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When TIG welding, there are three choices of welding current. They are: Direct Current Straight Polarity, Direct Current Reverse Polarity, and Alternating Current with High Frequency stabilization. Each of these has its applications, advantages, and disadvantages. A look at each type and its uses will help the operator select the best current type for the job. The type of current used will have a great effect on the penetration pattern as well as the bead configuration. The diagrams below show arc characteristics of each current polarity type.

**CHARACTERISTICS OF CURRENT TYPES FOR GAS TUNGSTEN ARC WELDING**

**TIG welding with DCSP (direct current straight polarity)** produces deep penetration because it concentrates the heat in the joint area. No cleaning action occurs with this polarity.

**TIG welding with DCRP (direct current reverse polarity)** produces good cleaning action as the argon ions flowing towards the work strike with sufficient force to break up oxides on the surface.

**TIG welding with ACHF (alternating current high frequency)** combines the good weld penetration on the negative half cycle with the desired cleaning action of the positive half cycle. High frequency reestablishes the arc which breaks each half cycle.
### SHIELD GAS SELECTOR CHART

<table>
<thead>
<tr>
<th>BASE METAL TYPE</th>
<th>THICKNESS RANGE</th>
<th>WELD TYPE</th>
<th>SHIELD GAS TYPE</th>
<th>CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ALUMINUM ALLOYS AND MAGNESIUM ALLOYS</strong></td>
<td>Thin Manual</td>
<td>Pure argon</td>
<td>Best arc starts, control of penetration, cleaning and appearance on thin gauges.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thick Manual</td>
<td>95 Ar - 5 H</td>
<td>Argon with hydrogen added increases heat input and improves bead contour with lower gas flows, improves weld puddle wetting and minimizes undercutting.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Purpose Manual</td>
<td>Argon or 95 Ar - 5 H</td>
<td>Argon or 95 Ar - 5 H can be used interchangeably on austenitic stainless steel.</td>
<td></td>
</tr>
<tr>
<td><strong>COPPER ALLOYS Cu-Ni ALLOYS</strong></td>
<td>Thin Manual</td>
<td>Pure argon</td>
<td>Good control of weld puddle, bead contour, and penetration on thin gauges.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thick Manual</td>
<td>75 Ar - 25 He</td>
<td>Increase heat input with good arc starts of argon, but with faster welding speeds.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Purpose Manual</td>
<td>75 Ar - 25 He</td>
<td>Increase heat input with good arc starts of argon, but with faster welding speeds.</td>
<td></td>
</tr>
<tr>
<td><strong>LOW CARBON ALLOYS AND LOW ALLOY STEELS</strong></td>
<td>Thin Manual</td>
<td>Pure argon</td>
<td>Best overall for good arc starts, control on penetration, cleaning and appearance.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Purpose Manual</td>
<td>Pure argon</td>
<td>Best overall for good arc starts, control on penetration, cleaning and appearance.</td>
<td></td>
</tr>
<tr>
<td><strong>STAINLESS STEELS AND DUPLEX ALLOYS</strong></td>
<td>Thin Manual</td>
<td>Pure argon</td>
<td>Argon’s high density provides optimum shielding and arc stability.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thick Manual</td>
<td>Argon or 75 Ar - 25 He</td>
<td>Argon with helium addition aids penetration for manual welding of thick sections.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Purpose Manual</td>
<td>Argon or 85 Ar - 15 H</td>
<td>Argon provides stable arc control, 85 Ar - 15 H doubles argon’s welding speeds.</td>
<td></td>
</tr>
<tr>
<td><strong>TITANIUM ALLOYS</strong></td>
<td>Thin Manual</td>
<td>Pure argon</td>
<td>Argon’s high density provides needed shielding of exposed areas at back of weld.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thick Manual</td>
<td>Argon or 75 Ar - 25 He</td>
<td>Argon with helium increases penetration and welding speed for thick sections.</td>
<td></td>
</tr>
</tbody>
</table>

