

Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding



American Welding Society



Key Words—Low-alloy steel, flux cored electrodes,
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Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding

Supersedes ANSI/AWS A5.29:1998

Prepared by
AWS A5 Committee on Filler Metals and Allied Materials

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

This specification prescribes the requirements for classification of low-alloy steel electrodes for flux cored arc welding. The requirements include chemical composition and mechanical properties of the weld metal and certain usability characteristics. Optional, supplemental designators are also included for improved toughness and diffusible hydrogen. Additional requirements are included for standard sizes, marking, manufacturing, and packaging. A guide is appended to the specification as a source of information concerning the classification system employed and the intended use of low-alloy steel flux cored electrodes.

This specification makes use of both U.S. Customary Units and the International System of Units (SI). Since these are not equivalent, each system must be used independently of the other.



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Foreword

(This Foreword is not a part of AWS A5.29/A5.29M:2005, *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*, but is included for informational purposes only.)

This document is the first of the A5.29 specifications which uses of both U.S. Customary Units and the International System of Units (SI) throughout. The measurements are not exact equivalents; therefore, each system must be used independently of the other, without combining values in any way. In selecting rational metric units, AWS A1.1, *Metric Practice Guide for the Welding Industry*, and ISO 554, *Welding consumables—Technical delivery conditions for welding filler metals—Type of product, dimensions, tolerances, and markings*, are used where suitable. Tables and figures make use of both U.S. Customary and SI Units, which, with the application of the specified tolerances, provides for interchangeability of products in both the U.S. Customary and SI Units.

This is the second revision of A5.29 that was issued initially in 1980. This revision contains specifications for an additional alloy composition (-B9) to meet the increasing demand for low-alloy flux cored electrodes.

This revision also includes new heat input limits which are applied to mechanical property tests, mechanical property requirements for testing more than one electrode size, specified welding parameters for the diffusible hydrogen tests, and the use of a “C” suffix to designate carbon dioxide shielding gas.

Historical Background

ANSI/AWS A5.29-80 *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*

ANSI/AWS A5.29:1998 *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS A5 Committee on Filler Metals and Allied Materials, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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

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Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding

1. Scope

1.1 This specification prescribes requirements for the classification of low-alloy steel electrodes for flux cored arc welding (FCAW) either with or without shielding gas. Iron is the only element whose content exceeds 10.5 percent in undiluted weld metal deposited by these electrodes. Metal cored low-alloy steel electrodes are not classified under this specification but are classified according to AWS A5.28/A5.28M.¹

1.2 Safety and health issues and concerns are beyond the scope of this standard and, therefore, are not fully addressed herein. Some safety and health information can be found in the nonmandatory Annex Sections A5 and A9. Safety and health information is available from other sources, including, but not limited to, ANSI Z49.1² and applicable federal and state regulations.

1.3 This specification makes use of both U.S. Customary Units and the International System of Units (SI). The measurements are not exact equivalents; therefore, each system must be used independently of the other without combining in any way when referring to weld metal properties. The specification with the designation A5.29 uses U.S. Customary Units. The specification A5.29M uses SI Units. The latter are shown within brackets [] or in appropriate columns in tables and figures. Standard dimensions based on either system may be used for the sizing of electrodes or packaging or both under the A5.29 and A5.29M specifications.

1. AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

2. ANSI standards are published by the American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

2. Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this AWS standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreement based on this AWS standard are encouraged to investigate the possibility of applying the most recent editions of the documents shown below. For undated references, the latest edition of the standard referred to applies.

2.1 The following AWS standards are referenced in the mandatory sections of this document:

(1) AWS A4.3, *Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*

(2) AWS A5.01, *Filler Metal Procurement Guidelines*

(3) AWS A5.32/A5.32M, *Specification for Welding Shielding Gases*

(4) AWS B4.0 or B4.0M, *Standard Methods for Mechanical Testing of Welds*.

2.2 The following ANSI standard is referenced in the mandatory sections of this document:

(1) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*.

2.3 The following ASTM standards³ are referenced in the mandatory sections of this document:

(1) ASTM A 36/A 36M, *Specification for Carbon Structural Steel*

(2) ASTM A 203/A 203M, *Specification for Pressure Vessel Plates, Alloy Steel, Nickel*

3. ASTM standards are published by the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

(3) ASTM A 285/A 285M, *Specification for Pressure Vessel Plates, Carbon Steel, Low-and Intermediate-Tensile Strength*

(4) ASTM A 302/A 302M, *Specification for Pressure Vessel Plates, Alloy Steel, Manganese-Molybdenum and Manganese-Molybdenum-Nickel*

(5) ASTM A 387/A 387M, *Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum*

(6) ASTM A 514/A 514M, *Specification for High-Yield Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding*

(7) ASTM A 537/A 537M, *Specification for Pressure Vessel Plates, Heat Treated, Carbon-Manganese-Silicon Steel*

(8) ASTM A 588/A 588M, *Specification for High-Strength Structural Steel with 50 ksi [345 MPa] Minimum Yield Point to 4 in [100 mm] Thick*

(9) ASTM DS-56 (SAE HS-1086), *Metals & Alloys in the Unified Numbering System*

(10) ASTM E 29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

(11) ASTM E 350, *Standard Test Methods for Chemical Analysis of Carbon Steel, Low Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron*

(12) ASTM E 1032, *Standard Test Method for Radiographic Examination of Weldments*.

2.4 The following MIL standards⁴ are referenced in the mandatory sections of this document:

(1) MIL-S-16216, *Specification for Steel Plate, Alloy, Structural, High Yield Strength (HY-80 and HY-100)*

(2) MIL-S-24645, *Specification for Steel Plate, Sheet, or Coil, Age-Hardening Alloy, Structural, High Yield Strength (HSLA-80 and HSLA-100)*

(3) NAVSEA Technical Publication T9074-BD-GIB-010/0300, *Base Materials for Critical Applications: Requirements for Low Alloy Steel Plate, Forgings, Castings, Shapes, Bars, and Heads of HY-80/100/130 and HSLA-80/100*.

2.5 The following ISO standard⁵ is referenced in the mandatory sections of this document:

4. For inquiries regarding MIL-S-16216 and MIL-S-24645 refer to internet website: <http://assist.daps.dla.mil/online>. Applications for copies of NAVSEA Technical Publication T9074-BD-GIB-010/0300 should be addressed to the Naval Inventory Control Point, 700 Robins Avenue, Philadelphia, PA 19111-5094.

5. ISO standards are published by the International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland.

(1) ISO 544, *Welding consumables—Technical delivery conditions for welding filler materials—Type of product, dimensions, tolerances, and marking*.

3. Classification

3.1 The flux cored electrodes covered by the A5.29 specification utilize a classification system based upon the U.S. Customary Units and are classified according to the following:

(1) The mechanical properties of the weld metal, as specified in Table 1U,

(2) The positions of welding for which the electrodes are suitable, as shown in Figure 1,

(3) Certain usability characteristics of the electrode (including the presence or absence of a shielding gas) as specified in Table 2 and Figure 1, and

(4) Chemical composition of the weld metal, as specified in Table 7.

3.1M The flux cored electrodes covered by the A5.29M specification utilize a classification system based upon the International System of Units (SI) and are classified according to the following:

(1) The mechanical properties of the weld metal, as specified in Table 1M,

(2) The positions of welding for which the electrodes are suitable, as shown in Figure 1,

(3) Certain usability characteristics of the electrode (including the presence or absence of a shielding gas) as specified in Table 2 and Figure 1, and

(4) Chemical composition of the weld metal, as specified in Table 7.

3.2 Electrodes classified under one classification shall not be classified under any other classification in this specification with the exception of the following: Gas shielded electrodes may be classified with 100% CO₂ (AWS A5.32 Class SG-C) shielding gas (“C” designator) and with a 75 to 80% argon/balance CO₂ (AWS A5.32 Class SG-AC-25 or SG-AC-20) shielding gas (“M” designator).

Electrodes may be classified under A5.29 using U.S. Customary Units, and/or under A5.29M using the International System of Units (SI). Electrodes classified under either classification system must meet all requirements for classification under that system. The classification system is shown in Figure 1.

3.3 The electrodes classified under this specification are intended for flux cored arc welding either with or without an external shielding gas. Electrodes intended for use without external shielding gas, or with the shielding gases specified in Table 2 are not prohibited from use with any other process or shielding gas for which they are found suitable.

Table 1U
A5.29 Mechanical Property Requirements

AWS Classification(s) ^{a, b}	Condition ^c	Tensile Strength (ksi)	Yield Strength (ksi)	% Elongation Minimum	Charpy V-Notch Impact Energy ^d Minimum
E7XT5-A1C, -A1M	PWHT	70–90	58 min.	20	20 ft-lbf @ –20°F
E8XT1-A1C, -A1M	PWHT	80–100	68 min.	19	Not Specified
E8XT1-B1C, -B1M, -B1LC, -B1LM	PWHT	80–100	68 min.	19	Not Specified
E8XT1-B2C, -B2M, -B2HC, -B2HM, -B2LC, -B2LM E8XT5-B2C, -B2M, -B2LC, -B2LM	PWHT	80–100	68 min.	19	Not Specified
E9XT1-B3C, -B3M, -B3LC, -B3LM, -B3HC, -B3HM E9XT5-B3C, -B3M	PWHT	90–110	78 min.	17	Not Specified
E10XT1-B3C, -B3M	PWHT	100–120	88 min.	16	Not Specified
E8XT1-B6C, ^e -B6M, ^e -B6LC, ^e -B6LM, ^e E8XT5-B6C, ^e -B6M, ^e -B6LC, ^e -B6LM ^e	PWHT	80–100	68 min.	19	Not Specified
E8XT1-B8C, ^e -B8M, ^e -B8LC, ^e -B8LM ^e E8XT5-B8C, ^e -B8M, ^e -B8LC, ^e -B8LM ^e	PWHT	80–100	68 min.	19	Not Specified
E9XT1-B9C, -B9M	PWHT	90–120	78 min.	16	Not Specified
E6XT1-Ni1C, -Ni1M	AW	60–80	50 min.	22	20 ft-lbf @ –20°F
E7XT6-Ni1	AW	70–90	58 min.	20	20 ft-lbf @ –20°F
E7XT8-Ni1	AW	70–90	58 min.	20	20 ft-lbf @ –20°F
E8XT1-Ni1C, -Ni1M	AW	80–100	68 min.	19	20 ft-lbf @ –20°F
E8XT5-Ni1C, -Ni1M	PWHT	80–100	68 min.	19	20 ft-lbf @ –60°F
E7XT8-Ni2	AW	70–90	58 min.	20	20 ft-lbf @ –20°F
E8XT8-Ni2	AW	80–100	68 min.	19	20 ft-lbf @ –20°F
E8XT1-Ni2C, -Ni2M	AW	80–100	68 min.	19	20 ft-lbf @ –40°F
E8XT5-Ni2C, ^e -Ni2M ^f	PWHT	80–100	68 min.	19	20 ft-lbf @ –75°F
E9XT1-Ni2C, -Ni2M	AW	90–110	78 min.	17	20 ft-lbf @ –40°F
E8XT5-Ni3C, ^e -Ni3M ^f	PWHT	80–100	68 min.	19	20 ft-lbf @ –100°F
E9XT5-Ni3C, ^e -Ni3M ^f	PWHT	90–110	78 min.	17	20 ft-lbf @ –100°F
E8XT11-Ni3	AW	80–100	68 min.	19	20 ft-lbf @ 0°F
E9XT1-D1C, -D1M	AW	90–110	78 min.	17	20 ft-lbf @ –40°F
E9XT5-D2C, -D2M	PWHT	90–110	78 min.	17	20 ft-lbf @ –60°F
E10XT5-D2C, -D2M	PWHT	100–120	88 min.	16	20 ft-lbf @ –40°F
E9XT1-D3C, -D3M	AW	90–110	78 min.	17	20 ft-lbf @ –20°F
E8XT5-K1C, -K1M	AW	80–100	68 min.	19	20 ft-lbf @ –40°F
E7XT7-K2	AW	70–90	58 min.	20	20 ft-lbf @ –20°F
E7XT4-K2	AW	70–90	58 min.	20	20 ft-lbf @ 0°F
E7XT8-K2	AW	70–90	58 min.	20	20 ft-lbf @ –20°F
E7XT11-K2	AW	70–90	58 min.	20	20 ft-lbf @ +32°F

(continued)

Table 1U (Continued)
A5.29 Mechanical Property Requirements

AWS Classification(s) ^{a, b}	Condition ^c	Tensile Strength (ksi)	Yield Strength (ksi)	% Elongation Minimum	Charpy V-Notch Impact Energy ^d Minimum
E8XT1-K2C, -K2M E8XT5-K2C, -K2M	AW	80–100	68 min.	19	20 ft-lbf @ –20°F
E9XT1-K2C, -K2M	AW	90–110	78 min.	17	20 ft-lbf @ 0°F
E9XT5-K2C, -K2M	AW	90–110	78 min.	17	20 ft-lbf @ –60°F
E10XT1-K3C, -K3M	AW	100–120	88 min.	16	20 ft-lbf @ 0°F
E10XT5-K3C, -K3M	AW	100–120	88 min.	16	20 ft-lbf @ –60°F
E11XT1-K3C, -K3M	AW	110–130	98 min.	15	20 ft-lbf @ 0°F
E11XT5-K3C, -K3M	AW	110–130	98 min.	15	20 ft-lbf @ –60°F
E11XT1-K4C, -K4M	AW	110–130	98 min.	15	20 ft-lbf @ 0°F
E11XT5-K4C, -K4M	AW	110–130	98 min.	15	20 ft-lbf @ –60°F
E12XT5-K4C, -K4M	AW	120–140	108 min.	14	20 ft-lbf @ –60°F
E12XT1-K5C, -K5M	AW	120–140	108 min.	14	Not Specified
E7XT5-K6C, -K6M	AW	70–90	58 min.	20	20 ft-lbf @ –75°F
E6XT8-K6	AW	60–80	50 min.	22	20 ft-lbf @ –20°F
E7XT8-K6	AW	70–90	58 min.	20	20 ft-lbf @ –20°F
E10XT1-K7C, -K7M	AW	100–120	88 min.	16	20 ft-lbf @ –60°F
E9XT8-K8	AW	90–110	78 min.	17	20 ft-lbf @ –20°F
E10XT1-K9C, -K9M	AW	100–120 ^g	82–97	18	35 ft-lbf @ –60°F
E8XT1-W2C, -W2M	AW	80–100	68 min.	19	20 ft-lbf @ –20°F
EXXTX-G, ^h -GC, ^h -GM ^h	The weld deposit composition, condition of test (AW or PWHT) and Charpy V-Notch impact properties are as agreed upon between the supplier and purchaser. Requirements for the tension test, positionality, slag system and shielding gas, if any, conform to those indicated by the digits used.				
EXXTG-X ^h	The slag system, shielding gas, if any, condition of test (AW or PWHT) and Charpy V-Notch impact properties are as agreed upon between the supplier and purchaser. Requirements for the tension test, positionality and weld deposit composition conform to those indicated by the digits used.				
EXXTG-G ^h	The slag system, shielding gas, if any, condition of test (AW or PWHT), Charpy V-Notch impact properties and weld deposit composition are as agreed upon between the supplier and purchaser. Requirements for the tension test and positionality conform to those indicated by the digits used.				

Notes:

- The “Xs” in actual classification will be replaced with the appropriate designators. See Figure 1.
- The placement of a “G” in a designator position indicates that those properties have been agreed upon between the supplier and purchaser.
- AW = As Welded. PWHT = Postweld heat treated in accordance with Table 6 and 9.4.1.2.
- Electrodes with the optional supplemental designator “J” shall meet the minimum Charpy V-Notch impact energy requirement for its classification at a test temperature 20°F lower than the test temperature shown in Table 1U for its classification.
- These electrodes are presently classified E502TX-X or E505TX-X in AWS A5.22-95. With the next revision of A5.22 they will be removed and exclusively listed in this specification.
- PWHT temperatures in excess of 1150°F will decrease the Charpy V-Notch impact properties.
- For this classification (E10XT1-K9C, -K9M) the tensile strength range shown is not a requirement. It is an approximation.
- The tensile strength, yield strength, and % elongation requirements for EXXTX-G, -GC, -GM; EXXTG-X and EXXTG-G electrodes are as shown in this table for other electrode classifications (not including the E10XT1-K9C, -K9M classifications) having the same tensile strength designator.

Table 1M
A5.29M Mechanical Property Requirements

AWS Classification(s) ^{a, b}	Condition ^c	Tensile Strength (MPa)	Yield Strength (MPa)	% Elongation Minimum	Charpy V-Notch Impact Energy ^d Minimum
E49XT5-A1C, -A1M	PWHT	490–620	400 min.	20	27 Joules @ –30°C
E55XT1-A1C, -A1M	PWHT	550–690	470 min.	19	Not Specified
E55XT1-B1C, -B1M, -B1LC, -B1LM	PWHT	550–690	470 min.	19	Not Specified
E55XT1-B2C, -B2M, -B2HC, -B2HM, -B2LC, -B2LM E55XT5-B2C, -B2M, -B2LC, -B2LM	PWHT	550–690	470 min.	19	Not Specified
E62XT1-B3C, -B3M, -B3LC, -B3LM, -B3HC, -B3HM E62XT5-B3C, -B3M	PWHT	620–760	540 min.	17	Not Specified
E69XT1-B3C, -B3M	PWHT	690–830	610 min.	16	Not Specified
E55XT1-B6C, -B6M, -B6LC, -B6LM E55XT5-B6C, -B6M, -B6LC, -B6LM	PWHT	550–690	470 min.	19	Not Specified
E55XT1-B8C, -B8M, -B8LC, -B8LM E55XT5-B8C, -B8M, -B8LC, -B8LM	PWHT	550–690	470 min.	19	Not Specified
E62XT1-B9C, -B9M	PWHT	620–830	540 min.	16	Not Specified
E43XT1-Ni1C, -Ni1M	AW	430–550	340 min.	22	27 Joules @ –30°C
E49XT6-Ni1	AW	490–620	400 min.	20	27 Joules @ –30°C
E49XT8-Ni1	AW	490–620	400 min.	20	27 Joules @ –30°C
E55XT1-Ni1C, -Ni1M	AW	550–690	470 min.	19	27 Joules @ –30°C
E55XT5-Ni1C, -Ni1M	PWHT	550–690	470 min.	19	27 Joules @ –50°C
E49XT8-Ni2	AW	490–620	400 min.	20	27 Joules @ –30°C
E55XT8-Ni2	AW	550–690	470 min.	19	27 Joules @ –30°C
E55XT1-Ni2C, -Ni2M	AW	550–690	470 min.	19	27 Joules @ –40°C
E55XT5-Ni2C, ^e -Ni2M ^e	PWHT	550–690	470 min.	19	27 Joules @ –60°C
E62XT1-Ni2C, -Ni2M	AW	620–760	540 min.	17	27 Joules @ –40°C
E55XT5-Ni3C, ^e -Ni3M ^e	PWHT	550–690	470 min.	19	27 Joules @ –70°C
E62XT5-Ni3C, ^e -Ni3M ^e	PWHT	620–760	540 min.	17	27 Joules @ –70°C
E55XT11-Ni3	AW	550–690	470 min.	19	27 Joules @ –20°C
E62XT1-D1C, -D1M	AW	620–760	540 min.	17	27 Joules @ –40°C
E62XT5-D2C, -D2M	PWHT	620–760	540 min.	17	27 Joules @ –50°C
E69XT5-D2C, -D2M	PWHT	690–830	610 min.	16	27 Joules @ –40°C
E62XT1-D3C, -D3M	AW	620–760	540 min.	17	27 Joules @ –30°C
E55XT5-K1C, -K1M	AW	550–690	470 min.	19	27 Joules @ –40°C
E49XT7-K2	AW	490–620	400 min.	20	27 Joules @ –30°C
E49XT4-K2	AW	490–620	400 min.	20	27 Joules @ –20°C
E49XT8-K2	AW	490–620	400 min.	20	27 Joules @ –30°C
E49XT11-K2	AW	490–620	400 min.	20	27 Joules @ 0°C

