

SPECIFICATION FOR CARBON AND LOW ALLOY STEEL RODS FOR OXYFUEL GAS WELDING



SFA-5.2



(Identical with AWS Specification A5.2-92)

1. Scope

This specification prescribes requirements for the classification of carbon and low alloy steel rods for oxyfuel gas welding.

PART A — GENERAL REQUIREMENTS

2. Classification

2.1 The welding rods covered by this specification are classified according to the mechanical properties of the weld metal in the "as-welded" condition, as shown in Table 1.

2.2 Welding rods classified under one classification shall not be classified under any other classification in this specification.

2.3 The welding rods classified under this specification are intended for oxyfuel gas welding, but that is not to prohibit their use for any other process for which they are found suitable.

3. Acceptance

Acceptance¹ of the welding rods shall be in accordance with the provisions of ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*.²

4. 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.³

5. Units of Measure and Rounding-Off Procedure

5.1 U.S. Customary Units are the standard units of measure in this specification. The SI units are given as equivalent values to the U.S. Customary Units. The standard sizes and dimensions in the two systems are not identical, and for this reason conversion from a standard size or dimension in one system will not always coincide with a standard size or dimension in

TABLE 1
TENSION TEST REQUIREMENTS

AWS Classification	Minimum Tensile Strength ^a		Elongation in 1-in. (25 mm) Percent, Min.
	ksi	MPa	
R45	Not Specified		Not Specified
R60	60	410	20
R65	65	450	16
R100	100	690	14
RXXX-G ^b	XXX ^b		Not Specified

NOTES:

- Specimens shall be tested in the as-welded condition.
- Classification designators (XXX) shall be based on minimum tensile strength of all-weld-metal tension test of the test assembly. These designators shall be limited to 45, 60, 65, 70, 80, 90, and 100.

¹ See section A3 (in the Appendix) for further information concerning acceptance, testing of the material shipped, and A5.01, *Filler Metal Procurement Guidelines*.

² AWS standards may be obtained from the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135.

³ See section A4 (in the Appendix) for further information concerning certification and the testing called for to meet this requirement.

TABLE 2
REQUIRED TESTS

AWS Classification	Chemical Analysis	Tension Test
R45	Required	Not required
R60	Required	Required
R65	Required	Required
R100	Required	Required
RXXX-G	Not required	Required

the other. Suitable conversions, encompassing standard sizes of both, can be made, however, if appropriate tolerances are applied in each case.

5.2 For the purpose of determining conformance with this specification, an observed or calculated value shall be rounded to the "nearest unit" in the last right-hand place of figures used in expressing the limiting value for quantities in accordance with the round-off rules given in ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*.⁴

PART B — TESTS, PROCEDURES, AND REQUIREMENTS

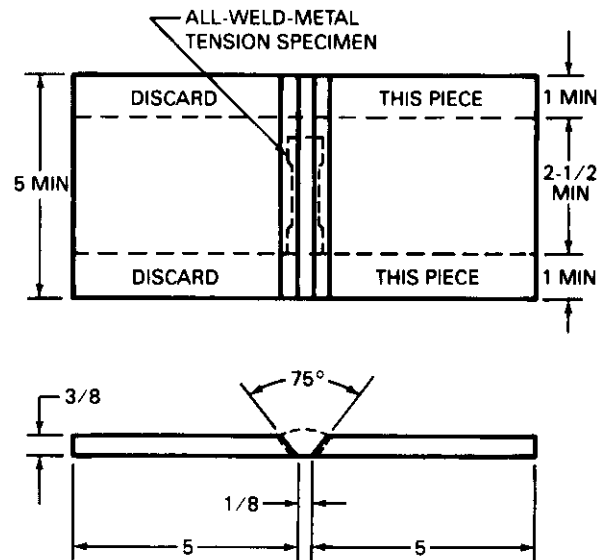
6. Summary of Tests

The tests required for each classification are specified in Table 2. The purpose of these tests is to determine the chemical composition of the welding rod and the mechanical properties of the weld metal. The base metal for the weld test assembly, the welding and testing procedures to be employed, and the results required are given in Section 8, Weld Test Assembly, Section 9, Chemical Analysis, and Section 10, Tension Test.

