

AWS B4.0:2016-AMD1
An American National Standard

Standard Methods for Mechanical Testing of Welds



AWS B4.0:2016-AMD1
An American National Standard

Approved by
American National Standards Institute

Standard Methods for Mechanical Testing of Welds

8th Edition

Supersedes AWS B4.0:2007

Prepared by the
AWS Committee on 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.



ISBN: 978-0-87171-889-1
© 2016 by American Welding Society
All rights reserved
Printed in the United States of America

Photocopy Rights. No portion of this standard may be reproduced, stored in a retrieval system, or transmitted in any form, including mechanical, photocopying, recording, or otherwise, without the prior written permission of the copyright owner. Authorization to photocopy items for internal, personal, or educational classroom use only or the internal, personal, or educational classroom use only of specific clients is granted by the American Welding Society provided that the appropriate fee is paid to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, tel: (978) 750-8400; Internet: <www.copyright.com>.

Statement on the Use of American Welding Society Standards

All standards (codes, specifications, recommended practices, methods, classifications, and guides) of the American Welding Society (AWS) are voluntary consensus standards that have been developed in accordance with the rules of the American National Standards Institute (ANSI). When AWS American National Standards are either incorporated in, or made part of, documents that are included in federal or state laws and regulations, or the regulations of other governmental bodies, their provisions carry the full legal authority of the statute. In such cases, any changes in those AWS standards must be approved by the governmental body having statutory jurisdiction before they can become a part of those laws and regulations. In all cases, these standards carry the full legal authority of the contract or other document that invokes the AWS standards. Where this contractual relationship exists, changes in or deviations from requirements of an AWS standard must be by agreement between the contracting parties.

AWS American National Standards are developed through a consensus standards development process that brings together volunteers representing varied viewpoints and interests to achieve consensus. While AWS administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in its standards.

AWS disclaims liability for any injury to persons or to property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this standard. AWS also makes no guarantee or warranty as to the accuracy or completeness of any information published herein.

In issuing and making this standard available, AWS is neither undertaking to render professional or other services for or on behalf of any person or entity, nor is AWS undertaking to perform any duty owed by any person or entity to someone else. Anyone using these documents should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. It is assumed that the use of this standard and its provisions is entrusted to appropriately qualified and competent personnel.

This standard may be superseded by new editions. This standard may also be corrected through publication of amendments or errata, or supplemented by publication of addenda. Information on the latest editions of AWS standards including amendments, errata, and addenda is posted on the AWS web page (www.aws.org). Users should ensure that they have the latest edition, amendments, errata, and addenda.

Publication of this standard does not authorize infringement of any patent or trade name. Users of this standard accept any and all liabilities for infringement of any patent or trade name items. AWS disclaims liability for the infringement of any patent or product trade name resulting from the use of this standard.

AWS does not monitor, police, or enforce compliance with this standard, nor does it have the power to do so. Official interpretations of any of the technical requirements of this standard may only be obtained by sending a request, in writing, to the appropriate technical committee. Such requests should be addressed to the American Welding Society, Attention: Managing Director, Technical Services Division, 8669 NW 36 St, # 130, Miami, FL 33166 (see Annex B). With regard to technical inquiries made concerning AWS standards, oral opinions on AWS standards may be rendered. These opinions are offered solely as a convenience to users of this standard, and they do not constitute professional advice. Such opinions represent only the personal opinions of the particular individuals giving them. These individuals do not speak on behalf of AWS, nor do these oral opinions constitute official or unofficial opinions or interpretations of AWS. In addition, oral opinions are informal and should not be used as a substitute for an official interpretation.

This standard is subject to revision at any time by the AWS B4 Committee on Mechanical Testing of Welds. It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn. Comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this standard are requested and should be addressed to AWS Headquarters. Such comments will receive careful consideration by the B4 Committee on Mechanical Testing of Welds and the author of the comments will be informed of the Committee's response to the comments. Guests are invited to attend all meetings of the AWS B4 Committee on Mechanical Testing of Welds to express their comments verbally. Procedures for appeal of an adverse decision concerning all such comments are provided in the Rules of Operation of the Technical Activities Committee. A copy of these Rules can be obtained from the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

This page is intentionally blank.

