AWS A5.36/A5.36M:2012
An American National Standard

Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal Arc Welding

American Welding Society®

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An American National Standard

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Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal Arc Welding

1st Edition

Supersedes AWS A5.20/A5.20M:2005 and 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 carbon and low-alloy steel flux cored electrodes for flux cored arc welding and metal cored electrodes for gas metal 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 diffusible hydrogen and to indicate conformance to special mechanical property requirements when the weld metal is deposited using low heat input, fast cooling rate and high heat input, slow cooling rate procedures. Additional requirements are included or referenced 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 carbon and low-alloy steel flux cored and metal 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 part of AWS A5.36/A5.36M:2012, *Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal Arc Welding*, but is included for informational purposes only.

This specification combines the two specifications previously issued by the American Welding Society for the classification of carbon and low-alloy steel flux cored electrodes (AWS A5.20/A5.20M, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*, and AWS A5.29/A5.29M, *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*). In addition, this specification includes provisions for the classification of carbon and low-alloy steel metal cored electrodes. Heretofore, carbon steel metal cored electrodes were classified under AWS A5.18/A5.18M, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding,* and low-alloy steel metal cored electrodes were classified under A5.28/A5.28M, *Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*. The user should be advised that the requirements for low-alloy metal cored electrodes classified under this specification may vary somewhat from those prescribed in AWS A5.28/A5.28M. This document uses 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 544, *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 new AWS A5.36/A5.36M specification utilizes two classification systems. The first of these is a "fixed classification system" which has been carried over to this specification from AWS A5.20/A5.20M or AWS A5.18/A5.18M, as applicable, for the classification of those carbon steel flux cored electrodes or carbon steel metal cored electrodes which, with the specific mechanical properties specified for them in AWS A5.20/A5.20M or AWS A5.18/A5.18M, have gained wide acceptance for single and multiple pass applications. The classification designations and requirements for these specific electrodes are unchanged from those previously specified in AWS A5.20/A5.20M or AWS A5.18/A5.18M. A listing of these electrodes with their requirements is given in Table 1.

This AWS A5.36/A5.36M specification also utilizes a new, "open classification system" which is introduced in this document for the classification of carbon and low-alloy steel flux cored and metal cored electrodes. The open classification system uses designators to indicate electrode type (Usability Designator), welding position capability, tensile strength, impact strength, shielding gas (with more options and new designations), condition of heat treatment, if any, and weld deposit composition. The change to an open classification system is being made to allow for the classification of flux cored and metal cored electrodes with classification options which (1) better define the performance capabilities of the advanced electrode designs that have been developed, and (2) reflect the application requirements of today's marketplace. In addition, the provision has been made in this document for the classification of metal cored electrodes (usability Designator T15) and two new electrode types (Usability Designators T16 and T17) for the classification of metal cored and flux cored electrodes designed for use with AC power sources with or without modified waveforms. The EXXT-2X classification has been discontinued. E lectrodes previously classified as E XXT-2X can now be classified under the new open classification system without requiring a unique "2" Usability Designator. The EXXT-13 electrode classification has been discontinued due to lack of commercial significance. For a complete listing of the affected existing electrode classifications and the corresponding equivalent classifications using the open classification system under AWS A5.36/A5.36M, refer to A9 in Annex A.

Two additional changes to note are (1) the fillet weld test, previously required under AWS A5.20/A5.20M and AWS A5.29/A5.29M (and also detailed in ISO 15792-3) is not a required test under AWS A5.36/A5.36M, and (2) the preheat

and interpass temperature requirements for the "D" optional, supplemental designator have been modified for better agreement with AWS D1.8/D1.8M, *Structural Welding Code—Seismic Supplement*

The A5.20/A5.20M:2005 specification being replaced is the fourth revision of the joint ASTM/AWS A5.20 document first issued in 1969. The A5.29/A5.29M:2005 specification being replaced is the third revision of AWS A5.29 that was introduced in 1980. The historical progressions of these two documents appear below:

Historical Background

AWS A5.20-69 ANSI W3.20-1973	*Specifications for Mild Steel Electrodes for Flux Cored Arc Welding*
ANSI/AWS A5.20-79	*Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*
ANSI/AWS A5.20-95	*Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*
AWS A5.20/A5.20M:2005	*Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*
ANSI/AWS A5.29-80	*Specification for Low-Alloy Steel Electrodes for Flux Cored Are Welding*
ANSI/AWS A5.29: 1998	*Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*
AWS A5.29/A5.29M:2005	*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.

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Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal Arc Welding

1. Scope

1.1 This specification prescribes requirements for the classification of carbon and low-alloy steel flux cored electrodes for flux cored arc welding (FCAW), either with or without shielding gas, and carbon and low-alloy steel metal cored electrodes for gas metal arc welding (GMAW). This new specification replaces both AWS A5.20/A5.20M, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*, and AWS A5.29/A5.29M, *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*. It also includes provisions for the classification of carbon and low-alloy steel metal cored electrodes which previously had been classified according to AWS A5.18/A5.18M, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*, or AWS A5.28/A5.28M, *Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*, as applicable. Iron is the only element of the undiluted weld metal deposited by the electrodes classified under this specification whose content exceeds 10.5%.

1.2 Safety issues and concerns are addressed in this standard, although health issues and concerns are beyond the scope of this standard. Some safety and health information can be found in nonmandatory Annex A, Clauses A5 and A10. Safety and health information is available from other sources, including, but not limited to, ANSI Z49.1 [1] 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 A5.36 uses U.S. Customary Units. The specification A5.36M uses the International System of Units (SI). 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 A5.36 and A5.36M 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 [2] are referenced in the mandatory sections of this document:

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

(2) AWS A3.0M/A3.0, *Standard Welding Terms and Definitions*

[1] ANSI Z49.1 is published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.
[2] AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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

(4) AWS A5.01M/A5.01 (ISO 14344 MOD), *Procurement Guidelines for Consumables—Welding and Allied Processes—Flux and Gas Shielded Electrical Welding Processes*

(5) AWS A5.02/A5.02M, *Specification for Filler Metal Standard Sizes, Packaging, and Physical Attributes*

(6) AWS A5.18/A5.18M, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*

(7) AWS A5.20/A5.20M, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*

(8) AWS A5.28/A5.28M, *Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*

(9) AWS A5.29/A5.29M, *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*

(10) AWS A5.32M/A5.32 (ISO 14175 MOD), *Welding Consumables—Gases and Gas Mixtures for Fusion Welding and Allied Processes*

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

(12) AWS D1.8/D1.8M, *Structural Welding Code—Seismic Supplement*

2.2 The following ASME standard [3] is referenced in the mandatory sections of this document:

(1) *ASME Boiler and Pressure Vessel Code*, Section IX, Welding and Brazing Qualifications

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

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

2.4 The following ASTM standards [4] are referenced in the mandatory sections of this document:

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

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

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

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

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

(6) ASTM A 506/A 506M, *Standard Specification for Alloy and Structural Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled*

(7) ASTM A 507/A 507M, *Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled*

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

(9) ASTM A 515/A 515M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service*

(10) ASTM A 516/A 516M, *Standard Specification for Pressure Vessel Plates, Carbon steel for Moderate- and Lower-Temperature Service*

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

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[3] ASME standards are available from ASME. 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.
[4] ASTM standards are published by the ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

(12) ASTM A 572/A 572M, *Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel*

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

(14) ASTM A 830/A 830M, *Standard Specification for Plates, Carbon Steel, Structural Quality, Furnished to Chemical Composition Requirements*

(15) ASTM A 913/A 913M, *Standard Specification for High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST)*

(16) ASTM A 992/A 992M, *Standard Specification for Structural Steel Shapes*

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

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

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

2.5 The following FEMA standard [5] is referenced in the mandatory section of this document.

(1) FEMA 353, *Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications*

2.6 The following MIL standards [6] 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*

2.7 The following ISO standard [7] is referenced in the mandatory sections of this document.

(1) ISO 80000-1, *Quantities and units — Part 1: General*

3. Classification

3.1 This new A5.36/A5.36M specification utilizes two classification systems. The first of these is a "fixed classification" system which has been carried over to this specification from AWS A5.20/A5.20M or from AWS A5.18/A5.18M, as applicable, for the classification of those carbon steel flux cored or metal cored electrodes which, with the specific mechanical properties specified for them in A5.20/A5.20M or A5.18/A5.18M, have gained wide acceptance for single pass and multiple pass applications. See Table 1 for a list of those classifications and the applicable requirements. The second classification system is an "open classification" system which is introduced with this specification for the classification of carbon and low-alloy steel flux cored electrodes and carbon and low-alloy steel metal cored electrodes. This open classification system provides the flexibility to classify an expanded number of electrode types with a variety of shielding gases (if any) to different requirements for strength, impact properties, weld metal composition, and condition of heat treatment.

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[5] FEMA documents are published for Federal Emergency Management Agency, and can be searched and downloaded for free from Internet. www.fema.gov.

[6] For inquiries regarding MIL-S-16216 and MIL-S-24645 refer to internet website: http://assist.daps.dla.mil/online. NAVSEA Technical Publication T9074-BD-GIB-010/0300 may be obtained from the Naval Inventory Control Point, 700 Robins Avenue, Philadelphia, PA 19111-5094, or may be downloaded from http://ntpdb.ddlomni.com.

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

Table 1
Electrode Classifications with Fixed Requirements [a]

Source Specification for Electrode Classification & Requirements	Classification Designation [b, c]	Electrode Type	Shielding Gas [d]	Weld Deposit Requirements	
				Mechanical Properties [e]	Weld Deposit [f]
AWS A5.20/A5.20M	E7XT-1C [g]	Flux Cored	C1	Tensile Strength: 70 ksi–95 ksi Minimum Yield Strength: 58 ksi [i] Min. Charpy Impact: 20 ft·lbf @ 0°F Minimum % Elongation: 22% [j]	CS1
	E7XT-1M [g]		M21		
	E7XT-5C [g]		C1	Tensile Strength: 70 ksi–95 ksi Minimum Yield Strength: 58 ksi [i] Min. Charpy Impact: 20 ft·lbf @ –20°F Minimum % Elongation: 22% [j]	CS1
	E7XT-5M [g]		M21		
	E7XT-6 [g]		None		CS3
	E7XT-8 [g]				
	E7XT-9C [g]		C1		CS1
	E7XT-9M [g]		M21		
	E7XT-12C [g]		C1	Tensile Strength: 70 ksi–90 ksi Minimum Yield Strength: 58 ksi [i] Min. Charpy Impact: 20 ft·lbf @ –20°F Minimum % Elongation: 22% [j]	CS2
	E7XT-12M [g]		M21		
	E70T-4 [g]		None	Tensile Strength: 70 ksi–95 ksi Minimum Yield Strength: 58 ksi [i] Min. Charpy Impact: Not Specified Minimum % Elongation: 22% [j]	CS3
	E7XT-7 [g]				
AWS A5.18/A5.18M	E70C-6M [h]	Metal Cored	M21	Tensile Strength: 70 ksi minimum Minimum Yield Strength: 58 ksi [i] Min. Charpy Impact: 20 ft·lbf @ –20°F Minimum % Elongation: 22% [j]	CS1

[a] These multiple pass electrodes are classified according to the fixed classification system utilized in AWS A5.20/A5.20M or A5.18/A5.18M, as applicable, which has been carried over for these specific electrodes as a part of AWS A5.36/A5.36M. The mechanical property and weld deposit requirements are as defined in this table. These same electrodes may also be classified to the same requirements or to different requirements using the open classification system introduced in this specification. In this case, the classification designations are as prescribed in Figure 1. See Table A.1 or Table A.3, as applicable, in Annex A for comparisons of the "fixed classification" designations and equivalent "open classification" designations for the above electrodes when both are classified to the requirements listed in this table.

[b] Under AWS A5.20/A5.20M, the "E" at the beginning of the classification designates an electrode. The "7" is the tensile strength designator. The "X" indicates the electrode's position of welding capability. A "0" is used to indicate flat and horizontal only. A "1" is used to indicate all position capability. The "T" identifies the electrode as a flux cored electrode The one or two digit number after the dash indicates the electrode's usability characteristics as defined in AWS A5.20/A5.20M. For the open classification system introduced in this A5.36/A5.36M specification, the "T" identifies the electrode as either a flux cored or a metal cored electrode. The "T" is combined with a one or two digit number as a part of the alpha-numeric designator for usability. See Table 4. Under AWS A5.18/A5.18M for classification E70C-6M, the "E" designates an electrode. The "70" indicates that the weld deposit will have a minimum tensile strength of 70 ksi. The "C" indicates that the electrode is a composite (metal cored) electrode. The "6" indicates the composition of the weld deposit produced with this electrode. The "M" indicates the type of shielding gas used.

[c] The electrodes shown in the shaded panels are self shielded.

[d] See Table 5.

[e] Mechanical properties are obtained by testing weld metal from the groove weld shown in Figure 2. Welding and testing shall be done as prescribed in this specification. The requirements for welding and testing are the same as those given in A5.20/A5.20M. All mechanical property testing for the classifications listed in this table shall be done in the as-welded condition.

[f] See Table 6.

[g] The "D," "Q," and "H" optional designators, which are not part of the electrode classification designation, may be added to the end of the designation as established in AWS A5.20/A5.20M, i.e., E7XT-XXD, E 7XT-XXQ, E7XT-XXHX, E 7XT-XXDHX, or E7XT-XXQHX, as applicable. The "J" optional, supplemental designator listed in A5.20/A5.20M is no longer required. The open classification system introduced in this A5.36/A5.36M specification eliminates the need for this designator.

[h] The "H" optional, supplemental designator, which is not part of the electrode classification designation, may be added to the end of the designation as established in AWS A5.18/A5.18M, i.e., E70C-6MHZ. Provisions for the "D" and "Q" optional, supplemental designators have not been established in A5.18/A5.18M and, as a result, may not be used with the E70C-6M designation. However, that does not preclude their use with metal core electrodes classified utilizing the open classification system under the A5.36/A5.36M specification.

[i] Yield strength at 0.2% offset.

[j] Percent elongation is in 2 in [50 mm] gage length when a 0.500 in [12 mm] nominal diameter tensile specimen and nominal gage length to diameter ratio of 4:1 is used.

The flux cored and metal cored electrodes covered by the A5.36 specification utilize a classification system based upon U.S. Customary Units. Electrodes covered by the A5.36M specification utilize a system based upon the International System of Units (SI). Under these specifications, flux cored and metal cored electrodes can be classified for multiple pass welding or for single pass welding. The groove weld test assembly shown in Figure 2 is used for the classification of multiple pass electrodes. The two-run butt weld test assembly shown in Figure 3 is used for the classification of single pass electrodes.

3.1.1 The flux cored electrodes classified utilizing the "fixed classification" system are classified for multiple pass welding based upon the following:

(1) The as-welded mechanical properties of the weld metal obtained with a particular shielding gas, if any, as specified in Table 1.

(2) The positions of welding for which the electrode is suitable, as indicated in Note b of Table 1.

(3) Certain usability characteristics of the electrode (including the presence or absence of a shielding gas). Refer to Note b of Table 1 and to Table 4.

3.1.2 The flux cored and metal cored electrodes classified utilizing the "open classification" system are classified based upon the following:

(1) The mechanical properties of the weld metal, as specified in Table 2, Table 3, and Table 7.

(2) The positions of welding for which the electrodes are suitable.

(3) Certain usability characteristics of the electrode (including the presence or absence of a shielding gas), as specified in Table 4.

(4) The nominal composition of the shielding gas used, if any, as specified in Table 5.

(5) The condition of postweld heat treatment, if any, as specified in Table 8.

(6) Chemical composition of the weld metal as specified in Table 6.

3.2 Electrodes classified under one classification shall not be classified under any other classification in this specification with the exception of the following:

(1) Electrodes may be classified utilizing the "fixed classification" system as indicated in Table 1 (if applicable), or utilizing the "open classification system," or both. Refer to Table A.1 or Table A.3, as applicable, in Annex A.

(2) Electrodes may be classified using different shielding gases. Refer to Table 5.

(3) Electrodes may be classified both in the as-welded and in the postweld heat treated (PWHT) conditions.

(4) Electrodes may be classified under A5.36 using U.S. Customary Units, or under A5.36M using the International System of Units (SI), or both. Standard dimensions based on either system may be used for sizing of electrodes or packaging, or both, under the A5.36 and A5.36M specifications. Electrodes classified under either A5.36 or A5.36M must meet all requirements for classification under that unit system. See Figure 1.

3.3 It is recognized that the documentation required by manufacturers, end users, and code bodies to transition from the classification of flux cored and metal cored electrodes from their previous classifications under AWS A5.20/A5.20M, AWS A5.29/A5.29M, AWS A5.18/A5.18M, or AWS A5.28/A2.28M, as applicable, to their new classification designations under AWS A5.36/A5.36M requires a provision for a transition period. Therefore, flux cored electrodes may be classified under AWS A5.20/A5.20M (or AWS A5.29/A5.29M, as applicable), under AWS A5.36/A5.36M, or under both. Metal cored electrodes may be classified under AWS A5.18/A5.18M (or AWS A5.28/A5.28M, as applicable), under AWS A5.36/A5.36M, or under both. Manufacturers, at their option, may list both electrode classifications on the labels and packaging. The provision for dual classification provided in this clause expires at the end of year 2015. At that time classification to AWS A5.36/A5.36M is required.

Table 2
Tension Test Requirements

Tensile Strength Designator		Single Pass Electrodes	For A5.36 Multiple Pass Electrodes U.S. Customary Units			For A5.36M Multiple Pass Electrodes International System of Units (SI)		
U.S. Customary Units	International System of Units (SI)	Minimum Tensile Strength ksi [MPa]	Tensile Strength (ksi)	Minimum Yield Strength [a] (ksi)	Minimum Percent Elongation [b]	Tensile Strength [MPa]	Minimum Yield Strength [a] [MPa]	Minimum Percent Elongation [b]
6	43	60 [430]	60–80	48	22	430–550	330	22
7	49	70 [490]	70–95	58	22	490–660	400	22
8	55	80 [550]	80–100	68	19	550–690	470	19
9	62	90 [620]	90–110	78	17	620–760	540	17
10	69	100 [690]	100–120	88	16	690–830	610	16
11	76	110 [760]	110–130	98	15[c]	760–900	680	15[c]
12	83	120 [830]	120–140	108	14[c]	830–970	740	14[c]
13	90	130 [900]	130–150	118	14[c]	900–1040	810	14[c]

[a] Yield strength at 0.2% offset.

