

Peak performance through  
innovation and expertise.  
The BOC Performance Line<sup>®</sup>  
and Competence Line<sup>®</sup>  
shielding gases.

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# The role of shielding gas

## What shielding gas can do

The primary function of the shielding gas in gas-shielding arc welding has been to protect molten and heated metal from the damaging effects of the surrounding air and to provide suitable conditions for the arc. If air comes in contact with the molten or heated metal, the oxygen in the air will oxidise the metal, the nitrogen might cause porosity or brittleness in the weld metal, and moisture from the air may also cause porosity.

The shielding gas composition affects the material transition from the molten electrode to the weld pool, which in turn influences the amount and size of the spatter created. It also affects the appearance of the weld bead, the weld geometry, the possible welding speed and plays a key role in the possible burn-off of alloying elements (which affects material strength) or oxide formation on the bead surface.

The figure below illustrates how the shielding gas influences the process and the results in GMA welding.

### Environment

The emission of fume and gases is influenced by the shielding gas.

### Shielding effect

Molten or heated metal is shielded from the air in a controlled shielding gas atmosphere.

### Metal transfer

The type of metal transfer is strongly influenced by the shielding gas. The shielding gas also influences the size and forces acting on the droplets.

### Arc stability

Arc stability and arc ignition are influenced by the shielding gas.

### Surface appearance

The amount of spatter and surface slag is also influenced by the shielding gas.

### Metallurgy and mechanical properties

The loss of alloying elements and pick-up of oxygen, nitrogen, and carbon is influenced by the shielding gas. This loss and pick-up will influence the mechanical properties of the weld metal.

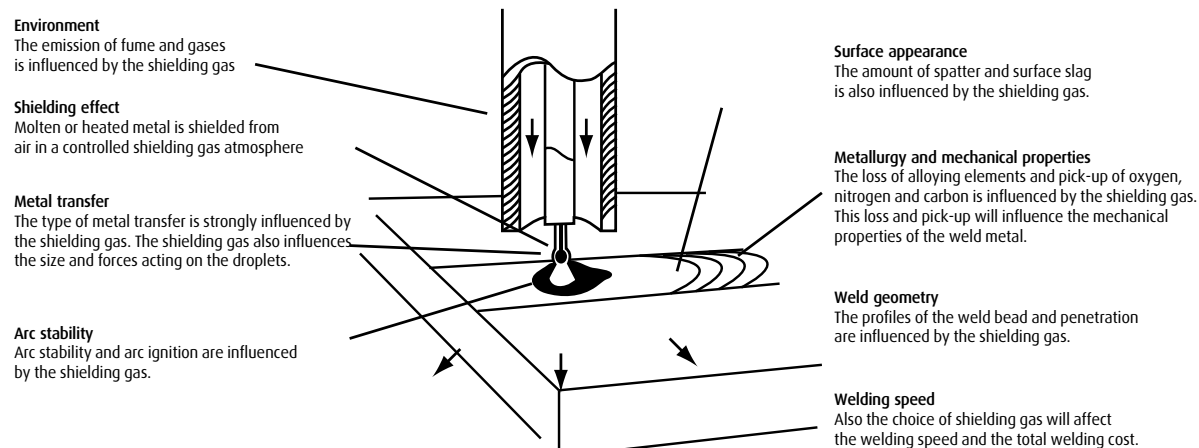
### Weld geometry

The profiles of the weld bead and penetration are influenced by the shielding gas.

### Welding speed

Also the choice of shielding gas will affect the welding speed and the total welding cost.

## The influence of shielding gas upon GMA welding



# The role of shielding gas

## Effects of the different shielding gas components

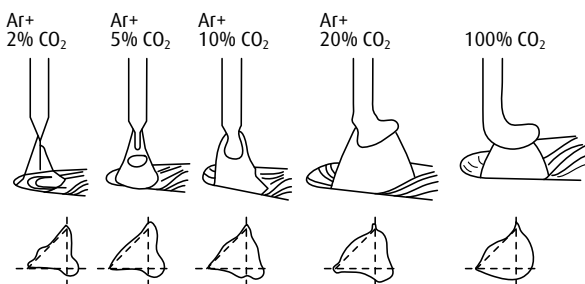
### Argon

Argon (Ar) is an inert gas. This means it does not oxidise and that it has no effect on the chemical composition of the weld metal. Argon is the main component in most shielding gases for GMA and GTA welding.

