

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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An American National Standard

Approved by the
American National Standards Institute
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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

2nd Edition

Supersedes AWS A5.36/A5.36M:2012

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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This standard is subject to revision at any time by the AWS A5 Committee on Filler Metals and Allied Materials. It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn. Comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this standard are requested and should be addressed to AWS Headquarters. Such comments will receive careful consideration by the AWS A5 Committee on Filler Metals and Allied Materials and the author of the comments will be informed of the Committee's response to the comments. Guests are invited to attend all meetings of the AWS A5 Committee on Filler Metals and Allied Materials to express their comments verbally. Procedures for appeal of an adverse decision concerning all such comments are provided in the Rules of Operation of the Technical Activities Committee. A copy of these Rules can be obtained from the American Welding Society, 8669 NW 36 St # 130, Miami, FL 33166.

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Foreword

This foreword is included for informational purposes only.

It is not part of [AWS A5.36/A5.36M:2016](#), *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 specification is the second edition that 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 [AWS 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 Filler Materials and Fluxes—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 [AWS A5.36/A5.36M](#) specification utilizes a new, “open classification system” introduced in this document for the classification of carbon and low-alloy steel flux cored and metal cored electrodes. This new classification system facilitates the introduction of new products designed to meet the ever changing requirements of today’s market. The open classification system uses designators to indicate electrode type (Usability Designator), welding position capability, tensile strength, notch toughness, 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 was 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 was 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 was discontinued in the 2012 edition. Electrodes previously classified as EXXT-2X can now be classified under the new open classification system without requiring a unique “2” Usability Designator. The EXXT-13 electrode classification was discontinued in the 2012 edition due to lack of commercial significance.

The [AWS A5.36/A5.36M](#) specification does not preclude the continued classification of carbon and low-alloy steel flux cored electrodes or carbon and low-alloy steel metal cored electrodes to [AWS A5.20/A5.20M](#), [AWS A5.29/A5.29M](#), [AWS A5.18/A5.18M](#), or [AWS A5.28/A5.28M](#), as applicable. It is recognized that many electrodes classified to the fixed requirements of these documents have gained wide acceptance for single and multiple pass applications. A number of the more widely used electrodes falling into this category have been retained in [AWS A5.36/A5.36M](#) with their existing designations and classification requirements. A listing of these electrode classifications with their requirements is given in Table A.1 in the Normative Annex A.

Additional changes to note are: (1) the Mn and Ni requirements for the K11 alloy type have been modified, (2) two new alloy types have been added, the K12 for high strength circumferential pipe welding and the K13 which is similar to the K2 alloy type but modified to allow for lower Mn content, (3) the heat input requirements for the “D” optional, supplemental designator for seismic applications have been changed to the requirements as specified in AWS A5.20/A5.20M:2005, (4) a protocol was introduced to allow the manufacturer to indicate conformance to impact requirements which are supplemental to and different from those used for electrode classification under this specification, (5) supplemental designators were provided to indicate more restrictive requirements for the Mn + Ni content of the B91 and B92 chromium-molybdenum weld deposits, and (6) a restriction was established prohibiting the use of the optional, supplemental diffusible hydrogen designator for self-shielded electrodes which produce weld deposits with greater than 1.3% aluminum content (Refer to A2.5 in Annex A).

Additionally, the format of this document has been modified for better clarity. The following items now appear in a Normative Annex: (1) a table listing existing electrode classifications having fixed requirements which are retained in this document, (2) optional, supplemental designators with their requirements, and (3) other special tests not required for classification.

The user’s attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights. By publication of this standard, no position is taken with respect to the validity of any such claim(s) or of any patent rights in connection therewith. If a patent holder has filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, then details may be obtained from the standards developer.

