AWS A5.29/A5.29M:2010
An American National Standard

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

American Welding Society

Approved American National Standard
ANSI

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Approved by the
American National Standards Institute
September 18, 2009

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

4th Edition

Supersedes AWS A5.29/A5.29M:2005

Prepared by the
American Welding Society (AWS) A5 Committee on Filler Metals and Allied Materials

Under the Direction of the
AWS Technical Activities Committee

Approved by the
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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International Standard Book Number: 978-0-87171-766-5
American Welding Society
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Foreword

This foreword is not part of AWS A5.29/A5.29M:2010, *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*, but is included for informational purposes only.

This document is the second 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 materials—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 third revision of A5.29 that was issued initially in 1980. In this revision, the quantity of "Mn + Ni" has been corrected from 1.5% to 1.50% in Note "d" of Table 7.

Historical Background

NSI/AWS A5.29-80	*Specification for Low-Alloy Steel Electrodes for Flux Cored Are Welding*
NSI/AWS A5.29:1998	*Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*
WS A5.29/A5.29M:2005	*Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*

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

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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 Z49.1[2] and applicable federal and ate regulations.

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

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*.

[1] AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.
[2] This ANSI standard is published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

2.3 The following ASTM standards[3] 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 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 eel, Ingot Iron, and Wrought Iron*

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

4 The following MIL standards[4] 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 standard[5] is referenced in the mandatory sections of this document:

(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,

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

[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 Varembé, Case postale 56, CH-1211 Geneva 20, Switzerland.

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,[f] -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,[f] -Ni3M[f]	PWHT	80–100	68 min.	19	20 ft·lbf @ –100°F
E9XT5-Ni3C,[f] -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

(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
E7XT11-K2	AW	70–90	58 min.	20	20 ft·lbf @ +32°F
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
12XT1-K5C, -K5M	AW	120–140	108 min.	14	Not Specified
7XT5-K6C, -K6M	AW	70–90	58 min.	20	20 ft·lbf @ –75°F
6XT8-K6	AW	60–80	50 min.	22	20 ft·lbf @ –20°F
7XT8-K6	AW	70–90	58 min.	20	20 ft·lbf @ –20°F
10XT1-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.				

[a] The "Xs" in actual classification will be replaced with the appropriate designators. See Figure1.
[b] The placement of a "G" in a designator position indicates that those properties have been agreed upon between the supplier and purchaser.
[c] AW = As Welded. PWHT = Postweld heat treated in accordance with Table 6 and 9.4.1.2.
[d] 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.
[e] 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.
[f] PWHT temperatures in excess of 1150°F will decrease the Charpy V-Notch impact properties.
[g] For this classification (E10XT1-K9C, -K9M) the tensile strength range shown is not a requirement. It is an approximation.
[h] 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.

(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% CO_2 (AWS A5.32 Class SG-C) shielding gas ("C" designator) and with a 75 to 80% argon/balance CO_2 (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 ystem of Units (SI). Electrodes classified under either classification system must meet all requirements for classifica- on under that system. The classification system is shown in Figure 1.

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

4. Acceptance

Acceptance[6] of the welding electrodes shall be in accordance with the provisions of AWS A5.01.

