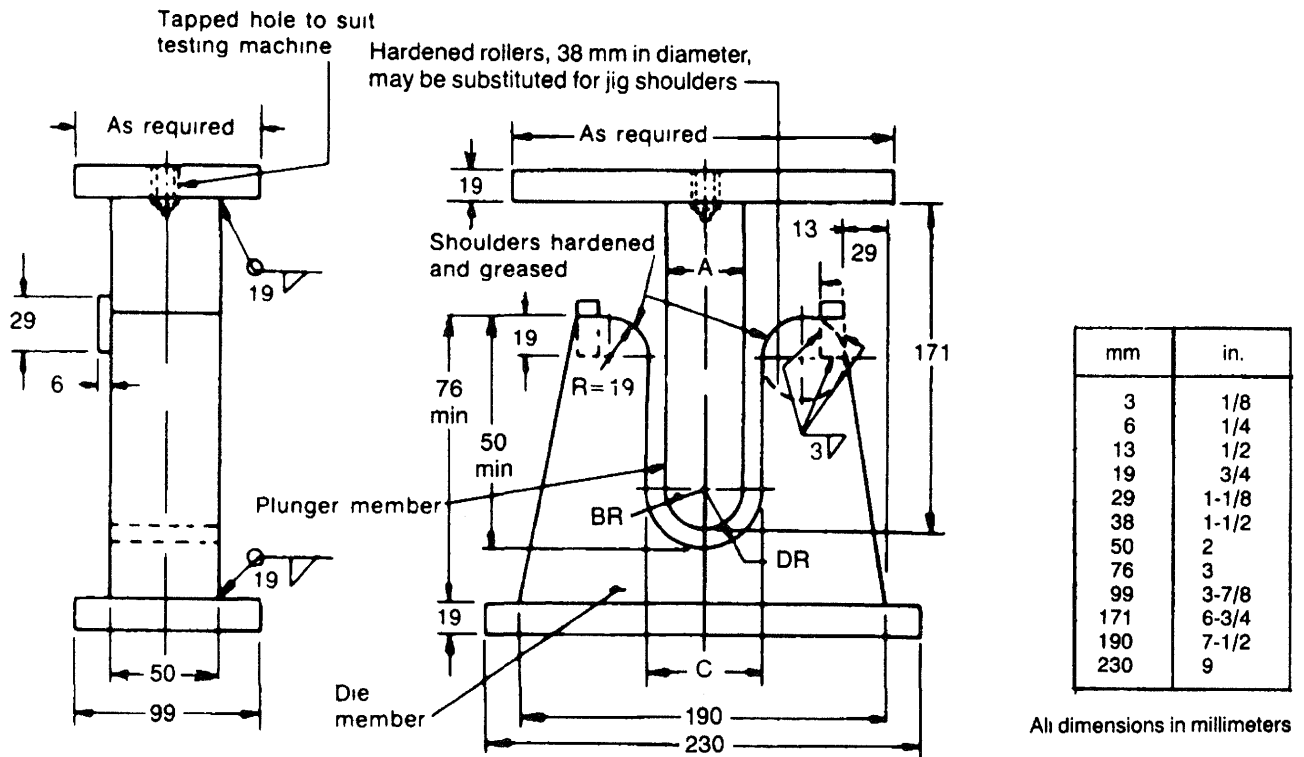


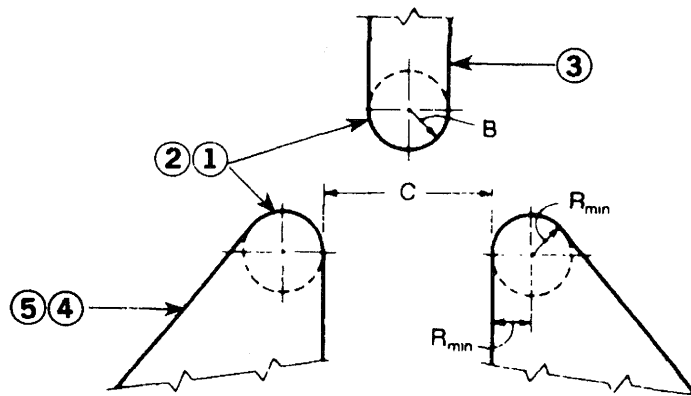
Fig. 4.3.2.1E—Pipes over 19 mm (3/4 in.)—procedure qualification