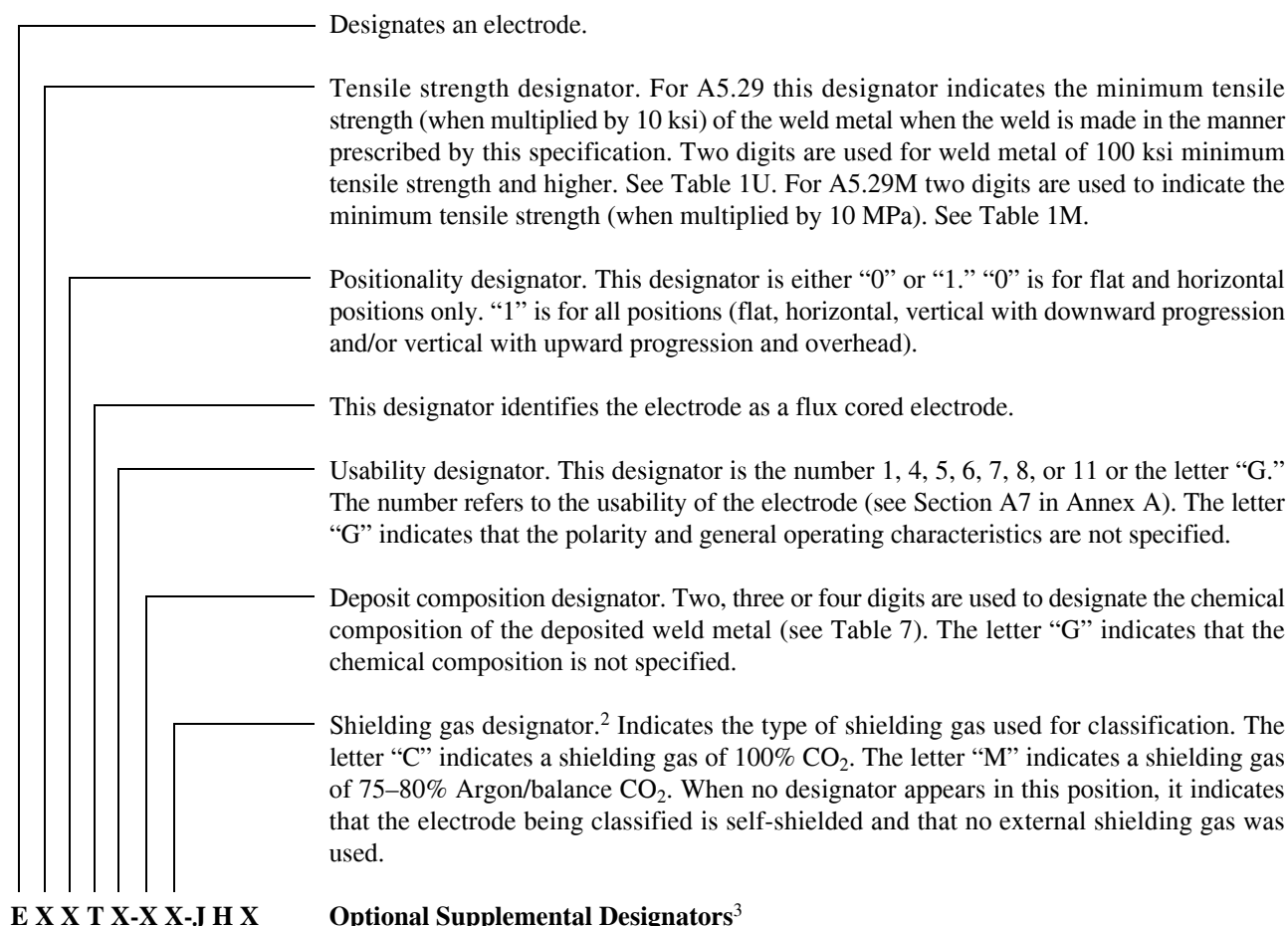
(continued)

Table 1M (Continued)
A5.29M Mechanical Property Requirements

AWS Classification(s) ^{a, b}	Condition ^c	Tensile Strength (MPa)	Yield Strength (MPa)	% Elongation Minimum	Charpy V-Notch Impact Energy ^d Minimum
E55XT1-K2C, -K2M E55XT5-K2C, -K2M	AW	550–690	470 min.	19	27 Joules @ –30°C
E62XT1-K2C, -K2M	AW	620–760	540 min.	17	27 Joules @ –20°C
E62XT5-K2C, -K2M	AW	620–760	540 min.	17	27 Joules @ –50°C
E69XT1-K3C, -K3M	AW	690–830	610 min.	16	27 Joules @ –20°C
E69XT5-K3C, -K3M	AW	690–830	610 min.	16	27 Joules @ –50°C
E76XT1-K3C, -K3M	AW	760–900	680 min.	15	27 Joules @ –20°C
E76XT5-K3C, -K3M	AW	760–900	680 min.	15	27 Joules @ –50°C
E76XT1-K4C, -K4M	AW	760–900	680 min.	15	27 Joules @ –20°C
E76XT5-K4C, -K4M	AW	760–900	680 min.	15	27 Joules @ –50°C
E83XT5-K4C, -K4M	AW	830–970	745 min.	14	27 Joules @ –50°C
E83XT1-K5C, -K5M	AW	830–970	745 min.	14	Not Specified
E49XT5-K6C, -K6M	AW	490–620	400 min.	20	27 Joules @ –60°C
E43XT8-K6	AW	430–550	340 min.	22	27 Joules @ –30°C
E49XT8-K6	AW	490–620	400 min.	20	27 Joules @ –30°C
E69XT1-K7C, -K7M	AW	690–830	610 min.	16	27 Joules @ –50°C
E62XT8-K8	AW	620–760	540 min.	17	27 Joules @ –30°C
E69XT1-K9C, -K9M	AW	690–830 ^f	560–670	18	47 Joules @ –50°C
E55XT1-W2C, -W2M	AW	550–690	470 min.	19	27 Joules @ –30°C
EXXTX-G, ^g -GC, ^g -GM ^g	The weld deposit composition, condition of test (AW or PWHT) and Charpy V-Notch impact properties are as agreed upon between the supplier and purchaser. Requirements for the tension test, positionality, slag system and shielding gas, if any, conform to those indicated by the digits used.				
EXXTG-X ^g	The slag system, shielding gas, if any, condition of test (AW or PWHT) and Charpy V-Notch impact properties are as agreed upon between the supplier and purchaser. Requirements for the tension test, positionality and weld deposit composition conform to those indicated by the digits used.				
EXXTG-G ^g	The slag system, shielding gas, if any, condition of test (AW or PWHT), Charpy V-Notch impact properties and weld deposit composition are as agreed upon between the supplier and purchaser. Requirements for the tension test and positionality conform to those indicated by the digits used.				

Notes:

- The “Xs” in actual classification will be replaced with the appropriate designators. See Figure 1.
- The placement of a “G” in a designator position indicates that those properties have been agreed upon between the supplier and purchaser.
- AW = As Welded. PWHT = Postweld heat treated in accordance with Table 6 and 9.4.1.2.
- Electrodes with the optional supplemental designator “J” shall meet the minimum Charpy V-Notch impact energy requirement for its classification at a test temperature 10°C lower than the test temperature shown in Table 1M for its classification.
- PWHT temperatures in excess of 620°C will decrease the Charpy V-Notch impact properties.
- For this classification (E69XT1-K9C, -K9M) the tensile strength range shown is not a requirement. It is an approximation.
- The tensile strength, yield strength, and % elongation requirements for EXXTX-G, -GC, -GM; EXXTG-X and EXXTG-G electrodes are as shown in this table for other electrode classifications (not including the E69XT1-K9C, -K9M classifications) having the same tensile strength designator.

Mandatory Classification Designators¹**Optional Supplemental Designators³**

Optional supplemental diffusible hydrogen designator (see Table 9).

The letter “J” when present in this position designates that the electrode meets the requirements for improved toughness and will deposit weld metal with Charpy V-Notch properties of at least 20 ft-lbf [27J] at a test temperature of 20°F [10°C] lower than the temperature shown for that classification in Table 1U [Table 1M].

Notes:

1. The combination of these designators constitutes the flux cored electrode classification. Note that specific chemical compositions are not always identified with specific mechanical properties in the specification. A supplier is required by the specification to include the mechanical properties appropriate for a particular electrode in the classification of the electrode. Thus, for example, a complete designation is E80T5-Ni3. EXXT5-Ni3 is not a complete classification.
2. See AWS A5.32/A5.32M, *Specification for Welding Shielding Gases*.
3. These designators are optional and do not constitute a part of the flux cored electrode classification.

Figure 1—A5.29/A5.29M Classification System

Table 2
Electrode Usability Requirements

Usability Designator	AWS Classification	Position of Welding ^{a, b}	External Shielding ^c	Polarity ^d	Application ^e
1	EX0T1-XC	H,F	CO ₂	DCEP	M
	EX0T1-XM		75–80 Ar/bal CO ₂		
	EX1T1-XC	H, F, VU, OH	CO ₂		
	EX1T1-XM		75–80 Ar/bal CO ₂		
4	EX0T4-X	H, F	None	DCEP	M
5	EX0T5-XC	H,F	CO ₂	DCEP	M
	EX0T5-XM		75–80 Ar/bal CO ₂		
	EX1T5-XC	H, F, VU, OH	CO ₂	DCEP or DCEN ^f	
	EX1T5-XM		75–80 Ar/bal CO ₂		
6	EX0T6-X	H, F	None	DCEP	M
7	EX0T7-X	H, F	None	DCEN	M
	EX1T7-X	H, F, VU, OH			
8	EX0T8-X	H, F	None	DCEN	M
	EX1T8-X	H, F, VU, OH			
11	EX0T11-X	H, F	None	DCEN	M
	EX1T11-X	H, F, VD, OH			
G	EX0TX-G	H,F	None	(g)	M
	EX0TX-GC		CO ₂	(g)	
	EX0TX-GM		75–80 Ar/bal CO ₂	(g)	
	EX0TG-X		Not Specified	Not Specified	
	EX0TG-G		Not Specified	Not Specified	
	EX1TX-G	H, F, VU or VD, OH	None	(g)	M
	EX1TX-GC		CO ₂	(g)	
	EX1TX-GM		75–80 Ar/bal CO ₂	(g)	
	EX1TG-X		Not Specified	Not Specified	
	EX1TG-G		Not Specified	Not Specified	

Notes:

- H = horizontal position, F = flat position, OH = overhead position, VU = vertical position with upward progression, VD = vertical position with downward progression.
- Electrode sizes suitable for out-of-position welding, i.e., welding positions other than flat or horizontal, are usually those sizes that are smaller than 3/32 in [2.4 mm] size or the nearest one called for in 9.4.1 for the groove weld. For that reason, electrodes meeting the requirements for the groove weld tests and the fillet weld tests may be classified as EX1TX-XX (where X represents the tensile strength, usability, deposit composition and shielding gas, if any, designators) regardless of their size. See Section A7 in Annex A and Figure 1 for more information.
- Properties of weld metal from electrodes that are used with external shielding gas will vary according to the shielding gas employed. Electrodes classified with a specific shielding gas should not be used with other shielding gases without first consulting the manufacture of the electrodes.
- The term “DCEP” refers to direct current electrode positive (dc, reverse polarity). The term “DCEN” refers to direct current electrode negative (dc, straight polarity).
- M = suitable for use on either single or multiple pass applications.
- Some EX1T5-XC, -XM electrodes may be recommended for use on DCEN for improved out-of-position welding. Consult the manufacturer for the recommended polarity.
- The polarity for electrodes with usability designators for other than G is as prescribed for those designators in this table.

4. Acceptance

Acceptance⁶ of the welding electrodes shall be in accordance with the provisions of AWS A5.01.

5. Certification

By affixing the AWS specification and classification designations to the packaging, or the classification designations to the product, the manufacturer certifies that the product meets the requirements of this specification.⁷

6. Rounding-Off Procedure

For the purpose of determining conformance with this specification, an observed or calculated value shall be

6. See Section A3 (in Annex A) for further information concerning acceptance, testing of the material shipped, and AWS A5.01.

7. See Section A4 (in Annex A) for further information concerning certification and the testing called for to meet this requirement.

rounded to the nearest 1,000 psi for tensile and yield strength for A5.29 [or to the nearest 10 MPa for tensile and yield strength for A5.29M] and to the nearest unit in the last right-hand place of figures used in expressing the limiting values for other quantities in accordance with the rounding-off method given in ASTM E 29.

7. Summary of Tests

7.1 The tests required for each classification are specified in Table 3. The purpose of these tests is to determine the mechanical properties, soundness, and chemical composition of the weld metal, and the usability of the electrode. The base metal for the weld test assemblies, the welding and testing procedures to be employed, and the results required are given in Sections 9 through 14.

7.2 The optional supplemental test for diffusible hydrogen in Section 15 is not required for classification, but is included for an optional electrode designation as agreed to between the purchaser and supplier. Another optional supplemental designator (J) may be used to indicate Charpy impact testing at lower than standard temperature (see Figure 1).

Table 3
Tests Required for Classification

AWS Classification(s)	Chemical Analysis	Radiographic Test	Tension Test	Impact Test	Fillet Weld Test
EXXT1-XC, -XM EX0T4-X EXXT5-XC, -XM EX0T6-X EXXT7-X EXXT8-X EXXT11-X	R	R	R	(a)	R ^b
E10XTX-K9X [E69XTX-K9X]	R	R ^c	R ^c	(a), (c)	R ^b
EXXTX-G, -GC, -GM	(d)	R	R	(d)	R ^b
EXXTG-X	R	R	R	(d)	R ^b
EXXTG-G	(d)	R	R	(d)	R ^b

Notes:

- The Charpy V-Notch impact test is required when the classification requires minimum impact properties as specified in Table 1U [Table 1M].
- For the fillet weld test, electrodes classified for downhand welding (EX0TX-XX electrodes) shall be tested in the horizontal position. Electrodes classified for all position welding (EX1TX-XX electrodes) shall be tested in both the vertical and overhead positions.
- The groove weld for this classification shall be welded in the vertical position with upward progression. See A7.9.4.9 in Annex A.
- As agreed upon between supplier and purchaser.

8. Retest

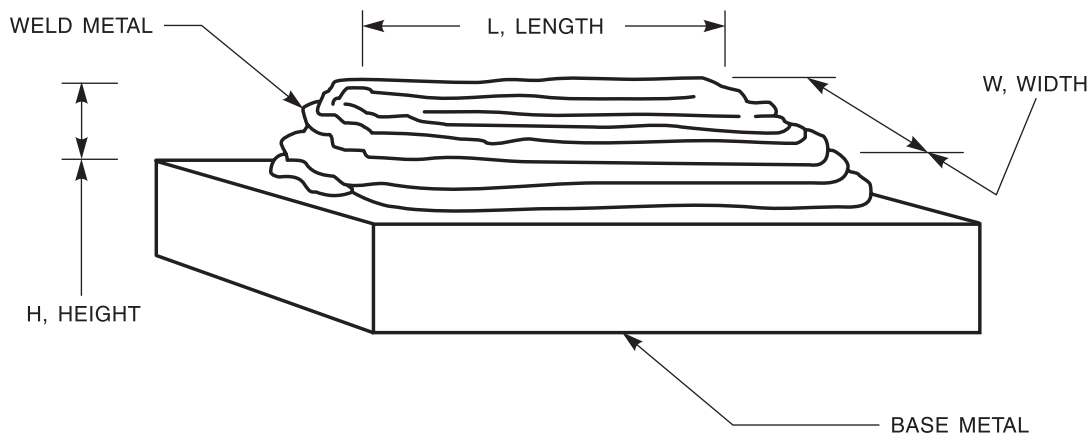
If the results of any test fail to meet the requirement, that test shall be repeated twice. The results of both retests shall meet the requirement. Material, specimens or samples for retest may be taken from the original test assembly or from one or two new test assemblies or samples. For chemical analysis, retest need be only for those specific elements that failed to meet the test requirement. If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification.

In the event that, during preparation or after completion of any test, it is clearly determined that specified or proper procedures were not followed in preparing the weld test assembly or test specimen(s) or in conducting the test, the test shall be considered invalid, without regard to whether the test was actually completed or

whether test results met, or failed to meet, the test requirement. That test shall be repeated, following proper specified procedures. In this case, the requirement for doubling the number of test specimens does not apply.

9. Test Assemblies

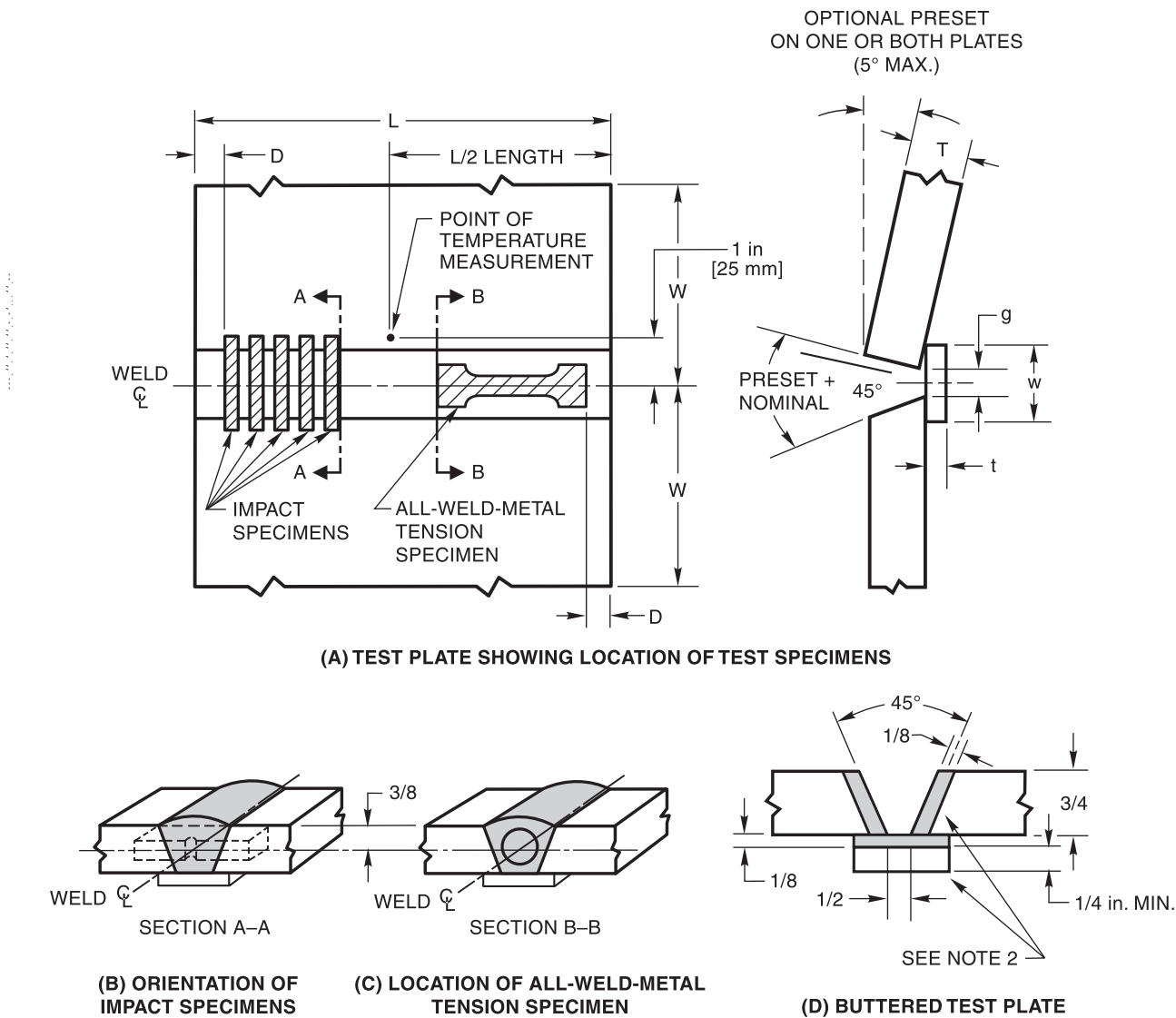
- 9.1 Two or three weld test assemblies are required, depending on the classification of the electrode and the manner in which the tests are conducted. They are as follows:
- (1) The weld pad in Figure 2 for chemical analysis of the weld metal,
 - (2) The groove weld shown in Figure 3 for mechanical properties and soundness of the weld metal, and
 - (3) The fillet weld shown in Figure 4, for usability of the electrode.



