

SPECIFICATION FOR TUNGSTEN AND TUNGSTEN ALLOY ELECTRODES FOR ARC WELDING AND CUTTING



SFA-5.12



(Identical with AWS Specification A5.12-92)

1. Scope

This specification prescribes the requirements for the classification of bare tungsten and tungsten alloy electrodes for gas tungsten arc welding and cutting and plasma arc welding and cutting.

PART A — GENERAL REQUIREMENTS

2. Classification

2.1 The tungsten and tungsten alloy electrodes covered by this specification are classified according to the chemical composition of the electrode as specified in Table 1.

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

2.3 No electrode meeting the requirements of any other classification, shall be classified under EWG.

2.4 The electrodes classified under this specification are intended for gas tungsten arc welding (GTAW), gas tungsten arc cutting (GTAC), plasma arc welding (PAW) or plasma arc cutting (PAC), but that is not to prohibit their use with any other process for which they are found suitable.

3. Acceptance

Acceptance¹ of the electrodes 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 identification 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 The units of measure in this specification are U.S. Customary Units and SI Units. Only one system of units shall be used for any given application of this specification. The two systems of units shall not be intermixed nor will conversions of one to the other be used.

5.2 For purposes of determining conformance with this specification, an observed or calculated value shall be rounded to the "nearest unit" in the last right-hand

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

² AWS standards can be obtained from the American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33135.

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

TABLE 1
CHEMICAL COMPOSITION REQUIREMENTS FOR ELECTRODES^a

AWS Classification	UNS Number ^b	W Min. (difference) ^c	Weight Percent				Other Oxides Or Elements Total	
			CeO ₂	La ₂ O ₃	ThO ₂	ZrO ₂		
			EWP	R07900	99.5	—	—	—
EWCe-2	R07932	97.3	1.8-2.2	—	—	—	—	0.5
EWLa-1	R07941	98.3	—	0.9-1.2	—	—	—	0.5
EWTh-1	R07911	98.3	—	—	0.8-1.2	—	—	0.5
EWTh-2	R07912	97.3	—	—	1.7-2.2	—	—	0.5
EWZr-1	R07920	99.1	—	—	—	0.15-	—	—
EWG ^d	—	94.5	—	—	—	0.40	—	0.5
----- NOT SPECIFIED -----								0.5

NOTES:

- The electrode shall be analyzed for the specific oxides for which values are shown in this table. If the presence of other elements or oxides is indicated, in the course of this work, the amount of those elements or oxides shall be determined to ensure that their total does not exceed the limits specified for "Other Oxides or Elements, Total" in the last column of the table.
- SAE/ASTM Unified Numbering System for Metals and Alloys.
- Tungsten content shall be determined by determining the measured content of all specified oxides and other oxides and elements and subtracting the total from 100%.
- Classification EWG must contain some oxide or element additive and the manufacturer must identify the type and nominal content of the oxide or element additive.

place of figures used in expressing the limiting value in accordance with the rounding-off method given in ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance With Specifications*.⁴

PART B — TEST, PROCEDURES, AND REQUIREMENTS

6. Summary of Test

Chemical analysis of the electrode is the only test required for classification of a product under this specification.

7. 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. Sample for retest may be taken from the original test sample or a new sample. For chemical analysis, retest need be only for those specific elements that failed to meet the test requirement.

8. Chemical Analysis

8.1 A sample of the electrode shall be prepared for chemical analysis.

8.2 The sample shall be analyzed by accepted analytical methods. The referee method shall be ASTM F288, *Specification for Tungsten Wire for Electron Devices and Lamps*.

8.3 The results of the analysis shall meet the requirements of Table 1 for the classification of the electrode under test.

8.4 The alloy additions shall be uniformly distributed throughout the electrodes so that the operation of the electrodes is not adversely affected.

PART C — MANUFACTURE, IDENTIFICATION, AND PACKAGING

9. 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.