Personnel (Amendment)

AWS Committee on Mechanical Testing of Welds

P. S. Lester, Chair	<i>AZZ WSI</i>
J. A. Grantham, Vice Chair	<i>Welding & Joining Management Group</i>
S. P. Hedrick, Secretary	<i>American Welding Society</i>
D. A. Fink	<i>The Lincoln Electric Company</i>
J. W. Sowards	<i>NIST Boulder</i>
L. Van Leaven	<i>Consultant</i>
R. F. Waite	<i>Consultant</i>

Advisors to the AWS Committee on Mechanical Testing of Welds

J. J. DeLoach, Jr	<i>Naval Surface Warfare Center</i>
E. L. Lavy	<i>Consultant</i>
L. Li	<i>University of Alberta</i>
J. A. Major	<i>The Lincoln Electric Company</i>
T. McGaughy	<i>Edison Welding Institute</i>
K. M. Merlo-Joseph	<i>Apeks Supercritical</i>
H. W. Mishler	<i>Consultant</i>
G. R. Pearson	<i>Anderson Laboratories</i>
A. G. Portz	<i>Consultant</i>
J. H. Smith	<i>Consultant</i>
W. W. StCyr II	<i>Consultant</i>
R. J. Wong	<i>Naval Surface Warfare Center</i>
K. Zerkle	<i>Consultant</i>

Personnel (Original)

AWS Committee on Mechanical Testing of Welds

L. Van Leaven, Chair	<i>Consultant</i>
P. S. Lester, Vice Chair	<i>AZZ WSI</i>
S. P. Hedrick, Secretary	<i>American Welding Society</i>
J. R. Crisci	<i>Consultant</i>
D. A. Fink	<i>The Lincoln Electric Company</i>
J. A. Grantham	<i>Welding & Joining Management Group</i>
J. W. Sowards	<i>NIST Boulder</i>
R. F. Waite	<i>Consultant</i>

Advisors to the AWS Committee on Mechanical Testing of Welds

J. J. DeLoach, Jr	<i>Naval Surface Warfare Center</i>
E. L. Lavy	<i>Consultant</i>
L. Li	<i>University of Alberta</i>
J. A. Major	<i>The Lincoln Electric Company</i>
T. McGaughy	<i>Edison Welding Institute</i>
K. M. Merlo-Joseph	<i>Apeks Supercritical</i>
H. W. Mishler	<i>Consultant</i>
G. R. Pearson	<i>Anderson Laboratories</i>
A. G. Portz	<i>Consultant</i>
J. H. Smith	<i>Consultant</i>
W. W. StCyr II	<i>Consultant</i>
R. J. Wong	<i>Naval Surface Warfare Center</i>
K. Zerkle	<i>Consultant</i>

Foreword

This foreword is not part of this standard 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 sections related to tension tests, shear tests, bend tests, fracture toughness tests, hardness tests, break tests (nick and fillet welds), selected weldability tests and process specific tests (stud weld tests and resistance weld tests).

This document extensively references 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 C3.2M/C3.2, *Standard Methods for Evaluating the Strength of Brazed Joints*. Additional information on the mechanical testing of welded joints may be obtained from the AWS Welding Handbook, Ninth Edition, Volume 1, which describes selected weldability test methods.

