

AWS B4.0M:2000 (R2010)
An American National Standard

Standard Methods for Mechanical Testing of Welds



American Welding Society



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AWS B4.0M:2000 (R2010)
An American National Standard

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Standard Methods for Mechanical Testing of Welds

1st Edition

Prepared by the
American Welding Society (AWS) B4 Committee on Mechanical Testing of Welds

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

Mechanical test methods that are applicable to welds and welded joints are described. For each testing method, information is provided concerning applicable American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), and American Petroleum Institute (API) documents; the required testing apparatus, specimen preparation, procedure to be followed, and report requirements are also described.



American Welding Society
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Foreword

This foreword is not part of AWS B4.0M:2000 (R2010), *Standard Methods for Mechanical Testing of Welds*, but is included for informational purposes only.

This standard covers the common tests for the mechanical testing of welds. They are defined and illustrated in five parts related to testing of groove welds, fillet welds, and stud welds. The tests include: bend tests, tension tests, fracture toughness tests, soundness tests, shear tests, nick-break test, hardness tests, stud weld tests, and selected weldability tests.

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 five parts. Additional information on the mechanical testing of welded joints may be obtained from the AWS Welding Handbook, Volume 1.

The values stated in SI Units and used throughout this document are to be regarded as standard. Recommendation for style and usage of SI Units may be found in [AWS A1.1](#), *Metric Practice Guide for the Welding Industry*.

An expanded section on weldability testing is included in this edition of B4.0M. Selected weldability test methods are described.

Safety Precautions. Safety precautions shall conform to the latest edition of ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, 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 and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS B4 Committee on Mechanical Testing of Welds, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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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) Postweld thermal or mechanical processing treatments

1.5 Safety Precautions. Safety precautions shall conform to the latest edition of ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, 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.

2. Applicable Documents

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

ANSI/ASME B46.1 Surface Texture

[ASTM E 190](#) Standard Method for Guided Bend Test for Ductility of Welds

[ASTM A 370](#) Standard Test Methods and Definitions for Mechanical Testing of Steel Products

[AWS A2.4](#) Standard Symbols for Welding, Brazing, and Nondestructive Examination

AWS A3.0 Standard Welding Terms and Definitions

The sources for these documents are the following:

American Society of Mechanical Engineers (ASME)
Three Park Avenue
New York, NY 10016

American Society for Testing and Materials (ASTM)
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

American Welding Society (AWS)
550 N.W. LeJeune Road
Miami, FL 33126

3. Summary of Method

3.1 The specimens are guided in the bending process by a test fixture that employs a mandrel with wraparound 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, is determined in a guided bend test.

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

5. Definitions and Symbols

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

Unless otherwise noted, the following designations are used:

A = plunger or mandrel radius
B = die radius
ID = inside diameter
L = test plate length
R = radius
S = surfacing weld thickness

T = specimen thickness
t = thickness of test weldment
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 wraparound 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 wraparound 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 required elongation and the thickness of the specimen. When specimens wider than 38 mm are to be bent, the mandrel shall be at least 6 mm wider than the specimen width.

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 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

conform to 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 conform to 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 conform to 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 Surfacing Weld 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 heat-affected zone (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

8.1.1 Transverse Specimens

(1) Place the tension side down on the supporting surface of the bend fixture shown in Figures A1 or A2. The weld shall be centered in the fixture with the centerline of the weld within 2 mm of the center of the fixture.

(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 described in 8.1.1 (2), (3), and (4) for Transverse Specimens.

8.2 Wraparound Bend Test Fixture. The specimen shall be firmly clamped on one end so that there is no sliding of the specimen relative to the mandrel during the bending operation. Alternatively, the specimen may be held stationary against a rotated, non-slipping mandrel of Diameter A by a stationary compressive roller. In this case the specimen is wrapped around the rotating mandrel by draw-bending the specimen from between the outer roller and the point where the rotating mandrel holds the specimen tight against the roller. The weld and heat-affected zones shall be completely within the bent portion of the specimen. Test specimens shall not be removed from the fixture until the point where the outer roller contacts the bend specimen has moved 180 degrees from its starting point along the convex surface of the bend specimen.

8.3 Specimen Inspection. The specimen shall be removed from the bend fixture and the tension surface of the specimen (weld metal and HAZ) visually examined for tears or other open defects, and all defect types, quantities, sizes and locations shall be recorded. 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. The weld and heat-affected zone shall be centered and completely within the bent portion of the specimen after testing.

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
- (2) Specimen thickness and width
- (3) Type of welded joint or surfacing weld
- (4) Welding Procedure Specifications and Procedure Qualification Record numbers (if applicable) including any supplemental information

- (5) Specific tests performed
- (6) Bend radius
- (7) Test temperature
- (8) Number of tests per condition or lot
- (9) The following additional information should be included: Number, type, size and location of defects, if any
- (10) Bend angle, if specimen fractured prior to bending 180 degrees
- (11) Any observation of unusual characteristics of the specimens or procedure

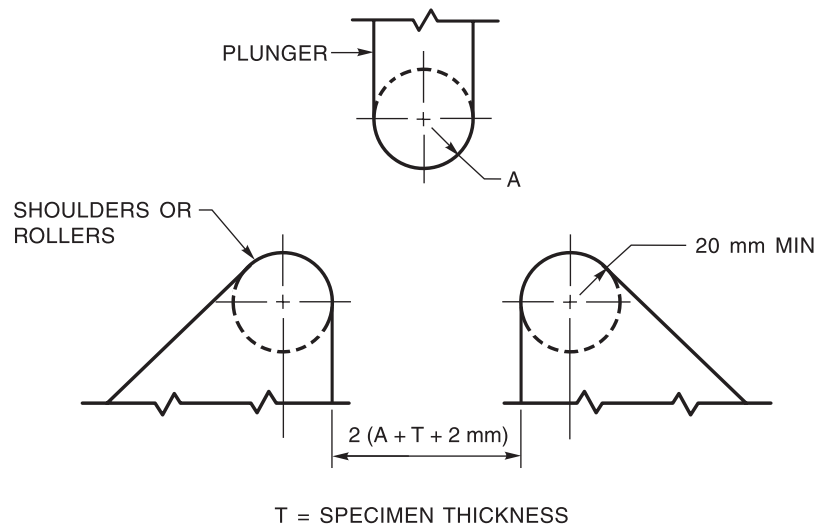
10. Commentary

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.

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 HAZ.