### GUIDE FOR SHIELD GAS FLOWS, CURRENT SETTINGS AND CUP SELECTION

<table>
<thead>
<tr>
<th>Electrode Diameter in inches (mm)</th>
<th>Cup Size</th>
<th>WELDING CURRENT (AMPS)</th>
<th>TUNGSTEN TYPE</th>
<th>ARGON FLOW - TUNGSTEN TYPE</th>
<th>ARGON FLOW - FERROUS METALS</th>
<th>ARGON FLOW - ALUMINUM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>AC Pure</td>
<td>AC Thoriated</td>
<td>DCSP Pure</td>
<td>DCSP Thoriated</td>
<td>Standard Body CFH (L/MN)</td>
</tr>
<tr>
<td>.020 (0.50)</td>
<td>3, 4 or 5</td>
<td>5 - 15</td>
<td>5 - 20</td>
<td>5 - 15</td>
<td>5 - 20</td>
<td>5-8 (3.4)</td>
</tr>
<tr>
<td>.040 (1.00)</td>
<td>4 or 5</td>
<td>10 - 40</td>
<td>15-80</td>
<td>15 - 70</td>
<td>20 - 80</td>
<td>5-10 (3.5)</td>
</tr>
<tr>
<td>1/16 (1.60)</td>
<td>6, 5 or 6</td>
<td>50 - 100</td>
<td>70 - 150</td>
<td>70 - 130</td>
<td>80 - 150</td>
<td>7-12 (4.6)</td>
</tr>
<tr>
<td>3/32 (2.40)</td>
<td>8, 7 or 8</td>
<td>100 - 160</td>
<td>140 - 233</td>
<td>150 - 220</td>
<td>150 - 250</td>
<td>10-15 (5.7)</td>
</tr>
<tr>
<td>1/8 (3.20)</td>
<td>10</td>
<td>150 - 210</td>
<td>220 - 325</td>
<td>220 - 330</td>
<td>240 - 350</td>
<td>10-18 (5.9)</td>
</tr>
</tbody>
</table>

For pure helium shielding gas, double flow rates shown. For argon-helium mixes with below 30% helium content, use figures shown. Always adjust gas flows to accommodate best shielding results.
**TUNGSTEN ELECTRODE SELECTOR CHART**

<table>
<thead>
<tr>
<th>BASE METAL TYPE</th>
<th>DESIRED RESULTS</th>
<th>WELDING CURRENT</th>
<th>ELECTRODE TYPE</th>
<th>SHIELD GAS</th>
<th>TUNGSTEN PERFORMANCE CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALUMINUM ALLOYS</td>
<td>General Purpose</td>
<td>ACHF</td>
<td>Pure (EW-P)</td>
<td>Argon</td>
<td>Balls easily, low cost, tends to spit at higher currents, used for non-critical welds only.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Zirconiated (EW-Zr)</td>
<td>Argon</td>
<td>Balls well, takes higher current, with less spitting and with better arc starts and arc stability than pure tungsten.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2% Thoriated (EW-Th)</td>
<td>Argon</td>
<td>Higher current range and stability, better arc starts, with lower tendency to spit, medium erosion.</td>
</tr>
<tr>
<td>ONLY THICK SECTIONS</td>
<td>Control penetration</td>
<td>DCRP</td>
<td>2% Ceriated (EW-Ce)</td>
<td>Helium</td>
<td>Lowest erosion rate, widest current range, AC or DC, no splitting, consistent arc starts and stability.</td>
</tr>
<tr>
<td>ONLY THIN SECTIONS</td>
<td>Increase penetration or travel speed</td>
<td>DCRP</td>
<td>2% Lanthanated (EW-La)</td>
<td>Helium</td>
<td>Lowest erosion rate, widest current range, no splitting, consistent arc starts, good stability.</td>
</tr>
<tr>
<td>COPPER ALLOYS, Cu-Ni ALLOYS AND NICKEL ALLOYS</td>
<td>General Purpose</td>
<td>DCSP</td>
<td>2% Thoriated (EW-Th)</td>
<td>Argon</td>
<td>Best stability at medium currents, good arc starts, medium tendency to spit, medium erosion rate.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2% Ceriated (EW-Ce)</td>
<td>Helium</td>
<td>Best stability at medium currents, good arc starts, medium tendency to spit, medium erosion rate.</td>
</tr>
<tr>
<td>ONLY THICK SECTIONS</td>
<td>Control penetration</td>
<td>ACHF</td>
<td>2% Ceriated (EW-Ce)</td>
<td>Helium</td>
<td>Best stability at medium currents, good arc starts, medium tendency to spit, medium erosion rate.</td>
</tr>
<tr>
<td>ONLY THIN SECTIONS</td>
<td>Increase penetration or travel speed</td>
<td>ACHF</td>
<td>2% Lanthanated (EW-La)</td>
<td>Helium</td>
<td>Best stability at medium currents, good arc starts, medium tendency to spit, medium erosion rate.</td>
</tr>
<tr>
<td>MILD STEELS, CARBON STEELS, ALLOY STEELS, STAINLESS STEELS AND TITANIUM ALLOYS</td>
<td>General Purpose</td>
<td>DCSP</td>
<td>2% Thoriated (EW-Th)</td>
<td>Argon</td>
<td>Best stability at medium currents, good arc starts, medium tendency to spit, medium erosion rate.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2% Ceriated (EW-Ce)</td>
<td>Helium</td>
<td>Best stability at medium currents, good arc starts, medium tendency to spit, medium erosion rate.</td>
</tr>
<tr>
<td>ONLY THICK SECTIONS</td>
<td>Control penetration</td>
<td>ACHF</td>
<td>2% Lanthanated (EW-La)</td>
<td>Helium</td>
<td>Best stability at medium currents, good arc starts, medium tendency to spit, medium erosion rate.</td>
</tr>
<tr>
<td>ONLY THIN SECTIONS</td>
<td>Increase penetration or travel speed</td>
<td>ACHF</td>
<td>2% Lanthanated (EW-La)</td>
<td>Helium</td>
<td>Best stability at medium currents, good arc starts, medium tendency to spit, medium erosion rate.</td>
</tr>
</tbody>
</table>

