TIG WELDING ALUMINUM

Although many metals are TIG welded, the metal most frequently associated with the process is aluminum, especially with metals of a smaller thickness. Many other processes, of course, can join aluminum, but in the lighter gauges the most applicable process is TIG. The popularity of aluminum in automotive applications has brought TIG welding to a new golden age. Mechanically strong and visually appealing, TIG welding is the number one process chosen by professional welders for professional racing teams, and the avid auto enthusiast or hobbyist.

THAT CONFUSING THING ABOUT ALUMINUM

The process is well suited for aluminum, but there are a few characteristics of the metal that bring up points that must be considered if this material is to be welded with consistent ease and quality.

The pure metal has a melting point less than 1200ºF and does not exhibit the color changes before melting so characteristic of most metals. For this reason, aluminum does not tell you when it is hot or ready to melt. The oxide or "skin" that forms so rapidly on its surface has a melting point almost three times as high (3200º+F). To add to this confusion, aluminum even boils at a lower temperature (2880ºF) than this oxide melts. The oxide is also heavier than aluminum and, when melted, tends to sink or be trapped in the molten aluminum. For these reasons, it is easy to see why as much as possible of this oxide "skin" must be removed before welding. Luckily, the reverse polarity half of the AC arc does an outstanding job of cleaning off quantities of this oxide ahead of the weld!

THAT ALUMINUM IS HOT!

Aluminum is an excellent conductor of heat. It requires large heat inputs when welding is begun, since much heat is lost in heating the surrounding base metal. After welding has progressed a while, much of this heat has moved ahead of the arc and pre-heated the base metal to a temperature requiring less welding current than the original cold plate. If the weld is continued farther on to the end of the two plates where there is nowhere for this pre-heat to go, it can pile up to such a degree as to make welding difficult unless the current is decreased. This explains why a foot or hand Amptrol™ (current control) is recommended with your Precision TIG 185 or Precision TIG 275 – it enables you to easily change the current while simultaneously welding.

Some aluminum alloys exhibit “hot short” tendencies and are crack sensitive. This means that at the range of temperatures where the liquid alloy is slushy (part solid and part liquid) or just turned solid, it has not quite enough tensile strength to resist the shrinkage stresses that are occurring from cooling and transformation. The proper choice of filler metal and welding procedures along with smaller beads can help eliminate many problems of this kind. Some experts recommend backstepping the first inch or so of each aluminum weld before finishing in the normal direction.

FILLING THE GAP

The metal produced in the weld pool is a combination of filler and parent metals that must have the strength, ductility, freedom from cracking, and the corrosion resistance required by the application. See table below for recommended filler metals for various aluminum alloys.

Maximum rate of deposition is obtained with filler wire or rod of the largest practical diameter while welding at the maximum practical welding current. Wire diameter best suited for a specific application depends upon the current that can be used to make the weld. In turn, the current is governed by the available power supply, joint design, alloy type and thickness, and the welding position.

RECOMMENDED FILLER METALS FOR VARIOUS ALUMINUM ALLOYS

	Recommended Filler Metal[1]	
Base Metal	**For Maximum As-Welded Strength**	**For Maximum Elongation**
EC	1100	EC 1260
1100	1100, 4043	1100, 4043
2219	2319	(2)
3003	5183, 5356	1100, 4043
3004	5554, 5356	5183, 4043
5005	5183, 4043, 5356	5183, 4043
5051	5356	5183, 4043
5052	5356, 5183	5183, 4043, 5356
5083	5183, 5356	5183, 5356
5086	5183, 5356	5183, 5356
5050	5356, 5183	5183, 5356, 5654
5052	5554, 5356	5356
5083	5356, 5554	5554, 5356
5086	5556	5183, 5356
6061	4043, 5183	5356[3]
6063	4043, 5183	5356[3]
7005	5356, 5183	5183, 5356
7039	5356, 5183	5183, 5356

Notes:

1. Recommendations are for plate of "0" temper.
2. Ductility of weldments of these base metals is not appreciably affected by filler metal elongation of these base metals is generally lower than that of other alloys listed.
3. For welded joints in 6061 and 6063 requiring maximum electrical conductivity use 4043 filler metal. However, if both strength and conductivity are required, use 5356 filler metal and increase the weld reinforcement to compensate for the lower conductivity of 5356.

A QUALITY DEPOSIT

Good weld quality is obtained only if the filler wire is clean and of high quality. If the wire is not clean, a large amount of contaminant may be introduced into the weld pool, because of the relatively large surface area of the filler wire with respect to the amount of weld metal being deposited.

Contaminants on the filler wire are most often an oil or a hydrated oxide. The heat of the welding releases the hydrogen from these sources, causing porosity in the weld. Aluminum welding wire is manufactured under rigorous control to exacting standards and is packaged to prevent contamination during storage. Since filler wire is alloyed, or diluted, with the base metal in the weld pool, the compositions of both the filler wire and the base metal affect the quality of the weld.

THE THREE *C*S: CLEAN, CLEAN AND CLEAN!

Pieces to be welded are usually formed, sheared, sawed, or machined prior to the welding operation. Complete removal of all lubricants from these operations is a prerequisite for high-quality welds.

Particular care must be taken to remove all oil, other hydrocarbons, and loose particles from sawed or seared edges prior to welding. Sheared edges should be clean and smooth – not ragged. For ease of cleaning, lubricants used in fabrication should be promptly removed.

To reduce the possibility of porosity and dross in welds, cleanliness of the welding surfaces cannot be overemphasized. Hydrogen can cause porosity, and oxygen can cause dross in welds. Oxides, greases, and oil films contain oxygen and hydrogen that, if left on the edges to be welded, will cause unsound welds with poor mechanical and electrical properties. Cleaning should be done just prior to welding. A summary of general cleaning procedures is given in the table below.

COMMON METHODS FOR CLEANING ALUMINUM SURFACES FOR WELDING

	Type of Cleaning	
Compounds Removed	**Welding Surfaces Only**	**Complete Piece**
Oil, grease moisture, and dust. (Use any method listed.)	• Wipe with mild alkaline solution and dry. • Wipe with hydrocarbon solvent, such as acetone or alcohol. • Wipe with proprietary solvents • Dip edges, using any of above	• Vapor degrease. • Spray degrease. • Steam degrease. • Immerse in alkaline solvent. • Immerse i proprietary solvent.
Oxides (Use any method listed)	• Dip edge in strong alkaline solution, then water, then nitric acid, Finish with rinse and dry. • Wipe with proprietary deoxidizers. • Remove mechanically, such as by wire-brushing, filling or grinding. For critical applications, scrape all joints and adjacent surfaces immediately prior to welding	• Immerse in strong alkaline solution, then water, then nitric acid. Finish with water rinse and dry. • Immerse in proprietary solutions.