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Arc welding and cutting — Nonconsumable tungsten electrodes — Classification

Soudage et coupage à l'arc — Électrodes non consommables en tungstène — Classification

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*.

This third edition cancels and replaces the second edition (ISO 6848:2004), which has been technically revised.

Introduction

Tungsten electrodes are used in a variety of welding and allied processes, including tungsten inert gas welding, plasma arc welding and cutting, plasma spraying, and atomic hydrogen welding. In contrast to most other welding electrodes, tungsten electrodes are not intended to become part of the weld deposit. Nevertheless, the chemical composition of a tungsten electrode has an important effect on its range of usage in welding and allied processes. Therefore, tungsten electrodes are classified according to their chemical composition.

Requests for official interpretations of any aspect of this International Standard should be directed to the Secretariat of ISO/TC 44/SC 3 via your national standards body. A complete listing of national standards bodies can be found at www.iso.org.

Arc welding and cutting — Nonconsumable tungsten electrodes — Classification

1 Scope

This International Standard specifies requirements for classification of nonconsumable tungsten electrodes for inert gas shielded arc welding, and for plasma welding, cutting and thermal spraying.

Information on conditions of use of these electrodes is given in Annex A (informative).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 80000-1:2009, *Quantities and units — Part 1: General*

3 Classification

Classification of a tungsten electrode is based upon its chemical composition.

4 Symbols and requirements

4.1 Symbol for the product/process

The symbol for gas shielded tungsten arc processes is the letter W.

4.2 Symbol for the chemical composition

The symbol for the chemical composition of the tungsten electrode is the chemical symbol(s) for the principal oxide additive(s) followed by digits indicating the nominal mass percent of the oxide additive multiplied by 10. If there is no additive, the symbol is the letter P. Table 1 lists the composition requirements for the various classifications.

5 Chemical analysis

Chemical analysis shall be performed on specimens of the electrode being classified. Any analytical technique may be used but, in cases of dispute, reference shall be made to established published methods.

6 Retests

If any test fails to meet the requirement, that test shall be repeated twice. The results of both retests shall meet the requirements. Specimens for retesting may be taken from the original test specimen or from a new test specimen. For chemical analysis, retests need only be for those specific elements that failed to meet their test requirement. If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification.

In the event that, during preparation or after completion of any test, it is clearly determined that prescribed or proper procedures were not followed in preparing the test specimen or test specimen(s), or in conducting the tests, the test shall be considered invalid, without regard to whether the test was actually completed, or whether the test results met, or failed to meet, the requirement. That test shall be repeated, following proper prescribed procedures. In this case, the requirement for doubling the number of test specimens does not apply.

7 Marking

Tungsten electrodes 50mm in length and above, as manufactured, shall be marked on the basis of their chemical composition, with one or more colour rings near one end of the electrode in accordance with Table 1.

The width of the colour rings shall be at least 3 mm. Alternatively, tungsten electrodes may have their classification symbols marked on the surface of the electrode near at least one end of the electrode.

For tungsten electrodes shorter than 50 mm in length, as manufactured, packaging shall be marked in accordance with Clause 11.

Table 1 — Chemical composition requirements for tungsten electrodes

Classification symbol	Chemical composition requirements				Colour code, RGB colour value and colour sample[a]
	Oxide addition		Impurities, mass percent	Tungsten, mass percent	
	Principal oxide	Mass percent			
WP	None		0,1 max.	Balance	Green #008000
WCe20	CeO_2	1,8 to 2,2	0,1 max.	Balance	Grey #808080
WLa10	La_2O_3	0,8 to 1,2	0,1 max.	Balance	Black #000000
WLa15	La_2O_3	1,3 to 1,7	0,1 max.	Balance	Gold #FFD700
WLa20	La_2O_3	1,8 to 2,2	0,1 max.	Balance	Blue #0000FF
WTh10	ThO_2	0,8 to 1,2	0,1 max.	Balance	Yellow #FFFF00

[a] RGB colour values and colour samples can be found at: https://msdn.microsoft.com/library/aa358802(v=vs.85).aspx

[b] Compositions not listed in this table are symbolized by the letters WG, followed by the chemical symbol(s) and digits for the major oxide additive(s) in accordance with the principle used for the other compositions.