⁴ASTM Standards can be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

TABLE 2
STANDARD SIZES

U.S. Customary Units		SI Units	
Diameter in.	Tolerance ± in. ^{b,c}	Diameter mm	Tolerance ± mm ^{b,c}
0.010 ^a	0.001	0.300	0.025
0.020	0.002	0.50	0.05
0.040	0.002	1.00	0.05
0.060	0.002	1.60	0.05
0.093	0.003	2.00	0.05
0.125 ($\frac{1}{8}$)	0.003	2.40	0.08
0.156 ($\frac{5}{32}$)	0.003	2.50	0.08
0.187 ($\frac{3}{16}$)	0.003	3.00	0.08
0.250 ($\frac{1}{4}$)	0.003	3.20	0.08
		4.00	0.08
		4.80	0.08
		5.00	0.08
		6.40	0.08
		8.00	0.08

NOTES:

- 0.010 in. (0.30 mm) electrodes are also available in coils.
- Tolerances, other than those listed, may be supplied as agreed upon between supplier and user.
- Tolerances shall apply to electrodes in both the clean finish and ground finish conditions.

10. Standard Sizes

10.1 Standard diameters for electrodes in straight lengths are as shown in Table 2.

10.2 The following are standard lengths:

U.S. Customary Units:

- 3 in., 6 in., and 7 in. ± $\frac{1}{16}$ in.;
12 in., 18 in., and 24 in. ± $\frac{1}{8}$ in.

SI Units:

- 50 mm, 75 mm, 150 mm, and 175 mm ± 1.0 mm

11. Finish and Uniformity

11.1 Electrodes shall be free of surface impurities, undesirable films, foreign inclusions, pipes, slivers, scale, etc., that would adversely affect the operation of the welding equipment or the properties of weld metal made using the electrodes.

11.2 Electrodes shall be available as either clean finish or ground finish.

11.3 Clean finish designates that a chemical treatment has been applied to clean the surface of the tungsten or tungsten alloy electrode after drawing or swaging.

11.4 Ground finish designates that the tungsten or tungsten alloy electrode has been cleaned of impurities

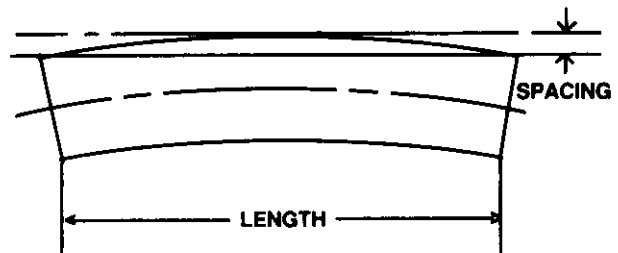


FIG. 1 MEASUREMENT PROCEDURE FOR
STRAIGHTNESS

after it has been centerless ground to a uniform size. It is supplied with a bright, polished surface.

11.5 For electrodes supplied with a ground finish, the maximum surface roughness shall be the following:

U.S. Customary Units: 32 microinches AARH

SI Units: 0.8 micrometers Ra

11.6 The electrodes, except when supplied in coil form, will be straight such that any element of its surface, over a specified length, must lie between two parallel lines of a specified spacing where the two lines and the nominal axis of the electrode share a common plane, as shown in Figure 1. The specified spacings and lengths are as follows:

U.S. Customary Units: 0.020 in. over a 4 in. length

SI Units: 0.5 mm over a 100 mm length

12. Standard Package Form

The standard package form is straight length. Standard package and package quantity shall be as agreed between the purchaser and manufacturer or supplier.

13. Electrode Identification

13.1 Electrodes shall be color coded in accordance with the requirements of Table 3.

13.2 The color coding may be accomplished by any method that meets the requirements of this specification. Such color coding shall have no adverse effect on the operation or use of the electrode.

14. Packaging

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

15. Marking of Packages

15.1 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 numbers (year of issue may be excluded), (For EWG classification, the type and nominal content of the oxide addition shall also be marked on the package)

(2) Supplier's name and trade designation

(3) Size and net quantity

(4) Lot, control, or heat number

15.2 The following precautionary information, as a minimum, shall be prominently displayed in legible print on all packages of the electrodes, 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.

ARC RAYS can injure eyes and burn skin.

ELECTRIC SHOCK can kill.

