ANSI/AWS A5.12/A5.12M-98
An American National Standard

Specification for Tungsten and Tungsten-Alloy Electrodes for Arc Welding and Cutting

American Welding Society

Key Words—Tungsten-alloy electrodes, gas tungsten arc welding electrodes, plasma arc welding electrodes, gas tungsten arc cutting electrodes, plasma arc cutting electrodes

ANSI/AWS A5.12/A5.12M-98
An American National Standard

Approved by
American National Standards Institute
February 5, 1998

Specification for Tungsten and Tungsten-Alloy Electrodes for Arc Welding and Cutting

Supersedes ANSI/AWS A5.12-92

Prepared by
AWS Committee on Filler Metals

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

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. Classification is based upon the chemical composition of the electrode. Standard sizes, finish, lengths, quantities, product identification, color coding and chemical composition limits are specified.

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.

American Welding Society
550 N.W. LeJeune Road, Miami, Florida 33126

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Foreword

(This Foreword is not a part of ANSI/AWS A5.12/A5.12M-98, *Specification for Tungsten and Tungsten-Alloy Electrodes for Arc Welding and Cutting*, but is included for information purposes only.)

This document is the first of the A5.12 specifications which makes use of both the 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, ANSI/AWS A1.1, *Metric Practice Guide for the Welding Industry,* is used where suitable. Tables and figures make use of both U.S. Customary Units and SI Units.

The current document is the fifth revision of the initial AWS/ASTM document issued in 1955. The evolution took place as follows:.

ASTM B297-55T AWS A5.12-55T	Tentative Specifications for Tungsten Arc Welding Electrodes
ASTM B297-65T AWS A5.12-65T	Tentative Specifications for Tungsten Arc Welding Electrodes
AWS A5.12-69 ANSI W3.12-73	Specification for Tungsten Arc Welding Electrodes
AWS/ANSI A5.12-80	Specification for Tungsten Arc Welding Electrodes
AWS/ANSI A5.12-92	Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding and Cutting

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS Committee on Filler Metals, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

Official interpretations of any of the technical requirements of this standard may be obtained by sending a request, in writing, to the Managing Director, Technical Services Division, American Welding Society. A formal reply will be issued after it has been reviewed by the appropriate personnel following established procedures.

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Specification for Tungsten and Tungsten-Alloy Electrodes for Arc Welding and Cutting

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. Normative References

2.1 The following ANSI/AWS standards[1] are referenced in the mandatory sections of this document:

(1) ANSI/AWS A1.1, *Metric Procedure Guide for the Welding Industry.*

(2) ANSI/AWS A5.01, *Filler Metal Procurement Guidelines.*

(3) ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes* (published by AWS).

2.2 The following ASTM standards[2] are referenced in the mandatory sections of this document:

(1) ASTM F288, *Specification for Tungsten Wire for Electron Devices and Lamps.*

(2) ASTM E29, *Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications.*

2.3 The following ISO standard[3] is referenced in the mandatory section of this document:

(1) ISO 6848, *Tungsten Electrodes for Inert Gas Shielded Arc Welding and for Plasma Cutting and Welding.*

3. Classification

3.1 The tungsten and tungsten-alloy electrodes covered by A5.12/A5.12M specification are classified using a system that is independent of the U.S. Customary Units and the International System of Units (SI). Classification is according to the chemical composition of the electrode as specified in Table 1. See Annex A7 for classification descriptions.

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

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

3.4 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.

4. Acceptance

Acceptance[4] of the electrodes shall be in accordance with the provisions of ANSI/AWS A5.01, *Filler Metal Procurement Guidelines.*

1. AWS Standards can be obtained from the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

2. ASTM Standards may be obtained from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

3. ISO Standards may be obtained from The American National Standards Institute (ANSI), 11 West 42nd Street, New York, NY 10036.