7. Retest

If any test fails to meet the requirement, that test shall be repeated twice. The results of both retests shall meet the requirement. Specimens or samples for retest may be taken from the original test assembly or sample, or from a new test assembly or sample. For chemical analysis, the retest need only be for those specific elements that failed to meet the test requirement.

⁴ ASTM standards may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.



NOTE: ALL DIMENSIONS EXCEPT ANGLES ARE IN INCHES.

SI EQUIVALENTS			
in.	mm	in.	mm
1/8	3.2	2-1/2	64
3/8	9.5	5	127
1	25		

FIG. 1 GROOVE WELD TEST ASSEMBLY FOR MECHANICAL PROPERTIES

8. Weld Test Assembly

8.1 Except for the R45 classification, one weld test assembly is required. It is the groove weld in Figure 1 for mechanical properties. The assembly shall be tested in the as-welded condition. No test assembly is required for the R45 classification.

8.2 Preparation of the weld test assembly shall be as prescribed in Figure 1. Base metal for the assembly shall be as required in Table 3 and shall meet the requirements of the appropriate ASTM specification shown there or an equivalent specification. Testing of the assembly shall be as prescribed in Section 10, Tension Test.

8.2.1 Welding shall be done using a $3/32$ in. or $1/8$ in. (2.4 mm or 3.2 mm) diameter welding rod.

TABLE 3
BASE METAL REQUIRED FOR TEST ASSEMBLIES

AWS Classification	Base Metal		UNS Number*
	Type	ASTM Specification	
R60	Carbon steel	A36, A285, grade C, or equivalent	K02600
R65	Carbon steel	A36, A285, grade C, or equivalent	K02600
R100	Low alloy steel	Any grade of A514, or equivalent	—
RXXX-G	Material shall have a tensile and chemical composition similar to that of the rod being classified.		

* SAE/ASTM Unified Numbering System for Metal and Alloys.

8.2.2 The welding shall be done in the flat position.

8.2.3 The weld test assembly shall be preheated to between 60°F (16°C) and 200°F (93°C) and the assembly shall be welded, using a maximum of five layers and having no layer exceeding $\frac{1}{8}$ in. (3.2 mm) in thickness. The filler metal shall be deposited using backhand welding with a neutral or slightly reducing flame. After welding each layer, the plate shall be allowed to cool in still air until the interpass temperature drops below 350°F (180°C) before proceeding with the next layer. The joint shall be completely welded without treatment of the reverse side (root surface). Maximum weld reinforcement shall be $\frac{1}{8}$ in. (3.2 mm).

8.2.4 After the last pass has been completed, the assembly shall be allowed to cool in still air to ambient temperature.

9. Chemical Analysis

9.1 A sample of the welding rod or the rod stock from which it is made shall be prepared for chemical analysis. Welding rod, when analyzed for elements that are present in the coating (copper flashing, for example), shall be analyzed without removing the coating. When the welding rod is analyzed for elements other than those in the coating, the coating may be removed, provided that this does not affect the results of the analysis.

9.2 The sample shall be analyzed by accepted analytical methods. The referee method shall be ASTM E350, *Standard Methods for Chemical Analysis of Carbon Steel, Low Alloy Steel, Silicon Electrical Iron, Ingot Iron, and Wrought Iron*.

9.3 The results of the analysis shall meet the requirements of Table 4 for the classification of the rod under test.

10. Tension Test

10.1 One all-weld-metal tension test specimen shall be removed from the groove weld described in Section 8, Weld Test Assembly, and shown in Figure 1. The dimensions of the test specimen shall be as specified in Figure 2.

10.2 The specimen shall be tested in the manner described in the tension test section of the latest edition of ANSI/AWS B4.0, *Standard Methods for Mechanical Testing of Welds*.