Document Development

This is the first revision of [AWS A5.36/A5.36M](#) specification that was issued initially in 2012. The history of the AWS A5.20 and AWS A5.29 specifications appear below:

AWS A5.20-69 ANSI W3.20-1973	<i>Specifications for Mild Steel Electrodes for Flux Cored Arc Welding</i>
ANSI/AWS A5.20-79	<i>Specification for Carbon Steel Electrodes for Flux Cored Arc Welding</i>
ANSI/AWS A5.20-95	<i>Specification for Carbon Steel Electrodes for Flux Cored Arc Welding</i>
AWS A5.20/A5.20M:2005	<i>Specification for Carbon Steel Electrodes for Flux Cored Arc Welding</i>
ANSI/AWS A5.29-80	<i>Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding</i>
ANSI/AWS A5.29:1998	<i>Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding</i>
AWS A5.29/A5.29M:2005	<i>Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding</i>
AWS A5.36/A5.36M:2012	<i>Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal Arc Welding</i>

Comments and suggestions for the improvement of this specification are welcome. They should be sent to the Secretary, Committee on Filler Metals and Allied Materials, American Welding Society, 8669 NW 36 St # 130, Miami, FL 33166.

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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). Carbon and low-alloy flux cored electrodes had previously been classified solely under [AWS A5.20/A5.20M](#), *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*, or [AWS A5.29/A5.29M](#), *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*. Carbon and low-alloy steel metal cored electrodes have previously been classified solely under [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*. 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 non-mandatory Annex Clauses B5 and B13. Safety and health information is available from other sources, including, but not limited to, ANSI Z49.1,¹ *Safety in Welding, Cutting, and Allied Processes*, 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 standards listed below contain provisions which, through reference in this text, constitute mandatory 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 AWS Standards²

- (1) [AWS A1.1](#), *Metric Practice Guide for the Welding Industry*
- (2) [AWS A3.0M/A3.0](#), *Standard Welding Terms and Definitions*
- (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*

¹ ANSI Z49.1 is published by the American Welding Society, 8669 NW 36 St # 130, Miami, FL 33166.

² AWS standards are published by the American Welding Society, 8669 NW 36 St # 130, Miami, FL 33166.

- (4) [AWS A5.01M/A5.01](#) (ISO 14344 MOD), *Welding Consumables—Procurement of Filler Metals and Fluxes*
- (5) [AWS A5.02/A5.02M:2007](#), *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/A5.32:2011](#) (ISO 14175:2008 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:2009](#), *Structural Welding Code—Seismic Supplement*
- (13) [AWS F3.2M/F3.2](#), *Ventilation Guide for Weld Fume*

2.2 ASME Standard³

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

2.3 ANSI Standard

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

2.4 ASTM Standards⁴

- (1) [ASTM A36/A36M](#), *Standard Specification for Carbon Structural Steel*
- (2) [ASTM A203/A203M](#), *Standard Specification for Pressure Vessel Plates, Alloy Steel, Nickel*
- (3) [ASTM A285/A285M](#), *Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength*
- (4) [ASTM A302/A302M](#), *Standard Specification for Pressure Vessel Plates, Alloy Steel, Manganese-Molybdenum and Manganese-Molybdenum-Nickel*
- (5) [ASTM A387/A387M](#), *Standard Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum*
- (6) [ASTM A506/A506M](#), *Standard Specification for Alloy and Structural Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled*
- (7) [ASTM A507/A507M](#), *Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled*
- (8) [ASTM A514/A514M](#), *Standard Specification for High-Yield Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding*
- (9) [ASTM A515/A515M](#), *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate and Higher Temperature Service*
- (10) [ASTM A516/A516M](#), *Standard Specification for Pressure Vessel Plates, Carbon Steel for Moderate and Lower Temperature Service*
- (11) [ASTM A537/A537M](#), *Standard Specification for Pressure Vessel Plates, Heat Treated, Carbon-Manganese-Silicon Steel*
- (12) [ASTM A572/A572M](#), *Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel*
- (13) [ASTM A588/A588M](#), *Standard Specification for High-Strength Low-Alloy Structural Steel up to 50 ksi [345 MPa] Minimum Yield Point with Atmospheric Corrosion Resistance*

³ ASME standards are published by ASME, 22 Law Dr, Box 2300, Fairfield, NJ 07007-2300.