WELD PAD SIZE, MINIMUM					
Length, L		Width, W		Height, H	
in	mm	in	mm	in.	mm
1-1/2	38	1/2	12	1/2	12

- Notes:
- 1. Base metal of any convenient size, of the type specified in Table 4, shall be used as the base for the weld pad.
 - 2. The surface of the base metal on which the filler metal is to be deposited shall be clean.
 - 3. The pad shall be welded in the flat position with successive layers to obtain undiluted weld metal, using the specified shielding gas (if any), using the polarity as specified in Table 2 and following the heat input requirements specified in Table 5.
 - 4. The number and size of the beads will vary according to the size of the electrode and the width of the weave, as well as with the amperage employed. The weave shall be limited to 6 times the electrode diameter.
 - 5. The preheat temperature shall not be less than 60°F [15°C] and the interpass temperature shall not exceed 325°F [165°C].
 - 6. The test assembly may be quenched in water (temperature unimportant) between passes to control interpass temperature.
 - 7. The minimum completed pad size shall be that shown above. The sample to be tested in Section 10 shall be taken from weld metal that is at least 3/8 in [10 mm] above the original base metal surface. See Table 4, Note c, for requirements when using ASTM A 36 or A 285 base steels.

Figure 2—Pad for Chemical Analysis of Deposited Weld Metal



L Test Plate Length (min.)	W Test Plate Width (min.)	T Test Plate Thickness	D Discard (min.)	I Bevel Angle	g Root Opening	w Backup Width (min.)	t Backup Thickness (min.)	M Buttered Layer (min.)
10 in [250 mm]	6 in [150 mm]	3/4 ± 1/32 in [20 ± 1 mm]	1 in [25 mm]	22.5° ± 2°	1/2 – 0 in, + 1/16 in [12 – 0 mm, + 1 mm]	Approx. 2 × g	1/4 in [6 mm]	1/8 in [3 mm]

- Notes:
1. Test plate thickness shall be 1/2 in [12 mm] and the maximum root opening shall be 1/4 in – 0 in, + 1/16 in [6 mm – 0 mm, + 1 mm] for 0.045 in [1.2 mm] and smaller diameters of the EXXT11-X electrode classifications.
 2. When required, edges of the grooves and contacting face of the backing shall be buttered as shown in (D). See Note a of Table 4.

Figure 3—Test Assembly for Mechanical Properties and Soundness of Weld Metal

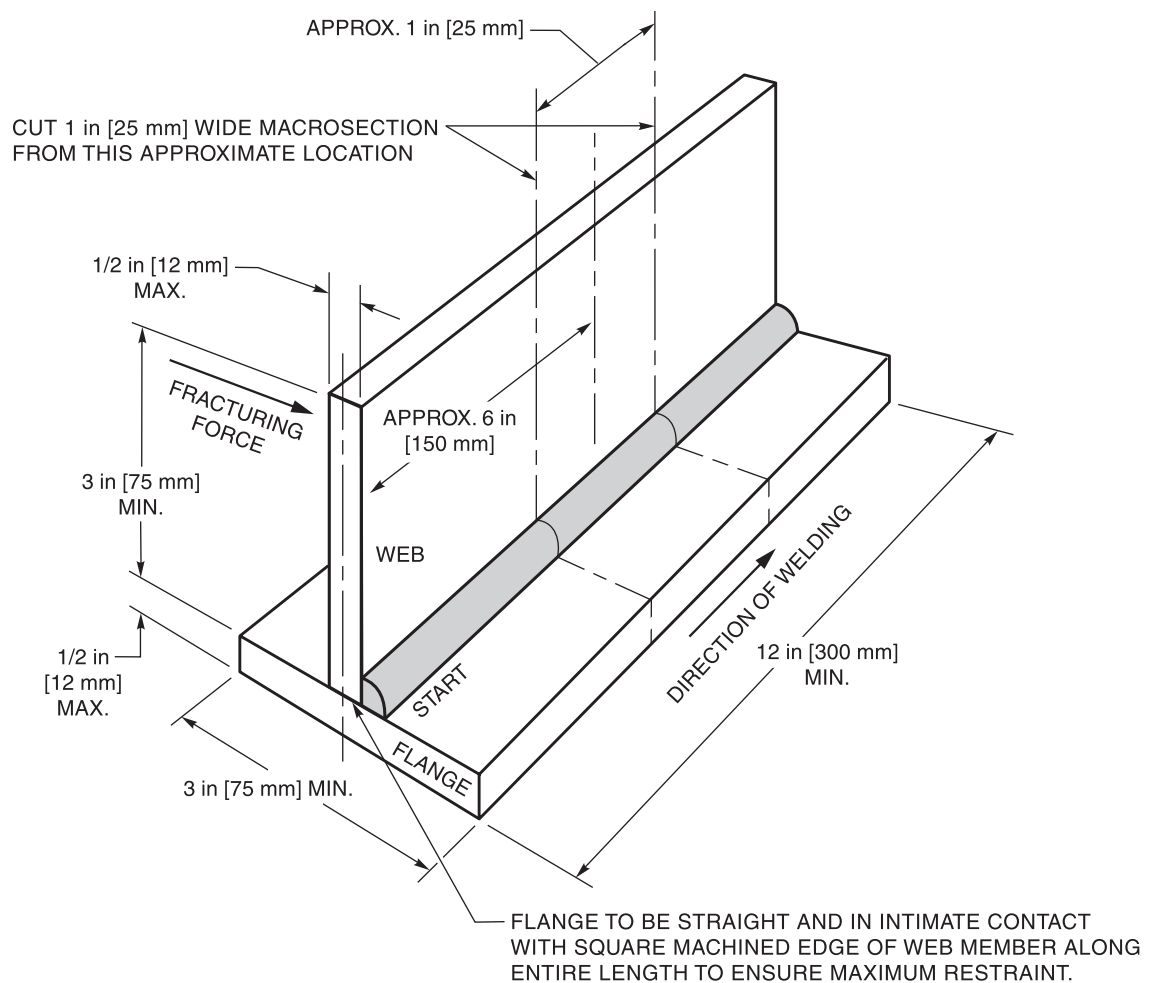
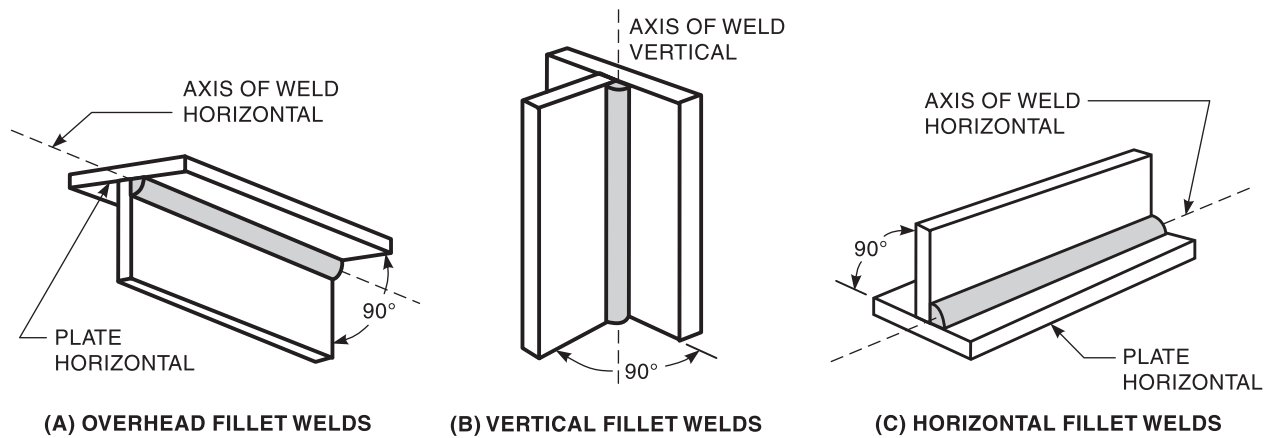


Figure 4—Fillet Weld Test Assembly

The sample for chemical analysis may be taken from the reduced section of the fractured tension test specimen or from a corresponding location (or any location above it) in the weld metal in the groove weld in Figure 3, thereby avoiding the need to make the weld pad. In case of dispute, the weld pad shall be the referee method.

9.2 Preparation of each test assembly shall be as specified in 9.3, 9.4, and 9.5. The base metal for each assembly shall be as required in Table 4 and shall meet the requirements of any one of the appropriate ASTM specifications shown there, or an equivalent specification. Testing of the assemblies shall be as specified in Sections 10 through 14.

9.3 Weld Pad. A weld pad shall be prepared as specified in Figure 2, except when one of the alternatives in 9.1 (taking the sample from the broken tension test specimen or from a corresponding location—or any location above it—in the weld metal in the groove weld in Figure 3) is selected. Base metal of any convenient size of the type specified in Table 4 (including note c to that table) shall be used as the base for the weld pad. The surface of the base metal on which the filler metal is deposited shall be clean. The pad shall be welded in the flat position with multiple layers to obtain undiluted weld metal (1/2 in [12 mm] minimum thickness). The preheat temperature shall not be less than 60°F [15°C] and the interpass temperature shall not exceed 325°F [165°C]. The welding procedure used for the weld pad shall satisfy the heat input requirements specified in Table 5. The slag shall be removed after each pass. The pad may be quenched in water between passes. The dimensions of the completed pad shall be as shown in Figure 2. Testing of this assembly shall be as specified in 10.2.

9.4 Weld Test Assemblies

9.4.1 Test Assembly for Multipass Electrodes. One or two groove weld test assemblies shall be prepared and welded as specified in Figure 3 and Table 5, using base metal of the appropriate type specified in Table 4. Preheat and interpass temperatures shall be as specified in Table 6. Testing of this assembly shall be as specified in Table 3. When ASTM A 36 or A 285 base metals are used, the groove faces and the contact face of the backing shall be buttered using an electrode of the same composition as the classification being tested except as noted in Table 4, Notes b and f. If a buttering procedure is used, the layer shall be approximately 1/8 in [3 mm] thick (see Figure 3, Note 2). The electrode diameter for one test assembly shall be 3/32 in [2.4 mm] or the largest diameter manufactured. The electrode diameter for the other test assembly shall be 0.045 in [1.2 mm] or the smallest size manufactured. If the maximum diameter manufactured is 1/16 in [1.6 mm] or less only the largest

diameter need be tested. The electrode polarity shall be as specified in Table 2. Testing of the assemblies shall be as required in Table 3 in the as-welded or PWHT condition as specified in Table 6.

9.4.1.1 Welding shall be in the flat position and the assembly shall be restrained (or preset as shown in Figure 3) during welding to prevent warpage in excess of 5 degrees. An assembly that is warped more than 5 degrees from plane shall be discarded. It shall not be straightened.

Prior to welding, the test assembly shall be heated to the preheat temperature specified in Table 6 for the electrode being tested. Welding shall continue until the assembly has reached the required interpass temperature specified in Table 6, measured by temperature indicating crayons or surface thermometers at the location shown in Figure 3. This interpass temperature shall be maintained for the remainder of the weld. Should it be necessary to interrupt welding, the assembly shall be allowed to cool in still air. The assembly shall be heated to a temperature within the specified interpass temperature range before welding is resumed.

9.4.1.2 When postweld heat treatment is required, the heat treatment shall be applied to the test assembly before the specimens for mechanical testing are removed. This heat treatment may be applied either before or after the radiographic examination.

The temperature of the test assembly shall be raised in a suitable furnace at the rate of 150° to 500°F [85° to 280°C] per hour until the postweld heat treatment temperature specified in Table 6, for the electrode classification, is attained. This temperature shall be maintained for one hour (–0, + 15 minutes), unless otherwise noted in Table 6. The test assembly shall then be allowed to cool in the furnace at a rate not greater than 350°F [200°C] per hour. It may be removed from the furnace when the temperature of the furnace has reached 600°F [300°C] and allowed to cool in still air.

9.4.2 Fillet Weld Test Assembly. A test assembly shall be prepared and welded as specified in Table 3 and shown in Figure 4, using base metal of the appropriate type specified in Table 4. The welding positions shall be as specified in Note b of Table 3.

Before assembly, the standing member (web) shall have one edge prepared throughout its length and the base member (flange) side shall be straight, smooth and clean. The test plates shall be assembled as shown in Figure 4. When assembled, the faying surfaces shall be in intimate contact along the entire length of the joint. The test assembly shall be secured with tack welds deposited at each end of the weld joint.

The welding procedure and the size of the electrode to be tested shall be as selected by the manufacturer. The

Table 4
Base Metal for Test Assemblies^{a, b, c, d}

Weld Metal Designation	ASTM and Military Standards	UNS Number ^e
A1	A 204, Grade A	K11820
	A 204, Grade B	K12020
	A 204, Grade C	K12320
B1, B2, B2L, B2H	A 387, Grade 11	K11789
B3, B3L, B3H	A 387, Grade 22	K21590
B6, B6L	A 387, Grade 5	S50200
B8, B8L	A 387, Grade 9	S50400
B9	A 387, Grade 91	K91560
Ni1	A 537, Class 1 or 2	K12437
Ni2, Ni3	A 203, Grade E	K32018
	HY-80 (per MIL-S-16216)	K31820
	HY-100 (per MIL-S-16216)	K32045
	HSLA-80 (per MIL-S-24645)	—
	HSLA-100 (per MIL-S-24645)	—
D1, D2, D3	A 302, Grade A	K12021
	A 302, Grade B	K12022
K1, K3, K4, K5, K7, K9 ^f	A 514, any grade	K11856
	HY-80 ^g	K31820
	HY-100 ^g	K32045
	HSLA-80 ^h	—
	HSLA-100 ^h	—
K2, K6, K8	A 537, Class 1 or 2	K12437
W2	A 588, Grade A	K11430
	A 588, Grade B	K12043
	A 588, Grade C	K11538

Notes:

- For the groove weld shown in Figure 3, ASTM A 36 or A 285 base metals may be used; however, the joint surfaces shall be buttered as shown in Figure 3 using any electrode of the same composition as the classification being tested.
- Buttering of the groove weld in Figure 3 is not required when using A36 or A285 base metals when testing EXXT4-X, EXXT6-X, EXXT7-X, EXXT8-X, and EXXT11-X electrodes with 70 ksi [490 MPa] or lower classification.
- ASTM A 36 or A 285 base metals may be used for the weld pad shown in Figure 2; however, the minimum weld metal height shall be increased to 5/8 in [16 mm]. The sample to be tested in Section 10 shall be taken from weld metal that is at least 1/2 in [12 mm] above the original base plate surface.
- The use of non-buttered ASTM A 36 or A 285 base metal is permitted for the fillet weld test.
- SAE/ASTM Unified Numbering System for Metals and Alloys.
- Buttering is not allowed for the K9 weld metal designation.
- According to MIL-S-16216 or NAVSEA Technical Publication T9074-BD-GIB-010/0300, Appendix B.
- According to MIL-S-24645 or NAVSEA Technical Publication T9074-BD-GIB-010/0300, Appendix A.

fillet weld shall be a single pass weld deposited in either the semiautomatic or mechanized mode as selected by the manufacturer. The fillet weld size shall not be greater than 3/8 in [10 mm]. The fillet weld shall be deposited only on one side of the joint as shown in Figure 4. Weld cleaning shall be limited to chipping, brushing, and needle scaling. Grinding, filing, or other metal cutting of the fillet weld face is prohibited. The testing of the assembly shall be as specified in Section 14.

10. Chemical Analysis

10.1 The sample for analysis shall be taken from weld metal produced with the flux cored electrode and the shielding gas, if any, with which it is classified. The sample shall be taken from a weld pad, or the reduced section of the fractured tension test specimen, or from a corresponding location, or any location above it, in the groove weld in Figure 3. In case of dispute, the weld pad shall be the referee method.

Table 5
Heat Input Requirements and Suggested Pass and Layer Sequence
for Multiple Pass Electrode Classifications

Diameter		Required Average Heat Input ^{a, b, c, d}		Suggested Passes per Layer		Suggested Number of Layers
in	mm	kJ/in	kJ/mm	Layer 1	Layer 2 to Top	
≤0.030 0.035	≤0.8 0.9	20–35	0.8–1.4	1 or 2	2 or 3	6 to 9
— 0.045 —	1.0 — 1.2	25–50	1.0–2.0	1 or 2	2 or 3	6 to 9
0.052 — 1/16	— 1.4 1.6	25–55	1.0–2.2	1 or 2	2 or 3	5 to 8
0.068 — 0.072 5/64 (0.078)	— 1.8 — 2.0	35–65	1.4–2.6	1 or 2	2 or 3	5 to 8
3/32 (0.094)	2.4	40–65	1.6–2.6	1 or 2	2 or 3	4 to 8
7/64 (0.109)	2.8	50–70	2.0–2.8	1 or 2	2 or 3	4 to 7
0.120 1/8 (0.125)	— 3.2	55–75	2.2–3.0	1 or 2	2	4 to 7
5/32 (0.156)	4.0	65–85	2.6–3.3	1	2	4 to 7

Notes:

a. The calculation to be used for heat input is:

$$(1) \text{ Heat Input (kJ/in)} = \frac{\text{volts} \times \text{amps} \times 60}{\text{Travel Speed (in/min)} \times 1000} \text{ or } \frac{\text{volts} \times \text{amps} \times 60 \times \text{arc time (min)}}{\text{Weld Length (in)} \times 1000}$$

or

$$(2) \text{ Heat Input (kJ/mm)} = \frac{\text{volts} \times \text{amps} \times 60}{\text{Travel Speed (mm/min)} \times 1000} \text{ or } \frac{\text{volts} \times \text{amps} \times 60 \times \text{arc time (min)}}{\text{Weld Length (mm)} \times 1000}$$

b. Does not apply to the first layer. The first layer shall have a maximum of two passes.

c. The average heat input is the calculated average for all passes excluding the first layer.

d. A non-pulsed, constant voltage (CV) power source shall be used.

