Pipeline Maintenance Welding Practices

API RECOMMENDED PRACTICE 1107
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ERRATA

On page 4, a paragraph was omitted; it should be inserted as follows:

Change the designation of the current paragraph 2.6.2.2, Acceptance Criteria, to **2.6.2.3 Acceptance Criteria**; *add the new Paragraph 2.6.2.2, Method of Testing. Paragraph 2.6.2.2, Method of Testing, should read as follows:*

2.6.2.2 Method of Testing

The tensile-strength specimens shall be broken under tensile load, using equipment capable of measuring the load at which failure occurs. The tensile strength shall be computed by dividing the maximum load at failure by the smallest cross-sectional area of the specimen, as measured before the load is applied.

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Pipeline Maintenance Welding Practices

SECTION 1—GENERAL

1.1 Scope

This recommended practice covers recommended maintenance welding practices that may be used when making repairs to or installing appurtenances on piping systems which are or have been in service in the compression, pumping, and transmission of crude petroleum, petroleum products, and fuel gases and, where applicable, when making repairs to distribution piping systems for these products. The welding may be done by shielded metal-arc welding, gas tungsten-arc welding, gas metal-arc welding, flux-cored arc welding, or oxyacetylene welding using a manual or semiautomatic welding technique or a combination of the techniques.

This recommended practice does not preclude using other methods besides welding to install appurtenances or make repairs.

Note: The scope of this document is limited to the necessary operations of welding and to the associated activities of welding necessary for preparing materials for welding and for inspecting completed welds.

1.2 Definition of Terms

1.2.1 GENERAL

Many of the welding terms used in this recommended practice are defined in AWS A3.0. Some additions to and modifications of these definitions are provided in 1.2.2.

1.2.2 DEFINITIONS

1.2.2.1 *Company* refers to the owner company or the engineering agency in charge. The company may act through an inspector or other authorized representatives.

1.2.2.2 The term *contractor* includes the prime contractor and any subcontractors engaged in work covered by this recommended practice.

1.2.2.3 *Weld* refers to the completed weld.

1.2.2.4 A *qualified welding procedure* is a tested and proved detailed method by which sound welds with suitable mechanical properties and appearance can be produced.

1.2.2.5 A *welder* is the person who makes the weld.

1.2.2.6 A *qualified welder* is a welder who has demonstrated his ability to produce welds that meet the requirements of Section 2 or 3.

1.2.2.7 The *root bead* is the first bead in a weld.

1.3 Equipment

The welding equipment, whether gas or arc, should be of a type and size suitable for the work and should be adequately maintained to ensure acceptable welds, continuity of operation, and safety of personnel. Arc-welding equipment must be operated within the amperage and voltage ranges given in the qualified welding procedure; gas-welding equipment must be operated according to the flame characteristics and within the tip sizes given in the qualified welding procedure. Any equipment which does not meet the requirements of the qualified welding procedure must be repaired or replaced.

1.4 Materials

1.4.1 PIPE, FITTINGS, AND REPAIR MATERIALS

This recommended practice applies to welding steel pipe, fittings, and repair materials which conform to the following specifications and standards:

a. API Specification 5L.
b. API Specification 5LS.
c. API Specification 5LX.
d. Applicable ASTM[1] standards.

This recommended practice also applies to materials with chemical and mechanical properties that comply with the specifications listed in Items a–c above, even if the materials were not manufactured in accordance with those specifications.

1.4.2 FILLER METAL

1.4.2.1 Type and Size

All filler metals must conform to one of the following specifications: AWS A5.1, AWS A5.2, AWS A5.5, AWS A5.18, AWS A5.20, or AWS A5.29. If the filler metals are not manufactured in accordance with one of these specifications, they are still acceptable as long as their chemical and mechanical properties comply with one of the specifications.

1.4.2.2 Storage and Handling of Filler Metals

Filler metals shall be stored and handled carefully to prevent damage to them and to the containers in which they are shipped. Filler metals in open containers shall be protected

[1]American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187.

from deterioration. Coated filler metals, low-hydrogen electrodes especially, shall be protected from excessive moisture changes and shall be cared for in strict accordance with the recommendations of the electrode manufacturer.

1.4.3 SHIELDING GASES

1.4.3.1 Types

Several types of atmospheres may be used to shield an arc; these may consist of inert gases, active gases, or mixtures of inert and active gases. The purity and dryness of these atmospheres influence considerably the welding, so their value should be suitable for the process and base metals The type of shielding atmosphere to be used should be qualified for the material and the welding process.

1.4.3.2 Storage and Handling of Shielding Gases

Shielding gases should be kept in the containers in which they are supplied, and these containers should be stored away from temperature extremes. Gases shall not be field intermixed in their containers, and gases of questionable purity and those in containers which show signs of damage shall not be used.

1.5 Referenced Publications

The most recent editions of the following standards, codes, and specifications are cited in this recommended practice.

API

Spec 5L	*Specification for Line Pipe*
Spec 5LS	*Specification for Spiral-Weld Line Pipe*
Spec 5LX	*Specification for High-Test Line Pipe*
Std 1104	*Welding of Pipelines and Related Facilities*

ASNT[2]

SNT-TC-1A	*Recommended Practice*

AWS[3]

A3.0	*Standard Welding Terms & Definitions*
A5.1	*Specification for Covered Carbon Steel Arc Welding Electrodes*
A5.2	*Specification for Carbon and Low Alloy Steel Rods for Oxyfuel Gas Welding*
A5.5	*Specification for Low Alloy Steel Covered Arc Welding Electrodes*
A5.18	*Specification for Carbon Steel Filler Metals for Gas Shielded Arc Welding*
A5.20	*Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*
A5.28	*Specification for Low Alloy Steel Filler Metals for Gas Shielded Arc Welding*
A5.29	*Specification for Low Alloy Steel Electrodes for Flux Cored Arc Welding*

SECTION 2—QUALIFICATION OF WELDING PROCEDURES

2.. Procedure Qualification

Before the maintenance welding is begun, a detailed procedure specification shall be established and qualified. For qualification, it shall be demonstrated that the procedure can produce welds that are sound and have suitable mechanical properties. The quality of the welds shall be determined by destructive testing.

These procedures shall be adhered to unless a change (see 2.4) is specifically authorized by the company. Circumferential butt-welding procedures shall be in accordance with API Standard 1104.

2.2 Records

The details of each qualified procedure shall be recorded. The records should show the complete results of the procedure qualification test. These records are to be maintained as long as the procedure is in use.

2.3 Procedure Specification

The procedure specification should include the following:

a. Process. Identify the welding process used and whether it is manual, semiautomatic, or a combination of these.

b. Pipe, fitting, and repair materials. Identify the materials to which the procedure applies, giving due consideration to carbon equivalents. Materials may be grouped (see 2.4, Item b) as long as the qualification test is made on the material with the highest specified minimum yield strength in the group.

c. Diameter group-material thickness group. Identify the ranges of diameters and material thicknesses over which the procedure applies. Diameter groups might be as follows:

1. Less than 2⅜ inches (60.3 millimeters).
2. From 2⅜ inches (60.3 millimeters) through 12¾ inches (323.8 millimeters).
3. Greater than 12¾ inches (323.8 millimeters).

Suggested thickness groups may be found in 3.3, Item e.

[2]American Society for Nondestructive Testing, 4153 Arlingate Plaza, Caller #28518, Columbus, Ohio 43228-0518.

[3]American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, FL 33135.

d. Pipeline operating conditions. Identify the pipeline operating conditions (liquid or gas contents, pressure, flow, and temperature) under which the procedure applies.
e. Joint design. For a groove weld, provide a sketch of the angle of the bevel, the size of the root face, and the root opening or space between the abutting members. Show the shape and size of the fillet welds. Designate the type of backup if one is used.
f. Filler metal and number of beads. Designate the sizes and classification number of the filler metal and the minimum number and sequence of the beads.
g. Electrical characteristics. Designate the current and polarity; show the range of voltage and amperage for each electrode, rod, and wire.
h. Flame characteristics. Designate whether the flame is neutral, carburizing, or oxidizing; for each size of rod or wire, designate the size of each orifice in the torch tip.
i. Direction of welding. Show whether the direction is uphill or downhill.
j. Cleaning and grinding. Show whether power tools or hand tools are used.
k. Shielding gas and flow rate. Designate the composition of the gas and the range of the flow rate.
l. Speed of travel. Show the range in inches per minute for each pass.
m. Preheat and postheat. Specify the methods, temperature, temperature control methods, and ambient temperature range.

2.4 Essential Variables

When any of the following changes are made in a welding procedure, the procedure shall be reestablished with a new procedure specification, and the specification shall be completely requalified. Changes other than those given in the following may be made in the procedure, and, as long as the procedure specification is revised to show the changes, a requalification does not have to be made.

a. Change in welding process or method of application. A change from the welding process established in 2.3, Item a.
b. Change in pipe, fitting, and repair materials. For this recommended practice, all carbon steels shall be grouped as follows (see note):
1. Specified minimum yield strength less than or equal to 42,000 pounds per square inch (289.58 megapascals).
2. Specified minimum yield strength greater than 42,000 pounds per square inch (289.58 megapascals) but less than 65,000 pounds per square inch (448.16 megapascals).
3. Specified minimum yield strength greater than or equal to 65,000 pounds per square inch (448.16 megapascals). For this group, each grade shall require a separate qualification test.
c. Change in joint design. Changes include the following:
1. A major change in joint dimensions. For groove welds, a major change in joint dimensions would include a change from a V groove to a U groove or from beveled ends to unbeveled ends.
2. A change from multiple to single pass welding.
d. Change in position. A change in the position of the pipe or attachment from the one used during the procedure qualification, unless the test assembly shown in Figure 1 was used in qualifying the procedure.
e. Change in material thickness (see note). A change from one material thickness group to another (see 3.3, Item e).
f. Change in filler metal. A change in electrode size by more than one nominal size or a change from one classification group to another. The filler metal groups are provided in Table 1.
g. Change in direction. A change from vertical downhill to vertical uphill or vice versa.
h. Change in shielding gas. A change from one gas to another or from one mixture to a different mixture.
i. Change in shielding-gas flow rate. An increase or a decrease in the shielding-gas flow rate from the range established in the procedure specification.
j. Change in speed of travel. A change in speed above or below the range established in the procedure specification.

Note: This grouping of materials and thicknesses does not imply that all materials and thicknesses within the group may be indiscriminately substituted for the materials and thicknesses used in the qualification test. The compatibility of the base materials and filler metals should be considered along with the effects of the piping contents on the physical properties of the weld.