**TUNGSTEN TIP PREPARATION**

**DCSP (EN)** or **DCRP (EP)**

- **General Purpose**
- **Flat**: 1/4” to 1/2” x Dia.
- **Taper Length**: 2 - 3” x Dia.
- **Purpose**: MAX: 1” x Dia.

**TUNGSTEN GRINDING**

- Shape by grinding longitudinally (never radially). Remove the sharp point to leave a truncated point with a flat spot. Diameter of flat spot determines amperage capacity. (See below)
- The included angle determines weld bead shape and size. Generally, as the included angle increases, penetration increases and bead width decreases.
- Use a medium (60 grit or finer) aluminum oxide wheel.

**TUNGSTEN EXTENSION**

**STANDARD PARTS**

- **General Purpose**
- **3” x Dia.**

**GAS LENS PARTS**

- **General Purpose**
- **3” x Dia.**

**IN DRAFT-FREE AREAS**

**TUNGSTEN ELECTRODE TIP SHAPES AND CURRENT RANGES**

Thoriated, ceriated, and lanthanated tungsten electrodes do not ball as readily as pure or zirconiated tungsten electrodes, and as such are typically used for DCSP welding. These electrodes maintain a ground tip shape much better than the pure tungsten electrodes. If used on AC, thoriated and lanthanated electrodes often spit. Regardless of the electrode tip geometry selected, it is important that a consistent tip configuration be used once a welding procedure is established. Changes in electrode geometry can have a significant influence not only on the weld bead width, depth of penetration, and resultant quality, but also on the electrical characteristics of the arc. Below is a guide for electrode tip preparation for a range of sizes with recommended current ranges.

<table>
<thead>
<tr>
<th>ELECTRODE DIAMETER</th>
<th>DIAMETER AT TIP</th>
<th>CONSTANT INCLUDED ANGLE, DEGREES</th>
<th>CURRENT RANGE, A</th>
<th>PULSED CURRENT RANGE, A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>.040</td>
<td>1.25</td>
<td>12</td>
<td>2.15</td>
</tr>
<tr>
<td>1.0</td>
<td>.040</td>
<td>.250</td>
<td>20</td>
<td>5.30</td>
</tr>
<tr>
<td>1.6</td>
<td>1/16</td>
<td>500</td>
<td>25</td>
<td>8.50</td>
</tr>
<tr>
<td>1.6</td>
<td>1/16</td>
<td>800</td>
<td>30</td>
<td>10.70</td>
</tr>
<tr>
<td>2.3</td>
<td>3/32</td>
<td>800</td>
<td>35</td>
<td>12.90</td>
</tr>
<tr>
<td>2.3</td>
<td>3/32</td>
<td>1100</td>
<td>45</td>
<td>15.150</td>
</tr>
<tr>
<td>3.2</td>
<td>1/8</td>
<td>1100</td>
<td>60</td>
<td>20.200</td>
</tr>
<tr>
<td>3.2</td>
<td>1/8</td>
<td>1500</td>
<td>90</td>
<td>25.250</td>
</tr>
</tbody>
</table>
**TUNGSTEN COLOR CODE AND PROPER TORCH USE**