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

Table 1
Chemical Composition Requirements for Electrodes[a]

AWS Classification	UNS Number[b]	Weight-Percent					
		W Min. (difference)[c]	CeO_2	La_2O_3	ThO_2	ZrO_2	Other Oxides or Elements Total
EWP[e]	R07900	99.5	—	—	—	—	0.5
EWCe-2[e]	R07932	97.3	1.8–2.2	—	—	—	0.5
EWLa-1[e]	R07941	98.3	—	0.8–1.2	—	—	0.5
EWLa-1.5	R97942	97.8	—	1.3–1.7	—	—	0.5
EWLa-2	R07943	97.3	—	1.8–2.2	—	—	0.5
EWTh-1[e]	R07911	98.3	—	—	0.8–1.2	—	0.5
EWTh-2[e]	R07912	97.3	—	—	1.7–2.2	—	0.5
EWZr-1[e]	R07920	99.1	—	—	—	0.15–0.40	0.5
EWG[d]	—	94.5	———	———	Not Specified	———	0.5

Notes:
a. 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 the work, the amount of those elements or oxides shall be determined to ensure that their total does not exceed the limit specified for "Other Oxides or Elements, Total" in the last column of the table.
b. SAE/ASTM Unified Numbering System for Metals and Alloys.
c. Tungsten content shall be determined by subtracting the total of all specified oxides and other oxides and elements from 100%.
d. Classification EWG must contain some compound or element additive and the manufacturer must identify the type and minimal content of the additive on the packaging.
e. See Table A2 for closely matching grades in ISO 6848.

5. 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.[5]

6. Units of Measure and Rounding-Off Procedure

6.1 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. The specification with the designation A5.12 uses U.S. Customary Units. The specification A5.12M uses SI Units. The latter are shown in appropriate columns in tables or within brackets [ ] when used in the text.

6.2 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 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.*

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

Part B
Tests, Procedures, and Requirements

7. Summary of Test

Chemical analysis of the electrode is the only test required for classification of a product under this specification. Electrodes must also meet the dimensional, surface finish, and identification requirements established in this specification.

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. 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.

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 test sample, 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 the prescribed procedures. In this case, the requirement for doubling the number of test specimens does not apply.

9. Chemical Analysis

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

9.2 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.*

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

9.4 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

10. 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.

11. Standard Sizes

Standard diameters and lengths are shown in Table 2. Sizes and tolerances other than those listed may be supplied as agreed between supplier and user.

12. Finish and Uniformity

12.1 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.

12.2 Electrodes shall be supplied with a ground finish. The ground finish designates that the electrode has been cleaned of impurities after it has been centerless ground

Table 2
Standard Sizes and Lengths

Size				Length			
Diameter (in.)	Tolerance[a] (± in.)	Diameter (mm)	Tolerance[a] (± mm)	Length (in.)	Tolerance[a] (± in.)	Length (mm)	Tolerance[a] (mm)
0.010	0.001					50[b]	±1.5
		0.300	0.025	3	1/16	75[b]	−1.0, +2.5
0.020	0.002	0.50[b]	0.05	6	1/16	150[b]	−1.0, +4.0
0.040	0.002	1.00[b]	0.05	7	1/8	175[b]	−1.0, +6.0
0.060[c]	0.002			12	1/8	305	±3.0
		1.60[b]	0.05	18	1/8	455	±3.0
		2.00[b]	0.05	24	1/8	610	±3.0
0.093 (3/32)	0.003	2.40	0.08				
		2.50[b]	0.08				
		3.00	0.10				
0.125 (1/8)	0.003	3.20[b]	0.10				
0.156 (5/32)	0.003	4.00[b]	0.01				
0.187 (3/16)	0.003	4.80	0.10				
		5.00[b]	0.10				
0.250 (1/4)	0.003	6.40	0.10				
		8.00[b]	0.10				

Notes:
a. Tolerances, other than those listed, may be supplied as agreed upon between supplier and user.
b Standard sizes and lengths in ISO 6848, though tolerances differ in some cases.
c. Although the metric size 1.6 mm (0.063 in.) is closer to 1/16 in. (0.0625 in.), it has been common industry practice to refer to the U.S. customary size 0.060 in. as 1/16 in.

to a uniform size. It shall be supplied with a bright, polished surface.