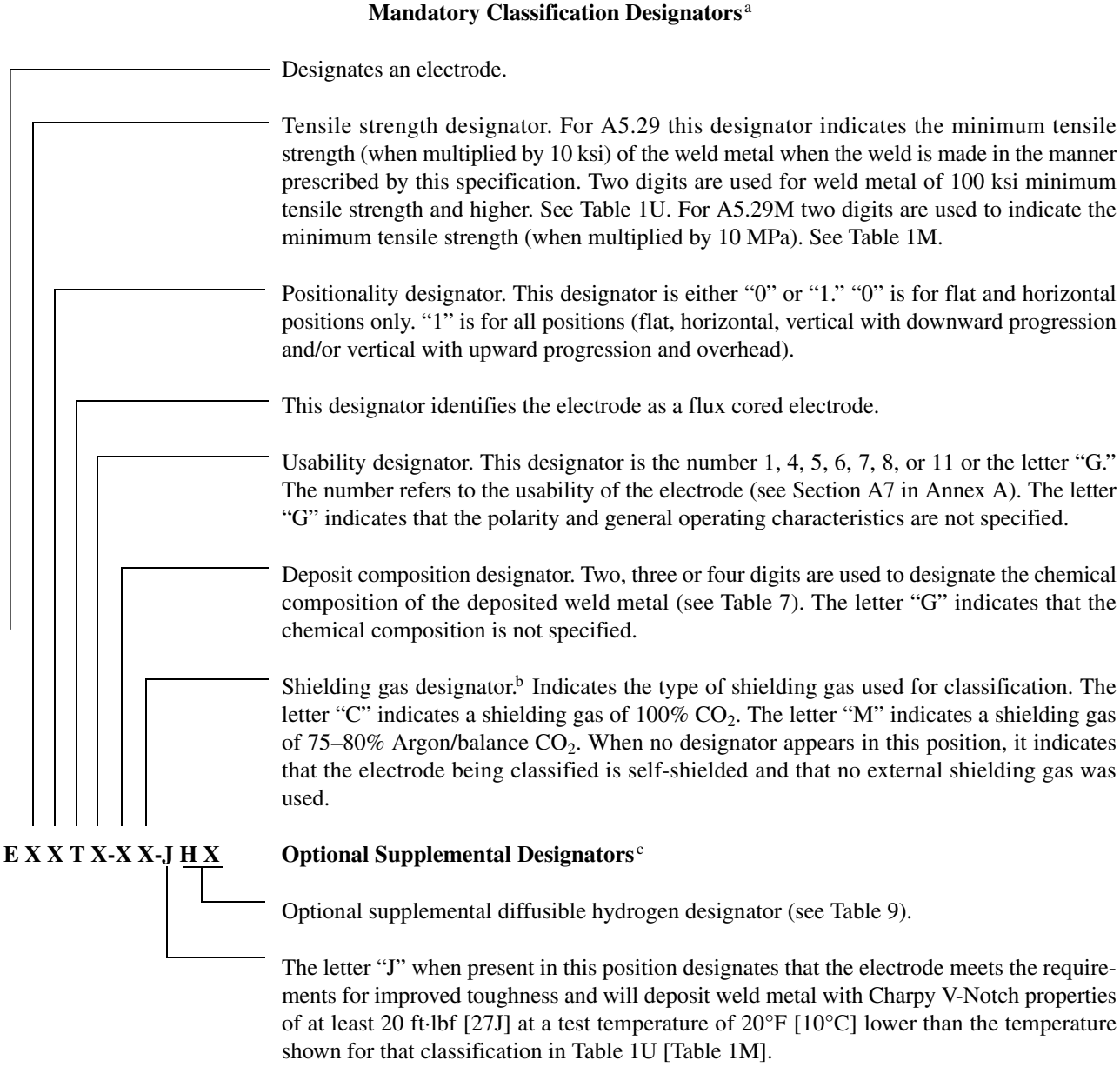
5. Certification

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 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.

[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.



[a] 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.

[b] See AWS A5.32/A5.32M, *Specification for Welding Shielding Gases*.

[c] These designators are optional and do not constitute a part of the flux cored electrode classification.

Source: Figure 1 of AWS A5.29/A5.29M:2005 (ERRATA/REPRINT)

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

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
62XT1-B9C, -B9M	PWHT	620–830	540 min.	16	Not Specified
43XT1-Ni1C, -Ni1M	AW	430–550	340 min.	22	27 Joules @ –30°C
49XT6-Ni1	AW	490–620	400 min.	20	27 Joules @ –30°C
49XT8-Ni1	AW	490–620	400 min.	20	27 Joules @ –30°C
55XT1-Ni1C, -Ni1M	AW	550–690	470 min.	19	27 Joules @ –30°C
55XT5-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
49XT5-K6C, -K6M	AW	490–620	400 min.	20	27 Joules @ –60°C
43XT8-K6	AW	430–550	340 min.	22	27 Joules @ –30°C
49XT8-K6	AW	490–620	400 min.	20	27 Joules @ –30°C
69XT1-K7C, -K7M	AW	690–830	610 min.	16	27 Joules @ –50°C
62XT8-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.				

[a] The "Xs" in actual classification will be replaced with the appropriate designators. See Figure1.
[b] The placement of a "G" in a designator position indicates that those properties have been agreed upon between the supplier and purchaser.
[c] AW = As Welded. PWHT = Postweld heat treated in accordance with Table 6 and 9.4.1.2.
[d] 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.
[e] PWHT temperatures in excess of 620°C will decrease the Charpy V-Notch impact properties.
[f] For this classification (E69XT1-K9C, -K9M) the tensile strength range shown is not a requirement. It is an approximation.
[g] 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.

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	

[a] H = horizontal position, F = flat position, OH = overhead position, VU = vertical position with upward progression, VD = vertical position with downward progression.

[b] 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.

[c] 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.

[d] The term "DCEP" refers to direct current electrode positive (dc, reverse polarity). The term "DCEN" refers to direct current electrode negative (dc, straight polarity).