Table 1 *(continued)*

Classification symbol	Chemical composition requirements				Colour code, RGB colour value and colour sample[a]
	Oxide addition		Impurities, mass percent	Tungsten, mass percent	
	Principal oxide	Mass percent			
WTh20	ThO_2	1,7 to 2,2	0,1 max.	Balance	Red #FF0000
WTh30	ThO_2	2,8 to 3,2	0,1 max.	Balance	Violet #EE82EE
WZr3	ZrO_2	0,15 to 0,50	0,1 max.	Balance	Brown #A52A2A
WZr8	ZrO_2	0,7 to 0,9	0,1 max.	Balance	White #FFFFFF
WG [b]	The manufacturer shall identify all additions and their nominal quantity		0,1 max.	Balance	Any colour or combination of colours not already used in this International Standard

[a] RGB colour values and colour samples can be found at: https://msdn.microsoft.com/library/aa358802(v=vs.85).aspx

[b] Compositions not listed in this table are symbolized by the letters WG, followed by the chemical symbol(s) and digits for the major oxide additive(s) in accordance with the principle used for the other compositions.

8 Standard sizes and tolerances

8.1 Electrode diameters

Standard electrode diameters and tolerances are given in Table 2. Other diameters and tolerances may be as agreed between supplier and purchaser.

Electrodes should fit through ring gages sized for their maximum allowable diameter in accordance with Table 2.

Table 2 — Standard electrode diameters and tolerances

Nominal Diameter mm	**Tolerance** mm
0,25	±0,02
0,30	±0,02
0,50	±0,05
1,0	±0,05
1,5	±0,05
1,6	±0,05
2,0	±0,05
2,4	±0,1
2,5	±0,1
3,0	±0,1
3,2	±0,1
4,0	±0,1
4,8	±0,1
5,0	±0,1
6,3	±0,1
6,4	±0,1
8,0	±0,1
10,0	±0,1

8.2 Electrode lengths

Standard electrode lengths and tolerances are given in Table 3. Other lengths and tolerances may be as agreed between supplier and purchaser.

Table 3 — Standard electrode lengths and tolerances

Nominal length mm	**Tolerance** mm
50	±1,5
75	$^{+2,5}_{-1,0}$
150	$^{+4}_{-1}$
175	$^{+6}_{-1}$
300	$^{+8}_{-1}$
450	$^{+8}_{-1}$
600	$^{+13}_{-1}$

9 Electrode shape and condition

9.1 Electrode straightness

Electrode straightness shall not vary by more than 0,5 mm over a length of 100 mm.

For shorter electrodes, the electrode straightness shall not vary by more than 0,13 mm over a length of 50 mm.

9.2 Electrode finish

Electrodes shall be supplied with a ground finish. The ground finish designates that the electrode has been cleaned of impurities after it has been centreless ground to a uniform size. It shall be supplied with a bright, polished surface. The average surface roughness, measured longitudinally, shall not exceed 0,8 µm Ra.

9.3 Electrode quality

The electrode surface shall be free of excessive impurities, undesirable films, foreign inclusions, slivers, cracks, scale and other defects. Electrodes shall be internally free of foreign inclusions or anything else that would adversely affect the operation of the electrode. Oxide additions shall be sufficiently uniformly distributed throughout the electrode so that the operation of the electrode is not adversely affected.

10 Rounding procedure

For purposes of determining compliance with the requirements of this International Standard, the actual test values obtained shall be subject to ISO 80000-1:2009, B.3, Rule A. If the measured values are obtained by equipment calibrated in units other than those of this International Standard, the measured values shall be converted to the units of this International Standard before rounding. If an arithmetic average value is to be compared to the requirements of this International Standard, rounding shall be done only after calculating the arithmetic average. The rounded results shall fulfil the requirements of the appropriate table for the classification under test.