---

**COLOR CODE AND ALLOYING ELEMENTS FOR VARIOUS TUNGSTEN ELECTRODE ALLOYS**

<table>
<thead>
<tr>
<th>AWS CLASSIFICATIONS</th>
<th>COLOR*</th>
<th>ALLOYING ELEMENT</th>
<th>ALLOYING OXIDE</th>
<th>NOMINAL WEIGHT OF ALLOYING OXIDE PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWP</td>
<td>Green</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EWCe-2</td>
<td>Orange</td>
<td>Cerium</td>
<td>CeO2</td>
<td>2</td>
</tr>
<tr>
<td>EWLa-1</td>
<td>Black</td>
<td>Lanthanum</td>
<td>La2O3</td>
<td>1</td>
</tr>
<tr>
<td>EWTh-1</td>
<td>Yellow</td>
<td>Thorium</td>
<td>ThO2</td>
<td>1</td>
</tr>
<tr>
<td>EWTh-2</td>
<td>Red</td>
<td>Thorium</td>
<td>ThO2</td>
<td>2</td>
</tr>
<tr>
<td>EWZr-1</td>
<td>Brown</td>
<td>Zirconium</td>
<td>ZrO2</td>
<td>.25</td>
</tr>
<tr>
<td>EWG</td>
<td>Gray</td>
<td>Not Specified**</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Color may be applied in the form of bands, dots, etc., at any point on the surface of the electrode.

**Manufacturers must identify the type and nominal content of the rare earth oxide additions.

---

**CORRECT TORCH AND ROD POSITIONING**

The suggested electrode and welding rod angles for welding a bead on plate. The same angles are used when making a butt weld. The torch is held 60° - 75° from the metal surface. This is the same as holding the torch 15° - 30° from the vertical.

Take special note that the rod is in the shielding gas during the welding process.

---

**SELECTING THE CORRECT TORCH NOZZLE**

Most nozzles used for GTAW are manufactured from ceramic materials, alumina (pink colored) and lava (white colored); the exit diameter (diameter closest to the arc) is manufactured in a variety of sizes. GTAW nozzles are also made in various lengths from short nozzles to extra-long nozzles.

Alumina nozzles are the most commonly used nozzles in GTAW. Alumina nozzles are molded from alumina oxide and the density of the alumina oxide determines the quality of the nozzle in relationship to impact resistance and thermal shock. Alumina nozzles are more impact resistant than lava nozzles. The impact resistance of the alumina nozzles makes them more durable and are used for general applications.

Ceramic (lava) cups are recommended for use in applications where high reflective heat is present. Alumina nozzles tend to break when used in confined areas or when high reflective heat is present. If this type of usage is contemplated, we recommend the use of ceramic (lava) cups. When alumina nozzles are fired in the oven at 3000° F during manufacturing, they shrink 18% in length and 27% in diameter. If the nozzle is subsequently used in a confined area, excessive heat is transferred back into the nozzle causing it to expand. Cooling shrinks the nozzle back to normal. The large difference between expansion and contraction results in breakage.

The exit diameter for any nozzle is specified in a number that represents the diameter in 1/16" increments. A number 5 nozzle is therefore 5/16" inside diameter. A number 6 nozzle is 6/16" or 3/8" and so on.

The diameter for any nozzle must be large enough to allow the entire weld area to be covered by the shielding gas. The exit diameter can be neither too large nor too small, or poor shielding gas coverage will result. (Refer to page 3 for correct cup size.)

---

**GAS LENS BENEFITS**

A collet body with a gas lens can be very useful to a welder. The purpose of a gas lens is to make the shielding gas exit the nozzle as a column instead of as a turbulent stream of gas that begins to spread out after exiting. The column of gas allows the electrode to stick out farther for visibility, allowing for better access to the weld area, and a reduction in gas flow (CFH/L/Min).
**ALUMINUM (ACHF)**

