

Specification for Carbon Steel Electrodes for Flux Cored Arc Welding



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An American National Standard

Approved by the
American National Standards Institute
June 1, 2021

Specification for

Carbon Steel Electrodes for

Flux Cored Arc Welding

6th Edition

Revises AWS A5.20/A5.20M: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 steel electrodes for flux cored arc welding. The requirements include chemical composition and mechanical properties of the weld metal and certain usability characteristics. It also includes optional supplemental designators for lower temperature toughness requirements, diffusible hydrogen limits, *and shielding gas range designators*. Additional requirements are included for standard sizes, marking, manufacturing, and packaging. A guide is appended to the specification as a source of information concerning the classification system employed and the intended use of carbon steel flux cored electrodes. This specification makes use of both U.S. Customary Units and the International System of Units (SI). Since these are not equivalent, each system must be used independently of the other.



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Foreword

This foreword is not part of this standard but is included for informational purposes only.

This document uses 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 values in any way. In selecting rational metric units, AWS A1.1, *Metric Practice Guide for the Welding Industry*, is used where suitable. Tables and figures make use of both U.S. Customary and SI Units which, with the application of the specified tolerances, provide for interchangeability of products in both the U.S. Customary and SI Units.

The current document is the fourth revision of the initial joint ASTM/AWS document issued in 1969.

This revision includes the following substantive changes, shown in *italic* font in this document:

- (1) *The “Q” optional supplemental designator has been removed due to lack of use.*
- (2) *The “D” optional supplemental designator has been removed, which will allow consistent rules to be published and updated in the AWS D1.8 specification.*
- (3) *A boron reporting requirement has been added.*
- (4) *Fillet weld testing references the procedures of AWS A4.5, and requirements have changed accordingly.*
- (5) *An alternate configuration similar to type 1.3 per ISO 15792-1:2020 has been added as an option for the groove weld shown in Figure 2.*
- (6) *Optional supplemental designators have been added to indicate ranges of shielding gases for which an electrode meets the requirements for classification, including any optional diffusible hydrogen (“HX”) or low temperature toughness (“J”) supplemental designators.*
- (7) *The EXXT-13 classification was removed due to lack of use.*
- (8) *Allows the techniques of computed radiography or digital radiography to be used on welds in place of film radiography although still in conjunction with ASTM E1032.*

Additionally, the format of this document has been modified for better clarity. The optional supplemental designators with their requirements now appear in a Normative Annex (Annex A). These include the “H” designators for diffusible hydrogen, the “J” designator to indicate enhanced impact properties, and the “OE” designators to indicate shielding gas ranges.

The document evolution took place as follows:

AWS A5.20-69	<i>Specifications for Mild Steel Electrodes for Flux Cored Arc Welding</i>
ANSI W3.20-1973	
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>

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.

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, 8669 NW 36 St, # 130, Miami, FL 33166.

All errata to a standard shall be published in the *Welding Journal* and posted on the AWS website.

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Specification for Carbon Steel Electrodes for Flux Cored Arc Welding

1. Scope

1.1 This specification prescribes requirements for the classification of carbon steel electrodes for flux cored arc welding (FCAW), either with or without shielding gas.

1.2 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 A5.20 uses U.S. Customary Units. The specification A5.20M uses SI Units. The SI Units 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 A5.20 and A5.20M specifications.

1.3 Safety and health issues and concerns are beyond the scope of this standard; some safety and health information is provided, but such issues are not fully addressed herein. Some safety and health information can be found in Clauses B5 and B9.

Safety and Health information is available from the following sources:

American Welding Society:

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

Material or Equipment Manufacturers:

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

Applicable Regulatory Agencies

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

2. Normative References

The documents listed below are referenced within this publication and are mandatory to the extent specified herein. Unless otherwise defined in this document, welding terms are as defined in AWS A3.0M/A3.0. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments to or revisions of any of these publications do not apply.

