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THE LINDE GROUP

Shielding gases.

The right gas working for you.

The right shielding gas does make a difference.

To most users a shielding gas is just there to protect the welding from the effects of oxygen and nitrogen in the atmosphere. While this is a key function of the shielding gas other benefits can be achieved by making the correct product choice.

Some are metallurgical such as improved corrosion resistance, some are mechanical such as tougher weld metal, some are financial such as reduced weld cost or improved productivity.

Understanding what shielding gases are capable of delivering to your business can bring about considerable financial rewards and so provide you with a clear competitive edge.

Choosing the right shielding gas for your needs.

The careful combinations of different gases, often tailored to specific materials, can improve the performance in any welding situation by lower manufacturing costs through:

- improving the weld metal properties, such as strength, corrosion resistance and toughness
- changing the weld bead shape and size
- improving the weld quality, by reducing defect and scrap rates
- increasing welding speeds, lowering production times
- being easier to use, requiring less training while maintaining weld quality

All these performance enhancements can result from the use of the correct shielding gas which can be directly translated into tangible savings.

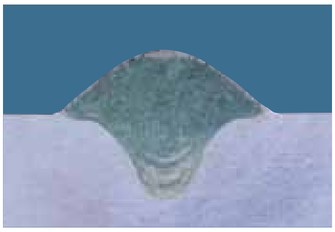
Weld metal properties

Although weld metal properties are primarily controlled by the consumable composition, the shielding gas can directly influence the strength, ductility, toughness and corrosion resistance of a weld.

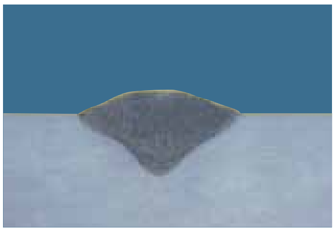
For instance, adding oxygen and/or carbon dioxide to a shielding gas for MAG welding carbon steel increases its oxidation potential. In general, for a given welding wire, the higher the oxidation potential of a shielding gas, the lower the strength and toughness of the weld. This occurs because the oxygen and carbon dioxide in the shielding gas increase the number of oxide inclusions and reduce the level of materials such as manganese and silicon in the weld metal.

Additionally, when MAG welding stainless steel, the amount of carbon dioxide in the shielding gas can have an effect on the corrosion resistance of the resulting weld metal. In particular, carbon transferred into the weld from the gas can produce unacceptably high carbon levels in the welded areas. If those welds are exposed to excessively high heat input during welding or elevated service temperatures, the material is likely to become sensitised to intergranular corrosion due to carbide precipitation. When welding "L"-grade stainless steels, it is important to keep the carbon dioxide level in the gas below 3 % to ensure that carbon pick up doesn't increase carbon in the weld metal above the 0.03 % specified maximum for the weld metal in order to prevent sensitisation. Standard stainless steels (non-"L"-grade) benefit from a limited CO_2 content since surface oxidation is greatly reduced. All Linde stainless steel MAG welding gases have carbon dioxide levels below 3 %.

Ar



Ar/He



The addition of helium to the shielding gas results in a hotter welding arc than that produced from pure argon.

Carbon dioxide

17.1 g

CORGON 18

8.6 g

CORGON 12S2

8.6 g

Weld shape and quality

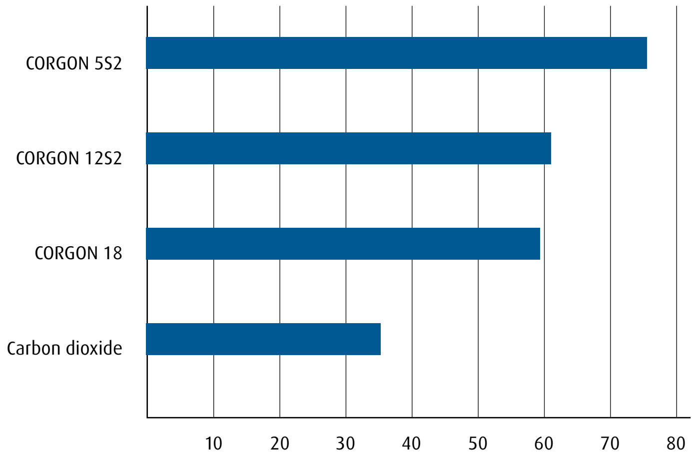
Although shielding gases with lower levels of oxygen and/or carbon dioxide usually result in weld metal having higher mechanical properties, these welds can suffer from greater numbers of fusion defects than those made from gases with higher oxidation potentials. Shielding gases with low oxidation potentials produce weld beads with a very narrow wineglass or finger like bead profile. However, adding carbon dioxide to the shielding gas makes the weld bead wider, deeper and more rounded, reducing the risk of fusion defects.