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Material	Thickness of specimens		B		C		D	
	mm	in.	mm	in.	mm	in.	mm	in.
P-52	2-10 incl.	1/16-3/8 incl.	5t	5t	12t+3	12t+1/8	6t+2	6t+1/16
P-51	2-10 incl.	1/16-3/8 incl.	4t	4t	10t+3	10t+1/8	5t+2	5t+1/16
P-11 & P-25	10 t	3/8 t	32 3-1/3t	1-1/4 3-1/3t	85 8-2/3t+3	3-3/8 8-2/3t+1/8	44 4-1/2t+2	1-11/16 4-1/2t+1/16
P-23 & B-171 Alloy 628	3	1/8	26	1-1/32	61	2-3/8	30	1-3/16
All others	0.7595-3.1453 10 t	0.0299-0.1345 3/8 t	6 19 2t	1/4 3/4 2t	22 61 6t+3	7/8 2-3/8 6t+1/8	11 30 3t+2	7/16 1-3/16 3t+1/16

Fig. 4.3.2.1F(1)— Guided-bend test jig

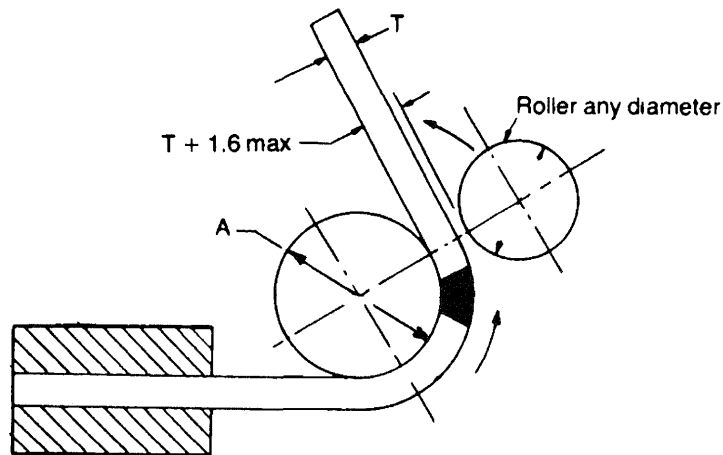


Material	Thickness of specimens		B		C	
	mm	in.	mm	in.	mm	in.
P-52	1.6-3 incl.	1/16-1/8 incl.	5t	5t	12t+3	12t+1/8
P-51	1.6-3 incl.	1/16-1/8 incl.	4t	4t	10t+3	10t+1/8
P-11 & P-25	10 t	3/8 t	32 3-1/3t	1-1/4 3-1/3t	85 8-2/3t+3	3-3/8 8-2/3t+1/8
P-23 & P-35 B-171, Alloy 628	3	1/8	26	1-1/32	61	2-3/8
All others	0.7595-3.4153 10 t	0.0299-0.1345 3/8 t	6 19 2t	1/4 3/4 2t	22 61 6t+3	7/8 2-3/8 6t+1/8

Notes:

1. Either hardened and greased shoulders or hardened rollers free to rotate shall be used.
2. The shoulders or rollers shall have a minimum bearing surface of 51 mm (2 in.) for placement of the specimen. The rollers shall be high enough above the bottom of the jig so that the specimens will clear the rollers when the ram is in the low position.
3. The ram shall be fitted with an appropriate base and shall be designed to minimize deflection and misalignment; provision shall be made for attachment to the testing machine. The ram to be used with the roller jig shall be of identical dimensions to the ram shown in Fig. 4.3.2.1F(1).
4. If desired, either the rollers or the roller supports may be made adjustable in the horizontal direction so that specimens of t thickness may be tested on the same jig.
5. The roller supports shall be fitted with an appropriate base designed to safeguard against deflection or misalignment and they shall be equipped with means for maintaining the rollers centered, midpoint and aligned with respect to the ram.
6. The weld and heat-affected zone in the case of a transverse weld-bend specimen shall be completely within the bend portion of the specimen after testing.