10.2 The top surface of the pad described in 9.3 and shown in Figure 2 shall be removed and discarded, and a sample for analysis shall be obtained from the underlying metal by any appropriate mechanical means. The sample shall be free of slag. The sample shall be taken at least 3/8 in [10 mm] from the nearest surface of the base metal. The sample from the reduced section of the fractured tension test specimen or from a corresponding location in the groove weld in Figure 3 shall be prepared for analysis by any suitable mechanical means.

10.3 The sample shall be analyzed by accepted analytical methods. The referee method shall be ASTM E 350.

10.4 The results of the analysis shall meet the requirements of Table 7 for the classification of electrode under test.

11. Radiographic Test

11.1 The welded test assembly described in 9.4.1 and shown in Figure 3 shall be radiographed to evaluate the soundness of the weld metal. In preparation for radiography, the backing shall be removed and both surfaces of the weld shall be machined or ground smooth and flush

Table 6
Preheat, Interpass, and PWHT Temperatures

AWS Classifications	Preheat and Interpass Temperature ^a		PWHT Temperature ^{a, b}	
	A5.29	A5.29M	A5.29	A5.29M
E6XT1-Ni1C, -Ni1M [E43XT1-Ni1C, -Ni1M] E7XT6-Ni1 [E49XT6-Ni1] E7XT8-Ni1 [E49XT8-Ni1] E8XT1-Ni1C, -Ni1M [E55XT1-Ni1C, -Ni1M] E7XT8-Ni2 [E49XT8-Ni2] E8XT1-Ni2C, -Ni2M [E55XT1-Ni2C, -Ni2M] E8XT8-Ni2 [E55XT8-Ni2] E8XT11-Ni3 [E55XT11-Ni3] E9XT1-Ni2C, -Ni2M [E62XT1-Ni2C, -Ni2M]	300 ± 25°F	150 ± 15°C	None	None
E7XT5-A1C, -A1M [E49XT5-A1C, -A1M] E8XT1-A1C, -A1M [E55XT1-A1C, -A1M] E8XT5-Ni1C, -Ni1M [E55XT5-Ni1C, -Ni1M] E8XT5-Ni2C, ^c -Ni2M ^c [E55XT5-Ni2C, ^c -Ni2M ^c] E8XT5-Ni3C, ^c -Ni3M ^c [E55XT5-Ni3C, ^c -Ni3M ^c] E9XT5-Ni3C, ^c -Ni3M ^c [E62XT5-Ni3C, ^c -Ni3M ^c] E9XT5-D2C, -D2M [E62XT5-D2C, -D2M] E10XT5-D2C, -D2M [E69XT5-D2C, -D2M]	300 ± 25°F	150 ± 15°C	1150 ± 25°F	620 ± 15°C
All Classifications with B1, B1L, B2, B2L, B2H, B3, B3L, or B3H Weld Metal Designations	350 ± 25°F	175 ± 15°C	1275 ± 25°F	690 ± 15°C
All Classifications with B6, B6L, B8, or B8L Weld Metal Designations	400 ± 100°F	200 ± 50°C	1375 ± 25°F ^d	745 ± 15°C ^d
E9XT1-B9C, -B9M [E62XT1-B9C, -B9M]	500 ± 100°F	260 ± 50°C	1400 ± 25°F ^d	760 ± 15°C ^d
All Classifications with D1, D3, K1, K2, K3, K4, K5, K6, K7, K8, K9, or W2 Weld Metal Designations	300 ± 25°F	150 ± 15°C	None	None
EXXTX-G, -GC, -GM EXXTG-X EXXTG-G	Not Specified ^e			

Notes:

- These temperatures are specified for testing under this specification and are not to be considered as recommendations for preheat and postweld heat treatment (PWHT) in production welding. The requirements for production welding must be determined by the user.
- The PWHT schedule is as follows: Raise to required temperature at a rate not to exceed 500°F [280°C] per hour, hold at required temperature for 1 hour –0 +15 minutes, furnace cool to 600°F [315°C] at a rate not exceeding 350°F [195°C] per hour, air cool.
- PWHT temperature in excess of 1150°F [620°C] will decrease Charpy V-Notch impact strength.
- Held at specified temperature for two hours –0 +15 minutes.
- See Table 1U [Table 1M], Note b.

with the original surfaces of the base metal or with a uniform reinforcement not exceeding 3/32 in [2.5 mm]. It is permitted on both sides of the test assembly to remove base metal to a depth of 1/16 in [1.5 mm] nominal below the original base metal surface in order to facilitate backing and/or buildup removal. Thickness of the weld metal shall not be reduced by more than 1/16 in [1.5 mm] less than the nominal base metal thickness. Both surfaces of the test assembly, in the area of the weld, shall be smooth enough to avoid difficulty in interpreting the radiograph.

11.2 The weld shall be radiographed in accordance with ASTM E 1032. The quality level of inspection shall be 2-2T.

11.3 The soundness of the weld metal meets the requirements of this specification if the radiograph shows:

- (1) no cracks, no incomplete fusion, and no incomplete penetration,
- (2) no slag inclusions longer than 1/4 in. [6 mm] or 1/3 of the thickness of the weld, whichever is greater, or

Table 7
Weld Metal Chemical Composition Requirements for Classification to A5.29/A5.29M

Weld Metal Designation	UNS Number ^b	Weight Percent ^a											
		C	Mn	P	S	Si	Ni	Cr	Mo	V	Al	Cu	Other
Molybdenum Steel Electrodes													
A1	W1703X	0.12	1.25	0.030	0.030	0.80	—	—	0.40–0.65	—	—	—	—
Chromium-Molybdenum Steel Electrodes													
B1	W5103X	0.05–0.12	1.25	0.030	0.030	0.80	—	0.40–0.65	0.40–0.65	—	—	—	—
B1L	W5113X	0.05	1.25	0.030	0.030	0.80	—	0.40–0.65	0.40–0.65	—	—	—	—
B2	W5203X	0.05–0.12	1.25	0.030	0.030	0.80	—	1.00–1.50	0.40–0.65	—	—	—	—
B2L	W5213X	0.05	1.25	0.030	0.030	0.80	—	1.00–1.50	0.40–0.65	—	—	—	—
B2H	W5223X	0.10–0.15	1.25	0.030	0.030	0.80	—	1.00–1.50	0.40–0.65	—	—	—	—
B3	W5303X	0.05–0.12	1.25	0.030	0.030	0.80	—	2.00–2.50	0.90–1.20	—	—	—	—
B3L	W5313X	0.05	1.25	0.030	0.030	0.80	—	2.00–2.50	0.90–1.20	—	—	—	—
B3H	W5323X	0.10–0.15	1.25	0.030	0.030	0.80	—	2.00–2.50	0.90–1.20	—	—	—	—
B6	W50231	0.05–0.12	1.25	0.040	0.030	1.00	0.40	4.0–6.0	0.45–0.65	—	—	0.50	—
B6L	W50230	0.05	1.25	0.040	0.030	1.00	0.40	4.0–6.0	0.45–0.65	—	—	0.50	—
B8	W50431	0.05–0.12	1.25	0.040	0.030	1.00	0.40	8.0–10.5	0.85–1.20	—	—	0.50	—
B8L	W50430	0.05	1.25	0.030	0.030	1.00	0.40	8.0–10.5	0.85–1.20	—	—	0.50	—
B9	W50531	0.08–0.13	1.20 ^d	0.020	0.015	0.50	0.80 ^d	8.0–10.5	0.85–1.20	0.15–0.30	0.04	0.25	Nb: 0.02–0.10 N: 0.02–0.07
Nickel Steel Electrodes													
Ni1	W2103X	0.12	1.50	0.030	0.030	0.80	0.80–1.10	0.15	0.35	0.05	1.8 ^c	—	—
Ni2	W2203X	0.12	1.50	0.030	0.030	0.80	1.75–2.75	—	—	—	1.8 ^c	—	—
Ni3	W2303X	0.12	1.50	0.030	0.030	0.80	2.75–3.75	—	—	—	1.8 ^c	—	—
Manganese-Molybdenum Steel Electrodes													
D1	W1913X	0.12	1.25–2.00	0.030	0.030	0.80	—	—	0.25–0.55	—	—	—	—
D2	W1923X	0.15	1.65–2.25	0.030	0.030	0.80	—	—	0.25–0.55	—	—	—	—
D3	W1933X	0.12	1.00–1.75	0.030	0.030	0.80	—	—	0.40–0.65	—	—	—	—

(continued)

Table 7 (Continued)
Weld Metal Chemical Composition Requirements for Classification to A5.29/A5.29M

Weld Metal Designation	UNS Number ^b	Weight Percent ^a											
		C	Mn	P	S	Si	Ni	Cr	Mo	V	Al	Cu	Other
Other Low-Alloy Steel Electrodes													
K1	W2113X	0.15	0.80–1.40	0.030	0.030	0.80	0.80–1.10	0.15	0.20–0.65	0.05	—	—	—
K2	W2123X	0.15	0.50–1.75	0.030	0.030	0.80	1.00–2.00	0.15	0.35	0.05	1.8 ^c	—	—
K3	W2133X	0.15	0.75–2.25	0.030	0.030	0.80	1.25–2.60	0.15	0.25–0.65	0.05	—	—	—
K4	W2223X	0.15	1.20–2.25	0.030	0.030	0.80	1.75–2.60	0.20–0.60	0.20–0.65	0.03	—	—	—
K5	W2162X	0.10–0.25	0.60–1.60	0.030	0.030	0.80	0.75–2.00	0.20–0.70	0.15–0.55	0.05	—	—	—
K6	W2104X	0.15	0.50–1.50	0.030	0.030	0.80	0.40–1.00	0.20	0.15	0.05	1.8 ^c	—	—
K7	W2205X	0.15	1.00–1.75	0.030	0.030	0.80	2.00–2.75	—	—	—	—	—	—
K8	W2143X	0.15	1.00–2.00	0.030	0.030	0.40	0.50–1.50	0.20	0.20	0.05	1.8 ^c	—	—
K9	W23230	0.07	0.50–1.50	0.015	0.015	0.60	1.30–3.75	0.20	0.50	0.05	—	0.06	—
W2	W2013X	0.12	0.50–1.30	0.030	0.030	0.35–0.80	0.40–0.80	0.45–0.70	—	—	—	0.30–0.75	—
G ^c	—	—	0.50 ^f	0.030	0.030	1.00	0.50 ^f	0.30 ^f	0.20 ^f	0.10 ^f	1.8 ^c	—	—

Notes:

- a. Single values are maximum unless otherwise noted.
b. ASTM DS-56 or SAE HS-1086. An “X,” when present in the last position, represents the usability designator for the electrode type used to deposit the weld metal. An exception to this applies to the T11 electrode type where a “9” is used instead of an “11.”
c. Applicable to self-shielded electrodes only. Electrodes intended for use with gas shielding normally do not have significant additions of aluminum.
d. Mn + Ni = 1.5% maximum. See A7.9.2 in Annex A.
e. In order to meet the alloy requirements of the G group, the undiluted weld metal shall have not less than the minimum specified for one or more of the following alloys: Mn, Ni, Cr, Mo, or V.
f. Minimum values.

no groups of slag inclusions in line that have an aggregate length greater than the thickness of the weld in a length 12 times the thickness of the weld except when the distance between the successive inclusions exceeds 6 times the length of the longest inclusion in the group, and

(3) no rounded indications in excess of those permitted by the radiographic standards in Figure 7.

In evaluating the radiograph, 1 in [25 mm] of the weld on each end of the test assembly shall be disregarded.

11.3.1 A rounded indication is an indication (on the radiograph) whose length is no more than three times its width. Rounded indications may be circular or irregular in shape, and they may have tails. The size of a rounded indication is the largest dimension of the indication, including any tail that may be present. The indication may be of porosity or slag. Test assemblies with indications larger than the large indications permitted in the radiographic standard (Figure 7) do not meet the requirements of this specification.

12. Tension Test

12.1 For multiple pass electrode classifications one all-weld-metal tension test specimen, as specified in the Tension Test section of AWS B4.0 or B4.0M, shall be machined from the welded test assembly described in 9.4.1 and shown in Figure 3. The tension test specimen shall have a nominal diameter of 0.500 in [12.5 mm] (0.250 in [6.5 mm] for some electrodes as indicated in Note 1 of Figure 3) and a nominal gage length to diameter ratio of 4:1.

12.1.1 After machining, but before testing, the tension test specimen for classifications to be tested in the as-welded condition as specified in Table 1U [Table 1M] may be aged at a temperature not to exceed 220°F [105°C] for up to 48 hours, then allowed to cool to room temperature. Refer to A8.3 for a discussion of the purpose of aging.

12.1.2 The specimen shall be tested in the manner described in the Tension Test section of AWS B4.0 or B4.0M.

12.1.3 The results of the all-weld-metal tension test shall meet the requirements specified in Table 1U or Table 1M, as applicable.

13. Impact Test

13.1 Five full-size Charpy V-Notch impact specimens, as specified in the Fracture Toughness Test section of AWS B4.0 or B4.0M, shall be machined from the welded test

assembly shown in Figure 3 for those classifications for which impact testing is required in Table 3.

The Charpy V-Notch specimens shall have the notched surface and the struck surface parallel with each other within 0.002 in. [0.05 mm]. The other two surfaces of the specimen shall be square with the notched or struck surfaces within 10 minutes of a degree. The notch shall be smoothly cut by mechanical means and shall be square with the longitudinal edge of the specimen within one degree.

The geometry of the notch shall be measured on at least one specimen in a set of five specimens. Measurement shall be done at a minimum 50X magnification on either a shadowgraph or metallograph. The correct location of the notch shall be verified by etching before or after machining.

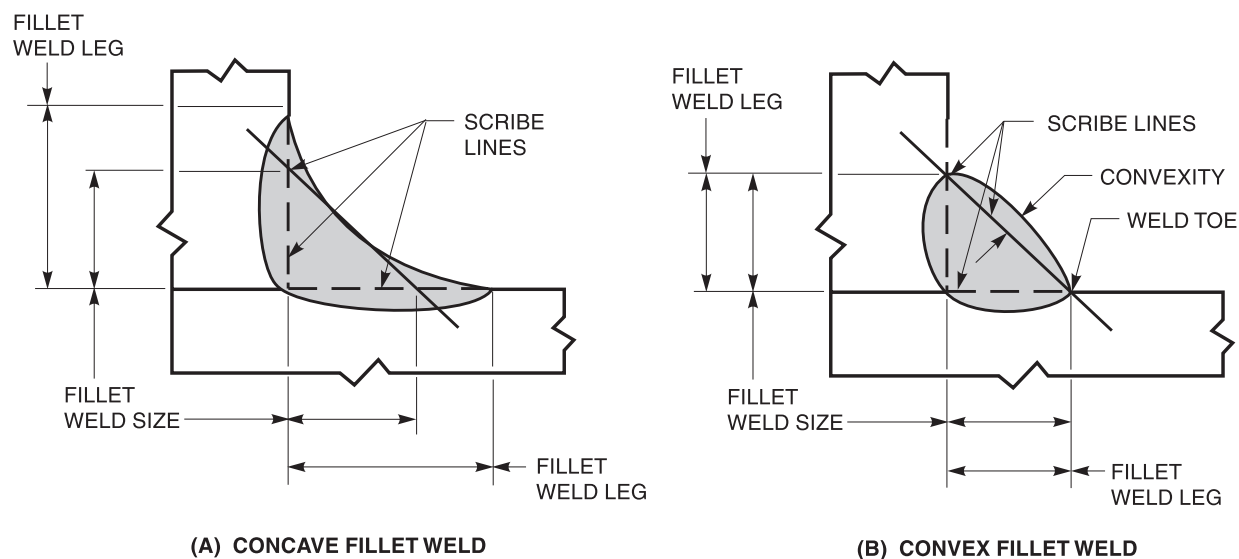
13.2 The five specimens shall be tested in accordance with the Fracture Toughness Test section of AWS B4.0 or B4.0M. The test temperature shall be that specified in Table 1U [Table 1M] for the classification under test. For those electrodes to be identified by the optional supplemental impact designator “J,” the test temperature shall be as specified in Note d of Table 1U [Table 1M].

13.3 In evaluating the test results, the lowest and the highest values obtained shall be disregarded. Two of the remaining three values shall equal or exceed the specified 20 ft-lbf [27 J] energy level. One of the three may be lower, but not lower than 15 ft-lbf [20 J], and the average of the three shall be not less than the required 20 ft-lbf [27 J] energy level. For the K9 classification, the average of all five values must meet the minimum requirement. One of five may be 10 ft-lbf [14 J] lower than the minimum requirement.

14. Fillet Weld Test

14.1 The fillet weld test, when required in Table 3, shall be made in accordance with the requirements of 9.4.2 and Figure 4. The entire face of the completed fillet shall be examined visually. There shall be no indication of cracks, and the weld shall be reasonably free of undercut, overlap, trapped slag, and surface porosity. After the visual examination, a specimen containing approximately 1 in [25 mm] of the weld in the lengthwise direction shall be prepared as shown in Figure 4. The cross-sectional surface of the specimen shall be polished and etched, and then examined as required in 14.2.

14.2 Scribe lines shall be placed on the prepared surface, as shown in Figure 5, and the leg lengths and convexity of the fillet shall be determined to the nearest 1/64 in [0.5 mm] by actual measurement. These measurements shall meet the requirements in Table 8 for convexity and permissible difference in the length of the legs.



Notes:

1. Fillet weld size is the leg length of the largest isosceles right triangle which can be inscribed within the fillet weld cross section.
2. Convexity is the maximum distance from the face of a convex fillet weld perpendicular to a line joining the weld toes.
3. Fillet weld leg is the distance from the joint root to the toe of the fillet leg.

Figure 5—Dimensions of Fillet Welds

Table 8
Dimensional Requirements for Fillet Weld Usability Test Specimens

Measured Fillet Weld Size ^a		Maximum Convexity ^{a, b}		Maximum Difference Between Fillet Weld Legs ^a	
in	mm	in	mm	in	mm
1/8	3.0	5/64	2.0	1/32	1.0
9/64	3.5	5/64	2.0	3/64	1.0
5/32	4.0	5/64	2.0	3/64	1.0
11/64	4.5	5/64	2.0	1/16	1.5
3/16	—	5/64	—	1/16	—
13/64	5.0	5/64	2.0	5/64	2.0
7/32	5.5	5/64	2.0	5/64	2.0
15/64	6.0	5/64	2.0	3/32	2.5
1/4	6.5	5/64	2.0	3/32	2.5
17/64	—	3/32	—	7/64	—
9/32	7.0	3/32	2.5	7/64	3.0
19/64	7.5	3/32	2.5	1/8	3.0
5/16	8.0	3/32	2.5	1/8	3.0
21/64	8.5	3/32	2.5	9/64	3.5
11/32	9.0	3/32	2.5	9/64	3.5
23/64	—	3/32	—	5/32	—
3/8	9.5	3/32	2.5	5/32	4.0

Notes:

- a. All measurements shall be rounded to the nearest 1/64 in [0.5 mm].
- b. Maximum convexity for EXXT5-XC, -XM electrodes may be 1/32 in [0.8 mm] larger than the listed requirements.

14.3 The remaining two sections of the test assembly shall be broken longitudinally through the fillet weld by a force exerted as shown in Figure 4. When necessary, to facilitate fracture through the fillet, one or more of the following procedures may be used:

- (1) A reinforcing bead, as shown in Figure 6(A), may be added to each leg of the weld.
- (2) The position of the web on the flange may be changed, as shown in Figure 6(B).
- (3) The face of the fillet may be notched, as shown in Figure 6(C).