Another good example of how the shielding gas can affect the quality or integrity of the weld metal is the welding of aluminium. When welding thick aluminium sections with pure argon as the shielding gas, porosity, lack of penetration and fusion defects can be an issue.

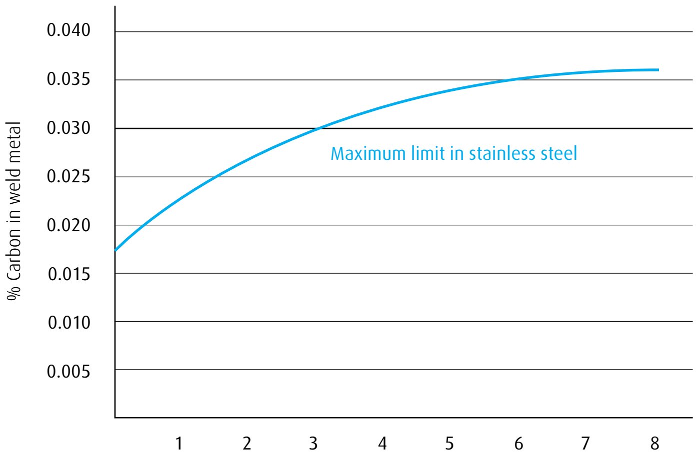
The addition of helium to argon in shielding gases such as VARIGON He30, He50 and He70 can significantly reduce these defects. This is because the high thermal conductivity of helium results in more energy being transferred into the weld. This in turn produces a hotter weld pool resulting in improved fusion and slower freezing times, allowing any entrapped gas more time to escape.

The shielding gas can improve the weld quality by reducing the level of weld reinforcement. Weld reinforcement can be a problem because it increases the stresses at the toes of a weld and in severe cases can lead to cracking at the edges of the weld, particularly under fatigue conditions. The normal method of removing or reducing the reinforcement is to grind off the surplus weld metal, but this is both costly and time consuming. A correctly balanced shielding gas will reduce the surface tension of the weld metal, allowing the solidifying weld pool to sink resulting in a weld with lower reinforcement.

Impact values at –20 °C (joules)



% CO_2 in gas



Operational performance

There are many ways in which a shielding gas can improve welding process performance. For example, VARIGON H5 uses the addition of hydrogen to argon for TIG welding austenitic stainless steel to produce a more fluid arc, which allows welding speeds to be significantly increased.

The use of pure carbon dioxide when MAG welding carbon steels can cause large amounts of spatter to be ejected from the weld pool. By using CORGON 18 the amount of spatter can be halved and by moving to CORGON 12S2 this value can be halved again. Removing spatter after welding is not only costly but it can cause problems if the component is subsequently painted or coated, as the small marks left by the spatter show up as surface imperfections.

A further example of improved welding performance can be found in the MIG and TIG welding of copper, where the addition of helium to argon results in a much more efficient transfer of energy from the arc to the weld, for example VARIGON He70 not only produces a much higher welding speed than pure argon but leads to a reduction in preheating temperatures needed before welding commences.

Ease of use

To get the best performance out of any welding product, whether the wire, power source or shielding gas, the skill and knowledge of the operator is always important. However, it is not only about the operator being able to set good welding conditions. In manual welding the process must be tolerant enough to allow for small variations in control by the operator to not create a defect in a weld. While this is most obvious in manual welding, in automatic and robotic applications changes in welding angle or direction of travel can cause similar effects.

For example, the balance of carbon dioxide and oxygen in CORGON 12S2 gives a large current/voltage envelope of good welding conditions, making this mixture extremely tolerant not only to set up variation, but it can cope with those small positional changes all welders make without compromising the weld quality.

The right shielding gas from Linde.

Choosing the right shielding gas is important for your business, marking the transformation from cost to profit.

Which gas is right?