Fig. 4.3.2.1F(2)— Guided-bend roller test jig



mm	in.
1.6	1/16

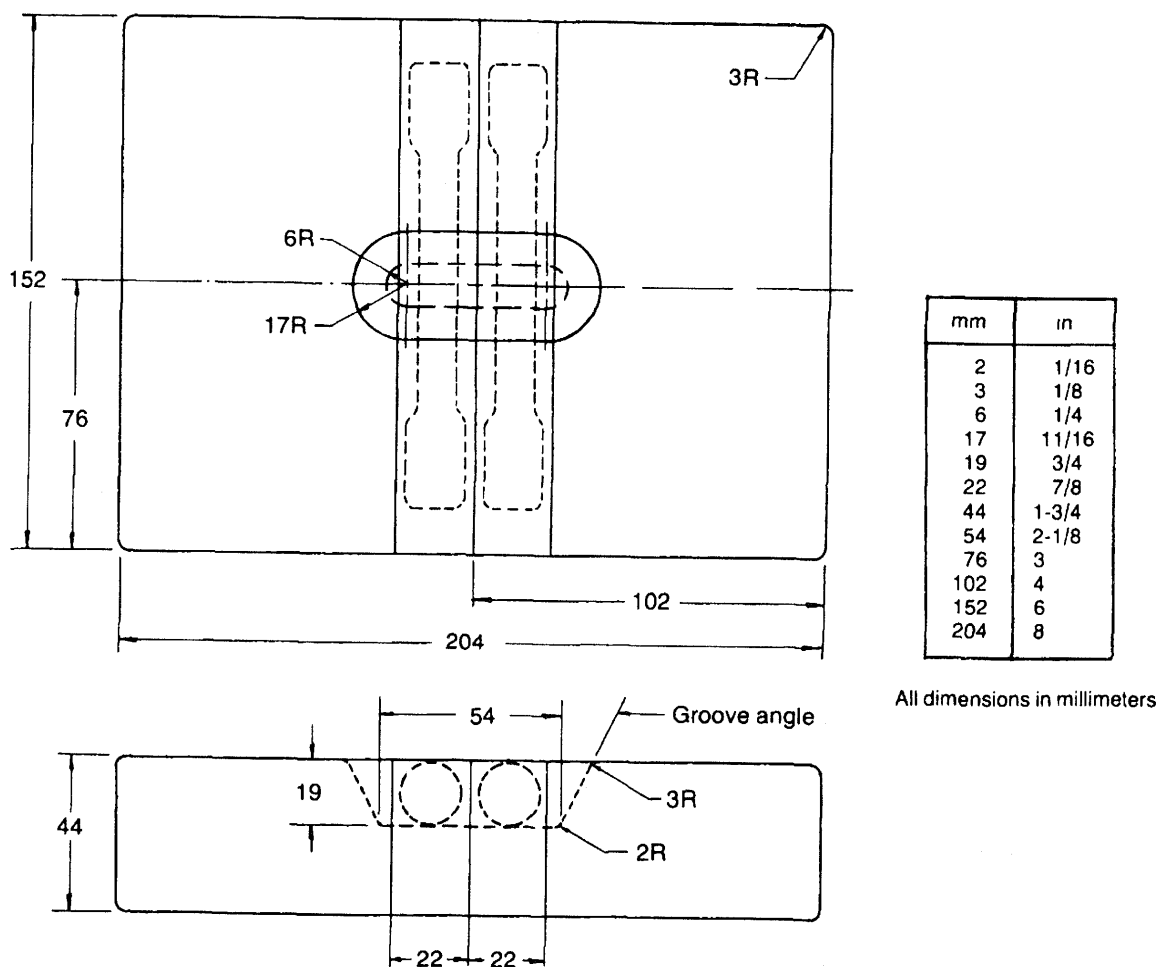
All dimensions in millimeters

Material	Thickness of specimens (t)		A	
	mm	in.	mm	in.
P-52	1.6-10 incl.	1/16-3/8 incl.	10t	10t
P-51	1.6-10 incl.	1/16-3/8 incl.	8t	8t
P-11 & P-25	10 t	3/8 t	63 6-2/3t	2-1/2 6-2/3t
P-23 & P-35 B-171, Alloy 628	3	3/8	52	2-1/16
All others	0.7595-3.1453 10 t	0.0299-0.1345 3/8 t	13 38 4t	1/2 1-1/2 4t

Notes:

1. Dimensions not shown are the option of the designer. The essential consideration is to have adequate rigidity so that the jig parts will not spring.
2. The specimen shall be firmly clamped on one end so that there is no sliding of the specimen during the bending operation.
3. Test specimens shall be removed from the jig when the outer roll has been removed 180 degrees from the starting point.