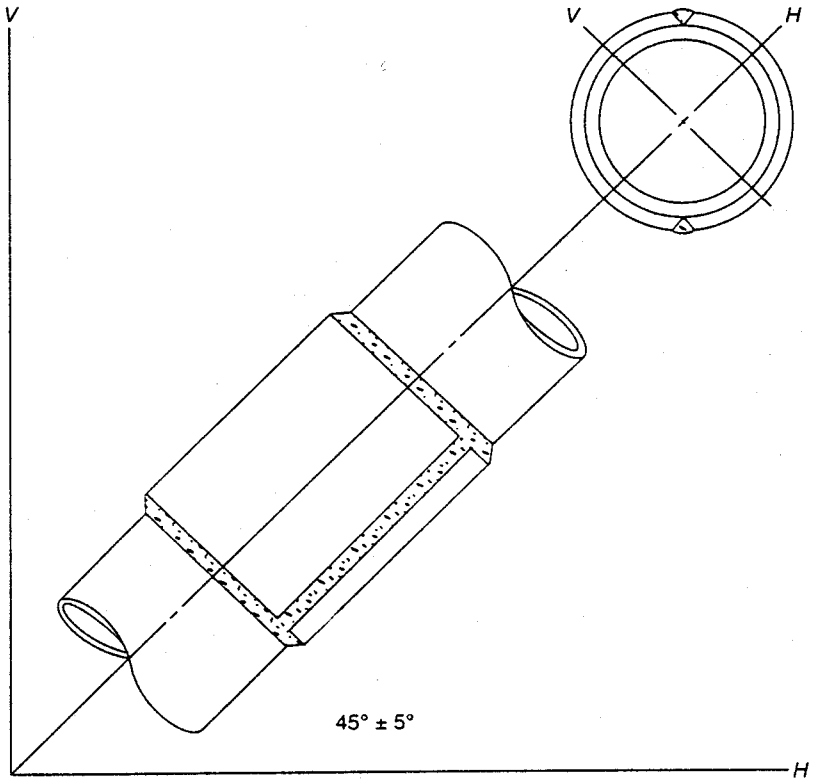
2.5 Welding of Test Assembly

A test assembly for qualifying a maintenance welding procedure is prepared by following all of the details of the procedure specification. A suggested test assembly for procedure qualification is shown in Figure 1. Consideration should be given to the cooling effects due to pipeline operating conditions during welding (for example, pressure, temperature, flow rate, fluid density) on the metallurgical and mechanical properties of the field maintenance welds. Test considerations may include the circulation of fluid inside the test pipe and pretest cooling of the test material.

2.6 Procedure Qualification Tests

2.6.1 PREPARATION

Test specimens are to be cut from the test assembly. Figure 2 shows suggested locations where test specimens should be cut from the test assembly shown in Figure 1. The minimum number of specimens and the tests to which they are to be subjected are listed in Table 2.



Note: This test position qualifies the procedure for all positions. Tests may be performed in other positions which will qualify the procedure for that position only.

Figure 1—Procedure Qualification Test Assembly

2.6.2 TENSILE TESTS

2.6.2.1 Preparation

tensile tests, the specimens from groove welds (see Figure 3) should be approximately 1 inch (25 millimeters) wide and at least 6 inches (152 millimeters) long. They may be machine or oxygen cut, and if necessary, the specimens are to be machined so that the sides are smooth and parallel. The specimens are to be flattened at room temperature before testing, and the backing material may be removed before the flattening.

2.6.2.2 Method of Testing

The tensile-strength specimens shall be broken under tensile load, using equipment capable of measuring the load at which failure occurs. The tensile strength shall be computed by dividing the maximum load at failure by the smallest cross-sectional area of the specimen, as measured before the load is applied.

2.6.2.3 Acceptance Criteria

The tensile strength of the weld, including the fusion zone of each specimen, shall be greater than or equal to the specified minimum tensile strength of the parent material, but the tensile strength of the weld does not have to be greater than or equal to the actual tensile strength of the parent material. If the specimen breaks outside of the weld and fusion zone

Table 1—Filler Metal Groups

Group[a]	AWS Specification[b]	Electrode
1	A5.1	E6010, E6011
	A5.5	E7010, E7011
2	A5.5	E8010, E8011
3	A5.1 or A5.5	E7015, E7016, E7018
	A5.5	E8015, E8016, E8018
4	A5.18	ER705-2
5	A5.18	ER705-6
6	A5.28	ER805-D2
7	A5.2	RG60
	A5.2	RG65
8	A5.20	E60T-7 or E60T-8
		E70T-1 through E70T-6
		E70T-G

Notes:
1. AWS=American Welding Society.
2. Other electrodes and filler metals may be used but shall require separate procedure qualification.
3. A shielding gas (see 2.4, item h) is to be used with the electrodes in Groups 4, 5, and 6 and with some of those in Group 8 of the referenced AWS specification.
[a]See 2.4, item f.
[b]See 1.4.2.1.

(that is, in parent material) and meets the specified minimum-tensile-strength requirements, the weld shall be accepted. If the specimen breaks in the weld or fusion zone, if its observed strength is greater than or equal to the specified minimum tensile strength of the parent material, and if it meets the requirements for soundness as set forth for the nick-break test (see 2.6.3.3), the weld shall also be accepted. If, however, the specimen breaks below the specified minimum tensile strength of the parent material, then the weld shall be set aside, and a new test weld shall be made.

2.6.3 NICK–BREAK TESTS

2.6.3.1 Preparation

The specimens for the nick-break tests should be approximately 1 inch (25.4 millimeters) wide and at least 6 inches (152 millimeters) long, and the welds should be located approximately in the center of each specimen. Specimens from groove welds are to be prepared as shown in Figure 4 while specimens from fillet welds are to be prepared as shown in Figure 5. The specimens may be machine or oxygen cut, and they are to be notched on each side to about an ¼-inch (3.17-millimeter) depth. A hand or machine cutting tool should be used to notch the specimens. Thermal cutting should not be used.

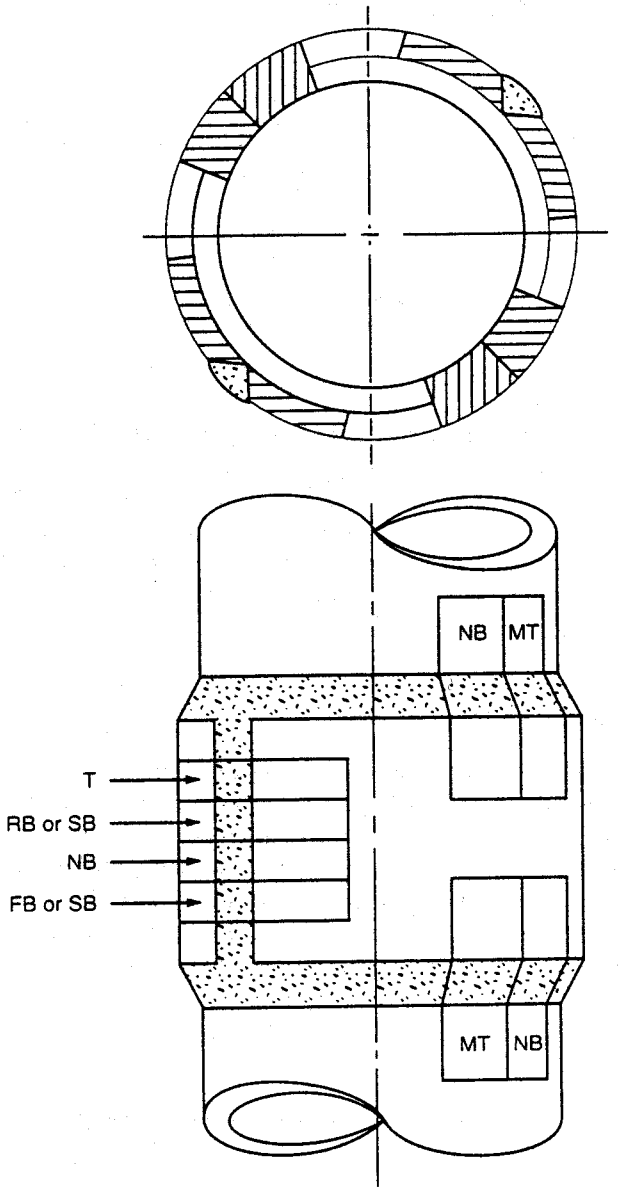
The nick-break specimens prepared from welds made with certain processes may fail through the piping material instead of through the weld. When previous testing experience indicates that failures through the piping material are to be expected, the external reinforcement may be notched to a depth not to exceed 1/16 inch (1.59 millimeters) measured from the original weld surface. As explained earlier, notching should be done with a hand or machine cutting tool. At the option of the company, the nick-break specimens may be macroetched before they are nicked.

2.6.3.2 Method of Testing

A nick-break-test specimen may be broken by pulling it in a tensile machine, by supporting its ends and striking its center, or by supporting one end and striking the other end with a hammer. The specimen may be flattened at room temperature before breaking. The exposed area of the fracture should be at least ¾ inch (19 millimeters) wide.

2.6.3.3 Acceptance Criteria

The exposed surfaces of each nick-break-test specimen should show complete penetration and fusion. The greatest dimension of any gas pocket should not exceed 1/16 inch (1.59 millimeters), and the combined areas of all of the gas pockets should not exceed 2 percent of the exposed surface area. Slag inclusion should not exceed a depth of ½ inch (0.79 millimeter) or a length of ¼ inch (3.17 millimeters), or one half the nominal wall thickness, whichever is smaller. There



Note: T=tensile; RB=root bend; FB=face bend; NB=nick break; SB=side bend; MT=macro test.

Figure 2—Location of Test Specimens—Maintenance Welding Procedure Qualification Test

should be at least ½ inch (12.7 millimeters) of sound weld metal between adjacent slag inclusions. The dimensions should be measured as shown in Figure 6.

2.6.4 ROOT– AND FACE–BEND TESTS

2.6.4.1 Preparation

The specimens for the root-bend and face-bend tests (shown in Figure 7) are to be approximately 1 inch (25.4 millimeters) wide and at least 6 inches (152 millimeters)

Table 2—Type and Number of Test Specimens—Procedure Qualification Test

Wall Thickness	Weld Type	Number of Specimens						
		Tensile	Nick Break	Root Bend	Face Bend	Side Bend	Macro Test	Total
≤½ inch	Groove	2	2	2	2			8
	Fillet		4[a]				4	8
>½ inch	Groove	2	2			4		8
	Fillet		4[a]				4	8

[a]At the owner's option, these specimens may be submitted to the macro-section test (see 2.6.6) before they are submitted to the nick-break test.

long; the long edges should be slightly rounded. The specimens may be machine or oxygen cut, and the cover and root-bead reinforcements are to be removed flush with the surfaces of the specimens. These surfaces should be smooth; any scratches which exist should be light and transverse to the weld. The specimen may be flattened at room temperature before testing.

2.6.4.2 Method of Testing

The specimens are to be bent in a guided bend test jig similar to the one shown in Figure 8. Each specimen is placed on the die with the weld at mid-span. Face-bend specimens should be placed with the face of the weld directed toward the gap, and root-bend specimens should be placed with the root of the weld directed toward the gap. The plunger is forced into the gap until the specimen is approximately U shaped.