AWS B4.0:2016, *Standard Methods for the Mechanical Testing of Welds*, is the eighth edition of the document initially published in 1942. The second edition (1974) incorporated metric conversions and the third edition (1977) incorporated minor changes. The fourth edition (1985) added the plane-strain fracture toughness test and the fifth edition (1992) added hardness testing and stud weld tests, and organized the tests by weld type. The sixth edition (1998) added six new weldability tests. The seventh edition included three new weldability tests (WIC, trough, and GBOP) and resistance weld tests. The current edition includes two new annexes (C and D) which address tensile testing of narrow groove welds. Several figures were updated and changes in text are indicated by a vertical margin line. Previous editions of the document are as follows:

AWS A4.0-42, *Standard Methods for Mechanical Testing of Welds*

AWS B4.0-74, *Standard Methods for Mechanical Testing of Welds*

AWS B4.0-77, *Standard Methods for Mechanical Testing of Welds*

AWS B4.0-85, *Standard Methods for Mechanical Testing of Welds*

AWS B4.0-92, *Standard Methods for Mechanical Testing of Welds*

AWS B4.0-98, *Standard Methods for Mechanical Testing of Welds*

AWS B4.0:2007, *Standard Methods for Mechanical Testing of Welds*

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, Committee on Standard Methods for Mechanical Testing of Welds, American Welding Society, 8669 NW 36 St, Miami, FL 33166.

Amendments

The following Amendments have been identified and incorporated in this reprint.

AWS Standard: B4.0:2016

Amendment Number: 1

Subject: Clause 7.2, replace reference ASTM A370 with ASTM E23:

ASTM Documents:

ASTM E23, Standard Test 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 E399, Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness K_{Ic} of Metallic Materials

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

ASTM E1820, Standard Test Method for Measurement of Fracture Toughness

ASTM E1823, Standard Terminology Relating to Fatigue and Fracture Testing

ASTM E1921, Standard Method for Determination of Reference Temperature, T_0 , for Ferritic Steels in the Transition Range.

AWS Standard: B4.0:2016

Amendment Number: 1

Subject: Clause 7.5.1, replace “ASTM A370” with “ASTM E23”:

7.5.1 The apparatus for conducting the various fracture toughness tests shall be in accordance with the latest edition of the following ISO and ASTM Standard Test Methods:

- (1) Charpy V-notch, ASTM E23;

AWS Standard: B4.0:2016

Amendment Number: 1

Subject: Clause 7.7.1, replace “ASTM A370” with “ASTM E23”:

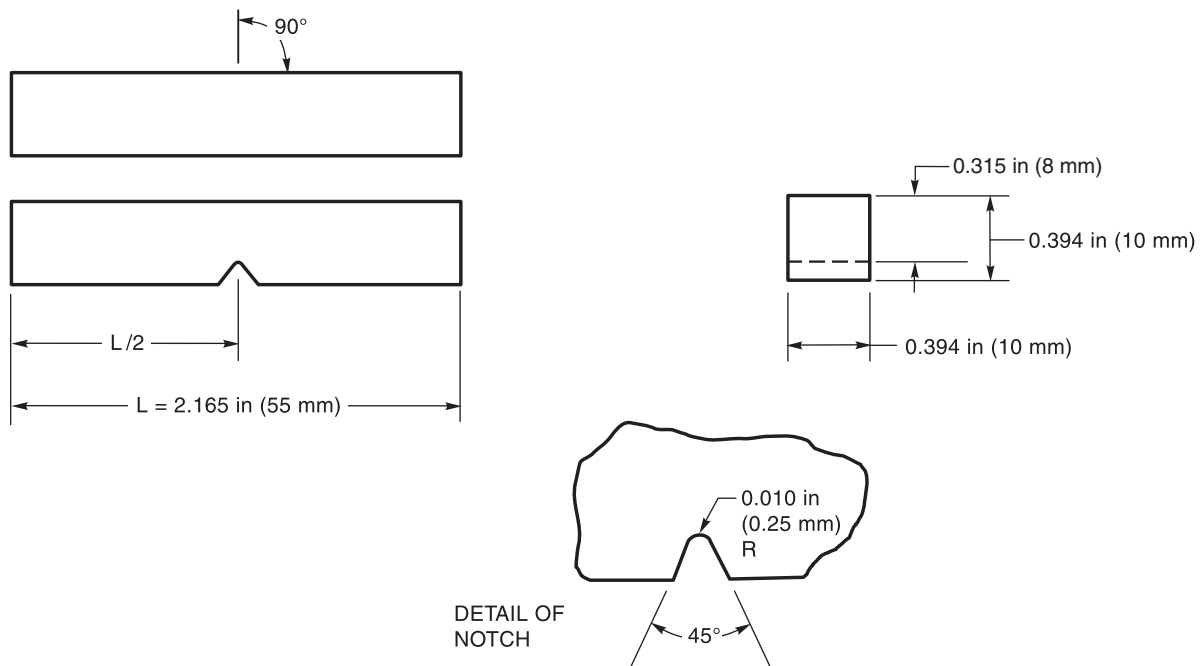
7.7.1 Test specimen preparation and test procedure for measuring the fracture toughness of a weldment shall be in accordance with the following ISO and ASTM standard test methods:

