How to "Correctly" Grind, Cut & Prepare Tungsten Welding Electrodes

BY

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"THE TUNGSTEN ELECTRODE EXPERTS"

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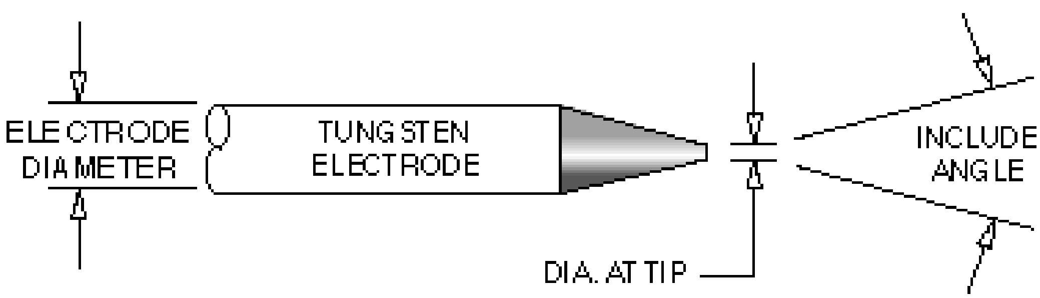
TABLE OF CONTENTS

1. INTRODUCTION

The tungsten electrode used in gas tungsten arc welding (GTAW) is a consumable. It serves merely as the terminal for the electric arc which produces the heat needed to join the base metal being welded. Filler metal may sometimes be added to the weld pool, depending on base metal thickness, joint design and weld characteristics desired.

The shape of the tungsten electrode tip is an important process variable in GTA welding. Tungsten electrode geometry has an affect on the arc shape (thereby affecting the weld bead size and shape), the weld penetration, and point longevity of the electrode. The electrode's geometry is thus a welding variable that should be monitored during weld procedure development. In addition, proper electrode grinding procedures and equipment should be used in order to ensure that electrodes are dimensionally correct. Finally, different tungsten materials pose different characteristics in arc start ability, electrode life, and contamination resistance. This makes the selection of the proper material for your application an important variable in welding performance. The proper preparation of your electrodes in each of these areas will provide the benefits of consistent welding with optimum performance.

This booklet is written to provide the Manufacturing Engineer a general reference for selecting the most appropriate tungsten material and emphasizes the importance of a correctly prepared, ground and cut tungsten electrode.



2. APPLICATIONS FOR TUNGSTEN WELDING ELECTRODES

ORBITAL TIG/TUBE WELDING

To produce the high quality orbital fusion welds required of today's high tech industries, tungsten electrode shape is an important variable that must be kept consistent. Most orbital manufacturers require a precise tungsten length.

ORBITAL TIG/PIPE WELDING

Orbital pipe welding application using TIG is primarily limited to the nuclear, pharmaceutical, and chemical processing industries. These industries, along with a few not mentioned, require X-ray perfect orbital pipe welds in the 125 amp - 300 amp current range.

A consistently prepared electrode is required for consistent current flow and arc voltage characteristics. Most orbital pipe welders use 3/32 or 1/8 diameter electrodes. They also must be cut-to-length, however, not as precise as the orbital tube welder.

MECHANIZED TIG WELDING

Mechanized TIG Welding encompasses a wide spectrum of applications such as precision bellows welding using .040 diameter tungsten electrode at 1.0 ampere up to high speed tube mills welding with a .250 diameter tungsten electrode using current as high as 600 amperes. A precise yet consistent electrode will have a dramatic effect in weld results and tungsten electrode life. Cutting the tungsten electrode is usually required if the electrode is grossly contaminated.

MANUAL TIG WELDING

Arc starting and arc stability from a consistently prepared tungsten electrode will be beneficial to the manual welder. Most hand welding 'FIG torches require a 7.0" long electrode be cut in half to fit the manual welding torch. This can be accomplished best with the diamond cutting mechanism described in this booklet.