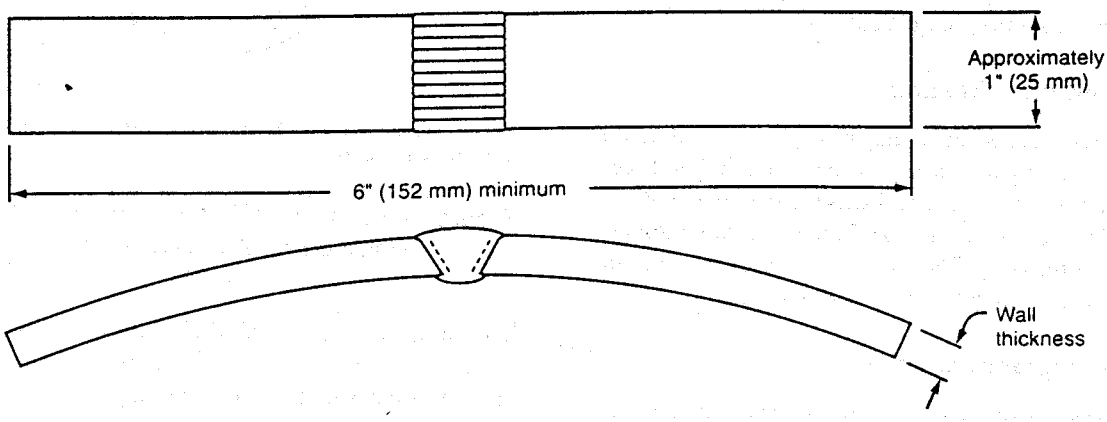
2.6.4.3 Acceptance Criteria

After bending, the bend test result shall be considered acceptable if, in any direction, no crack or other defect exceeding ⅛ inch (3.17 millimeters) or exceeding one half the nominal wall thickness, whichever is smaller, is present in the weld or between the weld and the fusion zone. Cracks that originate on the outer radius of the bend along the edges of the specimen during testing and that are less than ¼ inch (6.35 millimeters), measured in any direction, shall not be considered unless obvious defects are observed. Each specimen subjected to the bend test shall meet these requirements.

2.6.5 SIDE-BEND TESTS—GROOVE WELDS

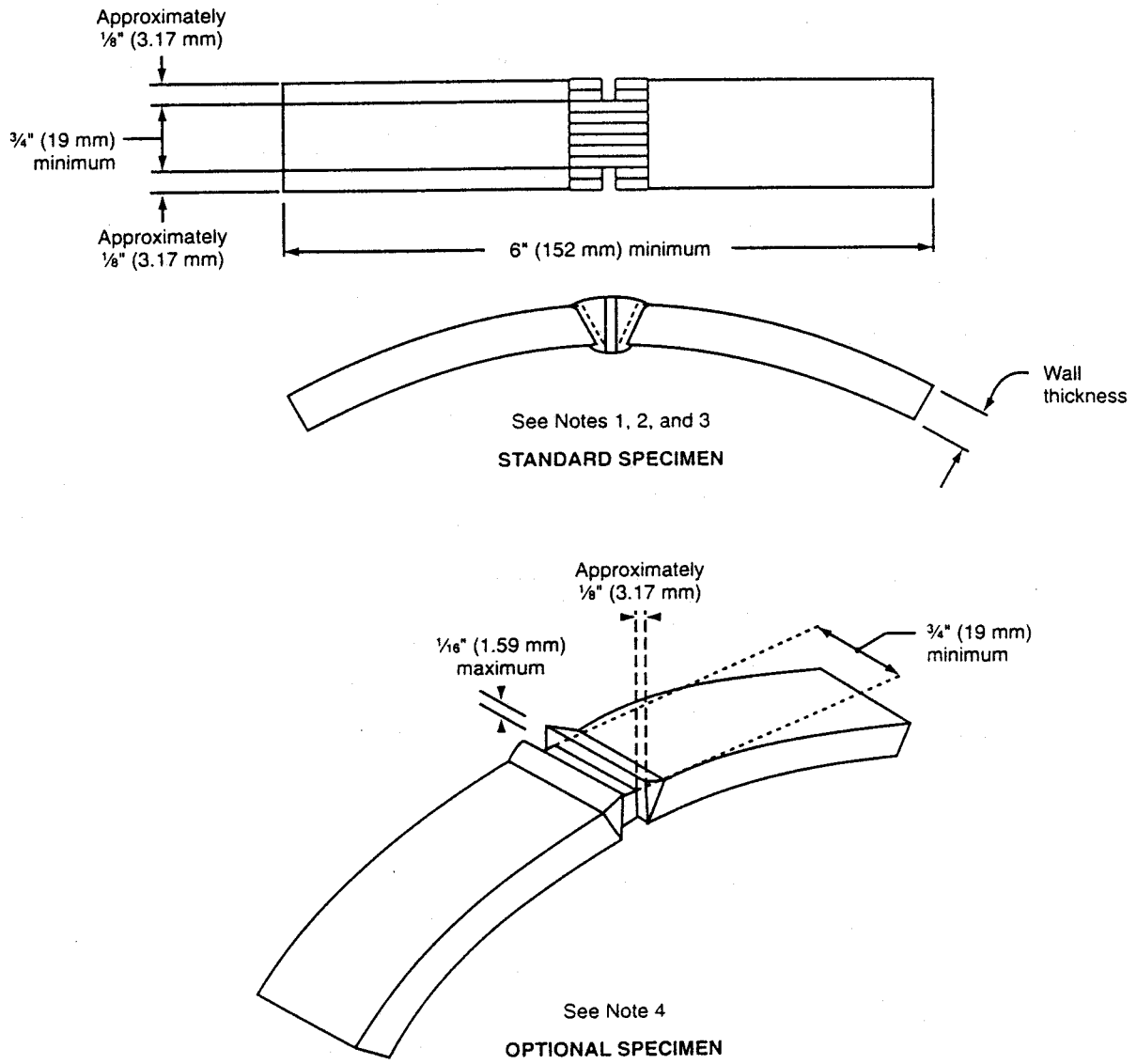
2.6.5.1 Preparation

The specimens for the side-bend tests (see Figure 9) are to be approximately ½ inch (12.7 millimeters) wide and at least



Notes:
1. The specimen may be machine or oxygen cut. Its edges shall be parallel and smooth.
2. The weld reinforcement should not be removed on either side of the specimen.
3. The specimen may be flattened at room temperature.
4. The backing material may be removed before flattening.

Figure 3—Tensile-Test Specimen—Groove Welds



Notes:
1. The specimen may be machine or oxygen cut. Its edges shall be parallel and smooth.
2. The weld reinforcement should not be removed on either side of the specimen.
3. The notch shall be cut using a saw or milling cutter.
4. The sides shall be notched as shown in the optional specimen, and the cap shall be welded. The transverse notch is not to exceed 1/16 inch (1.59 millimeters) in depth.

Figure 4—Nick-Break-Test Specimens—Groove Welds

6 inches (152 millimeters) long, and the long edges are to be slightly rounded. The specimens are to be machine or oxygen cut to approximately a ¾-inch (19-millimeter) width and are to be flattened at room temperature. After flattening, the specimens are to be machined or ground to a ½-inch (12.7-millimeter) width; the sides are to be made smooth and parallel. The cover and root-bead reinforcements are to be removed flush with the surfaces of the specimens.

2.6.5.2 Method of Testing

The specimens are to be bent in a guided bend test jig similar to the one shown in Figure 8. Each specimen is placed on the die with the weld at mid-span and the face of the weld at 90 degrees to the gap. The plunger is forced into the gap until the specimen is approximately U shaped.

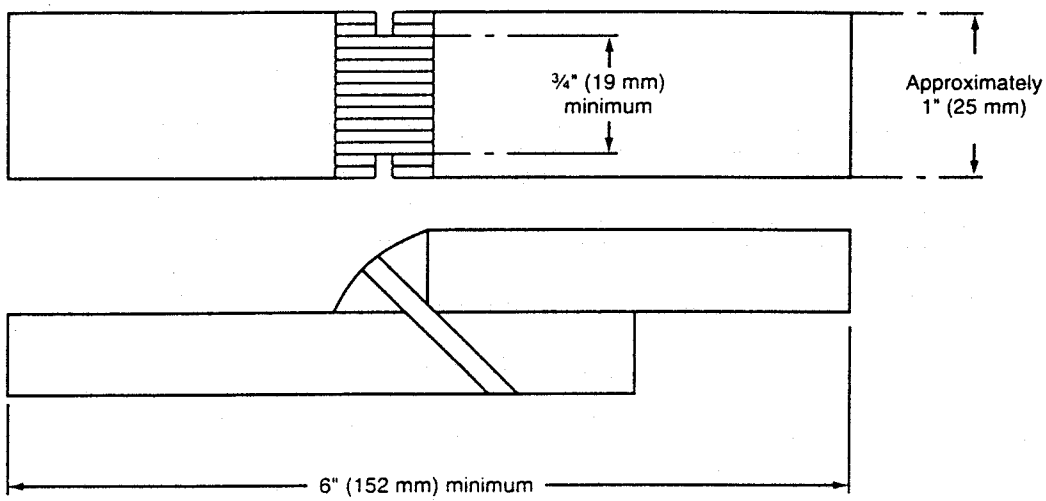
2.6.5.3 Acceptance Criteria

Each specimen should meet the root- and face-bend-test acceptance criteria (see 2.6.4.3).

2.6.6 MACRO–SECTION TESTS—FILLET WELDS

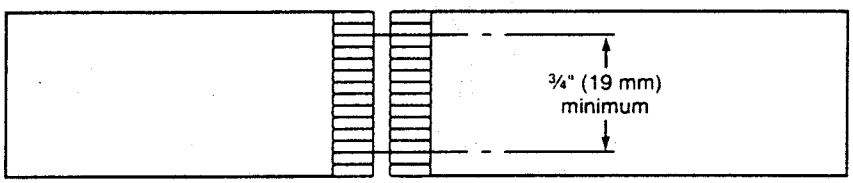
2.6.6.1 Preparation

The specimens for the macro-section test (see Figure 10) are to be at least 1 inch (25 millimeters) wide and long



See Notes 1 and 2

STANDARD SPECIMEN



See Note 3

OPTIONAL SPECIMEN

Notes:
1. The specimen may be notched $\frac{1}{8}$ inch (3.17 millimeters) deep.
2. The notch shall be cut using a saw or milling cutter.
3. The transverse notch is not to exceed $\frac{1}{16}$ inch (1.59 millimeters) in depth.