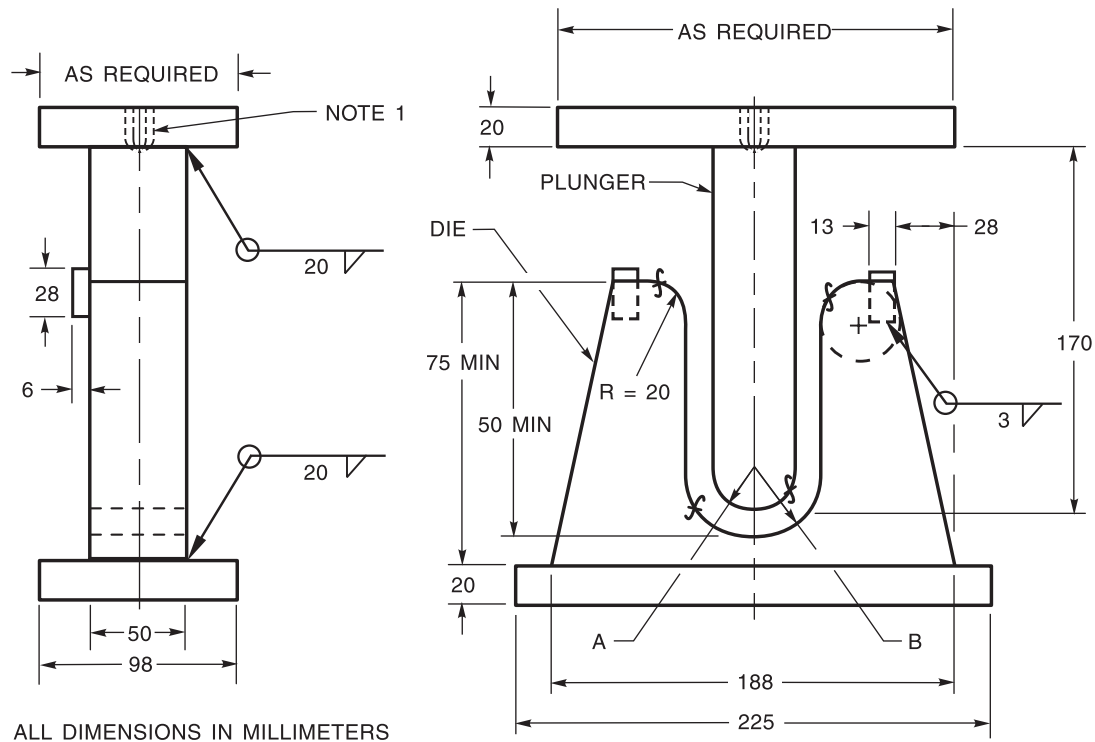
It is recommended that the wraparound fixture shown in Figure A3 be used in these situations or longitudinal bend specimens be used in place of the transverse guided bend specimens. Testing of welds in dissimilar metals (such as high tensile strength plate to ordinary structural grade steels) can produce 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.



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 50 mm for placement of the specimen.
3. The shoulders or rollers shall be high enough above the bottom of the 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 nomograph in Figure A4.

Figure A1—Typical Bottom Ejecting Guided Bend Test Fixture

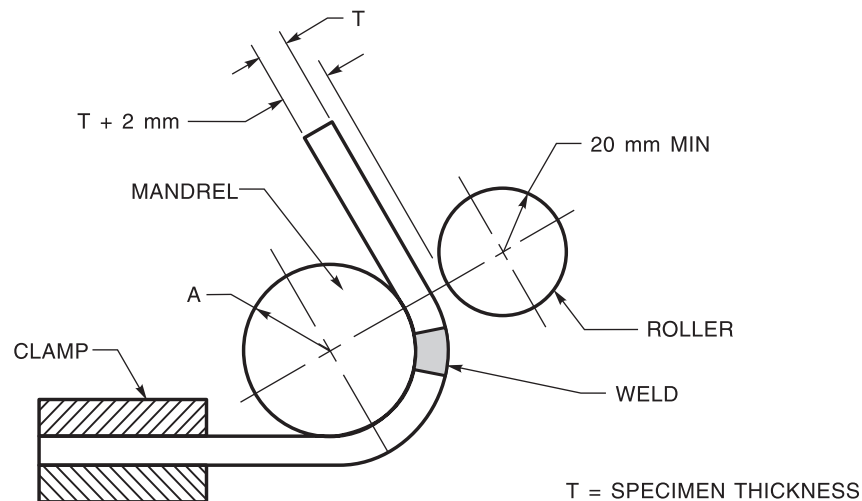


Fixture Dimensions for 20% Elongation of Weld		
Specimen Thickness, T mm	Plunger Radius, A mm	Die Radius, B mm
10	20	32
T	2T	A + T + 2

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. For a given specimen thickness, T , the maximum plunger radius, A , shall be as specified or as determined from the formula or nomograph in Figure A4. For example, fixture dimensions for 20% elongation and a specimen thickness, T , of 10 mm: the plunger radius, A , is equal to 20 mm and die radius, B , is equal to 32 mm.
6. Weld sizes indicated are recommendations. The actual size is the responsibility of the user to ensure rigidity and design adequacy.

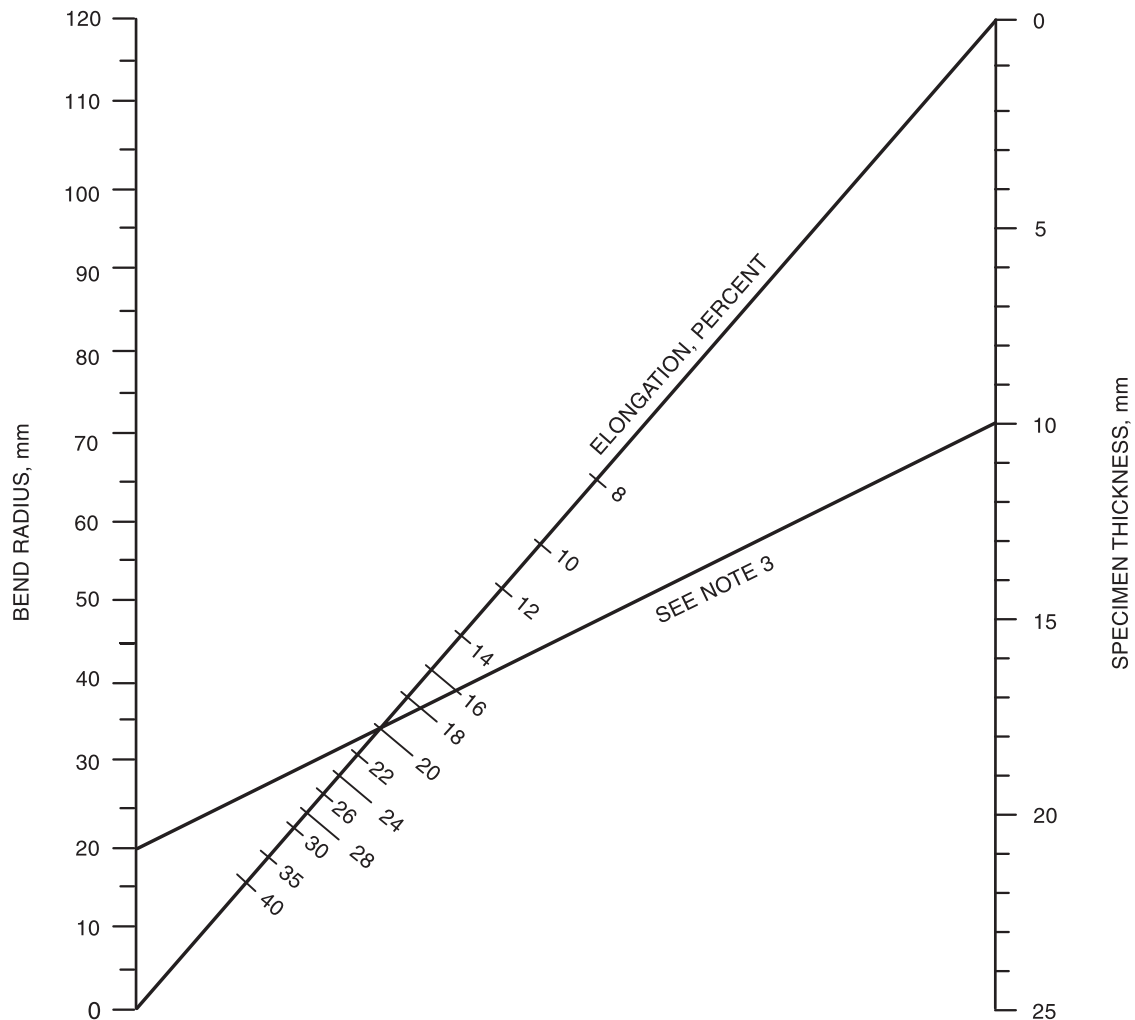
Figure A2—Typical Bottom Guided Bend Test Fixture