- (1) Charpy V-notch, ASTM E23, except that values up to and including 100% of the testing machine capacity shall be accepted and reported as fracture energy if the specimen breaks. The full machine capacity followed by a plus sign (+), shall be reported if the specimen is not broken. All these results may be used to calculate the average energy absorbed provided the minimum average required for acceptance is within the verified range of the machine;

AWS Standard: B4.0:2016

Amendment Number: 1

Subject: Figure 7.1, replace existing figure with new figure:



NOTE—Dimensional Tolerances shall be as follows:

Notch length to edge	$90^\circ \pm 2^\circ$
Adjacent sides shall be at	$90^\circ \pm 10$ minutes
Cross section dimensions	± 0.003 in (0.076 mm)
Length of specimen (L)	+0, -0.100 in (+0, -2.5 mm)
Centering of notch (L/2)	± 0.039 in (1 mm)
Angle of notch	$\pm 1^\circ$
Radius of notch	± 0.001 in (0.025 mm)
Finish requirements	63 microinches (1.5 micrometers) R_a on notched surface and opposite face; 125 microinches (3 micrometers) R_a on other two surfaces
Ligament length	± 0.001 in (0.025 mm)

Figure 7.1—Charpy V-Notch Impact Specimen

This page is intentionally blank.

Table of Contents

	Page No.
<i>Personnel</i>	v
<i>Foreword</i>	vii
<i>List of Tables</i>	xiii
<i>List of Figures</i>	xiii
1. Scope	1
2. Normative References	1
3. Terms and Definitions	2
4. Tension Tests	2
4.1 Scope	2
4.2 Normative References	2
4.3 Nomenclature	3
4.4 Summary of Methods	3
4.5 Significance	3
4.6 Apparatus	3
4.7 Specimens	3
4.8 Procedure	4
4.9 Report	6
4.10 Commentary	6
5. Shear Tests	13
5.1 Scope	13
5.2 Normative References	13
5.3 Summary of Method	13
5.4 Significance	13
5.5 Apparatus	13
5.6 Specimens	13
5.7 Procedure	14
5.8 Report	14
5.9 Commentary	14
6. Bend Tests	17
6.1 Scope	17
6.2 Normative References	17
6.3 Nomenclature	17
6.4 Summary of Method	17
6.5 Significance	17
6.6 Apparatus	18
6.7 Specimens	18
6.8 Procedure	19
6.9 Report	20
6.10 Commentary	20
7. Fracture and Notch Toughness Tests	32
7.1 Scope	32
7.2 Normative References	32