[b] In 2 in [50 mm] gage length when a 0.500 in [12.5 mm] nominal diameter tensile specimen and nominal gage length to diameter ratio of 4:1 (as specified in the Tension Test section of AWS B4.0) is used. In 1 in [25 mm] gage length when a 0.250 in [6.5 mm] nominal tensile specimen is used as permitted for 0.045 in [1.2 mm] and smaller sizes of the E7XT11-AZ-CS3 [E49XT11-AZ-CS3].

[c] Elongation requirement may be reduced by one percentage point if the tensile strength of the weld metal is in the upper 25% of the tensile strength range.

Table 3
Charpy Impact Test Requirements

A5.36 Requirements U.S. Customary Units			A5.36M Requirements International System of Units (SI)		
Impact Designator [a, b]	Maximum Test Temperature [c, d] (°F)	Minimum Average Energy Level	Impact Designator [a, b]	Maximum Test Temperature [c, d] (°C)	Minimum Average Energy Level
Y	+68	20 ft·lbf	Y	+20	27 J
0	0		0	0	
2	–20		2	–20	
4	–40		3	–30	
5	–50		4	–40	
6	–60		5	–50	
8	–80		6	–60	
10	–100		7	–70	
15	–150		10	–100	
Z	No Impact Requirements		Z	No Impact Requirements	
G	As agreed between supplier and purchaser				

[a] Based on the results of the impact tests of the weld metal, the manufacturer shall insert in the classification the appropriate designator from Table 3 above, as indicated in Figure 1.

[b] When classifying an electrode to A5.36 using U.S. Customary Units, the Impact Designator indicates the maximum impact test temperature in degrees Fahrenheit. When classifying to A5.36M using the International System of Units (SI), the Impact Designator indicates the maximum impact test temperature in degrees Celsius. With the exception of the Impact Designator "4," a given Impact Designator will indicate different temperatures depending upon whether classification is according to A5.36 in U.S. Customary Units or according to A5.36M in the International System of Units (SI). For example, a "2" Impact Designator when classifying to A5.36 indicates a test temperature of –20°F. When classifying to A5.36M, the "2" Impact Designator indicates a test temperature of –20°C, which is –4°F.

[c] Weld metal from an electrode that meets the impact requirements at a given temperature also meets the requirements at all higher temperatures in this table. For example, weld metal meeting the A5.36 requirements for designator "5" also meets the requirements for designators 4, 2, 0, and Y . [Weld metal meeting the A5.36M requirements for designator "5" also meets the requirements for designators 4, 3, 2, 0, and Y .]

[d] Filler metal classification testing to demonstrate conformance to a specified minimum acceptable level for impact testing, i.e., minimum energy at specified temperature, can be met by testing and meeting the minimum energy requirement at any lower temperature. In these cases, the actual temperature used for testing shall be listed on the certification documentation when issued.

Table 4
Electrode Usability Characteristics

Electrode Usability Designator [a]	Process	General Description of Electrode Type [b, c]	Typical Positions of Welding [d, e]	Polarity [f]
T1	FCAW-G	Flux cored electrodes of this type are gas shielded and have a rutile base slag. They are characterized by a spray transfer, low spatter loss, and a moderate volume of slag which completely covers the weld bead.	H, F, VU, & OH	DCEP
T1S	FCAW-G	Flux cored electrodes of this type are similar to the "T1" type electrodes but with higher manganese or silicon, or both. They are designed primarily for single pass welding in the flat and horizontal positions. The higher levels of deoxidizers in this electrode type allow single pass welding of heavily oxidized or rimmed steel.	H, F, VU, & OH	DCEP
T3S	FCAW-S	Flux cored electrodes of this type are self shielded and are intended for single pass welding and are characterized by a spray type transfer. The titanium-based slag system is designed to make very high welding speeds possible.	H, F	DCEP
T4	FCAW-S	Flux cored electrodes of this type are self shielded and are characterized by a globular type transfer. Its fluoride-based basic slag system is designed to make very high deposition rates possible and to produce very low sulfur welds for improved resistance to hot cracking.	H, F	DCEP
T5	FCAW-G	Flux cored electrodes of this type are gas shielded and are characterized by a globular transfer, slightly convex bead contour, and a thin slag that may not completely cover the weld bead. They have a lime-fluoride slag system and develop improved impact properties and better cold cracking resistance than typically exhibited by the "T1" type electrodes.	H, F, VU, & OH	DCEP or DCEN [g]
T6	FCAW-S	Flux cored electrodes of this type are self shielded and are characterized by a spray transfer. Its oxide-based slag system is designed to produce good low temperature impacts, good penetration into the root of the weld, and excellent slag removal.	H & F	DCEP
T7	FCAW-S	Flux cored electrodes of this type are self shielded and are characterized by a small droplet to spray type transfer. The fluoride-based slag system is designed to provide high deposition rates in the downhand positions with the larger diameters and out of position capabilities with the smaller diameters.	H, F, VU, & OH	DCEN
T8	FCAW-S	Flux cored electrodes of this type are self shielded and are characterized by a small droplet to spray type transfer. The fluoride-based slag system is designed to provide improved out-of-position control. The weld metal produced typically exhibits very good low temperature notch toughness and crack resistance.	H, F, VD, VU, & OH	DCEN
T9	FCAW-G	Flux cored electrodes of this type are similar in design and application to the T1 types but with improved weld metal notch toughness capabilities.	H, F, VU, & OH	DCEP

(Continued)

Table 4 (Continued)
Electrode Usability Characteristics

Electrode Usability Designator [a]	Process	General Description of Electrode Type [b, c]	Typical Positions of Welding [d, e]	Polarity [f]
T10S	FCAW-S	Flux cored electrodes of this type are self shielded and are characterized by a small droplet transfer. The fluoride-based slag system is designed to make single pass welds at high travel speeds on steel of any thickness.	H, F	DCEN
T11	FCAW-S	Flux cored electrodes of this type are self shielded and are characterized by a smooth spray type transfer, limited slag coverage, and are generally not recommended for the welding of materials over 3/4 in [20 mm] thick.	H, F, VD, & OH	DCEN
T12	FCAW-G	Flux cored electrodes of this type are similar in design and application to the T1 types. However, they have been modified for improved impact toughness and to meet the lower manganese requirements of the A-No. 1 Analysis Group in the ASME *Boiler and Pressure Vessel Code*, Section IX.	H, F, VU, & OH	DCEP
T14S	FCAW-S	Flux cored electrodes of this type are self shielded and are characterized by a smooth spray-type transfer. The slag system is designed for single pass welds in all positions and at high travel speeds.	H, F, VD, & OH	DCEN
T15	GMAW-C	Electrodes of this type are gas shielded composite stranded or metal cored electrodes. The core ingredients are primarily metallic. The nonmetallic components in the core typically total less than 1% of the total electrode weight. These electrodes are characterized by a spray arc and excellent bead wash capabilities. Applications are similar in many ways to solid GMAW electrodes.	H, F, OH, VD, & VU	DCEP or DCEN
T16	GMAW-C	This electrode type is a gas shielded metal cored electrode specifically designed for use with AC power sources with or without modified waveforms.	H, F, VD, VU, & OH	AC [h]
T17	FCAW-S	This flux cored electrode type is a self-shielded electrode specifically designed for use with AC power sources with or without modified waveforms.	H, F, VD, VU, & OH	AC [h]
G		As agreed between supplier and purchaser	Not specified	Not specified

[a] An "S" is added to the end of the Usability Designator when the electrode being classified is recommended for single pass applications only.
[b] For more information refer to A7, Description and Intended Use, in Annex A.
[c] Properties of weld metal from electrodes that are used with external shielding gas will vary according to the shielding gas used. Electrodes classified with a specific shielding gas should not be used with other shielding gases without first consulting the manufacturer of the electrode.
[d] H = horizontal position, F = flat position, OH = overhead position, VU = vertical position with upward progression, VD = vertical position with downward progression.
[e] Electrode sizes suitable for out-of-position welding, i.e., welding positions other that flat and horizontal, are usually those sizes that are smaller than the 3/32 in [2.4 mm] size or the nearest size called for in Clause 9 for the groove weld. For that reason, electrodes meeting the requirements for the groove weld tests may be classified as EX1TX-XXX-X (where X represents the tensile strength, usability, shielding gas, if any, condition of heat treatment, impact test temperature, and weld metal composition designators) regardless of their size.
[f] The term "DCEP" refers to direct current electrode positive (dc, reverse polarity). The term "DCEN" refers to direct current electrode negative (dc, straight polarity).
[g] Some EX1T5-XXX-X electrodes may be recommended for use on DCEN for improved out-of-position welding. Consult the manufacturer for the recommended polarity.
[h] For this electrode type the welding current can be conventional sinusoidal alternating current, a modified AC waveform alternating between positive and negative, an alternating DCEP waveform, or an alternating DCEN waveform.

Table 5
Composition Requirements for Shielding Gases

AWS A5.36/A5.36M Shielding Gas Designator [a]	AWS A5.32M/A5.32 Composition Ranges for Indicated Main/Sub Group [b]		Nominal Composition of Shielding Gases to be Used for Classification of Gas Shielded Electrodes to AWS A5.36/A5.36M		
	Oxidizing Components [c]			Oxidizing Components [c, e]	
	% CO_2	% O_2	ISO 14175 Designation [d]	% CO_2	% O_2
C1	100	—	C1	100	—
M12	$0.5 \le CO_2 \le 5$	—	M12 – ArC – 3	3	—
M13	—	$0.5 \le O_2 \le 3$	M13 – ArO – 2	—	2
M14	$0.5 \le CO_2 \le 5$	$0.5 \le O_2 \le 3$	M14 – ArCO – 3/2	3	2
M20	$5 < CO_2 \le 15$	—	M20 – ArC – 10	10	—
M21	$15 < CO_2 \le 25$	—	M21 – ArC – 20	20	—
M22	—	$3 < O_2 \le 10$	M22 – ArO – 7	—	7
M23	$0.5 \le CO_2 \le 5$	$3 < O_2 \le 10$	M23 – ArOC – 7/3	3	7
M24	$5 < CO_2 \le 15$	$0.5 \le O_2 \le 3$	M24 – ArCO – 10/2	10	2
M25	$5 < CO_2 \le 15$	$3 < O_2 \le 10$	M25 – ArCO – 10/7	10	7
M26	$15 < CO_2 \le 25$	$0.5 \le O_2 \le 3$	M26 – ArCO – 20/2	20	2
M27	$15 < CO_2 \le 25$	$3 < O_2 \le 10$	M27 – ArCO – 20/7	20	7
M31	$25 < CO_2 \le 50$	—	M31 – ArC – 38	38	—
M32	—	$10 < O_2 \le 15$	M32 – ArO – 12.5	—	12.5
M33	$25 < CO_2 \le 50$	$2 < O_2 \le 10$	M33 – ArCO – 38/6	38	6
M34	$5 < CO_2 \le 25$	$10 < O_2 \le 15$	M34 – ArCO – 15/12.5	15	12.5
M35	$25 < CO_2 \le 50$	$10 < O_2 \le 15$	M35 – ArCO – 38/12.5	38	12.5
Z	The designator "Z" indicates that the shielding gas used for electrode classification is not one of the shielding gases specified in this table but is a different composition as agreed upon between the supplier and purchaser.				

[a] The Shielding Gas Designators are identical to the Main group/Sub-group designators used in AWS A5.32M/A5.32:2011 [ISO 14175:2008 MOD], *Welding Consumables—Gases and Gas Mixtures for Fusion Welding and Allied Processes* , for these same shielding gases.
[b] Under AWS A5.32M/A5.32:2011, the inert gas used for the balance of the gas mixture may be either argon, helium, or some mixture thereof.
[c] The mixture tolerances are as follows:
For a component gas with a nominal concentration of >5%, ±10% of nominal.
For a component gas with a nominal concentration of 1%–5%, ±0.5% absolute.
For a component gas with a nominal composition of <1%, not specified in this standard.
[d] AWS A5.32M/A5.32:2011 shielding gas designators begin with "AWS A5.32 (ISO 14175)." That part of the designation has been omitted from the Shielding Gas Designator for brevity.
[e] The inert gas to be used for the balance of the gas mixtures specified for the classification of gas shielded flux cored and metal cored electrodes shall be argon.

3.4 The electrodes classified under this specification are intended for flux cored arc welding, either with or without an external shielding gas, or for gas metal arc welding with metal cored electrodes. Electrodes intended for use without external shielding gas, or with the shielding gases specified in Table 5, are not prohibited from use with any other process or shielding gas for which they are found suitable.

4. Acceptance

Acceptance [8] of the welding electrodes shall be in accordance with the provisions of AWS A5.01M/A5.01 (ISO 14344 MOD).

[8] See Clause A3 (in Annex A) for further information concerning acceptance, testing of the material shipped, and AWS A5.01M/A5.01 (ISO 14344 MOD).

Table 6
Weld Metal Chemical Composition Requirements [a]

Weld Metal Designation	UNS Number [b]	Weight Percent [c]											
		C	Mn	Si	S	P	Ni	Cr	Mo	V	Al	Cu	Other [d]
Carbon Steel Electrodes													
CS1 [e]	—	0.12	1.75	0.90	0.030	0.030	0.50 [f]	0.20 [f]	0.30 [f]	0.08 [f]	—	0.35 [f]	—
CS2 [e, g]	—	0.12	1.60	0.90	0.030	0.030	0.50 [f]	0.20 [f]	0.30 [f]	0.08 [f]	—	0.35 [f]	—
CS3 [e]	—	0.30	1.75	0.60	0.030	0.030	0.50 [f]	0.20 [f]	0.30 [f]	0.08 [f]	1.8 [f, h]	0.35 [f]	—
Molybdenum Steel Electrodes													
A1	W1703X	0.12	1.25	0.80	0.030	0.030	—	—	0.40–0.65	—	—	—	—
Chromium-Molybdenum Steel Electrodes													
B1	W5103X	0.05–0.12	1.25	0.80	0.030	0.030	—	0.40–0.65	0.40–0.65	—	—	—	—
B1L	W5113X	0.05	1.25	0.80	0.030	0.030	—	0.40–0.65	0.40–0.65	—	—	—	—
B2	W5203X	0.05–0.12	1.25	0.80	0.030	0.030	—	1.00–1.50	0.40–0.65	—	—	—	—
B2L	W5213X	0.05	1.25	0.80	0.030	0.030	—	1.00–1.50	0.40–0.65	—	—	—	—
B2H	W5223X	0.10–0.15	1.25	0.80	0.030	0.030	—	1.00–1.50	0.40–0.65	—	—	—	—
B3	W5303X	0.05–0.12	1.25	0.80	0.030	0.030	—	2.00–2.50	0.90–1.20	—	—	—	—
B3L	W5313X	0.05	1.25	0.80	0.030	0.030	—	2.00–2.50	0.90–1.20	—	—	—	—
B3H	W5323X	0.10–0.15	1.25	0.80	0.030	0.030	—	2.00–2.50	0.90–1.20	—	—	—	—
B6	W50231	0.05–0.12	1.20	1.00	0.030	0.025	0.40	4.0–6.0	0.45–0.65	—	—	0.35	—
B6L	W50230	0.05	1.20	1.00	0.030	0.025	0.40	4.0–6.0	0.45–0.65	—	—	0.35	—
B8	W50431	0.05–0.12	1.20	1.00	0.030	0.040	0.40	8.0–10.5	0.85–1.20	—	—	0.50	—
B8L	W50430	0.05	1.20	1.00	0.030	0.040	0.40	8.0–10.5	0.85–1.20	—	—	0.50	—
B91 [i]	W50531	0.08–0.13	1.20 [j]	0.50	0.015	0.020	0.80 [j]	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
B92	—	0.08–0.15	1.20 [j]	0.50	0.015	0.020	0.80 [j]	8.0–10.0	0.30–0.70	0.15–0.30	0.04	0.25	Nb: 0.02–0.08 W: 1.5–2.0 B: 0.006 N: 0.02–0.08 Co [k]
Nickel Steel Electrodes													
Ni1	W2103X	0.12	1.75	0.80	0.030	0.030	0.80–1.10	0.15	0.35	0.05	1.8 [h]	—	—
Ni2	W2203X	0.12	1.50	0.80	0.030	0.030	1.75–2.75	—	—	—	1.8 [h]	—	—
Ni3	W2303X	0.12	1.50	0.80	0.030	0.030	2.75–3.75	—	—	—	1.8 [h]	—	—

(Continued)

Table 6 (Continued)
Weld Metal Chemical Composition Requirements [a]

Weld Metal Designation	UNS Number[b]	Weight Percent[c]											
		C	Mn	Si	S	P	Ni	Cr	Mo	V	Al	Cu	Other[d]
Manganese-Molybdenum Steel Electrodes													
D1	W1913X	0.12	1.25–2.00	0.80	0.030	0.030	—	—	0.25–0.55	—	—	—	—
D2	W1923X	0.15	1.65–2.25	0.80	0.030	0.030	—	—	0.25–0.55	—	—	—	—
D3	W1933X	0.12	1.00–1.75	0.80	0.030	0.030	—	—	0.40–0.65	—	—	—	—
Other Low-Alloy Steel Electrodes													
K1	W2113X	0.15	0.80–1.40	0.80	0.030	0.030	0.80–1.10	0.15	0.20–0.65	0.05	—	—	—
K2	W2123X	0.15	0.50–1.75	0.80	0.030	0.030	1.00–2.00	0.15	0.35	0.05	1.8[h]	—	—
K3	W2133X	0.15	0.75–2.25	0.80	0.030	0.030	1.25–2.60	0.15	0.25–0.65	0.05	—	—	—
K4	W2223X	0.15	1.20–2.25	0.80	0.030	0.030	1.75–2.60	0.20–0.60	0.20–0.65	0.03	—	—	—
K5	W2162X	0.10–0.25	0.60–1.60	0.80	0.030	0.030	0.75–2.00	0.20–0.70	0.15–0.55	0.05	—	—	—
K6	W2104X	0.15	0.50–1.50	0.80	0.030	0.030	0.40–1.00	0.20	0.15	0.05	1.8[h]	—	—
K7	W2205X	0.15	1.00–1.75	0.80	0.030	0.030	2.00–2.75	—	—	—	—	—	—
K8	W2143X	0.15	1.00–2.00	0.40	0.030	0.030	0.50–1.50	0.20	0.20	0.05	1.8[h]	—	—
K9	W23230	0.07	0.50–1.50	0.60	0.015	0.015	1.30–3.75	0.20	0.50	0.05	—	0.06	—
K10	—	0.12	1.25–2.25	0.80	0.030	0.030	1.75–2.75	0.20	0.50	—	—	0.50	—
K11	—	0.15	1.00–2.00	0.80	0.030	0.030	0.40–1.00	0.20	0.50	0.05	1.8[h]	—	—
W2	W2013X	0.12	0.50–1.30	0.35–0.80	0.030	0.030	0.40–0.80	0.45–0.70	—	—	—	0.30–0.75	—
G	—	(m)	As agreed upon between supplier and purchaser										
GS[n]	—	As agreed upon between supplier and purchaser											

[a] The weld metal shall be analyzed for the specific elements for which values are shown in this table.
[b] Refer to ASTM DS-56/SAE HS-1086, *Metals & Alloys in the Unified Numbering System*. 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 "11" electrode type where a "9" is used instead of an "11."
[c] Single values are maximums.
[d] An analysis of the weld deposit for boron is required and shall be reported if this element is intentionally added or if it is known to be present at levels in excess of 0.0010%.
[e] The total of all the elements listed in this table for this classification shall not exceed 5%.
[f] fThe analysis of these elements shall be reported only if intentionally added.
[g] Meets the lower Mn requirements of the A-No. 1 Analysis Group in the ASME *Boiler and Pressure Vessel Code*, Section IX, Welding and Brazing Qualifications, QW-422.
[h] Applicable to self-shielded electrodes only. Electrodes intended for use with gas shielding normally do not have significant additions of aluminum.
[i] The "B91" designation is a new designation, replacing the "B9" designation previously used for this alloy type.
[j] Mn + Ni = 1.40% maximum. See A7.16.2 in Annex A.
[k] Analysis for Co is required to be reported if intentionally added, or if it is known to be present at levels greater than 0.20%.
[m] The limit for gas shielded electrodes is 0.18% maximum. The limit for self-shielded electrodes is 0.30% maximum.
[n] The composition of weld metal is not particularly meaningful since electrodes in this category are intended only for single pass welds. Dilution from the base metal in such welds is usually quite high. See A7.2 in Annex A.

