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MiniGuide.

Aluminium welding.

Content

Aluminium

Aluminium is nearly always alloyed with other metals to obtain a material with excellent properties. Normal alloy substances are silicon (Si), magnesium (Mg), manganese (Mn), copper (Cu) and zinc (Zn). Alloys that contains a maximum of 1.0 per cent by weight, of iron and silicon together, are called non-alloyed aluminium or pure aluminium.

EN standard
The numerical indications as used in EN standards; e.g. XX-EN AW-5754 or XX-EN AC-42000, consist of three parts:

XX EN		
XX	=	National standard
EN	=	European standard
AW-, AC-		
A	=	Aluminium
W	=	Plastic malleable alloys
C	=	Casting alloys
Alloy number		4 digits for plastic malleable alloys; 5 digits for casting alloys

The first digit in the alloy number refers to the main alloy element.

The main alloy elements in aluminium alloys:

Alloy number	Main alloy element
1xxx(x)	Non-alloy (pure aluminium)
2xxx(x)	Copper
3xxx(x)	Manganese
4xxx(x)	Silicon
5xxx(x)	Magnesium
6xxx(x)	Silicon + magnesium
7xxx(x)	Zinc
8xxx(x)	Miscellaneous

Aluminium alloys

Aluminium alloys are divided into plastic malleable alloys and casting alloys. The plastic malleable alloys are used for profiles and sheeting, and are the most commonly used in welded constructions.
These main groups are themselves divided into "Non-heat-treatable alloys" and "Heat-treatable alloys". A list of various plastic malleable alloys is shown below.

Non-heat-treatable alloys

XX EN AW Alloy number	ISO	Previous XX no.
1070A	Al99,7	LOCAL NUMBERS
1050A	Al99,5	LOCAL NUMBERS
1200	Al99,0	LOCAL NUMBERS
3103	AlMn1	LOCAL NUMBERS
3005	AlMn1Mg0.5	-
4015	AlSi2Mn	-
5005	AlMg1	LOCAL NUMBERS
5052	AlMg2.5	LOCAL NUMBERS
5754	AlMg3	LOCAL NUMBERS
5083	AlMg4.5Mn0.7	LOCAL NUMBERS

Heat-treatable alloys

XX EN AW Alloy number	ISO	Previous XX no.
6060	AlMgSi	LOCAL NUMBERS
6063	AlMg0.7Si	LOCAL NUMBERS
6005	AlSiMg	LOCAL NUMBERS
6082	AlSi1MgMn	LOCAL NUMBERS
7020	AlZn4.5Mg1	LOCAL NUMBERS
7021	AlZn5.5MgCu	-

Welding of aluminium

The process for welding aluminium differs from that for welding steel, due to the different physical properties of the materials.

Weldability
Different aluminium alloys are suitable for welding in different ways, and can be divided into groups according to their tendency to fracture.

Weldability of plastic malleable alloys:

Weldability	Scope XX EN AW	Example of alloys.
Easily weldable		
Non-alloy Al	all	1070A, 1050A, 1200
Non-heat-treatable	most	3103, 5052, 5083
Heat-treatable	some	6063, 6082, 7020
Partially weldable		
Heat-treatable	Contain Cu and Pb	2011, 2014

Deformations

The thermal conductivity for aluminium is three times higher than for steel. This, in combination with a greater thermal expansion and lower strength at increased temperatures, means that material deformations occur much more easily when welding aluminium than steel.

In order to minimise deformations, welding should be carried out with low heat input per unit length, which can be achieved through a high welding speed.

To further reduce deformations, a higher degree of fixturing can be used on the details. This will, of course, give residual voltage, but ultimately also the best end result. The welding sequence should be as symmetrical as possible.

Cleaning prior to welding

Hydrogen is the most dangerous impurity when welding aluminium. Hydrogen is present in moisture, and oil and grease which can accumulate in the porous aluminium oxide. The oxide (Al_2O_3) which exists on all aluminium, has such a high melting point that it does not melt during welding, and can therefore disturb the arc.

Therefore, in order to achieve a good end result, the oxides, oil, grease and moisture be removed from the weld location before beginning. Cleaning should be done in two stages:

1. Washing/degreasing with alcohol or acetone, for example

2. Mechanical oxide removal. Brushing with a stainless steel brush is the most common method, but blasting and scraping are also used

Following the oxide removal, the material should be welded within one to two hours, as the oxide layer immediately begins to reform.

