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Standard Methods for Mechanical Testing of Welds



American Welding Society

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Standard Methods for Mechanical Testing of Welds

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Prepared by
AWS Committee on Mechanical Testing of Welds

Under the Direction of
AWS Technical Activities Committee

Abstract

Eight mechanical test methods that are applicable to welds and welded joints are described. They are recognized as the standard methods for bend, tension, nick break, hardness and fracture toughness testing as well as fillet weld break and shear testing and stud weld testing. For each testing method, information is provided concerning applicable ANSI, ASTM, and API documents; the required testing, apparatus, specimen preparation, procedure to be followed, and report requirements.



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Foreword

(This Foreword is not a part of the ANSI/ AWS B4.0-92, *Standard Methods for Mechanical Testing of Welds*, but is included for information purposes only.)

This standard covers the most common tests for mechanical testing of welds. They are defined and illustrated in four parts related to testing of groove welds, testing of fillet welds, and stud welds. The tests include bend tests, tension tests, nick break tests, hardness tests, fracture toughness tests, fillet weld guided bend tests, fillet weld soundness tests, fillet weld shear tests, and appropriate tests for stud welds.

This document extensively uses American Society for Testing and Materials (ASTM) *Standard Methods* and specifies how to use these methods when testing weldments. It takes into consideration the variations in properties that can occur between different regions (base metal, heat-affected zone and weld metal) of a weldment.

Methods of hardness testing and mechanical property tests for base metals are covered by ASTM standards or the individual material specification. The joint tests for brazements are covered in AWS C3.2, *Standard Methods for Evaluating the Strength of Brazed Joints in Shear*.

This Foreword applies to all four parts. Additional information on the mechanical testing of welded joints may be obtained from the AWS *Welding Handbook*, Volume 1.

The values stated in U.S. customary units and used throughout this document are to be regarded as the standard, although conversions to metric (SI units), sometimes referred to as soft metric are provided. Metric units are rounded to the nearest 0.5 mm.

Safety Precautions. Safety precautions shall conform to the latest edition of ANSI/ ASC Z49.1, *Safety in Welding and Cutting*, published by the American Welding Society.

Note: This standard may involve hazardous materials, operations, and equipment. The standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to establish appropriate safety and health practices. The user should determine the applicability of any regulatory limitations prior to use.

Comments or inquiries on this standard are welcome. They should be addressed to the Secretary, AWS Committee on Mechanical Testing of Welds, American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135.

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

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Standard Methods for Mechanical Testing of Welds

Part A *Testing of Groove Welds*

A1. Bend Tests

1. Scope

1.1 This section covers the bend testing of groove welds in butt joints and the bend testing of surfacing welds. The standard gives the requirements for bend test specimen preparation, test parameters, and testing procedures but does not specify the bend radius requirements or acceptance criteria.

1.2 The base materials may be homogenous, clad, or otherwise surfaced, except for hardfacing.

1.3 This standard is applicable to the following, where specified:

- (1) Qualification of materials, welding personnel and welding procedures
- (2) Information, specifications of acceptance, manufacturing quality control
- (3) Research and development

1.4 When this standard is used, the following information shall be furnished:

- (1) The specific location and orientation of the specimens
- (2) The specific types of tests, for example, face-bend, side-bend, or root-bend, and number of specimens required
- (3) The type of data required and observations to be made
- (4) Bend radius or percent (%) elongation
- (5) Post weld thermal or mechanical processing treatments

2. Applicable Documents

Reference should be made to the latest edition of the following documents:

- | | |
|------------|---|
| ANSI B46.1 | Surface Texture (Surface Roughness, Waviness, and Lay) |
| ASTM E190 | Standard Method for Guided Bend Test for Ductility of Welds |
| ASTM A370 | Standard Test Methods and Definitions for Mechanical Testing of Steel Products |
| AWS A2.4 | Symbols for Welding, Brazing, and Nondestructive Examination |
| AWS A3.0 | Standard Welding Terms and Definitions Including Terms for Brazing, Soldering, Thermal Spraying and Thermal Cutting |

The sources for these documents are the following:

- American National Standard Institute (ANSI)
1430 Broadway
New York, New York 10018
- American Society for Testing & Materials (ASTM)
1916 Race Street
Philadelphia, Pennsylvania 19103-2287
- American Welding Society (AWS)
550 N.W. LeJeune Road
P.O. Box 351040
Miami, Florida 33135

2/Testing of Groove Welds

3. Summary of Method

3.1 The specimens are guided in the bending process with a test jig that employs a mandrel with wrap-around roller or end supports with plunger.

3.2 The maximum strain on the tension surface is controlled by the thickness of the specimen and the radius of the mandrel or plunger.

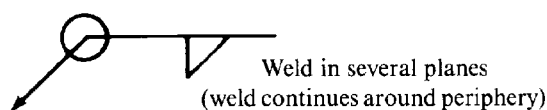
4. Significance

4.1 The ductility of a welded joint, as evidenced by its ability to resist tearing, and the presence of discontinuities on the tension surface are determined in a guided-bend test.

4.2 Bend tests are used to determine incomplete fusion, tearing, delamination, effect of bead configuration, and macro-discontinuities of weld cladding.

5. Definitions and Symbols

The welding symbols and terms used in this section are in accordance with the latest edition of ANSI/AWS A2.4, *Symbols for Welding, Brazing, and Nondestructive Examination* and ANSI/AWS A3.0, *Standard Welding Terms and Definitions*.



Unless otherwise noted, the following designations are used:

- A = plunger radius
- B = die radius
- ID = inside diameter
- L = test plate length
- R = radius
- S = surfacing weld thickness
- t = thickness of test weldment
- T = specimen thickness
- W = specimen width

6. Apparatus

6.1 Guided-bend specimens may be tested in either of two types of fixture. One type is the guided-bend fixture, which is designed to support and load the specimen in a three point bending mode. The alternate is a wrap-around bend fixture that fixes one end of the specimen and uses a roller to force the specimen to bend around a mandrel.

6.2 The guided-bend fixture shall have the dimensions given in Figures A1 or A2.

6.3 The wrap-around bend fixture shall have the dimensions given in Figure A3.

6.4 The radii of the plunger shown in Figures A1 and A2 or the mandrel shown in Figure A3 shall be specified, or determined from the relationship expressed by Figure A4 between minimum specified metal elongation, and the thickness of the specimen.

7. Specimens

Bend test specimens shall be prepared by cutting the weld and the base metal to form a specimen rectangular in cross section. The surfaces cut transverse to the weld shall be designated as the sides of the specimen; the other two surfaces shall be designated as the face and root surfaces, as appropriate. Transverse specimens may have the side, face, or root of the weld as the tension surface. Longitudinal specimens may have the face or the root of the weld as the tension surface of the specimen.

7.1 Transverse Side-Bend. The longitudinal axis of the specimen is perpendicular to the weld, and the specimen is bent so that one of the side surfaces becomes the tension surface of the specimen. The side showing the more significant discontinuities (if any) shall be the tension side. Transverse side-bend test specimens shall conform to the requirements of Figure A5. Transverse side-bend specimens are used for plates or pipe that are too thick for face-bend or root-bend specimens and are recommended for welds with narrow fusion zones.

7.2 Transverse Face-Bend. The longitudinal axis of the specimen is perpendicular to the weld and the specimen is bent so that the weld face becomes the tension surface of the specimen. Transverse face-bend specimens shall comply with the requirements of Figure A6 for plate and Figure A7 for pipe welds.

7.3 Transverse Root-Bend. The longitudinal axis of the specimen is perpendicular to the weld, and the specimen is bent so that the root surface of the weld becomes the tension surface of the specimen. Transverse root-bend specimens shall comply with the requirements of Figure A6 for plate and Figure A7 for pipe welds.

7.4 Longitudinal Face-Bend. The longitudinal axis of the specimen is parallel to the weld and the specimen is bent so that the face of the weld becomes the tension surface of the specimen. Longitudinal face-bend specimens shall comply with the requirements of Figure A8.

7.5 Longitudinal Root-Bend. The longitudinal axis of the specimen is parallel to the weld and the specimen is bent so that the root of the weld becomes the tension surface of the specimen. Longitudinal root-bend test specimens shall comply with the requirements of Figure A8.

7.6 Fillet Weld Root-Bend. The fillet weld root-bend test sample shall be welded and prepared as shown in Figure A9. The root of the weld shall be the tension surface of the specimen. The fillet weld-root bend test is an alternate to the fillet weld break test in some codes and specifications, (see Part B).

7.7 Weld Surfaced Specimens. The face-bend and side-bend specimens for surfacing welds shall conform to the requirements of Figure A10. The length of the specimens shall be perpendicular to the weld direction of transverse-bend specimens; the weld direction of the longitudinal bend specimens shall be parallel to the length of the specimen.

8. Procedure

Unless otherwise specified, the specimen shall be tested at ambient temperature, and deformation shall occur in a time period no shorter than 15 seconds and no longer than 2 minutes. If weld and HAZ are not within the curved portion of the specimen, the specimen shall be discarded and another specimen prepared and tested.

8.1 Guided-Bend Testing (Figures A1 and A2)

8.1.1 Transverse Specimens

(1) Place the tension side down on the supporting surface of the bend fixture shown in Figures A1 and A2. The centerline of the weld shall be at the mid-span within $\pm 1/16$ in. (1.5 mm).

(2) Any means may be used for smoothly moving the plunger in relation to the support members of the bend fixture.

(3) For bend fixtures with a bottom open (Figure A1), apply the load on the plunger until the specimen is bottom ejected.

(4) For bend fixtures with a bottom radius (Figure A2), the plunger shall force the specimen into the die until the specimen becomes U-shaped. The weld and heat-affected zones shall be centered and completely within the bent portion of the specimen after testing.

8.1.2 Longitudinal Specimens

(1) Center the tension side of the specimen on the supporting surfaces of the bend fixture.

(2) Proceed as in Transverse Specimens 8.1.1 (2), (3), and (4).

8.2 Wrap-Around Bend Test Jig (Figure A3). Clamp the specimen on one end to prevent the specimen from sliding during the bending operation. The weld and heat-affected zones shall be completely within the bent portion of the specimen after testing. Test specimens shall be removed from the bend fixture when the outer roll has been moved 180 degrees from the starting point.

8.3 Specimen Inspection. Remove the specimen from the bend fixture and visually examine the tension surface of the specimen (weld metal and heat-affected zones) for tears or other open defects and record all defect type, quantities, size and locations. When fracture of the weld specimen occurs prior to completing a 180 degree bend, the angle at which it fractured shall be recorded, if possible.

9. Report

In addition to the requirements of the applicable document, the report shall include the following:

- (1) Materials Identification
 - (a) Base metal specification
 - (b) Filler metal specification
 - (c) Specimen thickness and width
- (2) Type of welded joint or surfacing weld
- (3) Welding Procedure Specifications and Procedure Qualification Record numbers (if applicable), and any supplemental information provided, such as heat or lot numbers
- (4) Specific tests performed
- (5) Bend radius
- (6) Test temperature
- (7) Number of tests per condition or lot
- (8) The following additional information should be included: Number, type, size and location of defects, if any
- (9) Bend angle, if specimen fractured prior to bending 180 degrees
- (10) Any observation of unusual characteristics of the specimens or procedure

10. Commentary

When testing weld bend specimens having significantly different tensile and yield strengths using the test fixture shown in Figures A1 or A2, bending will not be uniformly distributed across the weld, HAZ and base metal. For example, if the deposited weld metal has a yield strength less than that of the base metal, yielding will begin in the weld first, resulting in a true bend radius less than that of the plunger. A smaller effective bend radius results in a more severe test of the deposited weld metal.

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On the other hand, when the deposited weld metal is stronger than the base metal, bending will begin in the HAZ and adjacent base metal, resulting in bending with a small radius at these points and little, if any, bending occurring in the weld metal. The obvious result of this situation is a more stringent test of the fusion zone of the weld. Consequently, it is recommended that the wrap-around fixture shown in Figure A3 be used in

these situations or longitudinal bend specimens be used in place of the transverse guided bend specimens. Testing of welds in dissimilar metals (such as high tensile strength plate to ordinary structural grade steels) can produce similar effects and result in invalid test results because of the tendency for the specimens to shift (slide sideways) during loading when using the fixtures shown in Figures A1 and A2.

A2. Tension Tests

1. Scope

1.1 This section covers the tension testing of welded joints.

1.2 This standard does not specify required properties or acceptance criteria.

1.3 When this standard is used as a portion of a specification for a welded structure or assembly, or for a qualification, the following information shall be furnished:

- (1) The specific type(s) and number of specimens required
- (2) Base metal specification/identification
- (3) Filler material specification/identification
- (4) The anticipated property values and whether they are maxima or minima
- (5) Location and orientation of the specimens
- (6) Report form when required
- (7) Postweld thermal or mechanical processing treatments

1.4 This standard is applicable to the following, when specified:

- (1) Qualification of materials, and welding procedures where specified mechanical properties are required
- (2) Information, basis for acceptance, and manufacturing quality control where mechanical properties are requested
- (3) Research and development

2. Applicable Documents

Reference should be made to the latest edition of the following documents:

- | | |
|------------|---|
| ANSI B46.1 | Surface Texture (Surface Roughness, Waviness and Lay) |
| ASTM E4 | Standard Practices for Load Verification of Testing Machines |
| ASTM E8 | Standard Methods of Tension Testing of Metallic Materials |
| ASTM A370 | Standard Test Methods and Definitions for Mechanical Testing of Steel Products |
| ASTM B557 | Standard Methods of Tension Testing Wrought and Cast Aluminum, and Magnesium Alloy Products |
| AWS A2.4 | Standard Symbols for Welding, Brazing, and Nondestructive Examination |

AWS A3.0 Standard Welding Terms and Definitions Including Terms for Brazing, Soldering, Thermal Spraying and Thermal Cutting

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3. Summary of Method

Tension testing of welded joints is done by means of a calibrated testing machine and devices following the procedures described in section 8 of Part A2.

4. Significance

4.1 Tension tests provide information on the load bearing capacities, joint efficiencies, strain hardening properties and ductility of welded joints. The data obtained from tension tests may include:

- (1) Ultimate tensile strength
- (2) Yield strength
- (3) Percent elongation
- (4) Percent reduction of area
- (5) Stress-strain diagram
- (6) Location and mode of fracture

4.2 Tension tests provide quantitative data which can be compared and otherwise analyzed and used in the design and analysis of welded structures. Fracture surfaces may also provide information on the presence and effects of discontinuities such as incomplete fusion, incomplete joint penetration, porosity, inclusions and cracking.

5. Definitions and Symbols

The welding symbols and terms used in this section are in accordance with ANSI/AWS A2.4, *Symbols for Welding, Brazing, and Nondestructive Examination*, and ANSI/AWS A3.0, *Standard Welding Terms and Definitions*.

6/Testing of Groove Welds

$$\sqrt{125} = 125 \text{ microinches}$$

Unless otherwise noted the following designations are used:

- A = length of reduced section
- B = length of end section
- C = dimension of grip section
- D = diameter
- E = length of shoulder and fillet
- F = diameter of shoulder
- G = gage length
- ID = inner diameter
- OD = outer diameter
- L = overall length
- P = load
- R = radius of fillet
- T = specimen thickness
- t = thickness of test weldment
- W = specimen width

6. Apparatus

The test shall be performed on a tensile testing machine in conformance with the requirements of ASTM E8. The machine shall be calibrated in accordance with ASTM E4.

7. Specimens

7.1 Test specimen type shall be specified by the applicable code, specification, or fabrication document. It is recommended that test specimens which provide the largest cross-sectional area be tested within the capabilities of available test equipment.

7.2 As-welded specimens are frequently distorted or mismatched. Removal of such distortion or mismatching by mechanical or thermal means is not permitted. Unless otherwise stated, specified specimens shall be tensile tested in the as-received condition.

7.3 Round Tension Test Specimens. The specimen having the largest diameter of those shown in Figure A11, that can be machined from the material, shall be tested.

(1) **Round All-Weld-Metal Specimen.** The all-weld-metal tension specimen is used for evaluation of the deposited weld metal ultimate tensile strength, yield strength, elongation, and reduction in area. When base metal dilution must be minimized for the specimen to be representative of weld metal, the groove faces may be

buttered with the same filler materials to be used in the weld joint, or alternatively, the root opening may be increased by 1/4 in. (6.5 mm). The reduced section of the tension specimens between the gage marks shall be located so that no buttering is included. It is recommended that the surface of the reduced section of the specimen be at least 1/8 in. (3 mm) from the fusion line along the bevel faces (see Figure A11).

(2) **Round Transverse Weld Specimen.** The transverse weld specimen is used together with the base metal or all-weld-metal tension tests to evaluate joint efficiency. Due to material or structural inhomogeneities, or both, in specimens taken transverse to the centerline of the weld, only ultimate tensile strength is normally determined.

7.4 Rectangular Tension Test Specimen, Transverse and Longitudinal. The tension specimens for welded butt joints other than pipe or tubing shall be either transverse weld tension specimens, or longitudinal weld tension specimens that comply with Figure A12 or A13. When thickness, t, of the test weld is beyond capacity of the available test equipment, the weld shall be divided through its thickness into as many specimens as required to cover the full weld thickness and still maintain the specimen size within the test equipment capacity. Unless otherwise specified, the results of the partial thickness specimens shall be averaged to determine the properties of the full thickness joint. Due to material or structural inhomogeneities, or both, in specimens taken transverse to the centerline of the weld, only ultimate tensile strength is normally determined.

7.5 Tubular Tension Test Specimen. Two types of specimens are used in determining the tensile properties of welded tubular products. For pipe or tubing larger than 2 in. (51.0 mm) nominal diameter, the reduced rectangular section specimen may be used. The full section specimen shall be used to test weld joints in pipe or tubing 2 in. (51.0 mm) or less nominal diameter and may be used for larger sizes subject to limitations of testing equipment.

(1) **Greater Than 2 Inch Diameter.** The reduced rectangular section specimen, shall comply with Figure A14. Specimens shall not be used for nominal wall thicknesses less than 3/8 in. (9.5 mm).

(2) **Less Than or Equal to 2 Inch Diameter.** The full section specimen shall comply with Figure A15.

7.6 Preparation. Excessively deep machine cuts that will cause invalid test data or that leave tears in the surface of the finished dimensions shall be avoided. Unless otherwise specified, the surface finish on surfaces requiring machining shall be as specified in the specimen drawings. Imperfections present in the gage length, which are incidental to welding, shall not be removed.

8. Procedure

8.1 The testing procedure for weld specimens shall be as specified in ASTM E8 except that unless otherwise specified, the rate of straining shall be between 0.05 and 0.5 in. per minute.

8.2 Round Tension Specimens (Figure A11). Mechanical properties, namely ultimate tensile strength, yield strength, elongation, and reduction of area, are determined for round all-weld-metal tension specimens. Unless otherwise specified, only ultimate tensile strength is determined for round transverse weld tension specimens.

Ultimate tensile strength =

$$\frac{\text{Maximum load}}{\text{Original cross-sectional area}} = \frac{P_{\max}}{\left(\frac{\pi D^2}{4}\right)}$$

(The minimum diameter shall be used)

Yield strength =

$$\frac{\text{Load at specified offset}}{\text{Original cross-sectional area}} = \frac{P_{\text{(specified offset)}}}{\left(\frac{\pi D^2}{4}\right)}$$

Elongation, percent =

$$\left(\frac{\text{Final gage length} - \text{original gage length}}{\text{Original gage length}} \right) \times 100$$

Reduction of area, percent =

$$\left(\frac{\text{Original area} - \text{final area}}{\text{Original area}} \right) \times 100$$

8.3 Rectangular Tension Tests (Figures A12, A13, A14) Ultimate Tensile Strength

The ultimate tensile strength calculation for rectangular tension test is the following:

$$\text{U.T.S.} = \frac{\text{Maximum load}}{\text{Original cross-sectional area}} = \frac{P_{\max}}{W \times T}$$

8.4 Tubular Tension Tests

The ultimate tensile strength calculation for reduced section (Figure A14) is the same as 8.3. The ultimate tensile strength calculation for full section (Figure A15) is as follows:

$$\text{U.T.S.} = \frac{\text{Maximum load}}{\text{Original area}} = \frac{P_{\max}}{0.7854 (OD^2 - ID^2)}$$

9. Report

In addition to the requirements of applicable documents, the report shall include the following:

- (1) Base metal specification
- (2) Filler metal specification
- (3) Welding procedure (process and parameters)
- (4) Specimen type
- (5) Joint geometry
- (6) Location of fracture and type of failure (ductile or brittle)
- (7) Calculated tensile strength
(For round all-weld metal specimen only: yield strength, % elongation, and % reduction of area)
- (8) Any observation of unusual characteristics of the specimens or procedure

8/Testing of Groove Welds

A3. Fracture Toughness Testing of Welds**1. Scope**

1.1 This section covers the fracture toughness testing of welds. Methods include Charpy V-notch (Cv), the Dynamic Tear (DT), the Plane-Strain Fracture Toughness (K_{Ic}) and the Drop Weight Nil-Ductility Temperature (DWNDT) Tests.

1.2 When a fracture toughness test is required, the preparation of the weld, the test specimen, and the test methods shall conform to this standard.

1.3 When this standard applies to weld metal, the width of the weld metal shall be equal to or exceed the thickness of the test specimen.

1.4 This standard is applicable to the following when specified:

(1) For qualification of materials, welding procedures, and welding personnel where a specified level of fracture toughness is required.

(2) For information, specification of acceptance, and manufacturing quality control where a minimum criterion for fracture toughness is requested. Detailed discussion of the selection of test method and a specified minimum value in a specific case is beyond the scope of this standard.

(3) Research and development.

1.5 When this standard is used the following information shall be furnished:

(1) The specific types and number of specimens required.