Table 7
Tests Required for Classification

General Electrode Category	Electrode Classification	Required Tests [a]				
		Chemical Analysis	Radiographic Test	Tension Test[b]	Impact Test	Bend Test
Multiple Pass Electrodes	EXXT1-XXX-X EXXT4-XX-X EXXT5-XXX-X EXXT6-XX-X EXXT7-XX-X EXXT8-XX-X EXXT9-XXX-X EXXT11-XX-X EXXT12-XXX-X EXXT15-XXX-X EXXT16-XXX-X EXXT17-XX-X EXXTG-XXX-X [d] EXXTX-ZXX-X [e] EXXTX-XGX-X [f] EXXTX-XXX-G [g]	R	R	R	R[c]	NR
Single Pass Electrodes	EXXT1S-X EXXT3S EXXT10S EXXT14S EXXTGS-X [d] EXXTXS-Z [e]	NR	NR	R	NR	R

[a] The letter "R" indicates the test is required. "NR" indicates the test is not required.
[b] Multiple pass classifications require an all weld metal longitudinal tension test. Single pass classifications require a transverse tension test.
[c] When the "Z" impact designator is used, the impact test is not required. See Table 3.
[d] When a "G" appears in the position shown, it indicates that the electrode type is not specified but is "as agreed upon between supplier and purchaser."
[e] When a "Z" appears in the position shown, it indicates that the type of shielding gas used is not specified but is "as agreed upon between supplier and purchaser."
[f] When a "G" appears in the position shown, it indicates that the condition of PWHT is not as specified in Table 8 but is "as agreed upon between supplier and purchaser."
[g] When a "G" appears in the position shown, it indicates that the deposited weld composition is "as agreed upon between supplier and purchaser."

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 [9].

6. Rounding-Off Procedure

For purposes of determining compliance with the requirements of this standard, the actual test values obtained shall be subjected to the rounding-off rules of ASTM E 29 or ISO 80000-1 (the results are the same). If the measured values are obtained by equipment calibrated in units other than those of the specified limit, the measured values shall be converted to the units of the specified limit before rounding off. If the average value is to be compared to the specified limit, rounding off shall be done only after calculating the average. An observed or calculated value shall be rounded to the nearest 1000 psi for tensile and yield strength for A5.36 [to the nearest 10 MPa for tensile and yield strength for A5.36M] and to the nearest unit in the last right-hand place of figures used in expressing the limiting values for other quantities. The rounded-off results shall fulfill the requirements for the classification under test.

[9] See Clause A4 (in Annex A) for further information concerning certification and the testing called for to meet this requirement.

Table 8
Preheat, Interpass, and PWHT Temperatures

AWS Weld Metal Designation	Preheat and Interpass Temperature [a]		Postweld Heat Treatment (PWHT) Temperature [a, b, c]	
	For A5.36 U.S. Customary Units	For A5.36M International System of Units (SI)	For A5.36 U.S. Customary Units	For A5.36M International System of Units (SI)
CS1, CS2, CS3	60°F Preheat minimum 300°F ±25°F Interpass	15°C Preheat minimum 150°C ± 15°C Interpass	1150°F ± 25°F	620°C ± 15°C
A1, Ni1, Ni2 [d], Ni3 [d], D2	300°F ± 25°F	150°C ± 15°C	1150°F ± 25°F	620°C ± 15°C
B1, B1L, B2, B2L, B2H, B3, B3L, B3H	350°F ± 25°F	175°C ± 15°C	1275°F ± 25°F	690°C ± 15°C
B6, B6L, B8, B8L	400°F ± 100°F	200°C ± 50°C	1375°F ± 25°F [e]	745°C ± 15°C [e]
B91, B92	500°F ± 100°F	260°C ± 50°C	1400°F ± 25°F [e]	760°C ± 15°C [e]
D1, D3, K1, K2, K3, K4, K5, K6, K7, K8, K9, K10, K11, W2	300°F ± 25°F	150°C ± 15°C	As agreed upon between supplier and purchaser	
EXXTX-XGX-X EXXTG-XGX-X EXXTX-XGX-G	As agreed upon between supplier and purchaser		As agreed upon between supplier and purchaser	

[a] These temperatures are specified for testing under this specification and are not to be consideredas recommendations for preheat and postweld heat treatment (PWHT) in production welding. The requirements for production welding must be determined by the user.
[b] Postweld heat treatment is required only for those classifications with the "P" designator for condition of heat treatment.
[c] The PWHT schedule is as described in 9.2.1.2 of this document.
[d] PWHT temperature in excess of 1150°F [620°C] will decrease Charpy V-Notch impact strength.
[e] Held at temperature for 2 hours –0 +15 minutes.

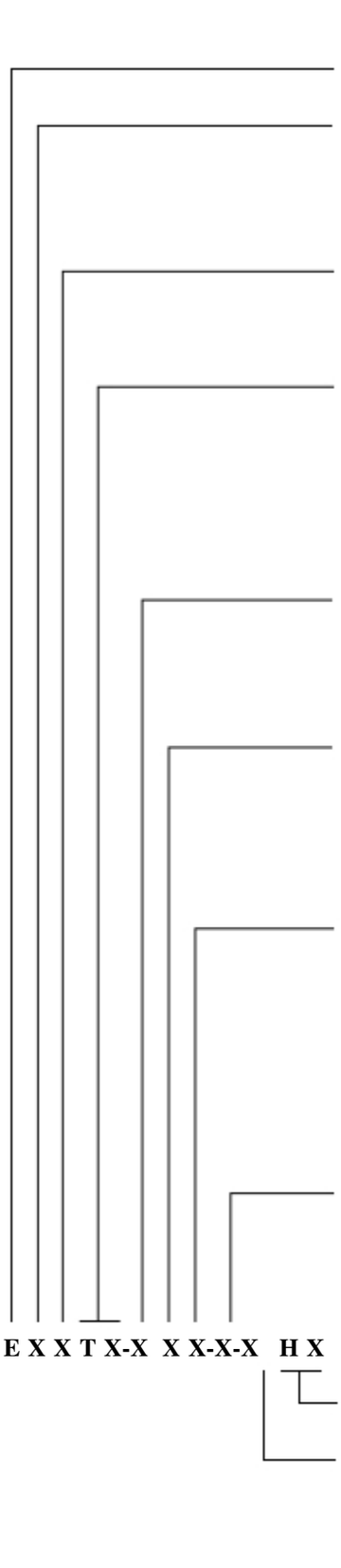
7. Summary of Tests

7.1 The tests required for each classification are specified in Table 7. 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 Clauses 9 through 14.

7.2 This document provides for three supplemental tests which are not required for classification but which are included for optional supplemental designators as agreed upon between supplier and purchaser.

7.2.1 The supplemental test for diffusible hydrogen is described in Clause 15 and utilizes designators H16, H8, H4, or H2.

7.2.2 The optional supplemental designator "D" or "Q" may be used to indicate conformance to the all-weld mechanical property requirements specified in Table 9 when the weld metal is deposited (1) using the low heat input, fast cooling rate procedure and (2) using the high heat input, slow cooling rate procedure specified in Clause 16 and Table 10. The "D" designator is intended to identify those electrodes that satisfy AWS D1.8/D1.8M and FEMA 353, when the welds are made in a manner prescribed in AWS D1.8/D1.8M and FEMA 353. The "Q" designator is intended to identify those E7XTX-XXX-X [E49XTX-XXX-X] classification electrodes that meet the additional anticipated requirements of the U.S. Navy.



Mandatory Classification Designators [a]

Designates an electrode.

Tensile Strength Designator. For A5.36 one or two digits indicate the minimum tensile strength (when multiplied by 10 000 psi) of weld metal deposited with the electrode under the welding conditions specified in this specification. For A5.36M two digits are used to indicate the minimum tensile strength (when multiplied by 10 Megapascals [MPa]). See Table 2.

Position Designator. This designator is either "0" or "1." A "0" is for flat and horizontal positions only. "1" is for all positions (flat, horizontal, vertical with downward progression, and/or vertical with upward progression and overhead).

Usability Designator. This letter is the letter "T" followed by some number from 1 through 17 or the letter "G." The letter "T" identifies the electrode as a flux cored electrode or metal cored electrode. This designator refers to the usability of the electrode with requirements for polarity and general operating characteristics (see Table 4). The letter "G" indicates that the polarity and general operating characteristics are not specified. An "S" appears at the end of this designator when the electrode being classified is intended for single pass welding only.

Shielding Gas Designator. Indicates the type of shielding gas, if any, used for classification (see Table 5). The letter "Z" in this position indicates that the shielding gas composition is as agreed upon between supplier and purchaser. When no designator appears in this position, it indicates that the electrode is self shielded and that no external shielding gas is used.

Designates the condition of heat treatment in which the tests were conducted. "A" is for as-welded and "P" is for postweld heat treated. The time and temperature of the PWHT is specified in 9.2.1.2 and Table 8. The letter "G" in this position indicates that the PWHT procedure is as agreed upon between supplier and purchaser. This designator omitted when the electrode being classified is intended for single pass welding only.

Impact Designator. For A5.36 this designator indicates the temperature in °F at or above which the impact strength of the weld metal referred to above meets or exceeds 20 ft·lbf. For A5.36M this designator indicates the temperature in °C at or above which the impact strength of the weld metal meets or exceeds 27 J. The impact designator may be either one or two digits (see Table 3). A "Z" in this position indicates that there are no impact requirements for the electrode classification. This designator is omitted when the electrode being classified is intended for single pass welding only. A "G" in this position indicates the impact requirements are not specified but are as agreed upon between purchaser and supplier.

Deposit Composition Designator. One, two or three characters are used to designate the composition of the deposited weld metal (see Table 6). The letter "G" indicates that the chemical composition is not specified. No designator used in this position when the electrode being classified is a single pass electrode.

Optional Supplemental Designators [b]

Optional, supplemental diffusible hydrogen designator (see Table 13).

For flux cored electrodes, the letter "D" or "Q" when present in this position indicates the weld metal will meet supplemental mechanical property requirements with welding done using low heat input, fast cooling rate procedures and using high heat input, slow cooling rate procedures as prescribed in Clause 16 (see Tables 9 and 10).

[a] The combination of these designators constitutes the flux cored electrode classification.

[b] These designators are optional and do not constitute a part of the flux cored or metal cored electrode classification, as applicable.

Figure 1—A5.36/A5.36M Open Classification System

The following are examples of typical electrode classifications. The examples shown are for the A5.36 system using U.S. Customary Units. Refer to Table 4 and A7 in Annex A for additional information on electrode usability characteristics.

E71T1-C1A2-CS1-H4. The complete classification designation for this electrode is E71T1-C1A2-CS1. It refers to an all position, flux cored electrode that, when used with C1 (CO_2) shielding gas and welded under the conditions prescribed in this specification, will produce weld metal in the as welded condition having a tensile strength of 70 ksi–95 ksi and Charpy V-Notch impact strength of at least 20 ft·lbf at –20°F. The weld deposit will meet the CS1 carbon steel composition requirements. The "H4" is not part of the electrode classification designation but is an optional, supplemental designator indicating that the weld metal will have a maximum average diffusible hydrogen of 4 mL/100 g of deposited weld metal when tested under the conditions of this specification.

E80T5-M21P6-Ni2. This is a complete classification designation for a flat and horizontal flux cored electrode that, when used with M21 shielding gas (see Table 5) under the conditions prescribed in this specification, will produce weld metal in the postweld heat treated condition having a tensile strength of 80 ksi–100 ksi and Charpy V-Notch impact strength of at least 20 ft·lbf at –60°F. The weld deposit composition conforms to the Ni2 composition requirements (see Table 6).

E71T8-A4-Ni1. This is a complete classification designation for a self shielded (no Shielding Gas Designator appears), all position flux cored electrode. It refers to an electrode that will produce weld metal that, when tested under the conditions prescribed in this specification, will have a tensile strength of 70 ksi–95 ksi and Charpy V-Notch impact strength of at least 20 ft·lbf at –40°F in the as welded condition. The weld deposit composition conforms to the Ni1 composition requirements for self-shielded electrodes.

E90T15-M22A2-D2. This is a complete classification designation for a flat and horizontal metal cored electrode. It refers to a metal cored electrode that, when used with M22 shielding gas (see Table 5) under the conditions prescribed in this specification, will produce weld metal in the as welded condition with a tensile strength of 90 ksi–110 ksi and Charpy V-Notch impact strength of at least 20 ft·lbf at –20°F. The weld deposit composition conforms to the D2 composition requirements (see Table 6).

E80T15S-M20. This is a complete classification designation for a single pass (only) metal cored electrode. Under the welding and testing conditions prescribed in this specification, this metal cored electrode, when used with M20 shielding gas (see Table 5) will produce weld metal having a minimum tensile strength of 80 ksi.

Figure 1 (Continued)—A5.36/A5.36M Open Classification System

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 of 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.

Table 9
Mechanical Property Requirements for "D" and "Q" Optional Supplemental Designators

Optional Supplemental Designator	Tensile Test Requirements	Minimum Charpy V-Notch Requirements
D	For E7XTX-XXX-X [E49XTX-XXX-X] classifications: 58 ksi [400 MPa] min. yield strength [a] 70 ksi [490 MPa] min. tensile strength 22% min. % elongation in 2 in [50 mm]	40 ft·lbf at +70°F [54 J at +20°C] (see Notes b, c)
	For E8XTX-XXX-X [E55XTX-XXX-X] classifications: 68 ksi [470 MPa] min. yield strength [a] 80 ksi [550 MPa] min. tensile strength 19% min. % elongation in 2 in [50 mm]	
Q	58 ksi to 80 ksi [400 MPa–550 MPa] yield strength [a] for high input, slow cooling rate test. 90 ksi [620 MPa] max. yield strength [a] for low heat input, fast cooling rate test. 22% min. % elongation in 2 in [50 mm] (see Note d).	20 ft·lbf at –20°F [27 J at –30°C] (see Note e)

[a] Yield strength measured at 0.2% offset.
[b] Five specimens are to be tested. The lowest and highest values obtained from each of five specimens from a single test plate shall be disregarded. Two of the remaining three values shall equal, or exceed, the specified toughness of 40 ft·lbf [54 J] energy level at the testing temperature. One of the three may be lower, but not lower than 30 ft·lbf [41 J], and the average of the three shall not be less than the required 40 ft·lbf [54 J] energy level.
[c] The electrode shall also meet a minimum toughness requirement of 20 ft·lbf at 0°F [27 J at –18°C] when tested according to the standard A5.36/A5.36M classification test requirements.
[d] Tensile specimens shall not be aged when testing for the "Q" designator.
[e] Five specimens shall be tested. One of the five specimens may be lower than the specified 20 ft·lbf [27 J] energy level, but not lower than 15 ft·lbf [20 J], and the average of the five shall not be less than the required minimum 20 ft·lbf [27 J] energy level.

Table 10
Procedure Requirements for "D" and "Q" Optional Supplemental Designators

Optional Supplemental Designator	Procedure Heat Input (fast or slow cooling rate)	Preheat Temperature °F [°C]	Interpass Temperature °F [°C]	Heat Input Requirement for Any Single Pass [a]	Required Average Heat Input for All Passes [a]
D	Low (fast cooling rate)	120°F [50°C] maximum	250°F [120°C] maximum	For electrode diameters < 3/32 in [2.4 mm]	
				38 kJ/in [1.5 kJ/mm] maximum	24 kJ/in–36 kJ/in [0.9 kJ/mm–1.4 kJ/mm]
				For electrode diameters ≥ 3/32 in [2.4 mm]	
				44 kJ/in [1.7 kJ/mm] maximum	35 kJ/in–42 kJ/in [1.4 kJ/mm–1.6 kJ/mm]
	High (slow cooling rate)	250°F [120°C] minimum	450°F [240°C] minimum	65 kJ/in [2.6 kJ/mm] minimum	65 kJ/in-85 kJ/in [2.6 kJ/mm–3.3 kJ/mm]
Q	Low (fast cooling rate)	70°F ± 25°F [20°C ± 15°C]	150°F max. [65°C max.]	33 kJ/in [1.3 kJ/mm] maximum	25 kJ/in–32 kJ/in [1.0 kJ/mm–1.3 kJ/mm]
	High (slow cooling rate)	300°F ± 25°F [150°C ± 15°C]	300°F ± 25°F [150°C ± 15°C]	65 kJ/in [2.6 kJ/mm] minimum	68 kJ/in–75 kJ/in [2.7 kJ/mm–3.0 kJ/mm]

[a] Does not apply to first layer. The first layer may have one or two passes.