By knowing what is the most important feature you want from your shielding gas – for example welding speed, lower defect levels, better mechanical properties – you can choose the right one for you.

Linde has put together a series of material related guides to help you make the right selection for each of your welding applications:

- Shielding gases for carbon and low alloy steels
- Shielding gases for stainless steels
- Shielding gases for non-ferrous materials

Ask your local Linde contact for a copy.

Making the right choice can really save you money.

A high percentage of manufacturers only measure the cost of welding either by the man hours to produce a component or in terms of the component costs of the gas and wire used over a period of time. While both these measures will give a rough measure as to the cost of a weld, they do not tell the whole story. In most literature on the topic of weld costing four elements are mentioned:

- Gas
- Wire
- Labour
- Power

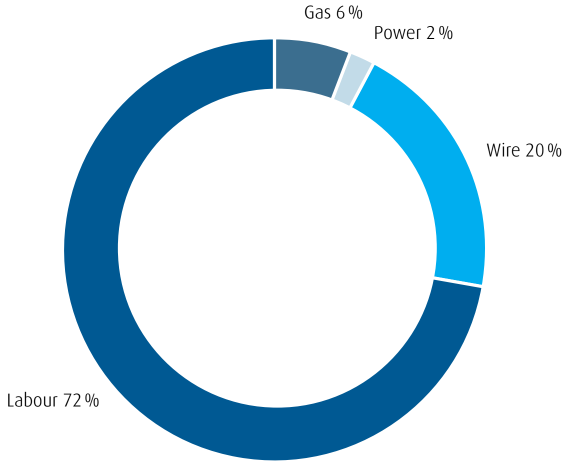
These four elements are the easiest to quantify but do not reveal the full cost.

Irrespective of the material being welded the cost of the gas is less than 10 % of the total cost incurred.

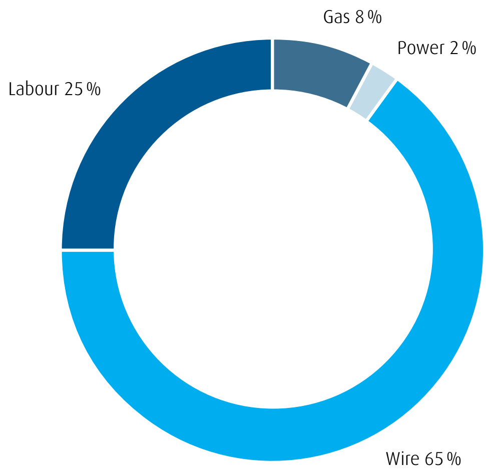
Reducing the reinforcement level, cleaning of spatter, removing defects from welds, removing surface imperfections, etc are all carried out using some form of grinding or finishing system. Grinding wheels and belts are very costly items and even in a medium sized fabrication shop, the annual spend on these items can run into thousands of Euros, not including the cost of the labour to carry out the work.

When welding thick material sections especially on stainless steel and non-ferrous materials, the cost of creating weld preparation can be high. Importantly, the larger the preparation used, the more welding wire and gas is needed to fill up the joint again. If smaller preps or even no preps are used because of the improved penetration and fusion characteristics of the shielding gas, then the cost savings can be huge.

Typical cost breakdown for MAG welding carbon steel



Typical cost breakdown for MAG welding stainless steel



For example, in carbon steel MAG welding every 8.5 grams of spatter generated is equivalent to 1 metre of 1.2 mm diameter welding wire being thrown on the floor. At high welding currents using carbon dioxide, over 17 grams of spatter is generated for every metre of weld completed.

If a weld defect is found in any component then costs rise considerably. Not only the cost of welding the component in the first place but additionally there is the cost of:

- testing, for example x-ray or ultrasonic
- removing the defect
- re-welding
- retesting

In the worst case if the component cannot be repaired and has to be scrapped, there is the additional cost of the raw material and any pre-welding work carried out, plus the further cost of making a new version.

By selecting the right shielding gas all these ancillary costs can either be significantly reduced or eliminated completely. It should be noted that there is no such thing as a universal solution: each application should be considered individually to ensure you maximise your profitability.

Frequently asked questions about shielding gases.