(2) Base metal specifications/identification

(3) Filler material specification/identification

(4) The anticipated property values and whether they are maxima or minima

(5) Location and orientation of the specimen and notch

(6) Joint geometry

(7) Test temperature

(8) Postweld thermal or mechanical treatments

2. Applicable Documents

Reference should be made to the latest edition of the following documents:

ASTM E23 Standard Methods for Notched Bar Impact Testing of Metallic Materials

ASTM E208 Standard Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels

ASTM A370 Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM E399 Test Method for Plane-Strain Fracture Toughness of Metallic Materials

ASTM E436 Standard Method for Drop-Weight Tear Tests of Ferritic Steels

ASTM E561 Standard Practice for R-Curve Determination

ASTM E604 Standard Test Method for Dynamic Tear Testing of Metallic Materials

ASTM E616 Standard Terminology Relating to Fracture Testing

ASTM B645 Standard Practice for Plane-Strain Fracture Toughness Testing of Aluminum Alloys

ASTM B646 Standard Practice for Fracture Toughness Testing of Aluminum Alloys

ASTM E740 Standard Practice for Fracture Testing with Surface-Crack Tension Specimens

ASTM E813 Standard Test Method for J_{Ic} , A Measure of Fracture Toughness

ASTM E992 Standard Practice for Determination of a Fracture Toughness of Steels Using Equivalent Energy Methodology

ASTM E1152 Standard Test Method for Determining J-R Curves

ASTM E1221 Standard Test Method for Determining Plane-Strain Crack-Arrest Fracture Toughness, K_{Ia} , of Ferritic Steels

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

AWS A3.0 Standard Welding Terms and Definitions Including Terms for Brazing, Soldering, Thermal Spraying and Thermal Cutting

The sources of these documents are the following:

American Society for Testing and Materials (ASTM)
1916 Race Street
Philadelphia, Pennsylvania 19103-2287

American Welding Society (AWS)
550 N.W. LeJeune Road
P.O. Box 351040
Miami, Florida 33135

3. Summary of Method

3.1 Specimens shall be removed from a weldment so that the results of the test are representative of the fracture toughness of the weld joint, in specific applications.

3.2 The method selected for fracture toughness testing shall be that required in the specification of a material, fabrication document, or as otherwise specified.

4. Significance

4.1 Fracture toughness testing provides a measure of resistance to crack initiation or propagation, or both.

4.2 The welding process and welding procedure have a significant effect on the mechanical properties of a weld joint. If the fracture toughness of a weld joint sample is to be representative of its structural performance, the same welding process and procedure must be used for the sample and the structure.

5. Definitions and Symbols

The welding symbols and terms used in this section are in accordance with the latest editions of ANSI/AWS A2.4, *Symbols for Welding, Brazing, and Nondestructive Examination*, and ANSI/AWS A3.0, *Standard Welding Terms and Definitions*.

6. Apparatus

The apparatus for conducting the various fracture toughness tests shall be in accordance with the following ANSI/ASTM Standard Methods:

- (1) Charpy V-notch, E23
- (2) Dynamic Tear, E604
- (3) Plane-Strain Fracture Toughness (Compact Tension), E399
- (4) Drop-Weight Nil-Ductility Transition Temperature, E208

7. Specimens

7.1 Sufficient information shall be provided to properly locate specimens and weld joint. For specimens removed from double bevel groove welds, the identification shall include a reference with respect to the side of the weld.

7.2 Unless otherwise specified, the weld metal width to specimen thickness relationship shall be as shown in Figure A16.

7.3 Test specimens shall not contain metal that has been affected thermally as a result of cutting or preparation.

7.4 Unless otherwise specified, the specimens shall not contain welding stops or starts.

7.5 Unless otherwise specified, the nominal dimensions, orientation, and notch location of specimens shall be that shown in Figures A17 through A22 respectively. Working drawings are provided in the referenced documents.

7.6 When an evaluation of the base metal or heat-affected zone, or both, is required, the location of the notch shall be specified.

8. Procedure

Test specimen preparation and test procedure for measuring the fracture toughness of a weldment shall be in accordance with the following ANSI/ASTM Standard Methods:

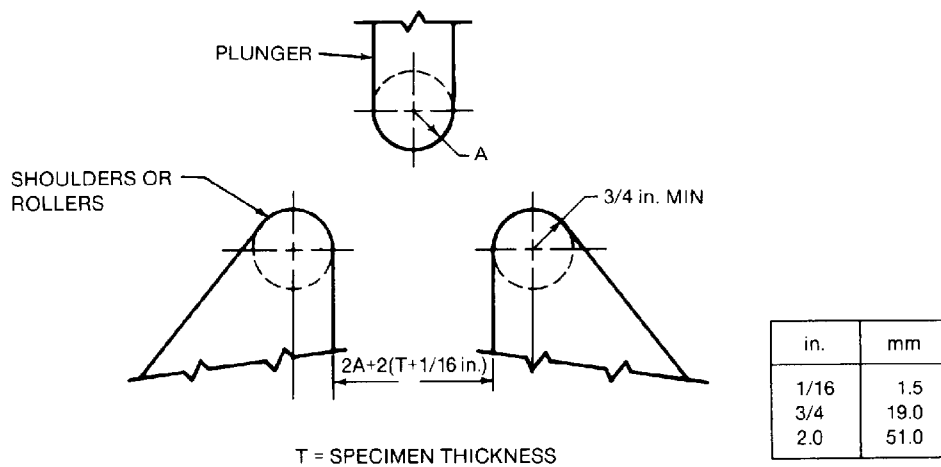
- (1) Charpy V-notch, E23
- (2) Dynamic Tear, E604
- (3) Compact Tension, E399
- (4) Drop-Weight Nil-Ductility Transition Temperature, E208

9. Report

In addition to the requirements of applicable documents, the report shall include the following:

- (1) Base metal specification
- (2) Filler metal specification
- (3) Welding procedure (process and parameters)
- (4) Joint Geometry
- (5) Specimen type
- (6) Specimen location and orientation
- (7) Type of test equipment
- (8) Fracture appearance and location
- (9) Test temperature
- (10) Energy absorbed
- (11) Any observation of unusual characteristics of the specimens or procedure

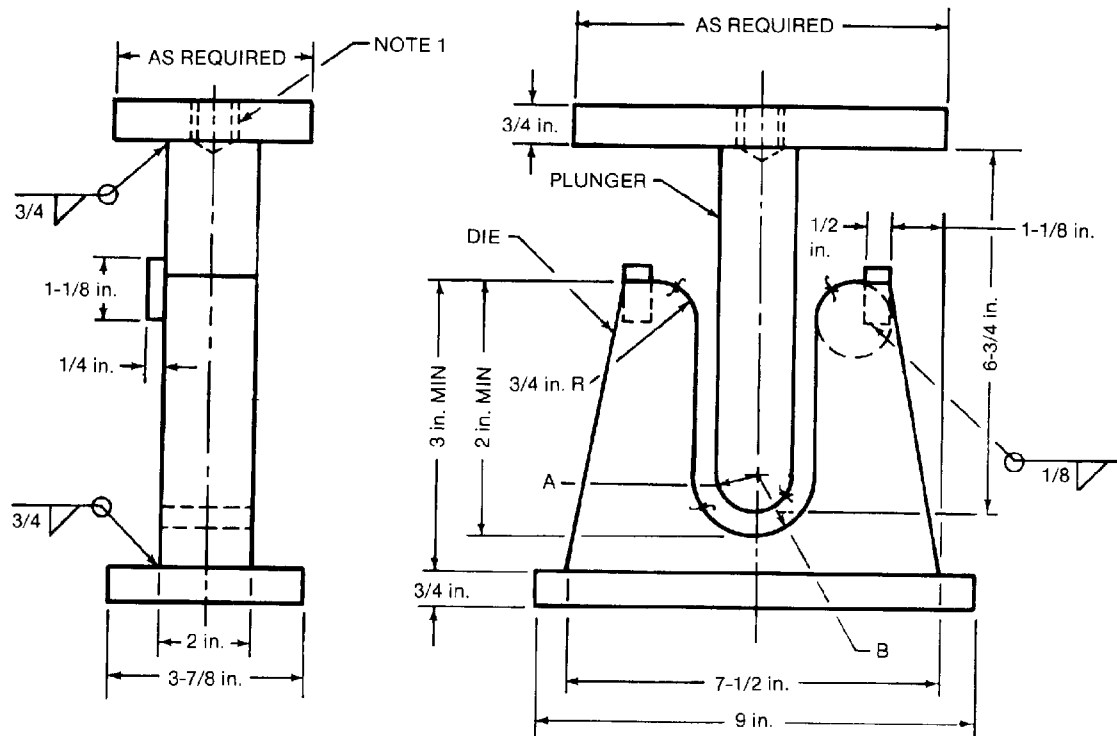
10/ Testing of Groove Welds



Notes:

1. Either hardened and greased shoulders or hardened rollers free to rotate shall be used.
2. The shoulder or rollers shall have a minimum bearing length of 2 in. (51.0 mm) for placement of the specimen.
3. The shoulders or rollers shall be high enough above the bottom of the testing bend fixture so that the specimen will clear the shoulders or rollers when the plunger is in the low position.
4. The plunger shall be fitted with an appropriate base and provision for attachment to the testing machine and shall be designed to minimize deflection or misalignment.
5. The shoulder or roller supports may be made adjustable in the horizontal direction so that specimens of various thickness may be tested in the same bend fixture.
6. The shoulder or roller supports shall be fitted to a base designed to maintain the shoulders or rollers centered and aligned with respect to the plunger, and minimize deflection or misalignment.
7. The maximum plunger radius, A, shall be as specified or as determined from the formula or nomogram in Figure A4.

Figure A1 — Typical Bottom Ejecting Guided-Bend Test Bend Fixture



Jig Dimensions for 20% Elongation of Weld					
Specimen Thickness, T		Plunger Radius, A		Die Radius, B	
in.	mm	in.	mm	in.	mm
3/8	(9.5)	3/4	(19.0)	1-3/16	(30.0)
T		2T		A+T+1/16	(A+T+1.5)

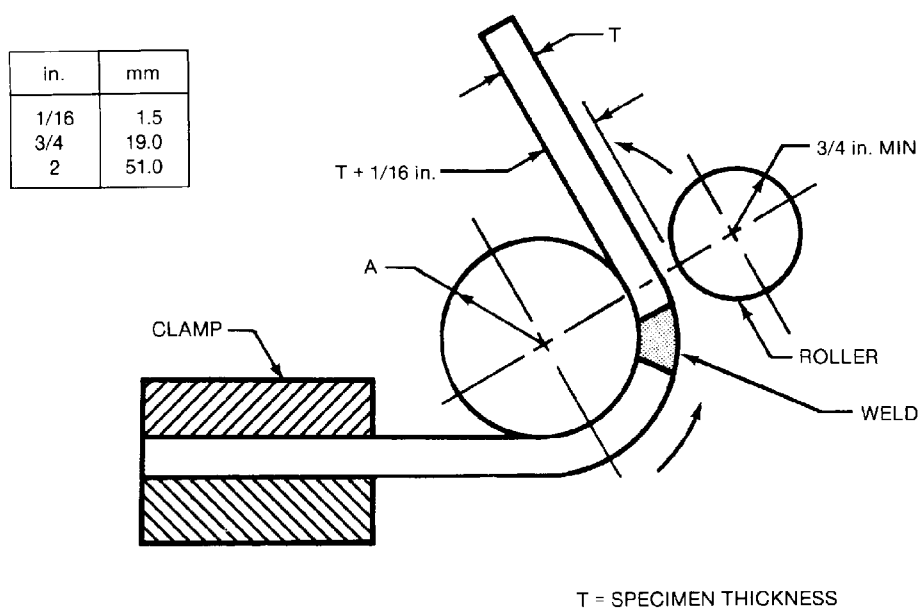
in.	mm
1/16	1.5
1/8	3.0
1/4	6.5
1/2	12.5
3/4	19.0
1-1/8	28.5
2	51.0
3	76.0
3-7/8	98.5
6-3/4	171.5
7-1/2	190.5
9	228.5

Notes:

1. Tapped hole of appropriate size, or other suitable means for attaching plunger to testing machine.
2. Either hardened and greased shoulders or hardened rollers free to rotate shall be used in die.
3. The plunger and its base shall be designed to minimize deflection and misalignment.
4. The plunger shall force the specimen into the die until the specimen becomes U-shaped. The weld and heat-affected zones shall be centered and completely within the bent portion of the specimen after testing.
5. The maximum plunger radius, A, shall be as specified or as determined from the formula or nomogram in Figure A4. The die radius, B, shall be equal to A+T+1/16 in. (1.5 mm).
6. Weld size indicated is a recommendation. The actual size is the responsibility of the user to ensure rigidity and design adequacy.

Figure A2 — Typical Bottom Guided-Bend Test Fixture

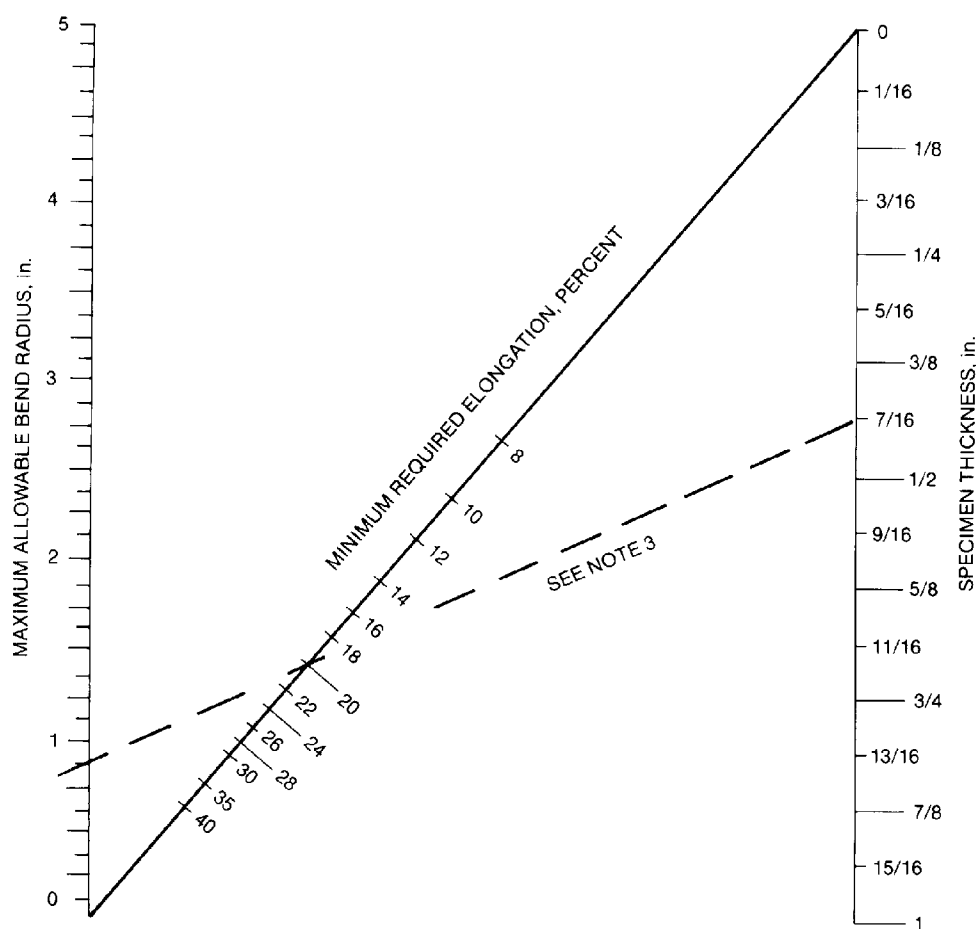
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Notes:

1. Radius A shall be as specified, or as determined from the nomogram in Figure A4. Dimensions not shown are the option of the designer, except that the minimum width of the components shall be 2 in. (51.0 mm).
2. It is essential to have adequate rigidity so that the bend fixture will not deflect during testing. The specimen shall be firmly clamped on one end so that it does not slide during the bending operation.
3. Test specimens shall be removed from the bend fixture when the outer roll has traversed 180° from the starting point.

Figure A3 — Alternative Wrap-Around Guided Bend Test Bend Fixture



in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
1/16	1.6	5/16	7.9	9/16	14.3	13/16	20.6	2	50.8
1/8	3.2	3/8	9.5	5/8	15.9	7/8	22.2	3	76.2
3/16	4.8	7/16	11.1	11/16	17.5	15/16	23.8	4	102
1/4	6.4	1/2	12.7	3/4	19.1	1	25.4	5	127

or

$$e = \frac{t}{2R-t} \times 100$$

where

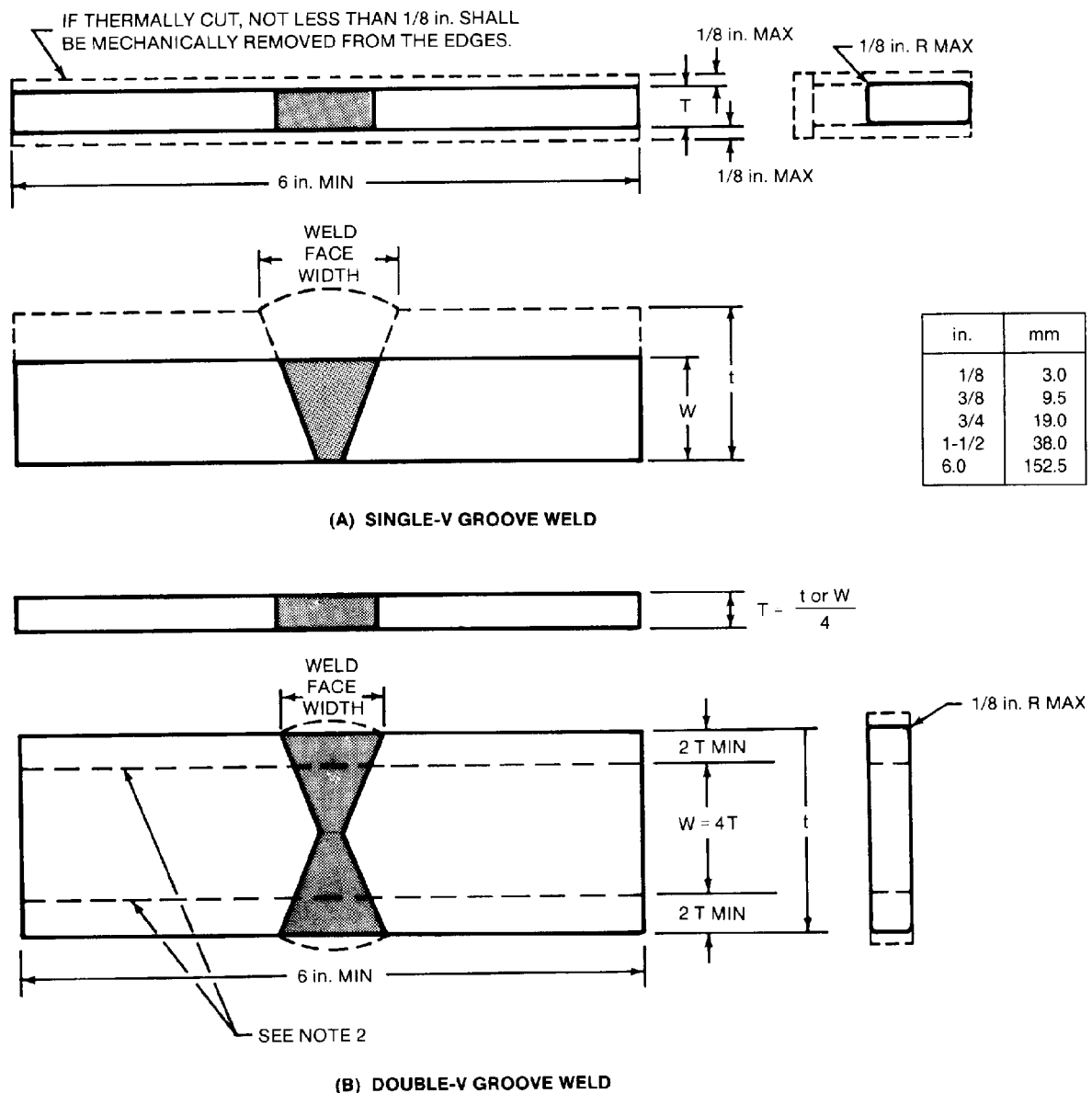
 e = percent elongation t = initial plate thickness, mm (in.) R = radius of curvature at the inside surface of the bend

Notes:

1. It is generally recommended that the specimen thickness for the bend tests be approximately 3/8 in. (9.5 mm). However, the specimen thickness may be any value within the range given above as dictated by the material thickness, available equipment, or the applicable specification.
2. Required accuracy of measurement is as follows:
 - (1) Specimen thickness $\pm 1/64$ in. (0.5 mm)
 - (2) Elongation: ± 1 percent
 - (3) Bend radius: $\pm 1/16$ in. (1.5 mm)
3. Example: If a standard requires a minimum elongation of 20 percent and if the specimen is 7/16 in. (11.0 mm) thick, a line is drawn between these two points and extended to determine the appropriate bend radius which would be 7/8 in. (22.0 mm).