American Welding Society (AWS) documents:

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

AWS A4.3-ADD1, *Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*

AWS 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*

AWS A5.01M/A5.01 (ISO 14344 MOD), *Welding Consumables—Procurement of Filler Metals and Fluxes*

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

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

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

American National Standards Institute (ANSI) document:

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

ASTM International (ASTM) documents:

ASTM A36/A36M, *Specification for Carbon Structural Steel*

ASTM A285/A285M, *Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength*

ASTM A515/A515M, *Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service*

ASTM A516/A516M, *Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*

ASTM A572/A572M, *Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel*

ASTM A830/A830M, *Standard Specification for Plates, Carbon Steel, Structural Quality, Furnished to Chemical Composition Requirements*

ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

ASTM E350, *Standard Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron and Wrought Iron*

ASTM E1032, *Standard Test Method for Radiographic Examination of Weldments*

ASTM E2033, *Standard Practice for Radiographic Examination Using Computed Radiography (Photostimulable Luminescence Method)*

ASTM E2698, *Standard Practice for Radiographic Examination Using Digital Detector Arrays*

International Organization for Standardization (ISO) documents:

ISO 15792-1:2020, *Welding Consumables — Test Methods — Part 1: Test Methods for All-Weld Metal Test Specifications in Steel, Nickel and Nickel-Alloys*

ISO 80000-1:2009, *Quantities and Units — Part 1: General. Corrected by ISO 80000-1:2009/Cor 1:2011*

3. Classification

3.1 The flux cored electrodes covered by this AWS A5.20 specification utilize a classification system based upon the U.S. Customary Units, as specified in Table 1 and as shown in Figure 1. The flux cored electrodes covered by this AWS A5.20M specification utilize a classification system based upon the International System of Units (SI), as specified in Table 1 and as shown in Figure 1.

3.1.1 Flux cored electrodes classified for multiple-pass welding are classified according to 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 and Figure 1.

(2) The positions of welding for which the electrode is suitable, as shown in Table 2.

(3) Chemical composition, as specified in Table 3.

(4) Certain usability characteristics of the electrode, as specified in Table 2.

3.1.2 Flux cored electrodes classified for single-pass welding are classified in the as-welded condition according to the following:

(1) The minimum tensile 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 shown in Table 2.

(3) Certain usability characteristics of the electrode as specified in Table 2.

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

(1) an electrode may be classified with 100% CO₂ shielding gas and with a 75%–80% Ar/balance CO₂ shielding gas and

(2) an E7XT-1C, -1M [E49XT-1C, -1M] may also be classified as an E7XT-9C, -9M [E49XT-9C, -9M] and/or E7XT-12C, -12M [E49XT-12C, -12M] providing the electrode meets all the requirements of each classification.

3.3 Electrodes may be classified under A5.20 using U.S. Customary Units or under A5.20M using the International System of Units (SI) or they may be classified under both systems. Electrodes classified under either classification system must meet all requirements for classification under that system. The classification system is shown in Figure 1.

3.4 The electrodes classified under this specification are intended for flux cored arc welding, either with or without an external shielding gas. Electrodes intended for use without external shielding gas or with the shielding gas specified in Table 2 are not prohibited from use with any other process or shielding gas for which they are found suitable. *See Clauses A3 and B8.4 for information on optional shielding gas range designators.*

4. Acceptance

Acceptance of the welding electrodes shall be in accordance with the provisions of AWS A5.01M/A5.01 and the tests and requirements of this specification. See Clause B3 for further information concerning acceptance, testing of the material shipped, and AWS A5.01M/A5.01.

5. Certification

By affixing the AWS specification and classification designations to the packaging or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification. See Clause B4 for further information concerning certification and the testing called for to meet this requirement.

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 Rule A in Clause B.3 of 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. If an 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 1000 psi (1 ksi) for tensile and yield strength for A5.20 [to the nearest 10 MPa for tensile and

yield strength for A5.20M] 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 4. The purpose of these tests is to determine one or more of the following attributes of the weld metal: (1) mechanical properties; (2) soundness; (3) chemical composition. Additionally, tests are used to determine 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 15.