Notes:

1. Radius A shall be as specified, or as determined from the nomograph in Figure A4. Dimensions not shown are the option of the designer, except that the minimum width of the components shall be 50 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 roller has traversed 180° from the starting point.

Figure A3—Typical Wraparound Guided Bend Test Fixture



or use the following formula:

$$e = \frac{T \times 100}{2A + T}$$

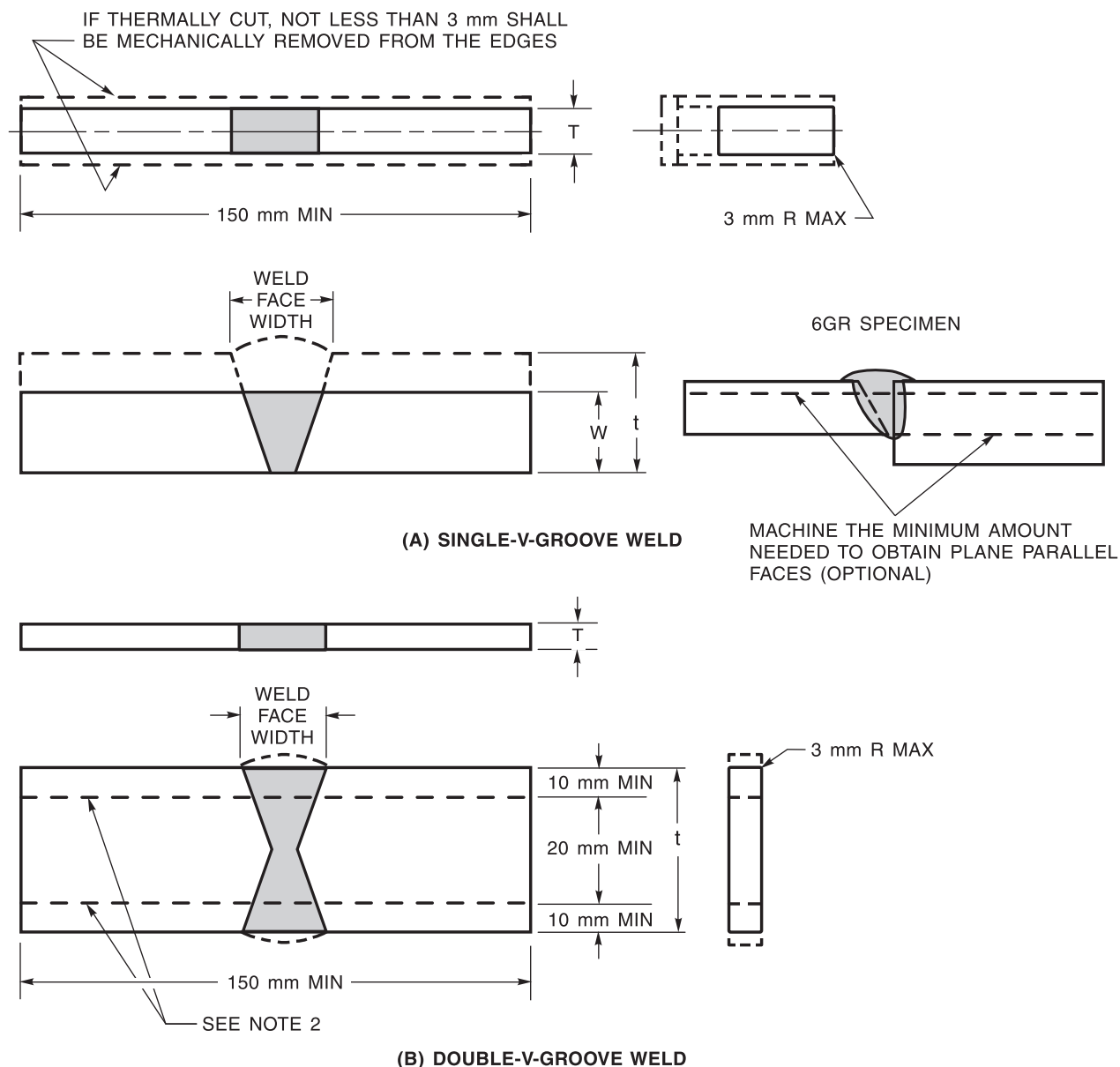
where:

- e = percent elongation at outer surface
- T = specimen thickness (mm)
- A = 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 10 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: ± 0.5 mm
 - (2) Elongation: ± 1 percent
 - (3) Bend radius: ± 1.6 mm
3. Example: If a standard requires a minimum elongation of 20 percent and if the specimen is 10 mm thick, a line is drawn between these two points and extended to determine the appropriate bend radius which would be 20 mm.