Figure 5—Nick-Break-Test Specimens—Fillet Welds

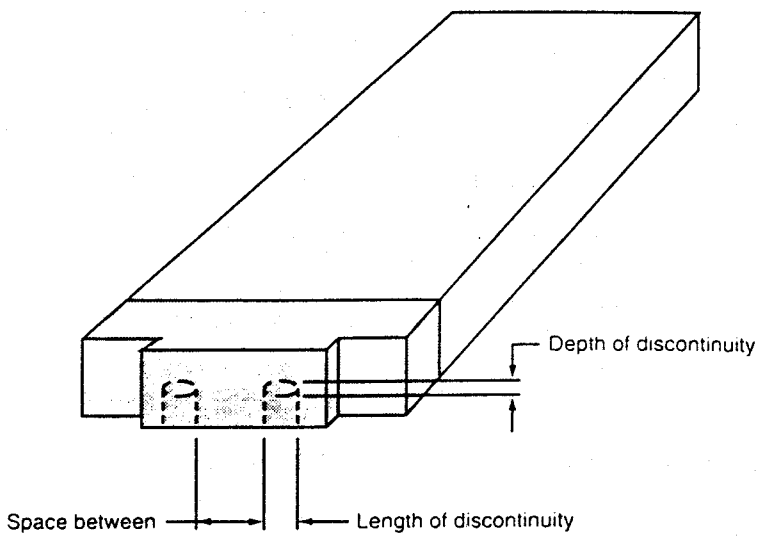
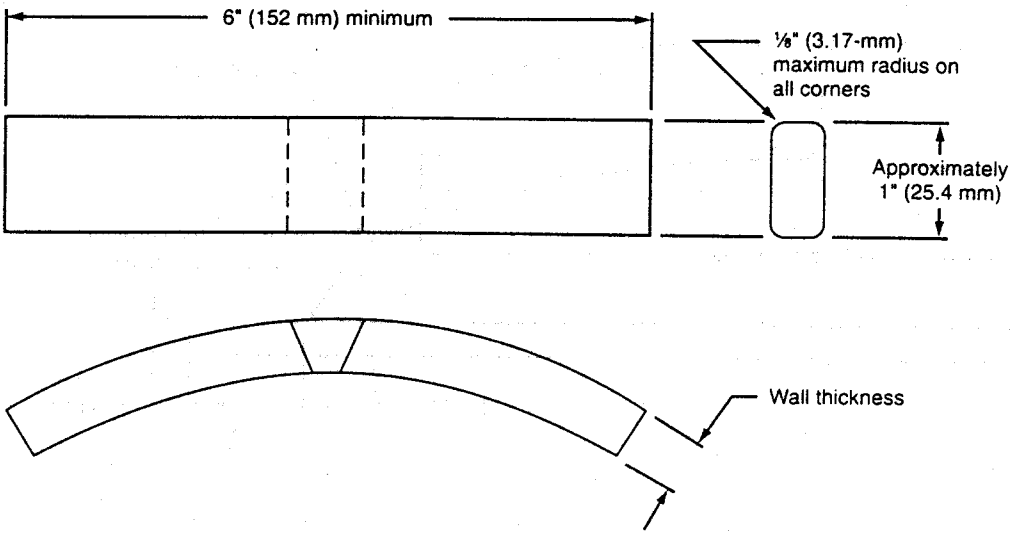
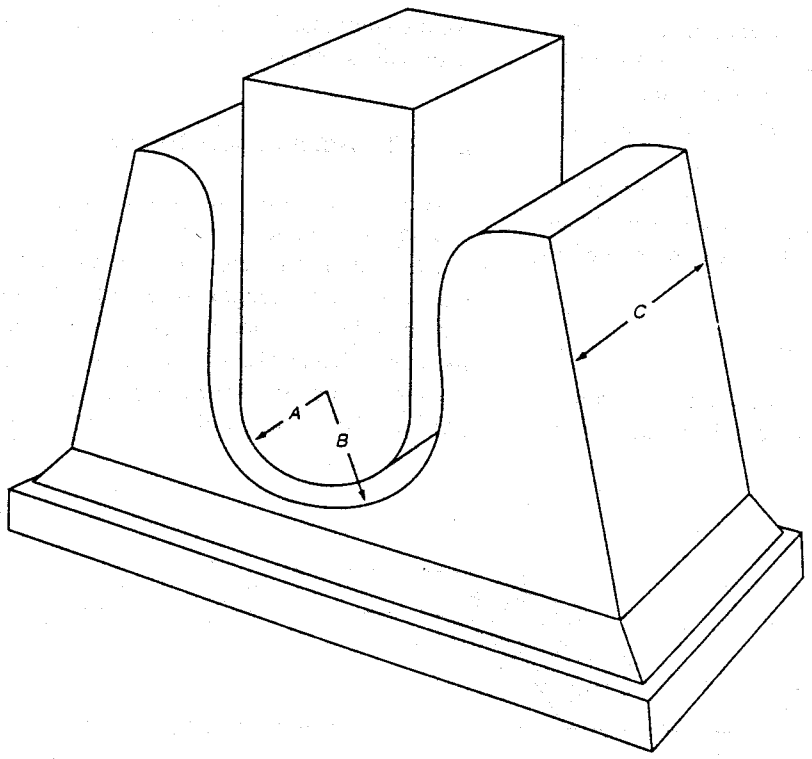


Figure 6—Dimensioning of Discontinuities in Weld Specimens



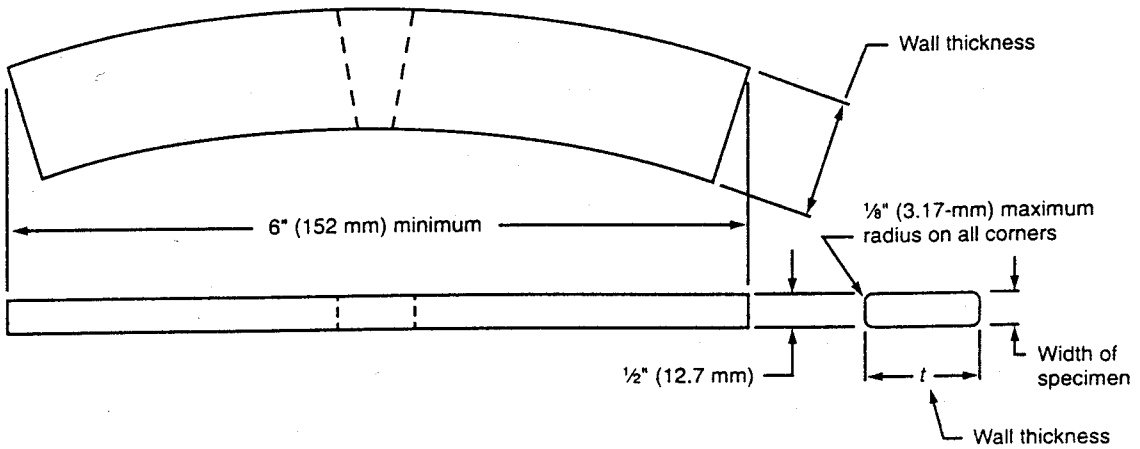
Notes:
1. The specimen may be machine or oxygen cut.
2. The weld reinforcement shall be removed from both faces flush with the surface of the specimen.
3. The specimen may be flattened at room temperature before testing.

Figure 7—Root-Bend- and Face-Bend-Test Specimens—Groove Welds



Notes:
1. Radius of plunger: A=1 7/16 inches (44.45 millimeters); radius of die: B=2 5/16 inches (58.74 millimeters); width of die: C=2 inches (50.8 millimeters).
2. Figure is not to scale.

Figure 8—Jig for Guided Bend Test



Notes:
1. The weld reinforcement shall be removed from both faces flush with the surface of the specimen.
2. The specimen may be machine cut to a ½-inch (12.7-millimeter) width, or it may be oxygen cut to approximately a ¾-inch (19-millimeter) width and then machined or ground smooth to a ½-inch (12.7-millimeter) width. The cut surfaces shall be smooth and parallel.
3. The specimen may be flattened at room temperature.

Figure 9—Side-Bend-Test Specimen—Groove Welds

enough to assure that the welds can be examined. For each specimen, at least one face of each cross section is to be ground smooth and etched with a suitable etchant, such as ammonium persulfate or hydrochloric acid, to give clear definition to the structure of the weld.

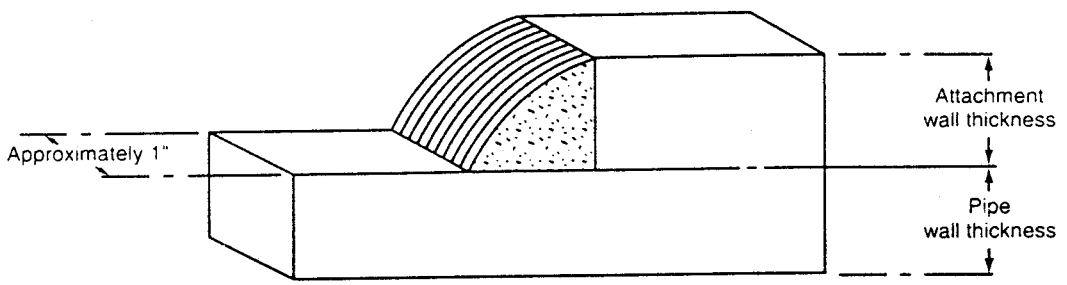
In lieu of taking special specimens for macro examinations, the nick-break specimens may be used. Nick-break spe ıens used for this purpose are to be examined before they are nicked.

2.6.6.2 Method of Examination

The cross section of the weld is to be visually examined with lighting that will sufficiently reveal the details of the weld soundness. The use of optic devices or dye penetrating materials is not necessary.

2.6.6.3 Acceptance Criteria

A visual examination of the cross section of the weld should show that it is completely fused at the root and free of cracks. The fillet weld should have leg lengths that are at least equal to the lengths specified in the procedure specification and should not deviate in concavity or convexity by more than 1/16 inch (1.59 millimeters). The depth of the undercutting should not exceed 1/32 inch (0.79 millimeter) or 12½ percent of the piping wall thickness, whichever is smaller.



Note: Smooth and etch at least one face of each weld specimen cross section with suitable etchant to give a clear definition to the weld structure.

Figure 10—Macro-Test Specimen—Fillet Welds

SECTION 3—WELDER QUALIFICATION

3.1 Purpose

The welder qualification test is meant to determine whether a welder has the ability to make sound welds using a previously qualified welding procedure. Before any maintenance welding is performed, a welder must be qualified in accordance with the applicable requirements of 3.1 to 3.6 of API Standard 1104 or 3.2 to 3.5 of this recommended practice. Welder qualification for circumferential butt welds shall be in accordance with API Standard 1104.