[e] M = suitable for use on either single or multiple pass applications.

[f] 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.

[g] The polarity for electrodes with usability designators for other than G is as prescribed for those designators in this table.

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).

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 all be considered invalid, without regard to whether the test was actually completed or whether test results met, or iled to meet, the test requirement. That test shall be repeated, following proper specified procedures. In this case, the quirement for doubling the number of test specimens does not apply.

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]

[a] The Charpy V-Notch impact test is required when the classification requires minimum impact properties as specified in Table 1U [Table 1M].
[b] 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.
[c] The groove weld for this classification shall be welded in the vertical position with upward progression. See A7.9.4.9 in Annex A.
[d] As agreed upon between supplier and purchaser.

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:

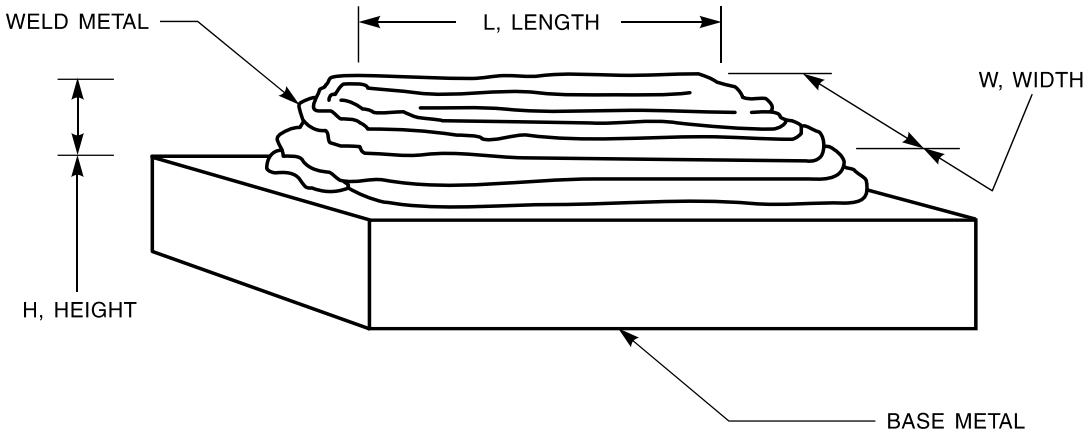
(1) The weld pad in Figure 2 for chemical analysis of the weld metal,

(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.

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.