10.3 The results of the tension test shall meet the requirements specified in Table 1.

PART C — MANUFACTURE, IDENTIFICATION, AND PACKAGING

11. Method of Manufacture

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

12. Standard Sizes and Lengths

Standard sizes for filler metals shall be as shown in Table 5.

TABLE 4
CHEMICAL COMPOSITION REQUIREMENTS FOR WELDING RODS AND ROD STOCK

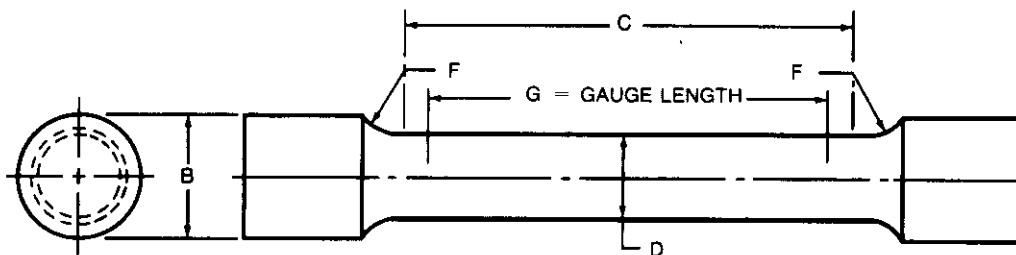
AWS Classification	UNS Number ^a	Amount, Percent by Weight ^b									
		C	Mn	Si	P	S	Cu	Cr	Ni	Mo	Al
R45	K00045	0.08	0.50 0.90	0.10 0.10	0.035	0.040	0.30	0.20	0.30	0.20	0.02
R60	K00060	0.15	to 1.40	to 0.35	0.035	0.035	0.30	0.20	0.30	0.20	0.02
R65	K00065	0.15	to 1.60	to 0.70	0.035	0.035	0.30	0.40	0.30	0.20	0.02
R100	K12147	0.18 to 0.23	0.70 to 0.90	0.20 to 0.35	0.025	0.025	0.15	0.40 to 0.60	0.40 to 0.70	0.15 to 0.25	0.02
RXXX-G ^c	-----	Not Specified -----									

NOTES:

a. SAE/ASTM Unified Numbering System for Metals and Alloys.

b. Single values are maximums.

c. Designators, "XXX" correspond to minimum strength of weld metal in the nearest ksi. See Note "b" of Table 1.

**Dimensions of Specimen, in.**

Test plate thickness	D	G	C	B	F, min	Approximate area, in. ²
3/8	0.250 ± 0.005	1.000 ± 0.005	1-11/4	3/8	0.18	0.05

Dimensions of specimen, mm

Test plate thickness	D	G	C	B	F, min	Approximate area, in. ²
9.5	6.40 ± 0.13	25.40 ± 0.13	32	9.5	4.6	32

Notes:

1. Dimensions G and C shall be as shown, but ends may be of any shape to fit the testing machine holders provided the load is axial.
2. The diameter of the specimen within the gauge length shall be slightly smaller at the center than at the ends. The difference shall not exceed one percent of the diameter.
3. The surface finish within the C dimension shall be no rougher than 63 μ in. (1.6 μ m).

FIG. 2 TENSION TEST SPECIMEN

TABLE 5
STANDARD FILLER METAL SIZES^a

Standard Package Form	Diameter		Tolerance	
	in.	mm	in.	mm
Straight lengths ^b	$\frac{1}{16}$ (0.062)	1.6	±0.002	±0.05
	$\frac{3}{32}$ (0.094)	2.4		
	$\frac{1}{8}$ (0.125)	3.2		
	$\frac{5}{32}$ (0.156)	4.0		
	$\frac{3}{16}$ (0.188)	4.8		
	$\frac{1}{4}$ (0.250)	6.4		

NOTES:

a. Other sizes and lengths may be supplied as agreed upon between the supplier and purchaser.

b. The standard length of the welding rod shall be 36 in., +0, - $\frac{1}{2}$ in. (900 mm, +15 mm, -0 mm).