12.3 For electrodes with a ground finish, the maximum surface roughness shall be 32 μin. AARH [0.8 μmRa].

12.4 The electrodes shall 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 spacing is 0.020 in. [0.5 mm] over a length of 4 in. [100 mm].

13. Standard Package Form

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

14. Electrode Identification

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

14.2 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.

15. Packaging

Electrodes 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) Specification and classification designation (year of issue may be excluded). (For EWG classification, the type and nominal content of the alloy 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.

16.2 Marking of any, or all, overpacking of unit packages with items listed in 16.1 shall be optional with the manufacturer.

16.3 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:

Table 3
Electrode Identification Requirements[a,b]

AWS Classification	Color
EWP	Green[c]
EWCe-2	Orange
EWLa-1	Black[c]
EWLa-1.5	Gold
EWLa-2	Blue
EWTh-1	Yellow[c]
EWTh-2	Red[c]
EWZr-1	Brown[c]
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.
c. Color code agrees with ISO 6848.

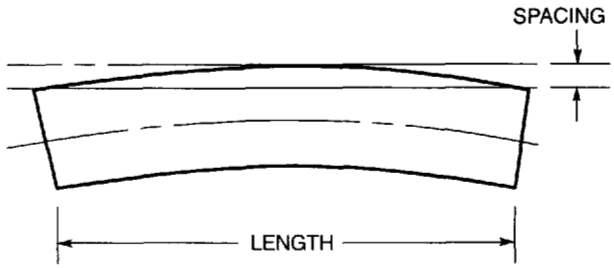

Figure 1—Measurement Procedure for Straightness

WARNING:

PROTECT yourself and others. Read and understand this information.

FUMES and GASES can be hazardous 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.
- Wear correct eye, ear, and body protection.
- Do not touch live electrical parts.
- See American National Standard ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126; and *OSHA Safety and Health Standards*, 29 CFR 1910, available from the U.S. Government Printing Office, Washington, DC 20402.

DO NOT REMOVE THIS INFORMATION

Annex

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

(This Annex is not a part of ANSI/AWS A5.12/A5.12M-98, *Specification for Tungsten and Tungsten-Alloy Electrodes for Arc Welding and Cutting*, but is included for information purposes 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 "G" Classification

A2.2.1 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.

A2.2.2 Request for Electrode Classification

(1) When an electrode cannot be classified according to some classification other than a "G" classification, the manufacturer may request that a classification be established for that electrode. The manufacturer may do this by following the procedure given here. When the manufacturer elects to use the "G" classification, the Committee on Filler Metals recommends that the manufacturer still request that a classification be established for that electrode, as long as the electrode is of commercial significance.

(2) A request to establish a new electrode classification must be a written request and it needs to provide sufficient detail to permit the Committee on Filler Metals or

the Subcommittee to determine whether the new classification or the modification of an existing classification is more appropriate, and whether either is necessary to satisfy the need. The request needs to state the variables and their limits, for such a classification or modification. The request should contain some indication of the time by which completion of the new classification or modification is needed.

(3) The request should be sent to the Secretary of the Committee on Filler Metals at AWS Headquarters. Upon receipt of the request, the Secretary will:

(a) Assign an identifying number to the request. This number will include the date the request was received.

(b) Confirm receipt of the request and give the identification number to the person who made the request.

(c) Send a copy of the request to the Chairman of the Committee on Filler Metals and the Chairman of the particular Subcommittee involved.

(d) File the original request.

(e) Add the request to the log of outstanding requests.

(4) All necessary action on each request will be completed as soon as possible. If more than 12 months lapse, the Secretary shall inform the requestor of the status of the request, with copies to the Chairpersons of the Committee and of the Subcommittee. Requests still outstanding after 18 months shall be considered not to have been answered in a "timely manner" and the Secretary shall report these to the Chair of the Committee on Filler Metals for action.

(5) The Secretary shall include a copy of the log of all requests pending and those completed during the preceding year with the agenda for each meeting of the Committee on Filler Metals. Any other publication of requests that have been completed will be at the option of the American Welding Society, as deemed appropriate.

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 a 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 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.

Electrodes sold as a standard size must also meet the dimensional, surface finish, and identification requirements established in this specification.