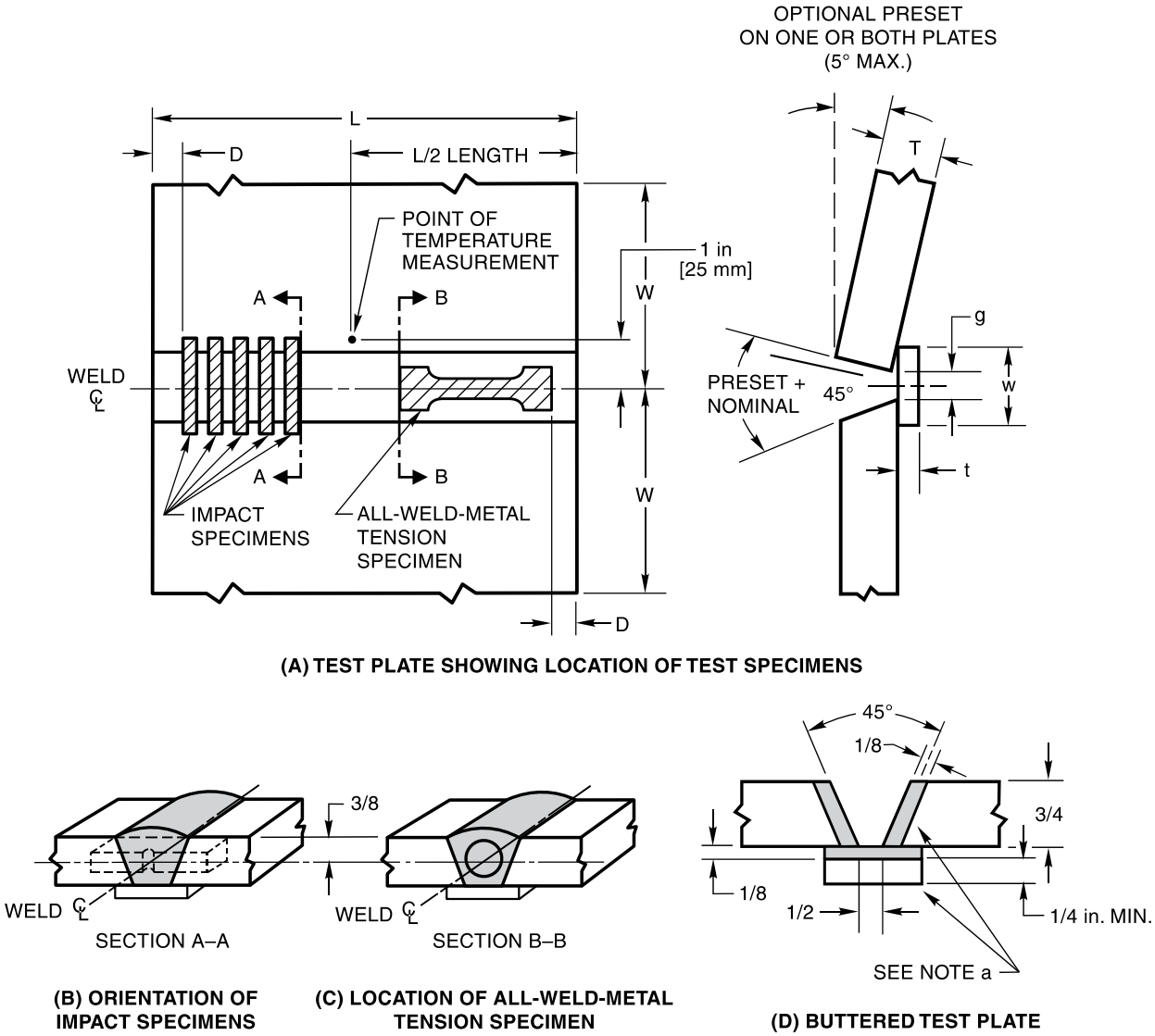


WELD PAD SIZE, MINIMUM					
Length, L		Width, W		Height, H	
in	mm	in	mm	in.	mm
1-1/2	38	1/2	12	1/2	12

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.

Source: Figure 2 of AWS A5.29/A5.29M:2005 (ERRATA/REPRINT).

Figure 2—Pad for Chemical Analysis of Deposited Weld Metal



(A) TEST PLATE SHOWING LOCATION OF TEST SPECIMENS

(B) ORIENTATION OF IMPACT SPECIMENS

(C) LOCATION OF ALL-WELD-METAL TENSION SPECIMEN

(D) BUTTERED TEST PLATE

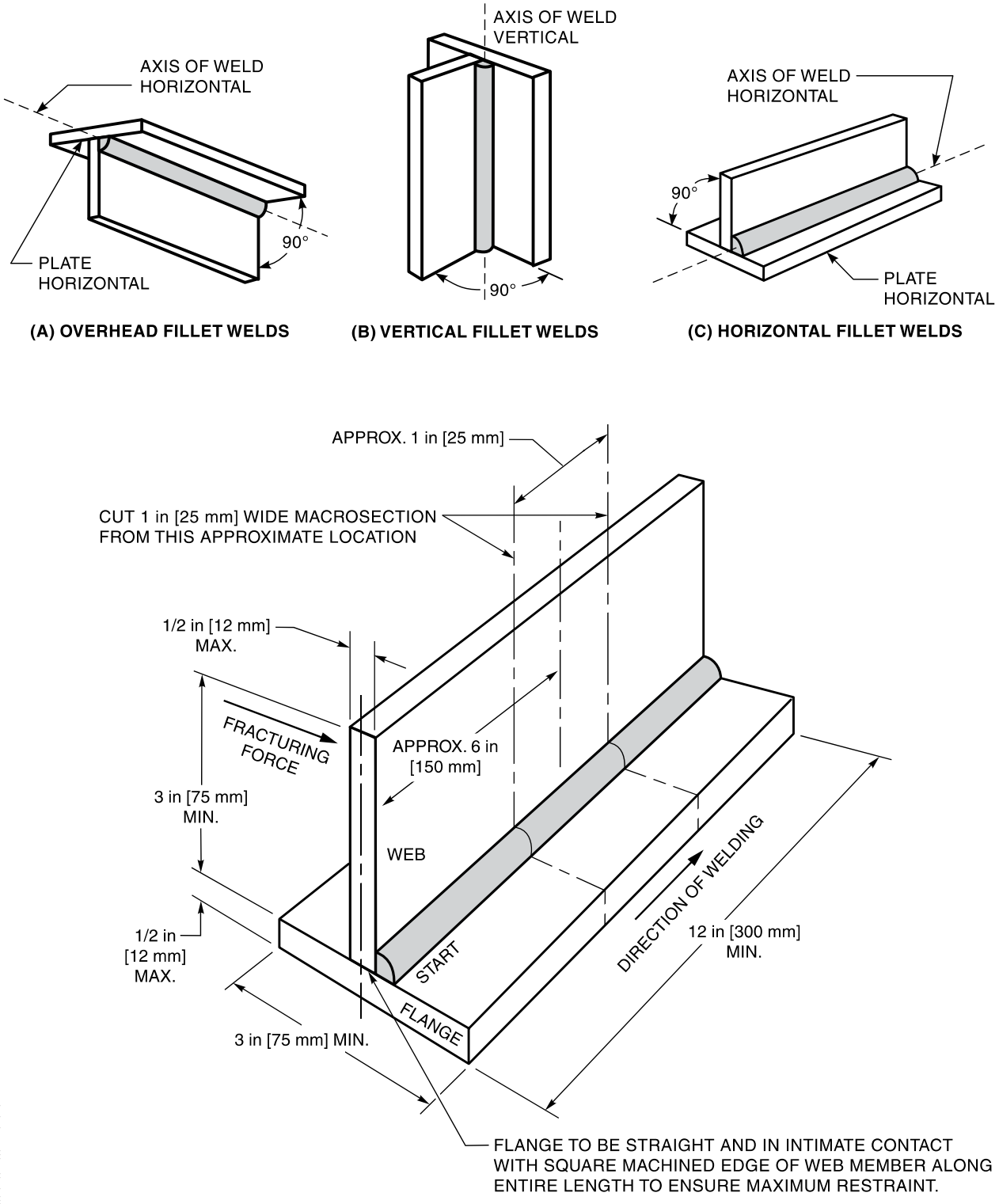
L Test Plate Length (min.)	W Test Plate Width (min.)	T Test Plate Thickness	D Discard (min.)	l Bevel Angle	g Root Opening	w Backup Width (min.)	t Backup Thickness (min.)	M Buttered Layer (min.)
10 in [250 mm]	6 in [150 mm]	3/4 ± 1/32 in [20 ± 1 mm]	1 in [25 mm]	22.5° ± 2°	1/2 – 0 in, + 1/16 in [12 –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