Filler metal

For both TIG and MIG welding, it is important to choose a filler metal with the correct chemical composition. This is to obtain the optimal properties in the weld in respect of strength, corrosion and the ability to remain fracture free.

Consult the filler metal manufacturer or handbooks to select the correct filler metal for the parent metal(s) to be welded.

Shielding gases

One function of the shielding gas is to protect the heated and melted metal from the surrounding air. Without this shielding, a considerable amount of oxidation, and also pores, can develop.

Other important factors affected by the shielding gas are: the stability of the arc, the welding speed, the welding geometry, resistance to corrosion, mechanical properties and the working environment. The shielding gas therefore has a considerable influence on the weld quality and productivity.

There are not as many elements that can be used in the shielding gas for aluminium as there are for steel and stainless steel. In practice, argon (Ar) is the main element used in the majority of cases. Helium (He) can be used as the main element, but is often used in concentrations of less than 50%. Small additions of nitrogen monoxide (NO) can provide advantages both in terms of welding technique and for the working environment.

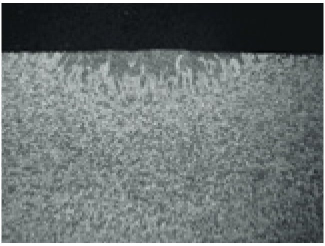
MISON® shielding gases

MISON® shielding gases are a group of gases from Linde which give optimal productivity and quality for MIG/MAG, cored wire and TIG welding. MISON® improves the working environment by reducing the amount of ozone. Adding 0.03% NO to the shielding gas reacts with any ozone as soon as it is created. For aluminium welding, there are two MISON® shielding gases which can both be used for TIG and MIG welding.

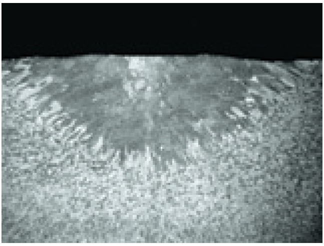
Shielding gases for aluminium welding

MISON® Ar. An all-round shielding gas for all TIG and MIG aluminium welding. In addition to a better working environment, the addition of NO provides a more stable arc than pure argon.

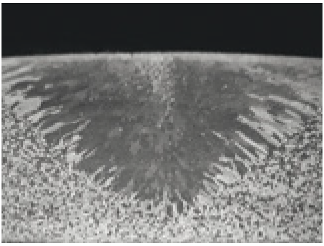
MISON® He30. An all-round shielding gas for the majority of TIG and MIG aluminium welding. Increased metal penetration and flow with the addition of helium. Enables a higher welding speed. In addition to a better working environment, the addition of NO provides a more stable arc.



Argon. An all-round shielding gas for all TIG and MIG aluminium welding. No improvement to the working environment.



VARIGONHe50. Shielding gas for TIG and MIG welding of slightly coarser aluminium. Increased metal penetration and flow with the addition of helium. Enables a higher welding speed.



VARIGONHe70. Shielding gas for TIG and MIG welding of primar ily coarse aluminium. Increased metal penetration and flow with the addition of helium. Enables a higher welding speed.

Optimising gas shielding for MIG and TIG welding

The amount of shielding gas must be sufficient to protect the melt from the surrounding air. A suitable shielding gas flow depends on factors such as: the type of shielding gas, the size of the gas cup (determined by the strength of the current/the size of the melt), draft and the type of groove/working position.

Factors to consider when obtaining a good gas shield

- To obtain a laminar gas flow, the flow must be adapted to the size of the gas cup. A flow that is too high or too low risks an insufficient gas shielding. Helium-rich shielding gases require a higher flow than with argon
- The flow is measured at the gas cup. Use a flow meter
- Avoid draft, which can disturb the gas shielding. If the drag cannot be shielded, one of the following can reduce the problem:
  - Reduce the distance between the gas cup and the work piece
  - Increase the gas flow
  - Use gas lens (TIG)
- Adhesive spatter on the inside of the gas cup can disturb the gas shielding (MIG welding). Check regularly and clean the gas cup as required
- Avoid having a large distance between the gas cup and the work piece

Pre- and post-flushing of shielding gases

The aim of pre-flushing the shielding gas is to remove impurities in the gas supply system and force out the air in the joint before welding commences. After longer pauses in the welding, e.g. overnight or weekends, then a longer flushing time is needed.
Post-flushing is used to shield the electrode (TIG) and the weld melt/hot metal after welding. In TIG welding, the post-flushing time can be up to 10 seconds. If the TIG electrode is discoloured after welding, the post-flushing time must be increased.