13. Finish and Uniformity

13.1 All welding rods shall have a smooth finish which is free from harmful segregation, oxides, piping, seams, slivers, depressions, scratches, scale, lime, or foreign matter except as permitted in 13.2 and 13.3.

13.2 A suitable protective coating may be applied to any welding rod in this specification.

13.3 The welding rods may be coated with the minimum amount of oil necessary to prevent rusting, but not sufficient to adversely affect weld properties, except that oil is not permitted when copper or other suitable coatings are used to prevent rusting.

14. Filler Metal Identification

Identification of individual welding rods is not a requirement of this specification but may be done as agreed upon between the purchaser and supplier.

15. Packaging

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

16. Marking of Packages

16.1 The following product information (as a minimum) shall be legibly marked so as to be visible from the outside of each unit package:

- (1) AWS Specification and classification designations (year of issue may be excluded)
- (2) Supplier's name and trade designation

(3) Size and net weight

(4) Lot, control, or heat number

16.2 The following precautionary information (as a minimum) shall be prominently displayed in legible print on all packages of welding rods, including individual unit packages enclosed within a larger package.

WARNING:

PROTECT yourself and others. Read and understand this information.

FUMES AND GASES can be dangerous to your health.

HEAT RAYS (INFRARED RADIATION from flame or hot metal) can injure eyes.

- Before use, read and understand the manufacturer's instructions, Material Safety Data Sheets (MSDSs), and your employer's safety practices.
- Keep your head out of the fumes.
- Use enough ventilation or exhaust at the flame, or both, to keep fumes and gases from your breathing zone and the general area.
- Wear correct eye, ear, and body protection.
- See American National Standard Z49.1, *Safety in Welding and Cutting*, published by the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135; OSHA Safety and Health Standards, 29 CFR 1910, available from the U.S. Government Printing Office, Washington, DC 20402.

DO NOT REMOVE THIS INFORMATION

Appendix

Guide to AWS Specification for Carbon and Low Alloy Steel Rods for Oxyfuel Gas Welding

(This Appendix is not a part of ANSI/AWS A5.2-92, *Specification for Carbon and Low Alloy Steel Rods for Oxyfuel Gas Welding*, but is included for information purposes only.)

A1. Introduction

This guide was designed to correlate the rod classifications with the intended applications so the specification can be used effectively. Such correlations are intended as examples rather than complete listings of the materials for which each filler metal is suitable.

A2. Classification System

A2.1 The system for identifying the rod classifications in this specification follows the standard pattern used in other AWS filler metal specifications. The letter "R" at the beginning of each classification designation stands for rod. The digits (45, 60, 65, and 100) designate a minimum tensile strength of the weld metal, in the nearest thousands of pounds per square inch, deposited in accordance with the test assembly preparation section of this specification.

A2.2 "G" Classification

A2.2.1 This specification includes filler metals classified as RXXX-G. The "G" indicates that the filler metal 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 filler metals that differ in one respect or another (chemical composition, for example) from all other classifications (meaning that the composition of the filler metal, 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 filler metals, each bearing the same "G" classification, may be quite different in some certain respect (chemical composition, again, for example).

A2.2.2 The point of difference (although not necessarily the amount of the difference) referred to above 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:

"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.

"Not Required" is used in those areas of the specification that refer to the test that must be conducted in order to classify a filler metal (or a welding material). It indicates that the test is *not required* because the requirements (results) 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 a filler metal 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 that product. The purchaser will also 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 ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*) in the purchase order.