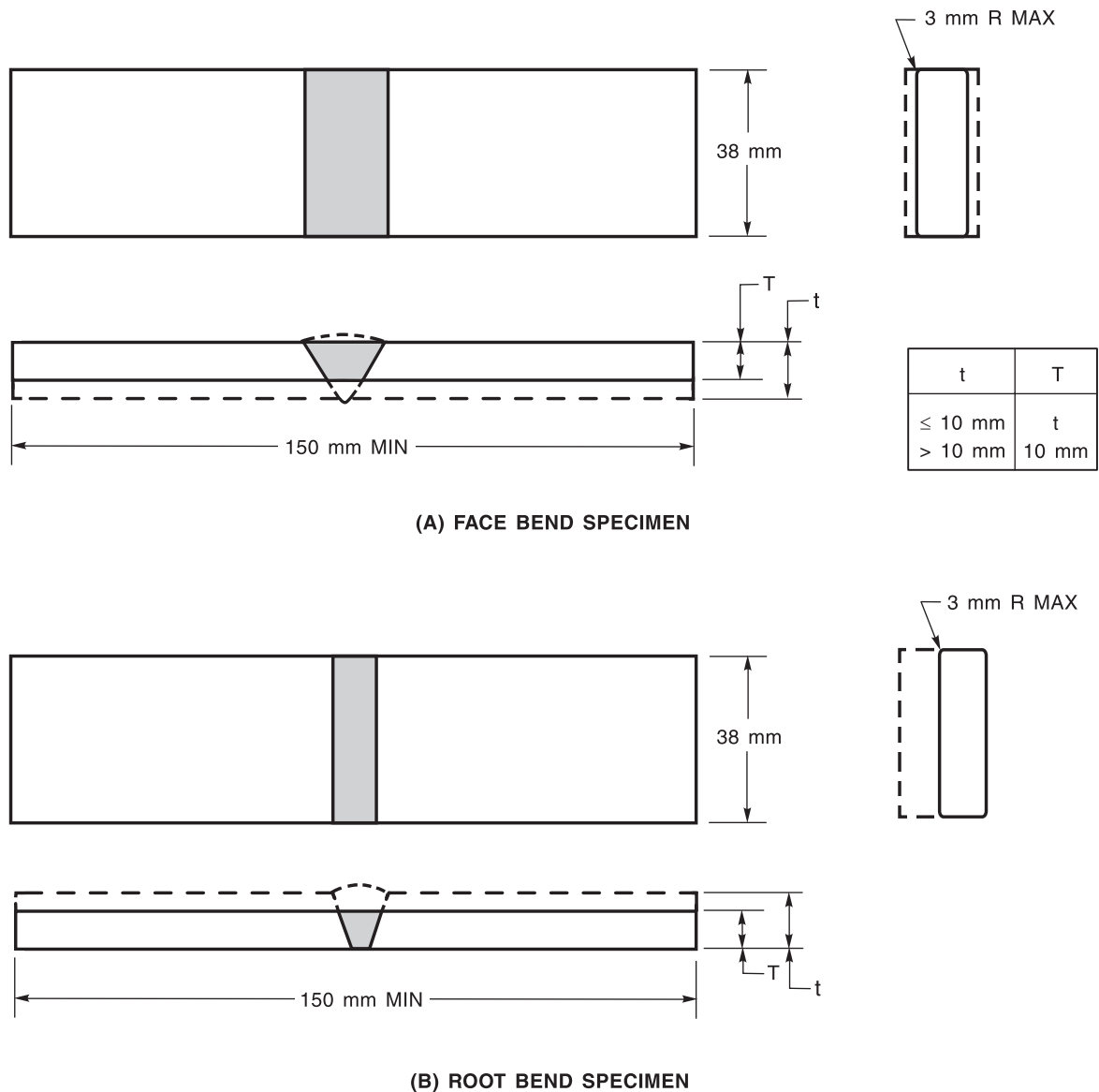
Figure A4—Bend Test Nomograph



Notes:

1. If the thickness, t , of a single-groove weld joint exceeds 38 mm, the specimen may be cut into approximately equal strips between 20 mm and 38 mm wide. Each strip shall be tested by bending to the same radius as specified or as determined by the nomograph in Figure A4.
2. If the plate thickness, t , of a double-groove weld joint exceeds 38 mm, the specimen may be cut into multiple strips so that the root of the weld is centered in one of the strips as shown. Whenever possible it is recommended that Note 1 to Figure A4 be followed regarding specimen thickness, T , with each specimen having a width exceeding its thickness. These strips shall be bent to the same radius as specified or as determined by the nomograph 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 should be equal to or exceed the width of the remaining weld face width in order to test the weld HAZ and base metal. If this requirement cannot be met, a greater thickness, T , may be chosen in accordance with the nomograph in Figure A4.
5. All longitudinal surfaces should be no rougher than 4 micrometers R_a . It is recommended that the lay of the surface roughness be oriented parallel to the longitudinal axis of the specimen.

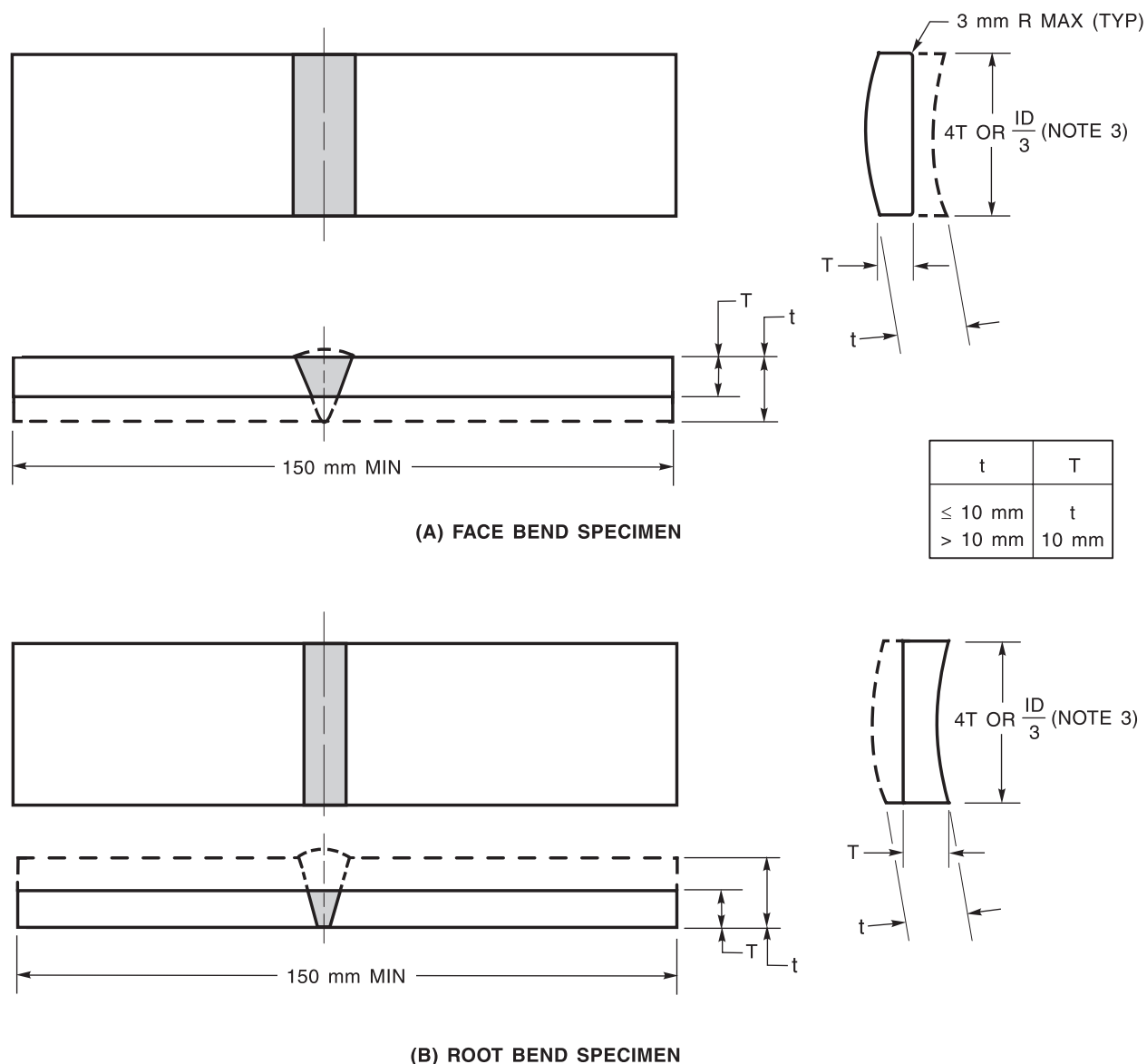
Figure A5—Transverse Side Bend Specimens (Plate)