Tests in which the weld metal pulls out of the base metal during bending are invalid. Specimens in which this occurs shall be replaced, specimen for specimen, and the test completed. In this case, the doubling of the specimens required for retest in Section 8 does not apply.

14.4 The fractured surfaces shall be examined. They shall be free of cracks and shall be reasonably free of porosity and trapped slag. Incomplete fusion at the root of the weld shall not exceed 20 percent of the total length of the weld. Slag beyond the vertex of the isosceles triangle with the hypotenuse as the face, as shown in Figure 5, shall not be considered incomplete fusion.

15. Diffusible Hydrogen Test

15.1 The 3/32 in [2.4 mm] or the largest diameter and the 0.045 in [1.2 mm] or the smallest diameter of an electrode to be identified by an optional supplemental diffusible hydrogen designator shall be tested according to one of the methods given in AWS A4.3. If the maximum diameter manufactured is 1/16 in [1.6 mm] or less, only the largest diameter need be tested. A mechanized welding system shall be used for the diffusible hydrogen test. Based upon

the average value of test results which satisfy the requirements of Table 9, the appropriate diffusible hydrogen designator may be added at the end of the classification.

15.2 Testing shall be done with electrode from a previously unopened container. Conditioning of the electrode prior to testing is not permitted. Conditioning can be construed to be any special preparation or procedure, such as baking the electrode, which the user would not usually practice. The shielding gas, if any, used for classification purposes shall also be used for the diffusible hydrogen test. Welds for hydrogen determination shall be made at a wire feed rate (or welding current) which is based upon the manufacturer's recommended operating range for the electrode size and type being tested. When using wire feed rate, the minimum wire feed rate to be used for the diffusible hydrogen test is given by the equation shown below. When using welding current, the equation shown is modified by substituting "welding current" wherever "WFR" appears. The voltage shall be as recommended by the manufacturer for the wire feed rate (or welding current) used for the test. The contact tip-to-work distance (CTWD) shall be at the minimum recommended by the manufacturer for the wire feed rate (or welding current) used for the test. The travel speed used shall be as required to establish a weld bead width that is appropriate for the specimen. See A8.2.7.

$$WFR_{\min} = WFR_{\text{mfg. min}} + 0.75 (WFR_{\text{mfg. max}} - WFR_{\text{mfg. min}})$$

where:

$WFR_{\min}$ is the minimum wire feed rate to be used for the diffusible hydrogen test

$WFR_{\text{mfg. min}}$ is the minimum wire feed rate recommended by the manufacturer

$WFR_{\text{mfg. max}}$ is the maximum wire feed rate recommended by the manufacturer

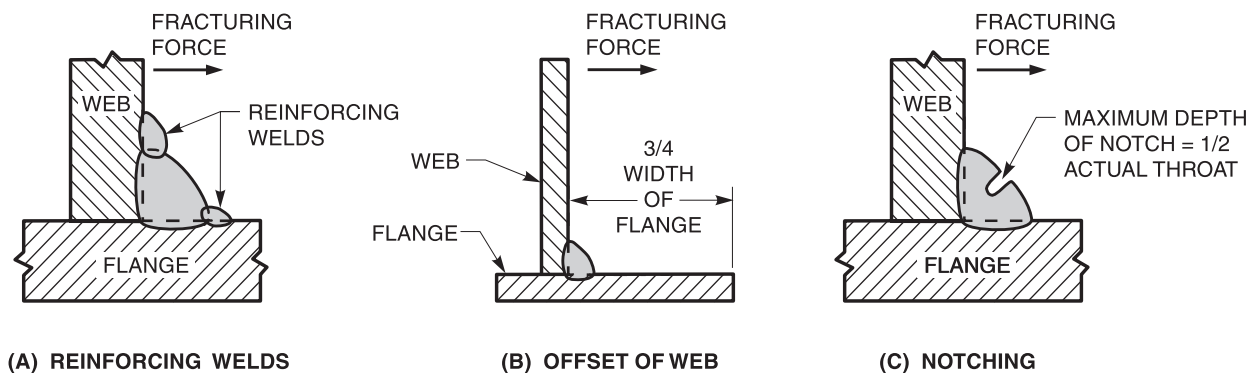
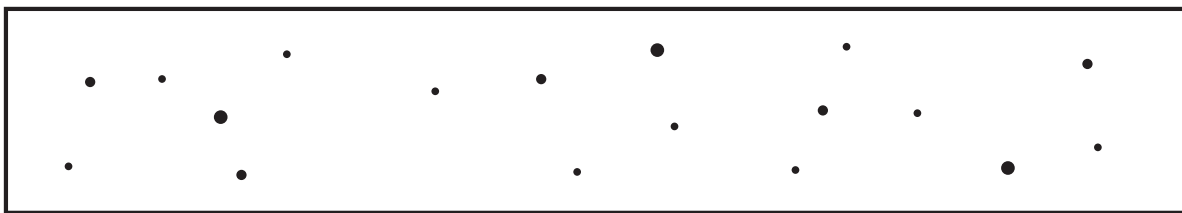


Figure 6—Alternate Methods for Facilitating Fillet Weld Fracture

**(A) ASSORTED ROUNDED INDICATIONS**

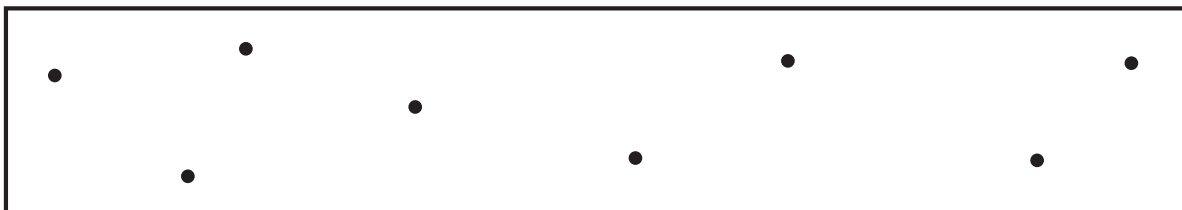
SIZE 1/64 in [0.4 mm] TO 1/16 in [1.6 mm] IN DIAMETER OR IN LENGTH.

MAXIMUM NUMBER OF INDICATIONS IN ANY 6 in [150 mm] OF WELD = 18, WITH THE FOLLOWING RESTRICTIONS:

MAXIMUM NUMBER OF LARGE 3/64 in [1.2 mm] TO 1/16 in [1.6 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 3.

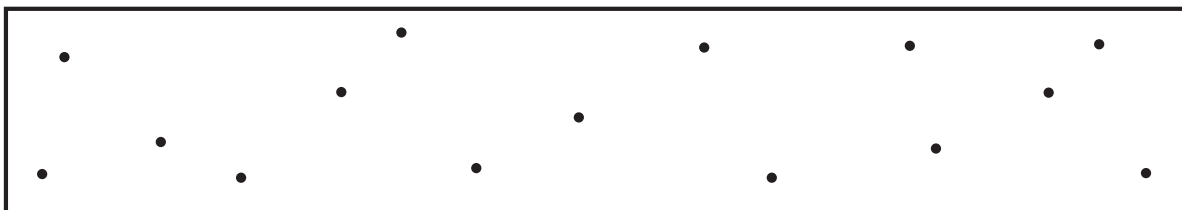
MAXIMUM NUMBER OF MEDIUM 1/32 in [0.8 mm] TO 3/64 in [1.2 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 5.

MAXIMUM NUMBER OF SMALL 1/64 in [0.4 mm] TO 1/32 in [0.8 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 10.

**(B) LARGE ROUNDED INDICATIONS**

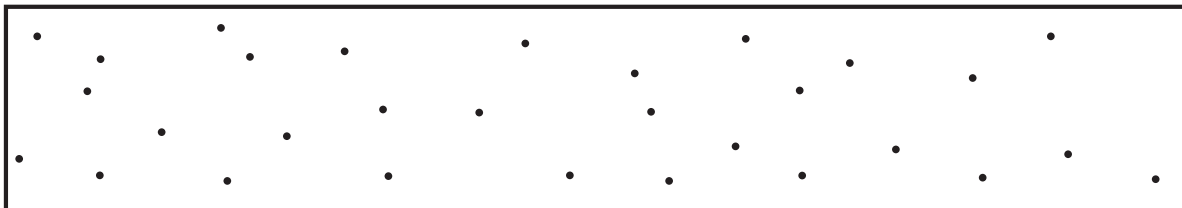
SIZE 3/64 in [1.2 mm] TO 1/16 in [1.6 mm] IN DIAMETER OR IN LENGTH.

MAXIMUM NUMBER OF INDICATIONS IN ANY 6 in [150 mm] OF WELD = 8.

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE 1/32 in [0.8 mm] TO 3/64 in [1.2 mm] IN DIAMETER OR IN LENGTH.

MAXIMUM NUMBER OF INDICATIONS IN ANY 6 in [150 mm] OF WELD = 15.

**(D) SMALL ROUNDED INDICATIONS**

SIZE 1/64 in [0.4 mm] TO 1/32 in [0.8 mm] IN DIAMETER OR IN LENGTH.

MAXIMUM NUMBER OF INDICATIONS IN ANY 6 in [150 mm] OF WELD = 30.

Notes:

1. In using these standards, the chart which is most representative of the size of the rounded indications present in the test specimen radiograph shall be used for determining conformance to these radiographic standards.
2. Since these are test welds specifically made in the laboratory for classification purposes, the radiographic requirements for these test welds are more rigid than those which may be required for general fabrication.
3. Indications whose largest dimension does not exceed 1/64 in [0.4 mm] shall be disregarded.

Figure 7—Radiographic Standards for Test Assembly in Figure 3

Table 9
Diffusible Hydrogen Limits for Weld Metal^a

Optional Supplemental Diffusible Hydrogen Designator ^{b,c,d}	Average Diffusible Hydrogen, Maximum ^c mL/100g Deposited Metal
H16	16.0
H8	8.0
H4	4.0

Notes:

- Limits on diffusible hydrogen when tested in accordance with AWS A4.3, as specified in Section 16.
- See Figure 1.
- The lower diffusible hydrogen levels (H8 and H4) may not be available in some classifications (see A8.2.8 in Annex A).
- Electrodes which satisfy the diffusible hydrogen limits for H4 category also satisfy the limits for the H8 and H16 categories. Electrodes which satisfy the diffusible hydrogen limits for the H8 category also satisfy the limits for the H16 category.
- These hydrogen limits are based on welding in air containing a maximum of 10 grains of water per pound [1.43 g/kg] of dry air. Testing at any higher atmospheric moisture level is acceptable provided these limits are satisfied (see 15.3).

15.3 For purposes of certifying compliance with diffusible hydrogen requirements, the reference atmospheric condition shall be an absolute humidity of ten (10) grains of moisture/lb [1.43 g/kg] of dry air at the time of welding.⁸ The actual atmospheric conditions shall be reported along with the average value for the tests according to AWS A4.3.

15.4 When the absolute humidity equals or exceeds the reference condition at the time of preparation of the test assembly, the test shall be acceptable as demonstrating compliance with the requirements of this specification provided the actual test results satisfy the diffusible hydrogen requirements for the applicable designator. If the actual test results for an electrode meet the requirements for the lower or lowest hydrogen designator, as specified in Table 9, the electrode also meets the requirements for all higher designators in Table 9 without need to retest.

16. Method of Manufacture

The electrodes classified according to this specification may be manufactured by any method that will produce electrodes that meet the requirements of this specification.

⁸ See A8.2.5 in Annex A.

Table 10
**Standard Sizes and
Tolerances of Electrodes^a**

U.S. Customary Units		International System of Units (SI)	
Diameter (in)	Tolerance (in)	Diameter (mm)	Tolerance (mm) ^b
0.030	±0.002	0.8	+0.02/−0.05
0.035	±0.002	0.9	+0.02/−0.05
0.040	±0.002	1.0	+0.02/−0.05
0.045	±0.002	—	—
—	—	1.2	+0.02/−0.05
0.052	±0.002	—	—
—	—	1.4	+0.02/−0.05
1/16 (0.062)	±0.002	1.6	+0.02/−0.06
0.068	±0.003	—	—
—	—	1.8	+0.02/−0.06
0.072	±0.003	—	—
5/64 (0.078)	±0.003	2.0	+0.02/−0.06
3/32 (0.094)	±0.003	2.4	+0.02/−0.06
7/64 (0.109)	±0.003	2.8	+0.02/−0.06
0.120	±0.003	—	—
1/8 (0.125)	±0.003	3.2	+0.02/−0.07
5/32 (0.156)	±0.003	4.0	+0.02/−0.07

Notes:

- Electrodes produced in sizes other than those shown may be classified by using similar tolerances as shown.
- The tolerances shown are as prescribed in ISO 544.

17. Standard Sizes

Standard sizes for filler metal in the different package forms such as coils with support, coils without support, drums, and spools are shown in Table 10 (see Section 19, Standard Package Forms).

18. Finish and Uniformity

18.1 All electrodes shall have a smooth finish that is free from slivers, depressions, scratches, scale, seams, laps (exclusive of the longitudinal joint), and foreign matter that would adversely affect the welding characteristics, the operation of the welding equipment, or the properties of the weld metal.

18.2 Each continuous length of electrode shall be from a single lot of material as defined in AWS A5.01, and welds, when present, shall have been made so as not to interfere with the uniform, uninterrupted feeding of the electrode on automatic and semiautomatic equipment.

18.3 Core ingredients shall be distributed with sufficient uniformity throughout the length of the electrode so as not to adversely affect the performance of the electrode or the properties of the weld metal.

18.4 A suitable protective coating may be applied to any electrode in this specification.

19. Standard Package Forms

19.1 Standard package forms are coils with support, coils without support, spools, and drums. Standard package

dimensions and weights for each form are given in Table 11 and Figures 8 and 9. Package forms, sizes, and weights other than these shall be as agreed by purchaser and supplier.

19.2 The liners in coils with support shall be designed and constructed to prevent distortion of the coil during normal handling and use and shall be clean and dry enough to maintain the cleanliness of the electrode.

19.3 Spools shall be designed and constructed to prevent distortion of the spool and electrode during normal handling and use and shall be clean and dry enough to maintain the cleanliness of the electrode.

Table 11
Packaging Requirements^a

Type of Package	Package Size ^b				Net Weight of Electrode ^c	
	in		mm		lb	kg
Coils without Support	(d)	(d)	(d)	(d)		
Coils with Support (see below)	6-3/4	ID	170	ID	14	6
	12	ID	300	ID	25, 30, 50, & 60	10, 15, 25, & 30
Spools	4	OD	100	OD	1-1/2 & 2-1/2	0.5 & 1.0
	8	OD	200	OD	10, 12, & 15	4.5, 5.5, & 7
	12	OD	300	OD	25, 30, 35, & 44	10, 15, & 20
	14	OD	350	OD	50 & 60	20 & 25
	22	OD	560	OD	250	100
	24	OD	610	OD	300	150
	30	OD	760	OD	600, 750, & 1000	250, 350, & 450
Drums	15-1/2	OD	400	OD	(d)	(d)
	20	OD	500	OD	(d)	(d)
	23	OD	600	OD	300 & 600	150 & 300

Coils with Support—Standard Dimensions and Weights^a

Electrode Size	Coil Net Weight ^c		Coil Dimensions			
	lb	kg	Inside Diameter of Liner		Width of Wound Electrode	
			in	mm	in (max)	mm (max)
All	14	6	6-3/4 ± 1/8	170 ± 3	3	75
	25 and 30	10 and 15	12 ± 1/8	300 +3, -10	2-1/2 or 4-5/8	65 or 120
	50, 60, & 65	20, 25, & 30	12 ± 1/8	300 +3, -10	4-5/8	120

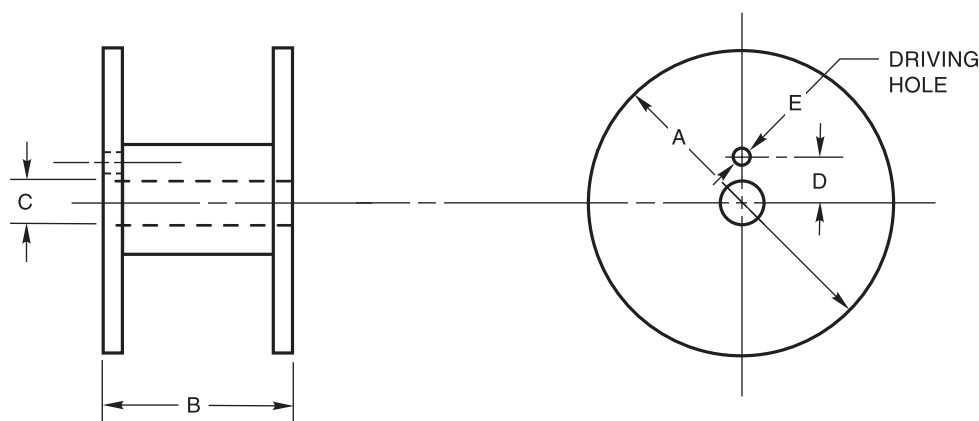
Notes:

a. Sizes and net weights other than those specified may be supplied as agreed between supplier and purchaser.

b. ID = inside diameter, OD = outside diameter

c. Tolerance on net weight shall be ±10 percent.

d. As agreed between supplier and purchaser.



DIMENSIONS									
Spools		4 in [100 mm]		8 in [200 mm]		12 in [300 mm]		14 in [350 mm]	
		in	mm	in	mm	in	mm	in	mm
A	Diameter, max. (Note 4)	4.0	102	8.0	203	12	305	14	355
B	Width	1.75	46	2.16	56	4.0	103	4.0	103
	Tolerance	±0.03	+0, -2	±0.03	+0, -3	±0.06	+0, -3	±0.06	+0, -3
C	Diameter	0.63	16	2.03	50.5	2.03	50.5	2.03	50.5
	Tolerance	+0.01, -0	+1, -0	+0.06, -0	+2.5, -0	+0.06, -0	+2.5, -0	+0.06, -0	+2.5, -0
D	Distance Between Axes	—	—	1.75	44.5	1.75	44.5	1.75	44.5
	Tolerance	—	—	±0.02	±0.5	±0.02	±0.5	±0.02	±0.5
E	Diameter (Note 3)	—	—	0.44	10	0.44	10	0.44	10
	Tolerance	—	—	+0, -0.06	+1, -0	+0, -0.06	+1, -0	+0, -0.06	+1, -0

Notes:

1. Outside diameter of barrel shall be such as to permit feeding of the filler metals.
2. Inside diameter of the barrel shall be such that swelling of the barrel or misalignment of the barrel and flanges will not result in the inside of the diameter of the barrel being less than the inside diameter of the flanges.
3. Holes are provided on each flange, but they need not be aligned. No driving holes required for 4 in [100 mm] spools.
4. Metric dimensions and tolerances conform to ISO 544 except that "A" specifies ± tolerances on the nominal diameter, rather than a plus tolerance only, which is shown here as a maximum.

Figure 8—Standard Spools—Dimensions of 4, 8, 12, and 14 in [100, 200, 300, and 350 mm] Spools

20. Winding Requirements

20.1 Electrodes on spools and in coils (including drums) shall be wound so that kinks, waves, sharp bends, overlapping, or wedging are not encountered leaving the electrode free to unwind without restriction. The outside end of the electrode (the end with which welding is to begin) shall be identified so it can be readily located and shall be fastened to avoid unwinding.

20.2 The cast and helix of electrode in coils, spools, and drums shall be such that the electrode will feed in an uninterrupted manner in automatic and semiautomatic equipment.