9. Test Assemblies

9.1 One or two weld test assemblies are needed, depending on the classification of the electrode and the manner in which the tests are conducted. They are as follows:

(1) For multiple pass electrodes, the groove weld test assembly showed in Figure 2 for mechanical properties, chemical analysis of the weld metal and soundness of the weld metal.

(2) For single pass electrodes, the test assembly in Figure 3 for mechanical properties.

(3) The weld pad in Figure 4 for chemical analysis of the weld metal, if required.

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 2, thereby avoiding the need to make the weld pad. In case of dispute, the groove weld shall be the referee method.

9.1.1 Preparation of each test assembly shall be as specified in Figure 2, 3, or 4, as applicable. The base metal for each assembly shall be as required in Table 11 and shall meet the requirements of any one of the appropriate ASTM or MIL specifications shown there, or an equivalent specification. Testing of the assemblies shall be as specified in Clauses 10 through 14.

9.2 Weld Test Assemblies

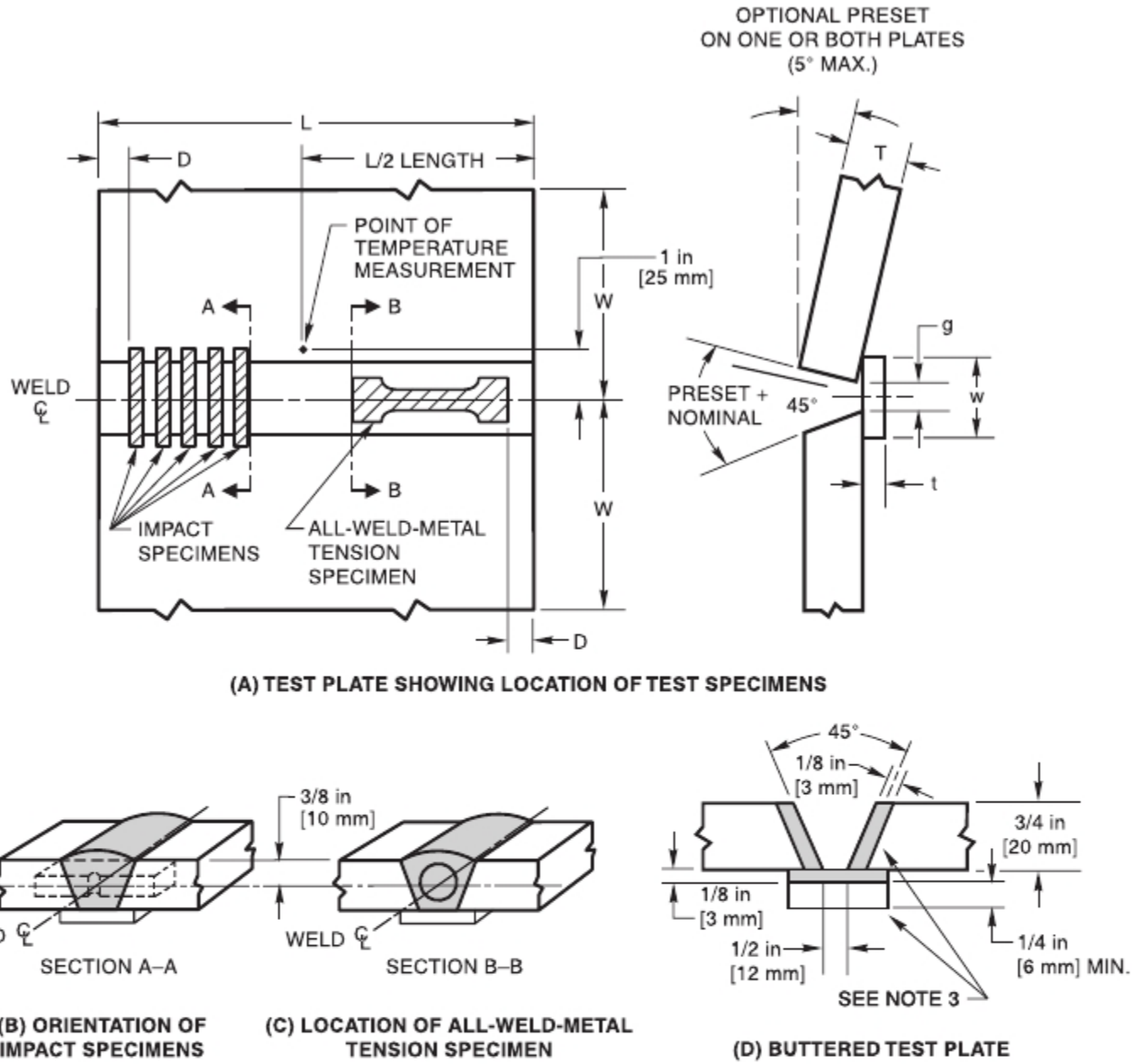
9.2.1 Test Assembly for Multipass Electrodes. One or two groove weld test assemblies shall be prepared and welded as specified in Figure 2 and Table 12, using base metal of the appropriate type specified in Table 11. Preheat and interpass temperatures shall be as specified in Table 8. Testing of this assembly shall be as specified in Table 7. When ASTM A 36 or ASTM A 285 base metals are used for low-alloy classifications (those other than CS1, CS2, and CS3), 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 11, Notes b and f. If a buttering procedure is used, the layer shall be approximately 1/8 in [3 mm] thick (see Figure 2, Note 3). 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 4. Testing of the assemblies shall be as required in Table 7 for electrodes classified in either the as-welded or PWHT condition, as applicable.

9.2.1.1 Welding shall be done in the flat position (except for the E10XTX-XXX-K9 [E69XTX-XXX-X] classification which shall be welded in the vertical position with upward progression), and the assembly shall be restrained (or preset as shown in Figure 2) during welding to prevent warpage in excess of 5°. An assembly that is warped more than 5° 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 8 for the electrode being tested. Welding shall continue until the assembly has reached the required interpass temperature specified in Table 8, measured by temperature indicating crayons or surface thermometers at the location shown in Figure 2. 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.

9.2.1.2 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°F to 500°F [85°C to 280°C] per hour until the postweld heat treatment temperature specified in Table 8, for the electrode classification, is attained. This temperature shall be maintained for one hour (–0, +15 minutes), unless otherwise noted in Table 7. 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.

9.2.2 Test Assembly for Single Pass Electrodes. For single pass electrodes a butt joint test assembly using base metal as specified in Table11 shall be prepared and welded as specified in Figure 3 and 9.2.2.1. After tack welding the plates at each end, the test assembly shall be welded in the flat position with one bead on each side.



(A) TEST PLATE SHOWING LOCATION OF TEST SPECIMENS

(B) ORIENTATION OF IMPACT SPECIMENS

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

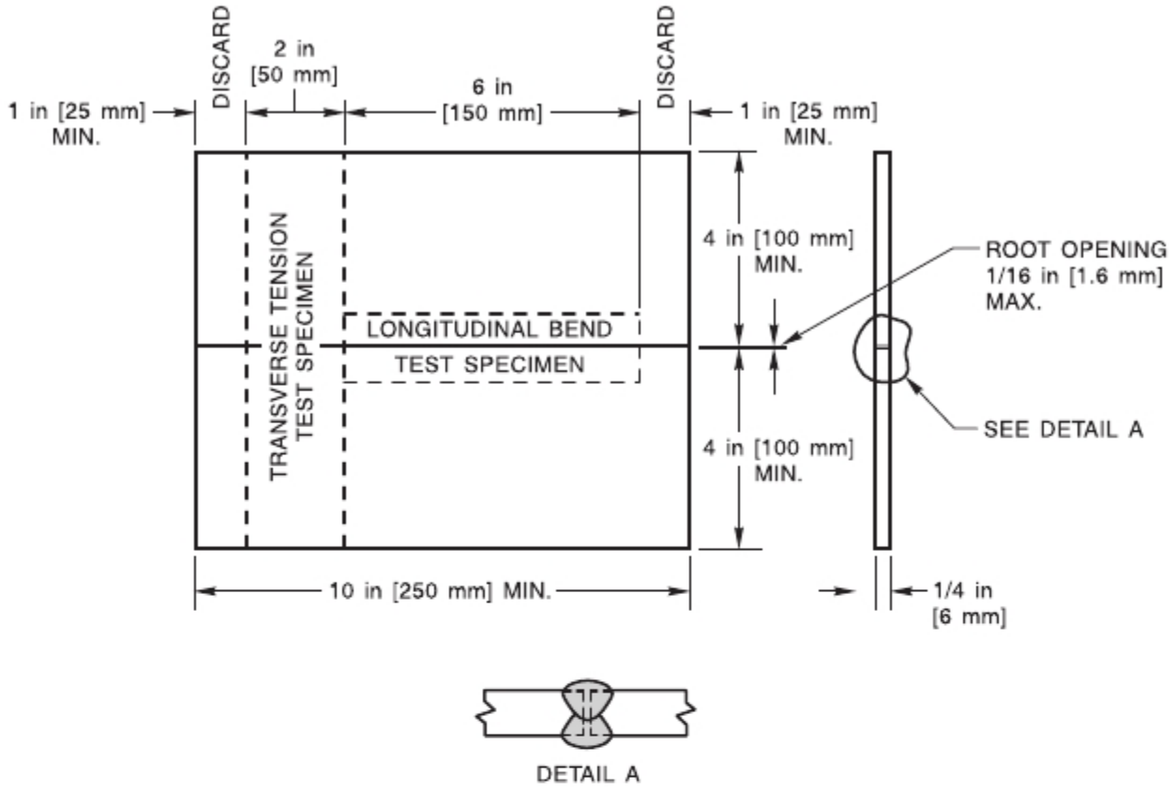
(D) BUTTERED TEST PLATE

L Test Plate Length (min.)	W Test Plate Width (min.)	T Test Plate Thickness	D Discard (min.)	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. An acceptable alternative to the test joint shown above is the use of a bevel angle of 10°, +2.5°, –0° with a root opening of 5/8 in, +1/16, –0 in [16 mm, +1 mm, –0 mm] similar to type 1.3 per ISO 15792-1:2000.
2. 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-AZ-CS3 electrode classifications.
3. When required, edges of the grooves and contacting face of the backing shall be buttered as shown in (D). See Note a of T able 10.

Source: Figure 3 of AWS A5.29/A5.29M:2005 (Errata/Reprint).

Figure 2—Test Assembly for Mechanical Properties and Soundness of Weld Metal for Welds made with Multiple-Pass Electrodes



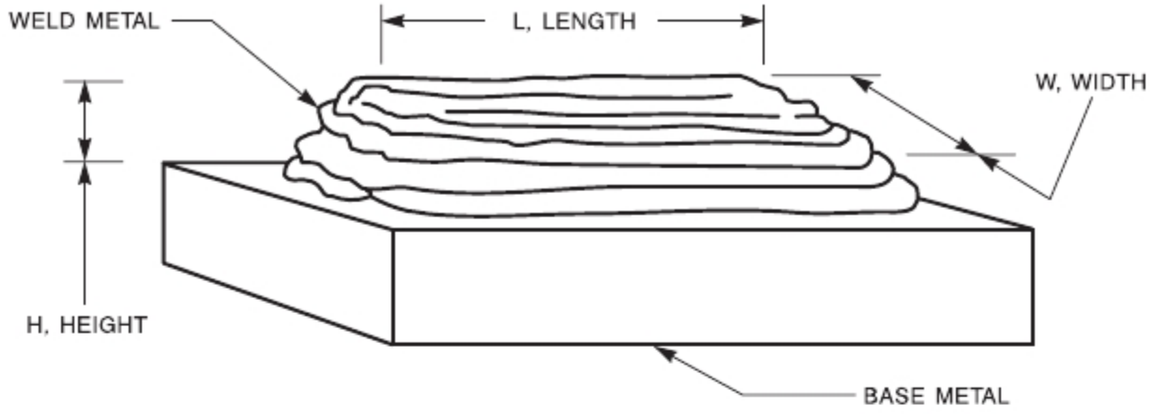
Notes:
1. Detail A shows the completed joint and approximate weld configuration.
2. Plate thickness may be reduced to 3/16 in [5 mm] for electrode of 0.068 in [1.7 mm] diameter or smaller.

Source: Figure 4 of AWS A5.20/A5.20M:2005.

Figure 3—Test Assembly for Transverse Tension and Longitudinal Guided Bend Tests for Welds made with Single-Pass Electrodes

9.2.2.1 Welding shall begin with the assembly at 60°F [15°C] minimum. When the weld bead has been completed on the face side, the assembly shall be turned over and the bead deposited on the root side, as shown in Figure 3. This sequence shall not be interrupted. The electrode size shall be either 3/32 in [2.4 mm] diameter or the size the manufacturer produces that is closest to the 3/32 in [2.4 mm] diameter. The welding polarity shall be as shown in Table 4 for the classification being tested. After welding has been completed and the assembly has cooled, the assembly shall be prepared and tested as specified in Clauses 12 and 13 in the as-welded condition (except for the aging of the bend test specimen specified in 13.2).

9.2.3 Weld Pad. As an alternative for determining weld deposit composition, a weld pad can be prepared as specified in Figure 4. Base metal of any convenient size of the type specified in Table 11 (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 12. The slag, if any, 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 4. Testing of this assembly shall be as specified in Clause 10.



WELD P AD 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 11, 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 T able 4 and following the heat input requirements specified in Table 12.
4. The number and size of the beads will vary according to the size of the electrode and the bead width, as well as with the amperage employed. The bead width shall be limited to 10 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 Clause 10 shall be taken from weld metal that is at least 3/8 in [10 mm] above the original base metal surface. See Table 11, 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 4—Pad for Chemical Analysis of Deposited Weld Metal

10. Chemical Analysis

10.1 The sample for analysis shall be taken from weld metal produced with the flux cored or metal cored electrode and the shielding gas, if any, with which it is classified. The sample shall be taken from 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 2. The weld pad described in 9.2.3 can also be used to produce the weld metal sample for chemical analysis. In case of dispute, the sample taken from the groove weld shall be the referee method.

10.2 The sample from 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 2 shall be prepared for analysis by any suitable mechanical means.

When the weld pad is used for analysis, the top surface of the pad described in 9.2.3 and shown in Figure 4 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. See note c of Table 11 for sampling requirements when ASTM A 36 or A 285 steel is used as the weld pad base metal.

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 6 for the classification of electrode under test.

Table 11
Base Metal for Test Assemblies [a, b, c]

Weld Metal Designation	ASTM and Military Standards [d]	UNS Number [e]
Single Pass Electrode Classifications	A 515/A 515M Grade 70 A 516/A 516M Grade 70	K03101 K02700
CS1, CS2, CS3	A 36/A 36M A 285/A 285M Grade C A 515/A 515M Grade 70 A 516/A 516M Grade 70 A 830/A 830M Grade 1015, 1018, or 1020	K02600 K02801 K03101 K02700 G10150, G10180, or G10200
A1	A 204, Grade A A 204, Grade B A 204, Grade C	K11820 K12020 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
B91	A 387, Grade 91	K91560
B92	A 387 Grade P92	K92460
Ni1	A 537, Class 1 or 2	K12437
Ni2, Ni3	A 203, Grade E HY-80[g] HY-100[g] HSLA-80[h] HSLA-100[h]	K32018 K31820 K32045 — —
D1, D2, D3	A 302 Grade A or B A506 A507	K12021, K12022 G41300 G41300
K1, K2, K3, K4, K5, K7, K9 [f], K10	A 514, any Grade HY-80[g] HY-100[g] HSLA-80[h] HSLA-100[h]	K11856 K31820 K32045 — —
K2, K6, K8, K11	A 537, Class 1 or 2	K12437
W2	A 588, Grade A A 588, Grade B A 588, Grade C	K11430 K12043 K11538
G	See Note a	—

[a] For the groove weld shown in Figure 2, ASTM A 36, A 285, or A 516 Grade 70 base metals may be used for low-alloy steel classifications however, the joint surfaces shall be buttered as shown in Figure 2 using any electrode of the same composition as the classification being tested. Buttering is not required for carbon steel classifications (CS1, CS2, and CS3). For the "G" weld metal designation the base metal may also be as agreed upon between supplier and purchaser.

[b] Buttering of the groove weld in Figure 2 is not required when using A 36 or A 285 base metals when testing the T4, T6, T7, T8, or T11 self-shielded multiple pass electrode types with 70 ksi [490 MPa] or lower classification.

[c] ASTM A 36 or A 285 base metals may be used for the weld pad referenced in 9.2.3. The minimum weld metal height shall be 5/8 in [16 mm]. The sample for analysis shall be taken from weld metal that is at least 1/2 in [12 mm] above the original plate surface.

[d] Chemically equivalent steels in other U.S. Customary grades or in any metric grades (in SI units) may also be used.

[e] As classified in ASTM DS-56/SAE HS-1086, *Metals & Alloys in the Unified Numbering System*.

[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.

Table 12
Heat Input Requirements and Suggested Pass and Layer Sequence for Multiple Pass Electrode Classifications

Diameter		Required Average Heat Input [a, b]		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] For all electrode types, except those with the T16 or T17 Usability Designator, the calculation to be used for heat input is:

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

or

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

These restrictions on heat input do not apply to the first layer. The first layer shall have a maximum of two passes. The average heat input is the calculated average for all passes excluding the first layer. A non-pulsed, constant voltage (CV) power source shall be used.

[b] For electrode types having the T16 or T17 Usability Designator, the welding procedure shall be as recommended by the manufacturer. The welding current shall be an alternating current with or without a modified waveform. The welding procedure used shall be consistent with procedures recommended by the manufacturer for commercial applications.

11. Radiographic Test

11.1 The groove weld described in 9.2.1 and shown in Figure 2 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] maximum 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] so that the thickness of the prepared radiographic test specimen equals at least the thickness of the base metal minus 1/16 in [1.5 mm]. 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 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 5. 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 5) 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 9.2.1 and shown in Figure 2. 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 2 of Figure 2) 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 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 2.