Notes:

1. The specimen edges may be thermally cut but, in this case, at least 3 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 nomograph in Figure A4.
3. If the weld joins base metals of 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 should be equal to or exceed the width of the remaining weld face. If this requirement cannot be met, a greater thickness, T, may be chosen in accordance with the nomograph in Figure A4.
6. All longitudinal surfaces should be no rougher than 4 micrometers R_a . It is recommended that the lay of the surface roughness be parallel to the longitudinal axis of the specimen.

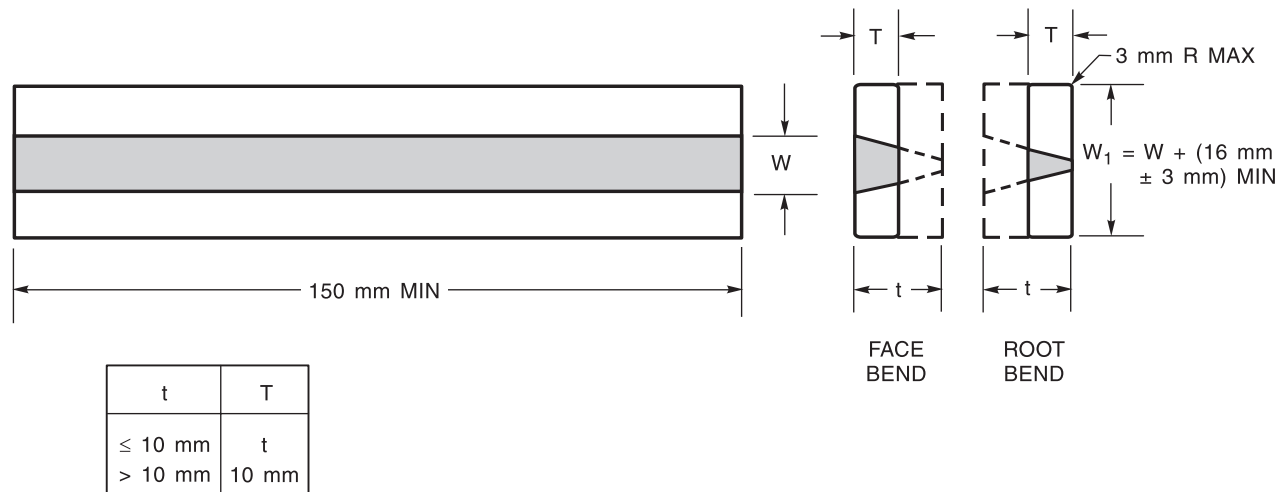
Figure A6—Transverse Face Bend and Root Bend Specimens (Plate)



Notes:

1. The specimen edges may be thermally cut but, in this case, at least 3 mm of material shall be mechanically removed from the thermally cut surfaces.
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. 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 should be equal to or exceed the weld width. If this requirement cannot be met, a greater thickness, T , may be chosen in accordance with the formula or nomograph in Figure A4.
6. All longitudinal surfaces should be no rougher than 4 micrometers R_a . It is recommended that the lay of the surface roughness be oriented parallel to the longitudinal axis of the specimen.

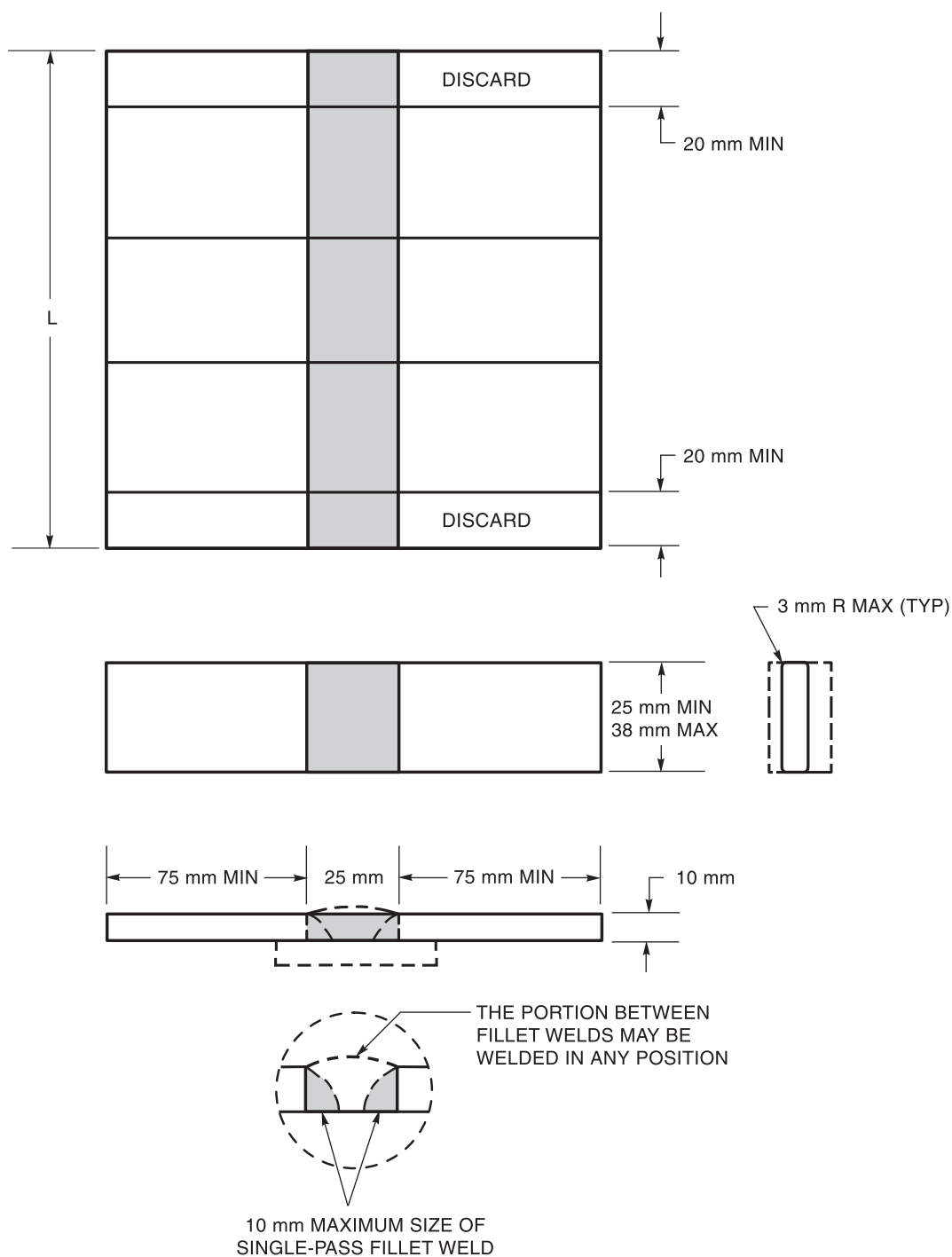
Figure A7—Transverse Face Bend and Root Bend Specimens (Pipe)