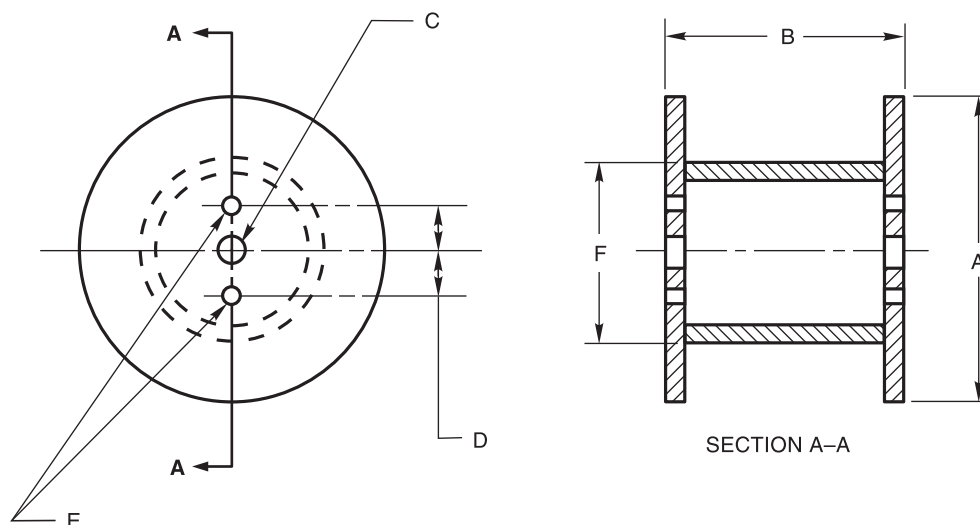
21. Electrode Identification

21.1 The product information and the precautionary information required in Section 23 for marking each package shall also appear on each coil, spool, and drum.

21.2 Coils without support shall have a tag containing this information securely attached to the electrode at the inside end of the coil.

21.3 Coils with support shall have the information securely affixed in a prominent location on the support.

21.4 Spools shall have the information securely affixed in a prominent location on the outside of at least one flange of the spool.



		DIMENSIONS					
		22 in [560 mm]		24 in [610 mm]		30 in [760 mm]	
Spools		in	mm	in	mm	in	mm
A	Diameter, max.	22	560	24	610	30	760
B	Width, max.	12	305	13.5	345	13.5	345
C	Diameter	1.31	35.0	1.31	35.0	1.31	35.0
	Tolerance	+0.13, -0	±1.5	+0.13, -0	±1.5	+0.13, -0	±1.5
D	Distance, Center-to-Center	2.5	63.5	2.5	63.5	2.5	63.5
	Tolerance	±0.1	±1.5	±0.1	±1.5	±0.1	±1.5
E	Diameter (Note 3)	0.69	16.7	0.69	16.7	0.69	16.7
	Tolerance	+0, -0.06	±0.7	+0, -0.06	±0.7	+0, -0.06	±0.7

Notes:

1. Outside diameter of barrel, dimension F, shall be such as to permit proper feeding of the electrode
2. Inside diameter of barrel shall be such that swelling of the barrel or misalignment of the barrel and flanges will not result in the inside of the diameter of the barrel being less than the inside diameter of the flanges.
3. Two holes are provided on each flange and shall be aligned on both flanges with the center hole.

Figure 9—Standard Spools—Dimensions of 22, 24, and 30 in [560, 610, and 760 mm] Spools

21.5 Drums shall have the information securely affixed in a prominent location on the outside of the drum.

22. Packaging

Electrodes shall be suitably packaged to ensure against damage during shipment and storage under normal conditions.

23. Marking of Packages

23.1 The following product information (as a minimum) shall be legibly marked so as to be visible from the outside of each unit package.

- (1) AWS specification (year of issue may be excluded) and classification designators along with applicable optional designators
- (2) Supplier's name and trade designation
- (3) Size and net weight
- (4) Lot, control, or heat number

23.2 The appropriate precautionary information⁹ given in ANSI Z49.1, latest edition (as a minimum) or its equivalent, shall be prominently displayed in legible print on all packages of electrodes, including individual unit packages enclosed within a larger package.

⁹ Typical examples of "warning labels" are shown in figures in ANSI Z49.1 for some common or specific consumables used with certain processes.

Nonmandatory Annexes

Annex A

Guide to AWS Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding

(This Annex is not a part of AWS A5.29/A5.29M:2005, *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*, but is included for informational purposes only.)

A1. Introduction

The purpose of this guide is to correlate the electrode classifications with their intended applications so the specification can be used effectively. Appropriate base metal specifications or welding processes are referred to whenever that can be done and when it would be helpful. Such references are intended only as examples rather than complete listings of the materials or welding processes for which each electrode is suitable.

A2. Classification System

A2.1 The system for identifying the electrode classifications in this specification follows, for the most part, the standard pattern used in other AWS filler metal specifications. An illustration of this system is given in Figure 1.

A2.2 Some of the classifications are intended to weld only in the flat and horizontal positions (E70T5-A1C, for example). Others are intended for welding in all positions (E81T1-Ni1M, for example). As in the case of shielded metal arc electrodes, the smaller sizes of flux cored electrodes are the ones used for out-of-position work. Flux cored electrodes larger than 5/64 in [2.0 mm] in diameter are usually used for horizontal fillets and flat position welding.

A2.3 Optional Supplemental designators are also used in this specification in order to identify electrode classifications that have met certain supplemental requirements as agreed to between supplier and purchaser. The optional supplemental designators are not part of the classification nor of its designation.

A2.3.1 Many of the classifications included in this specification have requirements for impact testing at various test temperatures as shown in Table 1U [Table 1M]. In order to include products with improved weld metal toughness at lower temperatures, an optional supplemental designator, J, has been added to identify classifications which, when tested, produce weld metal which exhibits 20 ft·lbf [27 J] at a temperature of 20°F [10°C] lower than the standard temperature shown in Table 1U [Table 1M]. The user is cautioned that although the improved weld metal toughness will be evidenced when welding is performed under conditions similar to the test assembly preparation method specified in this specification, other applications of the electrode, such as long-term postweld heat treatment or vertical up welding with high heat input, may differ markedly from the improved toughness levels given. The users should always perform their own property verification testing.

A2.3.2 This specification has included the use of optional designators for diffusible hydrogen (see Table 9 and A8.2) to indicate the maximum average value obtained under clearly defined test conditions in AWS A4.3. Electrodes that are designated as meeting the lower or lowest hydrogen limits as specified in Table 9, also are understood to be able to meet any higher hydrogen limits, when tested in accordance with Section 15. For example, see Note d of Table 9.

A2.4 “G” Classification

A2.4.1 This specification includes electrodes classified as EXXTX-G, -GC, -GM, EXXTG-X, and EXXTG-G. The “G” indicates that the electrode is of a “general” classification. It is “general” because not all of the particular requirements specified for each of the other classifications are specified for this classification. The intent in

establishing this classification is to provide a means by which electrodes that differ in one respect or another (chemical composition, for example) from all other classifications (meaning that the composition of the electrode—in the case of the example—does not meet the composition specified for any of the classifications in the specification) can still be classified according to the specification. The purpose is to allow a useful filler metal—one that otherwise would have to await a revision of the specification—to be classified immediately, under the existing specification. This means, then, that two electrodes—each bearing the same “G” classification—may be quite different in some certain respect (chemical composition, again, for example).

A2.4.2 The point of difference (although not necessarily the amount of that difference) between an electrode of a “G” classification and an electrode of a similar classification without the “G” (or even with it, for that matter) will be readily apparent from the use of the words “not required” and “not specified” in the specification. The use of these words is as follows:

(1) “Not Specified” is used in those areas of the specification that refer to the results of some particular test. It indicates that the requirements for that test are not specified for that particular classification.

(2) “Not Required” is used in those areas of the specification that refer to the tests that must be conducted in order to classify an electrode. It indicates that the test is not required because the requirements for the test have not been specified for that particular classification. Restating the case, when a requirement is not specified, it is not necessary to conduct the corresponding test in order to classify an electrode to that classification. When a purchaser wants the information provided by that test in order to consider a particular product of that classification for a certain application, the purchaser will have to arrange for that information with the supplier of the product. The purchaser will have to establish with that supplier just what the testing procedure and the acceptance requirements are to be for that test. The purchaser may want to incorporate that information (via AWS A5.01) in the purchase order.

A2.5 Request for Filler Metal Classification

A2.5.1 When an electrode cannot be classified according to some classification other than a “G” classification, the manufacturer may request that a classification be established for that filler metal. The manufacturer may do this by following the procedure given here. When the manufacturer elects to use the “G” classification, the Committee on Filler Metals and Allied Materials recommends that the manufacturer still request that a classification be established for that electrode as long as the filler metal is of commercial significance.

A2.5.2 A request to establish a new filler metal classification must be a written request and it needs to provide sufficient detail to permit the Committee on Filler Metals and Allied Materials or the Subcommittee to determine whether the new classification or the modification of an existing classification is more appropriate, and whether either is necessary to satisfy the need. In particular, the request needs to include:

(1) All classification requirements as given for existing classifications such as chemical composition ranges, mechanical property requirements, and usability test requirements.

(2) Any conditions for conducting the tests used to demonstrate that the product meets classification requirements. (It would be sufficient, for example, to state that welding conditions are the same as for other classifications.)

(3) Information on Descriptions and Intended Use, which parallels that for existing classifications, for that section of the Annex.

(4) Proposed ASME “F” Number, if appropriate.

A request for a new classification without the above information will be considered incomplete. The Secretary will return the request to the requestor for further information.

A2.5.3 The request should be sent to the Secretary of the Committee on Filler Metals and Allied Materials at AWS Headquarters. Upon receipt of the request, the Secretary will:

(1) Assign an identifying number to the request. This number will include the date the request was received.

(2) Confirm receipt of the request and give the identification number to the person who made the request.

(3) Send a copy of the request to the Chair of the Committee on Filler Metals and Allied Materials and the Chair of the particular subcommittee involved.

(4) File the original request.

(5) Add the request to the log of outstanding requests.

A2.5.4 All necessary action on each request will be completed as soon as possible. If more than 12 months lapse, the Secretary shall inform the requestor of the status of the request, with copies to the Chairs of the Committee and the Subcommittee. Requests still outstanding after 18 months shall be considered not to have been answered in a “timely manner” and the Secretary shall report these to the Chair of the Committee on Filler Metals and Allied Materials for action.

A2.5.5 The Secretary shall include a copy of the log of all requests pending and those completed during the preceding year with the agenda for each Committee on Filler Metals and Allied Materials meeting. Any other publication of requests that have been completed will be

at the option of the American Welding Society, as deemed appropriate.

A2.6 An international system for designating welding filler metals is under development by the International Institute of Welding (IIW) for possible adoptions as an ISO specification. The latest proposal for designating welding filler metals appears in AWS IFS:2002, *International Index of Welding Filler Metal Classifications*. Tables A1, A2, and A3 show the proposed ISO designations applicable to filler metal classifications included in this specification.

A3. Acceptance

Acceptance of all welding materials classified under this specification is in accordance with AWS A5.01 as the specification states. Any testing a purchaser requires of the supplier, for material shipped in accordance with this specification, shall be clearly stated in the purchase order, according to the provisions of AWS A5.01. In the absence of any such statement in the purchase order, the supplier may ship the material with whatever testing the supplier normally conducts on material of that

Table A1
Comparison of Approximate Equivalent Classifications^{a, b} for ISO/DIS 17632^c

ISO/DIS 17632A ^c	ISO/DIS 17632B	AWS A5.29	AWS A5.29M
	T493T5-XXP-2M3	E7XT5-A1X	E49XT5-A1X
T46Z Mo X X	T55ZT1-XXA-2M3	E8XT1-A1X	E55XT1-A1X
	T433T8-XNA-N1	E6XT8-K6	E43XT8-K6
	T493T8-XNA-N1	E7XT8-K6	E49XT8-K6
	T496T5-XXA-N1	E7XT5-K6X	E49XT5-K6X
T35 3 1Ni X X	T433T1-XXA-N2	E6XT1-Ni1X	E43XT1-Ni1X
T38 3 1Ni X X	E493T6-XNA-N2	E7XT6-Ni1	E49XT6-Ni1
	T493T8-XNA-N2	E7XT8-Ni1	E49XT8-Ni1
	T553T1-XXA-N2	E8XT1-Ni1X	E55XT1-Ni1X
T46 3 1Ni X X	T556T5-XXP-N2	E8XT5-Ni1X	E55XT5-Ni1X
	T493T8-XNA-N5	E7XT8-Ni2	E49XT8-Ni2
	T553T8-XNA-N5	E8XT8-Ni2	E55XT8-Ni2
T46 4 2Ni X X	T554T1-XXA-N5	E8XT1-Ni2X	E55XT1-Ni2X
T46 6 3Ni X X	T557T5-XXP-N7	E8XT5-Ni3X	E55XT5-Ni3X
T50 3 1NiMo X X	T554T5-XXA-N2M2	E8XT5-K1X	E55XT5-K1X
	T492T4-XNA-N3M1	E70T4-K2	E490T4-K2
	T493T7-XNA-N3M1	E7XT7-K2	E49XT7-K2
	T493T8-XNA-N3M1	E7XT8-K2	E49XT8-K2
	T553T1-XXA-N3M1	E8XT1-K2X	E55XT1-K2X
	T553T5-XXA-N3M1	E8XT5-K2X	E55XT5-K2X
	T553T1-XXA-NCC1	E8XT1-W2X	E55XT1-W2X

Notes:

- The requirements for the equivalent classifications shown are not necessarily identical in every respect.
- An “X” in the designations indicates the type of electrode core, the positionality or the type of shielding gas used (if any). The symbols “A” and “P” in ISO 17632B designations indicate whether the mechanical properties were achieved in the as-welded (A) or post-weld heat treated (P) condition, and the symbol “N” following an “X” applies (in ISO 17632B classifications) when no shielding gas is required.
- ISO/DIS 17632, *Welding consumables—Tubular cored electrodes for gas shielded and non-gas shielded metal arc welding of non-alloy and fine grain steels—Classification*.

Table A2
Comparison of Approximate Equivalent Classifications^{a, b} for ISO 17634^c

ISO 17634A ^c	ISO 17634B	AWS A5.29	AWS A5.29M
T Mo X X	T55TX-XX-2M3	E8XTX-A1X	E55XTX-A1X
T MoL X X	T49TX-XX-2M3	E7XTX-A1X	E49XTX-A1X
	T55TX-XX-CM	E8XTX-B1X	E55XTX-B1X
	T55TX-XX-CML	E8XTX-B1LX	E55XTX-B1LX
T CrMo1 X X	T55TX-XX-1CM	E8XTX-B2X	E55XTX-B2X
T CrMo1L X X	T55TX-XX-1CML	E8XTX-B2LX	E55XTX-B2LX
	T55TX-XX-1CMH	E8XTX-B2HX	E55XTX-B2HX
T CrMo2 X X	T55TX-XX-2C1M	E8XTX-B3X	E55XTX-B3X
T CrMo2L X X	T55TX-XX-2C1ML	E8XTX-B3LX	E55XTX-B3LX
	T55TX-XX-2C1MH	E8XTX-B3HX	E55XTX-B3HX
T CrMo 5 X X	T55TX-XX-5CM	E8XTX-B6X	E55XTX-B6X
	T55TX-XX-5CML	E8XTX-B6LX	E55XTX-B6LX
	T55TX-XX-9C1M	E8XTX-B8X	E55XTX-B8X
	T55TX-XX-9C1ML	E8XTX-B8LX	E55XTX-B8LX
	T55TX-XX-9C1MV	E9XTX-B9X	E62XTX-B9X

Notes:

a. The requirements for the equivalent classifications shown are not necessarily identical in every respect.

b. An “X” in the designations indicates the type of electrode core, the usability of the electrode, the positionality and the type of shielding gas used (if any), as applicable.

c. ISO 17634, *Welding consumables—Tubular cored electrodes for gas shielded metal arc welding of creep resisting steels—Classification*.

classification, as specified in Schedule F, Table 1, of AWS A5.01. Testing in accordance with any other schedule in that table must be specifically required by the purchase order. In such cases, acceptance of the material shipped will be in accordance with those requirements.

A4. Certification

The act of placing the AWS specification and classification designations and optional supplemental designators, if applicable, on the packaging enclosing the products, or the classification on the product itself, constitutes the supplier’s (manufacturer’s) certification that the product meets all of the requirements of that specification.

The only testing requirement implicit in this certification is that the manufacturer has actually conducted the tests required by the specification on material that is representative of that being shipped and that the material met the requirements of the specification. Representative

material, in this case, is material from any production run of that classification using the same formulation. Certification is not to be construed to mean that tests of any kind were necessarily conducted on samples of the specific material shipped. Tests on such material may or may not have been conducted. The basis for the certification required by the specification is the classification test of representative material cited above, and the Manufacturer’s Quality Assurance System in AWS A5.01.

A5. Ventilation During Welding

A5.1 Five major factors govern the quantity of fumes in the atmosphere to which welders and welding operators can be exposed during welding. These are:

- (1) Dimensions of the space in which welding is done (with special regard to the height of the ceiling).
- (2) Number of welders and welding operators working in that space.

Table A3
Comparison of Approximate Equivalent Classifications^{a, b} for ISO/DIS 18276^c

ISO/DIS 18276A ^c	ISO/DIS 18276B	AWS A5.29	AWS A5.29M
	T624T1-XXA-N4	E9XT1-Ni2X	E62XT1-Ni2X
	T627T5-XXP-N7	E9XT5-Ni3X	E62XT5-Ni3X
	T624T1-XXA-3M2	E9XT1-D1X	E62XT1-D1X
T55 4 MnMo X X	T625T5-XXP-4M2	E9XT5-D2X	E62XT5-D2X
T62 3 MnMo X X	T694T5-XXP-4M2	E10XT5-D2X	E69XT5-D2X
T55 1 MnMo X X	T622T1-XXA-3M3	E9XT1-D3X	E62XT1-D3X
	T625T5-XXA-N3M1	E9XT5-K2X	E62XT5-K2X
T55 2 MnNiMo X X	T692T1-XXA-N3M2	E10XT1-K3X	E69XT1-K3X
T55 4 MnNiMo X X	T695T5-XXA-N3M2	E10XT5-K3X	E69XT5-K3X
T62 1 Mn2NiMo X X	T762T1-XXA-N3M2	E11XT1-K3X	E76XT1-K3X
	T83ZT1-XXA-N3C1M2	E12XT1-K5X	E83XT1-K5X
T62 1 Mn2NiCrMo X X	T762T1-XXA-N4C1M2	E11XT1-K4X	E76XT1-K4X
T62 4 Mn2NiCrMo X X	T765T5-XXA-N4C1M2	E11XT5-K4X	E76XT5-K4X
T69 4 Mn2NiCrMo X X	T835T5-XXA-N4C1M2	E12XT5-K4X	E83XT5-K4X
	T695T1-XXA-N5	E10XT1-K7X	E69XT1-K7X
	T623T8-XNA-N2	E9XT8-K8	E62XT8-K8
	T695T1-XXA-N6C1M1	E10XT1-K9X	E69XT1-K9X

Notes:

- a. The requirements for the equivalent classifications shown are not necessarily identical in every respect.
- b. An “X” in the designations indicates the type of electrode core, the positionality and the type of shielding gas used (if any). The symbols “A” and “P” in ISO 18276B designations indicate whether the mechanical properties were achieved in the as-welded (A) or the post-weld heat treated (P) condition, and the symbol N following an X applies when no shielding gas is required.
- c. ISO/DIS 18276, *Welding consumables—Tubular cored electrodes for gas shielded and non-gas shielded metal arc welding of high strength steels—Classification*.