<table>
<thead>
<tr>
<th>Metal Grade</th>
<th>Joint Type</th>
<th>Tensile Size</th>
<th>Filler Rod Size</th>
<th>Cup Size</th>
<th>Shield Gas Flow</th>
<th>Welding Amperes</th>
<th>Travel Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16 (1.6 mm)</td>
<td>BUTT</td>
<td>1/16 (1.6 mm)</td>
<td>1.6 (2.5 mm)</td>
<td>6.4</td>
<td>ARGON</td>
<td>100 (628)</td>
<td>(25.6 mm)</td>
</tr>
<tr>
<td>1/8 (3.2 mm)</td>
<td>BUTT</td>
<td>1/8 (3.2 mm)</td>
<td>2.0 (3.2 mm)</td>
<td>6.4</td>
<td>ARGON</td>
<td>175 (1058)</td>
<td>(25.6 mm)</td>
</tr>
<tr>
<td>3/32 (2.4 mm)</td>
<td>BUTT</td>
<td>3/32 (2.4 mm)</td>
<td>1.8 (2.5 mm)</td>
<td>6.4</td>
<td>ARGON</td>
<td>175 (1058)</td>
<td>(25.6 mm)</td>
</tr>
</tbody>
</table>

**WELDING ALUMINUM**

The use of TIG welding for aluminum has many advantages for both manual and automatic processes. Filler metal can be either wire or rod and should be compatible with the base alloy. Filler metal must be dry, free of oxides, grease, or other foreign matter. If filler metal becomes damp, heat for 2 hours at 25°F before using. Although ACHF is recommended, DCRP has been successful up to 3/16", DCSP with helium shield gas is successful in mechanized applications.

**MAGNESIUM (ACHF)**

<table>
<thead>
<tr>
<th>Metal Grade</th>
<th>Joint Type</th>
<th>Tensile Size</th>
<th>Filler Rod Size</th>
<th>Cup Size</th>
<th>Shield Gas Flow</th>
<th>Welding Amperes</th>
<th>Travel Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16 (1.6 mm)</td>
<td>BUTT</td>
<td>1/16 (1.6 mm)</td>
<td>1.6 (2.5 mm)</td>
<td>6.4</td>
<td>ARGON</td>
<td>45 (278)</td>
<td>(25.6 mm)</td>
</tr>
<tr>
<td>1/8 (3.2 mm)</td>
<td>BUTT</td>
<td>1/8 (3.2 mm)</td>
<td>2.0 (3.2 mm)</td>
<td>6.4</td>
<td>ARGON</td>
<td>225 (1380)</td>
<td>(25.6 mm)</td>
</tr>
<tr>
<td>3/32 (2.4 mm)</td>
<td>BUTT</td>
<td>3/32 (2.4 mm)</td>
<td>1.8 (2.5 mm)</td>
<td>6.4</td>
<td>ARGON</td>
<td>225 (1380)</td>
<td>(25.6 mm)</td>
</tr>
</tbody>
</table>

**WELDING MAGNESIUM**

Magnesium alloys are in three groups, they are: [1] aluminum-zinc-magnesium, [2] aluminum-magnesium, and [3] manganese-magnesium. Since magnesium absorbs a number of harmful ingredients and oxidize rapidly when subjected to welding heat, TIG welding in an inert gas atmosphere is distinctly advantageous, the welding of magnesium is similar in many respects to the welding of aluminum. Magnesium was one of the first metals to be welded commercially by TIG. Magnesium requires a positive pressure of argon as a backup on the root side of the weld.

**DEOXIDIZED COPPER (DCSP)**

<table>
<thead>
<tr>
<th>Metal Grade</th>
<th>Joint Type</th>
<th>Tensile Size</th>
<th>Filler Rod Size</th>
<th>Cup Size</th>
<th>Shield Gas Flow</th>
<th>Welding Amperes</th>
<th>Travel Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16 (1.6 mm)</td>
<td>BUTT</td>
<td>1/16 (1.6 mm)</td>
<td>1.6 (2.5 mm)</td>
<td>6.4</td>
<td>ARGON</td>
<td>100 (628)</td>
<td>(25.6 mm)</td>
</tr>
<tr>
<td>1/8 (3.2 mm)</td>
<td>BUTT</td>
<td>1/8 (3.2 mm)</td>
<td>2.0 (3.2 mm)</td>
<td>6.4</td>
<td>ARGON</td>
<td>175 (1058)</td>
<td>(25.6 mm)</td>
</tr>
<tr>
<td>3/32 (2.4 mm)</td>
<td>BUTT</td>
<td>3/32 (2.4 mm)</td>
<td>1.8 (2.5 mm)</td>
<td>6.4</td>
<td>ARGON</td>
<td>175 (1058)</td>
<td>(25.6 mm)</td>
</tr>
</tbody>
</table>

**WELDING DEOXIDIZED COPPER**

Where extensive welding is to be done, the use of deoxidized (oxygen-free) copper is preferable over electrolytic tough pitch copper, although TIG welding has been used occasionally to weld zinc-bearing copper alloys, such as brass and commercial bronzes, it is not recommended because the shielding gas does not suppress the vaporization of zinc. For the same reason zinc bearing filler rods should not be used. There is some preference of helium for the inert atmosphere in welding thickness above 1/8" because of the improved weld metal fluidity. Preheating recommendations should be followed.