Figure A4—Selecting Maximum Bend Radius

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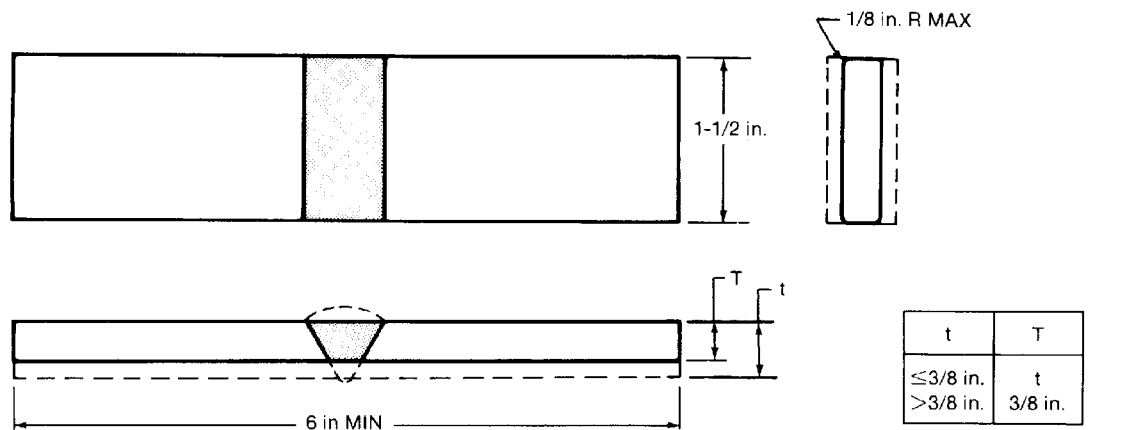


Notes:

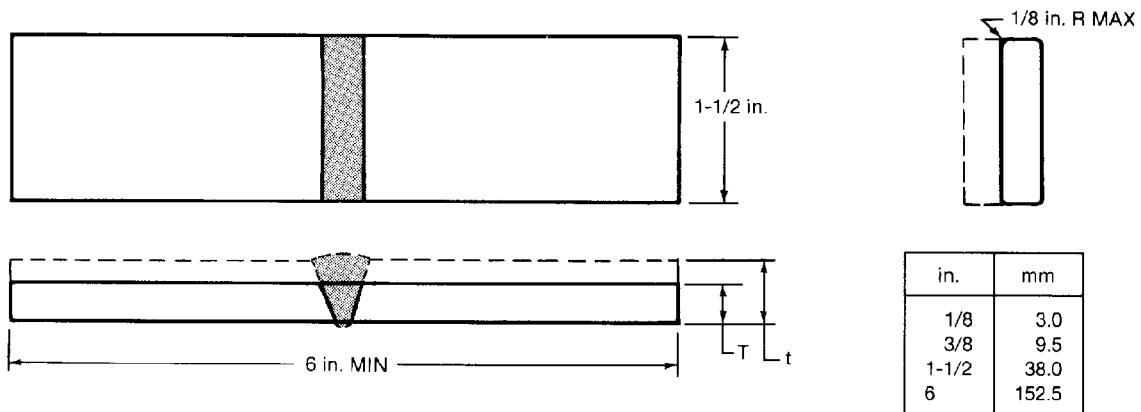
1. If the thickness, t , of a single-groove weld joint exceeds 1-1/2 in. (38.0 mm), the specimen may be cut into approximately equal strips between 3/4 in. (19.0 mm) and 1-1/2 in. (38.0 mm) wide. Each strip shall be tested by bending to the same radius as specified or as determined by the nomogram in Figure A4.
2. If the plate thickness, t , of a double-groove weld joint exceeds 1-1/2 in. (38.0 mm), the specimen may be cut into multiple strips as shown, so that the root of the weld is centered in one of the strips. These strips shall be bent to the same radius as specified or as determined by the nomogram in Figure A4.
3. The weld reinforcement and backing, if any, shall be mechanically removed flush with the specimen surface. For performance qualification, if sufficient material is available, acceptable undercut should be removed while maintaining specimen dimensions.
4. The diameter of the test plunger shall be equal to or exceed the width of the remaining weld face width. If this requirement cannot be met, a greater thickness, T , shall be chosen in accordance with the nomogram in Figure A4.
5. All longitudinal surfaces shall be no rougher than 125 microinches (3 μ m) RMS. It is recommended that the lay of the surface roughness be oriented parallel to the longitudinal axis of the specimen.

Figure A5 — Transverse Side-Bend Specimens (Plate)

Testing of Groove Welds/15



(A) FACE-BEND SPECIMEN



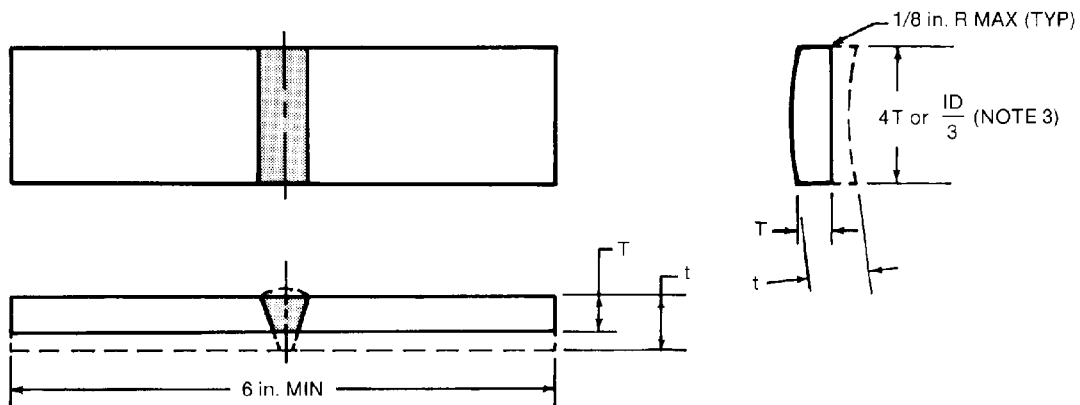
(B) ROOT-BEND SPECIMEN

Notes:

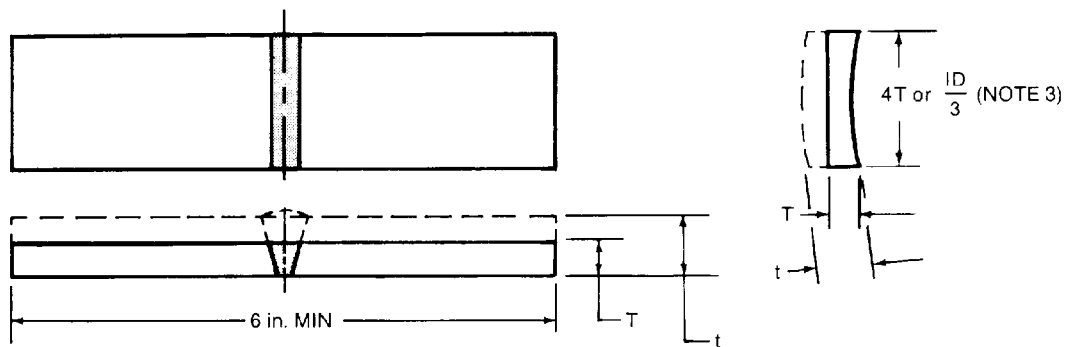
1. The specimen edges may be thermally cut but, in this case, at least 1/8 in. (3.0 mm) of material shall be mechanically removed from the thermally cut surface.
2. For clad metals having an elongation requirement of at least 25 percent, the specimen thickness, T, may be reduced when using a fixed bend-radius testing bend fixture. The specimen thickness shall be determined by the nomogram in Figure A4.
3. If the weld joins base metal with different thicknesses, the specimen should be reduced to a constant thickness based on the thinner base metal.
4. The weld reinforcement and backing, if any, shall be mechanically removed flush with the specimen surface. For performance qualification, if sufficient material is available, acceptable undercut should be removed while maintaining specimen dimensions.
5. The diameter of the test plunger shall be equal to or exceed the width of the remaining weld face. If this requirement cannot be met, a greater thickness, T, shall be chosen in accordance with the nomogram in Figure A4.
6. All longitudinal surfaces shall be no rougher than 125 microinches (3 μm) RMS. It is recommended that the lay of the surface roughness be parallel to the longitudinal axis of the specimen.

Figure A6 — Transverse Face-Bend and Root-Bend Specimens (Plate)

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(A) FACE-BEND SPECIMEN



(B) ROOT-BEND SPECIMEN

t	T
$\leq 3/8$ in.	t
$> 3/8$ in.	3/8 in.

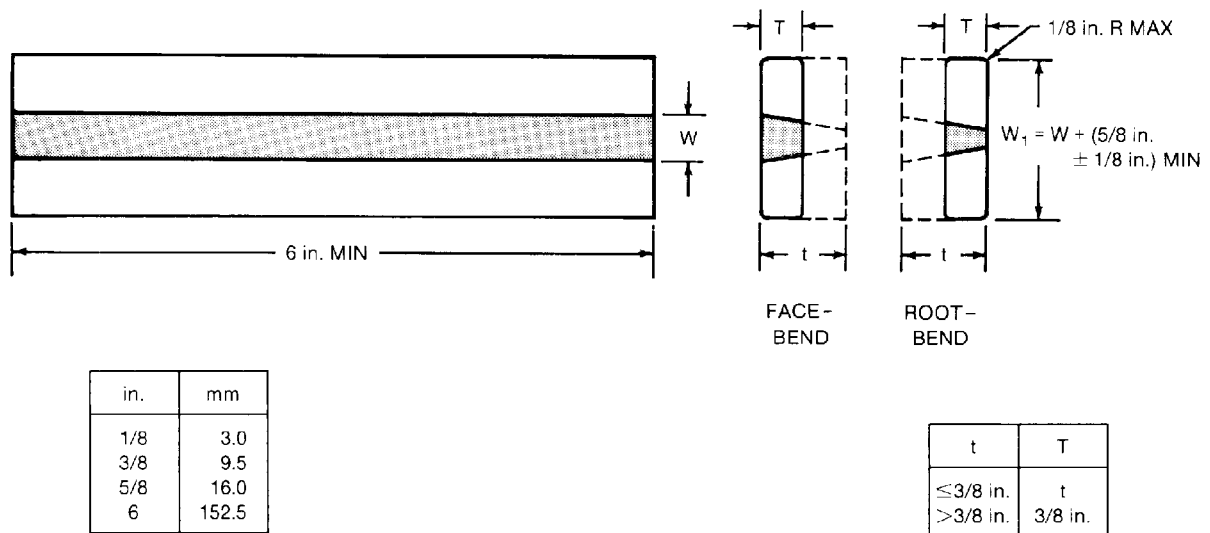
in.	mm
1/8	3.0
3/8	9.5
6	152.5

Notes:

1. The specimen edges may be thermally cut but, in this case, at least 1/8 in. (3.0 mm) of material shall be mechanically removed from the thermally cut surfaces.
2. If the weld joins base metal with different thicknesses, the specimen should be reduced to a constant thickness based on the thinner base metal.
3. The specimen width shall be $4T$, except that it shall not exceed $ID/3$ where ID is the inside diameter of the pipe.
4. The weld reinforcement and backing, if any, shall be mechanically removed flush with the specimen surface. If the back of the joint is recessed, this surface of the specimen may be removed to a depth not exceeding the recess. For performance qualification, if sufficient material is available, acceptable undercut should be removed while maintaining specimen dimensions.
5. The diameter of the test plunger shall be equal to or exceed the weld width. If this requirement cannot be met, a greater thickness, T , shall be chosen in accordance with the formula or nomogram in Figure A4.
6. All longitudinal surfaces shall be no rougher than 125 microinches ($3 \mu\text{m}$) RMS. It is recommended that the lay of the surface roughness be oriented parallel to the longitudinal axis of the specimen.

Figure A7 — Transverse Face-Bend and Root-Bend Specimens (Pipe)

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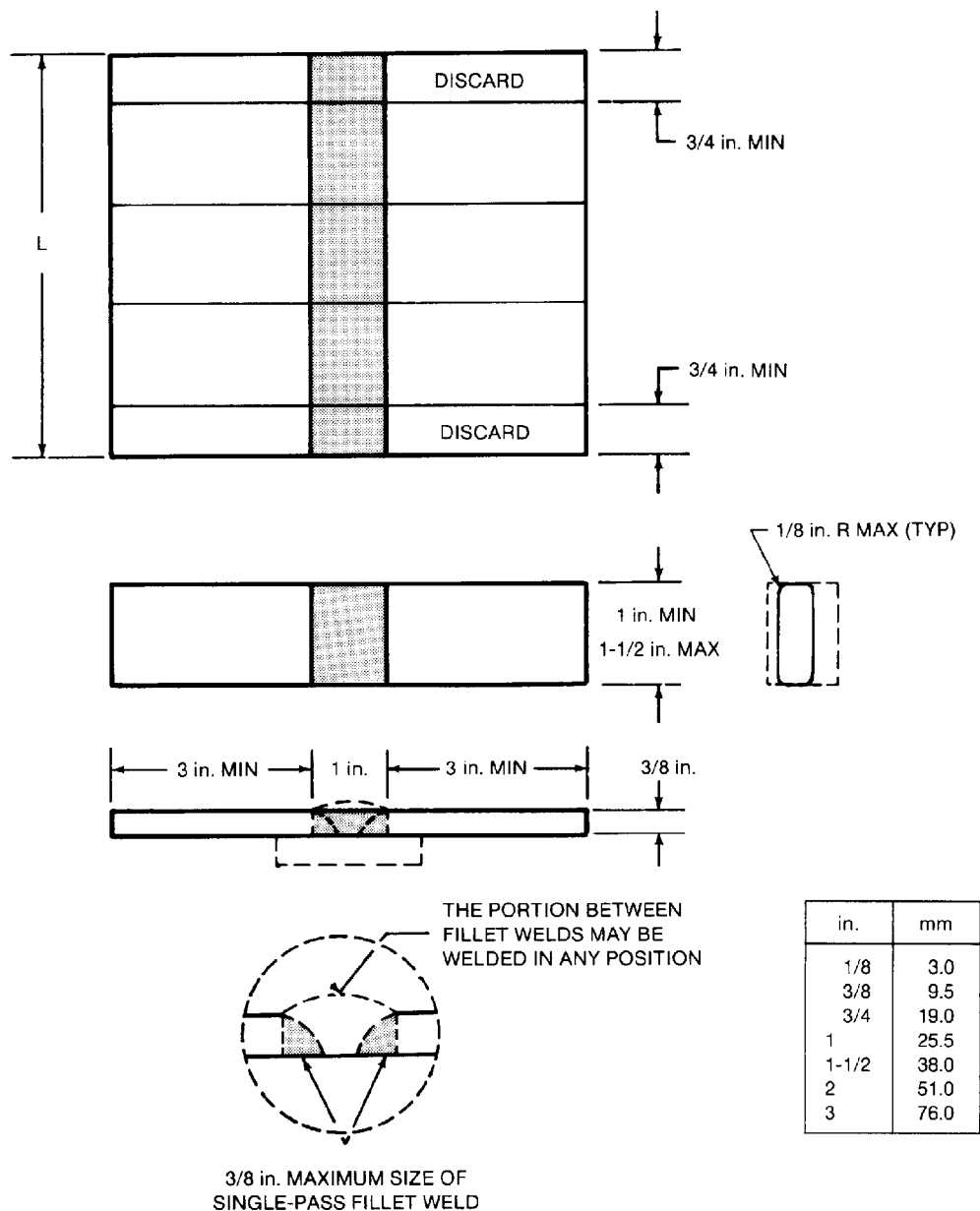


Notes:

1. The specimen edges may be thermally cut, but in this case, at least 1/8 in. (3.0 mm) of material shall be mechanically removed from the thermally cut surface.
2. If the weld joins base metals of different thicknesses, the specimen should be reduced to a constant thickness based on the thinner base metal.
3. Weld reinforcement and backing, if any, shall be mechanically removed flush with the surface of the specimen. For performance qualification, if sufficient material is available, acceptable undercut should be removed while maintaining specimen dimensions.
4. All longitudinal surfaces shall be no rougher than 125 microinches (3 μ m) RMS. It is recommended that the lay of the surface roughness be oriented parallel to the longitudinal specimen axis.

Figure A8 — Longitudinal Face-Bend and Root-Bend Specimen (Plate)

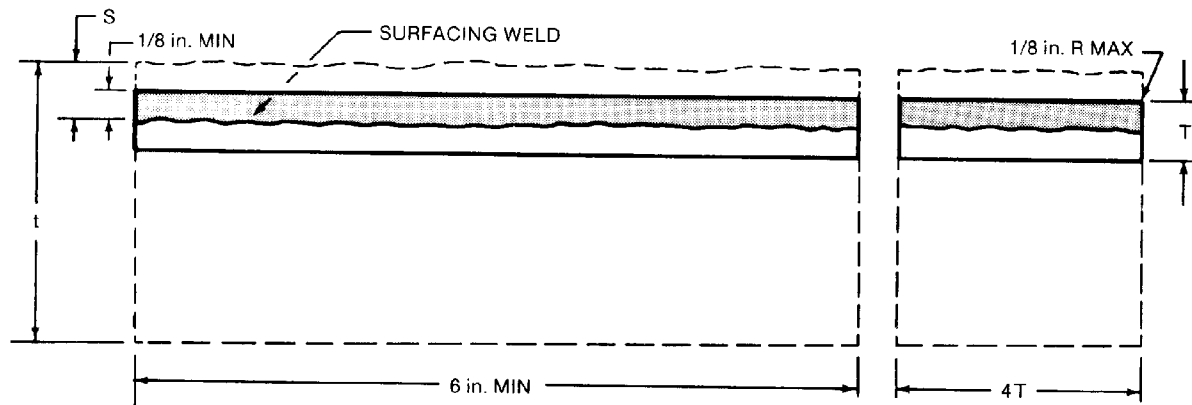
18/Testing of Groove Welds



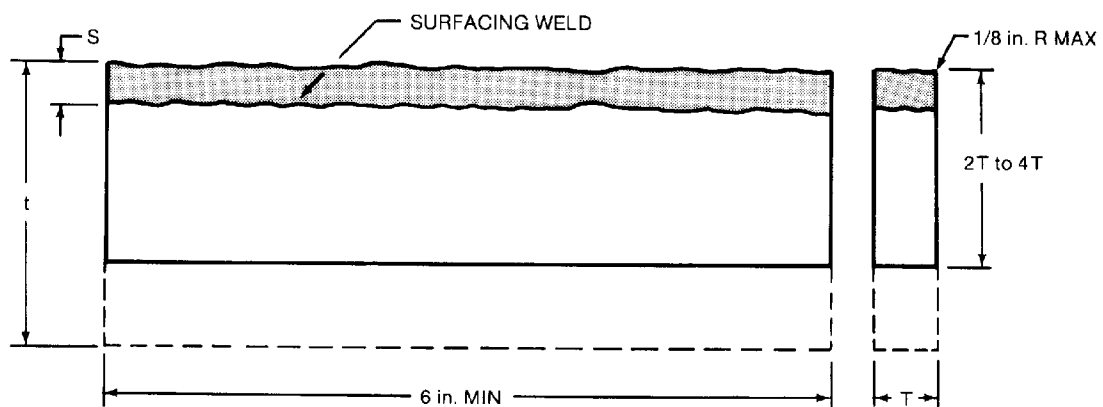
Notes:

1. The backing shall be $3/8$ in. by 2 in. (9.5 mm by 51.0 mm) minimum unless the test weld is to be inspected radiographically, in which case the backing bar shall be $3/8$ in. by 3 in. (9.5 mm by 76.0 mm) minimum. The backing bar shall be in intimate contact with the base plate.
2. The test plate length L , shall be sufficient for the required number of specimens. Specimens shall be removed mechanically from the test plate.
3. The weld reinforcement and backing bar shall be removed mechanically, flush with the base plate.
4. All longitudinal surfaces shall be no rougher than 125 microinches ($3 \mu\text{m}$) RMS. It is recommended that the lay of the surface roughness be oriented parallel with the longitudinal axis of the specimen.

Figure A9 — Fillet Weld Root-Bend Test Specimen



(A) FACE-BEND SPECIMEN



(B) SIDE-BEND SPECIMEN

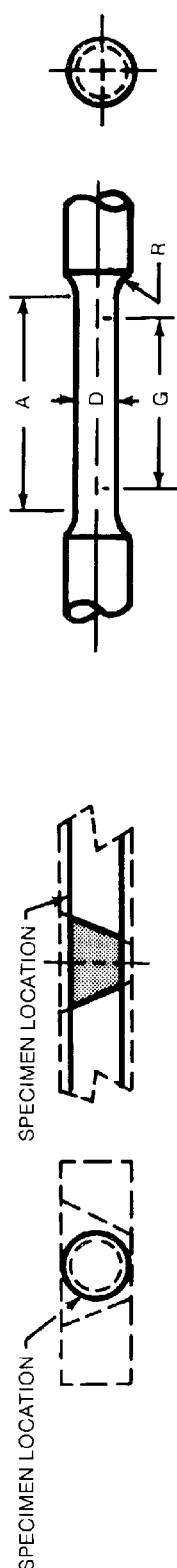
in.	mm
1/8	3.0
3/8	9.5
6	152.5

Notes:

1. The dimension, t , is the thickness of the applicable material to be weld surfaced. The dimension, T , is the thickness of the test specimen and shall be $3/8$ in. (9.5 mm) unless otherwise specified.
2. For the longitudinal bend test, the long axis of the specimen shall be parallel to the welding direction. For the transverse bend test, the long axis shall be perpendicular to the weld direction length of the test specimen.
3. The amount of surfacing weld removed from the face-bend specimen surface shall be the minimum necessary to obtain a smooth surface. The minimum thickness of surfacing weld after finishing shall be $1/8$ in. (3.0 mm).
4. All longitudinal surfaces shall be no rougher than 125 microinches ($3 \mu\text{m}$) RMS. It is recommended that the lay of the surface roughness be oriented with the longitudinal axis of the specimen.

Figure A10 — Surfacing Weld Face-Bend and Side-Bend Specimens

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Dimensions

	Standard specimen		Small-size specimens proportional to standard							
	in.	mm*	in.	mm*	in.	mm*	in.	mm*	in.	mm*
Nominal Diameter										
G. gage length	2.000±0.005	51.0±0.125	1.400±0.005	35.5±0.125	1.000±0.005	25.5±0.125	0.640±0.005	16.0±0.125	0.450±0.005	11.5±0.125
D. diameter (Note 1)	0.500±0.010	12.5±0.255	0.350±0.007	8.90±0.180	0.250±0.005	6.35±0.125	0.160±0.003	4.05±0.075	0.113±0.002	2.85±0.05
R. radius of filler min	3/8	9.5	1/4	6.5	3/16	5.0	5/32	4.0	3/32	2.5
A. length of reduced section min (Note 2)	2-1/4	57.0	1-3/4	44.5	1-1/4	32.0	3/4	19.0	5/8	16.0

Standard 0.500 in. round tension test specimens with 2 in. gage length and examples of small size specimens with 2 in. gage length and examples of small size specimens proportional to the standard specimen.

*Rounded to the nearest 0.5 mm or 0.05 mm

Notes:

1. The reduced section may have a gradual taper from the ends toward the center with the ends not more than 1 percent larger in diameter than the center (controlling dimension).
2. If desired, the length of the reduced section may be increased to accommodate an extensometer of any convenient gage length. Reference marks for the measurement of elongation should nevertheless be spaced at the indicated gage length.
3. The gage length and fillets shall be as shown but the ends may be of any form to fit the holders of the testing machine in such a way that the load shall be axial. If the ends are to be held in wedge grips it is desirable to make the length of the grip section great enough to allow the specimen to extend into the grips a distance equal to 2/3 or more of the length of the grips.
4. On the round specimens, the gage lengths are equal to 4 times the nominal diameter. In some product specifications other specimens may be provided for but unless the 4 to 1 ratio is maintained within dimensional tolerances, the elongation values may not be comparable with those obtained from the standard test specimen. Note that most metric based codes use a 5 to 1 ratio of gage length to diameter.
5. The use of specimens smaller than 0.25 in. diameter shall be restricted to cases when the material to be tested is of insufficient size to obtain larger specimens or when all parties agree to their use for acceptance testing. Smaller specimens require suitable equipment and greater skill in both machining and testing.
6. To permit easy calculations of stress from loads, five sizes of specimens have the following diameters: 0.505, 0.357, 0.252, 0.160, and 0.113 in. When the actual diameters agree with these values, the stresses or strengths may be computed using the multiplying factors: 5, 10, 20, 50, and 100.
7. For transverse weld specimens, the weld shall be approximately centered between gage marks.