[a] 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.

Note: 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.

Source: Figure 3 of AWS A5.29/A5.29M:2005 (ERRATA/REPRINT).

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



Source: Figure 4 of AWS A5.29/A5.29M:2005 (ERRATA/REPRINT).

Figure 4—Fillet Weld Test Assembly

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
1, 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]	—
2, K6, K8	A 537, Class 1 or 2	K12437
V2	A 588, Grade A	K11430
	A 588, Grade B	K12043
	A 588, Grade C	K11538

[a] 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.
[b] Buttering of the groove weld in Figure 3 is not required when using A 36 or A 285 base metals when testing EXXT4-X, EXXT6-X, EXXT7-X, EXXT8-X, and EXXT11-X electrodes with 70 ksi [490 MPa] or lower classification.
[c] 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.
[d] The use of non-buttered ASTM A 36 or A 285 base metal is permitted for the fillet weld test.
[e] SAE/ASTM Unified Numbering System for Metals and Alloys.
[f] Buttering is not allowed for the K9 weld metal designation.
[g] According to MIL-S-16216 or NAVSEA Technical Publication T9074-BD-GIB-010/0300, Appendix B.
[h] According to MIL-S-24645 or NAVSEA Technical Publication T9074-BD-GIB-010/0300, Appendix A.

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.

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

[a] The calculation to be used for heat input is:

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

or

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

[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.

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 a). 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.

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
ll Classifications with B1, B1L, B2, B2L, B2H, B3, B3L, or 3H Weld Metal Designations	350 ± 25°F	175 ± 15°C	1275 ± 25°F	690 ± 15°C
ll Classifications with B6, B6L, B8, or B8L Weld Metal esignations	400 ± 100°F	200 ± 50°C	1375 ± 25°F[d]	745 ± 15°C[d]
9XT1-B9C, -B9M [E62XT1-B9C, -B9M]	500 ± 100°F	260 ± 50°C	1400 ± 25°F[d]	760 ± 15°C[d]
ll 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]			

[a] 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.
[b] 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.
[c] PWHT temperature in excess of 1150°F [620°C] will decrease Charpy V-Notch impact strength.
[d] Held at specified temperature for two hours –0 +15 minutes.
[e] See Table 1U [Table 1M], Note b.

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 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.

0. Chemical Analysis

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

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 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,

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[e]	—	—	0.50[f]	0.030	0.030	1.00	0.50[f]	0.30[f]	0.20[f]	0.10[f]	1.8[c]	—	—

[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 = 1.50% 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.