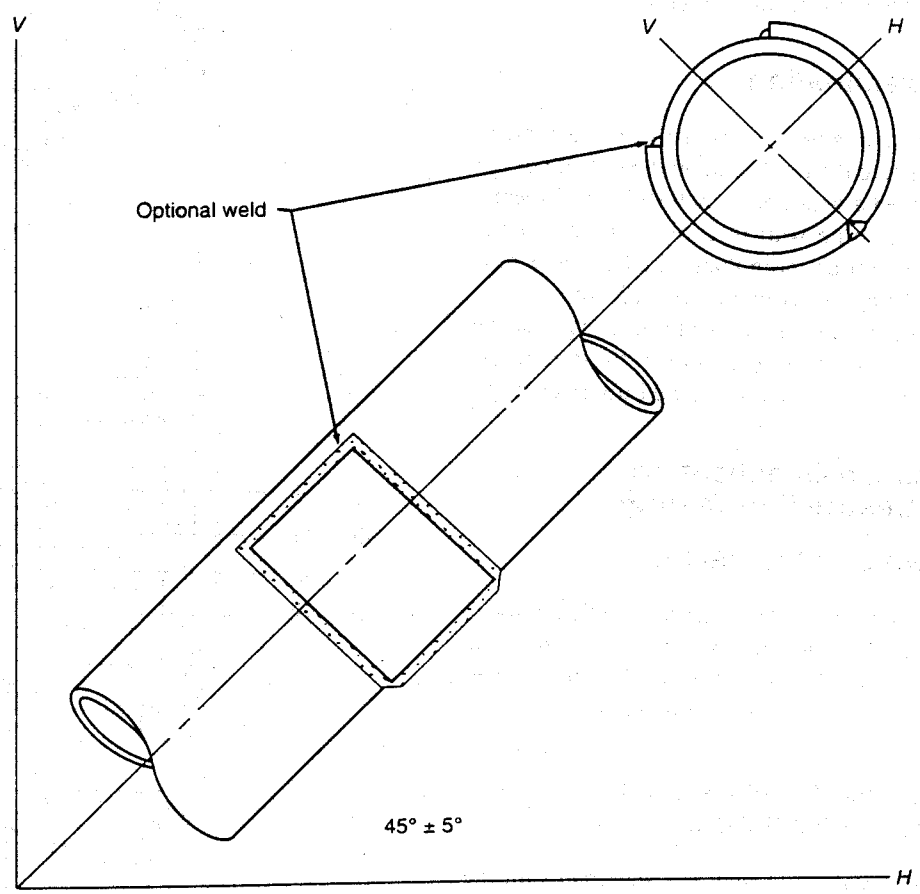
A welder who successfully welds a test assembly for a procedure qualification test is qualified for that procedure within the range of essential variables which govern welder qualification. Before starting the qualification tests, the welder should be allowed reasonable time to adjust the welding equipment used in the test. The welder is to use the same welding technique and to proceed with the same speed that he will use if he passes the test and is permitted to weld. The qualification of a welder is to be conducted in the presence of a company representative.

3.2 Welding of Test Assembly

A welder qualifying in accordance with this recommended practice is to weld a test assembly similar to the one shown in Figure 1 or 11. The essential variables associated with maintenance welding procedure qualification and welder qualification are not identical. Welder qualification is a function of certain essential variables which are set forth in 3.3.

3.3 Essential Variables for Welder Qualification

If any of the following essential variables occur, the welder using the new procedure is to be requalified.



Note: This test position qualifies the welder for all positions. Tests may be performed in other positions which will qualify the welder for that position only.

Figure 11—Welder Qualification Test Assembly

a. A change from one welding process or combination of processes to any other welding process or combination of processes.
b. A change in the direction of welding from vertical up to vertical down or vice versa.
c. A change in the filler metal classification from either Group 1 or Group 2 to Group 3 or from Group 3 to either Group 1 or Group 2 (see Table 1).
d. A change in the diameter group. A welder qualified on pipe having an outside diameter of less than 12¾ inches (323.8 millimeters) shall be qualified for all diameters less than or equal to the diameter used in his qualification test. A welder qualified on pipe having an outside diameter of greater than or equal to 12¾ inches (323.8 millimeters) shall be qualified on all pipe diameters.
e. A change in the nominal material wall thickness from one group to another. Some suggested thickness groups are as follows:
1. Less than 3/16 inch (4.78 millimeters).
2. From 3/16 inch to ¾ inch (4.76 millimeters to 19.05 millimeters).
3. Greater than ¾ inch (19.05 millimeters).

3.4 Visual Examination

The weld is to present a neat, workmanlike appearance. Undercutting adjacent to the final bead on the outside of the pipe should not exceed a depth of 1/32 inch (0.79 millimeter) or 12½ percent of the pipe wall thickness, whichever is smaller; there should not be more than 2 inches (50.8 millimeters) of undercutting in any continuous 12-inch (304.8-millimeter) length of weld or in one sixth the length of the weld, whichever is smaller. Failure to meet these requirements is sufficient cause for eliminating additional testing.

3.5 Performance Qualification Tests—Destructive Testing

3.5.1 SAMPLING OF TEST WELDS

Test specimens are to be cut from the test assembly locations shown in Figure 12. The type and minimum number of specimens are given in Table 3. Before testing, test specimens are to be air cooled to ambient temperature.

3.5.2 TENSILE-, NICK-BREAK-, AND BEND-TEST PROCEDURES

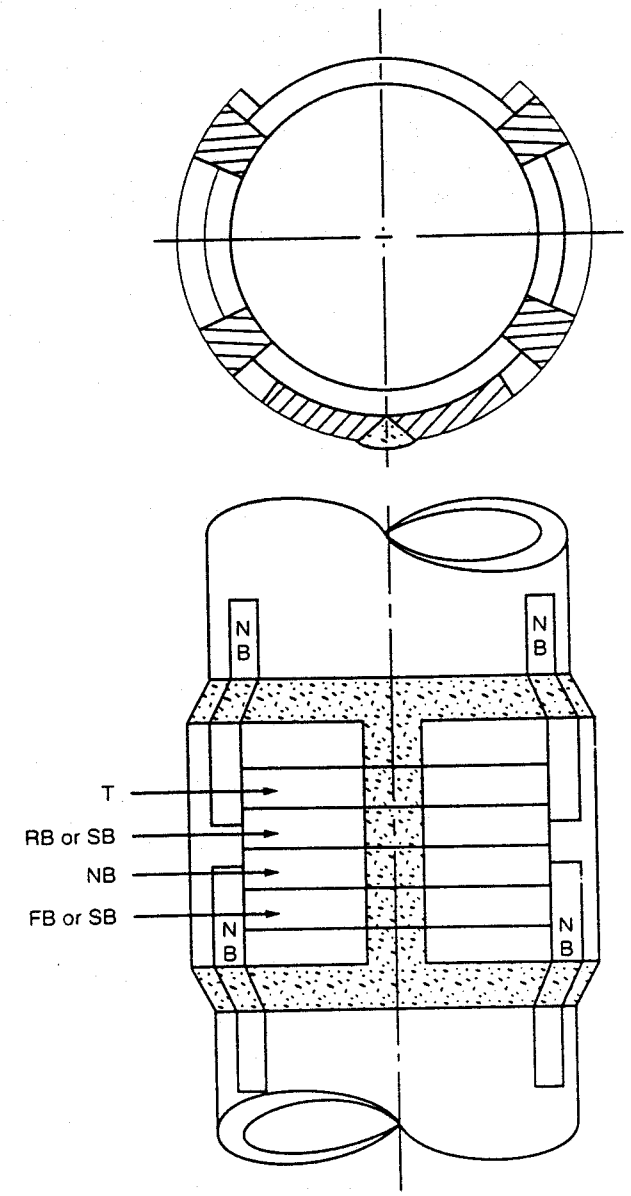
The tensile-, nick-break-, and bend-test specimens for the procedure qualification tests are to be prepared, and the tests are to be made as described in 2.6.2 through 2.6.5. The tensile tests may be omitted; if they are omitted, the specimens designated for the tests are to be subjected to the nick-break tests.

3.5.2.1 Tensile–Test Acceptance Criteria—Groove Welds

Each tensile-test specimen should meet the acceptance criteria for tensile tests, which are provided in 2.6.2.2. If any specimen fails to meet those criteria, the welder is disqualified.

3.5.2.2 Nick–Break–Test Acceptance Criteria

If any nick-break-test specimen shows defects exceeding those allowed by the acceptance criteria for nick-break tests provided in 2.6.3.3, the welder is disqualified.



Note: T=tensile; RB=root bend; FB=face bend; NB=nick break; SB=side bend.

Figure 12—Location of Test Specimens—Maintenance Welder Qualification Test

Table 3—Type and Number of Test Specimens—Welder Qualification Test

Wall Thickness	Weld Type	Number of Specimens					
		Tensile	Nick Break	Root Bend	Face Bend	Side Bend	Total
≤½ inch	Groove	1	1	1	1		4
	Fillet		4[a]				4
>½ inch	Groove	1	1			2	4
	Fillet		4[a]				4

[a]At the owner's option, these specimens may be submitted to the macro-section test (see 2.6.6) before they are submitted to the nick-break test.

3.5.2.3 Bend–Test Acceptance Criteria—Groove Welds

If any bend-test specimen shows defects exceeding those allowed by the acceptance criteria for root- and face-bend tests provided in 2.6.4.3 or for side-bend tests provided in 2.6.5.3, the welder is disqualified. It should be noted, though, that a weld in high-test pipe (API Specification 5L, Grades X42 and above) may not bend to the full U shape. A weld in high-test pipe is considered acceptable if the cracked specimen is broken apart and its exposed surface meets the nick-break-test acceptance criteria in 2.6.3.3.

If a bend-test specimen fails to meet these criteria and, in the opinion of the company representative, is not representative of the weld, the bend-test specimen may be replaced by an additional specimen cut adjacent to the one that failed. The welder is disqualified if the additional specimen also shows defects exceeding the specified limits.

3.5.3 MACRO–SECTION–TEST PROCEDURES AND TEST ACCEPTANCE CRITERIA—FILLET WELDS

The macro-section-test specimens are to be prepared and examined as described in 2.6.6.1 and 2.6.6.2. If any macro-section-test specimen does not meet the acceptance criteria in 2.6.6.3, the welder is disqualified.

3.6 Retest

If, in the opinion of the company, the failure of a welder to pass the test was because of unavoidable conditions or conditions beyond his control, the welder may be given a second opportunity to qualify. No further retests need to be given until the welder has submitted proof of subsequent welder training that is acceptable to the company.

3.7 Records of Qualified Welders

A record is to be made of the tests given to each welder and of the detailed results of each test. This record should be developed to suit the needs of the individual company and should be sufficiently detailed to demonstrate that the qualification test embodied the various requirements prescribed by this recommended practice. A list of qualified welders and the procedures in which they are qualified is to be maintained. A welder may be required to requalify if there is a question about his ability.

SECTION 4—SUGGESTED MAINTENANCE WELDING PRACTICES

4.1 General

For the pipe welding to be in accordance with this recommended practice, the welding is to be performed by qualified welders using qualified procedures. The surfaces to be welded are to be smooth; uniform; and free of laminations, tears, scale, slag, grease, paint, and other deleterious material which might adversely affect the welding. The joint design is to be in accordance with the welding procedure to be used.

Before welding on a piping system which is being or has been used for the compression, pumping, transmission, or distribution of crude petroleum, petroleum products, or fuel gases, welders should consider aspects that affect safety, such as operating pressure, flow conditions, and wall thickness at the location of the welding. All welders performing repair work shall be familiar with the safety precautions associated with cutting and welding on piping that contains or has contained liquid petroleum or fuel gases.

Particular consideration should be given to the fillet weld used to join a sleeve to a carrier pipe because the fillet weld is prone to underbead or delayed hydrogen cracking. With welds on pressurized and flowing piping systems, success has been achieved using low-hydrogen welding processes or electrodes with appropriately high-heat input that slows the cooling rate. The use of low-hydrogen electrodes requires that special attention be given to electrode care and handling requirements. The cracking process is related to the hydrogen absorbed by the hot weldment. A slow cooling rate is

necessary to permit diffusion and elimination of the hydrogen. Proper attention should be given to fit up and to the carbon equivalent factor and chemical composition of both the sleeve and the carrier pipe.