MANUAL & MECHANIZED PLASMA ARC WELDING

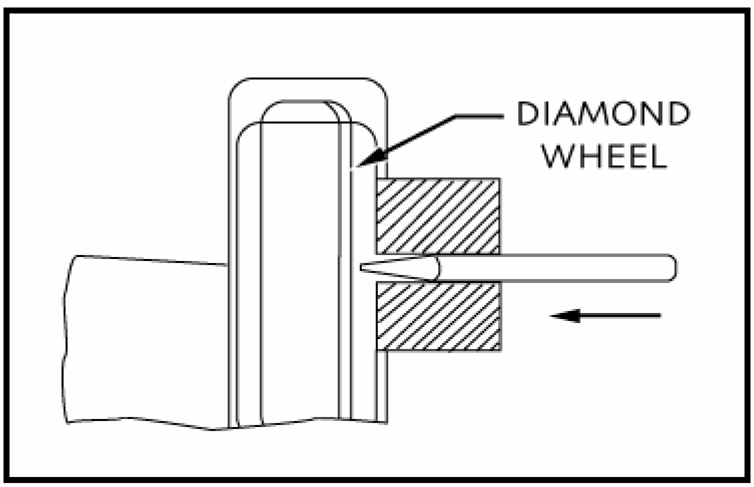
The plasma arc welding process requires a very precisely shaped, tungsten electrode. The tip of the tungsten must be kept concentric to the diameter to place it in the correct position centered in the plasma torch. This is a critical parameter adjustment in plasma arc welding. Most plasma welding torches also require a cut-to-length tungsten electrode.

3. STEP I: TUNGSTEN ELECTRODE TIP/FLAT PREPARATION

The shape of the tungsten electrode tip is an important process variable in gas tungsten arc welding. A good selection for quick arc initiation and arc stability is a two percent Thoriated tungsten electrode material with a fiat tip of the smallest diameter recommended for the current. Table 1.1 is a guide for electrode tip preparation for a range of sizes with recommended current ranges.
During the welding operation, the accurately ground tip of a tungsten electrode is at a temperature probably in excess of 3000 °C (5500 °F), and without a correct and consistent diameter flat at the tip of the tungsten electrode the following problems can occur:

- Pointed electrode tip drops into weld pool creating weld defect and X-ray defect.
- Reduction in electrode life.
- Arc instability
- Change in arc voltage from one electrode to next electrode because of inconsistent tip shape.

NOTE: New electrodes and cut electrodes already *have a flat* ***at the*** *tip of the electrode.*



Before regrinding, a used electrode is reconditioned by diamond grinding a new fiat at the tip.

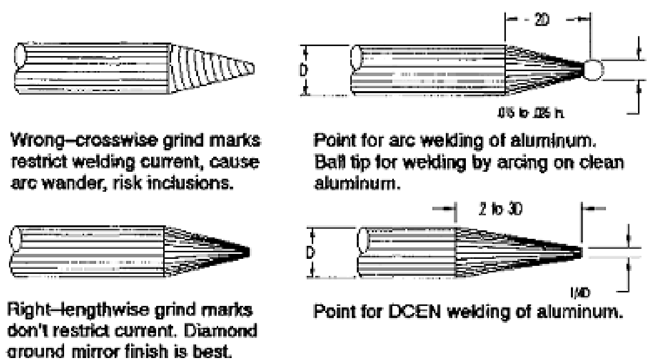
Table 1.1 - Tungsten Electrode Tip Shapes And Current Ranges						
DCSP (electrode negative) Electrode Diameter mm	**Diameter At Tip inches**	**Included angle, mm**	**Constant Current inches**	**Pulsed Current degrees**	**Range, A**	**Range, A**
1.02	0.040	0.125	0.005	12	2-15	2-25
1.02	0.040	0.25	0.010	20	5-30	5-60
1.59	0.062	0.5	0.020	25	8-50	8-100
1.59	0.062	0.8	0.030	30	10-70	10-140
2.38	0.093	0.8	0.030	35	12-90	12-180
2.38	0.093	**1.1**	0.045	45	15-150	15-250
3.18	0.125	1.1	0.045	60	20-200	20-300
3.18	0.125	1.5	0.060	90	25-250	25-350

4. STEP II: TUNGSTEN ELECTRODE GEOMETRY & GRINDING

TUNGSTEN ELECTRODE GEOMETRY

The shape of the tungsten electrode tip is an important process variable in GTAW. Tungsten electrodes may be used with a variety of tip preparations. In AC welding, pure or Zirconiated tungsten electrodes melt to form a hemispherical balled end. For DC welding, Thoriated, Ceriated, or Lanthanated tungsten electrodes are usually used. For the latter, the end is typically ground to a specific included angle, often with a truncated end. Various electrode tip geometries affect the weld bead shape and size. In general, as the included angle increases, the weld penetration increases and the width of the weld bead decreases. Although small diameter electrodes may be used with a square end preparation for DCEN (Direct Current Electrode Negative) welding, conical tips provide improved welding performance.