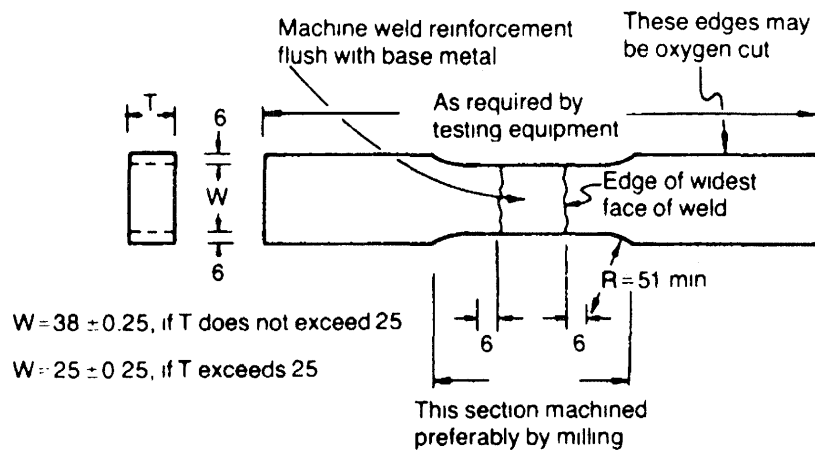
Fig. 4.3.2.1F(3)—Guided-bend wraparound test jig



Notes:

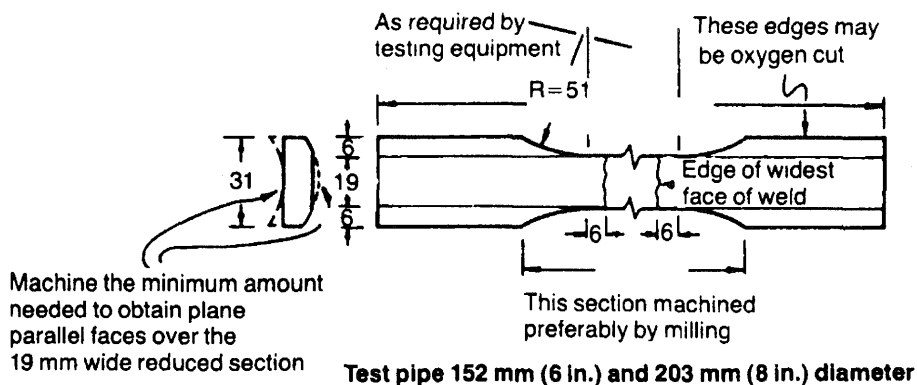
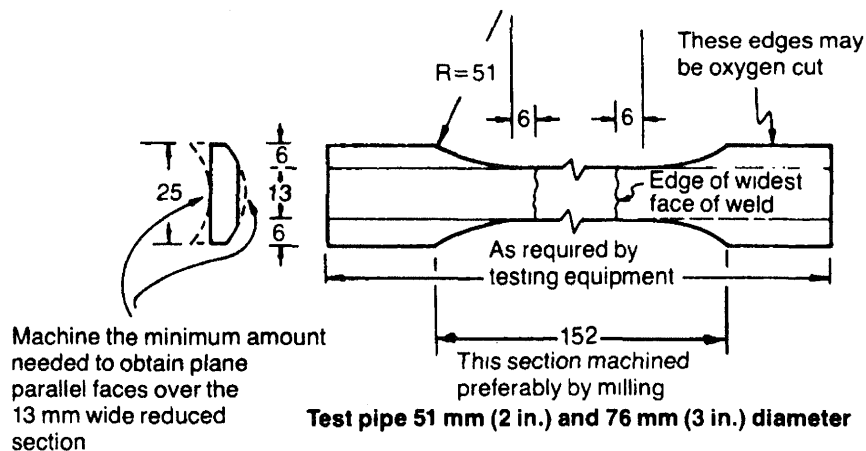
1. Groove angle—30° for electric arc welding, 45° for oxyfuel gas welding.
2. Tests required—two round 12.8 mm (0.505 in.) diameter tension test specimens transverse weld.
3. Transverse weld tensile strength must equal or exceed 80% of the minimum specified tensile strength for the base metal.
4. Performance or procedure qualification, or both, shall qualify for unlimited thickness only for the position in which the test assembly was welded.

Fig. 4.3.2.1G—Cast iron test assembly—procedure and performance qualification



For plates over 25 mm thick, specimens may be cut into the minimum number of approximately equal strips not exceeding 25 mm in thickness. Test each strip and average the results.

Test plate



mm	in.
0.25	0.001
6	1/4
13	1/2
19	3/4
25	1
31	1-1/4
38	1-1/2
51	2
76	3
152	6
203	8