4.2 Alignment

4.2.1 OFFSET

The offset between the abutting edges for groove welds should not exceed 1/16 inch (1.59 millimeters). To obtain this alignment, devices should be used, or misaligned surfaces can be built up with weld metal.

4.2.2 ROOT OPENING (COMPLETE ENCIRCLEMENT FITTINGS)

The root opening, the space between the abutting surfaces, should be sufficient to permit 100 percent penetration. Joints paralleling the axis of the carrier pipe may be fitted with a suitable tape or mild steel backup strip to prevent the weld metal from being fused to the surface of the carrier pipe.

4.3 Bevels

Edges of the pieces to be joined may be beveled by a machine tool or may be cut by an oxygen cutting process. The beveled edges are to be smooth and uniform with dimensions conforming to the procedure specification.

4.4 Weather Conditions

Welding shall not be done when the quality of the completed weld would be impaired by the prevailing weather conditions. Weather conditions that would cause impairment include, but are not limited to, airborne moisture, blowing sands, and high winds. Windshields may be used when practical. The company representative decides if weather conditions are suitable for welding.

4.5 Clearance

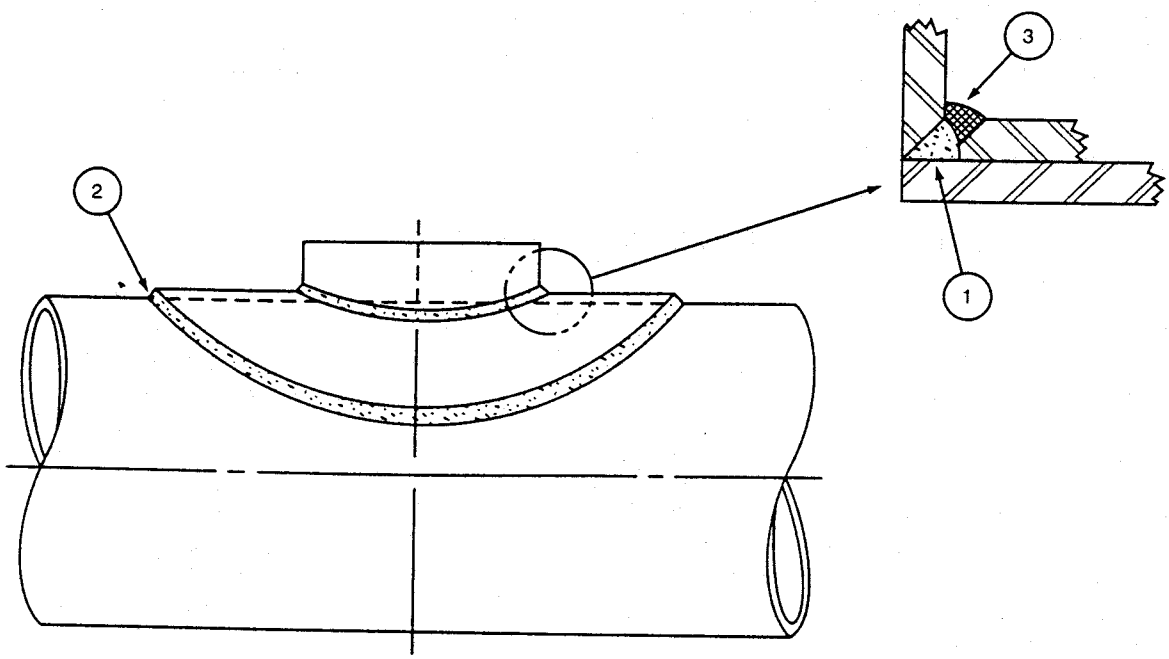
When bell holes are used, they should be large enough to provide the welder or welders with ready access to the work.

4.6 Cleaning

Weld slag, scale, and spatter should be removed from each weld bead and the adjacent base metal.

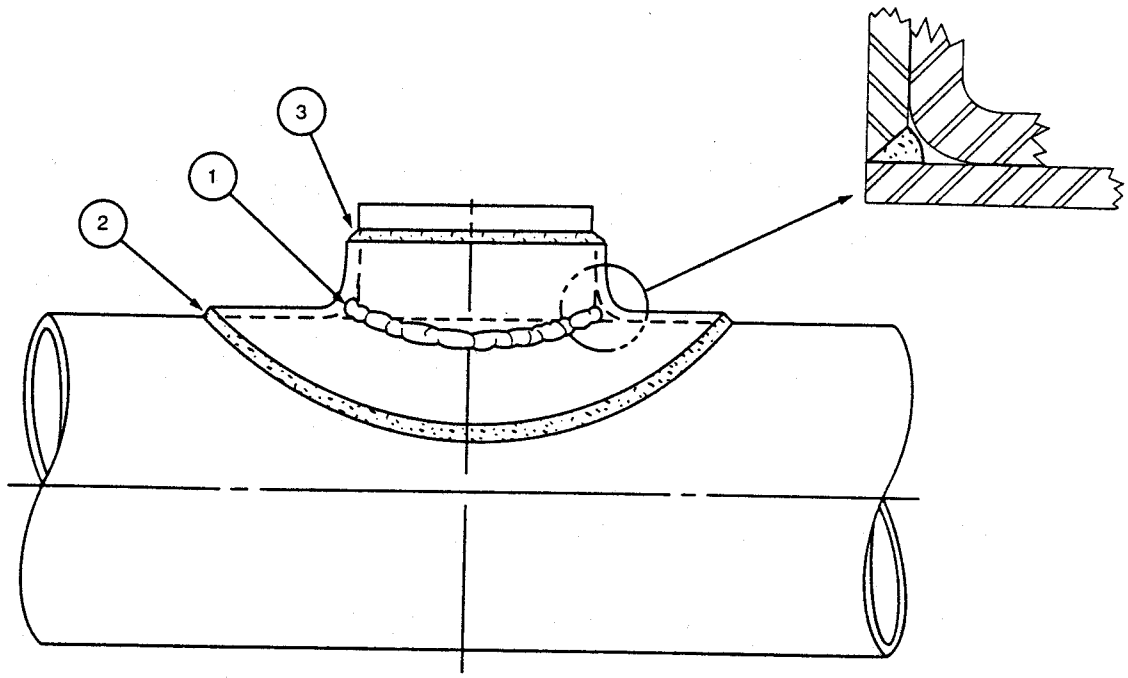
4.7 Welding Sequence

Suggested welding sequences for the welding of fittings are shown in Figures 13 through 18.



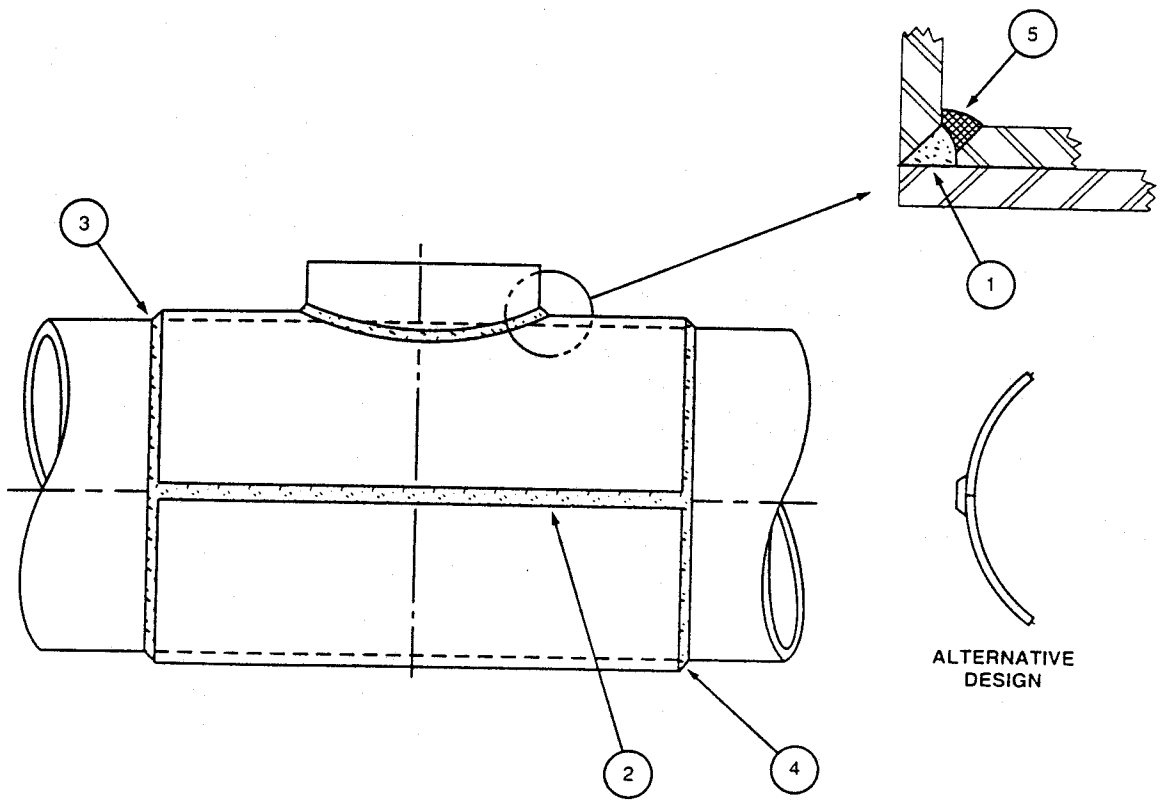
Note: This is the suggested welding sequence; others may be followed at the discretion of the company.

Figure 13—Reinforcing Pad



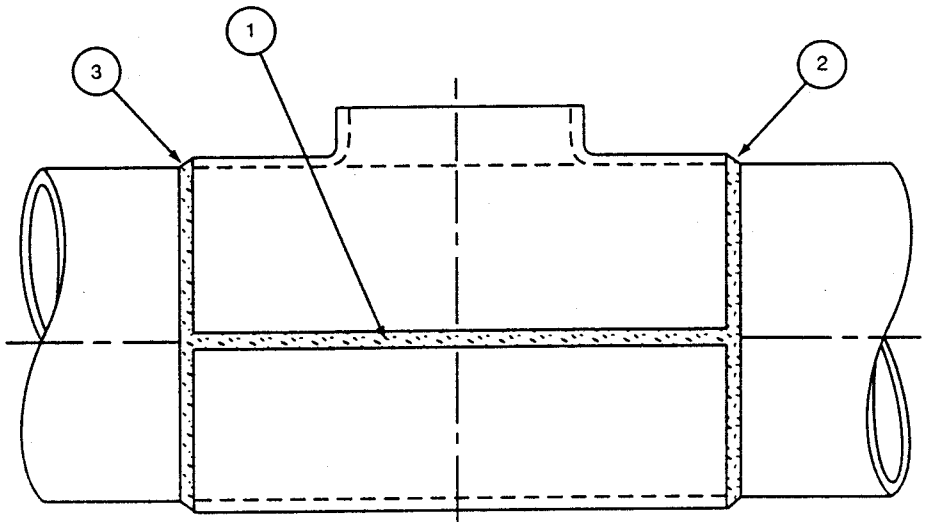
Note: This is the suggested welding sequence; others may be followed at the discretion of the company.