Figure A11 — Round Tensile Specimens

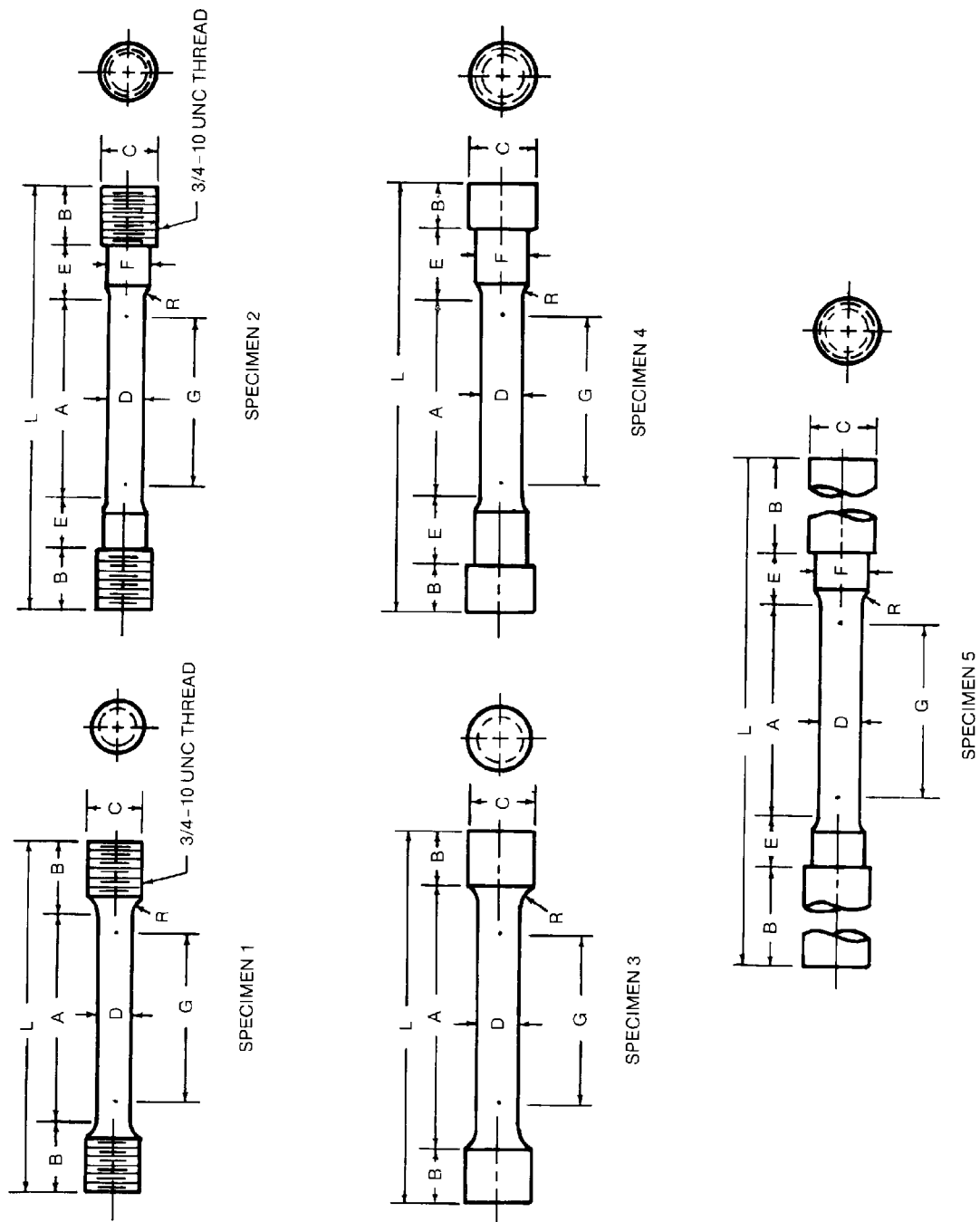


Figure A11 (Continued) — Round Tensile Specimens

Testing of Groove Welds/22

Dimensions

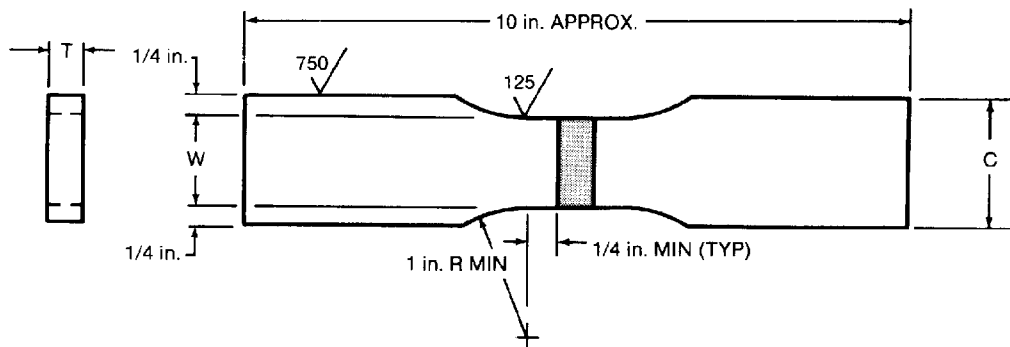
	Specimen 1		Specimen 2		Specimen 3		Specimen 4		Specimen 5	
	in.	mm*	in.	mm*	in.	mm*	in.	mm*	in.	mm*
G — gage length	2.000±0.005	51.0±0.125	2.000±0.005	51.0±0.125	2.000±0.005	51.0±0.125	2.000±0.005	51.0±0.125	2.000±0.005	51.0±0.125
D — diameter (Note 1)	0.500±0.010	12.5±0.255	0.500±0.010	12.5±0.255	0.500±0.010	12.5±0.255	0.500±0.010	12.5±0.255	0.500±0.010	12.5±0.255
R — radius of fillet min	3/8	9.5	3/8	9.5	1/16	1.5	3/8	9.5	3/8	9.5
A — length of reduced section	2-1/4 min.	57.0 min	2-1/4 min	57.0 min	4 approx	101.5 approx	2-1/4 min	57.0 min	2-1/4 min	57.0 min
L — over-all length approx.	5	127.0	5-1/2	139.5	5-1/2	139.5	4-3/4	19.0	9-1/2	241.5
B — length of end section (Note 2)	1-3/8 approx	35.0 approx	1 approx	25.5 approx	3/4 approx	19.0 approx	1/2 approx	12.5 approx	3 min	76.0 min
C — diameter of end section	3/4	19.0	3/4	19.0	23/32	18.0	7/8	22.0	5/8	19.0
E — length of shoulder and fillet section, approx.	—	—	5/8	16.0	—	—	3/4	19.0	5/8	16.0
F — diameter of shoulder	—	—	5/8	16.0	—	—	5/8	16.0	19/32	15.0

Various types of ends for standard round tension test specimens

Notes:

8. On specimen 5 it is desirable to make the length of the grip section sufficient to allow the specimen to extend into the grips a distance equal to 2/3 or more of the length of the grips.
9. The use of UNF series of threads (3/4 by 16, 1/2 by 20, 3/8 by 24, and 1/8 by 28) is recommended for high-strength, brittle materials to avoid fracture in the thread portion.
10. Surface finish within the gage length shall be no rougher than 63 microinches (2 μ in) RMS.

Figure A11 (Continued) — Round Tensile Specimens



T	W
≤ 1 in.	1.50 = 0.01 in.
≥ 1 in.	1.00 = 0.01 in.

$\sqrt{125} = 4$ MICROMETERS
 $\sqrt{750} = 24$ MICROMETERS

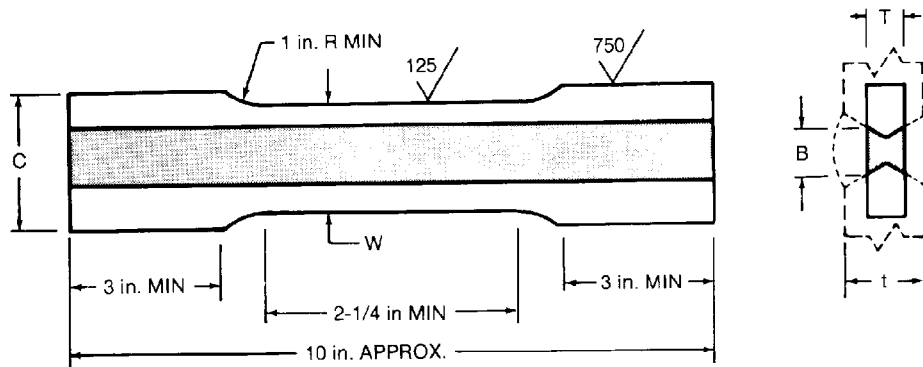
in.	mm
0.01	0.3
1/4	6.5
1	25.5
1-1/2	38.0
2	51.0
10	254.0

Notes:

1. Thin sheet metal being tested tends to tear and break near the shoulder. In such cases, dimension C shall be no greater than 1-1/3 times W.
2. Weld reinforcement and backing strip, if any, shall be removed flush with the surface of the specimen.
3. When the thickness, t, of the test weldment is such that it would not provide a specimen within the capacity limitations of the available test equipment, the specimen shall be parted through its thickness into as many specimens as required.
4. The length of reduced sections shall be equal to the width of the widest portion of weld, plus 1/4 in. (6.5 mm) minimum on each side.

Figure A12 — Transverse Rectangular Tension Test Specimen (Plate)

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125/ = 4 MICROMETERS

in.	mm
1/16	1.5
1/8	3.0
3/4	19.0
1	15.5
1-1/2	38.0
2	51.0
2-1/4	57.0
3	76.0
10	254.0

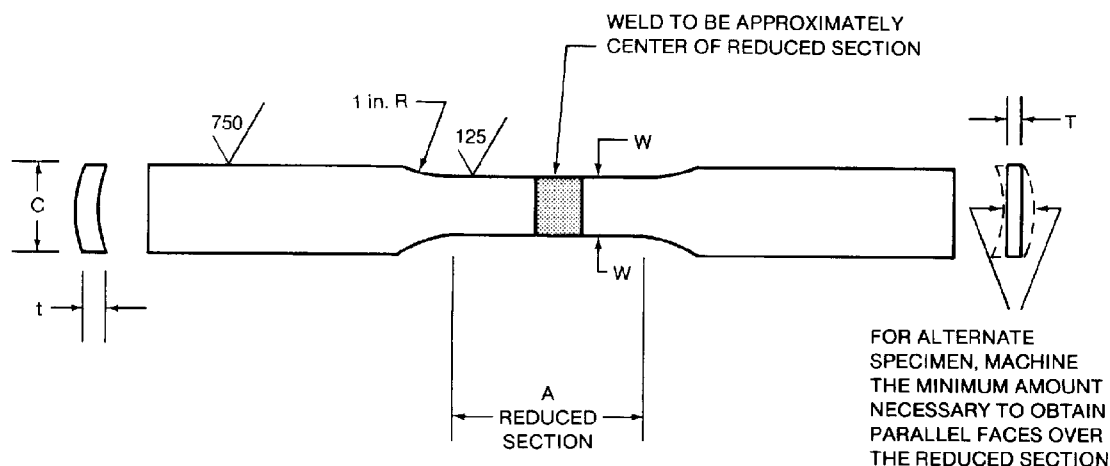
	Dimensions			
	Specimen 1		Specimen 2	
	in.	mm	in.	mm
W = width	1±0.005	25.5±1.5	1.50±0.125	38.0±3.0
B = width of weld	0.50 approx	12.5 approx	0.75 approx	19.0 approx
nominal C = width of grip section	1.5	38	2.0	57

Notes:

1. The weld reinforcement and backing, if any, shall be removed, flush with the surface of the specimen.
2. The width, B, of the weld may be varied to approximate 1/2 W by selecting an appropriate specimen thickness, T, and its location within the weld.
3. The width, W, may be varied within reason to accommodate the approximation of B = 1/2 W if it is not possible to meet the requirements of Note 2.
4. The grip sections of the specimen shall be symmetrical with the center line of the reduced section, within 1/8 in. (3.0 mm).

Figure A13 — Longitudinal and Rectangular Tension Test Specimen (Plate)

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ALL DIMENSIONS ARE IN INCHES

$$\sqrt{125} = 4 \text{ MICROMETERS}$$

$$\sqrt{750} = 24 \text{ MICROMETERS}$$

Specimen No.	W	C	A
1	$1/2 \pm 1/64$	1/16 approx	2-1/4 min
2	$3/4 \pm 1/34$	1 approx	2-1/4 min
3	$1 \pm 1/16$	1-1/2 approx	4-1/2 min
4	$1-1/2 \pm 1/8$	2 approx	2-1/4 min
			4-1/2 min
			9 min

in.	mm
0.01	0.3
1/64	0.4
1/32	0.8
1/16	1.5
1/8	3.0
3/8	9.5
1/2	12.5
3/4	19.0
1	25.5
1-1/16	27.0
1-1/2	38.0
2	51.0
2-1/4	57.0
4	101.5
4-1/2	114.5
8	203.0
9	228.5

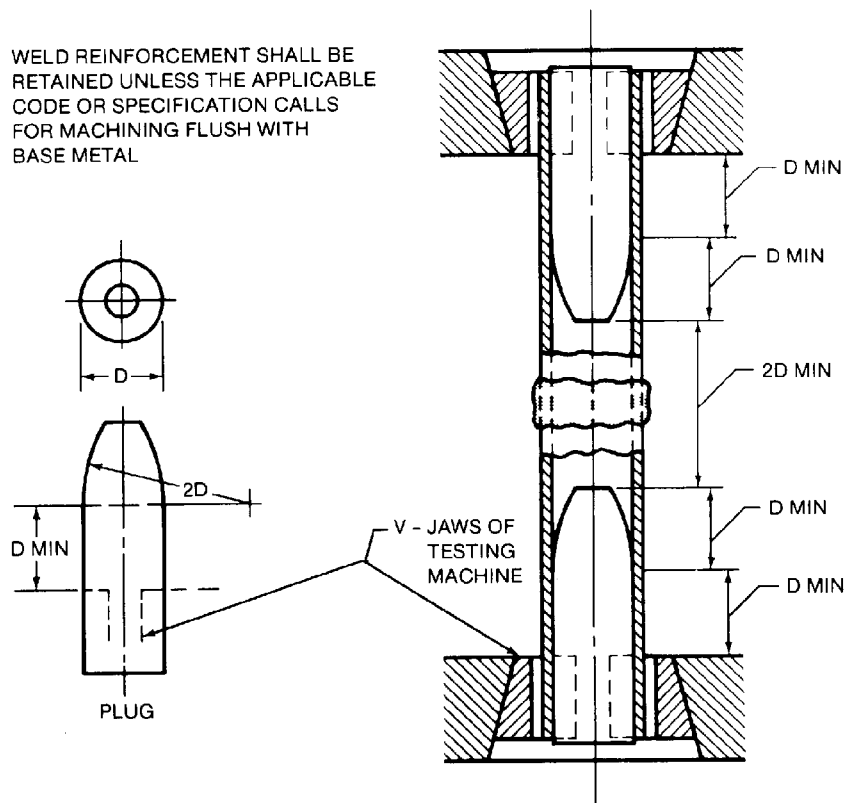
Notes:

1. The weld reinforcement and backing, if any, shall be removed flush with the specimen.
2. Alternate specimen shall not be used for nominal wall thickness less than 3/8 in. (9.5 mm).
3. Only grip sections of the specimen may be flattened.
4. In the case of full wall thickness specimens, cross-sectional area may be calculated by multiplying W and t (t = T).
5. T is the thickness of the test specimen as provided for in the applicable specification.
6. The reduced section shall be parallel within 0.010 in. and may have a gradual taper in width from the ends toward the center with the ends not more than 0.010 in. wider than the center.
7. The grip section of the specimen shall be symmetrical, with the center line of the reduced section within 1/8 in. (10 mm).

Figure A14 — Tension Specimen for Pipe Size Greater than 2 Inches Nominal

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WELD REINFORCEMENT SHALL BE
RETAINED UNLESS THE APPLICABLE
CODE OR SPECIFICATION CALLS
FOR MACHINING FLUSH WITH
BASE METAL



D = INSIDE DIAMETER OF PIPE

Figure A-15 — Tension Specimen for Pipe Size 2 Inches Nominal and Less

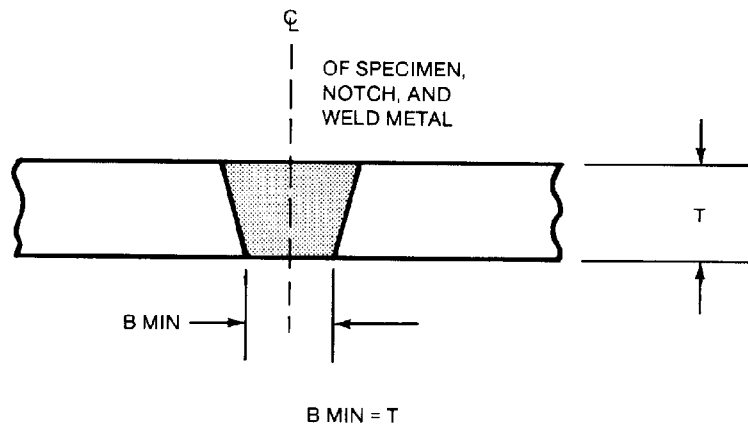


Figure A16 — Minimum Width of Weld Metal for a Weld-Metal Fracture Toughness Specimen