Notes:

1. The specimen edges may be thermally cut, but in this case, at least 3 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 should be no rougher than 4 micrometers R_a . It is recommended that the lay of the surface roughness be oriented parallel to the axis of the specimen.

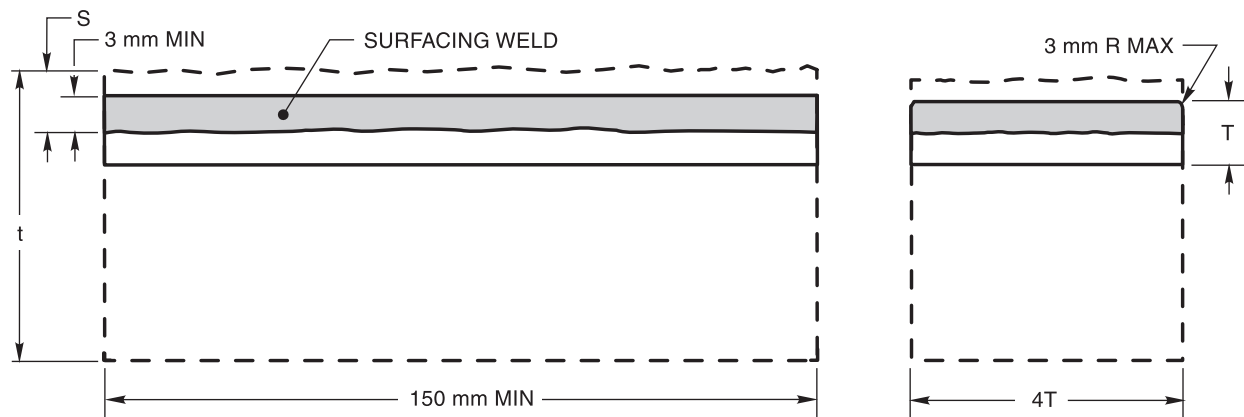
Figure A8—Longitudinal Face Bend and Root Bend Specimens (Plate)



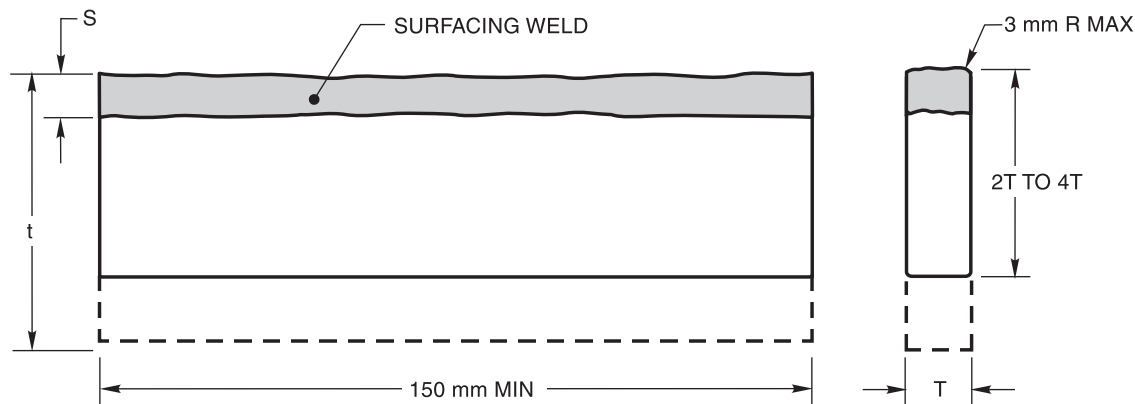
Notes:

1. The backing shall be 10 mm by 50 mm minimum unless the test weld is to be inspected radiographically, in which case the backing bar shall be 10 mm by 75 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 should be no rougher than 4 micrometers R_a . 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

Notes:

1. The dimension, T , is the thickness of the test specimen and shall be 10 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 3 mm.
4. All longitudinal surfaces should be no rougher than 4 micrometers R_a . 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

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 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 maximum or minimum requirements
- (5) Location and orientation of the specimens
- (6) Report form when required
- (7) Postweld thermal or mechanical processing treatments, as applicable

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

1.5 Safety Precautions. Safety precautions shall conform to the latest edition of ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, 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.

2. Applicable Documents

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

ANSI/ASME B46.1 Surface Texture

ASTM E 4 Standard Practices for Load Verification of Testing Machines

ASTM E 8 Standard Methods of Tension Testing of Metallic Materials

ASTM B 557 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

The sources of these documents are the following:

American Society of Mechanical Engineers (ASME)
Three Park Avenue
New York, NY 10016

American Society for Testing and Materials (ASTM)
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

American Welding Society (AWS)
550 N.W. LeJeune Road
Miami, FL 33126

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.

4. Significance

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

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

4.2 Tension tests provide quantitative data which can be compared and analyzed for use 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 [AWS A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination](#), and [AWS A3.0, Standard Welding Terms and Definitions](#).

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 E 8](#). The machine shall be calibrated in accordance with [ASTM E 4](#).

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 Unless otherwise stated, specified specimens shall be tensile tested in the as-received condition.

7.3 Round Tension Test Specimens. Round tension specimens with a 4:1 gage length to diameter ratio are shown in Figure A11. Round tension specimens with a 5:1 gage length to diameter ratio are shown in Annex B.