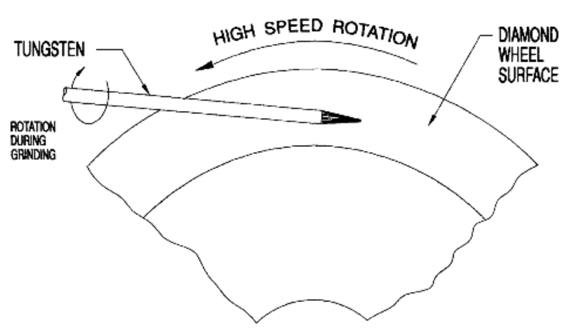
HOW TO PREPARE TUNGSTEN ELECTRODES



Regardless of the electrode tip geometry selected, it is important that consistent electrode geometry be used once a welding procedure is established. Changes in electrode geometry can significantly influence the weld bead shape and size; therefore, electrode tip configuration is a welding variable that should be studied during the welding procedure development.

TUNGSTEN ELECTRODE GRINDING

To produce optimum arc stability, diamond grinding of tungsten electrodes should be done with the axis of the electrode perpendicular to the axis of the grinding wheel. The diamond grinding wheel should be reserved for grinding only tungsten to eliminate possible contamination of the tungsten tip with foreign matter during the grinding operation. An exhaust system should be used when grinding Thoriated electrodes to remove the grinding dust from the work area.



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5. STEP III: TUNGSTEN CUTTING AND CUTTING TO LENGTH

One of the most overlooked areas of tungsten electrode preparation is the cutting operation or contaminated tip removal. What to do with contaminated tungsten electrodes is the most frequent problem confronting anyone doing TIG welding. A contaminated electrode produces an erratic arc and a dirty, contaminated weld. If the contamination of the electrode is small, however, it usually can be removed by regrinding. If contamination cannot be removed in this manner, the next step is to cut the contaminated portion off of the electrode.

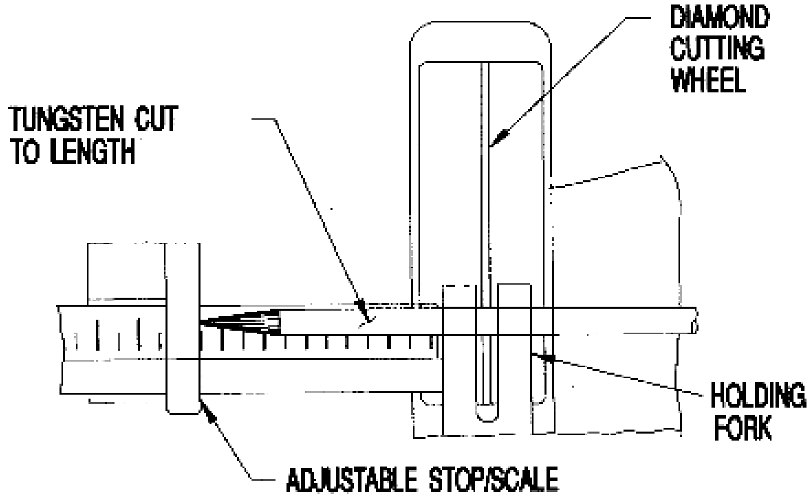
- **Cut tungsten electrodes .040/.062 diameter with wire cutters or used their hands.**
- **Cut tungsten electrodes 3/32 to 1/8 diameter by using 2 pairs of pliers and a twisting motion or notched the electrode on the grinding wheel and used two pairs of pliers.**
- **Cut tungsten electrodes over 1/8 diameter using a sharp hammer blow to the electrode on a sharp metal edge or notching the electrode on a grinding wheel and striking the electrode with a sharp blow from a hammer.**