7.3	Summary of Method	33
7.4	Significance	33
7.5	Apparatus	33
7.6	Specimens	33
7.7	Procedure	33
7.8	Report	34
8.	Hardness Tests	41
8.1	Scope	41
8.2	Normative References	41
8.3	Summary of Method	41
8.4	Significance	41
8.5	Apparatus	41
8.6	Specimens	42
8.7	Procedure	42
8.8	Report	42
8.9	Commentary	42
9.	Break Tests (Nick and Fillet Weld)	45
9.1	Nick Break Test	45
9.2	Fillet Weld Break Test	55
10.	Weldability Testing	60
10.1	Controlled Thermal Severity (CTS) Test	61
10.2	Cruciform Test	68
10.3	Implant Test	76
10.4	Lehigh Restraint Test	82
10.5	Varestraint Test	86
10.6	Oblique Y-Groove Test	92
10.7	Welding Institute of Canada (WIC) Test	99
10.8	Trough Test	104
10.9	Gapped Bead on Plate (GBOP) Test	109
11.	Process Specific Tests	111
11.1	Stud Weld Test	111
11.2	Resistance Welding Test	114
	Annex A (Informative)—Bibliography	141
	Annex B (Informative)—Requesting an Official Interpretation on an AWS Standard	143
	Annex C (Informative)—Recommended Practice for All-Weld-Metal Tensile Testing Of Narrow Groove Welds	145
	Annex D (Informative)—Recommended Practice for All-Weld-Metal Tensile Testing Of Narrow Groove Pipeline Girth Welds	155
	List of AWS Documents of the Mechanical Testing of Welding	167

List of Tables

Table	Page No.
D.1 Tension Test Specimen Dimensions.	160

List of Figures

Figure	Page No.
Tension Tests	
4.1 Round Tensile Specimens	7
4.2 Transverse Rectangular Tension Test Specimen (Plate).	9
4.3 Longitudinal Tension Test Specimens (Plates)	10
4.4 Reduced Rectangular Section Tension Specimens for Pipe.	11
4.5 Full Section Tension Specimen for Pipe	12
Fillet Weld Shear Tests	
5.1 Longitudinal Fillet Weld Shear Specimen	15
5.2 Transverse Fillet Weld Shear Specimen	16
5.3 Shear Strength Calculation.	16
Bend Tests	
6.1 Typical Bottom Ejecting Guided Bend Test Fixture	21
6.2 Typical Bottom Guided Bend Test Fixture	22
6.3 Typical Wraparound Guided Bend Test Fixture.	23
6.4 Transverse Side Bend Specimens (Plate and Pipe)	24
6.5 Transverse Face Bend and Root Bend Specimen (Plate).	25
6.6 Transverse Face Bend and Root Bend Specimens (Pipe)	26
6.7 Longitudinal Face Bend and Root Bend Specimens (Plate)	27
6.8 Fillet Weld Root Bend Test Specimen	28
6.9 Surfacing Weld Face Bend and Side Bend Specimen	29
6.10 Longitudinal Guided Fillet Weld Bend Test.	30
6.11 Bend Test Nomograph	31
Fracture and Notch Toughness Tests	
7.1 Charpy (Simple-Beam) Impact Test Specimens V-Notch and U-Notch	35
7.2 Dynamic Tear Test Specimen, Anvil Supports, and Striker	36
7.3 Compact Tension Fracture Toughness Specimen.	37
7.4 Standard Drop Weight Nil-Ductility Temperature Test Specimen.	38
7.5 Orientation of Weld Metal Fracture Toughness Specimens in a Double-Groove Weld Thick Section Weldment	39
7.6 Crack Plane Orientation Code for Compact Tension Specimens from Welded Plate	39
7.7 Recommended Ratio of Weld Metal to Specimen Thickness for Weld-Metal Fracture Toughness Specimen (Compact Tension Specimen)	40

Hardness Tests

8.1	Example Butt Weld Hardness Testing Locations	43
8.2	Example Fillet Weld Hardness Testing Locations	44

Nick-Break Tests

9.1.1	Nick-Break Testing Fixture Made Out of 6 in (152 mm) Pipe	48
9.1.2	Nick-Break Test Using Vise	49
9.1.3	Nick-Break Test Using Anvil	49
9.1.4	Nick-Break Test Specimen	50
9.1.5	Specimen for Flash Butt Welds	51
9.1.6	Specimens for Nick-Break Test of Branch Joint Connections	52
9.1.7	Pipe Sleeve Test Specimen	53
9.1.8	Fillet Welded Plate Specimens	54