12.2 For single pass electrode classifications, one transverse 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 9.2.2 and shown in Figure 3. The transverse rectangular tension specimen shall be a full thickness specimen machined transverse to the weld with a nominal reduced section width of 1.50 in [38 mm].

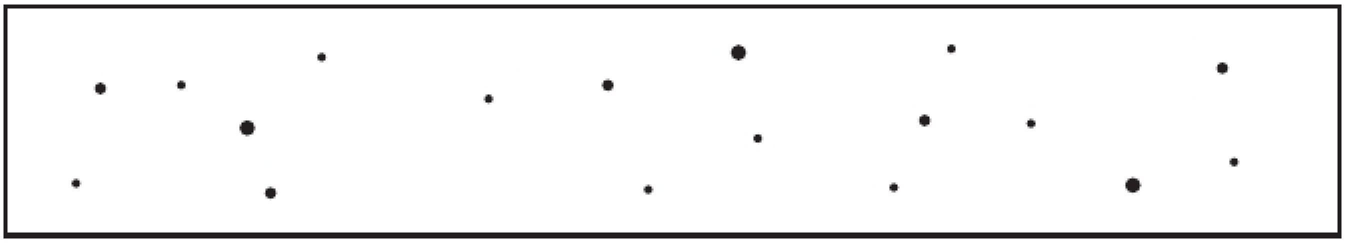
12.2.1 The specimen shall be tested in the manner described in the Tension Test section of AWS B4.0 or B4.0M.

12.2.2 The results of the tension test shall meet the requirements specified in Table 2.

13. Bend Test

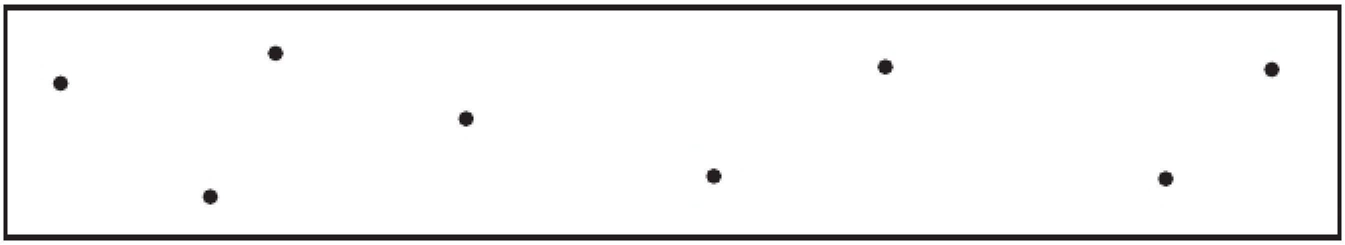
13.1 One longitudinal face bend test specimen, as required in Table 7, shall be machined from the welded test assembly described in 9.2.2 and shown in Figure 3. The dimensions of the specimen shall be as shown in Figure 3. Other dimensions of the bend specimen shall be as specified in the Bend Test section of AWS B4.0 or B4.0M.

13.2 After machining, but before testing, the specimen 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 on the purpose of aging.



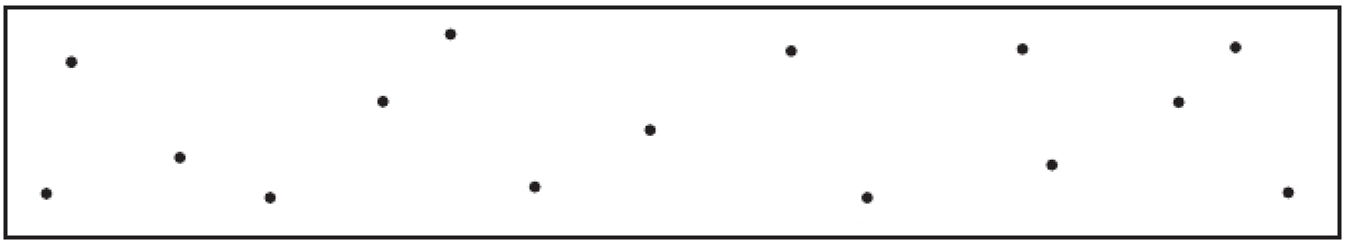
(A) ASSORTED ROUNDED INDICATIONS

SIZE 1/64 in TO 1/16 in [0.4 mm TO 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 TO 1/16 in [1.2 mm TO 1.6 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 3.
MAXIMUM NUMBER OF MEDIUM 1/32 in TO 3/64 in [0.8 mm TO 1.2 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 5.
MAXIMUM NUMBER OF SMALL 1/64 in TO 1/32 in [0.4 mm TO 0.8 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 10.



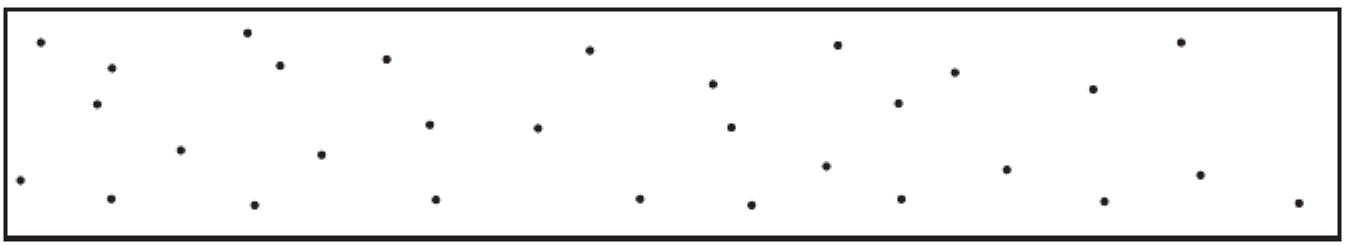
(B) LARGE ROUNDED INDICATIONS

SIZE 3/64 in TO 1/16 in [1.2 mm TO 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 TO 3/64 in [0.8 mm TO 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 TO 1/32 in [0.4 mm TO 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.

Source: Figure 7 of AWS A5.29/A5.29M:2005 (Errata/Reprint).

Figure 5—Radiographic Standard for Test Assembly in Figure 2

13.3 The specimen shall be tested in the manner described in the Bend Test section of AWS B4.0 or B4.0M by bending it uniformly through 180° over a 3/4 in [19 mm] radius using any suitable jig as specified in the Bend Test section of B4.0 or B4.0M. Positioning of the longitudinal face bend specimen shall be such that the weld face of the last side welded is in tension.

13.4 The specimen, after bending, shall conform to the 3/4 in [19 mm] radius, with an appropriate allowance for spring back, and the weld metal shall not show any crack or other open defect exceeding 1/8 in [3.2 mm] in any direction when examined with the unaided eye. Cracks in the base metal shall be disregarded, as long as they do not enter the weld metal. When base metal openings or cracks enter the weld metal, the test shall be considered invalid. Specimens in which this occurs shall be replaced, specimen for specimen, and the test completed. In this case, the doubling of specimens required in Clause 8 does not apply.

14. Impact Test

14.1 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 2 for those classifications for which impact testing is required (see Figure 1).

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.

14.2 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 3 for the classification under test.

14.3 In evaluating the test results for all classifications except the K9 low-alloy electrode classification, 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, except as noted in 14.4.

14.4 In evaluating the results for a K9 low-alloy electrode classification, all five impact values shall be included. At least four of the five shall be not less than the energy level specified for the classification. One of the five may be lower than that, but not lower than the minimum requirement by more than 10 ft·lbf [14 J]. The average of all five values must meet the minimum requirement.

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 13, 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"

Table 13
Diffusible Hydrogen Limits for Weld Metal [a]

Optional Supplemental Diffusible Hydrogen Designator [b, c, d]	Average Diffusible Hydrogen, Maximum [e] mL/100 g Deposited Metal
H16	16
H8	8
H4	4
H2	2

[a] Limits on diffusible hydrogen when tested in accordance with AWS A4.3, as specified in Clause 15.
[b] See Figure 1.
[c] The lower diffusible hydrogen levels (H8, H4, and H2) may not be available in some classifications (see A8.2 in Annex A).
[d] Electrodes which satisfy the diffusible hydrogen limits for H2 category also satisfy the limits for the H4, H8, and H16 categories. Electrodes which satisfy the diffusible hydrogen limits for the H4 category also satisfy the limits for the H8 and H16 categories. Electrodes which satisfy the diffusible hydrogen limits for H8 category also satisfy the limits for the H16 category.
[e] 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 A8.2 in Annex A).

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 in Annex A.

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

where:

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

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

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

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. [10] 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 13, the electrode also meets the requirements for all higher designators in Table 13 without need to retest.

16. "D" and "Q" Optional Supplemental Designator Tests

16.1 Each diameter of an electrode to be identified with either the "D" or "Q" optional supplemental designator (see Figure 1) shall be tested using both (1) a low heat input, fast cooling rate procedure and (2) a high heat input, slow cooling rate procedure as outlined in 16.2, 16.3, 16.4, 16.5, and Table 10.

16.1.1 Two test assemblies shall be prepared as shown in Figure 2. The base metals for the qualification of 70 ksi [490 MPa] minimum tensile strength filler metals shall conform to ASTM A 36, A 572 Grade 50, or A 992. Base metals for the qualification of 80 ksi [550 MPa] minimum tensile strength filler metals shall conform to ASTM A 36, A 572 Grade 50 or 65, or A 913 Grade 65, as agreed upon between the supplier and purchaser. Steel backing shall be of one of the five

[10] See A8.2.5 in Annex A.

specifications and grades listed above, but need not be the same as the base material used for the qualification test assemblies. The assemblies shall be restrained (or preset) during welding to prevent warpage in excess of 5°. An assembly that is warped more than 5° from plane shall be discarded. It shall not be straightened.

16.1.2 The low heat input, fast cooling rate groove weld for both the "D" and "Q" designators shall be welded in the 1G position.

16.1.3 The high heat input, slow cooling rate groove weld for both the "D" and "Q" designators shall be welded in the 1G position for electrodes classified for flat and horizontal welding (position designator "0").

For electrodes classified for all-position welding (position designator "1") the high heat input, slow cooling rate groove weld shall be made in the 3G position with upward progression.

16.2 When testing for the "D" designator, the welding of the low heat input, fast cooling rate groove weld shall begin with the test assembly at 120ºF [50ºC] maximum. Welding shall continue until the assembly has reached the interpass temperature of 250ºF [120ºC] maximum. This maximum interpass temperature shall be maintained for the remainder of the weld. Should it be necessary to interrupt the welding, the assembly shall be allowed to cool in still air at room temperature. The assembly shall be heated to between 120ºF [50ºC] and 250ºF [120ºC] before welding is resumed.

For electrode diameters less than 3/32 in [2.4 mm] the average heat input for all passes, exclusive of the first layer, shall be 24 kJ/in – 36 kJ/in [0.9 kJ/mm – 1.4 kJ/mm]. No individual pass, exclusive of the first layer, shall exceed 38 kJ/in [1.5 kJ/mm] heat input. See Table 10.

For electrode diameters 3/32 in [2.4 mm] or larger the average heat input for all passes, exclusive of the first layer, shall be 35 kJ/in – 42 kJ/in [1.4 kJ/mm – 1.6 kJ/mm]. No individual pass, exclusive of the first layer, shall exceed 44 kJ/in [1.7 kJ/mm] heat input. See Table 10.

16.3 When testing for the "D" designator, the welding of the high heat input, slow cooling rate groove weld shall begin with the test assembly preheated to 250°F [120°C] minimum. Welding shall continue until the test assembly has reached the interpass temperature of 450°F [240°C] minimum. See Table 10. This minimum 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 at room temperature. The assembly shall be heated to a temperature above the minimum interpass temperature before welding is resumed.

The average heat input for all passes, exclusive of the first layer, shall be 65 kJ/in – 85 kJ/in [2.6 kJ/mm – 3.3 kJ/mm]. No individual pass, exclusive of the first layer, shall be made at less than 65 kJ/in [2.6 kJ/mm] heat input. See Table 10.

16.4 When testing for the "Q" designator, the welding of the low heat input, fast cooling rate groove weld shall begin with the test assembly at 70°F ± 25°F [20°C ± 15°C]. Welding shall continue until the test assembly has reached the maximum interpass temperature of 150°F [65°C] which shall not be exceeded. Should it be necessary to interrupt welding, the assembly shall be allowed to cool in still air at room temperature. The assembly shall be heated to 150°F [65°C] maximum before welding is resumed.

The average heat input for all passes, exclusive of the first layer, shall be 25 kJ/in – 32 kJ/in [1.0 kJ/mm – 1.3 kJ/mm]. No individual pass, exclusive of the first layer, shall exceed 33 kJ/in [1.3 kJ/mm] heat input. See Table 10.

16.5 When testing for the "Q" designator, the welding of the high heat input, slow cooling rate groove weld shall begin with the test assembly preheated to 300°F ± 25°F [150°C ± 15°C] prior to welding. An interpass temperature of 300°F ± 25°F [150°C ± 15°C] 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 at room temperature. The assembly shall be heated to a temperature of 300°F ± 25°F [150°C ± 15°C] before welding is resumed.

The average heat input for all passes, exclusive of the first layer, shall be 68 kJ/in – 75 kJ/in [2.7 kJ/mm – 3.0 kJ/mm]. No individual pass, exclusive of the first layer, shall be made at less than 65 kJ/in [2.6 kJ/mm] heat input. See Table 10.

16.6 After welding has been completed and the assembly has cooled, the assembly shall be prepared and tested as shown in Figure 2 and as specified in Clauses 11, 12, and 14. The tension and impact tests shall meet the requirements specified in Table 9 for the "D" or "Q" designator, as applicable.

16.7 When certifying an electrode for the "D" or "Q" optional supplemental designator the actual average heat input used, exclusive of the first layer, for both the low heat input, fast cooling rate and high heat input, slow cooling rate groove welds shall be clearly stated on the test report(s).

17. 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.

18. Standard Sizes

18.1 Standard sizes for filler metal in the different package forms such as coils with support, coils without support, drums, and spools are as specified in AWS A5.02/A5.02M.

19. Finish and Uniformity

19.1 Finish and uniformity shall be as specified in 4.2 of AWS A5.02/A5.02M.

20. Standard Package Forms

20.1 Standard package forms are coils with support, coils without support, spools, and drums. Standard package dimensions and weights for each form shall be as specified in 4.3 of AWS A5.02/A5.02M:2007.

21. Winding Requirements

21.1 Winding requirements shall be as specified in 4.4.1 of AWS A5.02/A5.02M. The outermost layer of electrode on spools shall be at least 1/8 in [3 mm] from the rim (the OD) of the flanges of the spool.

21.2 The cast and helix of electrode in coils, spools, and drums shall be as specified in 4.4.2 of AWS A5.02/A5.02M.

22. Electrode Identification

22.1 Electrode identification, product information and the precautionary information shall be as specified in 4.5 of AWS A5.02/A5.02M.

23. Packaging

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

24. Marking of Packages

24.1 The product information (as a minimum) that shall be legibly marked so as to be visible from the outside of each unit package shall be as specified in 4.6.1 of AWS A5.02/A5.02M:2007.

24.2 The appropriate precautionary information [11] 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.

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

Annex A (Informative)

Guide to AWS Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal Arc Welding

This annex is not part of AWS A5.36/A5.36M:2012, *Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal 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 This AWS A5.36/A5.36M specification utilizes two different classification systems. The first of these is a "fixed classification system" which is carried over from A5.20/A5.20M, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*, or from A5.18/A5.18M, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*, as applicable, for the classification those carbon steel flux cored or metal cored electrodes which, with the specific requirements already established, have enjoyed wide acceptance for single and multiple pass applications. These specific electrode classifications and their requirements are given in Table 1. The second classification system utilized in this specification is an "open classification system" for the classification of flux cored and metal cored carbon and low-alloy steel electrodes. 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 (see Figure 1). It contains provisions for both multiple pass and single pass classifications. Classifications include designators for (1) tensile strength, (2) position of welding, (3) electrode usability characteristics, (4) shielding gas, if any, (5) condition of heat treatment, (6) impact toughness, and (7) weld deposit composition. This A5.36/A5.36M specification is used to classify flux cored electrodes previously classified under AWS A5.20/A5.20M, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding,* and AWS A5.29/A5.29M, *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding,* and metal cored electrodes previously classified under AWS A5.18/A5.18M, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*, and AWS A5.28/A5.28M, *Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*.

A2.1.1 Some of the classifications are intended to weld only in the flat and horizontal positions. Others are intended for welding in all positions. 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. Cored electrodes larger than 5/64 in [2.0 mm] in diameter are usually used for horizontal fillets and flat position welding.

A2.1.2 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. See 7.2.

A2.3 "G" Classification

A2.3.1 This specification includes electrodes classified as E XXTG-XXX-X, E XXTX-GXX-X, E XXTX-XGX-X, EXXTX-XXG-X, and EXXTX-XXX-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).

A2.3.2 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 A5.01M/A5.01 (ISO 14344 MOD)] in the purchase order.

A2.3.3 Request for Filler Metal Classification

(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 electrode. 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 electrode is of commercial significance.

(2) A request to establish a new electrode 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:

(a) All classification requirements as given for existing classifications such as chemical composition ranges *and* mechanical property requirements.

(b) 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.)

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

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.

(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:

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

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

(c) 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.

(d) File the original request.

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

(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.

(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.

A2.4 The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies. ISO provides for the classification of tubular cored products for carbon and low-alloy steels under their ISO 17632, *Welding consumables — Tubular cored electrodes for gas shielded and non-gas shielded metal arc welding of non-alloy and fine grain steels — Classification,* ISO 17634, *Welding consumables — Tubular cored electrodes for gas shielded metal arc welding of creep-resisting steels — Classification* and ISO 18276, *Welding consumables — Tubular cored electrodes for gas-shielded and non-gas shielded metal arc welding of high strength steels — Classification standards*.

A3. Acceptance

Acceptance of all cored welding electrodes classified under this specification is in accordance with AWS A5.01M/A5.01 (ISO 14344 MOD) 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 A5.01M/A5.01 (ISO 14344 MOD). 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 classification, as specified in Schedule F, Table 1, of AWS A5.01M/A5.01 (ISO 14344 MOD). 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 Program in AWS A5.01M/A5.01 (ISO 14344 MOD).