(3) Rate of evolution of fumes, gases, or dust according to the materials and processes used.

(4) The proximity of the welders or welding operators to the fumes as the fumes issue from the welding zone, and to the gases and dusts in the space in which they are working.

(5) The ventilation provided to the space in which the welding is done.

A5.2 American National Standard Z49.1 (published by the American Welding Society) discusses the ventilation that is required during welding and should be referred to for details. Attention is drawn particularly to the section on Ventilation in that document.

A6. Welding Considerations

A6.1 When examining the properties required of weld metal as a result of the tests made according to this specification, it should be recognized that in production, where the conditions and procedures may differ from those in this specification (electrode size, amperage, voltage, type and amount of shielding gas, position of welding, contact tip to work distance (CTWD), plate thickness, joint geometry, preheat and interpass temperatures, travel speed, surface condition, base metal composition and dilution, for example), the properties of the weld metal may also differ. Moreover, the difference may be large or small.

A6.2 Since it has not been possible to specify one single, detailed, welding procedure for all products classified under any given classification in this specification, details of the welding procedure used in classifying each product should be recorded by the manufacturer and made available to the user, on request. The information should include each of the items referred to in A6.1 above, as well as the actual number of passes and layers required to complete the weld test assembly.

A6.3 The toughness requirements for the different classifications in this specification can be used as a guide in the selection of electrodes for applications requiring some degree of low temperature notch toughness. For an electrode of any given classification, there can be a considerable difference between the impact test results from one assembly to another, or even from one impact specimen to another, unless particular attention is given to the manner in which the weld is made and prepared (even the location and orientation of the specimen within the weld), the temperature of testing, and the operation of the testing machine.

A6.4 Hardenability. There are inherent differences in the effect of the carbon content of the weld deposit on hardenability, depending on whether the electrode was gas shielded or self-shielded. Gas shielded electrodes generally employ a Mn-Si deoxidation system. The carbon content affects hardness in a manner which is typical of many carbon equivalent formulas published for carbon steel. Most self-shielded electrodes utilize an aluminum-based alloy system to provide for protection and deoxidation. One of the effects of the aluminum is to modify the effect of carbon on hardenability. Hardness levels obtained with self-shielded electrodes may, therefore, be lower than the carbon content would indicate (when considered on the basis of typical carbon equivalent formulas).

A7. Description and Intended Use of Flux Cored Electrodes

This specification may contain many different classifications of flux cored electrodes. The usability designator (1, 4, 5, 6, 7, 8, 11, or G) in each classification indicates a general grouping of electrodes that contain similar flux or core components and which have similar usability characteristics, except for the “G” classification where usability characteristics may differ between similarly classified electrodes.

A7.1 EXXT1-XC and EXXT1-XM Classifications. Electrodes of the EXXT1-XC group are classified with CO₂ shielding gas (AWS A5.32 Class SG-C). However, other gas mixtures (such as argon-CO₂) may be used to

improve usability, especially for out-of-position applications, when recommended by the manufacturer. Increasing the amount of argon in the argon-CO₂ mixture will increase the manganese and silicon contents, along with certain other alloys, such as chromium, in the weld metal. The increase in manganese, silicon, or other alloys will increase the yield and tensile strengths and may affect impact properties.

Electrodes in the EXXT1-XM group are classified with 75–80% argon/balance CO₂ shielding gas (AWS A5.32 Class SG-AC-25 or SG-AC-20). Their use with argon-CO₂ shielding gas mixtures having reduced amounts of argon or with CO₂ shielding gas may result in some deterioration of arc characteristics and out-of-position welding characteristics. In addition, a reduction of manganese, silicon, and certain other alloy contents in the weld metal will reduce the yield and tensile strengths and may affect impact properties.

Both the EXXT1-XC and EXXT1-XM electrodes are designed for single and multiple pass welding using DCEP polarity. The larger diameters (usually 5/64 in [2.0 mm] and larger) are typically used for welding in the flat position and for making fillet welds in the horizontal position. The smaller diameters (usually 1/16 in [1.6 mm] and smaller) are typically used for welding in all positions. These electrodes are characterized by a spray transfer, low spatter loss, flat to slightly convex bead contour, and a moderate volume of slag which completely covers the weld bead. Most electrodes of this classification have rutile base slag and may produce high deposition rates.

A7.2 EXXT4-X Classification. Electrodes of this classification are self-shielded, operate on DCEP, and have a globular type transfer. The slag system is designed to make very high deposition rates possible and to produce a weld that is very low in sulfur, which makes the weld very resistant to hot cracking. These electrodes are designed for low penetration beyond the root of the weld, enabling them to be used on joints which have been poorly fit, and for single and multiple pass welding.

A7.3 EXXT5-XC and EXXT5-XM Classifications. Electrodes of the EXXT5-XC classification are designed to be used with CO₂ shielding gas (AWS A5.32 Class SG-C); however, as with EXXT1-XC classifications, argon-CO₂ mixtures may be used to reduce spatter, when recommended by the manufacturer. Increasing the amount of argon in the argon-CO₂ mixture will increase the manganese and silicon contents, along with certain other alloys, which will increase the yield and tensile strengths and may affect impact properties.

Electrodes in the EXXT5-XM group are classified with 75–80% argon/balance CO₂ shielding gas (AWS A5.32 Class SG-AC-25 or SG-AC-20). Their use with

gas mixtures having reduced amounts of argon or with CO₂ shielding gas may result in some deterioration of arc characteristics, an increase in spatter, and a reduction of manganese, silicon, and certain other alloys in the weld metal. This reduction in manganese, silicon, or other alloys will decrease the yield and tensile strengths and may affect impact properties.

Electrodes of the EX0T5-XC and EX0T5-XM classifications are used primarily for single and multiple pass welds in the flat position and for making fillet welds in the horizontal position using DCEP or DCEN, depending on the manufacturer's recommendation. These electrodes are characterized by a globular transfer, slightly convex bead contour and a thin slag that may not completely cover the weld bead. These electrodes have a lime-fluoride base slag. Weld deposits produced by these electrodes typically have good to excellent impact properties and hot and cold crack resistance that are superior to those obtained with rutile base slags. Some EX1T5-XC and EX1T5-XM electrodes, using DCEN, can be used for welding in all positions. However, the operator appeal of these electrodes is not as good as those with rutile base slags.

A7.4 EXXT6-X Classification. Electrodes of this classification are self-shielded, operate on DCEP, and have a small droplet to spray type transfer. The slag system is designed to give good low temperature impact properties, good penetration into the root of the weld, and excellent slag removal, even in a deep groove. These electrodes are used for single and multipass welding in flat and horizontal positions.

A7.5 EXXT7-X Classification. Electrodes of this classification are self-shielded, operate on DCEN, and have a small droplet to spray type transfer. The slag system is designed to allow the larger sizes to be used for high deposition rates in the horizontal and flat positions, and to allow the smaller sizes to be used for all welding positions. These electrodes are used for single-pass and multiple pass welding and produce very low sulfur weld metal, which is very resistant to cracking.

A7.6 EXXT8-X Classification. Electrodes of this classification are self-shielded, operate on DCEN, and have a small droplet or spray type transfer. These electrodes are suitable for all welding positions, and the weld metal has very good low-temperature notch toughness and crack resistance. These electrodes are used for single-pass and multipass welds.

A7.7 EXXT11-X Classification. Electrodes of this classification are self-shielded, operate on DCEN and have a smooth spray-type transfer. These electrodes are intended for single-pass and multipass welding in all

positions. The manufacturer should be consulted regarding any plate thickness limitations.

A7.8 EXXTX-G, EXXTG-X, and EXXTG-G Classifications. These classifications are for multiple-pass electrodes that are not covered by any presently defined classification. The mechanical properties can be anything covered by this specification. Requirements are established by the digits chosen to complete the classification. Placement of the "G" in the classification designates that the alloy requirements, shielding gas/slag system, or both are not defined and are as agreed upon between supplier and purchaser.

A7.9 Chemical Composition. The chemical composition of the weld metal produced is often the primary consideration for electrode selection. The suffixes, which are part of each alloy electrode classification, identify the chemical composition of the weld metal produced by the electrode. The following paragraphs give a brief description of the classifications, intended uses, and typical applications.

A7.9.1 EXXTX-A1X (C-Mo Steel) Electrodes. These electrodes are similar to EXXT-XX carbon steel electrodes classified in AWS A5.20, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*, except that 0.5 percent molybdenum has been added. This addition increases the strength of the weld metal, especially at elevated temperatures, and provides some increase in corrosion resistance; however, it may reduce the notch toughness of the weld metal. This type of electrode is commonly used in the fabrication and erection of boilers and pressure vessels. Typical applications include the welding of C-Mo steel base metals, such as ASTM A 161, A 204, and A 302 Gr. A plate and A335-P1 pipe.

A7.9.2 EXXTX-BXX, EXXTX-BXLX and EXXTX-BXHX (Cr-Mo Steel) Electrodes. These electrodes produce weld metal that contain between 0.5 percent and 10 percent chromium, and between 0.5 percent and 1 percent molybdenum. They are designed to produce weld metal for high temperature service and for matching properties of the typical base metals as follows:

EXXTX-B1X	ASTM A 335-P2 pipe
	ASTM A 387 Gr. 2 plate
EXXTX-B2X	ASTM A 335-P11 pipe
	ASTM A 387 Gr. 11 plate
EXXTX-B2LX	Thin wall A 335-P11 pipe or
	A 213-T11 or A 213-T22 tube, as
	applicable, for use in the as-
	welded condition or for applica-
	tions where low hardness is a pri-
	mary concern.
EXXTX-B3X	ASTM A 335-P22 pipe
	ASTM A 387 Gr. 22 plate

EXXTX-B3LX	Thin wall A 335-P22 pipe or tube for use in the as-welded condition or for applications where lower hardness is a primary concern.
EXXTX-B6X	ASTM A 213-T5 tube ASTM A 335-P5 pipe
EXXTX-B8X	ASTM A 213-T9 tube ASTM A 335-P9 pipe
EXXTX-B9X	ASTM A 213-T91 tube ASTM A 335-P91 pipe

For two of these Cr-Mo electrode classifications, low carbon EXXTX-BXLX classifications have been established. While regular Cr-Mo electrodes produce weld metal with 0.05 percent to 0.12 percent carbon, the “L-grades” are limited to a maximum of 0.05 percent carbon. While the lower percent carbon in the weld metals will improve ductility and lower hardness, it will also reduce the high-temperature strength and creep resistance of the weld metal.

Several of these grades also have high-carbon grades (EXXTX-BXHX) established. In these cases, the electrode produces weld metal with 0.10 percent to 0.15 percent carbon, which may be required for high temperature strength in some applications.

Since all Cr-Mo electrodes produce weld metal which will harden in still air, both preheat and postweld heat treatment (PWHT) are required for most applications.

No minimum notch toughness requirements have been established for any Cr-Mo electrode classifications. While it is possible to obtain Cr-Mo electrodes with minimum toughness values at ambient temperatures down to 32°F [0°C], specific values and testing must be agreed to by supplier and purchaser.

For the EXXTX-B9X classification thermal treatment is critical and must be closely controlled. The temperature at which the microstructure has complete transformation into martensite (M_s) is relatively low; therefore, upon completion of welding and before post weld heat treatment, it is recommended to allow the weldment to cool to at least 200°F [93°C] to maximize transformation to martensite. The maximum allowable temperature for post weld heat treatment is also critical in that the lower transformation temperature (Ac_1) is also comparably low. To aid in allowing for an adequate post weld heat treatment, the restriction of Mn + Ni has been imposed (see Table 7, Note d). The combination of Mn and Ni tends to lower the Ac_1 temperature to the point where the PWHT temperature approaches the Ac_1 , possibly causing partial transformation of the microstructure. By restricting the Mn + Ni, the PWHT temperature will be sufficiently below the Ac_1 to avoid this partial transformation.

A7.9.3 EXXTX-DXX (Mn-Mo Steel) Electrodes. These electrodes produce weld metal, which contains

about 1.5 percent to 2 percent manganese and between 0.25 percent and 0.65 percent molybdenum. This weld metal provides better notch toughness than the C-0.5 percent Mo electrodes discussed in 7.9.1 and higher tensile strength than the 1 percent Ni, 0.5 percent Mo steel weld metal discussed in A7.9.4.1. However, the weld metal from these Mn-Mo steel electrodes is quite air-hardenable and usually requires preheat and PWHT. The individual electrodes under this electrode group have been designed to match the mechanical properties and corrosion resistance of the high-strength, low-alloy pressure vessel steels, such as A 302 Gr. B and HSLA steels and manganese-molybdenum castings, such as ASTM A 49, A 291, and A 735.

A7.9.4 EXXTX-KXX (Various Low-Alloy Steel Type) Electrodes. This group of electrodes produces weld metal of several different chemical compositions. These electrodes are primarily intended for as-welded applications. See Table 1U [Table 1M] for a comparison of the toughness levels required for each classification.

A7.9.4.1 EXXTX-K1X Electrodes. Electrodes of this classification produce weld metal with nominally 1 percent nickel and 0.5 percent molybdenum. These electrodes can be used for long-term stress-relieved applications for welding low-alloy, high strength steels, in particular 1 percent nickel steels.

A7.9.4.2 EXXTX-K2X Electrodes. Electrodes of this classification produce weld metal which will have a chemical composition of 1.5 percent nickel and up to 0.35 percent molybdenum. These electrodes are used on many high-strength applications ranging from 80 to 110 ksi [550 to 760 MPa] minimum yield strength steels. Typical applications would include the welding of offshore structures and many structural applications where excellent low-temperature toughness is required. Steel welded would include HY-80, HY-100, ASTM A 710, ASTM A 514, and similar high-strength steels.

A7.9.4.3 EXXTX-K3X Electrodes. Electrodes of this type produce weld deposits with higher levels of Mn, Ni and Mo than the EXXTX-K2X types. They are usually higher in strength than the -K1 and -K2 types. Typical applications include the welding of HY-100 and ASTM A 514 steels.

A7.9.4.4 EXXTX-K4X Electrodes. Electrodes of this classification deposit weld metal similar to that of the -K3 electrodes, with the addition of approximately 0.5 percent chromium. The additional alloy provides the higher strength for many applications needing in excess of 120 ksi [830 MPa] tensile strength, such as armor plate.

A7.9.4.5 EXXTX-K5X Electrodes. Electrodes of this classification produce weld metal which is designed to match the mechanical properties of the steels such as SAE 4130 and 8630 after the weldment is quenched and tempered. The classification requirements stipulate only as-welded mechanical properties, therefore, the end user is encouraged to perform qualification testing.

A7.9.4.6 EXXTX-K6X Electrodes. Electrodes of this classification produce weld metal which utilizes less than 1 percent nickel to achieve excellent toughness in the 60 and 70 ksi [430 and 490 MPa] tensile strength ranges. Applications include structural, offshore construction and circumferential pipe welding.

A7.9.4.7 EXXTX-K7X Electrodes. This electrode classification produces weld metal which has similarities to that produced with EXXTX-Ni2X and EXXTX-Ni3X electrodes. This weld metal has approximately 1.5 percent manganese and 2.5 percent nickel.

A7.9.4.8 EXXTX-K8X Electrodes. This classification was designed for electrodes intended for use in circumferential girth welding of line pipe. The weld deposit contains approximately 1.5 percent manganese, 1 percent nickel, and small quantities of other alloys. It is especially intended for use on API 5L X80 pipe steels.

A7.9.4.9 EXXTX-K9X Electrodes. This electrode produces weld metal similar to that of the -K2 and -K3 type electrodes but is intended to be similar to the military requirements of MIL-101TM and MIL-101TC electrodes in MIL-E-24403/2C. The electrode is designed for welding HY-80 steel.

A7.9.5 EXXTX-NiXX (Ni-steel) Electrodes. These electrodes have been designed to produce weld metal with increased strength (without being air-hardenable) or with increased notch toughness at temperatures as low as -100°F [-73°C]. They have been specified with nickel contents which fall into three nominal levels of 1 percent Ni, 2 percent Ni, and 3 percent Ni in steel.

With carbon levels up to 0.12 percent, the strength increases and permits some of the Ni-steel electrodes to be classified as E8XTX-NiXX and E9XTX-NiXX. However, some classifications may produce low-temperature notch toughness to match the base metal properties of nickel steels, such as ASTM A 203 Gr. A and ASTM A 352 Grades LC1 and LC2. The manufacturer should be consulted for specific Charpy V-notch impact properties. Typical base metals would also include ASTM A 302 and A 734.

Many low-alloy steels require postweld heat treatment to stress relieve the weld or temper the weld metal and heat-affected zone (HAZ) to achieve increased ductility. For most applications the holding temperature should not exceed the maximum temperature given in

Table 6 for the classification considered, since nickel steels can be embrittled at higher temperatures. Higher PWHT holding temperatures may be acceptable for some applications. For many other applications, nickel steel weld metal can be used without PWHT.

Electrodes of the EXXTX-NiXX type are often used in structural applications where excellent toughness (Charpy V-Notch or CTOD) is required.

A7.9.6 EXXTX-W2X (Weathering Steel) Electrodes. These electrodes have been designed to produce weld metal that matches the corrosion resistance and the coloring of the ASTM weathering-type structural steels. These special properties are achieved by the addition of about 0.5 percent copper to the weld metal. To meet strength, ductility, and notch toughness in the weld metal, some chromium and nickel additions are also made. These electrodes are used to weld typical weathering steel, such as ASTM A 242 and A 588.

A7.9.7 EXXTX-G, -GC, -GM (General Low-Alloy Steel) Electrodes. These electrodes are described in A2.4. These electrode classifications may be either modifications of other discrete classifications or totally new classifications. The purchaser and user should determine the description and intended use of the electrode from the supplier.

A8. Special Tests

A8.1 It is recognized that supplementary tests may need to be conducted to determine the suitability of these welding electrodes for applications involving properties such as hardness, corrosion resistance, mechanical properties at higher or lower service temperatures, wear resistance, and suitability for welding combinations of dissimilar metals. Supplemental requirements as agreed between purchaser and supplier may be added to the purchase order following the guidance of AWS A5.01.

A8.2 Diffusible Hydrogen Test

A8.2.1 Hydrogen-induced cracking of weld metal or the heat-affected zone generally is not a problem with carbon steels containing 0.3% or less carbon, nor with lower-strength alloy steels. However, the electrodes classified in this specification are sometimes used to join higher carbon steels or low-alloy, high-strength steels where hydrogen-induced cracking may be a serious problem.

A8.2.2 As the weld metal or heat-affected zone strength or hardness increases, the concentration of diffusible hydrogen that will cause cracking under given conditions of restraint and heat input becomes lower. This cracking (or its detection) is usually delayed some

hours after cooling. It may appear as transverse weld cracks, longitudinal cracks (especially in the root beads), and toe or underbead cracks in the heat-affected zone.

A8.2.3 Since the available diffusible hydrogen level strongly influences the tendency towards hydrogen-induced cracking, it may be desirable to measure the diffusible hydrogen content resulting from welding with a particular electrode. This specification has, therefore, included the use of optional designators for diffusible hydrogen to indicate the maximum average value obtained under a clearly defined test condition in AWS A4.3.