- 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, exhaust at the arc, or both, to keep fumes and gases away from your breathing zone and the general area.

TABLE 3
ELECTRODE IDENTIFICATION REQUIREMENTS^{a,b}

AWS Classification	Color
EWP	Green
EWCe-2	Orange
EWL a-1	Black
EWTh-1	Yellow
EWTh-2	Red
EWZr-1	Brown
EWG	Gray

NOTES:

- a. The actual color may be applied in the form of bands, dots, etc., at any point on the surface of the electrode.
- b. The method of color coding used shall not change the diameter of the electrode beyond the tolerances permitted.

- Wear correct eye, ear, and body protection.
- Do not touch live electrical parts.
- 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

15.3 Marking of any, or all, overpacking of unit packages with items listed in 15.1 shall be optional with the manufacturer.

Appendix

Guide to AWS Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding and Cutting

(This Appendix is not a part of ANSI/AWS A5.12-92, *Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding and Cutting*, but is intended for information only.)

A1. Introduction

A1.1 The purpose of this guide is to correlate the electrode classifications with their intended applications so the specification can be used effectively.

A1.2 Tungsten electrodes are nonconsumable in that they do not intentionally become part of the weld metal as do electrodes used as filler metals. The function of a tungsten electrode is to serve as one of the terminals of an arc which supplies the heat required for welding or cutting.

A2. Classification

A2.1 The system for identifying the electrode classifications in this specification follows the standard pattern used in other AWS filler metal specifications. The letter "E" at the beginning of the classification designation stands for electrode. The "W" indicates that the electrode is primarily tungsten. The "P" indicates that the electrode is essentially pure tungsten and contains no intentionally added alloying elements. The "Ce", "La", "Th", and "Zr" indicate that the electrode is alloyed with oxides of cerium, lanthanum, thorium, or zirconium, respectively. The numeral at the end of some of the classifications indicates a different chemical composition level or product within a specific group.

A2.2 This specification includes electrodes classified as EWG. The "G" indicates that the electrode is of a general classification. It is "general" because not all of the particular requirements specified for each of the other classifications are specified for this classification. The intent, in establishing this classification, is to

provide a means by which electrodes that differ in one respect or another (chemical composition, for example) from other classifications (meaning that the composition of the electrode—in the case of this 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 electrode—one that otherwise would have to await a revision of the specification—to be classified immediately, under the existing specification. This means, then, that two electrodes—each bearing the same "G" classification—may be quite different in some certain respect. To prevent the confusion that this situation could create, this specification requires the manufacturer to identify, in the label, the type and nominal content of the alloy addition made in the particular product.

A3. Acceptance

Acceptance of all welding materials classified under this specification is in accordance with ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*, as the specification states. Any testing the purchaser requires of the supplier, for material shipped in accordance with this specification, shall be clearly stated in the purchase order, according to the provisions of ANSI/AWS A5.01. In the absence of any such statement in the purchase order, the supplier may ship the material with whatever testing is normally conducted on 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 must be specifically required by the purchase

order. In such cases, acceptance of the material shipped will be in accordance with those requirements.

A4. Certification

The act of placing the AWS Specification and Classification designations on the packaging enclosing the product or the classification identification 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 test required by the specification on material that is representative of that being shipped and that that material 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 conducted.

The basis for the certification required by the specification is the classification test of "representative material" cited above, and the "Manufacturer's Quality Assurance Program" in 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 the welders or welding operators to the fumes as the fumes issue from the welding zone, and to the gases and dusts in the space in which they are working
- (5) The ventilation provided to the space in which the welding is done

A5.2 American National Standard Z49.1, *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 on Health Protection and Ventilation.

A6. Operation Characteristics

A6.1 The choice of an electrode classification, size, and welding current is influenced by the type and thickness of the base metals being welded. The capacity of tungsten electrodes to carry current is dependent upon numerous factors in addition to the classification and size, including type and polarity of the current, the shielding gas used, the type of equipment (air or water cooled), the extension of the electrode beyond the collet (sleeve or tube that holds the electrode), and the welding position. An electrode of a given size will have its greatest current-carrying capacity with direct current, electrode negative (straight polarity), less with alternating current, and still less with direct current, electrode positive (reverse polarity). Table A1 lists some typical current values that may be used with argon shielding gas. However, the other factors mentioned above should be carefully considered before selecting an electrode for a specific application.