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.

(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. Refer also to AWS F3.2M/F3.2, *Ventilation Guide for Weld Fume* .

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 carbon steel electrode was gas shielded or self-shielded. Gas shielded carbon steel 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 deoxidation 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 carbon steel 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 and Metal Cored Electrodes

This specification may contain many different classifications of flux cored and metal cored electrodes. The usability designator (1, 3, 4, 5, 6, 7, 8, 10, 11, 14, 15, 16, 17, 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 Flux Cored Electrode Classifications with the T1 Usability Designator. Electrodes with EXXT1-XXX-X designations (or E7XT-1C, E7XT-1M) have similar type slags and are designed for single and multiple pass welding using DCEP. The EX0T1-XXX-X electrodes are typically used for welding in the flat position and for welding fillet welds in the horizontal position. The EX1T1-XXX-X electrodes are classified for welding in all positions. Typically these electrodes are manufactured in smaller diameters (1/16 in [1.6 mm] and smaller) to facilitate out of position capability. How-

ever, some E X1T1-XXX-X electrodes may also be manufactured in larger diameters (5/64 in [2.0 mm] and larger). EXXT1-XXX-X 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. Electrodes of this classification have a rutile base slag and have the ability to produce high deposition rates.

Electrodes with EXXT1-C1XX-X designations are classified with CO_2 shielding gas (Shielding Gas Designator C1 in Table 5). When recommended by the manufacturer, these electrodes may be used with argon mixes that contain CO_2, O_2, or both. This is typically done to improve usability, especially for out-of-position welding. This specification provides for classifying T1 type electrodes with different argon blends (see Table 5), when appropriate, as determined by the manufacturer. Increasing the amount of argon in the gas blend beyond that recommended by the manufacturer may adversely affect weld metal performance (for example, penetration, chemical composition, strength, toughness, and crack resistance).

A7.2 Flux Cored Electrode Classifications with the T1S Usability Designator. Electrodes with the EXXT1S-X classification are essentially the EXXT1-XXX-X types with higher manganese or silicon, or both, and are designed primarily for single pass welding in the flat position and for welding fillet welds in the horizontal position. The higher levels of deoxidizers in these classifications allow single pass welding of heavily oxidized or rimmed steel. Weld metal composition requirements are not specified for single pass electrodes, since checking the composition of undiluted weld metal will not provide an indication of the composition of a single pass weld. Note that the EXXT1S-X classification included in this specification is new and is a direct substitute for the EXXT-2X classification listed in A5.20/A5.20M:2005.

The manganese content and the tensile strength of the weld metal of multiple-pass welds made with EXXT1S-X electrodes will be high. These electrodes can be used for welding base metals which have heavier mill scale, rust, or other foreign matter that cannot be tolerated by some electrodes of the EXXT1-XXX-X classifications. The arc transfer, welding characteristics, and deposition rates of these electrodes, however, are similar.

A7.3 Flux Cored Electrode Classifications with the T3S Usability Designator. Electrodes with EXXT3S classifications are self-shielded, used with DCEP and have a spray-type transfer. The slag system is designed to make very high welding speeds possible. The electrodes are used for single-pass welds in the flat, horizontal, and vertical (up to 20° incline) positions (downward progression) on sheet metal. Since these electrodes are sensitive to the effects of base metal quenching, they are not generally recommended for the following:

(1) T- or lap joints in materials thicker than 3/16 in [5 mm]

(2) Groove, edge, or corner joints in materials thicker than 1/4 in [6 mm]

The electrode manufacturer should be consulted for specific recommendations.

A7.4 Flux Cored Electrode Classifications with the T4 Usability Designator. Electrodes having EXXT4-XX-X classifications are self-shielded, operate on DCEP, and have a globular type transfer. The basic slag system is designed to make very high deposition rates possible and to produce a weld that is very low in sulfur for improved resistance to hot cracking. These electrodes produce welds with low penetration enabling them to be used on joints with varying gaps and for single and multiple pass welding.

A7.5 Flux Cored Electrode Classifications with the T5 Usability Designator. Electrodes of the EXXT5-C1XX-X (or E7XT-5C) classification are designed to be used with CO_2 shielding gas. However, when recommended by the manufacturer, these same electrodes may be classified and used with a blend of CO_2 with argon to reduce spatter and improve welding characteristics. This specification provides for the classifying T5 type electrodes for use with different shielding gases (see Table 5), when appropriate. Increasing the amount of argon in the shielding gas 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. T5 type electrodes may also be classified with a shielding gas which is a blend of argon with CO_2, O_2, or both (refer to Table 5). Their use with gas mixtures having reduced amounts of argon (with corresponding increases is CO_2 and/or O_2) 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 EXXT5-XXX-X 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 EXXT5-XXX-X 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.

A7.6 Flux Cored Electrode Classifications with the T6 Usability Designator. Electrodes having an EXXT6-XX-X (or E 7XT-6) classification are self-shielded, operate on DCE P, and have a 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 multiple pass welding in flat and horizontal positions.

A7.7 Flux Cored Electrode Classifications with the T7 Usability Designator. Electrodes having EXXT7-XX-X (or E7XT-7) classifications 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 hot cracking.

A7.8 Flux Cored Electrode Classifications with the T8 Usability Designator. Electrodes classified as EXXT8-XX-X (or E7XT-8) 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.

A7.9 Flux Cored Electrode Classifications with the T10S Usability Designator. Electrodes with EXXT10S classifications are self-shielded, operate on DCEN, and have a small droplet transfer. The electrodes are used for single-pass welds at high travel speeds on material of any thickness in the flat, horizontal, and vertical (up to 20° incline) positions.

A7.10 Flux Cored Electrode Classifications with the T11 Usability Designator. E lectrodes with E XXT11-XX-X classifications are self-shielded, operate on DCEN, and have a smooth spray-type transfer. They are general purpose electrodes for single- and multiple-pass welding in all positions. Their use is generally not recommended on thicknesses greater than 3/4 in [19 mm]. The electrode manufacturer should be consulted for specific recommendations.

A7.11 Flux Cored Electrode Classifications with the T14S Usability Designator. Electrodes with EXXT14S classifications are self-shielded, operate on DCEN, and have a smooth spray-type transfer. They are intended for single-pass welding. The slag system is designed with characteristics so that these electrodes can be used to weld in all positions and also to make welds at high speed. They are used to make welds on sheet metal up to 3/16 in [5 mm] thick, and often are specifically designed for galvanized, aluminized, or other coated steels. Since these welding electrodes are sensitive to the effects of base metal quenching, they are not generally recommended for the following:

(1) T- or lap joints in materials thicker than 3/16 in [5 mm]

(2) Groove, edge, or corner joints in materials thicker than 1/4 in [6 mm]

The electrode manufacturer should be consulted for specific recommendations.

A7.12 Metal Cored Electrode Classifications with the T15 Usability Designator. Electrodes classified as E70C-3C [E48C-3C], E70C-3M [E48C-3M], E70C-6C [E48C-6C], E70C-6M [E48C-6M] in AWS A5.18/A5.18M:2005, EXXC-X in AWS A5.28/A5.28M:2005, and EXXT15-XXX-X (or E70C-6M) in this specification are composite stranded or metal cored electrodes intended for both single and multiple pass applications. They are characterized by a spray arc and excellent bead wash characteristics. They are used for gas metal arc welding (GMAW). Metal cored electrodes are similar in many ways to solid GMAW electrodes.

A7.13 Metal Cored Electrode Classifications with the T16 Usability Designator. Electrodes classified as EXXT16-XXX-X are gas shielded metal cored electrodes specifically designed for use with AC power source with or without modified waveforms. The manufacturer should be consulted for application and welding procedure recommendations.

A7.14 Flux Cored Electrode Classifications with the T17 Usability Designator. Electrodes classified as EXXT17-XX-X are self shielded flux cored electrodes specifically designed for use with AC power sources with or without modified waveforms. The manufacturer should be consulted for application and welding procedure recommendations.

A7.15 EXXTG-XXX-X, EXXTX-XGX-X, EXXTX-XXG-X, EXXTX-XXX-G and EXXTG-ZXX-X Classifications. These classifications and combinations thereof 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 estab-

lished by the digits chosen to complete the classification. Placement of the “G” (“Z” for shielding gas) in the classification designates that the electrode usability characteristics, shielding gas used for classification, condition of heat treatment, Charpy impact requirements or weld metal composition requirements, as applicable, are not defined in this specification and are as agreed upon between supplier and purchaser.

A7.16 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.

A7.16.1 EXXTX-XXX-A1 (C-Mo Steel) Electrodes. These electrodes are similar to E XXTX-XXX carbon steel electrodes classified under this specification, except that 0.5% Mo has been added. This addition increases the strength of the weld metal, especially at elevated temperatures, and provides some increase in corrosion resistance; it may, however, 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 A 335-P1 pipe.

A7.16.2 EXXTX-XXX-BX, EXXTX-XXX-BXL, and EXXTX-XXX-BXH (Cr-Mo Steel) Electrodes. These electrodes produce weld metal that contain between 0.5% and 10% Cr, and between 0.5% and 1% Mo. They are designed to produce weld metal for high temperature service and for matching properties of the typical base metals as follows:

EXXTX-XXX-B1	ASTM A 335-P2 pipe ASTM A 387 Gr. 2 plate
EXXTX-XXX-B2	ASTM A 335-P11 pipe ASTM A 387 Gr. 11 plate
EXXTX-XXX-B2L	Thin wall ASTM A 335-P11 pipe or ASTM A 213-T11tube, as applicable, for use in the as-welded condition or for applications where low hardness is a primary concern.
EXXTX-XXX-B3	ASTM A 335-P22 pipe ASTM A 387 Gr. 22 plate
EXXTX-XXX-B3L	Thin wall ASTM A 335-P22 pipe or ASTM A 213-T22 tube for use in the as-welded condition or for applications where lower hardness is a primary concern.
EXXTX-XXX-B6	ASTM A 213-T5 tube ASTM A 335-P5 pipe
EXXTX-XXX-B8	ASTM A 213-T9 tube ASTM A 335-P9 pipe
EXXTX-XXX-B91	ASTM A 213-T91 tube ASTM A 335-P91 pipe
EXXTX-XXX-B92	ASTM A 213-T92 tube ASTM A 335-P92 pipe

For two of these Cr-Mo electrode classifications, low carbon EXXTX-XXX-BXL classifications have been established. While regular Cr-Mo electrodes produce weld metal with 0.05% to 0.12% carbon, the “L-grades” are limited to a maximum of 0.05% C. While the lower percent carbon in the weld metals will improve ductility and reduce 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-XXX-BXH) established. In these cases, the electrode produces weld metal with 0.10% to 0.15% 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-XXX-B91 and EXXTX-XXX-B92 classifications thermal treatment is critical and must be closely controlled. The temperature at which the microstructure has complete transformation into martensite (M_f) is relatively low; therefore, upon completion of welding and before post weld heat treatment, it is recommended to allow the weldment to cool to 200°F [93°C] or lower 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 6, footnote j). 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.

A7.16.3 EXXTX-XXX-DX (Mn-Mo Steel) Electrodes. These electrodes produce weld metal which contains about 1.5% to 2% Mn and between 0.25% and 0.65% Mo. This weld metal provides better notch toughness than the C-0.5% Mo electrodes discussed in A7.16.1 and higher tensile strength than the 1% nickel 0.5% Mo steel weld metal discussed in A7.16.4.1. 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 ASTM A 302 Gr. B and HSLA steels and Mn-Mo castings, such as ASTM A 49, A 291, and A 735.

A7.16.4 EXXTX-XXX-KX (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.

A7.16.4.1 EXXTX-XXX-K1 Electrodes. Electrodes of this classification produce weld metal with nominally 1% Ni and 0.5% Mo. These electrodes may also be used for long-term stress-relieved applications for welding low-alloy, high strength steels, in particular 1% nickel steels.

A7.16.4.2 EXXTX-XXX-K2 Electrodes. Electrodes of this classification produce weld metal which will have a chemical composition of 1.5% nickel and up to 0.35% Mo. These electrodes are used on many high-strength applications ranging from 80 ksi to 110 ksi [550 MPa 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.

A7.16.4.3 EXXTX-XXX-K3 Electrodes. Electrodes of this type produce weld deposits with higher levels of Mn, nickel and Mo than the EXXTX-XXX-K2 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.

A7.16.4.4 EXXTX-XXX-K4 Electrodes. Electrodes of this classification deposit weld metal similar to that of the -K3 electrodes, with the addition of approximately 0.5% Cr. The additional alloy provides the higher strength for many applications needing in excess of 120 ksi [830 MPa] tensile strength, such as armor plate.

A7.16.4.5 EXXTX-XXX-K5 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.

A7.16.4.6 EXXTX-XXX-K6 Electrodes. Electrodes of this classification produce weld metal which utilizes less than 1% nickel to achieve excellent toughness in the 60 ksi and 70 ksi [430 MPa and 490 MPa] tensile strength ranges. Applications include structural, offshore construction, and circumferential pipe welding.

A7.16.4.7 EXXTX-XXX-K7 Electrodes. This electrode classification produces weld metal which has similarities to that produced with EXXTX-XXX-Ni2 and EXXTX-XXX-Ni3 electrodes. This weld metal has approximately 1.5% manganese and 2.5% Ni. The weld metal for K7 allows for a higher alloying content of % Mn compared to the weld metal for Ni2/Ni3, which is useful for higher strength applications.

A7.16.4.8 EXXTX-XXX-K8 Electrodes. This classification was designed for electrodes intended for use in circumferential girth welding of line pipe. The weld deposit contains approximately 1.5% Mn, 1% Ni, and small quantities of other alloys. It is especially intended for use on API 5L X80 pipe steels.

A7.16.4.9 EXXTX-XXX-K9 Electrodes. These electrodes produce weld metal similar to that of the -K2 and -K3 type electrodes, but are intended to be similar to the military requirements of MIL-101TM and MIL-101TC electrodes in MIL-E-24403/2C. Theses electrodes are designed for welding HY-80 steel.

A7.16.4.10 EXXTX-XXX-K10 Electrodes. Electrodes of this classification produce weld metal which has similarities to that produced with EXXTX-XXX-Ni2 and EXXTX-XXX-Ni3 electrodes. The K10 weld metal has approximately 1.8% Mn, 2.0% Ni, up to 0.5% Mo, and up to 0.2% Cr. These electrodes are used on high-strength steel applications with minimum yield strength requirements of 80 ksi to 120 ksi [550 MPa to 830 MPa].

A7.16.4.11 EXXTX-XXX-K11 Electrodes. Electrodes of this classification produce weld metal similar to that of the -K6 type electrodes, but are intended for higher strength applications. Applications include structural, offshore construction and sour gas circumferential pipe welding where controlling Ni contents to 1% maximum is important.

A7.16.5 EXXTX-XXX-NiX (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% nickel, 2% nickel, and 3% nickel in steel.

With carbon levels up to 0.12%, the strength increases and permits some of the Ni-steel electrodes to be classified as E8XTX-XXX-NiX [E 55XTX-XXX-NiX] and E 9XTX-XXX-NiX [E 62XTX-XXX-NiX]. 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 7 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.

A7.16.6 EXXTX-XXX-W2 (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% Cu to the weld metal. To meet strength, ductility, and notch toughness in the weld metal, some Cr and Ni additions are also made. These electrodes are used to weld typical weathering steel, such as ASTM A 242, ASTM A 588, and ASTM A 709 Grade 50W.

A7.16.7 EXXTX-XXX-G (General Low-Alloy Steel) Electrodes. These electrodes are described in A2.3. 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, or for evaluating an electrode's positional usability characteristics. Supplemental requirements as agreed upon between purchaser and supplier may be added to the purchase order following the guidance of AWS A5.01M/A5.01 (ISO 14344 MOD).

A8.1.1 The fillet weld test is not required for the classification of an electrode under this specification. However, the fillet weld test can be used, as agreed upon between the purchaser and supplier, to assess the ability of an electrode to meet application requirements for positional usability and root penetration. Refer to AWS A4.5 (ISO 15792-3), *Standard Methods for Classification Testing of Positional Capacity and Root Penetration of Welding Consumables in a Fillet Weld*.

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 and metal cored electrodes deposit weld metal having diffusible hydrogen levels of less than 16 mL/100 g of deposited metal. For that reason, flux cored and metal 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 g 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 or metal 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 a self-shielded flux cored electrode or a gas-shielded flux cored or metal cored electrode. 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 and H2 levels. An electrode meeting the H4 or H2 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.

(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 and metal 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 con-

sidered "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 and metal cored electrodes will influence the values obtained on a diffusible hydrogen test. To address this, the AWS A5M Subcommittee 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 13. See Clause 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-M21XX-K2 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]	80 Ar/20 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]	80 Ar/20 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 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 in/min + 0.75 (550 in/min – 175 in/min) = 456 in/min. [WFR_{min}= 445 cm/min + 0.75 (1400 cm/min – 445 cm/min) = 1160 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 [1.6mm] diameter the minimum wire feed rate (WFR_{min}) to be used for the hydrogen test, as specified in 15.2, is WFR_{min} = 150 in/min +0.75 (375 in/min – 150 in/min) = 319 in/min [WFR_{min} = 380 cm/min + 0.75 (950 cm/min – 380 cm/min) = 808 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, H4, or H2 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 A5.36/A5.36M 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 A5.01M/A5.01 (ISO 14344 MOD).

A9. Discontinued Classifications

The EXXT-2X classification has been discontinued. Flux cored electrodes previously utilizing the "2" Usability Designator to indicate a single pass electrode can now be classified utilizing the open classification system introduced in this specification. The EXXT-13 electrode classification has been discontinued due to lack of commercial significance. With the exception of the classifications shown in Table 1, the classifications listed in the left hand columns of Tables A.1, A.2, and A.3 will be discontinued.

The equivalent classifications for these electrodes utilizing the open classification system in this specification are also noted in these tables. The classification systems used in A5.20/A5.20M, A5.29/A5.29M, A5.18/A5.18M, and A5.28/A5.28M are given below for comparison purposes.

