# TITANIUM WELDING

**General Information** Welding with titanium requires extreme cleanliness. Grind or file off mill scale. Clean surface oxides with a 35% nitric – 5 % hydrofluoric acid solution at room temperature, then rinse with water and air dry. Grease or oils should be cleaned with a non-chlorinated degreasing solvent, acetone or methanol. Light Oil can be washed away with a normal household detergent, then air dried. Titanium is a reactive metal and as such it is sensitive to embrittlement by oxygen, nitrogen, and hydrogen, within the weld zone area, at temperatures above 500°F. Consequently the weld metal must be protected against atmospheric contamination that may be caused by these elements. This can be most easily attained by holding the shielding gas over the weld area until it cools to approximately 600°F. Argon is the recommended shielding gas, however an argon-helium mixture will give greater penetration although at the expense of arc stability. The filler metal composition is usually matched to the grade of titanium being welded.

**Tungsten Electrodes** Although 2% Thoriated tungsten is normally used, there are also other tungsten electrodes that can be used. Please refer to the "Tungsten Electrode Selector Chart" in the Product Catalog.

**Welding Technique** In addition to clean joints and weld wire, proper parameters, and proper inert gas shielding, welder technique requires attention when titanium is being welded. Improper technique can be a source of weld contamination.

Before starting an arc in welding titanium, it is good practice to pre-purge torch, trailing shield and backup shield to be sure all air is removed. Whenever possible, high frequency arc starting should be used. Scratch starting with tungsten electrodes is a source of tungsten inclusions in titanium welds. On extinguishing the arc, the use of current downslope and a contactor, controlled by a single foot pedal, is encouraged. Torch shielding should be continued until the weld metal cools below 800 degrees F. Secondary and backup shielding should also be continued. A straw or blue color on the weld is indicative of premature removal of shielding gas.

**Preheating** is not generally needed for titanium shop welds. However, if the presence of moisture is suspected, due to low temperature, high humidity, or wet work area, preheating may be necessary. Gas torch heating (slightly oxidizing flame) of weld surfaces to about 150 degrees F. is generally sufficient to remove moisture.

**The arc length** for welding titanium without filler metal should be about equal to the electrode diameter. If filler metal is added, maximum arc length should be about 1-1/2 times the electrode diameter.

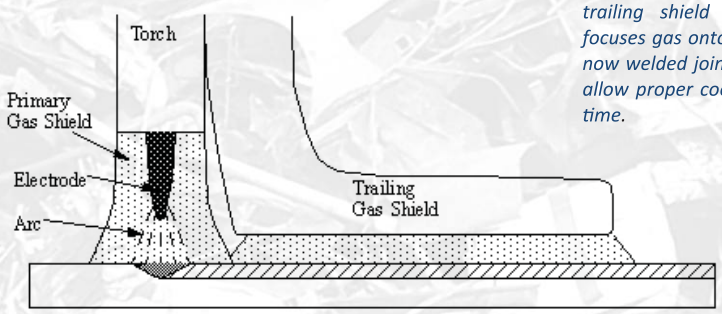
**Filler wire** should be fed into the weld zone at the junction of the weld joint and arc cone. Wire should be fed smoothly and continuously into the puddle. An intermittent dipping technique causes turbulence and may result in contamination of the hot end of the wire on removal from the shield. The contaminants are then transferred to the weld puddle on the next dip. Whenever the weld wire is removed from the inert gas shielding, the end should be clipped back about 1/2- inch to remove contaminated metal.

**Interpass temperatures** should be kept low enough, such that additional shielding is not required.

**Cleaning between passes** is not necessary if the weld bead remains bright and silvery. Straw or light blue weld discoloration can be removed by wire brushing with a clean stainless steel wire brush.

**Contaminated weld beads**, as evidenced by a dark blue, gray or white powdery color, must be completely removed by grinding. The joint must then be carefully prepared and cleaned before welding again.

*The attached diagram shows a trailing shield that focuses gas onto the now welded joint, to allow proper cooling time.*



## General Titanium Welding Parameters

| | GTA Without Filler | | | GTA With Filler | | | GMA | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gauge, in. | 0.030 | 0.060 | 0.090 | 0.060 | 0.090 | 0.125 | 0.125 | 0.250 | 0.500 | 0.625 |
| Electrode Dia., in. | 1/16 | 1/16 | 1/16-1/32 | 1/16 | 1/16-3/32 | 3/32-1/8 | 1/16 | 1/16 | 1/16 | 1/16 |
| Filler Wire Dia., in. | --- | --- | --- | 1/16 | 1/16 | 1/16 | --- | --- | --- | --- |
| Wire Feed Rate, ipm | --- | --- | --- | 22 | 22 | 20 | 200-225 | 300-320 | 375-400 | 400-425 |
| Voltage | 10 | 10 | 12 | 10 | 12 | 12 | 20 | 30 | 40 | 45 |
| Amperes | 25-35 | 90-100 | 190-200 | 120-130 | 200-210 | 220-230 | 250-260 | 300-320 | 340-360 | 350-370 |
| Nozzle ID, in. | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/44-1 | 3/44-1 | 3/44-1 | 3/4-1 |
| Primary Shield, cfh | 15A | 15A | 20A | 15A | 20A | 20A | 50A+15H | 50A+15H | 50A+15H | 50A+15H |
| Trailing Shield, cfh | 20A | 30A | 50A | 40A | 50A | 50A | 50A | 50A | 60A | 60A |
| Back-up Shield, cfh | 4H | 4H | 5H | 5H | 6H | 6H | 30H | 50H | 60H | 60H |
| Back-up Material | <-------Cu or Steel-------> | | | <-------Cu or Steel-------> | | | Cu | Cu | Cu | Cu |
| Back-up Groove, in. | 1/4 x 1/16 | 1/4 x 1/16 | 3/8x1/16 3/16x1/16 | 1/4 x 1/16 | 3/8x1/16 3/16x1/16 | 3/8x1/16 3/16x1/16 | 3/8x1/16 3/16x1/16 | 1/2x1/8 1/4x1/16 | 5/8x1/2 1/4x1/16 | 5/8x1/2 1/4x1/16 |
| Electrode Travel, ipm | 10 | 10 | 10 | 12 | 12 | 10 | 15 | 15 | 15 | 15 |
| Power Supply | DCSP | DCSP | DCSP | DCSP | DCSP | DCSP | DCRP | DCRP | DCRP | DCRP |

** Note** the letter “A” stands for Argon and the Letter “H” stands for Helium

These guidelines were developed on automatic equipment with backup bar, trailing shield and hold-down shoes. Parameters for manual welding are similar under similar welding conditions. If slower welding speeds are desirable, amperage must be reduced proportionately. Generally speaking, the lowest heat input consistent with good weld properties is desirable in welding titanium. It is good practice to weld test samples to optimize parameters for a particular welding application before committing material and manpower to the job.