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An American National Standard



Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding



American Welding Society



Key Words—Carbon steel welding electrodes, carbon steel welding rods, gas metal arc welding, gas tungsten arc welding, metal cored electrodes, plasma arc welding, stranded electrodes

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Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding

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Prepared by
AWS A5 Committee on Filler Metals and Allied Materials

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

This specification prescribes the requirements for classification of solid carbon steel electrodes and rods, composite stranded carbon steel electrodes, and composite metal cored carbon steel electrodes for gas shielded arc welding. Classification is based on chemical composition of the electrode for solid electrodes and rods, chemical composition of weld metal for composite stranded and composite metal cored electrodes and the as-welded mechanical properties of the weld metal for each. Additional requirements are included for manufacture, sizes, lengths, and packaging. A guide is appended to the specification as a source of information concerning the classification system employed and the intended use of the electrodes and rods.

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



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Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding

1. Scope

1.1 This specification prescribes requirements for the classification of carbon steel electrodes (solid, composite stranded, and composite metal cored) and rods (solid) for gas metal arc (GMAW), gas tungsten arc (GTAW), and plasma arc (PAW) welding.

1.2 Safety and health issues and concerns are beyond the scope of this standard and therefore are not fully addressed herein. Some safety and health information can be found in the nonmandatory Annex Sections A5 and A10. Safety and health information is available from other sources, including but not limited to ANSI Z49.1, *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 A5.18 uses U.S. Customary Units. The specification A5.18M uses SI Units. The latter are shown within brackets [] or in appropriate columns in tables and figures. Standard dimensions based on either system may be used for sizing of electrodes or packaging or both under the A5.18 or A5.18M specifications.

Part A *General Requirements*

2. Normative References

2.1 ASTM Standards¹

A 36/A 36M *Specification for Carbon Structural Steel*

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

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

A 515/A 515M *Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service*

A 516/A 516M *Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*

E 29 *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

E 350 *Standard Method for Chemical Analysis of Carbon Steel, Low Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron*

E 1032 *Standard Test Method for Radiographic Examination of Weldments*

2.2 AWS Standards²

AWS A5.01 *Filler Metal Procurement Guidelines*

AWS A5.32/ A5.32M *Specification for Welding Shielding Gases*

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

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

2.3 ANSI Standards³

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

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

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

Part B

Tests, Procedures, and Requirements

7. Summary of Tests

7.1 The tests required for each classification are specified in Table 5. The purpose of these tests is to determine the chemical composition, the mechanical properties, and soundness 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 Sections 9 through 14. See Section A4.2 in Annex A for requirements for classification based on gas tungsten arc welding (GTAW) only.

7.2 The optional test for diffusible hydrogen in Section 15, Diffusible Hydrogen Test, is not required for classification (see note c of Table 5).

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. Specimens for retest may be taken from the original test assembly or from one

or two new test assemblies. For chemical analysis, retest need be only for those specific elements that failed to meet their 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 prescribed or proper procedures were not followed in preparing the weld test assembly or test specimens, or in conducting the test, the test shall be considered invalid, without regard to whether the test was actually completed, or whether the test results met, or failed to meet, the requirement. That test shall be repeated, following proper prescribed procedures. In that case, the requirement for doubling the number of test specimens does not apply.

9. Weld Test Assemblies

9.1 At least one weld test assembly is required, and two may be required (depending on the electrode—solid as opposed to composite—and the manner in which the sample for chemical analysis is taken), as specified in Table 5. They are as follows:

(1) The groove weld in Figure 1 for mechanical properties and soundness of the weld metal for both