A9.1 The classification system for AWS A5.20/A5.20M:2005, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding* , is as follows:

$E^1X^2X^3T^4 - X^5X^6 - J^7X^8HX^9$

where:

1. "E" designates an electrode.
2. Tensile strength designator (one or two digits are used).
3. Position designator.
4. "T" identifies the electrode as a flux cored electrode.
5. Usability designator.
6. Shielding gas designator. No designator is used for self-shielded electrodes.
7. "J" is an optional supplemental designator indicating improved toughness.
8. "D" or "Q" is an optional supplemental designator indicating conformance to supplemental mechanical property requirements under slow cooling and fast cooling welding parameters.
9. "HX" is an optional supplemental diffusible hydrogen designator.

Table A.1
Existing A5.20/A5.20M [a] Classifications and Equivalent
A5.36/A5.36M Classifications Utilizing the Open Classification System

	A5.20/A5.20M Classifications	Equivalent Classifications Under A5.36 [A5.36M] [b]		A5.20/A5.20M Classifications	Equivalent Classifications Under A5.36 [A5.36M] [b]
1	E7XT-1C [E49XT-1C]	E7XT1-C1A0-CS1 [E49XT1-C1A2-CS1]	12	E7XT-8-J [E49XT-8-J]	E7XT8-A4-CS3 [E49XT8-A4-CS3]
2	E7XT-1M [E49XT-1M]	E7XT1-M21A0-CS1 [E49XT1-M21A2-CS1]	13	E7XT-9C [E49XT-9C]	E7XT1-C1A2-CS1 [c] [E49XT1-C1A3-CS1] [c]
3	E7XT-2C [E49XT-2C]	E7XT1S-C1 [E49XT1S-C1]	14	E7XT-9M [E49XT-9M]	E7XT1-M21A2-CS1 [c] [E49XT1-M21A3-CS1] [c]
4	E7XT-2M [E49XT-2M]	E7XT1S-M21 [E49XT1S-M21]	15	E7XT-10 [E49XT-10]	E7XT10S [E49XT10S]
5	E7XT-3 [E49XT-3]	E7XT3S [E49XT3S]	16	E7XT-11 [E49XT-11]	E7XT11-AZ-CS3 [E49XT11-AZ-CS3]
6	E7XT-4 [E49XT-4]	E7XT4-AZ-CS3 [E49XT4-AZ-CS3]	17	E7XT-12C [E49XT-12C]	E7XT1-C1A2-CS2 [E49XT1-C1A3-CS2]
7	E7XT-5C [E49XT-5C]	E7XT5-C1A2-CS1 [E49XT5-C1A3-CS1]	18	E7XT-12M [E49XT-12M]	E7XT1-M21A2-CS2 [E49XT1-M21A3-CS2]
8	E7XT-5M [E49XT-5M]	E7XT5-M21A2-CS1 [E49XT5-M21A3-CS1]	19	E7XT-12M-J [49XT-12M-J]	E7XT1-M21A4-CS2 [d] [E49XT1-M21A4-CS2] [d]
9	E7XT-6 [E49XT-6]	E7XT6-A2-CS3 [E49XT6-A3-CS3]	20	E6XT-13 [E43XT-13]	The EXXT-13 electrode type is obsolete
10	E7XT-7 [E49XT-7]	E7XT7-AZ-CS3 [E49XT7-AZ-CS3]	21	E7XT-13 [E49XT-13]	
11	E7XT-8 [E49XT-8]	E7XT8-A2-CS3 [E49XT8-A3-CS3]	22	E7XT-14 [E49XT-14]	E7XT14S [E49XT14S]

[a] *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding* .

[b] The "X" which appears as part of the electrode designations in this table represents the Position Designator. A "1" in this position indicates that the electrode has all position capabilities. A "0" indicates that the electrode is intended for flat and horizontal positions only. See Figure 1.

[c] The new open classification system utilized in this document eliminates the need for a "T9" electrode type. The "T9" is essentially a "T1" type electrode with Charpy impact requirements at –20°F [–30°C] instead of at 0°F [–20°C]. Under the new classification system this difference is indicated by the use of different Impact Designators.

[d] The new classification system utilized in this document eliminates the need for the "J" optional supplemental designator. The "J" designator in A5.20/A5.20M:2005 required the test temperature for impact toughness to be –40°F [–40°C]. Under the new classification System the impact designator "4" is used to indicate the –40°F [–40°C] test temperature.

Table A.2
Existing A5.29/A5.29M [a] Classifications and Equivalent A5.36/A5.36M Classifications Utilizing the Open Classification System

	A5.29/A5.29M Classifications	Equivalent Classifications Under A5.36 [A5.36M] [b]		A5.29/A5.29M Classifications	Equivalent Classifications Under A5.36 [A5.36M] [b]
1	E7XT5-A1C [E49XT5-A1C]	E7XT5-C1P2-A1 [E49XT5-C1P3-A1]	23	E9XT1-B3HC [E62XT1-B3HC]	E9XT1-C1PZ-B3H [E62XT1-C1PZ-B3H]
2	E7XT5-A1M [E49XT5-A1M]	E7XT5-M21P2-A1 [E49XT5-M21P3-A1]	24	E9XT1-B3HM [E62XT1-B3HM]	E9XT1-M21PZ-B3H [E62XT1-M21PZ-B3H]
3	E8XT1-A1C [E55XT1-A1C]	E8XT1-C1PZ-A1 [E55XT1-C1PZ-A1]	25	E9XT5-B3C [E62XT5-B3C]	E9XT5-C1PZ-B3 [E62XT5-C1PZ-B3]
4	E8XT1-A1M [E55XT1-A1M]	E8XT1-M21PZ-A1 [E55XT1-M21PZ-A1]	26	E9XT5-B3M [E62XT5-B3M]	E9XT5-M21PZ-B3 [E62XT5-M21PZ-B3]
5	E8XT1-B1C [E55XT1-B1C]	E8XT1-C1PZ-B1 [E55XT1-C1PZ-B1]	27	E10XT1-B3C [E69XT1-B3C]	E10XT1-C1PZ-B3 [E69XT1-C1PZ-B3]
6	E8XT1-B1M [E55XT1-B1M]	E8XT1-M21PZ-B1 [E55XT1-M21PZ-B1]	28	E10XT1-B3M [E69XT1-B3M]	E10XT1-M21PZ-B3 [E69XT1-M21PZ-B3]
7	E8XT1-B1LC [E55XT1-B1LC]	E8XT1-C1PZ-B1L [E55XT1-C1PZ-B1L]	29	E8XT1-B6C [E55XT1-B6C]	E8XT1-C1PZ-B6 [E55XT1-C1PZ-B6]
8	E8XT1-B1LM [E55XT1-B1LM]	E8XT1-M21PZ-B1L [E55XT1-M21PZ-B1L]	30	E8XT1-B6M [E55XT1-B6M]	E8XT1-M21PZ-B6 [E55XT1-M21PZ-B6]
9	E8XT1-B2C [E55XT1-B2C]	E8XT1-C1PZ-B2 [E55XT1-C1PZ-B2]	31	E8XT1-B6LC [E55XT1-B6LC]	E8XT1-C1PZ-B6L [E55XT1-C1PZ-B6L]
10	E8XT1-B2M [E55XT1-B2M]	E8XT1-M21PZ-B2 [E55XT1-M21PZ-B2]	32	E8XT1-B6LM [E55XT1-B6LM]	E8XT1-M21PZ-B6L [E55XT1-M21PZ-B6L]
11	E8XT1-B2HC [E55XT1-B2HC]	E8XT1-C1PZ-B2H [E55XT1-C1PZ-B2H]	33	E8XT5-B6C [E55XT5-B6C]	E8XT5-C1PZ-B6 [E55XT5-C1PZ-B6]
12	E8XT1-B2HM [E55XT1-B2HM]	E8XT1-M21PZ-B2H [E55XT1-M21PZ-B2H]	34	E8XT5-B6M [E55XT5-B6M]	E8XT5-M21PZ-B6 [E55XT5-M21PZ-B6]
13	E8XT1-B2LC [E55XT1-B2LC]	E8XT1-C1PZ-B2L [E55XT1-C1PZ-B2L]	35	E8XT5-B6LC [E55XT5-B6LC]	E8XT5-C1PZ-B6L [E55XT5-C1PZ-B6L]
14	E8XT1-B2LM [E55XT1-B2LM]	E8XT1-M21PZ-B2L [E55XT1-M21PZ-B2L]	36	E8XT5-B6LM [E55XT5-B6LM]	E8XT5-M21PZ-B6L [E55XT5-M21PZ-B6L]
15	E8XT5-B2C [E55XT5-B2C]	E8XT5-C1PZ-B2 [E55XT5-C1PZ-B2]	37	E8XT1-B8C [E55XT1-B8C]	E8XT1-C1PZ-B8 [E55XT1-C1PZ-B8]
16	E8XT5-B2M [E55XT5-B2M]	E8XT5-M21PZ-B2 [E55XT5-M21PZ-B2]	38	E8XT1-B8M [E55XT1-B8M]	E8XT1-M21PZ-B8 [E55XT1-M21PZ-B8]
17	E8XT5-B2LC [E55XT5-B2LC]	E8XT5-C1PZ-B2L [E55XT5-C1PZ-B2L]	39	E8XT1-B8LC [E55XT1-B8LC]	E8XT1-C1PZ-B8L [E55XT1-C1PZ-B8L]
18	E8XT5-B2LM [E55XT5-B2LM]	E8XT5-M21PZ-B2L [E55XT5-M21PZ-B2L]	40	E8XT1-B8LM [E55XT1-B8LM]	E8XT1-M21PZ-B8L [E55XT1-M21PZ-B8L]
19	E9XT1-B3C [E62XT1-B3C]	E9XT1-C1PZ-B3 [E62XT1-C1PZ-B3]	41	E8XT5-B8C [E55XT5-B8C]	E8XT5-C1PZ-B8 [E55XT5-C1PZ-B8]
20	E9XT1-B3M [E62XT1-B3M]	E9XT1-M21PZ-B3 [E62XT1-M21PZ-B3]	42	E8XT5-B8M [E55XT5-B8M]	E8XT5-M21PZ-B8 [E55XT5-M21PZ-B8]
21	E9XT1-B3LC [E62XT1-B3LC]	E9XT1-C1PZ-B3L [E62XT1-C1PZ-B3L]	43	E8XT5-B8LC [E55XT5-B8LC]	E8XT5-C1PZ-B8L [E55XT5-C1PZ-B8L]
22	E9XT1-B3LM [E62XT1-B3LM]	E9XT1-M21PZ-B3L [E62XT1-M21PZ-B3L]	44	E8XT5-B8LM [E55XT5-B8LM]	E8XT5-M21PZ-B8L [E55XT5-M21PZ-B8L]

(Continued)

Table A.2 (Continued)
Existing A5.29/A5.29M [a] Classifications and Equivalent
A5.36/A5.36M Classifications Utilizing the Open Classification System

	A5.29/A5.29M Classifications	Equivalent Classifications Under A5.36 [A5.36M] [b]		A5.29/A5.29M Classifications	Equivalent Classifications Under A5.36 [A5.36M] [b]
45	E9XT1-B9C [c] [E62XT1-B9C] [c]	E9XT1-C1PZ-B91 [E62XT1-C1PZ-B91] or E10XT1-C1PZ-B91 [E69XT1-C1PZ-B91]	65	E8XT5-Ni3M [E55XT5-Ni3M]	E8XT5-M21P10-Ni3 [E55XT5-M21P7-Ni3]
46	E9XT1-B9M [c] [E62XT1-B9M] [c]	E9XT1-M21PZ-B91 [E62XT1-M21PZ-B91] or E10XT1-M21PZ-B91 [E69XT1-M21PZ-B91]	66	E9XT5-Ni3C [E62XT5-Ni3C]	E9XT5-C1P10-Ni3 [E62XT5-C1P7-Ni3]
47	E6XT1-Ni1C [E43XT1-Ni1C]	E6XT1-C1A2-Ni1 [E43XT1-C1A3-Ni1]	67	E9XT5-Ni3M [E62XT5-Ni3M]	E9XT5-M21P10-Ni3 [E62XT5-M21P7-Ni3]
48	E6XT1-Ni1M [E43XT1-Ni1M]	E6XT1-M21A2-Ni1 [E43XT1-M21A3-Ni1]	68	E8XT11-Ni3 [E55XT11-Ni3]	E8XT11-A0-Ni3 [E55XT11-A2-Ni3]
49	E7XT6-Ni1 [E49XT6-Ni1]	E7XT6-A2-Ni1 [E49XT6-A3-Ni1]	69	E9XT1-D1C [E62XT1-D1C]	E9XT1-C1A4-D1 [E62XT1-C1A4-D1]
50	E7XT8-Ni1 [E49XT8-Ni1]	E7XT8-A2-Ni1 [E49XT8-A3-Ni1]	70	E9XT1-D1M [E62XT1-D1M]	E9XT1-M21A4-D1 [E62XT1-M21A4-D1]
51	E8XT1-Ni1C [E55XT1-Ni1C]	E8XT1-C1A2-Ni1 [E55XT1-C1A3-Ni1]	71	E9XT5-D2C [E62XT5-D2C]	E9XT5-C1P6-D2 [E62XT5-C1P5-D2]
52	E8XT1-Ni1M-J [E55XT1-Ni1M-J]	E8XT1-M21A4-Ni1 [d] [E55XT1-M21A4-Ni1] [d]	72	E9XT5-D2M [E62XT5-D2M]	E9XT5-M21P6-D2 [E62XT5-M21P5-D2]
53	E8XT1-Ni1M [E55XT1-Ni1M]	E8XT1-M21A2-Ni1 [E55XT1-M21A3-Ni1]	73	E10XT5-D2C [E69XT5-D2C]	E10XT5-C1P4-D2 [E69XT5-C1P4-D2]
54	E8XT5-Ni1C [E55XT5-Ni1C]	E8XT5-C1P6-Ni1 [E55XT5-C1P5-Ni1]	74	E10XT5-D2M [E69XT5-D2M]	E10XT5-M21P4-D2 [E69XT5-M21P4-D2]
55	E8XT5-Ni1M [E55XT5-Ni1M]	E8XT5-M21P6-Ni1 [E55XT5-M21P5-Ni1]	75	E9XT1-D3C [E62XT1-D3C]	E9XT1-C1A2-D3 [E62XT1-C1A3-D3]
56	E7XT8-Ni2 [E49XT8-Ni2]	E7XT8-A2-Ni2 [E49XT8-A3-Ni2]	76	E9XT1-D3M [E62XT1-D3M]	E9XT1-M21A2-D3 [E62XT1-M21A3-D3]
57	E8XT8-Ni2 [E55XT8-Ni2]	E8XT8-A2-Ni2 [E55XT8-A3-Ni2]	77	E8XT5-K1C [E55XT5-K1C]	E8XT5-C1A4-K1 [E55XT5-C1A4-K1]
58	E8XT1-Ni2C [E55XT1-Ni2C]	E8XT1-C1A4-Ni2 [E55XT1-C1A4-Ni2]	78	E8XT5-K1M [E55XT5-K1M]	E8XT5-M21A4-K1 [E55XT5-M21A4-K1]
59	E8XT1-Ni2M [E55XT1-Ni2M]	E8XT1-M21A4-Ni2 [E55XT1-M21A4-Ni2]	79	E7XT7-K2 [E49XT7-K2]	E7XT7-A2-K2 [E49XT7-A3-K2]
60	E8XT5-Ni2C [E55XT5-Ni2C]	E8XT5-C1P8-Ni2 [E55XT5-C1P6-Ni2]	80	E7XT4-K2 [E49XT4-K2]	E7XT4-A0-K2 [E49XT4-A2-K2]
61	E8XT5-Ni2M [E55XT5-Ni2M]	E8XT5-M21P8-Ni2 [E55XT5-M21P6-Ni2]	81	E7XT8-K2 [E49XT8-K2]	E7XT8-A2-K2 [E49XT8-A3-K2]
62	E9XT1-Ni2C [E62XT1-Ni2C]	E9XT1-C1A4-Ni2 [E62XT1-C1A4-Ni2]	82	E7XT11-K2 [E49XT11-K2]	(e) [E49XT11-A0-K2]
63	E9XT1-Ni2M [E62XT1-Ni2M]	E9XT1-M21A4-Ni2 [E62XT1-M21A4-Ni2]	83	E8XT1-K2C [E55XT1-K2C]	E8XT1-C1A2-K2 [E55XT1-C1A3-K2]
64	E8XT5-Ni3C [E55XT5-Ni3C]	E8XT5-C1P10-Ni3 [E55XT5-C1P7-Ni3]	84	E8XT1-K2M [E55XT1-K2M]	E8XT1-M21A2-K2 [E55XT1-M21A3-K2]

(Continued)

Table A.2 (Continued)
Existing A5.29/A5.29M [a] Classifications and Equivalent
A5.36/A5.36M Classifications Utilizing the Open Classification System

	A5.29/A5.29M Classifications	Equivalent Classifications Under A5.36 [A5.36M] [b]		A5.29/A5.29M Classifications	Equivalent Classifications Under A5.36 [A5.36M] [b]
85	E8XT5-K2C [E55XT5-K2C]	E8XT5-C1A2-K2] [E55XT5-C1A3-K2]	102	E11XT5-K4M [E76XT5-K4M]	E11XT5-M21A6-K4 [E76XT5-M21A5-K4]
86	E8XT5-K2M [E55XT5-K2M]	E8XT5-M21A2-K2 [E55XT5-M21A3-K2]	103	E12XT5-K4C [E83XT5-K4C]	E12XT5-C1A6-K4 [E83XT5-C1A5-K4]
87	E9XT1-K2C [E62XT1-K2C]	E9XT1-C1A0-K2 [E62XT1-C1A2-K2]	104	E12XT5-K4M [E83XT5-K4M]	E12XT5-M21A6-K4 [E83XT5-M21A5-K4]
88	E9XT1-K2M [E62XT1-K2M]	E9XT1-M21A0-K2 [E62XT1-M21A2-K2]	105	E12XT1-K5C [E83XT1-K5C]	E12XT1-C1AZ-K5 [E83XT1-C1AZ-K5]
89	E9XT5-K2C [E62XT5-K2C]	E9XT5-C1A6-K2 [E62XT5-C1A5-K2]	106	E12XT1-K5M [E83XT1-K5M]	E12XT1-M21AZ-K5 [E83XT1-M21AZ-K5]
90	E9XT5-K2M [E62XT5-K2M]	E9XT5-M21A6-K2 [E62XT5-M21A5-K2]	107	E7XT5-K6C [E49XT5-K6C]	E7XT5-C1A8-K6 [E49XT5-C1A6-K6]
91	E10XT1-K3C [E69XT1-K3C]	E10XT1-C1A0-K3 [E69XT1-C1A2-K3]	108	E7XT5-K6M [E49XT5-K6M]	E7XT5-M21A8-K6 [E49XT5-M21A6-K6]
92	E10XT1-K3M [E69XT1-K3M]	E10XT1-M21A0-K3 [E69XT1-M21A2-K3]	109	E6XT8-K6 [E43XT8-K6]	E6XT8-A2-K6 [E43XT8-A3-K6]
93	E10XT5-K3C [E69XT5-K3C]	E10XT5-C1A6-K3 [E69XT5-C1A5-K3]	110	E7XT8-K6 [E49XT8-K6]	E7XT8-A2-K6 [E49XT8-A3-K6]
94	E10XT5-K3M [E69XT5-K3M]	E10XT5-M21A6-K3 [E69XT5-M21A5-K3]	111	E10XT1-K7C [E69XT1-K7C]	E10XT1-C1A6-K7 [E69XT1-C1A5-K7]
95	E11XT1-K3C [E76XT1-K3C]	E11XT1-C1A0-K3 [E76XT1-C1A2-K3]	112	E10XT1-K7M [E69XT1-K7M]	E10XT1-M21A6-K7 [E69XT1-M21A5-K7]
96	E11XT1-K3M [E76XT1-K3M]	E11XT1-M21A0-K3 [E76XT1-M21A2-K3]	113	E9XT8-K8 [E62XT8-K8]	E9XT8-A2-K8 [E62XT8-A3-K8]
97	E11XT5-K3C [E76XT5-K3C]	E11XT5-C1A6-K3 [E76XT5-C1A5-K3]	114	E10XT1-K9C [E69XT1-K9C]	(f)
98	E11XT5-K3M [E76XT5-K3M]	E11XT5-M21A6-K3 [E76XT5-M21A5-K3]	115	E10XT1-K9M [E69XT1-K9M]	(f)
99	E11XT1-K4C [E76XT1-K4C]	E11XT1-C1A0-K4 [E76XT1-C1A2-K4]	116	E8XT1-W2C [E55XT1-W2C]	E8XT1-C1A2-W2 [E55XT1-C1A3-W2]
100	E11XT1-K4M [E76XT1-K4M]	E11XT1-M21A0-K4 [E76XT1-M21A2-K4]	117	E8XT1-W2M [E55XT1-W2M]	E8XT1-M21A2-W2 [E55XT1-M21A3-W2]
101	E11XT5-K4C [E76XT5-K4C]	E11XT5-C1A6-K4 [E76XT5-C1A5-K4]			

[a] *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding* .