A8.2.4 Most flux cored electrodes deposit weld metal having diffusible hydrogen levels of less than 16 mL/100 grams of deposited metal. For that reason, flux cored electrodes are generally considered to be low hydrogen. However, some commercially available products will, under certain conditions, produce weld metal with diffusible hydrogen levels in excess of 16 mL/100 grams of deposited metal. Therefore it may be appropriate for certain applications to utilize the optional supplemental designators for diffusible hydrogen when specifying the flux cored electrodes to be used.

A8.2.5 The use of a reference atmospheric condition during welding is necessitated because the arc is subject to atmospheric contamination when using either self-shielded or gas-shielded flux cored electrodes. Moisture from the air, distinct from that in the electrode, can enter the arc and subsequently the weld pool, contributing to the resulting observed diffusible hydrogen. This effect can be minimized by maintaining as short an arc length as possible consistent with a steady arc. Experience has shown that the effect of arc length is minor at the H16 level, but can be very significant at the H4 level. An electrode meeting the H4 requirements under the reference atmospheric conditions may not do so under conditions of high humidity at the time of welding, especially if a long arc length is maintained.

A8.2.6 The user of this information is cautioned that actual fabrication conditions may result in different diffusible hydrogen values than those indicated by the designator. The welding consumable is not the only source of diffusible hydrogen in the welding process. In actual practice, the following may contribute to the hydrogen content of the finished weldment.

(1) **Surface Contamination.** Rust, primer coating, anti-spatter compounds, dirt and grease can all contribute to diffusible hydrogen levels in practice. Consequently, standard diffusible hydrogen tests for classification of welding consumables require test material to be free of contamination. AWS A4.3 is specific as to the cleaning procedure for test material.

(2) **Atmospheric Humidity.** The welding arc is subject to atmospheric contamination when using either a self-shielded or gas shielded welding consumable. Moisture from the air, distinct from that in the welding consumable, can enter the arc and subsequently the weld pool, contributing to the resulting observed diffusible hydrogen. AWS A4.3 has established a reference atmospheric condition at which the contribution to diffusible hydrogen from atmospheric humidity is considered to be negligible. This influence of atmospheric humidity also can be minimized by maintaining as short an arc length as possible consistent with a steady arc. For flux cored electrodes arc length is controlled primarily by arc voltage. Experience has shown that the effect of arc length is minor at the H16 level, but can be very significant at the H4 level. An electrode meeting the H4 requirements under the reference atmospheric conditions may not do so under conditions of high humidity at the time of welding, especially if a long arc length is maintained.

(3) **Shielding Gas.** The reader is cautioned that the shielding gas itself can contribute significantly to diffusible hydrogen. Normally, welding grade shielding gases are intended to have very low dew points and very low impurity levels. This, however, is not always the case. Instances have occurred where a contaminated gas cylinder resulted in a significant increase of diffusible hydrogen in the weld metal. Further, moisture permeation through some hoses and moisture condensation in unused gas lines can become a source of diffusible hydrogen during welding. In case of doubt, a check of gas dew point is suggested. A dew point of -40°F [-40°C] or lower is considered satisfactory for most applications.

(4) **Absorbed/Adsorbed Moisture.** Flux cored electrodes can absorb/adsorb moisture over time which contributes to diffusible hydrogen levels. This behavior is well documented for shielded metal arc electrode coverings exposed to the atmosphere. Hydration of oxide films and lubricants on solid electrode surfaces under what may be considered “normal” storage conditions has also been reported to influence diffusible hydrogen. Moisture absorption/adsorption can be particularly significant if material is stored in a humid environment in damaged or open packages, or if unprotected for long periods of time. In the worst case of high humidity, even overnight exposure of unprotected electrodes can lead to a significant increase of diffusible hydrogen. For these reasons, indefinite periods of storage should be avoided. The storage and handling practices necessary to safeguard the condition of a welding consumable will vary from one product to another even within a given classification. Therefore, the consumable manufacturer should always be consulted for recommendations on storage and handling practice. In the event the electrode has been exposed, the

manufacturer should be consulted regarding probable damage to its controlled hydrogen characteristics and possible reconditioning of the electrode.

(5) **Effect of Welding Process Variables.** Variations in welding process variables (e.g., amperage, voltage, contact tip to work distance, type of shielding gas, current type/polarity, single electrode vs. multiple electrode welding, etc.) are all reported to influence diffusible hydrogen test results in various ways. For example, with respect to contact tip to work distance, a longer CTWD will promote more preheating of the electrode, causing some removal of hydrogen-bearing compounds (e.g., moisture, lubricants, etc.) before they reach the arc. Consequently, the result of longer CTWD can be to reduce diffusible hydrogen. However, excessive CTWD with external gas shielded welding processes may cause some loss of shielding if the contact tip is not adequately recessed in the gas cup. If shielding is disturbed, more air may enter the arc and increase the diffusible hydrogen. This may also cause porosity due to nitrogen pickup.

Since welding process variables can have a significant effect on diffusible hydrogen test results, it should be noted that an electrode meeting the H4 requirements, for example, under the classification test conditions should not be expected to do so consistently under all welding conditions. Some variation should be expected and accounted for when making welding consumable selections and establishing operating ranges in practice.

A8.2.7 As indicated in A8.2.6(5), the welding procedures used with flux cored electrodes will influence the values obtained on a diffusible hydrogen test. To address this, the AWS A5M Subcommittee on Carbon and Low-Alloy Steel Electrodes for Flux Cored Arc Welding has incorporated into its specification test procedure requirements for conducting the diffusible hydrogen test when determining conformance to the hydrogen optional supplemental designator requirements shown in Table 9. See Section 15. The following is provided as an example.

EXAMPLE: Manufacturer ABC, an electrode manufacturer, recommends and/or publishes the following procedure range for its E81T1-K2M electrode.

Electrode Diameter	Shielding Gas	Wire Feed Rate in/min [cm/min]	Arc Voltage (volts)	CTWD in [mm]	Deposition Rate lbs/hr [kg/hr]
0.045 in [1.2 mm]	75 Ar/ 25 CO ₂	175–300 [445–760] 300–425 [760–1080] 425–550 [1080–1400]	21–25 24–28 27–30	1/2–3/4 [12–20] 5/8–7/8 [16–22] 3/4–1 [20–25]	3.3–5.8 [1.5–2.6] 5.8–8.1 [2.6–3.7] 8.1–10.5 [3.7–4.8]
1/16 in [1.6 mm]	75 Ar/ 25 CO ₂	150–225 [380–570] 225–300 [570–760] 300–375 [760–950]	22–25 24–27 26–31	3/4–1 [20–25] 7/8–1-1/8 [22–29] 1–1-1/4 [25–32]	5.4–8.0 [2.5–3.6] 8.0–10.8 [3.6–4.9] 10.8–12.2 [4.9–5.5]

Based upon the manufacturer's recommended operating range, the minimum wire feed rate and the CTWD to be used for hydrogen testing are determined as follows:

1. For 0.045 in [1.2 mm] diameter the minimum wire feed rate (WFR_{min}) to be used for the hydrogen test, as specified in 15.2, is $WFR_{min} = 175 \text{ in/min} + 0.75 (550 \text{ in/min} - 175 \text{ in/min}) = 456 \text{ in/min}$ [$WFR_{min} = 445 \text{ cm/min} + 0.75 (1400 \text{ cm/min} - 445 \text{ cm/min}) = 1160 \text{ cm/min}$].

The CTWD to be used for the hydrogen test is 3/4 in [20 mm], the minimum CTWD recommended by the manufacturer for the test wire feed rate of 456 in/min [1160 cm/min].

2. For 1/16 in [1.6 mm] diameter the minimum wire feed rate (WFR_{min}) to be used for the hydrogen test, as specified in 15.2, is $WFR_{min} = 150 \text{ in/min} + 0.75 (375 \text{ in/min} - 150 \text{ in/min}) = 319 \text{ in/min}$ [$WFR_{min} = 380 \text{ cm/min} + 0.75 (950 \text{ cm/min} - 380 \text{ cm/min}) = 808 \text{ cm/min}$].

The CTWD to be used for the hydrogen test is 1 in [25 mm], the minimum CTWD recommended by the manufacturer for the test wire feed rate of 319 in/min [808 cm/min].

A8.2.8 All classifications may not be available in the H16, H8, or H4 diffusible hydrogen levels. The manufacturer of a given electrode should be consulted for availability of products meeting these limits.

A8.3 Aging of Tensile Specimens. Weld metals may contain significant quantities of hydrogen for some time after they have been made. Most of this hydrogen gradually escapes over time. This may take several weeks at room temperature or several hours at elevated temperatures. As a result of this eventual change in hydrogen level, ductility of the weld metal increases toward its inherent value, while yield, tensile and impact strengths remain relatively unchanged. The A5.29 and A5.29M specifications permit the aging of the tensile test specimens at elevated temperatures not exceeding 220°F [105°C] for up to 48 hours before cooling them to room temperature and subjecting them to tension testing. The purpose of this treatment is to facilitate removal of hydrogen from the test specimen in order to minimize discrepancies in testing.

Aging treatments are sometimes used for low hydrogen electrode deposits, especially when testing high strength deposits. Note that aging may involve holding test specimens at room temperature for several days or holding at a high temperature for a shorter period of time. Consequently, users are cautioned to employ adequate preheat and interpass temperatures to avoid the deleterious effects of hydrogen in production welds. The purchaser may, by mutual agreement with the supplier, have the thermal aging of specimens prohibited for all mechanical testing done to schedule I or J of AWS A5.01.

A9. Changes or Obsolete Classifications

The E80T1-W classification from A5.29-80 has been changed to E8XT1-W2C, -W2M to conform to other documents.

A10. General Safety Considerations

A10.1 Safety and health issues and concerns are beyond the scope of this standard and, therefore, are not fully

addressed herein. Some safety and health information can be found in Annex A5. Safety and health information is available from other sources, including but not limited to Safety and Health Fact Sheets listed in A10.3, ANSI Z49.1 and applicable federal and state regulations.

A10.2 Safety and Health Fact Sheets. The Safety and Health Fact Sheets listed below are published by the American Welding Society (AWS). They may be downloaded and printed directly from the AWS website at <http://www.aws.org>. The Safety and Health Fact Sheets are revised and additional sheets added periodically.

A10.3 AWS Safety and Health Fact Sheets Index (SHF)

No.	Title
1	<i>Fumes and Gases</i>
2	<i>Radiation</i>
3	<i>Noise</i>
4	<i>Chromium and Nickel in Welding Fume</i>
5	<i>Electric Hazards</i>
6	<i>Fire and Explosion Prevention</i>
7	<i>Burn Protection</i>
8	<i>Mechanical Hazards</i>
9	<i>Tripping and Falling</i>
10	<i>Falling Objects</i>
11	<i>Confined Space</i>
12	<i>Contact Lens Wear</i>
13	<i>Ergonomics in the Welding Environment</i>
14	<i>Graphic Symbols for Precautionary Labels</i>
15	<i>Style Guidelines for Safety and Health Documents</i>
16	<i>Pacemakers and Welding</i>
17	<i>Electric and Magnetic Fields (EMF)</i>
18	<i>Lockout/Tagout</i>
19	<i>Laser Welding and Cutting Safety</i>
20	<i>Thermal Spraying Safety</i>
21	<i>Resistance Spot Welding</i>
22	<i>Cadmium Exposure from Welding & Allied Processes</i>
23	<i>California Proposition 65</i>
24	<i>Fluxes for Arc Welding and Brazing: Safe Handling and Use</i>
25	<i>Metal Fume Fever</i>
27	<i>Thoriated Tungsten Electrodes</i>
29	<i>Grounding of Portable and Vehicle Mounted Welding Generators</i>

Annex B

Guidelines for Preparation of Technical Inquiries for AWS Technical Committees

(This Annex is not a part of AWS A5.29/A5.29M:2005, *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*, but is included for informational purposes only.)

B1. Introduction

The AWS Board of Directors has adopted a policy whereby all official interpretations of AWS standards will be handled in a formal manner. Under that policy, all interpretations are made by the committee that is responsible for the standard. Official communication concerning an interpretation is through the AWS staff member who works with that committee. The policy requires that all requests for an interpretation be submitted in writing. Such requests will be handled as expeditiously as possible but due to the complexity of the work and the procedures that must be followed, some interpretations may require considerable time.

B2. Procedure

All inquiries must be directed to

Managing Director, Technical Services
American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126

All inquiries must contain the name, address, and affiliation of the inquirer, and they must provide enough information for the committee to fully understand the point of concern in the inquiry. Where that point is not clearly defined, the inquiry will be returned for clarification. For efficient handling, all inquiries should be type-written and should also be in the format used here.

B2.1 Scope. Each inquiry must address one single provision of the standard, unless the point of the inquiry involves two or more interrelated provisions. That provision must be identified in the scope of the inquiry, along

with the edition of the standard that contains the provisions or that the inquirer is addressing.

B2.2 Purpose of the Inquiry. The purpose of the inquiry must be stated in this portion of the inquiry. The purpose can be either to obtain an interpretation of a standard's requirement, or to request the revision of a particular provision in the standard.

B2.3 Content of the Inquiry. The inquiry should be concise, yet complete, to enable the committee to quickly and fully understand the point of the inquiry. Sketches should be used when appropriate and all paragraphs, figures and tables (or the Annex) which bear on the inquiry must be cited. If the point of the inquiry is to obtain a revision of the standard, the inquiry must provide technical justification for that revision.

B2.4 Proposed Reply. The inquirer should, as a proposed reply, state an interpretation of the provision that is the point of the inquiry, or the wording for the proposed revision, if that is what the inquirer seeks.

B3. Interpretation of Provisions of the Standard

Interpretations of provisions of the standard are made by the relevant AWS Technical Committee. The secretary of the committee refers all inquiries to the chair of the particular subcommittee that has jurisdiction over the portion of the standard addressed by the inquiry. The subcommittee reviews the inquiry and the proposed reply to determine what the response to the inquiry should be. Following the subcommittee's development of the response, the inquiry and the response are presented to the entire committee for review and approval. Upon

approval by the committee, the interpretation will be an official interpretation of the Society, and the secretary will transmit the response to the inquirer and to the *Welding Journal* for publication.

B4. Publication of Interpretations

All official interpretations will appear in the *Welding Journal*.

B5. Telephone Inquiries

Telephone inquiries to AWS Headquarters concerning AWS standards should be limited to questions of a general nature or to matters directly related to the use of the standard. The Board of Directors' policy requires that all AWS staff members respond to a telephone request for an official interpretation of any AWS standard with the information that such an interpretation can be

obtained only through a written request. The Headquarters staff cannot provide consulting services. The staff can, however, refer a caller to any of those consultants whose names are on file at AWS Headquarters.

B6. The AWS Technical Committee

The activities of AWS Technical Committees in regard to interpretations are limited strictly to the interpretation of provisions of standards prepared by the committee or to consideration of revisions to existing provisions on the basis of new data or technology. Neither the committee nor the staff is in a position to offer interpretive or consulting services on (1) specific engineering problems or (2) requirements of standards applied to fabrications outside the scope of the document or points not specifically covered by the standard. In such cases, the inquirer should seek assistance from a competent engineer experienced in the particular field of interest.

AWS Filler Metal Specifications by Material and Welding Process

	OFW	SMAW	GTAW GMAW PAW	FCAW	SAW	ESW	EGW	Brazing
Carbon Steel	A5.2	A5.1	A5.18	A5.20	A5.17	A5.25	A5.26	A5.8, A5.31
Low-Alloy Steel	A5.2	A5.5	A5.28	A5.29	A5.23	A5.25	A5.26	A5.8, A5.31
Stainless Steel		A5.4	A5.9, A5.22	A5.22	A5.9	A5.9	A5.9	A5.8, A5.31
Cast Iron	A5.15	A5.15	A5.15	A5.15				A5.8, A5.31
Nickel Alloys		A5.11	A5.14		A5.14			A5.8, A5.31
Aluminum Alloys		A5.3	A5.10					A5.8, A5.31
Copper Alloys		A5.6	A5.7					A5.8, A5.31
Titanium Alloys			A5.16					A5.8, A5.31
Zirconium Alloys			A5.24					A5.8, A5.31
Magnesium Alloys			A5.19					A5.8, A5.31
Tungsten Electrodes			A5.12					
Brazing Alloys and Fluxes								A5.8, A5.31
Surfacing Alloys	A5.21	A5.13	A5.21	A5.21	A5.21			
Consumable Inserts			A5.30					
Shielding Gases			A5.32	A5.32			A5.32	

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AWS Filler Metal Specifications and Related Documents

Designation	Title
FMC	<i>Filler Metal Comparison Charts</i>
IFS	<i>International Index of Welding Filler Metal Classifications</i>
UGFM	<i>User's Guide to Filler Metals</i>
A4.2M/A4.2	<i>Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal</i>
A4.3	<i>Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding</i>
A4.4M	<i>Standard Procedures for Determination of Moisture Content of Welding Fluxes and Welding Electrode Flux Coverings</i>
A5.01	<i>Filler Metal Procurement Guidelines</i>
A5.1/A5.1M	<i>Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding</i>
A5.2	<i>Specification for Carbon and Low Alloy Steel Rods for Oxyfuel Gas Welding</i>
A5.3/A5.3M	<i>Specification for Aluminum and Aluminum-Alloy Electrodes for Shielded Metal Arc Welding</i>
A5.4	<i>Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding</i>
A5.5	<i>Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding</i>
A5.6	<i>Specification for Covered Copper and Copper Alloy Arc Welding Electrodes</i>
A5.7	<i>Specification for Copper and Copper Alloy Bare Welding Rods and Electrodes</i>
A5.8/A5.8M	<i>Specification for Filler Metals for Brazing and Braze Welding</i>
A5.9	<i>Specification for Bare Stainless Steel Welding Electrodes and Rods</i>
A5.10/A5.10M	<i>Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods</i>
A5.11/A5.11M	<i>Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding</i>
A5.12/A5.12M	<i>Specification for Tungsten and Tungsten-Alloy Electrodes for Arc Welding and Cutting</i>
A5.13	<i>Specification for Surfacing Electrodes for Shielded Metal Arc Welding</i>
A5.14/A5.14M	<i>Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods</i>
A5.15	<i>Specification for Welding Electrodes and Rods for Cast Iron</i>
A5.16/A5.16M	<i>Specification for Titanium and Titanium Alloy Welding Electrodes and Rods</i>
A5.17/A5.17M	<i>Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding</i>
A5.18/A5.18M	<i>Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding</i>
A5.19	<i>Specification for Magnesium Alloy Welding Electrodes and Rods</i>
A5.20/A5.20M	<i>Specification for Carbon Steel Electrodes for Flux Cored Arc Welding</i>
A5.21	<i>Specification for Bare Electrodes and Rods for Surfacing</i>
A5.22	<i>Specification for Stainless Steel Electrodes for Flux Cored Arc Welding and Stainless Steel Flux Cored Rods for Gas Tungsten Arc Welding</i>
A5.23/A5.23M	<i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i>
A5.24/A5.24M	<i>Specification for Zirconium and Zirconium Alloy Welding Electrodes and Rods</i>
A5.25/A5.25M	<i>Specification for Carbon and Low-Alloy Steel Electrodes and Fluxes for Electroslag Welding</i>
A5.26/A5.26M	<i>Specification for Carbon and Low-Alloy Steel Electrodes for Electrode Gas Welding</i>
A5.28/A5.28M	<i>Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding</i>
A5.29/A5.29M	<i>Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding</i>
A5.30	<i>Specification for Consumable Inserts</i>
A5.31	<i>Specification for Fluxes for Brazing and Braze Welding</i>
A5.32/A5.32M	<i>Specification for Welding Shielding Gases</i>

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