Figure 14—Reinforcing Saddle



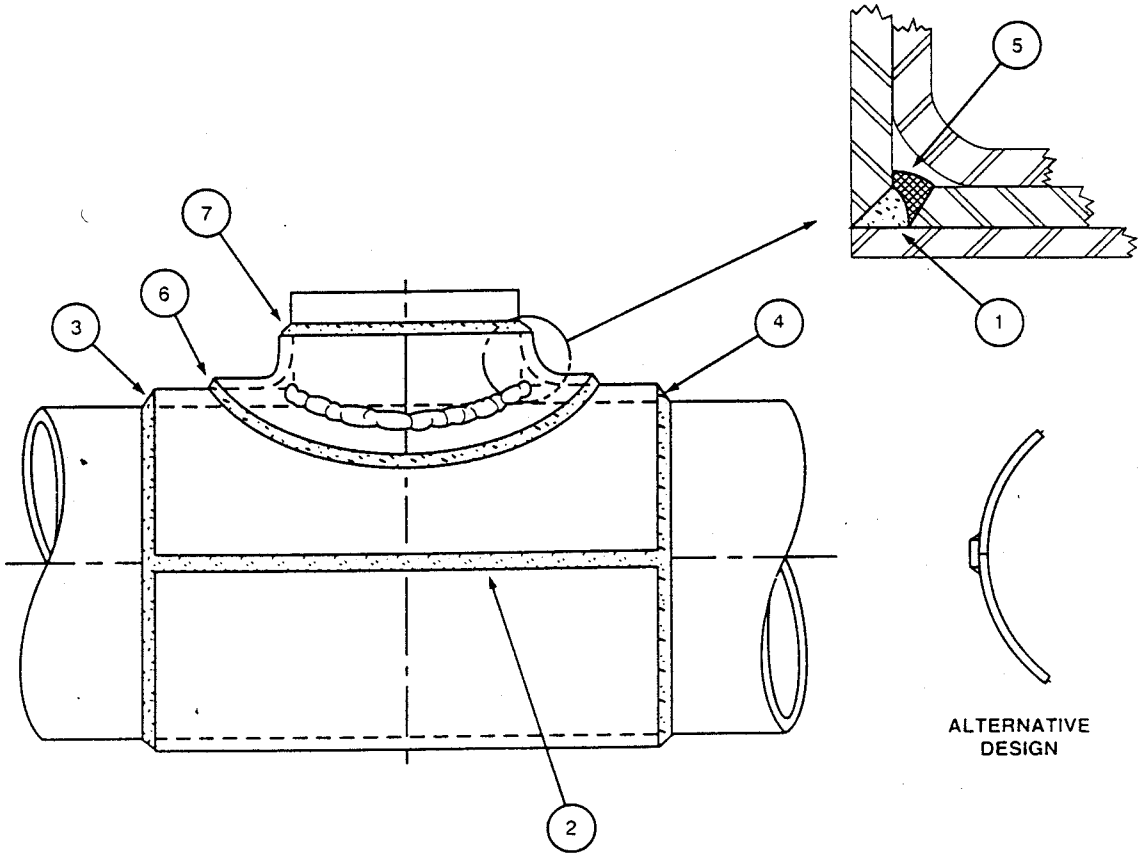
Note: This is the suggested welding sequence; at the discretion of the company, others may be followed and circumferential welds numbers 3 and 4 need not be made.

Figure 15—Encirclement Sleeve



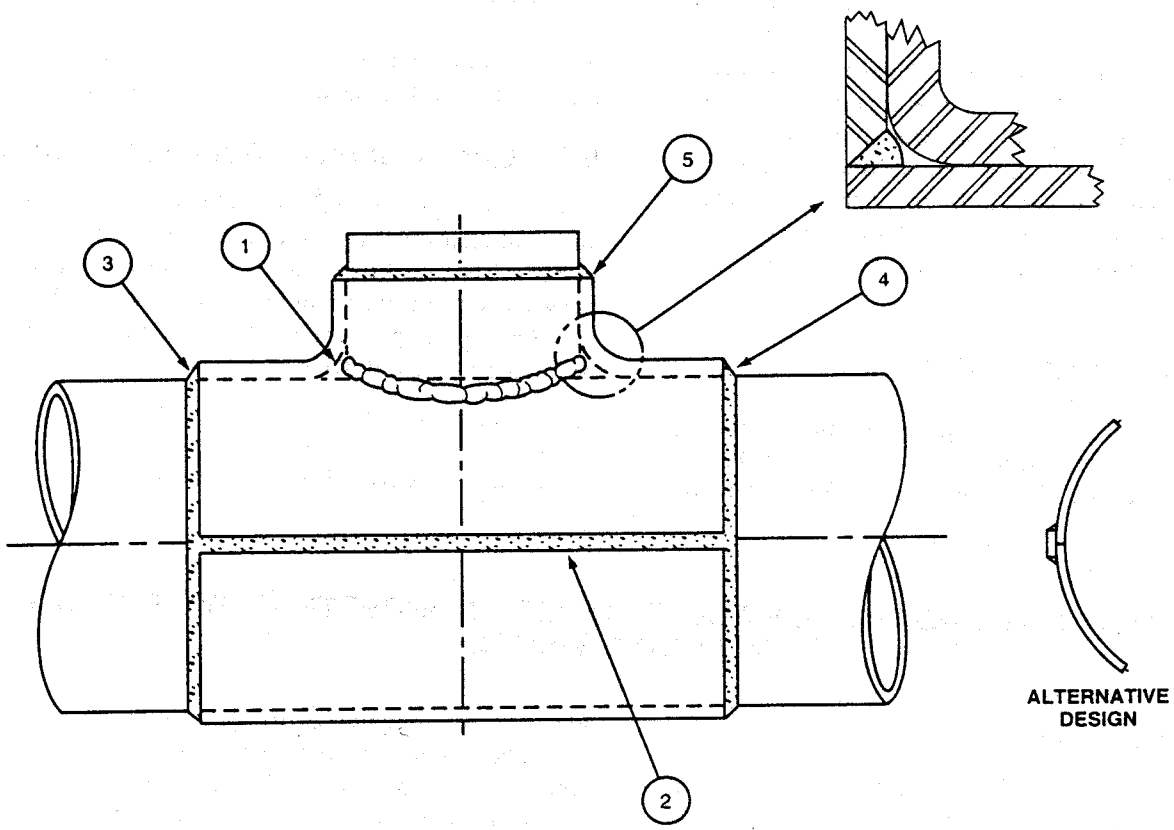
Notes:
1. This is the suggested welding sequence; others may be followed at the discretion of the company.
2. When in operation, the fitting is at pipeline pressure.

Figure 16—Encirclement Tee



Note: This is the suggested welding sequence; at the discretion of the company, others may be followed and circumferential welds 3 and 4 need not be made.

Figure 17—Encirclement Sleeve and Saddle



Note: This is the suggested welding sequence; others may be followed at the discretion of the company.

Figure 18—Encirclement Saddle

SECTION 5—INSPECTION AND TESTING OF MAINTENANCE WELDS

5.1 Right of Inspection

The company has the right to inspect all of the welds by visual and nondestructive testing methods. The inspection may be made during and after the completion of the welding. The frequency of inspection shall be as specified by the company.

5.2 Visual Inspection

All welds shall be visually inspected for geometric conformance with the procedure specification and for conformance with Section 6.

5.3 Nondestructive Testing

The company should consider the size, the grade, the operating stress, the location of the piping, the fluid to be transported in it, and the inherent limitations of the nondestructive testing methods when determining the degree of inspection and the methods to be used. One or more nondestructive testing methods may be used in addition to visual inspection.

The nondestructive testing should be done in accordance with Section 8 of API Standard 1104. The welds shall meet the standards provided in Section 6 of this recommended practice.

5.4 Certification of Nondestructive Testing Personnel

5.4.1 PROCEDURES FOR CERTIFYING NONDESTRUCTIVE TESTING PERSONNEL

For the test method to be used, nondestructive testing personnel shall be certified in accordance with the recommendations of ASNT SNT-TC-1A, and only Level II or Level III personnel shall interpret the test results.

5.4.2 RECORD OF CERTIFIED NONDESTRUCTIVE TESTING PERSONNEL

A record of certified nondestructive testing personnel shall be kept by the company, and this record shall include

the results of the certification tests, the agency and person granting the certification, and the date of certification. Nondestructive testing personnel may need to be recertified if there is any question about their ability. Also, at the option of the company, they may need to be recertified at the beginning of a project or construction schedule. In any event, recertification shall be required at least every 3 years.

5.5 Right of Rejection

The company shall have the right to accept or reject any weld that does not meet the requirements of the methods by which it was inspected. The welder who makes a weld that fails to comply with the requirements may be disqualified from further work at the discretion of the company.

5.6 Qualification of Welding Inspectors

Welding inspectors shall be qualified by their experience with and their training in the specific inspection task they perform. Their qualifications shall be acceptable to the company, and documentation of these qualifications shall be retained by the company and shall include, but not necessarily be limited to, the following:

a. Education and experience.
b. Training.
c. Results of any qualification examinations.

SECTION 6—STANDARDS OF ACCEPTABILITY: NONDESTRUCTIVE TESTING (INCLUDING VISUAL)

6.1 Introduction

These standards of acceptability apply to the determination of the size and type of defects located by visual and nondestructive testing. While circumferential and longitudinal butt welds shall meet the standards of acceptability set forth in API Standard 1104, fillet welds shall meet the standards of acceptability set forth in this section.

6.2 Limitations of Test Methods

Since nondestructive testing methods give limited indication, the company may reject welds which appear to meet these standards of acceptability if, in its opinion, the depth of a discontinuity may be detrimental to the weld.

6.3 Incomplete Fusion

Incomplete fusion (IF) is defined as a discontinuity between weld metal and base metal which is open to the external surface. Incomplete fusion shall be unacceptable when any of the following conditions exist:

a. The length of an individual indication of incomplete fusion exceeds 1 inch (25.4 millimeters).
b. The total length of indications of incomplete fusion in any continuous 12-inch (304.8-millimeter) length of weld exceeds 1 inch (25.4 millimeters).
c. The total length of indications of incomplete fusion exceeds 8 percent of the weld length of any weld less than 12 inches (304.8 millimeters) in length.

6.4 Porosity

Porosity (P), including surface porosity, is caused by gas trapped by solidifying weld metal. It is generally spherical but may be elongated or irregular in shape like piping (wormhole) porosity. Surface porosity that occurs on any weld pass and, in the opinion of the company, is excessive shall be removed before the deposition of additional passes. When measuring the size of the radiographic indications that porosity produces, the maximum dimension of the indications shall apply to this acceptance standard.