Impurities in the gas supply system and how to avoid them

If the shielding gas contains impurities, problems will arise both during and after welding. The impurities seldom arise from the gas cylinder/tank, but mostly occur between the cylinder and the gas cup.

Source of impurities:	Action to take:
Insufficient flushing of gas system, e.g. after long pauses in work.	Flush for a longer time.
Diffusion of moisture and air in the hoses.	Use diffusion-secure hoses designed for shielding gas, e.g. in accordance with EN 559.
Leaks in the hoses and connections.	Check regularly. Use leak detection spray on the connections.
Excessively long hoses.	Do not use hoses that are longer than necessary.
Leaks in the water-cooled welding equipment.	Check the equipment regularly.

Practical advice for aluminium welding

- Use a gas cup with at least a 16 mm internal diameter when MIG welding
- When TIG welding, use a gas cup with an internal diameter of at least 4 x the electrode diameter
- When TIG welding, the end of the filler metal should be held in the shielding gas atmosphere during the entire welding process
- Pay attention when cleaning prior to welding – degreasing and brushing with a stainless steel brush
- Use start and stop bits when welding crack-sensitive alloys
- Be sure to use the right type of filler metal for the alloys to be welded
- Weld with as high a speed as possible, to minimise the energy per unit length
- Ideally, use the push-pull feed system in MIG welding
- If a standard pusher feed system is used, use as short a hose bundle as possible
- Ideally, do not use the same welding equipment for both steel/ stainless steel and aluminium. If this is not possible, have a hose bundle or at the very least have a wire guide that is solely for aluminium

Cutting of aluminium

Plasma and laser cutting are - along with mechanical cutting - the most effective methods for cutting aluminium.

Plasma cutting

Plasma arc cutting (PAC) is a very effective method for cutting aluminium. The method is suitable for thicknesses varying from thin foil up to 200 mm.

Choice of gas

A variety of gases can be used for plasma cutting. The deciding factor for choosing the gas is the thickness of the material.

Thin material: (double gas nozzle)	
Primary gas:	N_2
Secondary gas:	N_2
Medium/thick material: (double gas nozzle)	
Primary gas:	$Ar/H_2/N_2$
Secondary gas:	N_2

Cutting quality

New technology in terms of equipment and gas mixtures has, in only a few years, radically improved the quality that it is possible to achieve in plasma cutting. However, uneven edges are still one of the method's disadvantages, even if the trend towards higher currents and speeds can reduce the problem.

Laser cutting

Laser cutting of aluminium is suitable for thicknesses of up to around 8 mm. The advantages are even edges and a high cutting speed. A CO_2 laser is normally used, with an output of between 1.5 and 4 kW.

Choice of gas

When cutting aluminium, oxygen or nitrogen can be used as a cutting gas. Clean cutting surfaces can be achieved with nitrogen and oxygen and by using high pressure. It is proven that nitrogen is a somewhat better option when cutting aluminium alloys, whilst oxygen is more suitable for pure aluminium.

Cutting quality

Compared to plasma cutting, laser cutting can give more even edges a smaller cutting width and fewer thermal effects on the material in use.

The role of cutting gas

- The gas transports the molten material away from the cut edge
- Sometimes the gas reacts with the metal that is being cut
- The additional heat being created contributes to increasing the cutting speed
- The gas cools the cut edge, which helps to reduce the surface area affected by the heat generated by the cutting
- The gas prevents steam and particles contaminating the nozzle

Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, our task is to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

Linde offers more. We create added value, clearly discernible competitive advantages and greater profitability. Each concept is tailored specifically to meet our customers' requirements – offering standardized as well as customised solutions. This applies to all industries and all companies regardless of their size.

Linde – ideas become solutions.

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