Many of the problems associated with cutting tungsten electrodes is based upon the material itself. Tungsten is a very brittle material because of its high hardness and the above methods should be avoided because they cause many safety and weld quality problems. For example:

- **Splintering or shattering the electrode by use of pliers, notching or hammer blow can cause severe eye and hand injury.**
- **Fractured tungsten electrodes can cause arc instability and break off during welding creating gross weld defect.**

The correct way to cut tungsten electrodes or remove a contaminated tip is noted in the illustration of DGP Model DGP-2 below. The tungsten should be rigidly secured on either side of the cut. The cutting wheel should be diamond to provide a clean, contamination free, smooth separation. This will insure the electrode is never fractured or splintered during the cut off operation. . The adjustable stop and scale permits cutting electrodes to a selectable length. This is very beneficial in a variety of automatic and manual welding applications.

NEVER use a silicone carbide type wheel which contaminates the tungsten



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6. SELECTING THE BEST TUNGSTEN COMPOSITION

To correctly prepare your tungsten electrode for welding you must first select the composition and diameter best suited for your application. Below listed are the 5 most commonly produced tungsten welding electrodes for TIG DC, TIG-AC, and Plasma welding:

PURE TUNGSTEN (EWP Classification - Green Stripe)

2% CERIATED TUNGSTEN (EWCe Classification - Orange Stripe)

1% ZIRCONIATED TUNGSTEN (EWZr Classified - Brown Stripe)

1% THORIATED TUNGSTEN (EWTh-1 Classification - *Yellow Stripe)*

2% THORIATED TUNGSTEN (EWTh-2 Classification - Red Stripe)

All values are based on the use of argon as the shielding gas. Other current values may be employed depending on the shielding, gas, type of equipment, and application. Electrodes are produced with either a clean finish or ground finish. Electrodes with a clean finish have been chemically cleaned to remove surface impurities after the forming operation. Those with a ground finish have been centerless ground to remove surface imperfections.

ELECTRODE SIZES AND CURRENT CAPACITIES

Tungsten and Thoriated tungsten electrode sizes and current ranges are listed in Table 1.2, along with shield-gas cup diameters recommended for use with different types of welding power. This table provides a useful guide for selecting the correct electrode for specific applications involving different current levels and power supplies. Current levels in excess of those recommended for a given electrode size and tip configuration will cause the tungsten to erode or melt. Tungsten particles may fall into the weld pool and become defects in the weld joint. Current too low for a specific electrode diameter can cause arc instability. Direct current with the electrode positive requires a much larger diameter to support a given level of current because the tip is not cooled by the evaporation of electrons but heated by their impact. In general, a given electrode diameter on DCEP would be expected to handle only 10 percent of the current possible with the electrode negative. With alternating current, the tip is cooled during the electrode negative cycle and heated when positive. Therefore, the current carrying capacity of an electrode on AC is between that of DCEN and DCEP. In general, it is about 50 percent less than that of DCEN.

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Electrode Dia., Inches	Straight Polarity Direct Current, Amps	Reverse Polarity Direct Current, Amps	High-Frequency Unbalanced Wave AC, Amps		High-Frequency Balanced Wave AC, Amps	
	EWP, EWTh-1, EWTh-2	EWP, EWTh-1, EWTh-2	EWP	EWPTh-1, EWPTh-2, EWZr	EWP	EWPTh-1, EWPTh-2, EWZr
0.010	up to 15	n/a	up to 15	up to 15	up to 15	up to 15
0.020	5-20	n/a	5-15	5-20	10-20	5-20
0.040	15-80	n/a	10-60	15-80	20-30	20-60
1/16	70-150	10-20	50-100	70-150	30-80	60-120
3/32	150-250	15-30	100-160	140-235	60-130	100-180
1/8	250-400	25-40	150-210	225-325	100-180	160-250
5/32	400-500	40-55	200-275	300-400	160-240	200-320
3/16	500-750	55-80	250-350	400-500	190-300	290-390
1/4	750-1000	80-125	325-450	500-630	250-400	340-525

EPP ELECTRODE CLASSIFICATION (GREEN STRIPE)

Pure tungsten electrodes (EWP) contain a minimum of 99.5 percent tungsten, with no intentional alloying elements. The current-carrying capacity of pure tungsten electrodes is lower than that of the alloyed electrodes. Pure tungsten electrodes are used mainly with AC for welding aluminum and magnesium alloys. The tip of the EWP electrode maintains a clean, balled end, which provides good arc stability. They may also be used with DC, but they do not provide the arc initiation and arc stability characteristics of Thoriated, Ceriated, or Lanthanated electrodes.