**LOW ALLOY STEEL (DCSP)**

<table>
<thead>
<tr>
<th>Metal Grade</th>
<th>Joint Type</th>
<th>Tensile Size</th>
<th>Filler Rod Size</th>
<th>Cup Size</th>
<th>Shield Gas Flow</th>
<th>Welding Amperes</th>
<th>Travel Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16 (1.6 mm)</td>
<td>BUTT</td>
<td>1/16 (1.6 mm)</td>
<td>1.6 (2.5 mm)</td>
<td>6.4</td>
<td>ARGON</td>
<td>100 (628)</td>
<td>(25.6 mm)</td>
</tr>
<tr>
<td>1/8 (3.2 mm)</td>
<td>BUTT</td>
<td>1/8 (3.2 mm)</td>
<td>2.0 (3.2 mm)</td>
<td>6.4</td>
<td>ARGON</td>
<td>175 (1058)</td>
<td>(25.6 mm)</td>
</tr>
<tr>
<td>3/32 (2.4 mm)</td>
<td>BUTT</td>
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<td>ARGON</td>
<td>175 (1058)</td>
<td>(25.6 mm)</td>
</tr>
</tbody>
</table>

**WELDING LOW ALLOY STEEL**

Mild and low carbon steels with less then 0.30% carbon and less than 1% thickness generally do not require preheat. An exception to this allowance is welding on highly restrained joints. These joints should be preheated 50 to 100°F to minimize shrinkage cracks in the base metal. Low alloy steels such as the chromium-molybdenum steels will have heat affected zones after welding, if the preheat temperature is too low. This is caused by rapid cooling of the base material and the formation of martensitic structures. A 250 to 400°F preheat temperature will slow the cooling rate and prevent the martensitic structure.
<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>CAUSE</th>
<th>SOLUTION</th>
</tr>
</thead>
</table>
| **EXCESSIVE ELECTRODE CONSUMPTION** | 1. Inadequate gas flow.  
2. Improper electrode size for current required.  
3. Operating of reverse polarity.  
4. Electrode contamination.  
5. Excessive heating inside torch.  
6. Electrode oxidizing during cooling.  
7. Shield gas incorrect. | 1. Increase gas flow.  
2. Use larger electrode.  
3. Use larger electrode or change polarity.  
4. Remove contaminated portion, then prepare again.  
5. Replace collet, try wedge collet or reverse collet.  
6. Increase gas post flow time to 1 sec, per 10 amps.  
7. Change to proper gas (no oxygen or Co2). |
| **ERRATIC ARC**                 | 1. Incorrect voltage (arc too long).  
2. Current too low for electrode size.  
3. Electrode contaminated.  
4. Joint too narrow.  
5. Contaminated shield gas, dark stains on the electrode or weld bead indicate contamination.  
6. Base metal is oxidized, dirty or oily. | 1. Maintain short arc length.  
2. Use smaller electrode or increase current.  
3. Remove contaminated portion, then prepare again.  
4. Open joint groove.  
5. The most common cause is moisture or aspirated air in gas stream. Use welding grade gas only. Find the source of the contamination and eliminate it promptly.  
6. Use appropriate chemical cleaners, wire brush, or abrasives prior to welding. |
| **INCLUSION OF TUNGSTEN OR OXIDES IN WELD** | 1. Poor scratch starting technique.  
2. Excessive current for tungsten size used.  
3. Accidental contact of electrode with puddle.  
4. Accidental contact of electrode to filler rod.  
5. Using excessive electrode extension.  
6. Inadequate shielding or excessive drafts.  
7. Wrong gas.  
8. Heavy surface oxides not being removed. | 1. Many codes do not allow scratch starts. Use copper strike plate. Use high frequency arc starter.  
2. Reduce the current or use larger electrode.  
3. Maintain proper arc length.  
4. Maintain a distance between electrode and filler metal.  
5. Reduce the electrode extension to recommended limits.  
6. Increase gas flow, shield arc from wind, or use gas lens.  
7. Do not use Ar-02 or Ar-Co2 GMA (MIG) gases for TIG welding.  
8. Use ACHF, adjust balance control for maximum cleaning, or wire brush and clean the weld joint prior to welding. |
| **POROSITY IN WELD DEPOSIT**    | 1. Entrapped impurities, hydrogen, oil, nitrogen, water vapor.  
2. Defective gas hose or electrode loss connection.  