7.2 This document provides for *three* supplemental tests which are not required for classification but which are used when the corresponding optional supplemental designator is added to the electrode classification.

7.2.1 The supplemental test for diffusible hydrogen “HX” is described in Clause A1 in Annex A.

7.2.2 The optional supplemental designator “J” may be used to indicate that the electrode being classified meets the requirements for improved toughness and will deposit weld metal with Charpy V-Notch properties of at least 20 ft-lbf at -40°F [27 J at -40°C] when welds are made in a manner prescribed by this specification. See Clause A2 in Annex A.

7.2.3 *The optional tests for an oxygen equivalent gas range supplemental designator “OE H/L” are not required for classification, but may be used to indicate that the electrode being classified meets the same classification requirements, including any optional diffusible hydrogen (“HX”) or low temperature toughness (“J”) supplemental designators when tested with other shielding gases. See Clause A3 in 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 sample or from one or two new test assemblies or samples. For chemical analysis, retest need be only for those specific elements that failed to meet the test requirement. If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification.

In the event that, during preparation or after completion of any test, it is clearly determined that specified or proper procedures were not followed in preparing the weld test assembly or test specimen(s) or in conducting the test, the test shall be considered invalid, without regard to whether the test was actually completed or whether test results met or failed to meet the 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 more of the following four test assemblies are required, depending on the classification of the electrode and the manner in which the tests are conducted:

- (1) For multiple-pass electrodes, the test assembly in Figure 2, for mechanical properties and soundness of the weld metal.
- (2) For single-pass electrodes, the test assembly in Figure 3, for mechanical properties and soundness of the weld metal.
- (3) The weld pad in Figure 4, for chemical analysis of the weld metal.
- (4) The fillet weld test assembly in Figure 5 for usability of the electrode.

The sample for chemical analysis may be taken from the reduced section of the fractured tension test specimen or from a corresponding location (or any location above it) along the centerline of 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 sample shall be the referee method.

9.2 Preparation of each test assembly shall be as specified in Clauses 9.3 through 9.6, as applicable. The base metal for each assembly shall be as specified in Table 5 and shall meet the requirements of any one of the appropriate ASTM specifications shown there or a chemically equivalent specification. Electrodes shall be tested without “conditioning.” Conditioning can be considered to be any special preparation or procedure, such as baking the electrode, which the user would not normally practice. Testing of the welded test assemblies shall be as specified in Clauses 10 through 15.

9.3 Weld Pad. A weld pad shall be prepared as specified in Figure 4, except when an alternative in 9.1 (taking the sample from the broken tension test specimen or from a corresponding location or any location above it along the centerline of the weld metal in the groove weld in Figure 2) is selected. Base metal of any convenient size, of the type specified in Table 5, shall be used as the base metal 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 welding procedure used for the weld pad shall satisfy the heat input requirements specified in Table 6. The preheat temperature shall not be less than 60°F [15°C] and the interpass temperature shall not exceed 325°F [165°C]. The slag shall be removed after each pass. The pad may be quenched in water between passes, but must be dry before the start of the next pass. The dimensions of the completed pad shall be as shown in Figure 4. Testing of this assembly shall be as specified in Clause 10.

9.4 Test Assembly for Multipass Electrodes. For multipass electrodes (EXXT-1X, EXXT-4, EXXT-5X, EXXT-6, EXXT-7, EXXT-8, EXXT-9X, EXXT-11, EXXT-12X, and EXXT-G) one or two groove weld test assemblies shall be prepared and welded as specified in Figure 2 and Table 6, using the base metal of the appropriate type specified in Table 5. The electrode diameter for one test assembly shall be 3/32 in [2.4 mm] or the largest diameter manufactured. The electrode diameter for the other test assembly shall be 0.045 in [1.2 mm] or the smallest size manufactured. If the maximum diameter manufactured is 1/16 in [1.6 mm] or less only the largest diameter need be tested. The electrode polarity shall be as specified in Table 2. Welding shall be in the flat position and the assembly shall be restrained or preset during welding to prevent warpage in excess of 5°. A completed weld assembly that is more than 5 degrees out of plane shall be discarded. Test assemblies shall not be straightened. Welding shall begin at 60°F [15°C] minimum. Welding shall continue until the assembly has reached a temperature of 300°F ± 25°F [150°C ± 15°C], 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 of 300°F ± 25°F [150°C ± 15°C] before welding is resumed. Testing of the assemblies shall be in the as-welded condition and as specified in Table 4.