⁴ ASTM Standards are published by ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

(14) [ASTM A830/A830M](#), *Standard Specification for Plates, Carbon Steel, Structural Quality, Furnished to Chemical Composition Requirements*

(15) [ASTM A913/A913M](#), *Standard Specification for High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST)*

(16) [ASTM A992/A992M](#), *Standard Specification for Structural Steel Shapes*

(17) [ASTM E29](#), *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

(18) [ASTM E350](#), *Standard Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron*

(19) [ASTM E1032](#), *Standard Test Method for Radiographic Examination of Weldments*

2.5 FEMA Standard⁵

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

2.6 MIL Standards⁶

(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 ISO Standard⁷

(1) ISO 15792-1-Amendment 1 (2011), *Welding consumables-Test methods-Part 1: Test methods for all-weld metal test specimens in steel, nickel and nickel alloys (Amendment 1)*

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

3. Classification

3.1 Retained Classifications. Thirteen multiple pass and two single pass carbon steel flux cored electrode classifications and two carbon steel metal cored electrode classification have been carried over to this document from AWS A5.20/A5.20M or [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 these classifications, have gained wide acceptance for single pass or multiple pass applications. Note that these classifications utilize a fixed classification system with fixed requirements for shielding gas (if any), condition of heat treatment, tensile properties and Charpy impact properties. See Table A.1 in the normative annex for a list of these classifications and the applicable requirements.

3.2 Open Classification System. An “open classification” system has been developed for this specification for the classification of carbon and low-alloy steel flux cored and metal cored electrodes. This open classification system provides the flexibility to readily classify these electrodes to meet a broad range of applications and market requirements. Provisions have been made for new electrode types, a greater selection of shielding gases and more options for strength level, impact properties, and condition of heat treatment.

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://quicksearch.dla.mil>. NAVSEA Technical Publication T9074-BD-GIB-010/0300 may be obtained from the Naval Inventory Control Point, 700 Robins Ave., Philadelphia, PA 19111-5094, or may be downloaded from <http://ntpdb.ddl.mil>.

⁷ ISO standards are published by the International Organization for Standardization, ISO Central Secretariat, chemin de Blandonnet 8, Case postale 401, 1214 Vernier, Geneva, Switzerland.

3.2.1 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 1 and Table 2.
- (2) The welding positions 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 3.
- (4) The nominal composition of the shielding gas used, if any, as specified in Table 4.
- (5) The condition of postweld heat treatment (PWHT), if any, as specified in Table 8.
- (6) Chemical composition of the weld metal as specified in Table 5.

3.3 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, electrodes can be separately classified for use in making welds consisting of either single or multiple passes. The single V-groove assembly shown in Figure 2 shall be used for the qualification of electrodes for multiple pass welds. For qualification of electrodes for single pass applications, the double-square assembly shown in Figure 3 is required.

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

- (1) Electrodes classified under [AWS A5.20/A5.20M](#), [AWS A5.29/A5.29M](#), [AWS A5.18/A5.18M](#) or [AWS A5.28/A5.28M](#) may also be classified under [AWS A5.36/A5.36M](#) providing all the requirements of each specification are met.
- (2) Electrodes may be classified using different shielding gases. Refer to Table 4.
- (3) Electrodes may be classified both in the as-welded and in the postweld heat treated 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.

3.5 The electrodes classified under this specification are intended for flux cored arc welding (FCAW), either with or without an external shielding gas, or for gas metal arc welding (GMAW) with metal cored electrodes. Electrodes intended for use without external shielding gas, or with the shielding gases specified in Table 4, are not prohibited from use with any other process or shielding gas for which they are found suitable.