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 involved

(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 ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes* (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 percent that of copper and a thermal conductivity which is 44 percent 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.

A7. Description and Intended Use of Electrodes

A7.1 EWP Electrode Classification (Green). 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

Table A1
Typical Current Ranges for Tungsten Electrodes*

Electrode Diameter		Amperes					
		DCEN (DCSP)	DCEP (DCRP)	Alternating Current Unbalanced Wave		Alternating Current Balanced Wave	
in.	mm	EWX-X	EWX-X	EWP	EWX-X	EWP	EWX-X
0.010	0.30	up to 15	not applicable	up to 15	up to 15	up to 15	up to 15
0.020	0.50	5–20	not applicable	10–20	5–20	5–15	5–20
0.040	1.00	15–80	not applicable	20–60	15–80	10–30	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	4.80	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

*All values are based on the use of argon gas. Other current values may be employed depending on the shielding gas, type of equipment and application.

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 (Orange). The EWCe-2 electrodes are tungsten electrodes containing about two percent cerium oxide, referred to as ceria. 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 one percent CeO, but only one grade, EWCe-2, has been incorporated in this specification as having commercial significance.

The advantages of tungsten electrodes containing ceria, compared to pure tungsten, include increased ease of starting, improved arc stability and reduced rate of vaporization or burn-off. Unlike thoria, ceria is not a radioactive material. These advantages increase with increased ceria content. These electrodes operate successfully with alternating current or direct current, either polarity.

A7.3 EWLa-X Electrode Classifications. The EWLa-X electrodes are tungsten electrodes containing lanthanum oxide, referred to as lanthana. The advantages and operating characteristics of these electrodes are similar to that of the EWCe-2 electrodes. Unlike thoria, lanthana is not a radioactive material.

A7.3.1 EWLa-1 Electrode Classification (Black). The EWLa-1 electrodes are tungsten electrodes which contain nominally 0.8-1.2 weight-percent (wt.-%) lanthanum oxide, referred to as lanthana. The advantages and operating characteristics of this electrode type are very similar to those of EWCe-2 electrodes.

A7.3.2 EWLa-1.5 Electrode Classification (Gold). EWLa-1.5 designates a tungsten electrode containing 1.3-1.7 wt.-% of dispersed lanthanum oxide (La_2O_3) for enhanced arc starting and stability, reduced tip erosion rate, and extended operating current range. These electrodes can be used as nonradioactive substitutes for 2% thoriated tungsten as the operating characteristics are very similar. Lanthanated tungsten can be used for both dcen and ac applications.

A7.3.3 EWLa-2 Electrode Classification (Blue). EWLa-2 designates a tungsten electrode containing 1.8-2.2 wt.-% of dispersed lanthanum oxide (La_2O_3). The EWLa-2 electrode has the highest volume of oxides of any of the specific single-additive AWS-specified electrodes types, which serves to enhance arc starting and stability, reduce tip erosion rate, and extend operating current range. Lanthanated tungsten electrodes can be used for both dcen and ac applications.

A7.4 EWTh-X Electrode Classifications. The EWTh-X electrodes are tungsten electrodes containing thorium oxide, referred to as thoria. The thoria 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.

SAFETY NOTE

Thoria is a low-level radioactive material. 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.

The following statement was developed by the International Institute of Welding (IIW) Commission VIII on Health and Safety:

STATEMENT OF COMMISSION VIII ON HEALTH ASPECTS IN THE USE OF THORIATED TUNGSTEN ELECTRODES

"Thorium oxides are found in Thoriated Tungsten Electrodes up to 4.2% (ISO 6848-WT 40 Electrode). Thorium is radioactive and may present hazards by external and internal exposure. If alternatives are technically feasible, they should be used.

"Several studies carried out on Thoriated Electrodes have shown that due to the type of radiation generated, external radiation risks—during storage, welding, or disposal of residues—are negligible under normal conditions of use.

"On the contrary, during the grinding of electrode tips there is generation of radioactive dust, with the risk of internal exposure. Consequently, it is necessary to use local exhaust ventilation to control the dust at the source, complemented if necessary by respiratory protective equipment. The risk of internal exposure during welding is considered negligible since the electrode is consumed at a very slow rate.