11 Marking and packaging

11.1 Marking

The following information, as a minimum, shall be legibly marked so as to be visible from the outside of each package:

a) the number of this International Standard, i.e. ISO 6848;

b) electrode classification symbol in accordance with Table 1;

c) electrode diameter;

d) electrode length;

e) net quantity of electrodes;

f) supplier's name and trade designation;

g) lot, control or heat number.

11.2 Packaging

Packaging shall ensure that the tungsten electrodes are protected from all damage or staining when they are properly transported and stored.

12 Classification examples

Example 1: A nonconsumable tungseten electrode with a chemical composition of La_2O_3 1,3 – 1,7 %, impurities max 0,1 % and W balance for the alloy symbol WLa15, in accordance with Table 1, is designated:

ISO 6848 — WLa15

where

ISO 6848 is the number of this International Standard, and

WLa15 indicates the chemical composition La_2O_3 1,3 – 1,7 %.

Example 2: A nonconsumable tungsten electrode with a chemical composition of La_2O_3 1,3 – 1,7 %, ZrO_2 0,05 %, CeO_2 0,05 % and W balance for the alloy symbol WG, in accordance with Table 1, is designated:

ISO 6848 — WG La15Ce0,5Zr0,5

where

ISO 6848 is the number of this International Standard,

WG indicates that the chemical composition ranges are not specified in ISO 6848 (see Table 1), and

La15Ce0,5Zr0,5 indicates the chemical composition, i.e. La_2O_3 1,3 – 1,7 %, CeO_2 0,05 %, ZrO_2 0,05 % and W balance.

Annex A
(informative)

Conditions of use

A.1 Influence of the type of current

A.1.1 General

The electric arc may be supplied with either direct current or alternating current. Table A.1 indicates which type of current is generally more suitable to the type of metal or alloy to be welded.

A.1.2 Direct current supply

The arc behaviour is different depending on whether the electrode is connected to the positive or negative terminal of the power source. With electrode positive (d.c.+) polarity, there is greater output heat at the electrode and less penetration of the work than with electrode negative (d.c.–) polarity. The current-carrying capacity of an electrode of a given size will therefore be lower with positive polarity than with negative polarity.

A.1.3 Alternating current supply

With alternating current (a.c.) supply, the current changes direction each half-cycle. The arc alternates between electrode positive polarity and electrode negative polarity. The current-carrying capacity of an electrode is then less than when it is used with electrode negative polarity, but greater than when it is used with electrode positive polarity.

Table A.1 — Suitability of current supply type

Type of metal or alloy to be welded	Direct current [a]		Alternating current [a]
	Electrode negative (–)	Electrode positive (+)	
Aluminium and its alloys (thickness ≤ 2,5 mm)	Acceptable	Acceptable	Best
Aluminium and its alloys (thickness > 2,5 mm)	Acceptable	N.R.	Best
Magnesium and its alloys	N.R.	Acceptable	Best
Non-alloy steels and low alloy steels	Best	N.R.	N.R.
Stainless steels	Best	N.R.	N.R.
Copper	Best	N.R.	N.R.
Bronze	Best	N.R.	Acceptable
Aluminium bronze	Acceptable	N.R.	Best
Silicon bronze	Best	N.R.	N.R.
Nickel and its alloys	Best	N.R.	Acceptable
Titanium and its alloys	Best	N.R.	Acceptable

[a] N.R. = Not recommended.

A.2 Arc current

The electrode size should be selected so that the current value is high enough for the arc to cover the whole area of the electrode tip, which is then heated up to a temperature approaching its melting temperature.

If the current is too low for the electrode size selected, the arc may be erratic and unstable, and tungsten particles may be ejected.