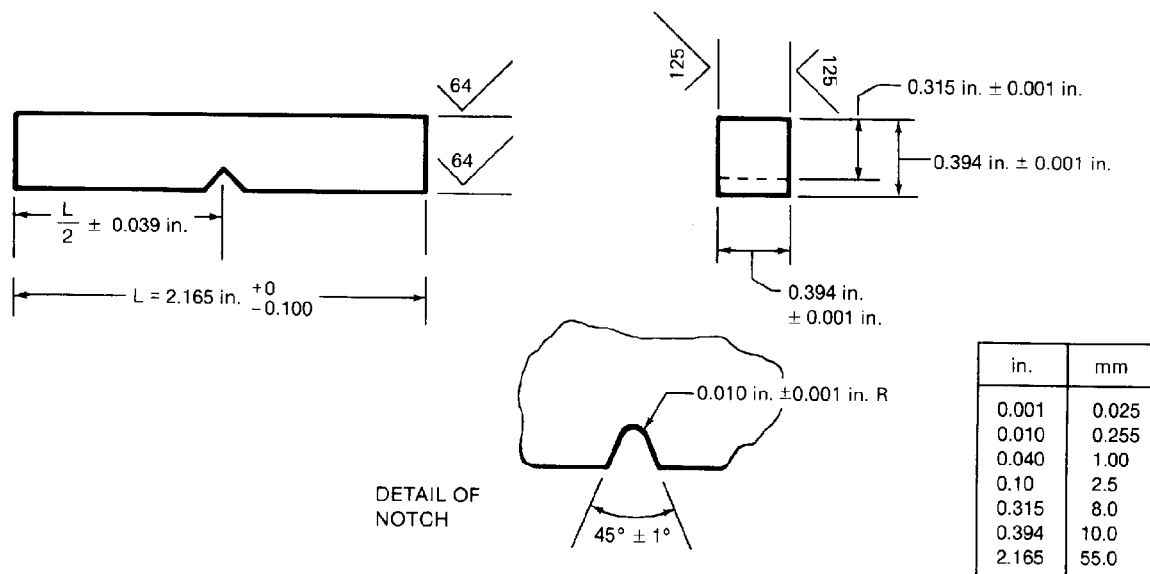


Figure A17 — Charpy V-Notch Impact Specimen

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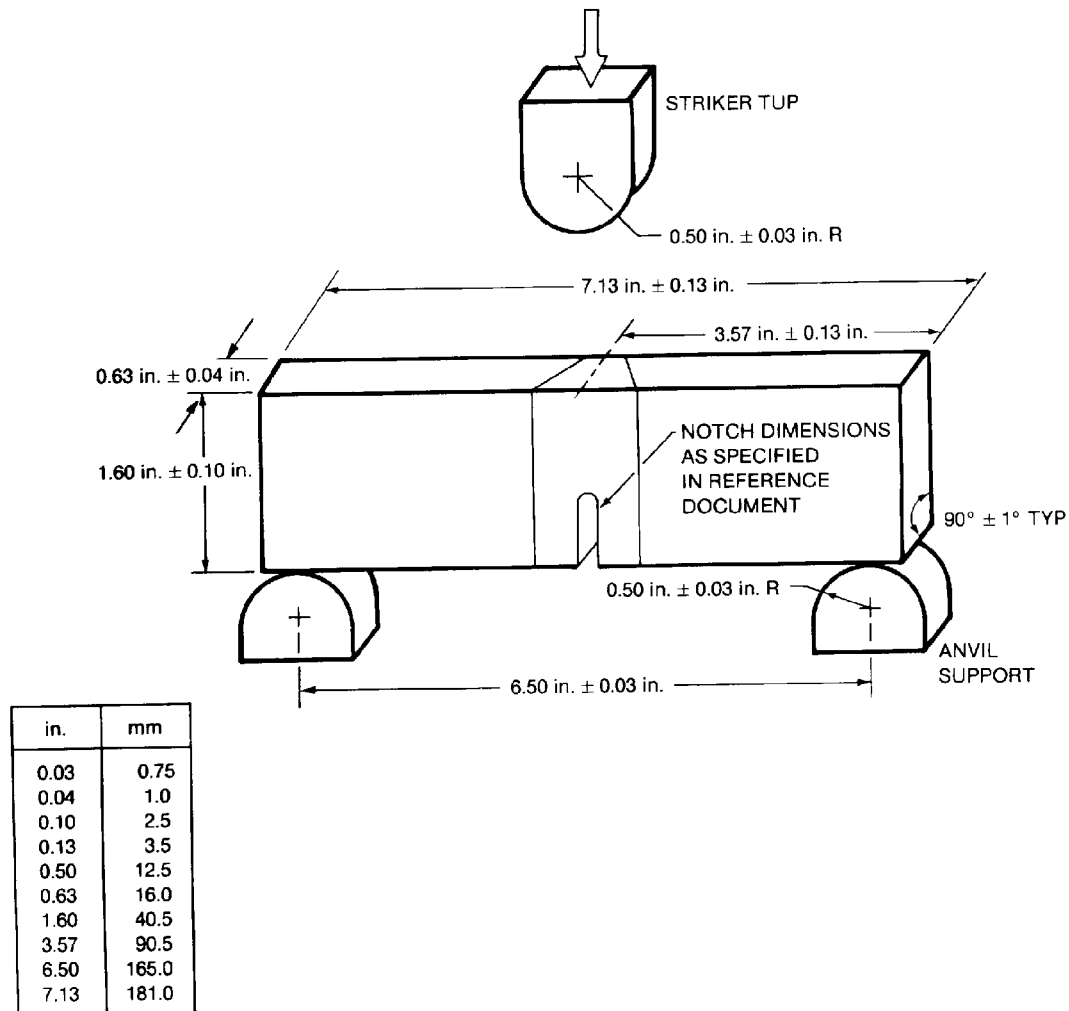
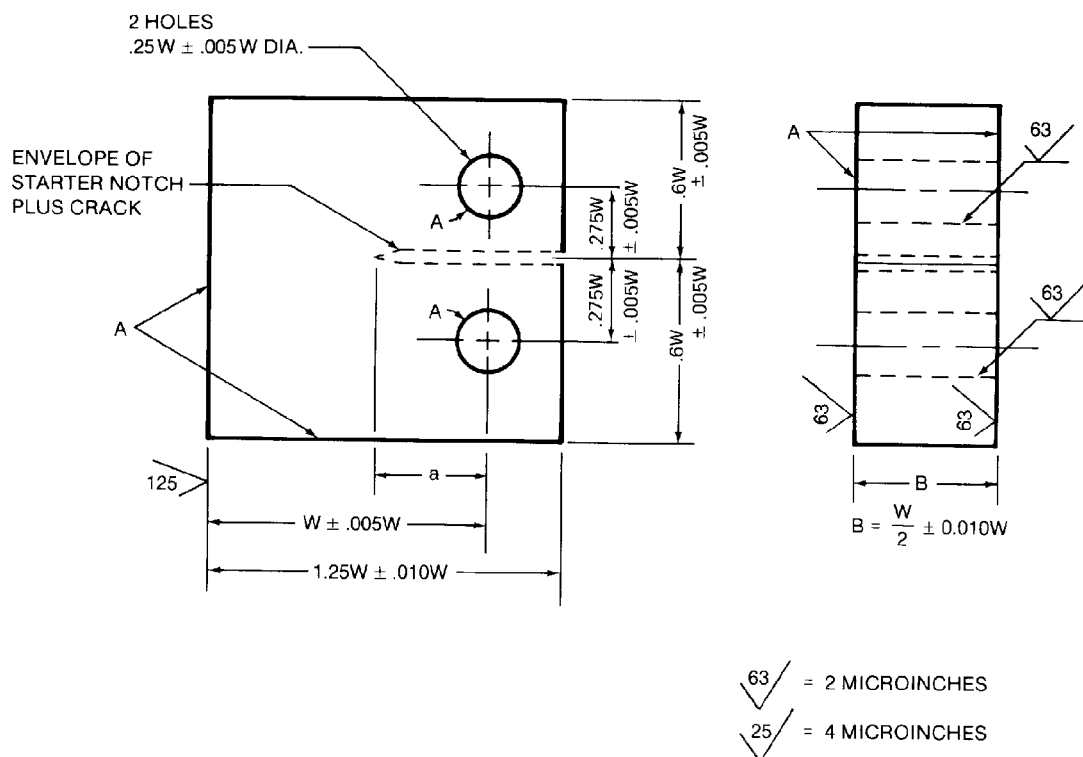


Figure A18—Dynamic Tear Test Specimen, Anvil Supports, and Striker

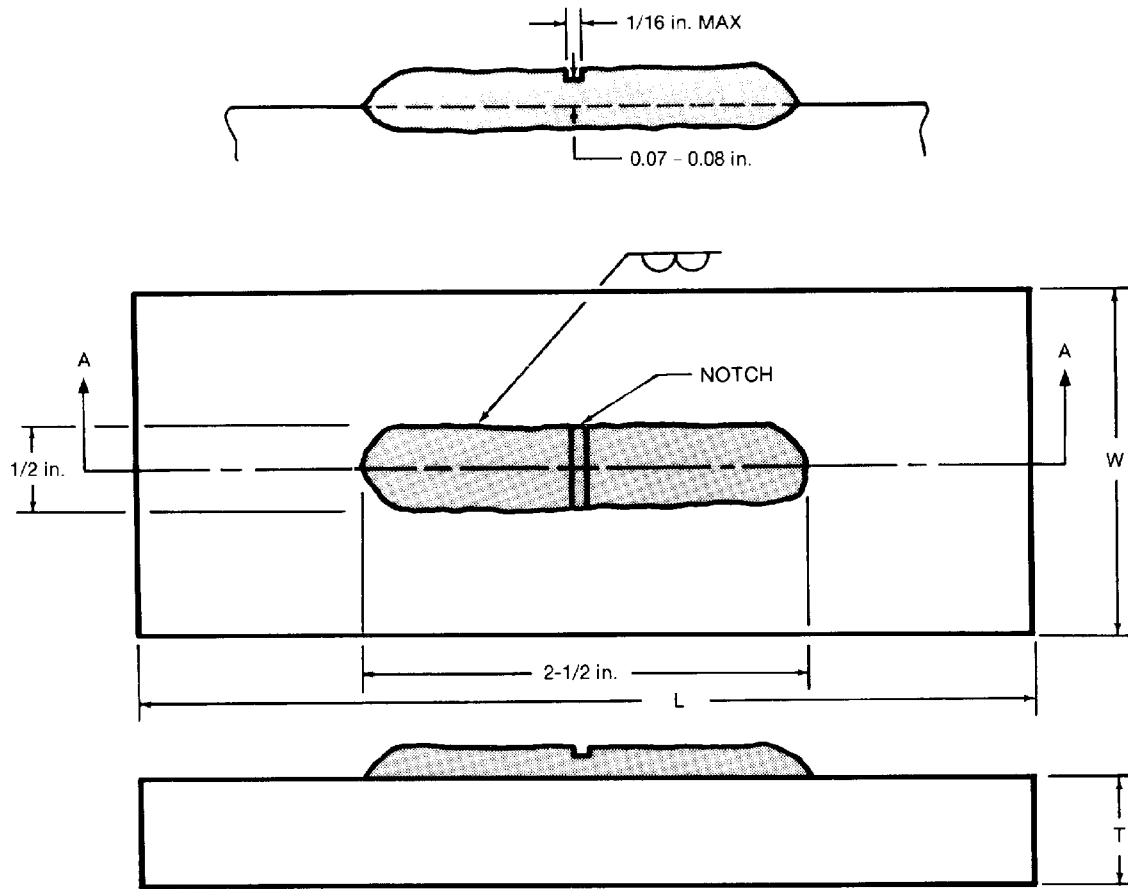


Notes:

1. Dimensions a, B, and W are to be determined in accordance with ASTM E399.
2. Surfaces marked A shall be perpendicular and parallel as applicable to within 0.002W total indicator reading (TIR).
3. The intersection of the crack starter tips with the two specimen faces shall be equally distant from the top and bottom edges of the specimen within 0.005W.
4. Integral or attachable knife edges for clip gage attachment to the crack mouth may be used.

Figure A19—Plane Strain Fracture Toughness Specimen (Compact Tension Specimen)

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Specimen Type			
Dimension in.	P-1 Dimensions	P-2 Dimensions	P-3 Dimensions
T, thickness	1.0	0.75	0.62
L, length	14.0	5.0	5.0
W, width	3.5	2.0	2.0

in.	mm
1/16	1.5
0.07	1.8
0.08	2.0
1/2	12.5
0.62	15.5
0.75	19.0
1	25.4
2	51.0
2-1/2	63.5
3	76.0
3.5	89.0
5.0	127.0
14.0	355.5

Figure A20 — Standard Drop Weight Nil-Ductility Temperature Test Specimens (ASTM E208)

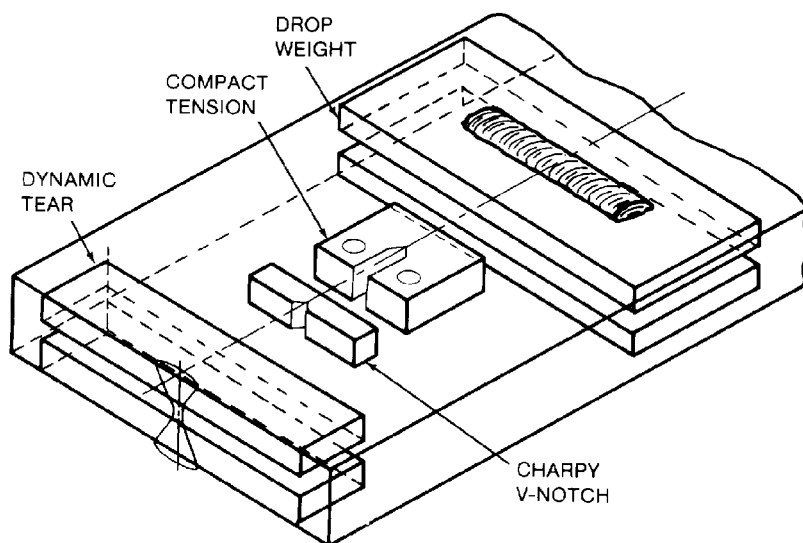


Figure A21 — Orientation of Weld Metal Fracture Toughness Specimens to a Double-Groove Weld Joint in Thick Section Weldments

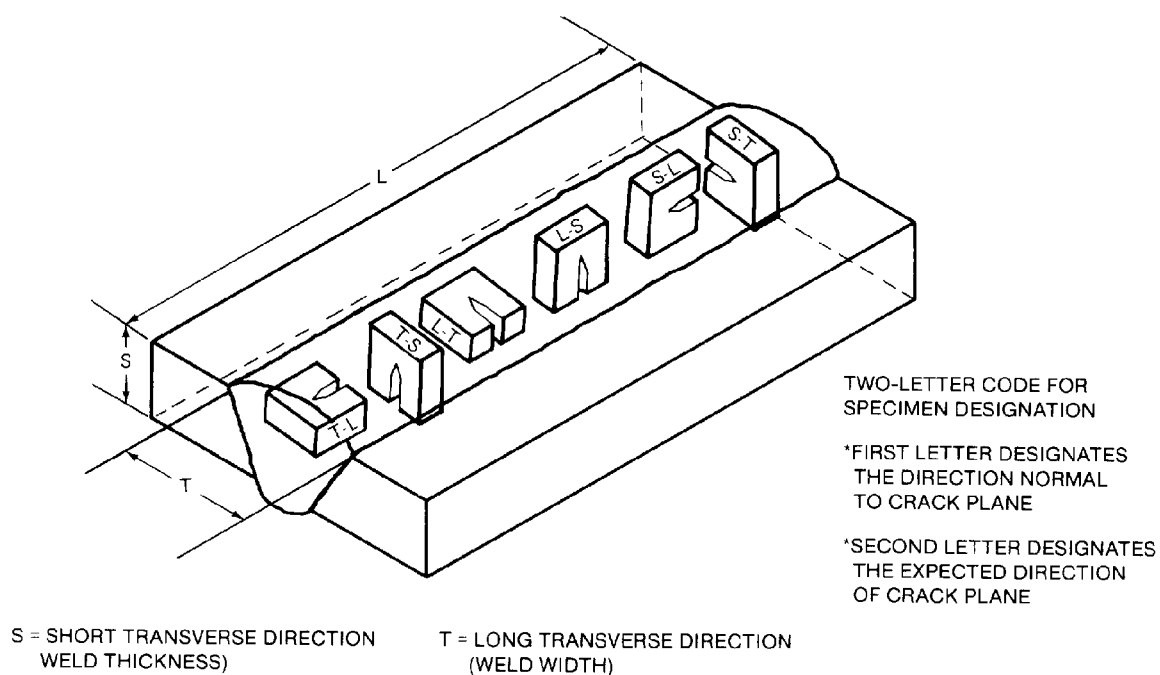


Figure A22 — Crack Plane Orientation Code for Compact Tension Specimens From Welded Plate

Part B

Testing of Fillet Welds

B1. Longitudinal Guided Bend Test

See Part A1, 7.6 Fillet Weld Root Bend Test.

1. Scope

1.1 This section covers the bend testing of fillet welds in ferrous and nonferrous metals. The standard gives the requirements for guided-bend test specimen preparation, test parameters, and testing procedures, but does not specify the requirements or acceptance criteria.

1.2 The base materials may be homogenous, clad, or otherwise surfaced, except for hardfacing.

1.3 This standard is applicable to the following, where specified:

- (1) Qualification of materials, welding personnel and welding procedures
- (2) Information, specifications of acceptance, manufacturing quality control
- (3) Research and development

1.4 When this standard is used, the following information shall be furnished:

- (1) The type of data required and observations to be made
- (2) Bend radius required or percent (%) elongation
- (3) Post weld thermal or mechanical processing treatments

2. Applicable Documents

Reference should be made to the latest edition of the following documents:

- | | |
|------------|---|
| ANSI B46.1 | Surface Texture (Surface Roughness, Waviness, and Lay) |
| AWS A2.4 | Standard Symbols for Welding, Brazing, and Nondestructive Examination |
| AWS A3.0 | Standard Welding Terms and Definitions Including Terms for Brazing, Soldering, Thermal Spraying and Thermal Cutting |

The sources of these documents are the following:

American National Standards Institute
1430 Broadway
New York, New York 10018

American Welding Society
550 N.W. LeJeune Road
P.O. Box 351040
Miami, Florida 33135

3. Summary of Method

Longitudinal fillet weld specimens are guided in the bending process with a bend test fixture that employs a mandrel and wrap-around roller or end supports and plunger.

4. Significance

The ductility of the welded joint, as evidenced by its ability to resist failure and the presence of defects on the tension surface, is determined in the longitudinal fillet weld guided bend test.

5. Definitions and Symbols

The welding symbols and terms used in this standard shall be in accordance with the latest edition of ANSI/AWS A2.4, *Symbols for Welding, Brazing, and Nondestructive Examination*, and ANSI/AWS A3.0, *Standard Welding Terms and Definitions*.

6. Apparatus

6.1 Longitudinal fillet weld guided bend specimens are to be tested in a guided bend test fixture designed to support and load the specimen in a three point bending mode.

6.2 The fixture shall have the dimensions shown in Figure B1.

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7. Specimens

Longitudinal fillet weld bend test specimens are prepared by making two fillet welds on a tee joint and machining the specimen as shown in Figure B1.

8. Procedure

8.1 Unless otherwise specified, the specimens shall be tested at ambient temperature, and deformation shall occur in a time period no shorter than one half minute and no longer than two minutes.

8.2 The specimen is to be positioned in the bend fixture as shown in Figure B1 and a force applied sufficient to affect bending.

9. Report

In addition to the requirements of applicable documents the report shall include the following:

- (1) Base Metal Specification
- (2) Filler Metal Specification
- (3) Test Temperature
- (4) Number of Tests
- (5) Number, Type, Size and Location of Discontinuities noted, if any
- (6) Bend angle if specimen fractures prior to bending to 180 degrees

B2. Soundness Tests

1. Scope

This section covers the fillet weld soundness test procedures, test parameters, and methods of obtaining data and the observations usually required, but does not specify the requirements or acceptance criteria. When this standard is used as a portion of a standard, or detail specifications, the following information should be furnished:

- (1) The specific tests and the number of specimens that are required
- (2) Specific orientation of specimens within the weld sample
- (3) The type of data required and observations to be made
- (4) The limiting numerical values
- (5) The interpretation, if any, of the data and observations

2. Applicable Documents

Reference should be made to the latest edition of the following documents:

- | | |
|------------|--|
| ANSI B46.1 | Surface Texture (Surface Roughness, Waviness, and Lay) |
| AWS A2.4 | Standard Symbols for Welding, Brazing, and Nondestructive Examination |
| AWS A3.0 | Standard Welding Terms and Definitions Including Terms for Brazing, Soldering, Thermal Spraying, and Thermal Cutting |

The sources of these documents are the following:

American National Standards Institute (ANSI)
1430 Broadway
New York, New York 10018

American Welding Society (AWS)
550 N.W. LeJeune Road
P.O. Box 351040
Miami, Florida 33135

3. Summary of Method

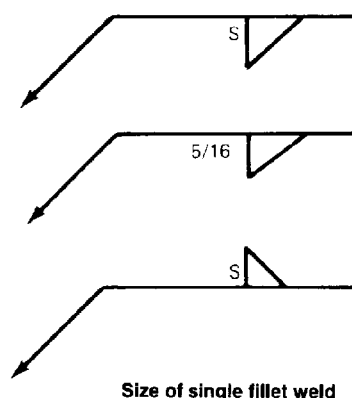
One leg of a T-joint is bent upon the other so as to place the root of the weld in tension. The load is maintained until the legs of the joint come into contact with each other or discontinuities appear in the weld.

4. Significance

The purpose of this test is to determine the soundness of fillet welded joints. This test is qualitative in nature with acceptance determined by the extent and nature of any flaws present.

5. Definitions and Symbols

The welding symbols and terms used in this section are in accordance with the latest editions of ANSI/AWS A2.4, *Symbols for Welding, Brazing, and Nondestructive Examination* and ANSI/AWS A3.0, *Standard Welding Terms and Definitions*.



Unless otherwise noted, the following designations are used:

- S = specified fillet size,
t = (plate thickness) = T (specimen thickness)

6. Apparatus

Apparatus used shall be capable of firmly holding the specimen and applying the required force.

7. Specimens

7.1 Fillet Weld Break — Procedure Qualification. The uncoated fillet weld break specimen shall be welded and prepared for the test shown in Figure B2. The weld shall meet the visual requirements of the applicable standard.

7.2 Fillet Weld Break — Primer Coated Procedure Qualification. The fillet weld break specimen shall be welded over primer coated material and prepared for test as shown in Figure B3. The weld shall present a reasonably uniform appearance and shall meet the visual inspection requirements of the applicable code or standard.

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7.3 Fillet Weld Break — Galvanized Procedure Qualification. The fillet weld break specimen shall be welded over galvanized material and prepared for test as shown in Figure B4. The weld shall present a reasonably uniform appearance and shall meet the visual inspection requirements of the applicable code or standard.

7.4 Fillet Weld Break — Welder Qualification. The fillet weld break specimen for welder qualification shall be welded and prepared as shown in Figure B5. The weld shall meet the visual requirements of the applicable code or standard.

7.5 Fillet Break — Tack Welder Qualification. The uncoated fillet weld break specimen for tack welder performance qualification shall be welded and prepared for test as shown in Figure B6. The weld shall present a reasonably uniform appearance and shall meet the visual inspection requirements of the applicable code or standard.

7.6 Fillet Weld Nick Break Test. See Part C1.

8. Procedure

A force as shown in Figure B7 or other forces causing the root of the weld to be in tension shall be applied to the specimen.

The load shall be increased until the specimen fractures or bends flat upon itself.

If the specimen fractures, the fracture surfaces shall be examined visually for evidence of discontinuities such as cracks, inclusions, or lack of penetration.

9. Report

In addition to requirements of the applicable documents (see 2), the report shall include the following:

- (1) Base metal specification
- (2) Filler metal specification
- (3) Fillet weld size
- (4) Welding procedure (Process and Parameters)
- (5) Specimen type
- (6) Fracture appearance
- (7) Number, type, size, and locations of visible inclusions or discontinuities
- (8) Any observation of unusual characteristics of the specimens or procedure

B3. Shear Tests

1. Scope

1.1 This section covers fillet weld shear tests of welds in plate.

1.2 When a fillet weld shear test is required, the preparation of the test specimens and the testing procedure shall conform to this standard.

1.3 This standard does not specify requirements or acceptance criteria.

1.4 This standard is applicable to the following when specified:

(1) Qualification of welding personnel and welding procedures

(2) Information, basis for inspection, and fabrication quality control when acceptance criteria have been established

(3) Research and development

1.5 When this standard is used, the following information shall be furnished:

(1) Welding process used

(2) The specified type of test and the number of specimens that are required

(3) Base metal specification/identification and thickness

(4) Position(s) of welding

(5) Filler metal specification/identification and diameter

(6) Type and flow rate of any shielding gas used

(7) Postweld thermal treatment, if applicable

(8) Report form including type of data and observations to be made

(9) Acceptance criteria

2. Applicable Documents

References should be made to the latest edition of the following documents:

ASTM F4 Standard Practices for Load Verification of Testing Machines

ASTM E8 Standard Methods of Tension Testing of Metallic Materials

AWS A2.4 Symbols for Welding, Brazing, and Non-destructive Examination

AWS A3.0 Standard Welding Terms and Definitions

The sources of these documents are the following:

American Welding Society
550 N.W. LeJeune Road
P.O. Box 351040
Miami, Florida 33135

American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103-2287

3. Summary of Method

The fillet weld shear test places a tensile load on a specimen prepared so that the load shears the fillet welds. The weld shearing strength is reported as (1) load per unit length of weld (for welds that fail), and (2) shear stress on the throat of the weld.

4. Significance

4.1 Fillet weld shear tests provide information on the load bearing capacities and joint efficiencies of welded joints. The data obtained from fillet weld shear tests may include:

(1) Unit shear load

(2) Shear strength

(3) Location and mode of fracture

4.2 Fillet weld shear tests provide quantitative data which can be compared and otherwise analyzed and used in the design and analysis of welded structures. Fracture surfaces may also provide information on the presence and effects of discontinuities such as lack of fusion/penetration, porosity, inclusions and cracking.

5. Definitions and Symbols

The welding symbols and terms used in this section are in accordance with the latest edition of ANSI/AWS A2.4, *Symbols for Welding, Brazing, and Nondestructive Examination*, and ANSI/AWS A3.0, *Standard Welding Terms and Definitions*.

6. Apparatus

The test shall be performed on a tensile machine in conformance with ASTM E8. The machine shall be calibrated in accordance with ASTM E4.

7. Specimens

7.1 Longitudinal Shear Strength Specimen. The specimen shall be welded as shown in Figure B8 and inspected visually. The surface contour and size of the fillet welds shall be in accordance with the applicable standard, or other specified acceptance criteria. The specimen shall be machined as shown in Figure B9 before testing.

