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# Choose Wisely When Welding Aluminum

Fig. 1 — Aluminum is a popular material in general industrial applications due to its lightweight strength and corrosion resistance, making it a suitable material for helping to lower vehicle emissions.

*Material condition and shielding gas selection are key considerations for successful aluminum joining*

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Due to its lightweight strength and corrosion resistance, aluminum is a popular material in general industrial applications — Fig. 1. These characteristics make aluminum a desirable material when the reduction of weight leads to lower vehicle emissions. As a result, it is an ever-increasingly sourced component of fuel-efficient road transportation. There are numerous aluminum chemical compositions, each designed for a particular service condition and structural load.

Many applications require joining the aluminum, and often the joining method of choice is welding. There are a number of welding processes suitable for joining aluminum. Two of the most common are gas tungsten arc welding (GTAW) and gas metal arc welding (GMAW).

While there are a number of variables involved with welding aluminum, there are two in particular that will be addressed in this article: shielding gas and material condition. Shielding gas can impact the width of the bead as well as the depth of penetration in certain specific instances. Material condition affects a number of preparation and joining steps.

## Rethinking Your Shielding Gas Selection

Shielding gas is a necessity when welding aluminum. Gas suppliers often see that the selection of gas is driven by ease of use, heat-input needs, and cost. The

*Fig. 2 — Welding thicker or heavier aluminum sections requires a high heat input to satisfactorily join the metal.*

thermal conductivity of aluminum is such that thicker or heavier sections require a high heat input to satisfactorily join the metal — Fig. 2.

We see many customers choosing to add helium to their normal shielding gas, for example, 100% argon. Adding helium forces the constant-current power supply to deliver more voltage, which will add heat. This works quite well, except for the cost of the shielding gas. Helium is more costly than argon, so significant additions such as 50% or even 75% helium content gets expensive.

While demand for helium, a nonrenewable resource, has been steadily growing in different applications, the worldwide availability of this product continues to be extremely tight. In addition, with demand exceeding the global available supply, prices have steadily increased.

One way to gain the benefits of helium without the cost is to use small additions of nitrogen in the argon shielding gas. For example, the addition of 600 PPM of nitrogen to argon for GMAW delivers effects similar to adding ~30% helium to argon. Adding nitrogen to aluminum creates aluminum nitrides, which are highly emissive (because the surface more efficiently emits thermal energy) and can deliver similar results as helium blends at a reasonable price.

Shielding gas purity is another key consideration, as using poor quality gases can contaminate a weld quickly. Maintaining a high standard of quality is crucial when welding aluminum. One way to ensure quality is to adhere to the American Welding Society (AWS) A5.32, *Specification for Welding Shielding Gases*, or follow the requirements in AWS D1.2, *Structural Welding Code — Aluminum*.

For pure argon, AWS A5.32 requires less than 40 PPM of moisture, which should be taken as an absolute maximum. For argon, AWS D1.2:2008 requires 99.997% global purity and a 10.5 PPM moisture limit. In the 2014 edition, these values are 99.99% and 40 PPM. Be aware that this may not be pure enough. For best results, a shielding gas product with less than 3 PPM of moisture and 5 PPM of $O_2$ content is recommended.

### Key Takeaways

The following shielding gas suggestions can enable better welding of aluminum:

- Consider using nitrogen instead of helium in your shielding gas mixes when welding aluminum.
- Gas purity should be maintained to AWS standards; a shielding gas product with less than 3 PPM of moisture and 5 PPM of $O_2$ content is recommended.

## Controlling Material Conditions

Aluminum's well-known resistance to corrosion is due to a very thin layer of aluminum oxide ($Al_2O_3$), which protects the underlying base metal. This is a useful property, but is not without some additional concerns. The oxide layer is tenacious, but unfortunately, aluminum melts at ~1100°F and the oxide layer melts at ~3700°F. When welding, it is necessary to remove as much oxide as possible to allow the arc to deliver its heat to the weldment properly.

*Fig. 3 — When welding aluminum, it is necessary to remove as much oxide as possible to allow the arc to deliver its heat to the weldment properly. This can be done with scraping, grinding, or brushing, but care must be taken to not embed the oxides deeper into the base metal.*

Cleaning off this oxide can be done by scraping, grinding, or brushing, but care must be taken to prevent overly rough surface preparation from embedding the oxides deeper into the base metal — Fig. 3. Additionally, sheared aluminum must be carefully checked to ensure the edge is not "smeared" with trace deposits from tools, trapping oxides and other contamination on the edge to be welded.

For the highest quality welds, it is recommended to wipe the weld area with an approved solvent that removes any residual oils and water. Isopropyl alcohol is commonly used for this purpose, as it is an excellent solvent for nonpolar compounds, as well as a rapid drying agent to help remove water.

While welding aluminum, the presence of water or moisture of any kind, and hydrocarbons, is a significant problem as they decompose into hydrogen in the welding arc. Aluminum is susceptible to porosity due to the difference in solubility of hydrogen in molten and solid aluminum.

Moisture contamination can occur in inconspicuous ways. Simply moving a piece of aluminum from a cool, air-conditioned space to a humid shop environment can cause condensation to form on the surface of the metal. Even worse, aluminum oxide readily absorbs moisture, making it even more difficult to eliminate the source of the hydrogen.

Grinding residue from carbon steel can also become embedded in the surface, causing problems in welding, as well as in the finished product service life.

## Key Takeaways

The following suggestions about material control can enable better welding of aluminum:

• If any sort of machining operation is used to prepare the base metal, remove any residual lubricants.

• Carefully check sheared aluminum to ensure the edge is not "smeared," trapping oxides and other contamination on the edge to be welded.

• When preparing to weld aluminum, store raw material properly, preferably indoors.

## Summary

While there are far more variables involved in the successful use and joining of aluminum, material condition and proper selection of shielding gas are among the most important. However, some of the least obvious root causes can lead to significant welding problems. Careful cleaning and preparation of base metal is critical to any aluminum welding effort, and a reasoned selection of shielding gas can make the process far more robust, reduce porosity, and add the needed energy to the welding arc. WJ

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