If, however, the current is too high, it will cause the electrode to overheat and its tip to melt. Drops of molten tungsten may fall into the weld, and the arc will become erratic and unstable. Table A.2 provides recommended current ranges depending on the type of power supply and electrode diameter. A high current value provides, in addition to a more stable arc, a higher concentration of heat, but this is limited depending on the conditions of use. An adequate degree of taper of the electrode tip with d.c.– polarity permits improvement of these conditions; e.g. the degree of taper of the electrode tip should be chosen according to the current used. A more obtuse angle is recommended at higher currents for a given electrode diameter.

Tungsten electrodes when used with alternating current or with direct current positive polarity may form a molten ball on the arcing end of the electrode. A pure tungsten electrode may produce tungsten inclusions in the weld when used on a.c. or d.c.+ without having accurate control of amperage and arc length. The use of tungsten with oxide additions will alleviate this problem.

Many modern a.c. welding power supplies allow the balance between the d.c.+ and d.c.– portions of the current cycle to be varied. When the d.c.+ portion of the cycle is increased relative to the d.c.– portion, the recommended average current is decreased somewhat from the ranges given in Table A.2. Conversely, when the d.c.– portion is increased relative to the d.c.+ portion, the recommended average a.c. current is increased somewhat from the ranges given in Table A.2.

A.3 Further remarks

The choice of an electrode type and size and of the welding current is influenced by the type and thickness of the parent metal to be welded or cut. The capacity of tungsten electrodes to carry current is dependent upon a number of other factors, in particular, the type of equipment used (gas- or water-cooled), the extension of the electrode beyond the nozzle, and the welding position.

An electrode of a given size will have its greatest current-carrying capacity with direct current, electrode negative; less with alternating current, and still less with direct current, electrode positive.

Table A.2 lists some typical current values that may be used with argon shielding. Use of alternate shielding gases (including mixtures) may reduce the current carrying capacity of a given size of tungsten electrode. The other factors mentioned above should be carefully considered before selecting an electrode for a specific application.

Table A.2 — Approximate current ranges depending on the electrode diameter

Electrode diameter mm	Direct current A			Alternating current A		
	Electrode negative (–)	Electrode positive (+)		Arc Balance 50 % electrode (+) / 50 % electrode (–)		Arc Balance 30 % electrode (+) / 70 % electrode (–)
	Tungsten with oxide additives	Tungsten with oxide additives	Pure tungsten	Pure tungsten	Tungsten with oxide additives	Tungsten with oxide additives
0,25	up to 15	not applicable	not applicable	up to 15	up to 15	up to 15
0,30	up to 15	not applicable	not applicable	up to 15	up to 15	up to 15
0,50	2 to 20	not applicable	not applicable	2 to 15	2 to 15	2 to 15
1,0	10 to 75	not applicable	not applicable	25 to 60	25 to 75	25 to 80
1,5	45 to 150	10 to 20	10 to 20	45 to 80	40 to 100	40 to 115
1,6	45 to 150	10 to 20	10 to 20	50 to 100	40 to 110	40 to 125
2,0	60 to 200	15 to 25	15 to 25	60 to 130	60 to 130	60 to 150
2,4	75 to 220	15 to 30	15 to 30	70 to 130	65 to 150	60 to 175
2,5	75 to 230	17 to 30	17 to 30	70 to 130	65 to 150	60 to 175
3,0	80 to 290	20 to 35	20 to 35	80 to 140	70 to 160	70 to 210
3,2	85 to 330	20 to 35	20 to 35	90 to 150	75 to 170	75 to 250
4,0	100 to 400	35 to 50	35 to 50	95 to 170	85 to 210	85 to 310
4,8	120 to 480	50 to 70	50 to 70	100 to 240	90 to 300	95 to 340
5,0	130 to 550	50 to 70	50 to 70	100 to 280	90 to 350	100 to 390
6,3	150 to 630	65 to 100	65 to 100	120 to 350	–	115 to 450
6,4	150 to 650	70 to 125	70 to 125	125 to 375	–	–
8,0	–	–	–	–	–	–
10,0	–	–	–	–	–	–

NOTE If no value is given, no recommendation is available.

ICS 25.160.20

Price based on 9 pages