EWRH-1 (YELLOW STRIPE) & EWTH-2 (RED STRIPE) ELECTRODE CLASSIFICATIONS

The thermionic emission of tungsten can be improved by alloying it with metal oxides that have very low work functions. As a result, the electrodes are able to handle higher welding currents without failing. Thorium oxide is one such additive. To prevent identification problems with these and other types of tungsten electrodes, they are color coded. Two types of Thoriated tungsten electrodes are available. The EWTh-1 and EWTh-2 electrodes contain 1 percent and 2 percent thorium oxide (THO2) called *thoria,* respectively, evenly dispersed through their entire lengths. Thoriated tungsten electrodes are superior to pure tungsten electrodes in several respects. The thoria provides about 20 percent higher current-carrying capacity, generally longer life, and greater resistance to contamination of the weld. With these electrodes, arc starting is easier, and the arc is more stable than with pure tungsten or Zirconiated tungsten electrodes.

The EWTh-1 and EWTh-2 electrodes were designed for DCEN applications. They maintain a sharpened tip configuration during welding, which is desirable for welding steel. They are not often used with AC because it is difficult to maintain the balled end, which is necessary with AC welding, without splitting the electrode.

Thorium is a very low-level radioactive material. 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 the appropriate safety personnel.

EWCE ELECTRODE CLASSIFICATION (ORANGE STRIPE)

Tungsten electrodes were first introduced into the United States market in the early 1980's. These electrodes were developed as possible replacements for Thoriated electrodes because cerium, unlike thorium, is not a radioactive element. The EWCe-2 electrodes are tungsten electrodes containing 2 percent cerium oxide (CEO2), referred to as *ceria.* Compared with pure tungsten, the Ceriated electrodes exhibit a reduced rate of vaporization or burn-off. These advantages of ceria improve with increased ceria content. EWCe-2 electrodes will operate successfully with AC or DC.

EWLA ELECTRODE CLASSIFICATION

The EWLa-1 electrodes were developed around the same time as the Ceriated electrodes and for the same reason, that lanthanum is not radioactive. These electrodes contain 2 percent lanthanum oxides (La203), referred to as *lanthana.* The advantages and operating characteristics of these electrodes are very similar to the Ceriated tungsten electrodes, also called rare earth.

EWZR ELECTRODE CLASSIFICATION (BROWN STRIPE)

Zirconiated tungsten electrodes (EWZr) contain a small amount of zirconium oxide (ZrO2). Zirconiated tungsten electrodes have welding characteristics that generally fall between those of pure and Thoriated tungsten. They are the electrode of choice for AC welding because they combine the desirable arc stability characteristics and balled end typical of pure tungsten with the current capacity and starting characteristics of Thoriated tungsten. They have higher resistance to contamination than pure tungsten.

7. SAFETY SUGGESTIONS

Tungsten welding electrodes should never be manually ground on an abrasive belt or wheel (particularly silicone carbide). The risk of injury when hand (manually) grinding a very hard brittle material like tungsten is quite high. It is important to always follow standard safety guidelines when operating high speed grinding equipment.

- Wear approved safety glasses
- No loose clothing which may get caught in moving parts
- Wear protective hair covering to contain long hair
- Wear safety shoes with non-slip sole
- A vacuum system is recommended to remove tungsten, especially thorium dust
- Never operate power tools when tired, intoxicated or when taking medication that causes drowsiness

The most common injuries to the manual tungsten electrode grinder are eye and finger related. Holding and grinding the tungsten electrode by hand has resulted in burned fingers, laceration to fingers and splintered tungsten electrodes in hand or fingers.

Eye injury generally occurs from manually grinding tungsten electrodes without a safety shield or safety glasses. Small slivers of tungsten electrode may become stuck in the operator's eye.