Fillet Weld Break Tests

9.2.1	Fillet Weld Break Specimen for Procedure Qualification	57
9.2.2	Fillet Weld Break Specimen for Primer Coated Materials	57
9.2.3	Fillet Weld Break Specimen for Galvanized Materials	58
9.2.4	Fillet Weld Break Specimen for Welder Qualification	58
9.2.5	Fillet Weld Break Specimen for Tack Welder Qualification	59
9.2.6	Method of Testing Fillet Weld Break Specimen	59

Weldability Testing**Controlled Thermal Severity (CTS) Test**

10.1.1	Fixture Used to Position CTS Specimen for Welding	63
10.1.2	CTS Test Specimen	64
10.1.3	Cooling Bath Arrangement for CTS Test	65
10.1.4	Sectioning of CTS Specimen	66
10.1.5	Typical Locations of Microhardness Impressions for this Optional Test on CTS Specimens	66
10.1.6	Suggested Data Sheet for CTS Test	67

Cruciform Test

10.2.1	Cruciform Test Assembly	71
10.2.2	Locations of Specimens for Examination of Cracks in Cruciform Test	72
10.2.3	Schematic Illustration of the Attached Plate in the Slotted Cruciform Specimen	72
10.2.4	Sectioning for the Longitudinal Notch	73
10.2.5	Sectioning for the Transverse Notch	73
10.2.6	Location of Metallographic Specimens for Examination of Cracks in the Slotted Cruciform Test	74
10.2.7	Suggested Data Sheet for Cruciform Test	75

Implant Test

10.3.1	Implant Test Specimen and Fixture	79
10.3.2	Typical Data for Implant Test Series	80
10.3.3	Suggested Data Sheet for Implant Test	81

Lehigh Restraint Test

10.4.1	Lehigh Restraint Weld-Metal Cracking Test Specimen	84
10.4.2	Suggested Data Sheet for Lehigh Test	85

Varestraint Test

10.5.1	Varestraint Test Fixture and Specimen	89
10.5.2	Auxiliary Bending Plates	90
10.5.3	Typical Indications on Top Surface of Test Weld	90
10.5.4	Suggested Data Sheet for Varestraint Test	91

Oblique Y-Groove Test

10.6.1	Oblique Y-Groove Test Assembly	95
10.6.2	Oblique Y-Groove Test Weld Configuration	96
10.6.3	Suggested Data Sheet for Oblique Y-Groove Test	98

Welding Institute of Canada (WIC) Test

10.7.1	Schematic Illustration of the WIC Test Assembly	102
10.7.2	Illustration of the Straight Y Joint Design for the WIC Specimen	102
10.7.3	Illustration of the Oblique Y Joint Design for the WIC Specimen	102
10.7.4	Suggested Data Sheet for WIC Test	103

Trough Test

10.8.1	Trough Test Specimen	107
10.8.2	Location of Weld Starts, Stops, and Tension Test Specimens (Side View)	107
10.8.3	Suggested Data Sheet for Trough Test	108

Gapped Bead On Plate (GBOP) Test

10.9.1	Specimen Dimensions and Test Set-Up	110
--------	---	-----

Stud Weld Tests

11.1.1	Equipment for Bend Tests for Welded Studs	112
11.1.2	Equipment for Applying a Tensile Load to a Welded Stud Using Torque	113