All dimensions in millimeters

Fig. 4.3.2.1.1A—Reduced section tension specimens

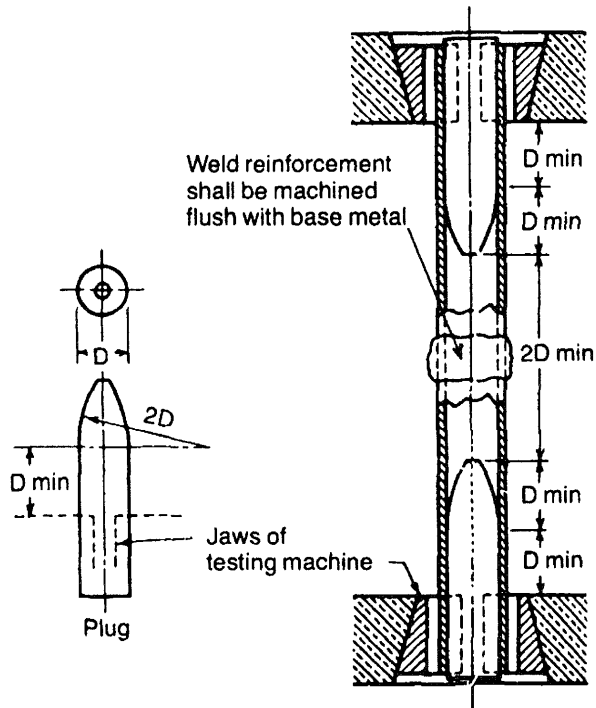


**Fig. 4.3.2.1.1B—Tension—full section
—small diameter pipe**

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the convex surface of the specimen after bending, except that cracks occurring on the corners shall not be considered, unless there is definite evidence that they result from slag inclusions or other internal discontinuities.

4.3.3.3 Macroetch Test. Visual examination of the cross sections of the weld metal and the heat-affected zone shall show complete fusion and freedom from cracks. Fusion beyond the root is not necessary unless specified by the welding procedure specification. There shall not be more than 3.2 mm (1/8 in.) difference in the length of the legs of the fillet.

4.3.3.4 Visual Inspection. The following is required for a sample weld to pass visual inspection:

4.3.3.4.1 The weld shall be free of cracks and surface discontinuities (slag and porosity).

4.3.3.4.2 The weld shall be free of craters.

4.3.3.4.3 For butt joints, the face of the weld shall be at least flush with the surface (no underfill), and the weld shall merge smoothly with the base metal. Weld face reinforcement shall not exceed the following:

Test material thickness (t)		Maximum face reinforcement (R)	
mm	in.	mm	in.
9.5 and less	3/8 and less	1/4t	1/4t
Over 9.5 to 19.1	Over 3/8 to 3/4 incl.	3.2	1/8
Over 19.1	Over 3/4	4.8	3/16

4.3.3.4.4 Depth of undercut shall not be more than 0.8 mm (1/32 in.).

4.3.3.4.5 The root of the groove weld shall be examined, and there shall be no evidence of cracks, incomplete fusion or inadequate joint penetration. The root surface concavity or root reinforcement (in welds made from one side only) shall not exceed the values shown in the table below:

Test material thickness (t)		Maximum root surface concavity		Maximum root reinforcement	
mm	in.	mm	in.	mm	in.
9.5 and less	3/8 and less	1.6	1/16	1.6	1/16
Over 9.5	Over 3/8	1.6	1/16	3.2	1/8

4.3.3.4.6 Profiles of fillet and groove welds shall be in accordance with Fig. 4.3.3.4.6 and the following:

(1) The faces of fillet welds may be slightly convex, flat or slightly concave as shown in Fig. 4.3.3.4.6A, B, and C. Unacceptable profiles are shown in Fig. 4.3.3.4.6D.

(2) Groove weld profiles shall be free of the discontinuities shown in Fig. 4.3.3.4.6F.

(3) Welds shall be free from overlap.

4.3.4 Repair of Test Assembly

4.3.4.1 Test assemblies may be repair welded, using the written welding procedure being qualified, only under the following conditions:

(1) No cracks other than crater cracks may be repair welded. Other cracks shall not be repaired.

(2) Only one cycle of repair welding is permitted.

(3) All test results, including a description of the nondestructive test results which failed to meet the requirements and the repair work performed to correct the condition, shall be made a part of the joint welding procedure qualification test record.

(4) The defects repaired are representative of defects that would be rejected by nondestructive tests required for production work.

(5) The repair welding is representative of repair welding that would be permitted on production work.

5. Performance Qualification

5.1 General. When this document is specified by owner or architect/engineer as the governing document, the manufacturer/contractor shall be responsible for conducting the applicable performance tests of each welder/operator according to the rules of this section before the welder/operator engages in any production work.

Performance tests shall be conducted to conform to the manufacturer's approved welding procedure specifications (refer to Section 4) and shall be documented on appropriate performance qualification records (refer to Appendix A).

Performance qualification applicants shall be familiarized with parameters of the applicable joint welding procedure specification. It is recommended that the manufacturer's representative conducting these tests possess sufficient technical and supervisory ability to conduct such tests and