3. Filler material is damp (particularly aluminum).  
4. Melted electrodes oxidizing during cooling.  
5. Excessive travel speed with rapid freezing of weld trapping gases before they escape.  
6. Contaminated shield gas. | 1. Do not weld on wet material. Remove condensation from line with adequate gas pre-flow time.  
2. Check hoses and connections for leaks.  
3. Dry filler metal in oven prior to welding.  
4. Replace filler metal.  
5. Change to a different alloy composition which is weldable. These impurities can cause a tendency to crack when hot.  
6. Lower the travel speed.  
7. Replace the shielding gas. |
| **CRACKING IN WELDS**           | 1. Hot cracking in heavy section or with metals which are hot shorts.  
2. Crater cracks due to improperly breaking the arc or terminating the weld at the joint edge.  
3. Post weld cold cracking, due to excessive joint restraint, rapid cooling, or hydrogen embrittlement.  
5. Underbead cracking from brittle microstructure. | 1. Preheat, increase weld bead cross-section size, change weld bead contour. Use metal with fewer alloy impurities.  
2. Reverse direction and weld back into previous weld at edge. Use Amptack or foot control to manually down slope current.  
3. Preheat prior to welding, use pure or non-contaminated gas. Increase the bead size. Prevent cratering or notches. Change the weld joint design.  
4. Increase bead size. Decrease root opening, use preheat, prevent cratering.  
5. Eliminate sources of hydrogen, joint restraint, and use preheat. |
| **INADEQUATE SHIELDING**        | 1. Many codes do not allow scratch starts. Use copper strike plate. Use high frequency arc starter.  
2. Reduce the current or use larger electrode.  
3. Maintain proper arc length.  
4. Maintain a distance between electrode and filler metal.  
5. Reduce the electrode extension to recommended limits.  
6. Increase gas flow, shield arc from wind, or use gas lens.  
7. Do not use Ar-02 or Ar-Co2 GMA (MIG) gases for TIG welding.  
8. Use ACHF, adjust balance control for maximum cleaning, or wire brush and clean the weld joint prior to welding. | 1. Many codes do not allow scratch starts. Use copper strike plate. Use high frequency arc starter.  
2. Reduce the current or use larger electrode.  
3. Maintain proper arc length.  
4. Maintain a distance between electrode and filler metal.  
5. Reduce the electrode extension to recommended limits.  
6. Increase gas flow, shield arc from wind, or use gas lens.  
7. Do not use Ar-02 or Ar-Co2 GMA (MIG) gases for TIG welding.  
8. Use ACHF, adjust balance control for maximum cleaning, or wire brush and clean the weld joint prior to welding. |
| **ARC BLOW**                    | 1. Inadequate gas flow.  
2. Improper electrode size for current required.  
3. Operating of reverse polarity.  
4. Electrode contamination.  
5. Excessive heating inside torch.  
6. Electrode oxidizing during cooling.  
7. Shield gas incorrect. | 1. Increase gas flow.  
2. Use larger electrode.  
3. Use larger electrode or change polarity.  
4. Remove contaminated portion, then prepare again.  
5. Replace collet, try wedge collet or reverse collet.  
6. Increase gas post flow time to 1 sec, per 10 amps.  
7. Change to proper gas (no oxygen or Co2). |
| **SHORT PARTS LIFE**            | 1. Short water cooled leads life.  
2. Cup Shattering or cracking in use.  
3. Short collet life.  
4. Short torch head life.  
5. Gas hoses balloon, bursting, or blowing off while hot. | 1. Verify coolant flow direction, return flow must be on the power cable lead.  
2. Change cup size or type, change tungsten position, refer to chart.  
3. Ordinary style is split and twists or jams, change to wedge style.  
4. Do not operate beyond rated capacity, use water cooled model, do not bend rigid torches.  
5. Incorrect flowmeter. TIG flowmeters operate at 35 ps with low flows. MIG flowmeters operate with high flows at 65 psi or more. |