"Precautions must be taken in order to control any risks of exposure during the disposal of dust from grinding devices.

"The above statement is based on a considered view of the available reports. Commission VIII will continue to keep these aspects under review."

A7.4.1 EWTh-1 Electrode Classification (Yellow). These electrodes were designed for direct current applications. They have the thoria 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 nonferrous materials, is difficult to maintain.

A7.4.2 EWTh-2 Electrode Classification (Red). The higher thoria content in the EWTh-2 electrode causes the operating characteristic improvements to be more pronounced than in the lower thoria content EWTh-1.

A7.4.3 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 alternating current welding, the balled end does not melt and so emission is not as good as from a liquid ball on an EWP electrode.

A7.5 EWZr-1 Electrode Classification (Brown). 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 (Gray). The EWG electrode is a tungsten electrode containing an unspecified alloy addition. The purpose of the addition is to affect the nature or characteristics of the arc, as defined by the manufacturer. Although no alloy addition is specified, the manufacturer must identify any specific additions and the nominal 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. A welding current which is too low to properly heat the electrode tip may cause instability of the welding arc or inability to maintain a welding arc.

A8.2 The electrode should be properly cut and ground tapered by following the supplier's suggested procedures. Breaking for severing an electrode is not recommended since it 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. Oxidized, discolored, or otherwise contaminated electrodes will cause difficult arc starting and may prevent starting depending upon conditions and the arc starting method used.

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

The EWTh-3 classification was discontinued in the ANSI/AWS A5.12-92 revision of this specification, as having no commercial significance. For information about this classification, the user is referred to the ANSI/AWS A5.12-80 revision.

A10. International Classifications

The international standard, ISO 6848, classifies many of the grades in this specification. The compositions are virtually the same, though the limits differ slightly in some cases. The classification designations of the corresponding grades are shown in Table A2. Table 2 indicates the standard metric sizes and lengths which correspond to sizes which appear in the ISO standard. Table 3 indicates the classifications which bear the same color marking.

Table A2
Comparable Classifications in ISO 6848 Standard

AWS Classification		ISO Codification	
EWP	(green)	WP	(green)
EWCe-2	(orange)	WC 20	(gray)
EWLA-1	(black)	WL 10	(black)
EWLa-1.5	(gold)		
EWLa-2	(blue)		
EWTh-1	(yellow)	WT 10	(yellow)
EWTh-2	(red)	WT 20	(red)
EWZr-1	(brown)	WZ 3	(brown)
EWG	(gray)		

A11. General Safety Considerations

A11.1 Burn Protection. Molten metal, sparks, slag, and hot work surfaces are produced by welding, cutting, and allied processes. These can cause burns if precautionary measures are not used. Workers should wear protective clothing made of fire-resistant material. Pant cuffs, open pockets, or other places on clothing that can catch and retain molten metal or sparks should not be worn. High-top shoes or leather leggings and fire-resistant gloves should be worn. Pant legs should be worn over the outside of high-top shoes. Helmets or hand shields that provide protection for the face, neck, and ears, and a head covering to protect the head should be used. In addition, appropriate eye protection should be used.

When welding overhead or in confined spaces, ear plugs to prevent weld spatter from entering the ear canal should be worn in combination with goggles or equivalent to give added eye protection. Clothing should be kept free of grease and oil. Combustible materials should not be carried in pockets. If any combustible substance has been spilled on clothing, a change to clean, fire-resistant clothing should be made before working with open arcs or flame. Aprons, cape-sleeves, leggings, and shoulder covers with bibs designed for welding service should be used. Where welding or cutting of unusually thick base metal is involved, sheet metal shields should be used for extra protection. Mechanization of highly hazardous processes or jobs should be considered. Other personnel in the work area should be protected by the use of noncombustible screens or by the use of appropriate protection as described in the previous paragraph.

Before leaving a work area, hot workpieces should be marked to alert other persons of this hazard. No attempt should be made to repair or disconnect electrical equipment when it is under load.