A6.2 Tungsten has an electrical conductivity that is about 30% that of copper and a thermal conductivity which is 44% that of copper. Therefore, there will be more heating as current is passed through the tungsten electrode. When welding with tungsten electrodes, the arc tip should be the only hot part of the electrode; the remainder should be kept as cool as possible.

A6.3 One method of preventing electrode overheating is to keep the extension of the electrode from the collet short. If the extension is too long, even a relatively low current can cause the electrode to overheat and melt above the terminus of the arc. Conversely, if the current density is too low, the arc will be erratic and unstable.

A6.4 Many electrode classifications contain emissive oxide additions. These additions lower the temperature at which the electrode emits electrons, to a temperature below the melting point of tungsten. Such an electrode operates cooler, or it can operate at higher currents as will be noted from Table A1. Benefits of these additions include easier starting, particularly when using superimposed high frequency, more stable operation, and reduced contamination. These benefits are noted in the description listed for the various classifications containing oxide additives.

A6.5 All tungsten electrodes may be used in a similar manner. However, electrodes of each classification have distinct advantages with respect to other classifications. The following section discusses the specific electrode classifications with regard to their operating characteristics and usability.

TABLE A1
TYPICAL CURRENT RANGES FOR TUNGSTEN ELECTRODES^a

Electrode Diameter		DCEN (DCSP) A	DCEP (DCRP) A	Alternating Current Unbalanced Wave A		Alternating Current Balanced Wave A	
in.	mm	EWX-X	EWX-X	EWP	EWX-X	EWP	EWX-X
0.010	0.30	Up to 15	na ^b	Up to 15	Up to 15	Up to 15	Up to 15
0.020	0.50	5-20	na	5-15	5-20	10-20	5-20
0.040	1.00	15-80	na	10-60	15-80	20-30	20-60
0.060	1.60	70-150	10-20	50-100	70-150	30-80	60-120
0.093	2.40	150-250	15-30	100-160	140-235	60-130	100-180
0.125	3.20	250-400	25-40	150-200	225-325	100-180	160-250
0.156	4.00	400-500	40-55	200-275	300-400	160-240	200-320
0.187	5.00	500-750	55-80	250-350	400-500	190-300	290-390
0.250	6.40	750-1000	80-125	325-450	500-630	250-400	340-525

NOTES:

- a. All are values based on the use of argon gas. Other current values may be employed depending on the shielding gas, type of equipment and application.
b. na = not applicable

A7. Description and Intended Use of Electrodes

A7.1 EWP Electrode Classification. The EWP electrodes are unalloyed tungsten electrodes (99.5 percent tungsten minimum). Their current-carrying capacity is lower than that of other electrodes. They provide good stability when used with alternating current, either balanced wave or continuously high frequency stabilized. They may be used with direct current and also with either argon or helium, or a combination of both, as a shielding gas. They maintain a clean, balled end, which is preferred for aluminum and magnesium welding. These electrodes have reasonably good resistance to contamination of the weld metal by the electrode, although the oxide containing electrodes are superior in this respect. EWP electrodes are generally used on less critical applications, except for welding aluminum and magnesium. The lower cost EWP electrodes can be used for less critical applications where some tungsten contamination of welds is acceptable.

A7.2 EWCe-2 Electrode Classification. The EWCe-2 electrodes were first introduced into the United States market in 1987. Several other grades of this type electrode are commercially practical, including electrodes containing 1% CeO₂, but only one grade, EWCe-2, has been incorporated in this specification as having the commercial significance.

The EWCe-2 electrodes are tungsten electrodes containing cerium oxide, referred to as ceria. Advantages of tungsten electrodes containing ceria, compared to pure tungsten, include increased ease of starting, im-

proved arc stability and reduced rate of vaporization or burn-off. These advantages increase with increased ceria content. Unlike thorium, ceria is not a radioactive material.