4. Acceptance

Acceptance⁸ of the welding electrodes shall be in accordance with the provisions of [AWS A5.01M/A5.01](#) (ISO 14344 MOD).

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 Procedure

For purposes of determining compliance with the requirements of this standard, the actual test values obtained shall be subjected to the rounding rules of [ASTM E29](#) or ISO 80000-1 (the results are the same).⁹

⁸ See Clause B3 in Annex B for further information concerning acceptance, testing of the material shipped, and [AWS A5.01M/A5.01](#) (ISO 14344 MOD).

⁹ See Clause B4 in Annex B for further information concerning certification and the testing called for to meet this requirement.

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. If the average value is to be compared to the specified limit, rounding shall be done only after calculating the average. An observed or calculated value shall be rounded to the nearest 1 000 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 results shall fulfill the requirements for the classification under test.

7. Summary of Tests

7.1 The tests required for each classification are specified in Table 6. The purpose of these tests is to determine the mechanical properties, soundness, and chemical composition of the weld metal. 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 five supplemental tests and requirements which are optional and not required for classification. Refer to Clause 15, and Clauses A2 through A6 in Normative Annex A.

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.

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 shown 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 7 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 9, using base metal of the appropriate type specified in Table 7. Preheat and interpass temperatures shall be as specified in Table 8. Testing of this assembly shall be as specified in Table 6. When ASTM A36 or [ASTM A285](#) 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 7, 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 indicated in Table 3. Testing of the assemblies shall be as required in Table 6 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-K9] 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, surface thermometers or contact pyrometers at the location shown in Figure 2. Measurement of interpass temperature shall occur prior to application of subsequent weld passes and be measured within one inch of the edge of the weld groove. 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 (PWHT) is required, it shall be performed prior to removal of the mechanical test specimens. 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 (PWHT) 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 8. 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 Table 7 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.

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 3 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 7 (including Note c in the 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 (1/12 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 9. 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.

10. Chemical Analysis

10.1 The sample for chemical 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.

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 7 for sampling requirements when ASTM A36 or A285 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 E350.

10.4 The results of the analysis shall meet the requirements of Table 5 for the classification of electrode under test.

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 E1032. 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 joint penetration;
- (2) No slag inclusions longer than 1/4 in [6 mm] or 1/3 of the thickness of the weld, whichever is greater, and 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 (see 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 gauge 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 B10 in Annex B 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 1.

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 1.

13. Bend Test

One longitudinal bend test specimen, as required in Table 6, 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](#).

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, and then allowed to cool to room temperature. Refer to B10 in Annex B for a discussion on the purpose of aging.

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 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 (refer to Figure 1 or Table 6 and Table A.1, as applicable) and as required for supplemental tests (refer to Annex A).

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 and shall be square with the longitudinal edge of the specimen within 1°.

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 50× 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 maximum test temperature shall be that specified in Table 2 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 impact value may be lower, but not more than 10 ft-lbf [14 J] lower than the minimum average energy level requirement. The average of all five values must meet the minimum requirement.

15. Optional, Supplemental Tests and Requirements

Provisions are made in this specification for five additional tests. These tests are optional and are not required for electrode classification. The optional, supplemental designators which indicate conformance to the supplemental test requirements do not constitute a part of the electrode classification designation.

15.1 Diffusible Hydrogen Test. An optional, supplemental designator (H2, H4, H8 or H16) is used to indicate the diffusible hydrogen content of the deposited weld metal. Refer to Clause A2 in Annex A.

15.2 Test for Seismic Applications. A “D” optional, supplemental designator is used to indicate conformance to requirements for weld metal deposited using a low heat input, fast cooling rate procedure and a high heat input, slow cooling rate procedure. These requirements are similar to those prescribed in AWS D1.8/D1.8M:2009, *Structural Welding Code-Seismic Supplement*. Refer to Clause A3 in Annex A.