A3. Acceptance

Acceptance of all welding materials classified under this specification is in accordance with ANSI/AWS A5.01, as the specification states. Any testing a purchaser requires of the supplier for material shipped in accordance with this specification needs to be clearly stated in the purchase order according to the provisions of ANSI/AWS A5.01. In the absence of any such statement in the purchase order, the supplier may ship the material of that classification as specified in Schedule F, Table 1, of ANSI/AWS A5.01. Testing in accordance with any other Schedule in that Table shall 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 on the packaging enclosing the product or the classification on the product itself, constitutes the supplier's (manufacturer's) certification that the product meets all of the requirements of the 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 has met the requirements of the specification. Representative material, in this case, is 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 made. 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 ANSI/AWS A5.01.

A5. Ventilation During Welding

A5.1 Five major factors govern the quantity of fumes in the atmosphere to which welders and welding operators are exposed during welding:

- (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 welders or welding operators to the fumes as they issue from the welding zone, and to the gases and dust 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, *Safety in Welding and Cutting* (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 of that document titled, Ventilation.

A6. Welding Considerations

A6.1 The test assembly required in this specification is welded according to established techniques of the oxyfuel gas process.

A6.2 The oxyfuel gas to the torch should be adjusted to give a neutral or slightly reducing flame. This assures the absence of the oxidizing flame which could adversely influence weld quality. The extent of the excess fuel gas is measured by the length of the streamer (the so-called "feather") of unburned fuel gas visible at the extremity of the inner cone. This streamer should measure about $\frac{1}{8}$ to $\frac{1}{4}$ the length of the inner cone of the flame. Excessively long streamers should be avoided, since they may add carbon to the weld metal.

A6.3 In forehand welding, the torch flame points ahead in the direction of welding, and the welding rod precedes the torch flame. To distribute the heat and molten weld metal, it is necessary to use opposing oscillating motions for the flame and welding rod. This may cause excessive melting of the base metal and mixing of base metal and weld metal. Weld metal properties may be altered.

A6.4 In backhand welding, the torch flame points back at the molten metal, and the welding rod is interposed between the flame and molten metal. There is significantly less manipulation of the flame, the welding rod, and the molten metal. Therefore, a backhand weld is more likely to approach the chemical composition of undiluted weld metal.

A7. Description and Intended Use of Carbon and Low Alloy Steel Rods

A7.1 Oxyfuel gas welding rods have no coverings to influence usability of the rod. Thus, the ability to

weld in the vertical or overhead position is essentially a matter of welder skill and can be affected to some degree by the chemical composition of the rod.

A7.2 Class R45 welding rods are a low carbon steel composition used for the welding of steel, where the minimum tensile strength requirement does not exceed 45 ksi (310 MPa).

A7.3 Class R60 welding rods are used for the oxyfuel gas welding of carbon steels, where the minimum tensile strength requirement does not exceed 60 ksi (415 MPa). Class R60 rods are carbon steel composition.

A7.4 Class R65 welding rods are used for the oxyfuel gas welding of carbon and low alloy steels, where the minimum tensile strength requirement does not exceed 65 ksi (450 MPa). Class R65 welding rods may have either a low alloy or a carbon steel composition.

A7.5 Class R100 welding rods are used for the oxyfuel gas welding of low alloy steel, where the minimum tensile strength requirement does not exceed 100 ksi (690 MPa) in the as-welded condition. Users are cautioned that response of the weld metal and base metal to postweld heat treatment may be different.

A8. Special Tests

It is recognized that supplementary tests may be necessary to determine the suitability of these welding

rods for applications involving properties not considered in this specification. In such cases, additional tests to determine specific properties such as corrosion resistance, mechanical properties at high and low temperatures, wear resistance, and suitability for welding combinations of dissimilar metals may need to be conducted.

A9. Discontinued Classifications

A number of rod classifications have been discontinued during the numerous revisions of this specification. These discontinued classifications are listed in Table A1 along with the year they were last published in this specification.

**TABLE A1
DISCONTINUED CLASSIFICATIONS**

AWS Classifications	Last Published Date
GA 50	1946
GA 60	1946
GA 65	1946
GB 45	1946
GB 60	1946
GB 65	1946
RG 45	1969
RG 60	1969
RG 65	1969