(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 6 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 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. Only the ultimate tensile strength is normally determined for specimens taken transverse to the centerline of the weld.

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 of the test weldment is beyond the 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. Only ultimate tensile strength is normally determined in specimens taken transverse to the centerline of the weld.

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 75 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 75 mm or less nominal diameter and may be used for larger sizes subject to limitations of testing equipment.

(1) Greater Than 75 mm Diameter. The reduced rectangular-section specimen shall comply with Figure A14.

(2) Less Than or Equal to 75 mm Diameter. The full-section specimen shall comply with Figure A15. Only ultimate tensile strength is normally determined in specimens taken transverse to the centerline of the weld.

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. The surface finish on surfaces requiring machining shall be as specified in the specimen drawings. Imperfections present within the gage length due to welding shall not be removed.

8. Procedure

8.1 The testing procedure for weld specimens shall be as specified in [ASTM E 8](#).

8.2 Round Tension Specimens. Mechanical properties, namely ultimate tensile strength (UTS), yield strength at the specified offset, yield point if it occurs, elongation in a specified gage length and reduction of area are determined for round all-weld-metal tension specimens. If a yield point is reported, it shall have been determined in accordance with [ASTM E 8](#). The minimum original diameter shall be used for all calculations. For round transverse weld tension specimens, only ultimate tensile strength is determined, unless otherwise specified.

Ultimate Tensile Strength =

$$\frac{\text{Maximum Load}}{\text{Original Cross Sectional Area}} = \frac{P_{(\text{MAXIMUM})}}{\left(\frac{\pi D^2}{4}\right)}$$

Yield Strength at Specified Offset =

$$\frac{\text{Load at Specified Offset}}{\text{Original Cross Sectional Area}} = \frac{P_{(\text{Specified Offset})}}{\left(\frac{\pi D^2}{4}\right)}$$

Yield Point =

$$\frac{\text{Maximum Load prior to Specified Offset}}{\text{Original Cross Sectional Area}} = \frac{P_{(yp)}}{\left(\frac{\pi D^2}{4}\right)}$$

Percent Elongation =

$$\frac{\text{Final gage length} - \text{Original gage length}}{\text{Original gage length}} \times 100 =$$

$$\frac{G_f - G_o}{G_o} \times 100$$

Percent Reduction of Area =

$$\frac{(\text{Original Diameter})^2 - (\text{Final Diameter})^2}{(\text{Original Diameter})^2} \times 100 =$$

$$\frac{D_o^2 - D_f^2}{D_o^2} \times 100$$

8.3 Rectangular Tension Tests (Figures A12, A13, A14). The ultimate tensile strength calculation for rectangular tension test is the following:

Ultimate Tensile Strength =

$$\frac{\text{Maximum Load}}{\text{Original Area}} = \frac{P_{(\text{MAXIMUM})}}{W \times T}$$

8.4 Tubular Tension Tests. The ultimate tensile strength calculation for reduced section (Figure A14) is the same as shown in section 8.3. The ultimate tensile strength calculation for full section (Figure A15) is as follows:

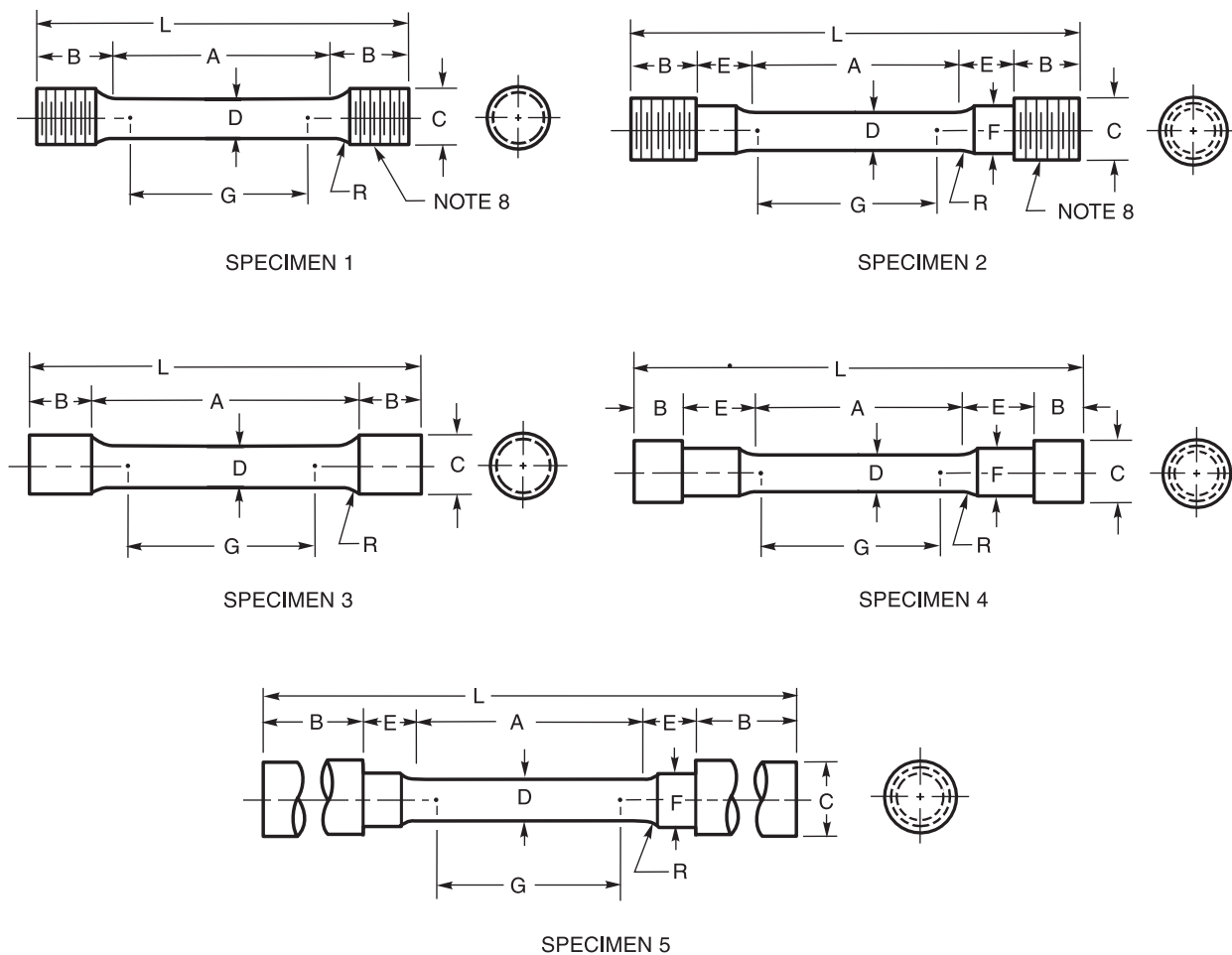
Ultimate Tensile Strength =

$$\frac{\text{Maximum Load}}{\text{Original Area}} = \frac{P_{(\text{MAXIMUM})}}{0.7854 \times (OD^2 - ID^2)}$$