Table 5
Required Tests

AWS Classification		Chemical Analysis		Radiographic Test	Tension Test	Bend Test	Impact Test	Diffusible Hydrogen Test
A5.18	A5.18M	Electrode	Weld Metal					
Solid Electrodes								
ER70S-2	ER48S-2	Required	Not Required	Required	Required	Not Required	Required	c
ER70S-3	ER48S-3	Required	Not Required	Required	Required	Not Required	Required	c
ER70S-4	ER48S-4	Required	Not Required	Required	Required	Not Required	Not Required	c
ER70S-6	ER48S-6	Required	Not Required	Required	Required	Not Required	Required	c
ER70S-7	ER48S-7	Required	Not Required	Required	Required	Not Required	Required	c
ER70S-G	ER48S-G	Required	Not Required	Required	Required	Not Required	Not Required	c
Composite Electrodes								
E70C-3X	E48C-3X	Not Required	Required	Required	Required	Not Required	Required	c
E70C-6X	E48C-6X	Not Required	Required	Required	Required	Not Required	Required	c
E70C-G(X)	E48C-G(X)	Not Required	Required	Required	Required	Not Required	Not Required	c
E70C-GS(X) ^a	E48C-GS(X) ^a	Not Required	Not Required	Not Required	Required ^b	Required	Not Required	c

Notes:

a. Intended for single pass welding.

b. Transverse tension test. All others are all-weld-metal tension tests.

c. Optional diffusible hydrogen test is required only when specified by the purchaser or when the manufacturer puts the diffusible hydrogen designator on the label (also see A2.2 and A8.2 in Annex A).

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 times 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 4 for the classification under test.

14.3 In evaluating the test results, the lowest and the highest values obtained shall be disregarded. Two of the remaining three values shall equal, or exceed, the specified 20 ft-lbf [27 J] energy level. One of the three may be lower, but not lower than 15 ft-lbf [20 J], and the average of the three shall be not less than the required 20 ft-lbf [27 J] energy level.

14.4 For classifications with the “N” (nuclear) designation, three additional specimens shall be prepared. These specimens shall be tested at room temperature. Two of the three shall equal, or exceed, 75 ft-lbf [100 J], and the third shall not be lower than 70 ft-lbf [95 J]. The average of the three shall equal, or exceed, 75 ft-lbf [100 J].

15. Diffusible Hydrogen Test

15.1 For each electrode to be designated by an optional supplemental diffusible hydrogen designator, the 0.045 in or 1/16 in [1.2 mm or 1.6 mm] size, or the size that the manufacturer produces that is closest to one of these sizes if the specified sizes are not produced, shall be tested according to one of the methods given in AWS A4.3. Based upon the average value of test results which satisfy the requirements of Table 7, the optional supplemental diffusible hydrogen designator may be added at the end of the classification.

15.2 Testing shall be done without rebaking or otherwise conditioning the electrode, unless the manufacturer recommends otherwise. If the electrode is rebaked, that fact, along with the method used for rebaking, shall be noted on the test report.

15.3 For purposes of certifying compliance with optional diffusible hydrogen requirements, the reference atmospheric condition shall be an absolute humidity of 10 grains of water vapor per pound [1.43 g/kg] of dry air at the time of welding. The actual atmospheric conditions shall be reported, along with the average value for the test, according to AWS A4.3.⁷

⁷ See A8.2 (in Annex A).

Table 7
Optional Diffusible Hydrogen Requirements

AWS Classifications	Optional Supplemental Diffusible Hydrogen Designator ^{a,b}	Average Diffusible Hydrogen, Maximum (mL/100g Deposited Metal) ^c
All	H16	16.0
All	H8	8.0
All	H4	4.0

Notes:

- See Note c to Table 5.
- This designator is added to the end of the complete electrode classification designation.
- Some classifications may not be capable of meeting the lower average diffusible hydrogen levels (H8 and H4).

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 optional supplemental designator. Likewise, if the actual test results for an electrode meet the requirements for the lower, or lowest hydrogen designator, as specified in Table 7, the electrode also meets the requirements of all higher hydrogen designators in Table 7 without need to retest.

Part C

Manufacture, Identification, and Packaging

16. Method of Manufacture

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

17. Standard Sizes

Standard sizes for electrodes and rods in the different package forms (straight lengths, coils with support, coils without support, drums, and spools—see Section 19, Standard Package Forms) are as shown in Table 8.