A7.2.1 EWCe-2 electrodes contain about two percent ceria. They will operate successfully with alternating current or direct current, either polarity.

A7.3 EWLa-1 Electrode Classification. The EWLa-1 electrodes are tungsten electrodes which contain nominally 1% lanthanum oxide, referred to as lanthana. The advantages and operating characteristics of this electrode type are very similar to those of EWCe-2 electrodes.

A7.4 EWTh-X Electrode Classifications. The EWTh-X electrodes are tungsten electrodes containing thorium oxide, referred to as thorium. The thorium in all classes is responsible for increasing the usable life of these electrodes over the EWP electrodes because of their higher electron emission, better arc starting and arc stability. They generally have longer life and provide greater resistance to tungsten contamination of the weld.

Thorium is a very low level radioactive material. For the amount of thorium present in these electrodes, the level of radiation has not been found to represent a health hazard. However, if welding is to be performed in confined spaces for prolonged periods of time or if electrode grinding dust might be ingested, special precautions relative to ventilation should be considered. The user should consult appropriate safety personnel.

A7.4.1 EWTh-1 and EWTh-2 electrodes were designed for direct current applications. They have the thorium content dispersed evenly throughout their entire length. They maintain a sharpened point well, which is desirable for welding steel. They can be used on alternating current work, but a satisfactory balled end, which is desirable for the welding of non-ferrous materials, is difficult to maintain.

A7.4.2 Should it be desired to use these electrodes for alternating current welding, then balling can be accomplished by briefly, and carefully, welding with direct current electrode positive prior to welding with alternating current. During AC welding, the balled end does not melt and so emission is not as good as from a liquid ball on an EWP electrode. The higher thorium content in the EWTh-2 electrode causes the operating characteristic improvements to be more pronounced than in the lower thorium content EWTh-1.

A7.5 EWZr-1 Electrode Classification. The EWZr-1 electrode is a tungsten electrode containing zirconium oxide, referred to as zirconia. This electrode is preferred for applications where tungsten contamination of the weld must be minimized. This electrode performs well when used with alternating current as it retains a balled end during welding and has a high resistance to contamination.

A7.6 EWG Electrode Classification. The EWG electrode is a tungsten electrode containing an unspecified addition of an unspecified rare earth oxide or combination of oxides. The purpose of the addition is to affect the nature or characteristics of the arc, as defined by the manufacturer.

Although no rare earth oxide addition is specified, the manufacturer must identify the specific addition or additions and the nominal quantity or quantities added.

A8. General Recommendations

These recommendations, when followed, should maintain high weld quality and promote welding economy in any specific application.

A8.1 The appropriate current (type and magnitude) should be selected for the electrode size to be used. Too great a current will cause excessive melting, dripping, or volatilization of the electrode. Too small a current will cause cathode bombardment and erosion due to the low temperature and result in arc instability.

A8.2 The electrode should be properly broken or ground tapered by following the supplier's suggested procedures. Improper breaking may cause a jagged end or a bent electrode, which usually results in a poorly shaped arc and excessive electrode heating.

A8.3 The electrodes should be handled carefully and kept as clean as possible. To obtain maximum cleanliness, they should be stored in their original package until used.

A8.4 The shielding gas flow should be maintained until the electrode has cooled. When the electrodes are properly cooled, the arc end will appear bright and polished. When improperly cooled, the end may oxidize and appear to have a colored film which can, unless removed, adversely affect the weld quality on subsequent welds. All connections, both gas and water, should be checked for tightness.

A8.5 The electrode extension within the gas shielding pattern should be kept to a minimum, generally dictated by the application and equipment. This is to ensure protection of the electrode by the gas even at low gas flow rates.

A8.6 The equipment and, in particular, the shielding gas nozzle should be kept clean and free of weld spatter. A dirty nozzle adversely influences the gas shielding. This contributes to improper gas flow patterns and arc wandering, which can result in poor weld quality. It may also contribute to excessive electrode consumption.

A9. Discontinued Classifications

In this revision of the specification, the EWTh-3 classification has been discontinued, as no longer having commercial significance. For information referring to this classification, the user is referred to the AWS A5.12-80 revision of this specification.