Disconnection under load produces arcing of the contacts and may cause burns or shock, or both. (*Note: Burns can be caused by touching hot equipment such as electrode holders, tips, and nozzles. Therefore, insulated gloves should be worn when these items are handled, unless an adequate cooling period has been allowed before touching.*)

The following sources are for more detailed information on personal protection:

(1) ANSI/ASC Z41.1, *Safety-Toe Footwear*, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

(2) ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes.* American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

(3) ANSI/ASC Z87.1, *Practice for Occupational and Educational Eye and Face Protection*, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

(4) *Code of Federal Regulations*, Title 29, Labor, Chapter XVII, Part 1910, OSHA General Industry Standards. Available from the U.S. Government Printing Office, Washington, DC 20402.

A11.2 Electrical Hazards. Electric shock can kill. However, it can be avoided. Live electrical parts should not be touched. The manufacturer's instructions and recommended safe practices should be read and understood. Faulty installation, improper grounding, and incorrect operation and maintenance of electrical equipment are all sources of danger.

All electrical equipment and the workpieces should be grounded. The workpiece lead is not a ground lead. It is used only to complete the welding circuit. A separate connection is required to ground the workpiece.

The correct cable size should be used, since sustained overloading will cause cable failure and result in possible electrical shock or fire hazard. All electrical connections should be tight, clean, and dry. Poor connections can overheat and even melt. Further, they can produce dangerous arcs and sparks. Water, grease, or dirt should not be allowed to accumulate on plugs, sockets, or electrical units. Moisture can conduct electricity.

To prevent shock, the work area, equipment, and clothing should be kept dry at all times. Welders should wear dry gloves and rubber-soled shoes, or stand on a dry board or insulated platform. Cables and connections should be kept in good condition. Improper or worn electrical connections may create conditions that could cause electrical shock or short circuits. Worn, damaged, or bare cables should not be used. Open-circuit voltage should be avoided. When several welders are working with arcs of different polarities, or when a number of alternating current machines are being used, the open-circuit volt-

ages can be additive. The added voltages increase the severity of the shock hazard.

In case of electric shock, the power should be turned **OFF**. If the rescuer must resort to pulling the victim from the live contact, nonconducting materials should be used. If the victim is not breathing, cardiopulmonary resuscitation (CPR) should be administered as soon as contact with the electrical source is broken. A physician should be called and CPR continued until breathing has been restored, or until a physician has arrived. Electrical burns are treated as thermal burns; that is, clean, cold (iced) compresses should be applied. Contamination should be avoided; the area should be covered with a clean, dry dressing; and the patient should be transported to medical assistance.

Recognized safety standards such as ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes*, and NFPA No. 70, *National Electrical Code*, available from the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269, should be followed.

A11.3 Fumes and Gases. Many welding, cutting, and allied processes produce fumes and gases which may be harmful to health. Fumes are solid particles which originate from welding filler metals and fluxes, the base metal, and any coatings present on the base metal. Gases are produced during the welding process or may be produced by the effects of process radiation on the surrounding environment. Management, welders, and other personnel alike should be aware of the effects of these fumes and gases. The amount and composition of these fumes and gases depend upon the composition of the filler metal and base metal, welding process, current level, arc length, and other factors.

The possible effects of overexposure range from irritation of eyes, skin, and respiratory system to more severe complications. Effects may occur immediately or at some later time. Fumes can cause symptoms such as nausea, headaches, dizziness, and metal fume fever. The possibility of more serious health effects exists when especially toxic materials are involved. In confined spaces, the shielding gases and fumes might displace breathing air and cause asphyxiation. One's head should always be kept out of the fumes. Sufficient ventilation, exhaust at the arc, or both, should be used to keep fumes and gases from one's breathing zone and the general area.

In some cases, natural air movement will provide enough ventilation. Where ventilation may be questionable, air sampling should be used to determine if corrective measures should be applied.

More detailed information on fumes and gases produced by the various welding processes may be found in the following:

(1) The permissible exposure limits required by OSHA can be found in *Code of Federal Regulations*, Title 29, Chapter XVII, Part 1910. The OSHA General Industry Standards are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

(2) The recommended threshold limit values for these fumes and gases may be found in *Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment*, published by the American Conference of Governmental Industrial Hygienists (ACGIH), Kemper Woods Center, 1330 Kemper Meadow Drive, Cincinnati, OH 45240.