### Carbon Dioxide and Oxygen

Pure argon cannot be used for GMA welding of steels since the arc becomes too unstable. An oxidising gas component is therefore used to stabilise the arc and to ensure a smooth metal transfer during welding. This oxidising component may be either Carbon Dioxide ( $\text{CO}_2$ ), Oxygen ( $\text{O}_2$ ) or a combination of these gases. The amount of the oxidising component added will depend on the material type and application.

The electrical arc in gas-shielded arc welding can be divided into three parts: the arc plasma, the cathode area and the anode area. In the GMA welding, where the filler metal constitutes the positive electrode (the anode), the cathode area is on the workpiece in the form of one or more cathode spots. The oxidising additive is necessary to stabilise these cathode spots, otherwise the arc will tend to flicker around on the surface of the workpiece, forming spatter, irregular weld bead and minimal penetration.



The metal transfer and penetration profile can be changed by selecting different argon-carbon dioxide mixtures. The figure shows the type of metal transfer in spray arc and typical penetration profile for mixtures with 2%  $\text{CO}_2$  up to pure  $\text{CO}_2$ . Higher  $\text{CO}_2$  content gives better side wall penetration but more spatter and fume. For most applications, the penetration given by a few percent of  $\text{CO}_2$  is acceptable. A spray arc cannot be achieved when using 100%  $\text{CO}_2$ .

### Carbon Dioxide or Oxygen?

There are often advantages in using  $\text{CO}_2$  in argon. One is the slight improvement in weld geometry and appearance over carbon dioxide-argon mixtures. This occurs because of the differences in weld pool fluidity, surface tension and oxides in the molten metal. With  $\text{CO}_2$  instead of  $\text{O}_2$ , there is also less oxidation and slag formation which can have an effect on the appearance of the weld as well as the need for cleaning the weld.

Another advantage is improved penetration, especially side wall penetration. This is mainly a factor of the higher arc voltage and the energy employed when welding with  $\text{CO}_2$  in the mixture.

### Helium

Helium (He) is like argon – an inert gas. Helium is used together with argon and a small percent of  $\text{CO}_2$  or  $\text{O}_2$  for GMA welding of stainless steel. In its pure state, or mixed with argon, it is used as a shielding gas for GTA and MIG welding. Compared with argon, helium provides better side wall penetration and higher welding speeds, by generating a more energy-rich arc. The process is more sensitive to arc length variations with helium as a shielding gas, however, and the arc is more difficult to strike when TIG welding.

### Hydrogen

Hydrogen ( $\text{H}_2$ ) can be added to shielding gases for GTA welding of austenitic stainless steels in order to reduce oxide formation. The addition also means more heat in the arc and a more constricted arc, which improves penetration. It also gives a smoother transition between weld bead and base metal.

For root protection purposes, hydrogen addition is commonly used. It is not recommended for root protection of austenitic-ferritic (Duplex) steels. For this application, argon or high purity nitrogen should be used.

### Nitrogen

Nitrogen ( $\text{N}_2$ ) is used as an additive in shielding gases for GTA welding of austenitic, duplex and superduplex stainless steels. These steels are alloyed with up to 0.5% nitrogen in order to increase the mechanical properties and resistance against pitting. If the shielding gas contains a few percent of nitrogen, nitrogen losses in the weld metal can be reduced.

Nitrogen with 5% hydrogen is a common root protection gas that delivers a good reducing effect. Pure nitrogen will further increase pitting resistance at the root when welding austenitic duplex and superduplex stainless steels.

# A versatile tool in the value-added process.

## The two product lines – Competence Line® and Performance Line®.

In order to achieve both technically and economically high-quality weld seams, everything involved in the process – material, equipment, process gas and welding technology has to do its part. This requires a new attitude towards our products. Shielding gases are much more than ‘welding consumable commodity’, they also:

- Influence the arc – both electrically and thermally
- Determine viscosity and surface tension – both of the drop and of the pool
- Control wetting properties
- Control penetration, seam geometry and seam surface
- React metallurgically with filler metal and pool
- Influence radiation, heat transfer and arc efficiency
- Determine metal transfer and energy distribution in the arc
- Influence certain pollutant emissions

These properties have to be optimally utilised in order to reap the full potential of gases in the welding process. Through our understanding of how this tool functions, we are able to make an active contribution towards the added value in our customers’ production processes

Our customers continue to demand specialised solutions to keep pace with the growing requirements in the field of welding. Advances made in equipment and materials science, new measuring technologies and simulation techniques require state-of-the-art, innovative gas products. Expensive specialised materials require customised solutions – sometimes even at a molecular level. Gases require the same diversification as materials and joining processes. To improve product transparency and to make selecting a product easier, we will be offering two product lines in the future. Both lines contain shielding gases for every conceivable material and process combination.