1. Why am I getting holes in my welds?

Holes (porosity) is usually caused by gas trapped inside the cooling weld metal. While gases such as nitrogen are one of the main causes of porosity, other sources such as water, oil and grease on the material can be as much of a problem. The main causes of porosity are:

- too high or too low a flow of shielding gas – too high and air is entrained into the shield; too low and the gas cannot protect the cooling weld metal from the atmosphere.
- poor welder technique – too long a stick-out or bad torch angle
- incorrect choice of shielding gas – shielding gases containing hydrogen and/or nitrogen are beneficial for some materials but can cause porosity in others.
- poorly maintained equipment – if hose fittings are not tightened, or if there are gas leaks in the power source or torch, air can be entrained into the shielding gas. Also some types of hose are permeable and can allow moisture to enter the shielding gas which can lead to porosity in the weld.
- surface contamination – oil, grease, water and other contaminants on the surface of the welded component can add hydrogen into the weld metal causing porosity.

Please note that this is not an exhaustive list.

2. Why can I not use pure argon for MAG welding steels?

While it is possible to MAG weld steels with pure argon, the arc produced is very unstable and erratic, and the resultant weld will have a lot of spatter and an unsatisfactory penetration profile.

When MAG welding steels, a small amount of oxidising gas (either carbon dioxide or oxygen) is needed to help stabilise the arc and produce sound welds. It is therefore best to use an argon/CO_2 mixture.

3. Why am I getting a lot of spatter on my welds?

There are several reasons that spatter may be generated, but the most common causes are:

- using unstable welding conditions – incorrect voltage for a given welding current
- poor welder technique – too long a stick-out or bad torch angle
- surface contamination on the component – oil, grease, moisture, etc.
- surface coatings – paint or zinc galvanising
- using carbon dioxide as the shielding gas – mixed gases are more stable producing less spatter

Training the welder to set good welding conditions and cleaning the component properly can eliminate many of the problems.

4. Why do I get cracks in my stainless steel welding?

There are two main types of cracking in stainless steels: "hot cracking" and "cold cracking".

Hot cracking, correctly termed "solidification cracking", tends to be a problem in austenitic stainless steels. It is called "hot cracking" as it tends to occur immediately after welding while the weld is still hot. Weld metal solidification cracking is more likely in fully austenitic structures which are more crack sensitive than those containing a small amount of ferrite. The best way to prevent cracking is to choose a consumable which has a high enough ferrite content to ensure that the weld metal does not crack.

Cold cracking, correctly termed "hydrogen cracking", occurs in welds which are not tolerant to hydrogen (e.g. martensitic stainless steels). Hydrogen dissolves in the weld metal while it is molten then after solidification it diffuses to small defects in the weld and hydrogen gas forms, building up in pressure as the weld cools. Then, when the pressure is sufficiently high, and the weld is cool and more brittle, this internal pressure can causes the weld to crack. This may not occur until many hours after welding. The best way to prevent this form of cracking to ensure there are no sources of hydrogen close to the weld, moisture, grease, etc.

5. What causes the "sooty" deposit when welding aluminium?

This "sooty" deposit is not soot (carbon) at all, but a form of aluminium oxide.

When welding occurs some of the parent material and filler wire is volatilised by the welding arc. As this fine metal vapour leaves the area covered by the shielding gas, it reacts with air, forming aluminium oxide which condenses on the component being welded. The higher the welding current used, the greater the amount of oxide produced.

It is not always possible to eliminate this problem, but altering the torch angle and ensuring correct shielding gas coverage can minimise the effect. Also, if the weld is cleaned immediately after welding, the oxide is much easier to remove than if it is left until the weld is cold.

6. Can my shielding gas un-mix?

Because of thermodynamics, at the high pressures at which shielding gases are supplied the components in a shielding gas will always mix together.

Physicists have proven that if it were possible to layer one gas on top of the other without disturbing the previous layer at 200 bar a homogeneous mixture would be achieve within 40 days.

However, Linde's filling plants are designed to mix the gases thoroughly as the cylinder is filled meaning that a homogeneous mixture can be created in minutes rather than weeks.

Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, it is our task 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 standardised as well as customised solutions. This applies to all industries and all companies regardless of their size.

If you want to keep pace with tomorrow's competition, you need a partner by your side for whom top quality, process optimisation, and enhanced productivity are part of daily business. However, we define partnership not merely as being there for you but being with you. After all, joint activities form the core of commercial success.

Linde – ideas become solutions.

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