(3) The results of an AWS-funded study are available in a report entitled, *Fumes and Gases in the Welding Environment*, available from the American Welding Society.

A11.4 Radiation. Welding, cutting, and allied operations may produce radiant energy (radiation) harmful to health. One should become acquainted with the effects of this radiant energy.

Radiant energy may be ionizing (such as x-rays), or nonionizing (such as ultraviolet, visible light, or infrared). Radiation can produce a variety of effects such as skin burns and eye damage, depending on the radiant energy's wavelength and intensity, if excessive exposure occurs.

A11.4.1 Ionizing Radiation. Ionizing radiation is produced by the electron beam welding process. It is ordinarily controlled within acceptance limits by use of suitable shielding enclosing the welding area.

A11.4.2 Nonionizing Radiation. The intensity and wavelengths of nonionizing radiant energy produced depend on many factors, such as the process, welding parameters, electrode and base-metal composition, fluxes, and any coating or plating on the base metal. Some processes, such as resistance welding, and cold pressure welding ordinarily produce negligible quantities of radiant energy. However, most arc welding and cutting processes (except submerged arc when used properly), laser beam welding and torch welding, cutting, brazing, or soldering can produce quantities of nonionizing radiation such that precautionary measures are necessary. Protection from possible harmful effects caused by nonionizing radiant energy from welding include the following measures:

(1) One should not look at welding arcs except through welding filter plates which meet the requirements of ANSI/ASC Z87.1, *Practice for Occupational and Educational Eye and Face Protection*, published by the American National Standards Institute. Transparent welding curtains are not intended as welding filter plates, but rather are intended to protect passersby from incidental exposure.

(2) Exposed skin should be protected with adequate gloves and clothing as specified in ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society.

(3) Reflections from welding arcs should be avoided, and all personnel should be protected from intense reflections. (*Note: Paints using pigments of substantially zinc oxide or titanium dioxide have a lower reflectance for ultraviolet radiation.*)

(4) Screens, curtains, or adequate distance from aisles, walkways, etc., should be used to avoid exposing passersby to welding operations.

(5) Safety glasses with UV-protective side shields provide some beneficial protection from ultraviolet radiation produced by welding arcs.

A11.4.3 Ionizing radiation information sources include the following:

(1) ANSI/AWS F2.1-78, *Recommended Safe Practices for Electron Beam Welding and Cutting*, available from the American Welding Society.

(2) Manufacturer's product information literature.

A11.4.4 The following include nonionizing radiation information sources:

(1) American National Standards Institute. ANSI/ASC Z136.1, Safe Use of Lasers, New York, NY: American National Standards Institute.

(2) ———. ANSI/ASC Z87.1, *Practice for Occupational and Educational Eye and Face Protection*. New York, N.Y.: American National Standards Institute.

(3) ———. ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes*: American Welding Society.

(4) Hinrichs, J. F. "Project Committee on Radiation—Summary Report." *Welding Journal*, January 1978.

(5) Moss, C. E. "Optical Radiation Transmission Levels through Transparent Welding Curtains." *Welding Journal*, March 1979.

(6) Moss, C. E., and Murray, W. E. "Optical Radiation Levels Produced in Gas Welding, Torch Brazing, and Oxygen Cutting." *Welding Journal*, September 1979.

(7) Marshall, W. J., Sliney, D. H., *et al.* "Optical Radiation Levels Produced by Air-Carbon Arc Cutting Processes. *Welding Journal*, March 1980.

(8) National Technical Information Service. Nonionizing radiation protection special study No. 42-0053-77, *Evaluation of the Potential Hazards from Actinic Ultraviolet Radiation Generated by Electric Welding and Cutting Arcs*. Springfield, Va.: National Technical Information Service. ADA-033768.