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7.2 Transverse Shear Strength Specimen. The specimen shall be prepared as shown in Figure B10 and inspected visually. The surface contour and size of the fillet welds shall be in accordance with the applicable standard, or other specified acceptance criteria. Wider plate widths may be used to obtain multiple specimens. When multiple specimens are prepared from a single welded assembly, the results for each individual specimen are to be reported.

7.3 Preparation. The data obtained from a fillet weld shear strength specimen may be affected by certain preparation and testing variables. For the transverse specimen, the gap left between the lapped plates during the specimen preparation magnifies the stresses at the root of the weld, thus lowering its strength. Nonuniformity of fillet weld contour will affect the test values. The specimen is also sensitive to any underbead cracking or undercut.

8. Procedure

8.1 The length of weld and average leg dimension of each weld shall be measured and reported. The theoretical throat is calculated from these dimensions.

8.2 The specimen shall be positioned in the testing machine so that the tensile load is applied parallel to the longitudinal axis of the specimen.

8.3 The specimen shall be loaded in tension until the welds are sheared.

8.4 A test shall be considered invalid if the specimen fails in the base metal (i.e., tensile overload) and an additional test specimen shall be prepared and tested.

8.5 Unit shear load in pounds per unit length of weld (lb/in) is determined by dividing the maximum load by the total length of weld under test.

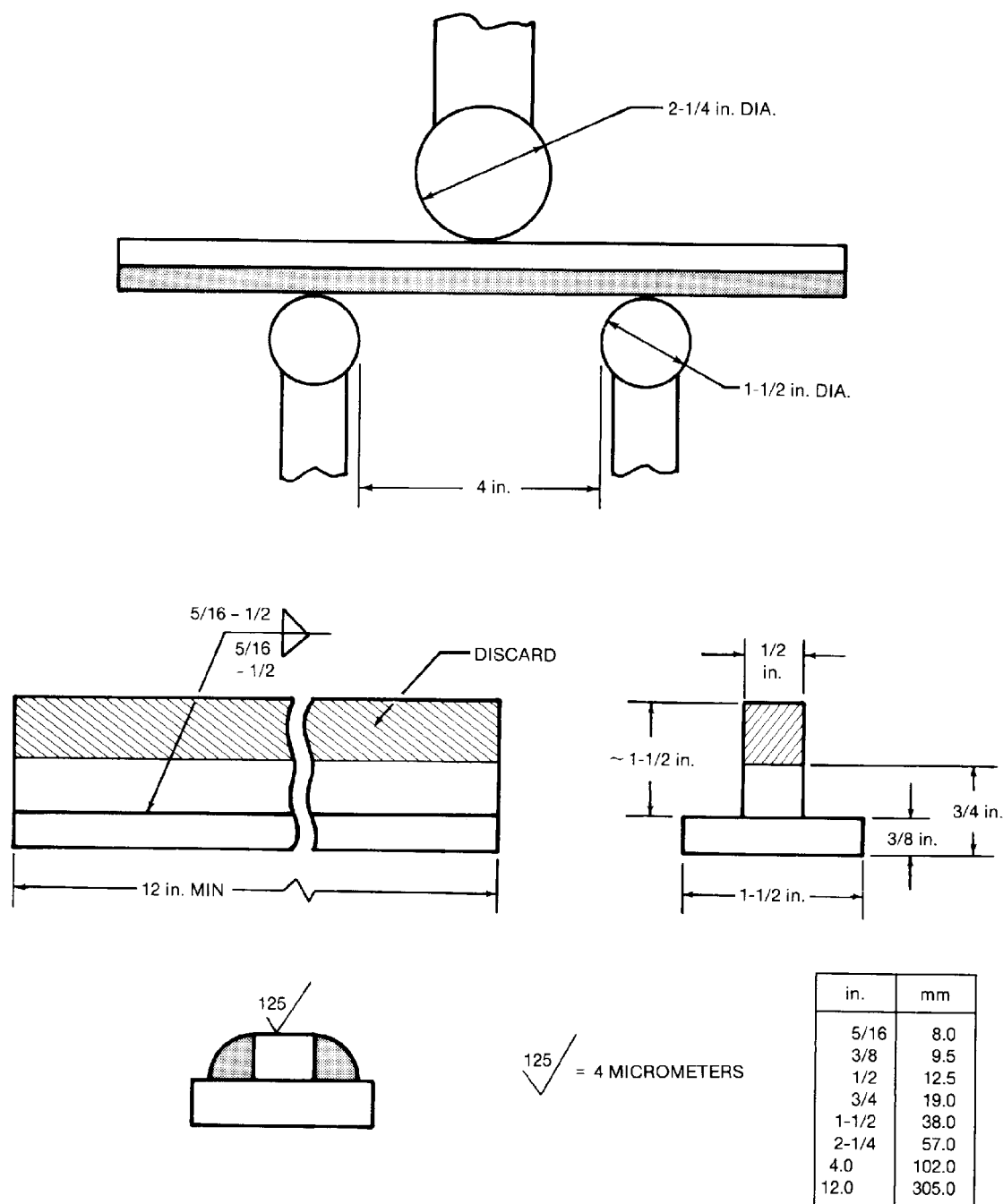
8.6 Shear strength in force per unit area (psi) acting on the throat of the fillet weld, is determined by dividing the unit shear load in pounds per linear inch by the average throat dimensions of the welds that sheared (see Figure B11).

8.7 Eccentric loading during testing will make the specimen more sensitive to certain defects such as weld discontinuities at the ends of the fillet welds.

9. Report

In addition to the requirements of the applicable standard, or other user specified requirements, the report should indicate the following:

- (1) Specimen identification
- (2) Welding procedure number or identification
- (3) Specimen type (longitudinal or transverse)
- (4) Unit shear load
- (5) Shear strength
- (6) Location of fracture
- (7) Actual throat dimensions, if it has been measured
- (8) Any observation of unusual characteristics of the specimen, fracture surfaces or procedure



Notes:

1. Mandrel diameter shown is for a maximum for 3/4 in. (19.0 mm) thick specimen.
2. Other thicknesses of bottom plate and fillet weld leg size may be utilized, provided the mandrel diameter does not exceed 3 times the specimen thickness. In these cases, the support clearance should be the mandrel diameter plus twice the specimen thickness plus 1/4 in. (6.5 mm)

Figure B1 — Longitudinal Guided Fillet Weld Bend Test

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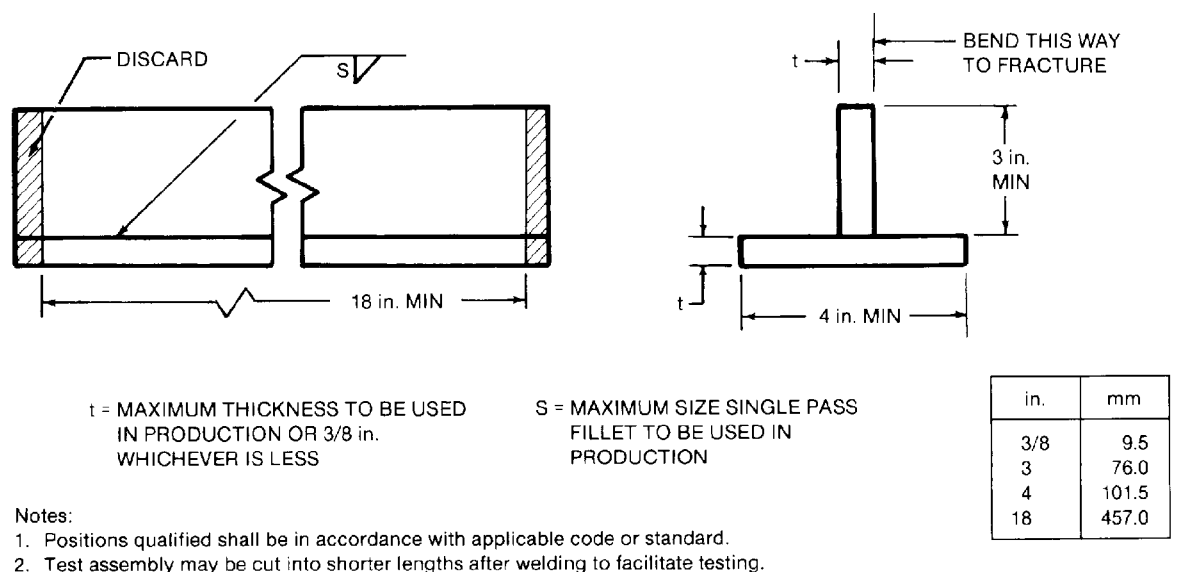


Figure B2 — Fillet Weld Break Specimen for Procedure Qualification

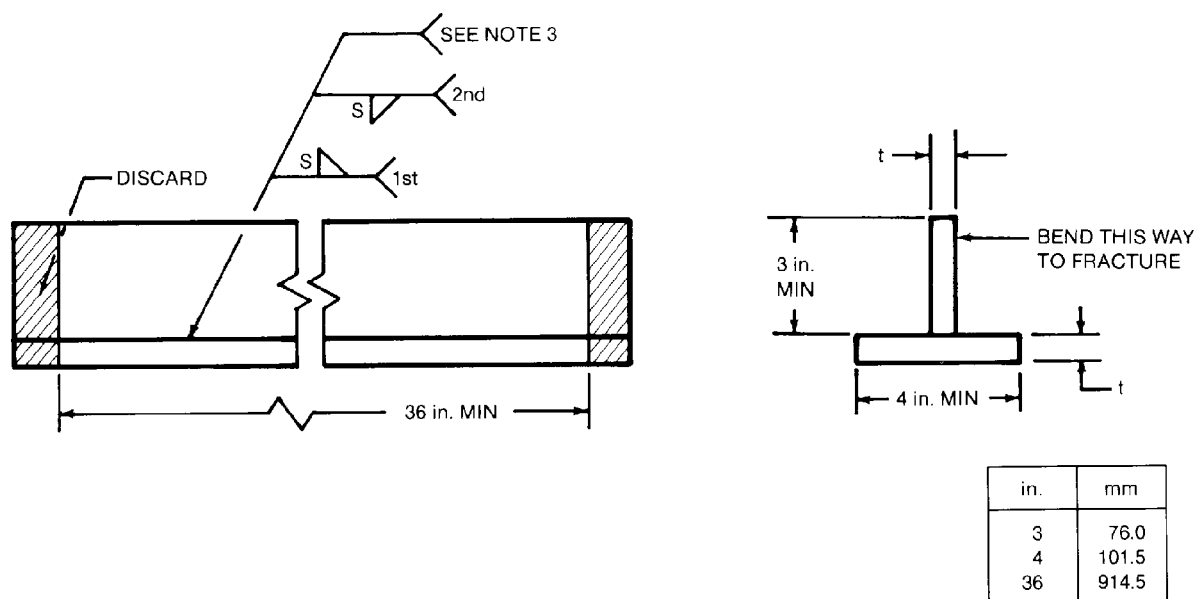
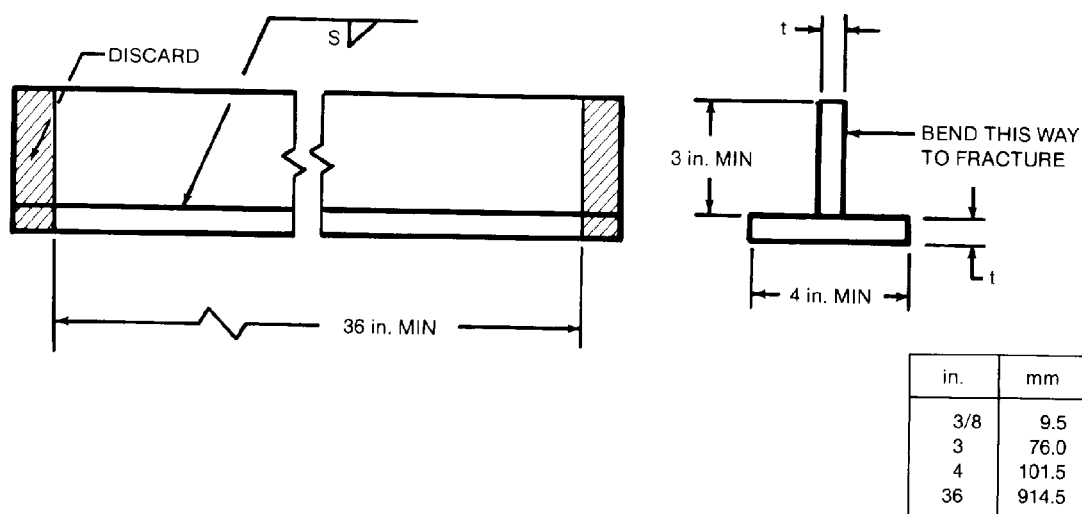


Figure B3 — Fillet Weld Break Specimen for Primer Coated Materials

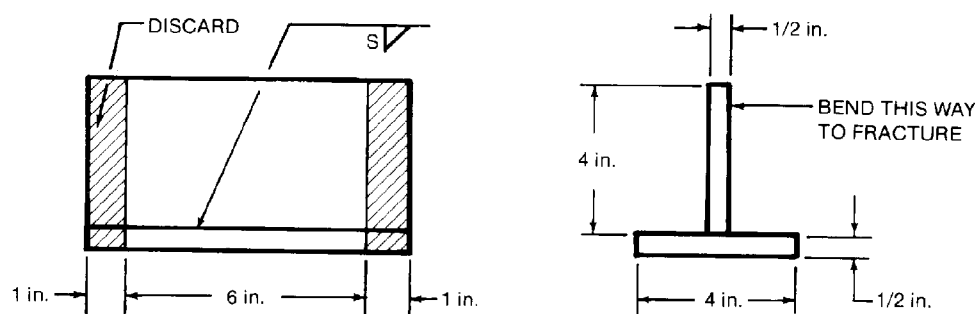
Testing of Fillet Welds/41



Notes:

1. Plate thickness, t , shall be maximum used in production or 3/8 in. (9.5 mm), whichever is less.
2. Weld size, S , shall be maximum single pass fillet weld to be used in production.
3. Although entire 36 in. (914.5 mm) length is to be tested, the test assembly may be cut into shorter lengths after welding to facilitate fracturing for examination.
4. Galvanized plating shall be the same grade, specification, and maximum thickness as that used in production.

Figure B4 — Fillet Weld Break Specimen for Galvanized Materials



Notes:

1. Stop and restart near center.
2. Unless otherwise specified, specimen thickness and dimensions are minimum.

in.	mm
5/16	8.0
1/2	12.5
1	25.5
4	101.5
6	152.5
8	203.0

Figure B5 — Fillet Weld Break Specimen for Welder Qualification

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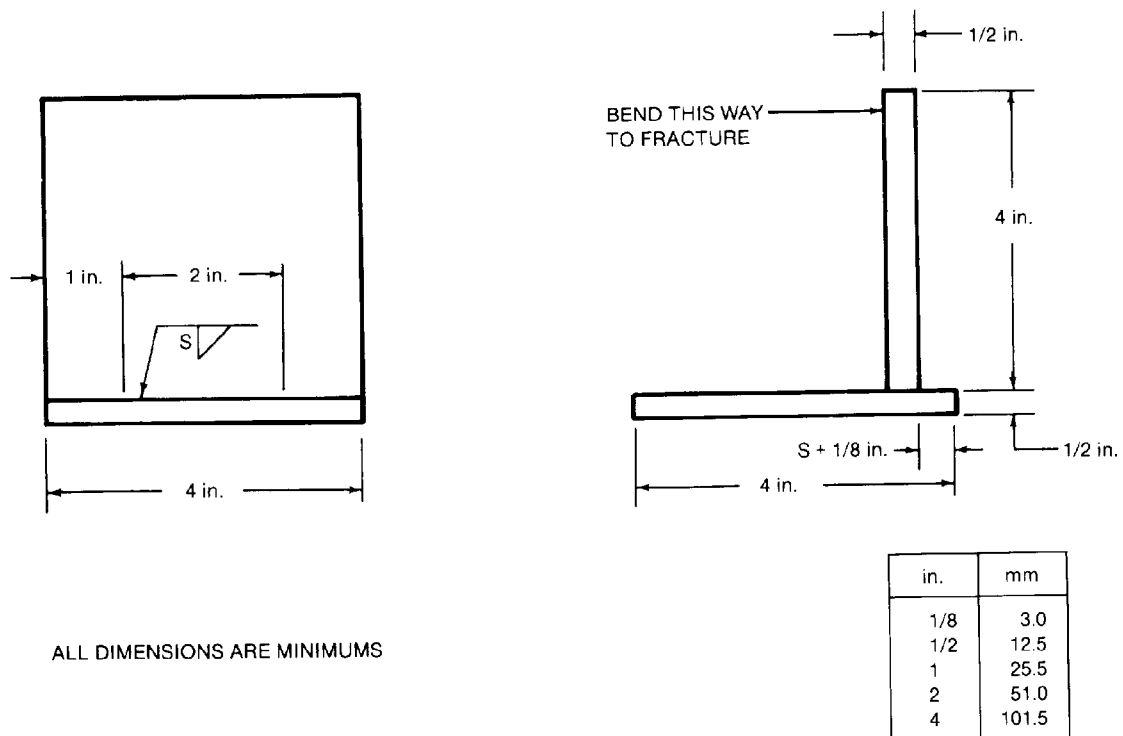


Figure B6 — Fillet Weld Break Specimen for Tack Welder Qualification

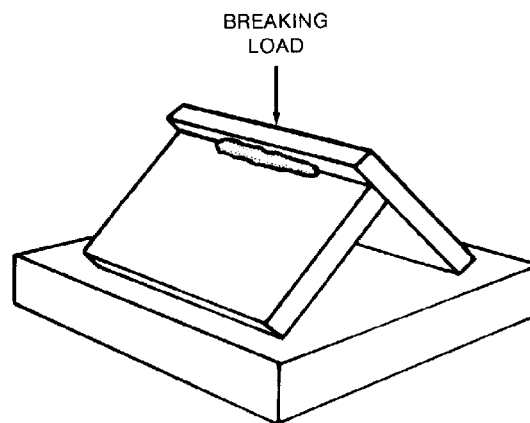
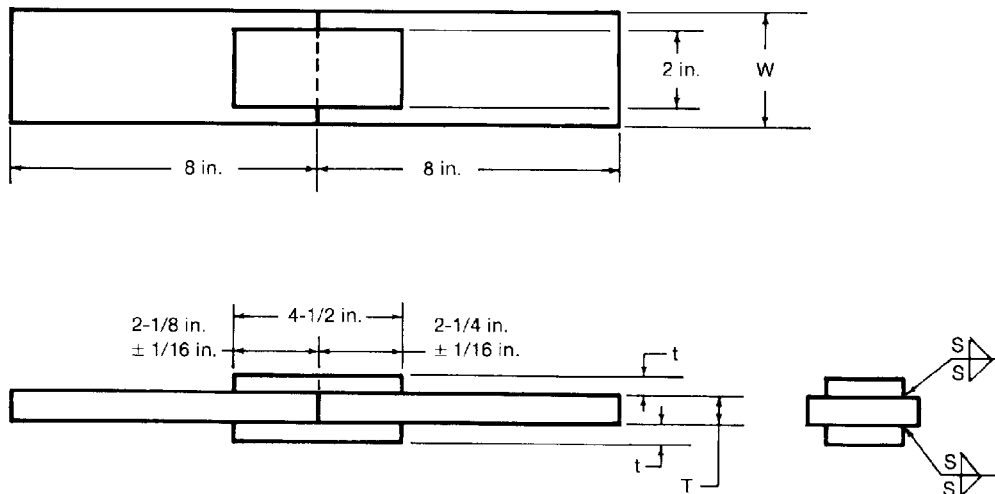


Figure B7 — Method of Testing Fillet Weld Break Specimen



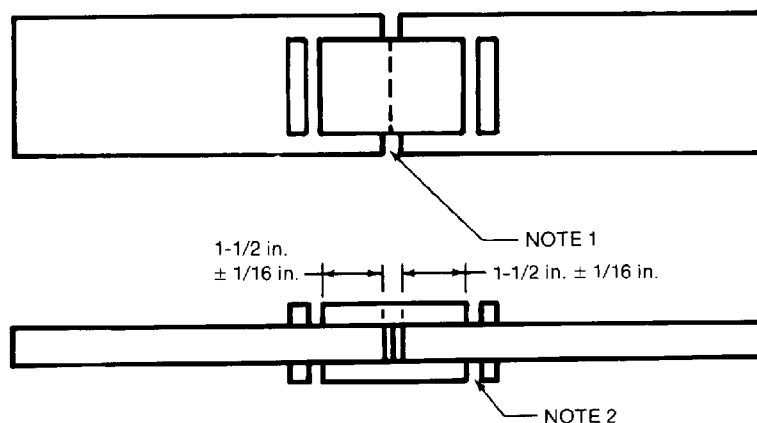
DIMENSIONS

	in.	in.	in.	in.
Size of Weld S	1/8	1/4	3/8	1/2
Thickness t	3/8	1/2	3/4	1
Thickness T	3/8	3/4	1	1-1/4
Width W	3	3	3	3-1/2

in.	mm
1/16	1.5
1/8	3.0
1/4	6.0
3/8	9.5
1/2	13.0
3/4	19.0
1	25.0
1-1/4	32.0
2	51.0
2-1/4	57.0
3	76.0
3-1/2	89.0
4-1/2	114.0
8	203.0

Figure B8 — Longitudinal Fillet Weld Shearing Specimen Before Machining

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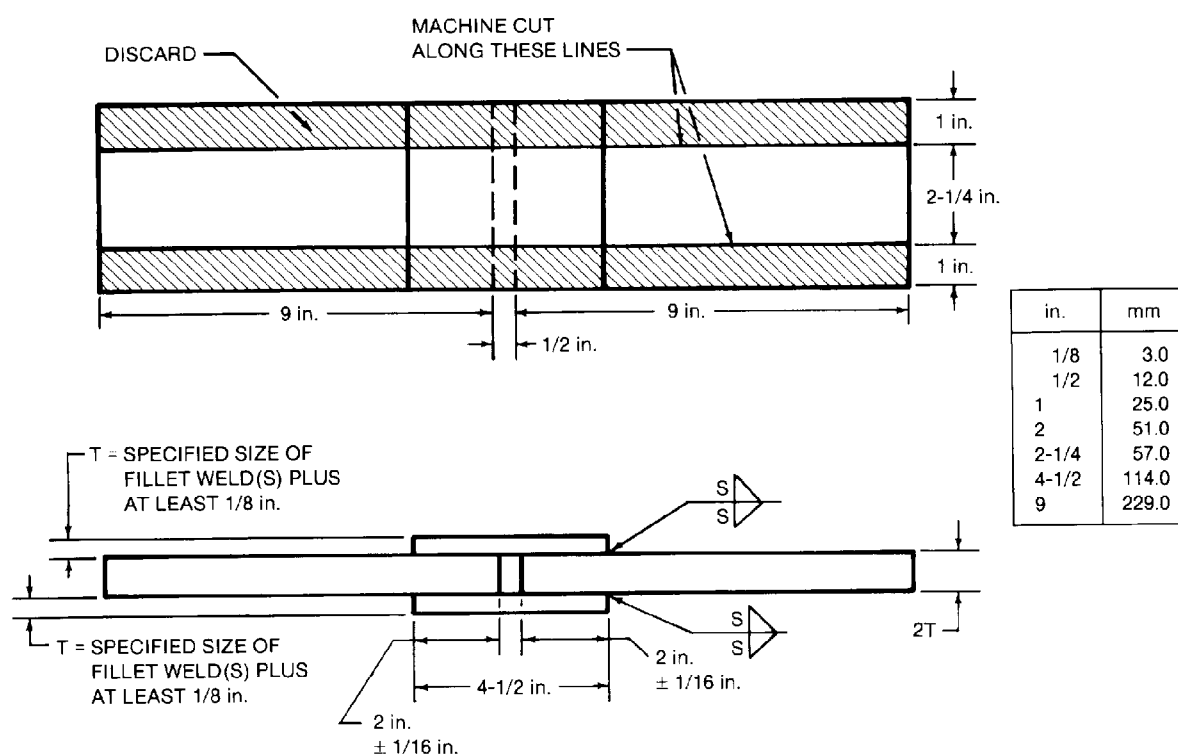


in.	mm
1/16	1.5
1-1/2	38.0

Notes:

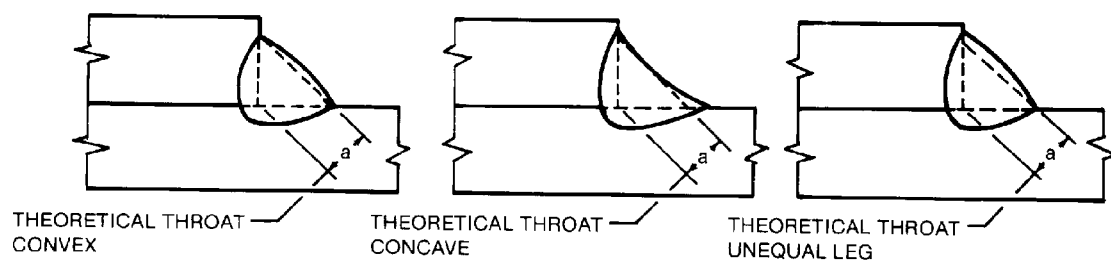
1. Slot machined through root of test fillet weld.
2. Depth of machined notch shall extend through thickness of lap plate.