9. Report

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

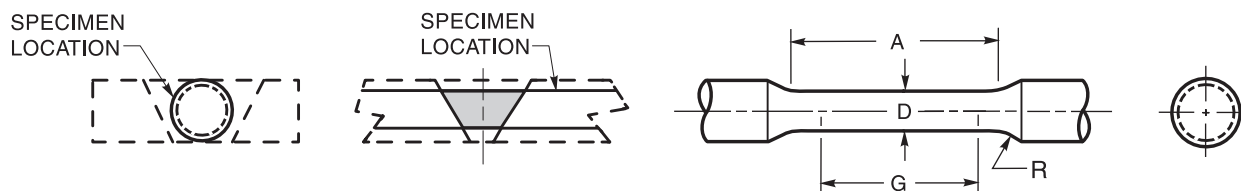
- (1) Base metal specification
- (2) Filler metal specification
- (3) Welding procedure (process and parameters)
- (4) Specimen type
- (5) Joint geometry
- (6) Location of fracture and type of failure (ductile or brittle)
- (7) Calculated ultimate tensile strength
- (8) For round all-weld-metal specimen only: yield strength at the specified offset, yield point if it occurs, percent elongation in the specified gage length and percent reduction of area
- (9) Any observation of unusual characteristics of the specimens or procedure



Dimensions in mm*					
	Specimen 1	Specimen 2	Specimen 3	Specimen 4	Specimen 5
G. Gage length	50.0 ± 0.1	50.0 ± 0.1	50.0 ± 0.1	50.0 ± 0.1	50.0 ± 0.1
D. Diameter (Note 1)	12.5 ± 0.2	12.5 ± 0.2	12.5 ± 0.2	12.5 ± 0.2	12.5 ± 0.2
R. Radius of fillet, min	10	10	10	10	10
A. Length of reduced section	57	57	100	57	57
L. Overall length, approx	127	140	140	121	242
B. Length of end section (Note 2)	35 approx	25 approx	19 approx	13 approx	76 min
C. Diameter of end section	20	20	18	22	20
E. Length of shoulder and fillet section, approx	—	16.0	—	19	16
F. Diameter of shoulder	—	16	—	16	15

Various types of ends for standard round tension test specimens

Figure A11—Round Tensile Specimens—4:1 Gage Length to Diameter



Dimensions in mm*					
	Standard Specimen	Small-Size Specimens Proportional To Standard Specimen			
Nominal Diameter	12.5	9.0	6.5	4.0	3.0
G. Gage length	50.0 ± 0.1	36.0 ± 0.1	26.0 ± 0.1	16.0 ± 0.1	12.0 ± 0.1
D. Diameter (Note 1)	12.5 ± 0.2	9.0 ± 0.1	6.5 ± 0.1	4.0 ± 0.1	3.0 ± 0.1
R. Radius of fillet, min	10	6	5	4	2
A. Length of reduced section, min (Note 2)	57	45	32	19	16

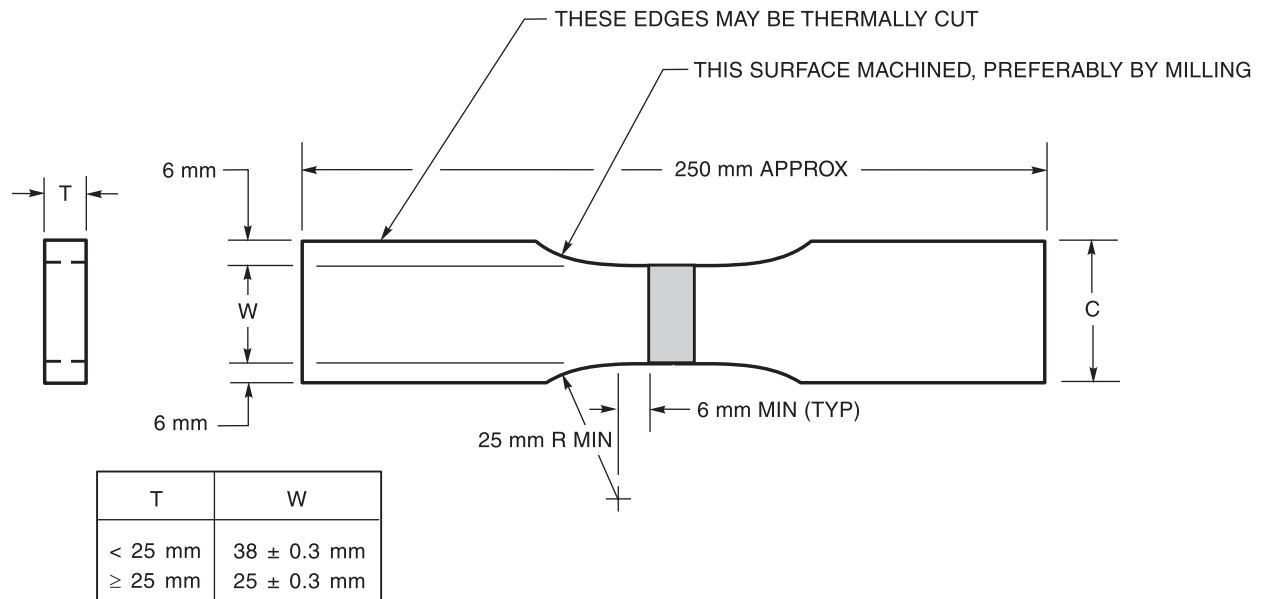
Standard 12.5 mm round tension test specimens with 50 mm gage length and examples of small size specimens proportional to the standard specimen.

*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. 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 other metric based codes use a 5 to 1 ratio of gage length to diameter (see Annex B).
5. The use of specimens smaller than 6.5 mm 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. For transverse weld specimens, the weld shall be approximately centered between gage marks.
7. 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.
8. Any standard thread size is permissible that provides for proper alignment and aids in assuring that the specimen will break within the reduced section.
9. The use of a fine series of thread is recommended for high-strength, brittle materials to avoid fracture in the threaded portion.
10. Surface finish within the gage length shall be no rougher than 2 micrometers R_a .

Figure A11 (Continued)—Round Tensile Specimens—4:1 Gage Length to Diameter



Notes:

1. Thin base 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 the width of the reduced section.
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 6 mm minimum on each side.
5. All surfaces in the reduced section should be no rougher than 4 micrometers R_a .
6. Narrower widths (W and C) may be used when necessary. In such cases, the width of the reduced section should be as large as the width of the material being tested permits. If the width of the material is less than W , the sides may be parallel throughout the length of the specimen.

Figure A12—Transverse Rectangular Tension Test Specimen (Plate)