9.5 Test Assembly for Single-Pass Electrodes. For single-pass electrodes (EXXT-2X, EXXT-3, EXXT-10, EXXT-14, and EXXT-GS) a butt joint test assembly using base metal as specified in Table 5 shall be prepared as specified in Figure 3. The welding procedure shall be selected by the manufacturer. After tack welding the plates at each end, the test assembly shall be welded in the flat position with one bead on each side. 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 2 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).

9.6 Fillet Weld Test Assembly. The fillet weld test, when required in Table 4, shall be made in accordance with the requirements of AWS A4.5M/A4.5 using any of the base metals listed in Table 5. When specified for an EX0T-XX classification, the test assembly shall be welded in the horizontal position. When specified for an EX1T-XX classification, two test assemblies are required, one welded in the vertical position and one welded in the overhead position. The progression for vertical welding shall be either upward or downward depending on the classification (see Table 2).

Before assembly, the standing member (web) shall have one edge prepared throughout its length and the base member (flange) side shall be straight, smooth, and clean. The test plates shall be assembled as shown in Figure 5. When assembled the faying surfaces shall be in intimate contact along the entire length of the joint. The test assembly shall be secured with tack welds deposited at each end of the weld joint.

The welding procedure and the size of the electrode to be tested shall be as selected by the manufacturer. The fillet weld shall be a single-pass weld deposited either semiautomatically or automatically as selected by the manufacturer. Both

pieces to form the test assembly shall have cross sections of 3/8 in [10 mm] to 1/2 in [12 mm] thickness by 3 in [75 mm] minimum width. The length of the weld shall be 12 in [300 mm] minimum.

The fillet weld size shall not be greater than 3/8 in [10 mm]. Weld cleaning shall be limited to chipping, brushing, and needle scaling. Grinding, filing, or other metal cutting of the fillet weld face is prohibited. The testing of the assembly shall be as specified in Clause 15.

10. Chemical Analysis

10.1 When specified in Table 4, the sample for chemical analysis shall be taken from weld metal produced with the flux cored electrode and the shielding gas (if any) with which it is classified. The sample may be taken from the reduced section of the fractured tension test specimen or from a corresponding location or any location above it along the weld centerline in the groove weld in Figure 2. The sample for chemical analysis shall be prepared for analysis by any means that will not affect the chemical composition.

10.2 The weld pad described in 9.3 may also be used to produce the weld metal sample for chemical analysis. The top surface of the pad described in 9.3 and shown in Figure 4 shall be removed and discarded and a sample for analysis shall be obtained from the underlying metal by any means that will not affect the chemical composition. 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. In case of dispute, the analysis of the sample taken from the groove weld shall be the referee method.

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 3 for the classification of electrode under test.

11. Radiographic Test

11.1 The welded test assembly described in 9.4 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] nominal below the original base metal surface in order to facilitate backing and/or buildup removal. The 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 one of the following. The quality level of inspection shall be 2-2T.

(1) Film Radiography: ASTM E1032.

(2) *Computed Radiography (CR): ASTM E2033 and the requirements of ASTM E1032 except where CR differs from film. The term film, as used within ASTM E1032, applicable to performing radiography in accordance with ASTM E2033, refers to phosphor imaging plate.*

(3) *Digital Radiography (DR): ASTM E2698 and the requirements of ASTM E1032 except where DR differs from film. The term film, as used within ASTM E1032, applicable to performing radiography in accordance with ASTM E2698, refers to digital detector array (DDA).*

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