Figure B9 — Longitudinal Fillet Weld Specimen After Machining



in.	mm
1/8	3.0
1/2	12.0
1	25.0
2	51.0
2-1/4	57.0
4-1/2	114.0
9	229.0

Figure B10 — Transverse Fillet Weld Shear Specimen



$$\tau = \frac{P}{\ell \times a}$$

where:

- P = load
- ℓ = total length of fillet weld sheared
- a = theoretical throat dimension
- τ = shear strength of weld

Figure B11 — Shear Strength Calculation

Part C

Tests Applicable to Groove and Fillet Welds

C1. Nick Break Test

1. Scope

1.1 This section covers nick break testing of welds in pipe or plate.

1.2 When a nick break test is required, the preparation of the test specimens and the testing procedures shall conform to this standard.

1.3 This standard does not specify requirements or acceptance criteria.

1.4 This standard is applicable to the following when specified:

(1) Qualification of materials, welding personnel, and welding procedures

(2) Information, basis for inspection, and fabrication quality control when acceptance criteria have been established

(3) Research and development

1.5 When this standard is used, the following information shall be furnished:

(1) Welding process used

(2) The specific tests and the number of specimens that are required

(3) Base metal specification/identification

(4) Position of welding

(5) Filler metal specification/identification (when used)

(6) Location and orientation of the specimens

(7) Whether external weld reinforcement is to be notched

(8) Manner of breaking specimen

(9) Report form including type of data and observations to be made

(10) Postweld thermal treatment, if applicable

(11) Acceptance criteria

2. Applicable Documents

References should be made to the latest edition of the following documents:

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

AWS A3.0 Standard Welding Terms and Definitions

AWS D10.12 Recommended Practices and Procedures for Welding Low Carbon Steel Pipe

API STD 1104 Welding of Pipelines and Related Facilities

API RP1107 Recommended Pipe Line Maintenance Welding Practices

The sources of these documents are the following:

American Welding Society
550 N.W. LeJeune Road
P.O. Box 251040
Miami, Florida 33135

American Petroleum Institute
2101 L Street, Northwest
Washington, DC 20037

3. Summary of Method

The specimen is fractured by one of three methods:

(1) Specimens are broken by supporting the ends and striking one side in the center with a hammer or by supporting one end and striking the other with a hammer.

(2) Specimens are loaded in tension on a testing machine until fracture occurs.

(3) Specimens are broken by supporting the ends and applying a load at the center of the opposite side.

4. Significance

4.1 The nick break test is used to evaluate the proper technique and welding parameters necessary to obtain sound groove or fillet welded joints in pipe or plate. The nick break test is also used, on occasion, to verify (by destructive testing) results obtained by nondestructive techniques.

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4.2 Nick break tests are often the only technique available to evaluate flash butt welds, pressure welds, or inertia (friction) welds in pipe or plate.

4.3 No significance should be attached to the magnitude of the load required for fracture.

5. Definitions and Symbols

The welding symbols and terms used in this section are in accordance with the latest edition of ANSI/AWS A2.4, *Symbols for Welding, Brazing, and Nondestructive Examination*, and ANSI/AWS A3.0, *Standard Welding Terms and Definitions*.

6. Apparatus

6.1 Apparatus used shall be capable of firmly supporting the specimen on one or both ends when fractured by use of a hammer. See Figures C1, C2 and C3.

6.2 Tests may also be performed either by loading in tension or three point bending.

7. Specimens

7.1 Specimens from Butt Welds. Nick break specimens shall be prepared by cutting the joint and the base metal to form a rectangular cross section. See Figure C5. The specimens may be either machine cut or flame cut. Edges shall be relatively smooth and parallel. They shall be notched with a hacksaw or bandsaw or thin abrasive wheel (disc). Notches are located as shown in Figure C4.

7.2 Full-sized Specimens. Small weld assemblies may be tested in their entirety using the complete assembly as the specimen. In those cases, the assembly shall be notched at the weld edges to a depth of approximately 1/8 in. (3.0 mm) and across the reinforcement to a depth of approximately 1/16 in. (1.5 mm) similar to that shown in Figure C4. These may be modified to suit individual assemblies, but the specimen configuration must be reported.

7.3 Specimens from Flash Butt Welds. Nick break specimens shall be prepared by cutting the joint and base metal to form a rectangular cross section. The specimens shall be as shown in Figure C5, and may either be machine or flame cut or cut by other suitable means.

The sides of the specimen may be macroetched to locate the fusion line. The sides of the specimen may be notched along the fusion line with a saw and or by other suitable means. Each notch shall be approximately 1/8 in. (3.0 mm) deep. The outside diameter weld reinforcement for a solid, round configuration shall be notched to the base metal surface and up to 10% below.

For pipe and tube configurations, in addition to matching the outside diameter, the inside diameter weld reinforcement may be notched to the base metal surface, and up to 10% below. For rectangular and square configurations, the top and bottom weld reinforcement shall be notched to the base metal surface and up to 10% below. Weld reinforcement need not be removed from either side of the specimen. See Figure C5.

7.4 Specimens from Fillet Welds. There are different types of nick break test specimens for testing fillet welded joints.

7.4.1 Pipe branch connections are tested using machine-cut or flame-cut specimens from the crotch areas and 90° from crotch (point) areas as shown in Figure C6. The specimens should be approximately 2 in. (51.0 mm) wide and 3 in. (76.0 mm) in length and notched as shown in Figure C6.

7.4.2 Pipe sleeve type connections (Figure C7) are tested using machine-cut or flame-cut specimens equally spaced around the circumference. The specimens should be at least 3 in. (76.0 mm) wide and 6 in. (152.5 mm) long and notched as shown in Figure C7.

7.4.3 Plate fillet welded joints are tested by machine-cut or flame-cut specimens from a lap joint design shown in Figure C8. The specimens should be approximately 3 in. (76.0 mm) wide and 6 in. (152.5 mm) long and notched as shown in Figure C8.

8. Procedure

The specimens shall be broken by supporting the ends and striking or applying a load to the opposite side, by supporting one end and striking the other end with a hammer, or by pulling in a tensile machine.

When a hammer is used to fracture the specimen, one side is hit twice and then the specimen is turned 180° and the other side is hit twice. This procedure is continued until the specimen is broken.

9. Report

In addition to reporting the test results as required by the applicable documents, the report shall also include the following:

- (1) Base metal specification
- (2) Filler metal specification.
- (3) Welding procedure (process and parameters).
- (4) Testing procedure.
- (5) Fracture appearance.
- (6) Number, type, size and location of inclusions or discontinuities in the fracture surface.
- (7) Any observation of unusual characteristics of the specimen or procedure.

C2. Hardness Testing of Welds

1. Scope

1.1 This section covers the indentation hardness testing of welds. Methods include the Brinell, Rockwell, Vickers and Knoop hardness tests.

1.2 When hardness tests are required, test specimen preparation and testing procedures shall conform to this standard.

1.3 This standard does not specify acceptance criteria.

1.4 This standard is applicable to the following, when specified:

(1) Qualification of materials, and welding procedures through assessment of mechanical and metallurgical properties, as specified

(2) Information, basis for acceptance, and manufacturing quality control where criteria for mechanical properties are requested

(3) Research and development

1.5 When this standard is used the following information shall be furnished:

(1) The specific type of test and number of specimens required

(2) The specific location and orientation of test specimens

(3) The specific locations within a test specimen to be tested and number of tests (indentations) required, and surface preparation

(4) Base metal specification/identification

(5) Filler metal specification/identification.

2. Applicable Documents

Reference should be made to the latest edition of the following documents:

ASTM E3 Standard Methods of Preparation of Metallographic Specimens.

ASTM E10 Standard Test Method for Brinell Hardness of Metallic Materials.

ASTM E18 Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials.

ASTM E92 Standard Test Method for Vickers Hardness of Metallic Materials.

ASTM E110 Standard Test Method for Indentation Hardness of Metallic Materials by Portable Hardness Testers.

ASTM E384 Standard Test Method for Microhardness of Materials.

AWS A3.0 Standard Welding Terms and Definitions Including Terms for Brazing, Soldering, Thermal Spraying and Thermal Cutting.

The sources of these documents are:

American Society for Testing and Materials (ASTM)
1916 Race Street
Philadelphia, Pennsylvania 19103-2287

American Welding Society (AWS)
550 N.W. LeJeune Road
P.O. Box 351040
Miami, Florida 33135

3. Summary of Method

A calibrated machine forces an indenter, of specified geometry and under a predetermined load, into the surface of the test specimen and some measure of the resultant impression is expressed as a specific measure of hardness.

4. Significance

Hardness tests provide quantitative data which can be compared and otherwise analyzed and used in the design of welding procedures and the analysis of weld failures. The Brinell and Rockwell tests produce relatively large indentations and consequently are used for evaluating large weld joint areas. The Vickers and Knoop hardness tests, which produce relatively small indentations, are widely used for hardness measurements in cross sections of small welds or extremely localized weld areas.

When selecting a hardness test method for use on weld overlays, the thickness of the overlays and the base metal must be within the ASTM recommendation for the particular hardness testing technique.

5. Definitions

The welding terms used in this section are in accordance with ANSI/AWS A3.0, *Standard Welding Terms and Definitions*.

6. Apparatus

The apparatus for conducting the various hardness tests shall be in accordance with the applicable ASTM standard test method:

(1) Brinell, E10

(2) Rockwell, E18

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- (3) Vickers, E92
- (4) Microhardness (Knoop and Vickers), E384
- (5) Portable Hardness, E110

7. Specimens

All requirements of the applicable ASTM standard test methods, except those modified by the following sections, shall apply.

7.1 Brinell and Rockwell hardness test methods are only permitted for base metal and weld metal evaluation unless otherwise specified.

7.2 Vickers and Knoop hardness test methods are the only test methods permitted for fine scale traverse across single or multiple weld regions, unless otherwise specified.

7.3 Weld metal hardness tests are only permitted on either weld joint cross sections or on local areas of the weld reinforcement ground smooth before testing.

7.3.1 In order to qualify as a valid weld metal test, the edge of an impression shall be no closer than three times the major dimension of an indentation from the edge of the ground area of the reinforcement on welded assemblies.

7.3.2 In order to qualify as a valid weld metal test, the edge of an impression shall be within the weld metal and no closer than 1/8 inch (3 mm) from the weld interface line.

7.4 Portable hardness test methods are only permitted for base metal evaluation, unless otherwise specified.

8. Procedure

Test procedures for measuring hardness in weldments shall be in accordance with the applicable ASTM Standard Test Method:

- (1) Brinell, E10
- (2) Rockwell, E18
- (3) Vickers, E92
- (4) Microhardness (Knoop and Vickers), E384
- (5) Portable Hardness E110

9. Report

In addition to the requirements of the applicable documents (section 2), the report shall include the following:

- (1) Base metal specification
- (2) Filler metal specification
- (3) Type of welded joint or surfacing weld
- (4) Welding procedure (process and parameters)
- (5) Type of test equipment
- (6) Specimen location and orientation
- (7) Location of impressions
- (8) Any observation of unusual characteristics of the specimen or procedure

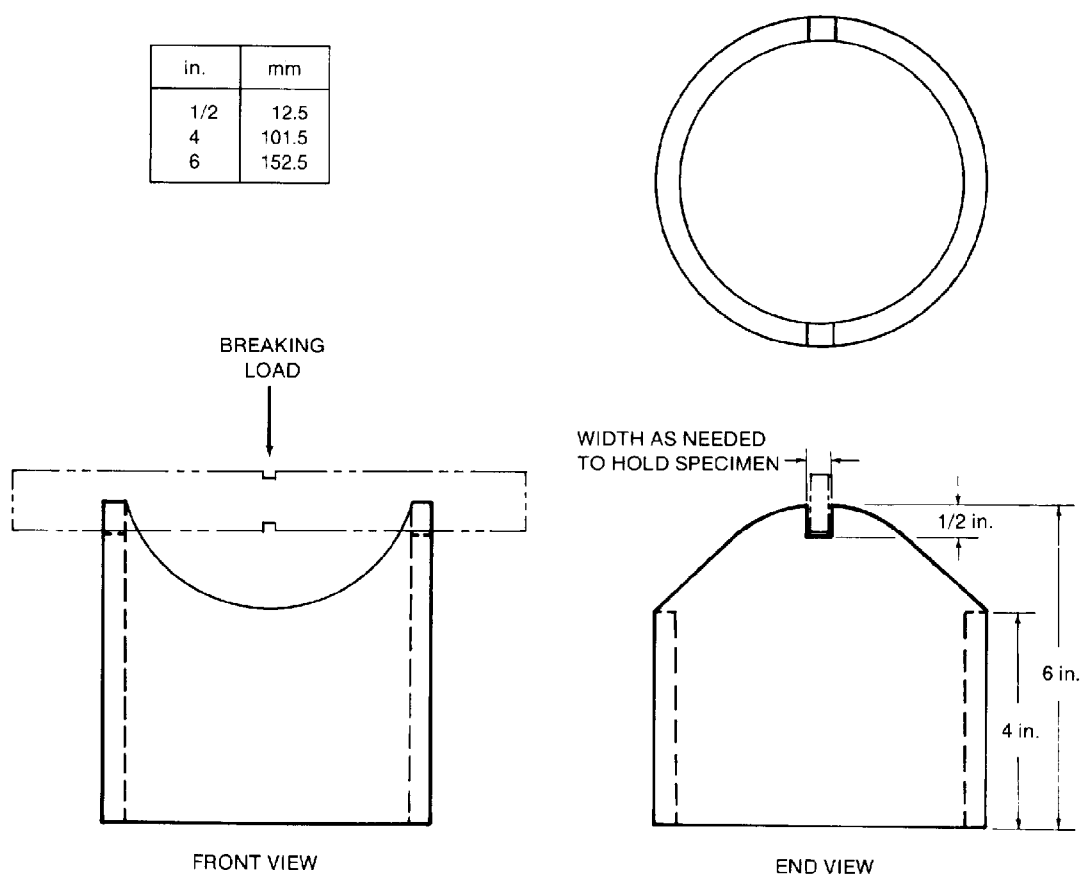
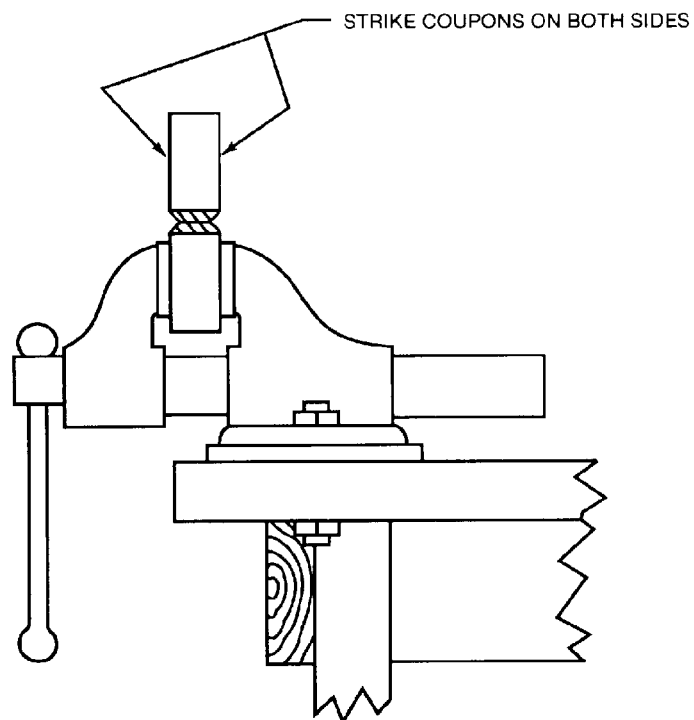
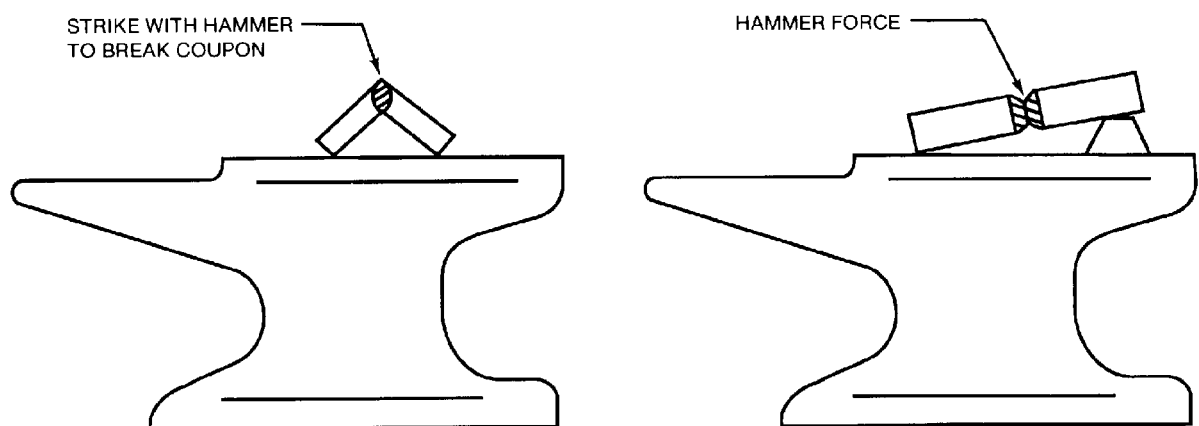


Figure C1 — Nick Break Testing Fixture Made Out of 6 in. Pipe

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**Figure C2 — Nick Break Test Using Vise****Figure C3 — Testing of Filled Welded Coupons**