Resistance Weld Tests

11.2.1	Peel Test Specimen	122
11.2.2	Peel Test	123
11.2.3	Measurement of a Weld Button Resulting from the Peel Test	123
11.2.4	Bend Test Specimen	124
11.2.5	Spot Weld Chisel Test	125
11.2.6	Specimen for Tension Shear Test and Tension Shear Impact Test	126
11.2.7	Twisting Angle (γ at Fracture in Tension Shear Test	126
11.2.8	Cross-Tension Test Specimens	127
11.2.9	Fixture for Cross-Tension Test [for Thicknesses up to 0.19 in (4.8 mm)]	128
11.2.10	Fixture for Cross-Tension Test [for Thicknesses 0.19 in (4.8 mm) and Over]	129
11.2.11	Specimen for U Specimen Tension Test and U Specimen Shear Impact Test	130
11.2.12	U-Tension Test Jig	131
11.2.13	Pull Test (90 ° Peel Test)	132
11.2.14	Test Specimen and Typical Equipment for Torsion-Shear Test	133
11.2.15	Drop-Impact Test Specimen	134
11.2.16	Drop-Impact Test Machine	135
11.2.17	Test Fixture for Shear-Impact Loading Test	135
11.2.18	Test Fixture for Tension-Impact Loading Test	136
11.2.19	Fatigue Testing Machine	137
11.2.20	Pillow Test for Seam Welds	138
11.2.21	Suggested Data Sheet for Resistance Spot and Projection Welding	139
11.2.22	Suggested Data Sheet for Resistance Seam Welding	140

All-Weld-Metal Tensile Testing of Narrow Groove Welds

C.1	Tensile Specimen Location in Narrow Groove Weld Cross Section	145
C.2	Typical Narrow Groove Weld Joints	146
C.3	AWM Strip Tensile Blank	147
C.4	Preparation of AWM Strip Tensile Blank	147
C.5	Photographs of Blanks Etched with 3%–5% Nital	148
C.6	Measurement of Weld Width for Determination of Specimen Width	149
C.7	AWM Strip Tensile Specimen Dimensional Requirements	150
C.8	AWM Strip Tensile Specimen Prior to Test	151
C.9	AWM Strip Tensile Test	152

All-Weld-Metal Tensile Testing of Narrow Groove Pipeline Girth Welds

D.1	Tensile Specimen Location in Narrow Groove Weld Cross Section	155
D.2	Typical Narrow Groove Weld Joints	156
D.3	Schematic Diagram of AWM Strip Tensile Blank	157
D.4	AWM Strip Tensile Blank	158

D.5	Preparation of AWM Strip Tensile Blank	159
D.6	Photographs of Blanks Etched with 3%–5% Nital	162
D.7	Measurement of Weld Width for Determination of Specimen Width	163
D.8	AWM Strip Tensile Specimen Dimensional Requirements	164
D.9	AWM Strip Tensile Specimen Prior to Test	164
D.10	AWM Strip Tensile Test	165

Standard Methods for Mechanical Testing of Welds

1. Scope

This specification establishes standard methods for mechanical testing of welds. The significance of each test, test apparatus, preparation of the test specimens, and the test procedure are described. Example test results sheets are provided.

It is beyond the scope of this document to define the required mechanical properties or acceptance criteria for the weld metal.

This standard makes sole use of U.S. Customary Units. Approximate mathematical equivalents in the International System of Units (SI) are provided for comparison in parentheses or in appropriate columns in tables and figures.

Safety and health issues and concerns are beyond the scope of this standard and therefore are not addressed herein.

Safety and health information is available from the following sources:

American Welding Society:

- (1) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*
- (2) AWS Safety and Health Fact Sheets
- (3) Other safety and health information on the AWS website

Material or Equipment Manufacturers:

- (1) Safety Data Sheets supplied by materials manufacturers
- (2) Operating Manuals supplied by equipment manufacturers

Applicable Regulatory Agencies

Work performed in accordance with this standard may involve the use of materials that have been deemed hazardous, and may involve operations or equipment that may cause injury or death. This standard does not purport to address all safety and health risks that may be encountered. The user of this standard should establish an appropriate safety program to address such risks as well as to meet applicable regulatory requirements. ANSI Z49.1 should be considered when developing the safety program.

2. Normative References

The following standards contain provisions which, through reference in this text, constitute mandatory provisions of this AWS standard. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

AWS documents:

AWS A1.1, *Metric Practice Guide for the Welding Industry*;

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

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