(9) National Technical Information Service. Nonionizing radiation protection special study No. 42-0312-77, *Evaluation of the Potential Retina Hazards from Optical Radiation Generated by Electrical Welding and Cutting Arcs*. Springfield, Va.: National Technical Information Service. ADA-043023.

AWS Filler Metal Specifications by Material and Welding Process

	OFW	SMAW	GTAW GMAW PAW	FCAW	SAW	ESW	EGW	Brazing
Carbon Steel	A5.2	A5.1	A5.18	A5.20	A5.17	A5.25	A5.26	A5.8, A5.31
Low-Alloy Steel	A5.2	A5.5	A5.28	A5.29	A5.23	A5.25	A5.26	A5.8, A5.31
Stainless Steel		A5.4	A5.9, A5.22	A5.22	A5.9	A5.9	A5.9	A5.8, A5.31
Cast Iron	A5.15	A5.15	A5.15	A5.15				A5.8, A5.31
Nickel Alloys		A5.11	A5.14		A5.14			A5.8, A5.31
Aluminum Alloys		A5.3	A5.10					A5.8, A5.31
Copper Alloys		A5.6	A5.7					A5.8, A5.31
Titanium Alloys			A5.16					A5.8, A5.31
Zirconium Alloys			A5.24					A5.8, A5.31
Magnesium Alloys			A5.19					A5.8, A5.31
Tungsten Electrodes			A5.12					
Brazing Alloys and Fluxes								A5.8, A5.31
Surfacing Alloys	A5.13, A5.21	A5.13, A5.21	A5.13, A5.21					
Consumable Inserts			A5.30					
Shielding Gases			A5.32	A5.32			A5.32	

AWS Filler Metal Specifications and Related Documents

AWS Designation	Title
FMC	Filler Metal Comparison Charts
UGFM	Users Guide for Filler Metals
A4.2	Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Austenitic-Ferritic Stainless Steel Weld Metal
A4.3	Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding
A5.01	Filler Metal Procurement Guidelines
A5.1	Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
A5.2	Specification for Carbon and Low-Alloy Steel Rods for Oxyfuel Gas Welding
A5.3	Specification for Aluminum and Aluminum Alloy Electrodes for Shielded Metal Arc Welding
A5.4	Specification for Stainless Steel Welding Electrodes for Shielded Metal Arc Welding
A5.5	Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding
A5.6	Specification for Covered Copper and Copper Alloy Arc Welding Electrodes
A5.7	Specification for Copper and Copper Alloy Bare Welding Rods and Electrodes
A5.8	Specification for Filler Metals for Brazing and Braze Welding
A5.9	Specification for Bare Stainless Steel Welding Electrodes and Rods
A5.10	Specification for Bare Aluminum and Aluminum Alloy Welding Electrodes and Rods
A5.11	Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding
A5.12	Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding and Cutting
A5.13	Specification for Solid Surfacing Welding Rods and Electrodes
A5.14	Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods
A5.15	Specification for Welding Electrodes and Rods for Cast Iron
A5.16	Specification for Titanium and Titanium Alloy Welding Electrodes and Rods
A5.17	Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding
A5.18	Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding
A5.19	Specification for Magnesium Alloy Welding Electrodes and Rods
A5.20	Specification for Carbon Steel Electrodes for Flux Cored Arc Welding
A5.21	Specification for Composite Surfacing Welding Rods and Electrodes
A5.22	Specification for Stainless Steel Electrodes for Flux Cored Arc Welding and Stainless Steel Flux Cored Rods for Gas Tungsten Arc Welding
A5.23	Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding
A5.24	Specification for Zirconium and Zirconium Alloy Welding Electrodes and Rods
A5.25	Specification for Carbon and Low-Alloy Steel Electrodes and Fluxes for Electroslag Welding
A5.26	Specification for Carbon and Low-Alloy Steel Electrodes for Electrogas Welding
A5.28	Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding
A5.29	Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding
A5.30	Specification for Consumable Inserts
A5.31	Specification for Fluxes for Brazing and Braze Welding
A5.32	Specification for Welding Shielding Gases

For ordering information, contact the AWS Order Department, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126. Telephones: (800) 334-9353, (305) 443-9353, ext. 280; FAX (305) 443-7559.