[b] The "X" which appears as part of the electrode designations in this table represents the Position Designator. A "1" in this position indicates that the electrode has all position capabilities. A "0" indicates that the electrode is intended for flat and horizontal positions only. See Figure 1.

[c] Under AWS A5.29/A5.29M, the tensile strength requirement for this classification is 90 ksi–120 ksi [620 MPa–830 MPa]

[d] The new classification system utilized in this document eliminates the need for "J" optional supplemental designator. The "J" designator in A5.29/A5.29M required the test temperature for impact toughness to be 20°F [10°C] lower than the –20°F [–30°C] normally required for this alloy. Under the new classification system an impact designator (in this example, "4" is used to indicate the –40°F [–40°C] toughness requirement).

[e] Under AWS A5.29/A5.29M:2005, the E7XT11-K2 electrode has an impact requirement of 20 ft·lbf @ +32°F. This document does not include a Charpy impact designator for that test temperature. As a result, there is no direct equivalent for the E7XT11-K2 electrode classification in Customary Units under this specification.

[f] Under AWS A5.29/A5.29M:2005, the E10XT1-K9C, -K9M [E69XT1-K9C, -K9M] electrode has an impact requirement of 35 ft·lbf @ –60°F [47 J @ –50°C]. This document does not include a provision for a 35 ft·lbf [47 J] impact strength level. As a result, there is no direct equivalent for this electrode under this specification.

Table A.3
Existing A5.18/A5.18M [a] and A5.28/A5.28M [b] Classifications and Equivalent A5.36/A5.36M Classifications Utilizing the Open Classification System

	A5.18/A5.18M Classifications	Equivalent Classifications Under A5.36 [A5.36M] [c]		A5.28/A5.28M Classifications	Equivalent Classifications Under A5.36 [A5.36M] [b]
1	E70C-3X [E48C-3X]	E7XT15-C1A0-CS1 or E7XT15-M21A0-CS1 [E49XT15-C1A2-CS1 or [E49XT15-M21A2-CS1]	9	E80C-Ni1 [E55C-Ni1]	E8XT15-M13A5-Ni1 or E8XT15-M22A5-Ni1 [e]
2	E70C-6X [E48C-6X]	E7XT15-C1A2-CS1 or E7XT15-M21A2-CS1 [E49XT15-C1A3-CS1 or [E49XT15-M21A3-CS1]	10	E80C-Ni2 [E55C-Ni2]	E8XT15-M13P8-Ni2 or E8XT15-M22P8-Ni2 [E55XT15-M13P6-Ni2 or E55XT15-M22P6-Ni2]
	A5.28/A5.28M Classifications	Equivalent Classifications Under A5.36 [A5.36M] [c]	11	E80C-Ni3 [E55C-Ni3]	E8XT15-M13P10-Ni3 or E8XT15-M22P10-Ni3 [f]
1	E70C-B2Ld [E49C-B2Ld]	E7XT15-M13PZ-B2L or E7XT15-M22PZ-B2L [E49XT15-M13PZ-B2L or E49XT15-M22PZ-B2L]	12	E90C-D2 [E62C-D2]	E9XT15-M13A2-D2 or E9XT15-M22A2-D2 [E62XT15-M13A3-D2 or E62XT15-M22A3-D2]
2	E80C-B2 [E55C-B2]	E8XT15-M13PZ-B2 or E8XT15-M22PZ-B2 [E55XT15-M13PZ-B2 or E55XT15-M22PZ-B2]	13	E90C-K3 [E62C-K3]	E9XT15-M20A6-K3 [h] [E62XT15-M20A5-K3] [h]
3	E80C-B3L [E55C-B3L]	E8XT15-M13PZ-B3L or E8XT15-M22PZ-B3L [E55XT15-M13PZ-B3L or E55XT15-M22PZ-B3L]	14	E100C-K3 [E69C-K3]	E10XT15-M20A6-K3 [h] [E69XT15-M20A5-K3] [h]
4	E90C-B3 [E62C-B3]	E9XT15-M13PZ-B3 or E9XT15-M22PZ-B3 [E62XT15-M13PZ-B3 or E62XT15-M22PZ-B3]	15	E110C-K3 [E76C-K3]	E11XT15-M20A6-K3 [h] [E76XT15-M20A5-K3] [h]
5	E80C-B6 [E55C-B6]	E8XT15-M13PZ-B6 or E8XT15-M22PZ-B6 [E55XT15-M13PZ-B6 or E55XT15-M22PZ-B6]	16	E110C-K4 [E76C-K4]	E11XT15-M20A6-K4 [h] [E76XT15-M20A5-K4] [h]
6	E80C-B8 [E55C-B8]	E8XT15-M13PZ-B8 or E8XT15-M22PZ-B8 [E55XT15-M13PZ-B8 or E55XT15-M22PZ-B8]	17	E120C-K4 [E83C-K4]	E12XT15-M20A6-K4 [h] [E83XT15-M20A5-K4] [h]
7	E90C-B9g [E62C-B9] g	E9XT15-M20PZ-B91 [h] [E62XT15-M20PZ-B91] [h] or E10XT15-M20PZ-B91 [h] [E69XT15-M20PZ-B91] [h]	18	E80C-W2 [E55C-W2]	E8XT15-M20A2-W2 [h] [E55XT15-M20A3-W2] [h]
8	E70C-Ni2 [E49C-Ni2]	E7XT15-M13P8-Ni2 or E7XT15-M22P8-Ni2 [E49XT15-M13P6-Ni2 or E49XT15-M22P6-Ni2]			

[a] *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding* .
[b] *Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding* .
[c] The "X" which appears as part of the electrode designations in this table represents the Position Designator. A "1" in this position indicates that the electrode has all position capabilities. A "0" indicates that the electrode is intended for flat and horizontal positions only. See Figure 1.
[d] The minimum tensile requirement for this electrode classification specified in AWS A5.28/A5.28M is 75 000 psi [515 MPa]. The replacement classification listed for this electrode requires a minimum tensile of 70 000 psi [490 MPa].
[e] Under the International System of Units (SI) the Charpy impact requirement for this electrode type is 27 J @ –45°C. This document does not include an Impact Designator for that specific test temperature.
[f] In A5.28/A5.28M the Charpy impact requirement for this electrode in the International System of Units (SI) is 27 J @ –75°C. This document does not include an Impact Designator for that specific test temperature.
[g] Under AWS A5.28/A5.28M, the tensile strength requirement for this classification is 90 ksi [620 MPa] minimum.
[h] Under AWS A5.28/A5.28M, this electrode type was classified with an Argon/5%–25% CO_2 shielding gas (AWS A5.32/A5.32M types SG-AC-5 through SG-AC-25). Therefore, the replacement classification may be either this classification or one with M21 shielding gas substituted for the M20 shielding gas.

A9.2 The classification system for AWS A5.29/A5.29M:2005, *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*, is as follows:

E[1]X[2]X[3]T[4]X[5] X[6]X[7] – J[8]HX[9]

where:

1. "E" designates an electrode.
2. Tensile strength designator (one or two digits are used).
3. Position designator.
4. "T" identifies the electrode as a flux cored electrode.
5. Usability designator.
6. Deposit composition designator.
7. Shielding gas designator.
8. "J" is an optional supplemental designator indicating improved toughness.
9. "HX" is an optional supplemental diffusible hydrogen designator.

A9.3 The classification system for AWS A5.18/A5.18M:2005, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*, is as follows:

E[1]X[2]C[3] – X[4]Y[5]HZ[6]

where:

1. "E" designates an electrode.
2. Tensile strength designator (two digits).
3. "C" indicates a composite (metal cored) electrode.
4. Indicates composition of weld metal produced by the composite electrode.
5. Shielding gas designator. "C" in this position indicates a 100% CO_2 shielding gas. An "M" in this position indicates a 75–80% Argon/balance CO_2 shielding gas.
6. "HZ" is an optional supplemental diffusible hydrogen designator.

A9.4 The classification system for AWS A5.28/A5.28M:2005, *Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*, is as follows:

E[1]X[2]C[3] – X[4]HZ[5]

where:

1. "E" designates an electrode.
2. Tensile strength designator (two digits).
3. "C" indicates a composite (metal cored) electrode.
4. Indicates composition of weld metal produced by the composite electrode.
5. "HZ" is an optional supplemental diffusible hydrogen designator.

NOTE: There is no designator for shielding gas in A5.28/A5.28M. The shielding gas to be used for classification is specified in Table 3 of this specification.

A10. General Safety Considerations

A10.1 Safety issues and concerns are addressed in this standard, although health issues and concerns are beyond the scope of this standard. 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.l, 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) [12]

No.	Title
1	*Fumes and Gases*
2	*Radiation*
3	*Noise*
4	*Chromium and Nickel in Welding Fume*
5	*Electrical Hazards*
6	*Fire and Explosion Prevention*
7	*Burn Protection*
8	*Mechanical Hazards*
9	*Tripping and Falling*
10	*Falling Objects*
11	*Confined Spaces*
12	*Contact Lens Wear*
13	*Ergonomics in the Welding Environment*
14	*Graphic Symbols for Precautionary Labels*
15	*Style Guidelines for Safety and Health Documents*
16	*Pacemakers and Welding*
17	*Electric and Magnetic Fields (EMF)*
18	*Lockout/Tagout*
19	*Laser Welding and Cutting Safety*
20	*Thermal Spraying Safety*
21	*Resistance Spot Welding*
22	*Cadmium Exposure from Welding & Allied Processes*
23	*California Proposition 65*
24	*Fluxes for Arc Welding and Brazing: Safe Handling and Use*
25	*Metal Fume Fever*
26	*Arc Welding Distance*
27	*Thoriated Tungsten Electrodes*
28	*Oxyfuel Safety: Check Valves and Flashback Arrestors*
29	*Grounding of Portable and Vehicle Mounted Welding Generators*
30	*Cylinders: Safe Storage, Handling, and Use*
31	*Eye and Face Protection for Welding and Cutting Operations*
33	*Personal Protective Equipment (PPE) for Welding & Cutting*
34	*Coated Steels: Welding and Cutting Safety Concerns*
36	*Ventilation for Welding & Cutting*
37	*Selecting Gloves for Welding & Cutting*

[12] AWS standards are published by American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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Annex B

Guidelines for the Preparation of Technical Inquiries

This annex is not part of AWS A5.36/A5.36M:2012, *Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal Arc Welding*, but is included for informational purposes only.

B1. Introduction

The American Welding Society (AWS) Board of Directors has adopted a policy whereby all official interpretations of AWS standards are handled in a formal manner. Under this policy, all interpretations are made by the committee that is responsible for the standard. Official communication concerning an interpretation is directed 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 shall be directed to:

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

All inquiries shall contain the name, address, and affiliation of the inquirer, and they shall provide enough information for the committee to understand the point of concern in the inquiry. When the point is not clearly defined, the inquiry will be returned for clarification. For efficient handling, all inquiries should be typewritten and in the format specified below.

B2.1 Scope. Each inquiry shall address one single provision of the standard unless the point of the inquiry involves two or more interrelated provisions. The provision(s) shall be identified in the scope of the inquiry along with the edition of the standard that contains the provision(s) the inquirer is addressing.

B2.2 Purpose of the Inquiry. The purpose of the inquiry shall be stated in this portion of the inquiry. The purpose can be 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 understand the point of the inquiry. Sketches should be used whenever appropriate, and all paragraphs, figures, and tables (or annex) that bear on the inquiry shall be cited. If the point of the inquiry is to obtain a revision of the standard, the inquiry shall 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 provide the wording for a proposed revision, if this 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 is an official interpretation of the Society, and the secretary transmits 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* and will be posted on the AWS web site.

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 AWS *Board Policy Manual* 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. Headquarters staff cannot provide consulting services. However, the staff can refer a caller to any of those consultants whose names are on file at AWS Headquarters.

B6. AWS Technical Committees

The activities of AWS technical committees regarding interpretations are limited strictly to the interpretation of provisions of standards prepared by the committees or to consideration of revisions to existing provisions on the basis of new data or technology. Neither AWS staff nor the committees are in a position to offer interpretive or consulting services on (1) specific engineering problems, (2) requirements of standards applied to fabrications outside the scope of the document, or (3) 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, A5.36	A5.36	A5.17	A5.25	A5.26	A5.8, A5.31
Low-Alloy Steel	A5.2	A5.5	A5.28, A5.36	A5.36	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	A5.34	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	*Filler Metal Comparison Charts*
IFS	*International Index of Welding Filler Metal Classifications*
UGFM	*User's Guide to Filler Metals*
A4.2M (ISO 8249 MOD)	*Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal*
A4.3	*Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*
A4.4M	*Standard Procedures for Determination of Moisture Content of Welding Fluxes and Welding Electrode Flux Coverings*
A4.5M/A4.5 (ISO 15792-3 MOD)	*Standard Methods for Classification Testing of Positional Capacity and Root Penetration of Welding Consumables in a Fillet Weld*
A5.01M/A5.01 (ISO 14344 MOD)	*Procurement Guidelines for Consumables —Welding and Allied Processes —Flux and Gas Shielded Electrical Welding Processes*
A5.02/A5.02M	*Specification for Filler Metal Standard Sizes, Packaging, and Physical Attributes*
A5.1/A5.1M	*Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*
A5.2/A5.2M	*Specification for Carbon and Low-Alloy Steel Rods for Oxyfuel Gas Welding*
A5.3/A5.3M	*Specification for Aluminum and Aluminum-Alloy Electrodes for Shielded Metal Arc Welding*
A5.4/A5.4M	*Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding*
A5.5/A5.5M	*Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*
A5.6/A5.6M	*Specification for Copper and Copper-Alloy Electrodes for Shielded Metal Arc Welding*
A5.7/A5.7M	*Specification for Copper and Copper-Alloy Bare Welding Rods and Electrodes*
A5.8/A5.8M	*Specification for Filler Metals for Brazing and Braze Welding*
A5.9/A5.9M	*Specification for Bare Stainless Steel Welding Electrodes and Rods*
A5.10/A5.10M	*Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods*
A5.11/A5.11M	*Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding*
A5.12M/A5.12 (ISO 6848 MOD)	*Specification for Tungsten and Oxide Dispersed Tungsten Electrodes for Arc Welding and Cutting*
A5.13/A5.13M	*Specification for Surfacing Electrodes for Shielded Metal Arc Welding*
A5.14/A5.14M	*Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods*
A5.15	*Specification for Welding Electrodes and Rods for Cast Iron*
A5.16/A5.16M	*Specification for Titanium and Titanium-Alloy Welding Electrodes and Rods*
A5.17/A5.17M	*Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*
A5.18/A5.18M	*Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*
A5.19	*Specification for Magnesium Alloy Welding Electrodes and Rods*
A5.21/A5.21M	*Specification for Bare Electrodes and Rods for Surfacing*
A5.22/A5.22M	*Specification for Stainless Steel Flux Cored and Metal Cored Welding Electrodes and Rods*
A5.23/A5.23M	*Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*
A5.24/A5.24M	*Specification for Zirconium and Zirconium-Alloy Welding Electrodes and Rods*
A5.25/A5.25M	*Specification for Carbon and Low-Alloy Steel Electrodes and Fluxes for Electroslag Welding*
A5.26/A5.26M	*Specification for Carbon and Low-Alloy Steel Electrodes for Electrogas Welding*
A5.28/A5.28M	*Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*
A5.30/A5.30M	*Specification for Consumable Inserts*
A5.31	*Specification for Fluxes for Brazing and Braze Welding*
A5.32M/A5.32 (ISO 14175 MOD)	*Welding Consumables—Gases and Gas Mixtures for Fusion Welding and Allied Processes*
A5.34/A5.34M	*Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding*
A5.36/A5.36M	*Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal Arc Welding*

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