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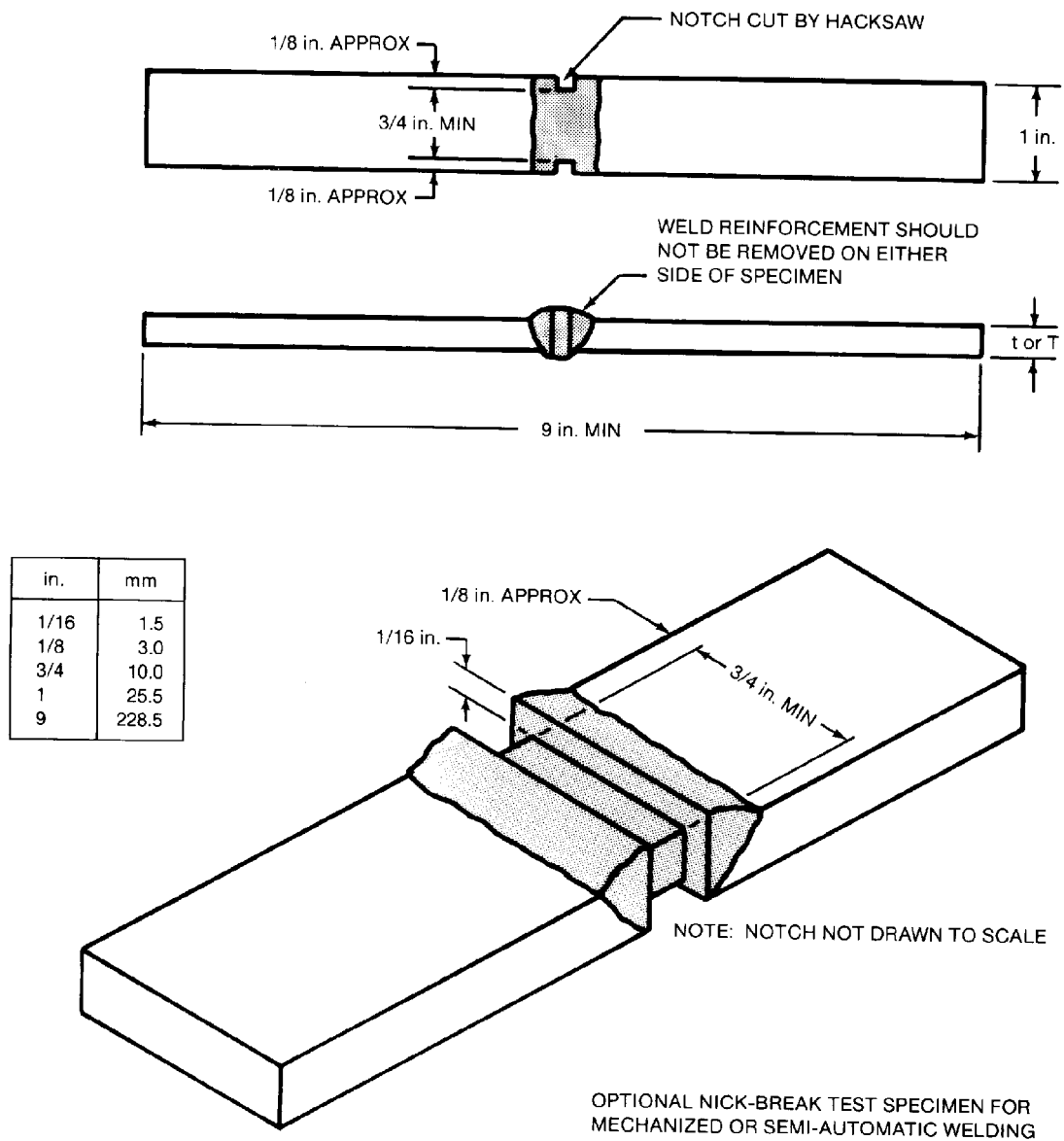
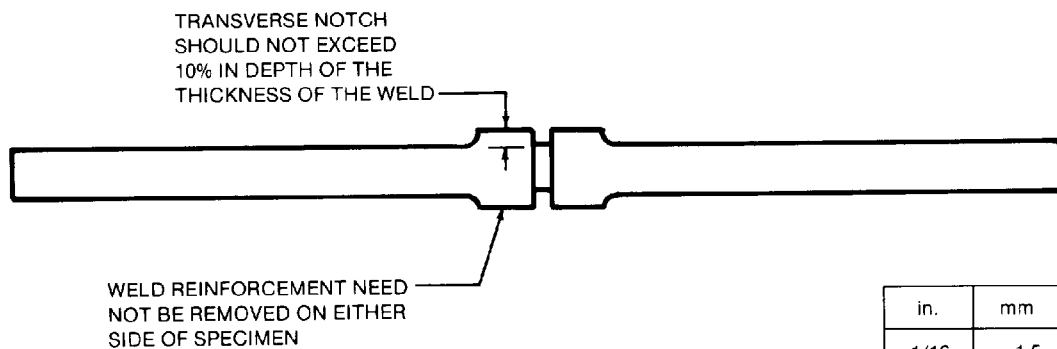
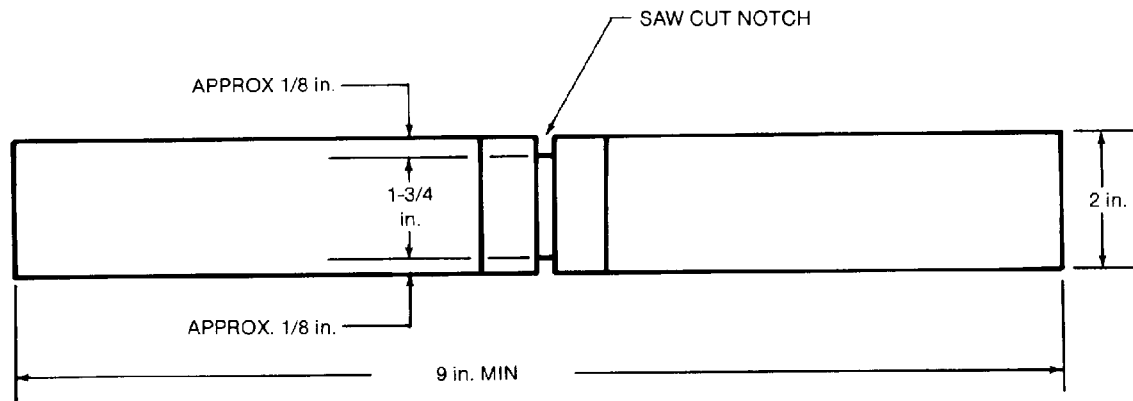


Figure C4 — Nick Break Test Specimen

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in.	mm
1/16	1.5
1/8	3.0
3/4	10.0
1	25.5
9	228.5

Figure C5—Specimen for Flash Butt Welds

Tests Applicable to Groove and Fillet Welds/55

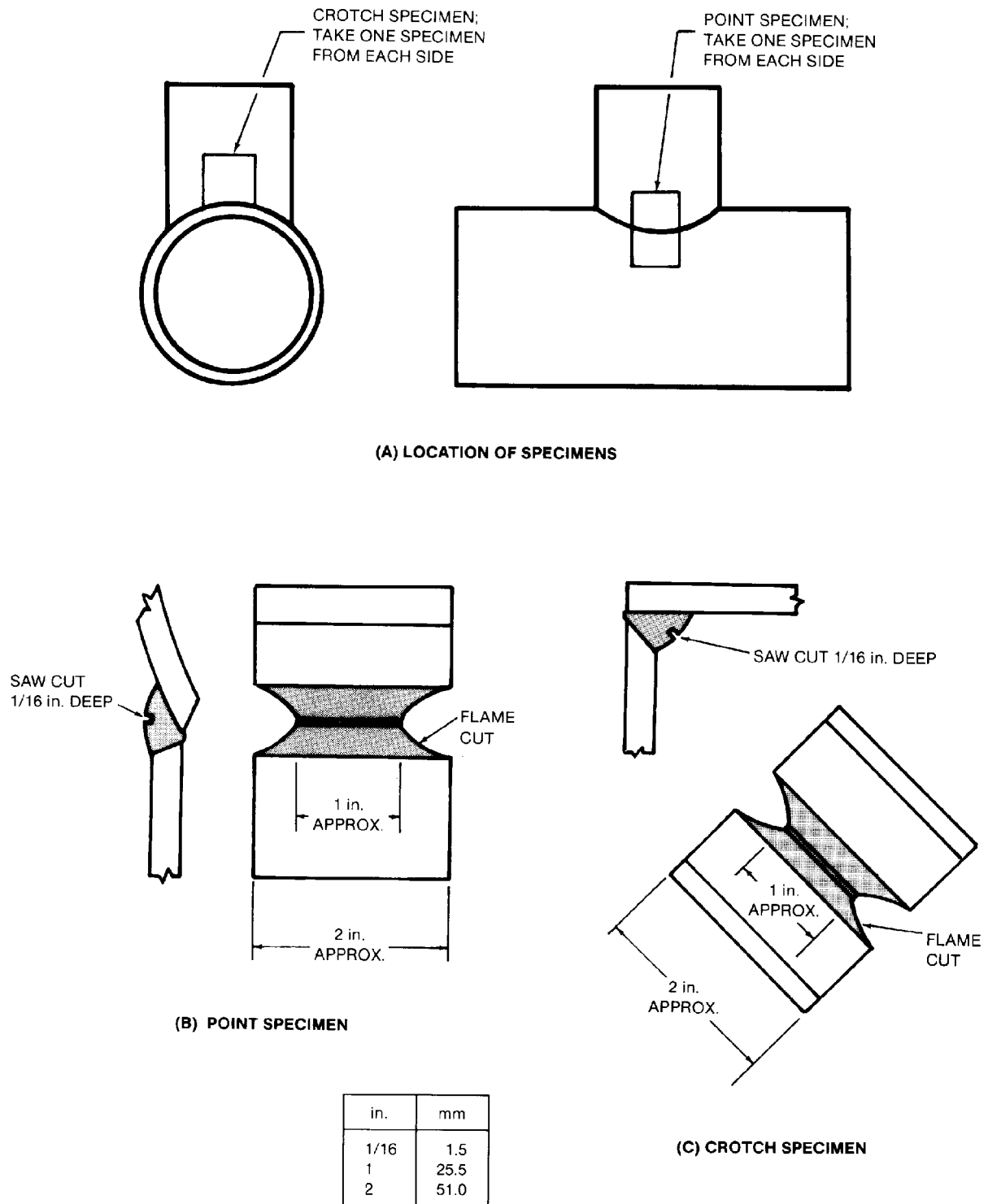
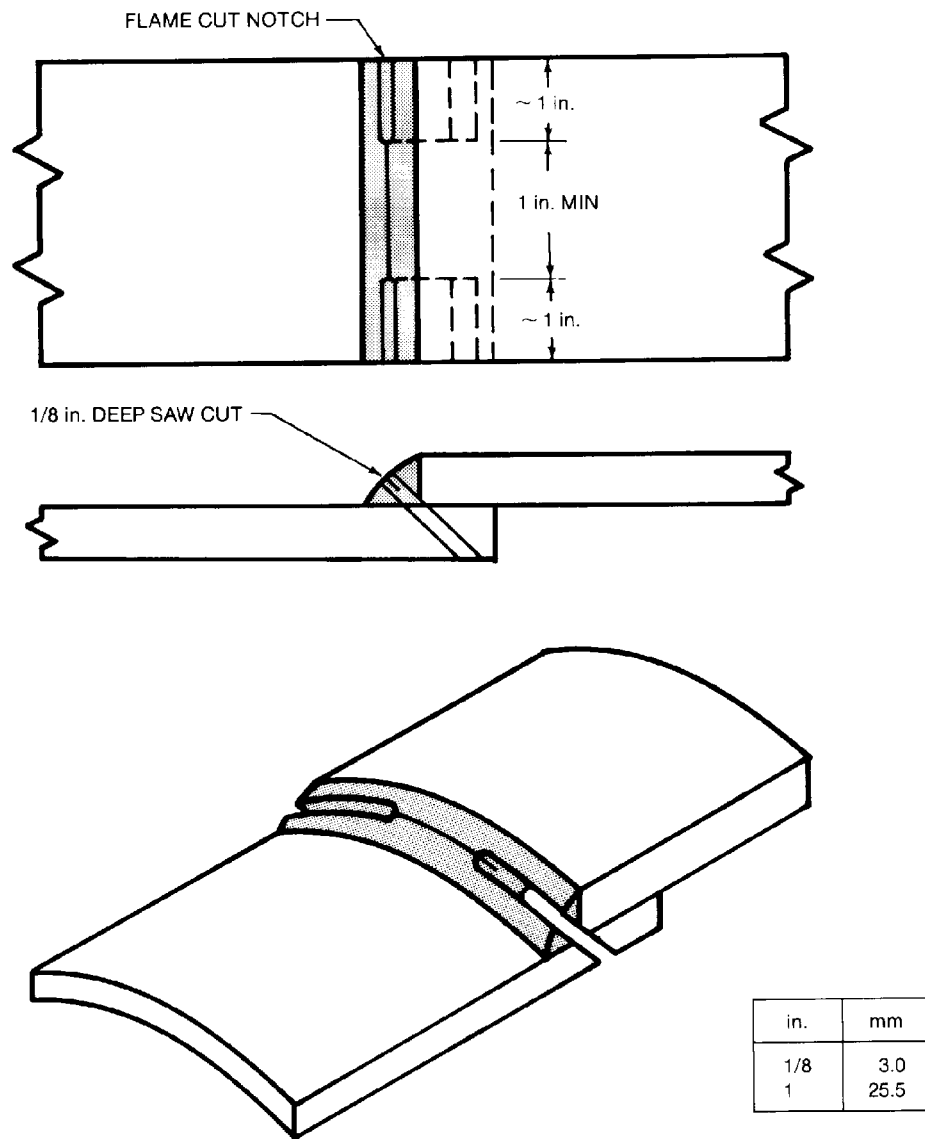
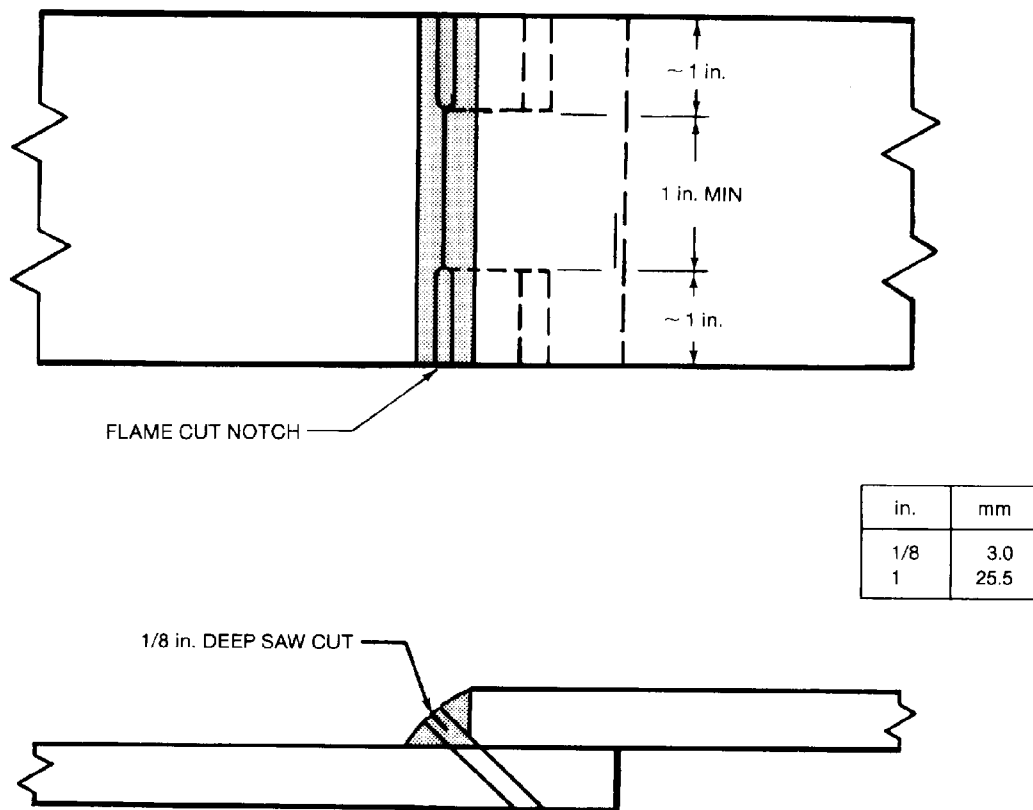


Figure C6 — Coupons for Nick Break Test of Branch Joint Connections

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**Figure C7 — Pipe Sleeve Test Coupon**

Tests Applicable to Groove and Fillet Welds/57

**Figure C8 — Fillet Welded Plate Joints**

Part D

Testing of Stud Welds

1. Scope

1.1 This section covers mechanical testing of stud welds.

1.2 When testing of stud welds is required, the testing procedure shall conform to this standard.

1.3 This standard does not specify requirements or acceptance criteria.

1.4 This standard is applicable to the following, when specified:

(1) Qualification of materials, welding operators, and welding procedures

(2) Information, basis of inspection, and fabrication quality control (when acceptance criteria have been established)

(3) Research and development

1.5 When this standard is used, the following information shall be furnished:

(1) The specific tests and number of specimens that are required

(2) Base metal specification/identification

(3) Position of welding

(4) Stud analyses or specification (part number), or both

(5) Weld parameters including current and time, and type of power supply

(6) Type of testing (i.e., bend or torque)

(a) Bend testing: the maximum angle of bend must be specified.

(b) Torque testing: the torque to be used must be specified.

(7) Acceptance criteria

2. Applicable Documents

References should be made to the latest edition of the following documents:

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

AWS A3.0 Standard Welding Terms and Definitions Including Terms for Brazing, Soldering, Thermal Spraying and Thermal Cutting

AWS C5.4 Recommended Practices for Stud Welding

AWS D1.1 Structural Welding Code Steel

The source of these documents is the following:

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

3. Summary of Method

3.1 The specimen is tested by one of two methods:

(1) The stud is bent by striking with a hammer or bending it using a length of tube or pipe.

(2) A tensile load is applied to the stud by appropriate fixturing. This commonly is accomplished by use of a torque wrench and a stand off sleeve.

4. Significance

4.1 Mechanical testing of arc welded studs is used to evaluate weld soundness, tensile properties, and ductility of the stud weld.

4.2 These tests are primarily used as a welding procedure qualification method to evaluate welding parameters and surface preparation.

5. Definitions and Symbols

The welding symbols and terms used in this section are in accordance with the latest edition of ANSI/AWS A2.4, *Symbols for Welding, Brazing, and Nondestructive Examination* and ANSI/AWS A3.0, *Standard Welding Terms and Definitions*.

6. Apparatus

Apparatus used shall be capable of firmly holding the test assembly and applying the bend force, or torque as needed.

7. Specimens

7.1 Test specimens shall be prepared by welding the studs being tested (qualified) to specimen plates of the appropriate base metal as specified in 1.5 (2).

7.2 Test specimens shall be made using the appropriate automatic timing, voltage, current, and gun settings for lift and plunge as recorded in 1.5 (5).

8. Procedure

The following are two alternate test procedures as specified in 1.5 (6).

8.1 Bend Testing. The required number of welded specimens shall be tested by bending the required number of degrees from their original axis. Bending may be done by striking the stud with a hammer or by bending it using a length of tube or pipe as shown in Figure D1.

8.2 Torque Testing. The required number of stud welded specimens shall be tested by applying a torque using equipment as shown in Figure D2.

A steel sleeve, or washers, of appropriate size are placed over the stud. A nut of the same material as the stud is tightened against the washer bearing on the sleeve, using a torque wrench. Tightening the nut applies the tensile load to the weld. Torque is applied until the specified level is reached, or the weld fails.

9. Report

In addition to the requirements of applicable documents, the report shall include the following:

- (1) Test results and observations
- (2) The information listed in 1.5
- (3) Drawings showing shapes and dimensions of studs and arc shields

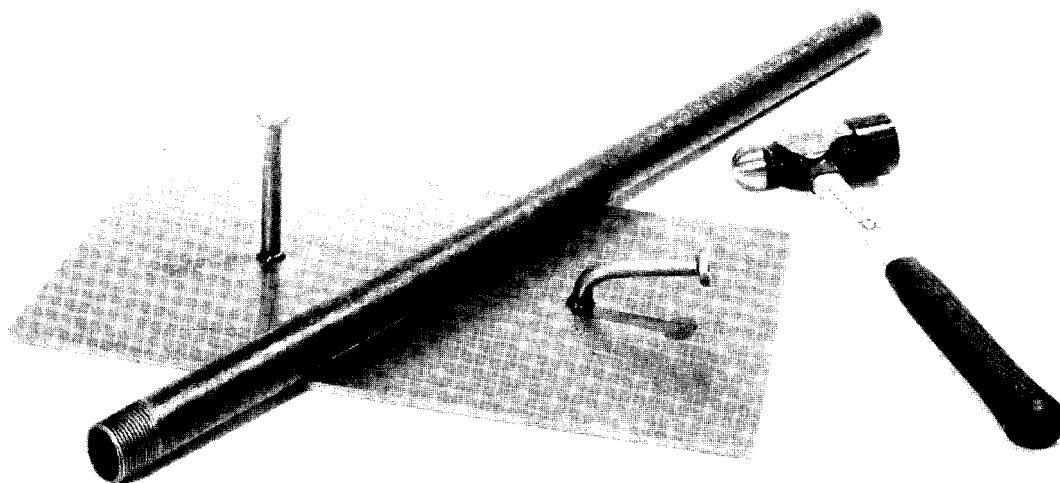
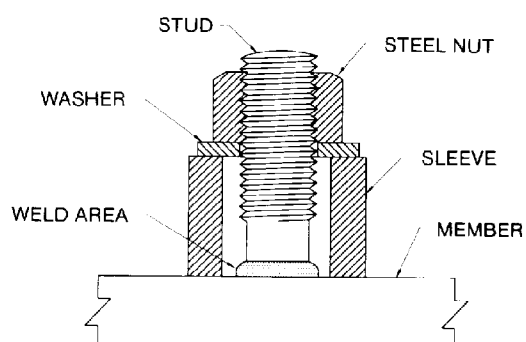


Figure D1 — Bend Test for Welded Studs to Determine Acceptable Welding Procedures



Note: The dimensions shall be appropriate to the size of the stud. The threads of the stud shall be clean and free of lubricant other than the residue of cutting oil.

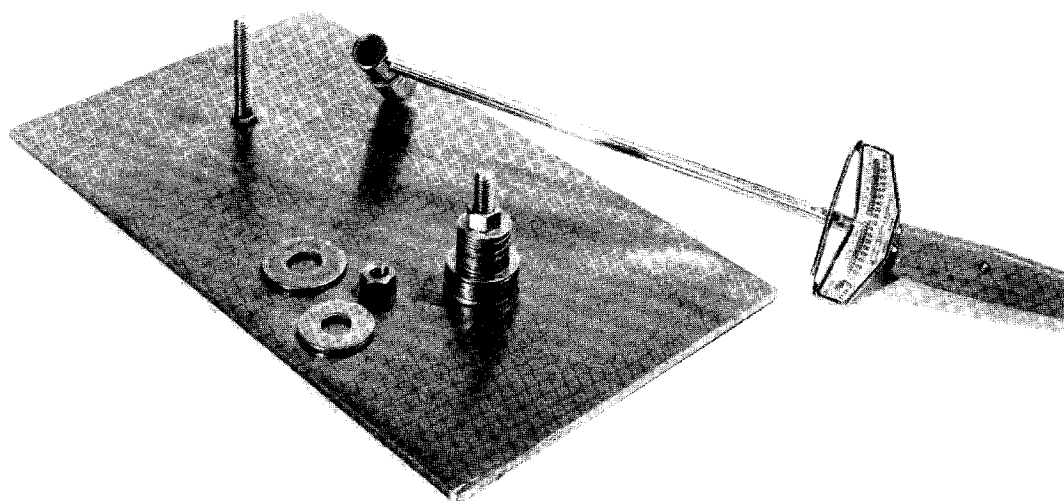


Figure D2 — Method of Applying a Tensile Load to a Welded Stud Using Torque