6.4.1 Porosity shall be unacceptable when any of the following conditions exist:

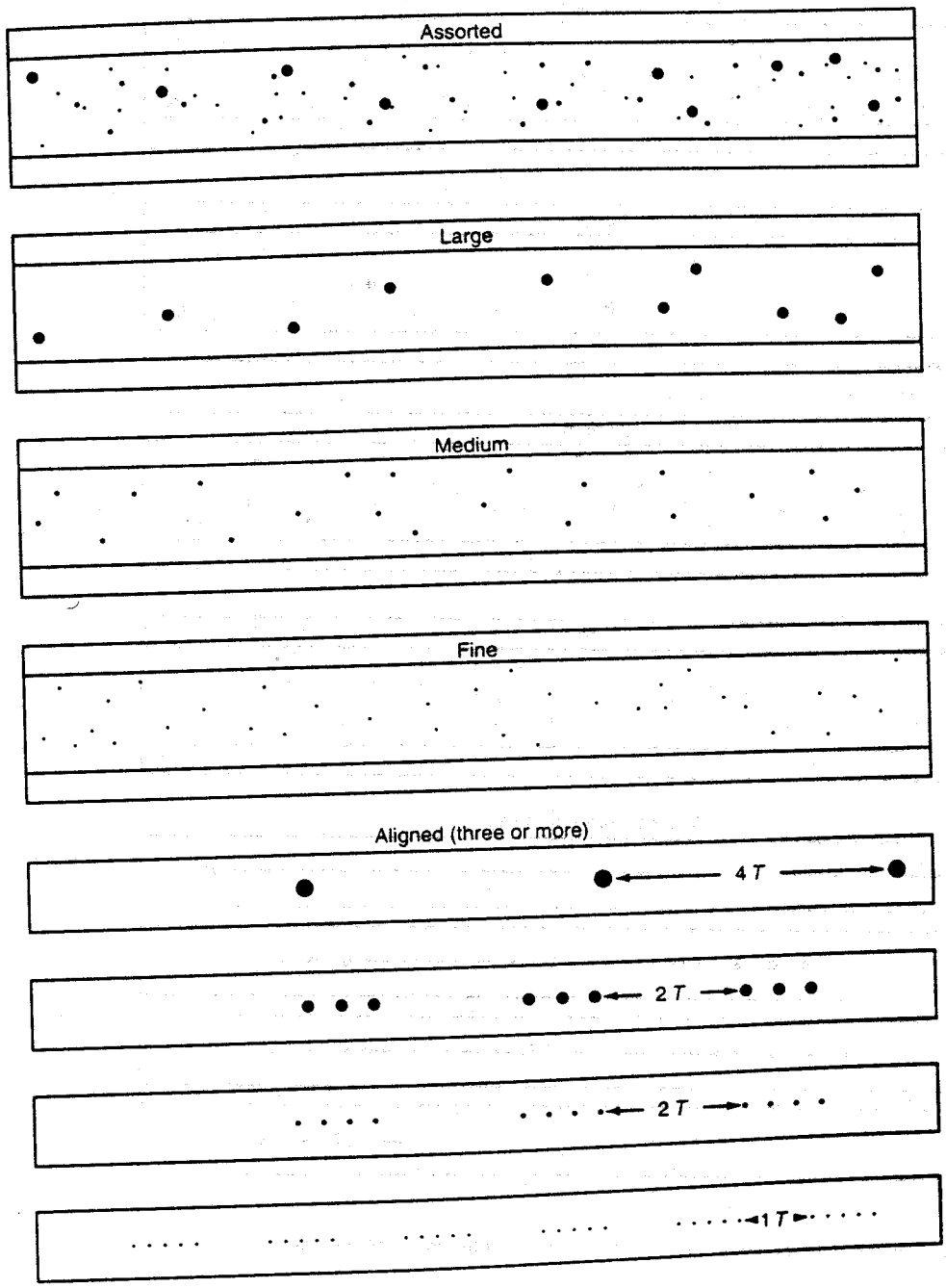
a. The size of an individual pore exceeds $\frac{1}{8}$ inch (3.17 millimeters).
b. The size of an individual pore exceeds 25 percent of the thinnest of the nominal wall thicknesses joined.
c. The distribution of scattered porosity exceeds the concentration permitted by Figure 19 or 20.

6.4.2 Cluster porosity (CP) occurring in any pass except the finish pass shall comply with the requirements of 6.4.1. Cluster porosity occurring in the finish pass shall be unacceptable when any of the following conditions exist:

a. The diameter of the cluster exceeds $\frac{1}{2}$ inch (12.7 millimeters).
b. The total accumulated length of cluster porosity in any continuous 12-inch (304.8-millimeter) length of weld exceeds $\frac{1}{2}$ inch (12.7 millimeters).
c. Any individual pore within a cluster exceeds $\frac{1}{16}$ inch (1.59 millimeters) in size.

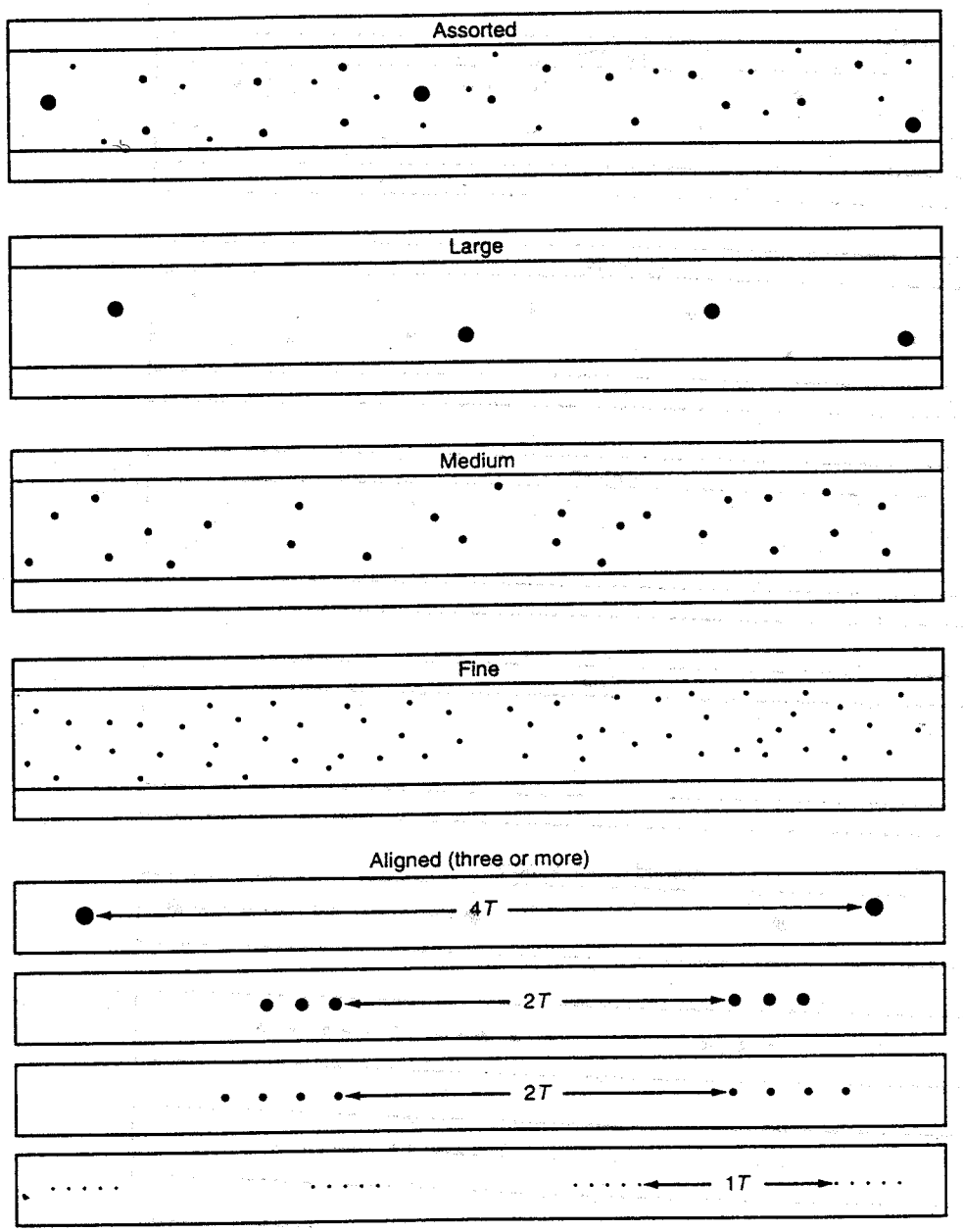
6.5 Cracks

Shallow crater cracks or star cracks which are located at the stopping point of weld beads and which are the result of



Note: The size of the gas pockets is not drawn to scale; for the proper dimensions, see 6.4.1.

Figure 19—Maximum Distribution of Gas Pockets: Wall Thicknesses Less Than or Equal to ½ Inch (12.7 Millimeters)



Note: The size of the gas pockets is not drawn to scale: for the proper dimensions, see 6.4.1.

Figure 20—Maximum Distribution of Gas Pockets: Wall Thicknesses Greater Than ½ Inch (12.7 Millimeters)

weld metal contraction during solidification are not considered injurious defects unless their length exceeds 5/32 inch (3.97 millimeters). With the exception of these shallow crater cracks, no weld containing cracks, regardless of their size or location, shall be acceptable.

6.6 Undercutting

Undercutting is a groove melted into the base metal adjacent to the toe or root of a weld and left unfilled by weld metal. Undercutting adjacent to the cover or root bead shall not exceed the limits specified in Table 4.

Table 4—Undercutting Limits

Depth	Length
Over 1/32 inch (0.79 millimeter) or over 12 1/2 percent of the pipe wall thickness, whichever is smaller	Not acceptable
Over 1/64 inch (0.4 millimeter) through 1/32 inch (0.79 millimeter) or over 6 percent to 12 1/2 percent of the pipe wall thickness, whichever is smaller	2 inches (50.8 millimeters) in a continuous weld of 12 inches (304.8 millimeters) or 1/8 the length of the weld, whichever is smaller
1/64 inch (0.4 millimeter) or 6 percent of the pipe wall thickness, whichever is smaller	Acceptable, regardless of length

SECTION 7—REPAIR OR REMOVAL OF DEFECTS

7.1 Authorization for Repair by Welding

Defects may not be repaired without prior company authorization.

7.2 Removal and Preparation for Repair of Defects

Before any repairs are made, the defects shall be entirely removed to the sound metal, and all slag and scale shall be removed. When conditions require it, preheating should be performed.

7.3 Testing of Repairs

Repaired areas shall be reinspected using the same method that was previously used. Additional inspection methods may also be used.

7.4 Procedure for Repair of Cracks

With the company's authorization, cracks in or adjacent to welds may be repaired if the following conditions exist:

a. The crack is less than 8 percent of the weld length.
b. A complete repair procedure has been developed and documented. The repair procedure shall include the following:
   1. Method of exploration of the crack area.
   2. Method of crack removal.
   3. Preheat and interpass heat requirement.
   4. Welding procedure and type of electrodes.
   5. Post-heat treatment if required.
c. The repair is made under the supervision of a technician experienced in repair welding techniques.
d. The weld is made by a qualified welder.
e. The newly prepared groove is examined by a magnetic particle or liquid penetrant test to assure that the crack is completely removed.

Other cracks are to be eliminated by removing the section of piping containing them.