15.3 Test for Military Applications. A “Q” optional, supplemental designator is used to indicate conformance to requirements specified for military applications for weld metal deposited using a low heat input, fast cooling rate procedure and a high heat input, slow cooling rate procedure. Note that this designator can only be applied to carbon steel flux cored electrodes. Refer to Clause A4 in Annex A.

15.4 Procedure for Indicating Conformance to Supplemental Impact Requirements. It is recognized that occasionally an electrode is fully capable of meeting the Charpy V-Notch requirements specified for an application which are different from the requirements specified for the electrode classification. In these cases, a manufacturer may indicate conformance to these application impact requirements on test certificates, labels and packaging immediately after or below the electrode classification. These adjunct conformance statements are supplemental and do not constitute part of the AWS electrode classification or requirements. Refer to Clause A5 in Annex A.

15.5 Supplemental Designators to Indicate Conformance to Reduced Levels of Mn + Ni in B91 and B92 Type Deposits. Some applications of B91 and B92 type weld deposits may require lower levels of Mn + Ni than the 1.40% maximum specified in Table 5. Supplemental designators are provided to indicate that the weld deposit meets 1.20% or 1.00% maximum Mn + Ni. Refer to Clause A6 in Annex A.

16. Method of Manufacture

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

17. Standard Sizes

Standard sizes for filler metal in the different package forms such as coils with support, coils without support, drums, and spools are as specified in [AWS A5.02/A5.02M:2007](#).

18. Finish and Uniformity

Finish and uniformity shall be as specified in 4.2 of [AWS A5.02/A5.02M:2007](#).

19. Standard Package Forms

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](#).

20. Winding Requirements

20.1 Winding requirements shall be as specified in 4.4.1 of [AWS A5.02/A5.02M:2007](#). 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.

20.2 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:2007](#).

21. Filler Metal Identification

Electrode identification, product information and the precautionary information shall be as specified in 4.5 of [AWS A5.02/A5.02M:2007](#).

22. Packaging

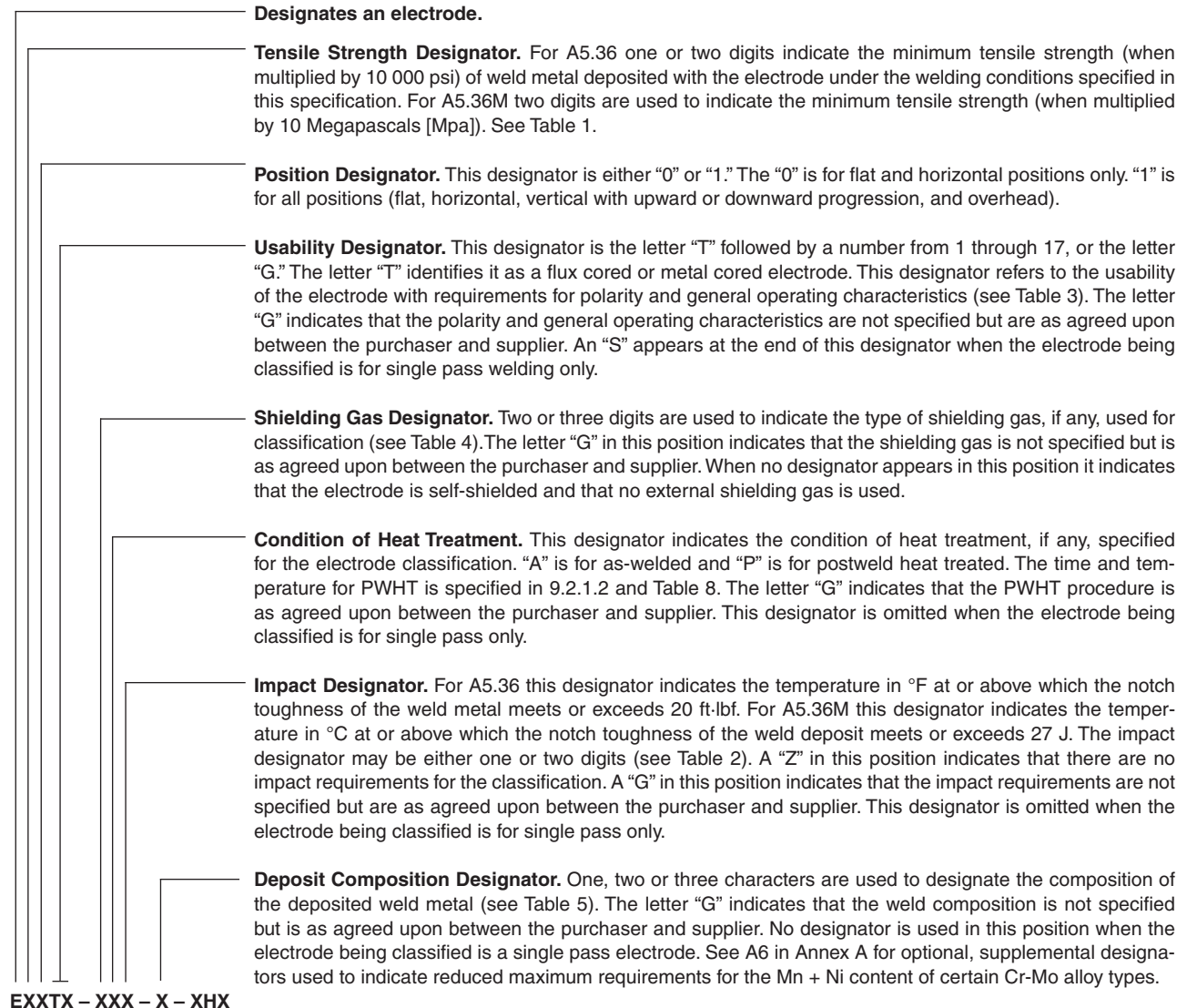
Electrodes shall be suitably packaged to ensure against damage during shipment and storage under normal conditions.

23. Marking of Packages

23.1 The 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](#).

23.2 The appropriate precautionary information¹⁰ 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.

¹⁰ Typical examples of “warning labels” and precautionary information are shown in figures in ANSI Z49.1 for some common or specific consumables used with certain processes.

Mandatory Classification Designators^a**Optional, Supplemental Designators^b**

Optional, Supplemental Diffusible Hydrogen Designator (see Table A.2 in Annex A).

“D” and “Q” Optional, Supplemental Designators. The letter “D” or “Q” when present in this position, indicates that 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 Clauses A3 and A4 in Annex A.

^a The combination of these designators constitutes the flux cored or metal cored electrode classification.

^b These designators are optional and do not constitute a part of the flux cored or metal cored electrode classification.

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 3 and Annex B (Clauses B7 and B8) 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 (CO₂) 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 70–95 ksi and notch toughness (Charpy V-Notch) 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 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 4) under the conditions prescribed in this specification, will produce weld metal in the postweld heat treated condition having a tensile strength of 80–100 ksi and notch toughness (Charpy V-Notch) of at least 20 ft lbf at –60°F. The weld deposit composition conforms to the Ni2 composition requirements (see Table 5).

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 70–95 ksi and notch toughness (Charpy V-Notch) of at least 20 ft lbf at –40°F in the as-welded condition. The weld deposit composition conforms to the Ni1 composition requirements.

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 4) under the conditions prescribed in this specification, will produce weld metal in the as-welded condition with a tensile strength of 90–110 ksi and notch toughness (Charpy V-Notch) of at least 20 ft lbf at –20°F. The weld deposit composition conforms to the D2 composition requirements (see Table 5).

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 4) will produce weld metal having a minimum tensile strength of 80 ksi.

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