### Competence Line®

Proven gases and gas mixtures offering the very highest quality and supported by outstanding BOC service. This line contains our all-rounders, such as Argoshield® Universal, Stainshield® Light and argon, products that are indispensable to everyday welding technology and are ranked amongst some of the best-selling gas products in the world.

- Reliability
- Quality
- Versatility
- User-friendliness

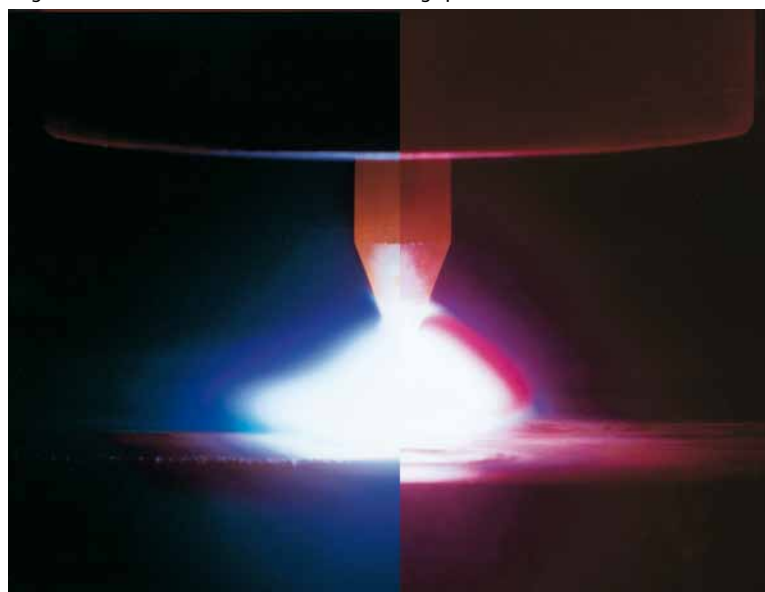
### Performance Line®

Highly productive specialists with ad mixtures of helium, nitrogen or hydrogen. These components improve arc efficiency and enhance heat transfer from the arc to the joint, resulting in higher welding speeds. If improvements in quality alone are required, helium or hydrogen can be used without increasing the welding speed. For example, helium can be used as an additive in many robot applications to better compensate for component tolerances. The wider acting arc improves edge wetting and reduces lack of fusion problems resulting in greater output and improved quality.

A TIG arc with Argon (Competence Line®) and Argoplas® 5 (Performance Line®) as the shielding gas.

Argon

Argoplas® 5



# Are you using the right gases correctly?

## Frequently asked questions.

Here are a few of the many thousands of questions BOC engineers are asked every year. Some of you will know the answer but for others, the answer may not be what you were expecting.

### Can my gases have separated in the cylinder?

Gases don't separate in a cylinder. In a cylinder, the gas molecules are constantly in motion and this ensures total mixing. If gases didn't stay mixed, air would have separated into oxygen and nitrogen by now!

### Why am I getting holes in my welds?

Holes (porosity) are usually caused by gas entrapment 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 can't 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. Surface contamination – oil, grease, water and other contamination on the welded component can add hydrogen into the weld metal

This is not an exhaustive list but most causes of porosity are caused by poor housekeeping and/or poor welding procedures.

### Why can I not use pure argon for GMA welding steels?

While it is possible to GMA-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 GMA welding steels, a small amount of oxidising gas (either carbon dioxide or oxygen) is needed to help to stabilise the arc and produce sound welds.

TIG Arc



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

There are several causes of spatter, but the most common 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 component – oil, grease, moisture
- surface coatings such as paint and zinc galvanising
- using carbon dioxide as the shielding gas – mixed gases are more stable and produce less spatter

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

## I get cracking when welding stainless steels. Why?

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

Hot cracking, properly called '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, properly called 'hydrogen cracking', occurs in welds that are intolerant of 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 cause the weld to crack. This may not occur until many hours after welding.

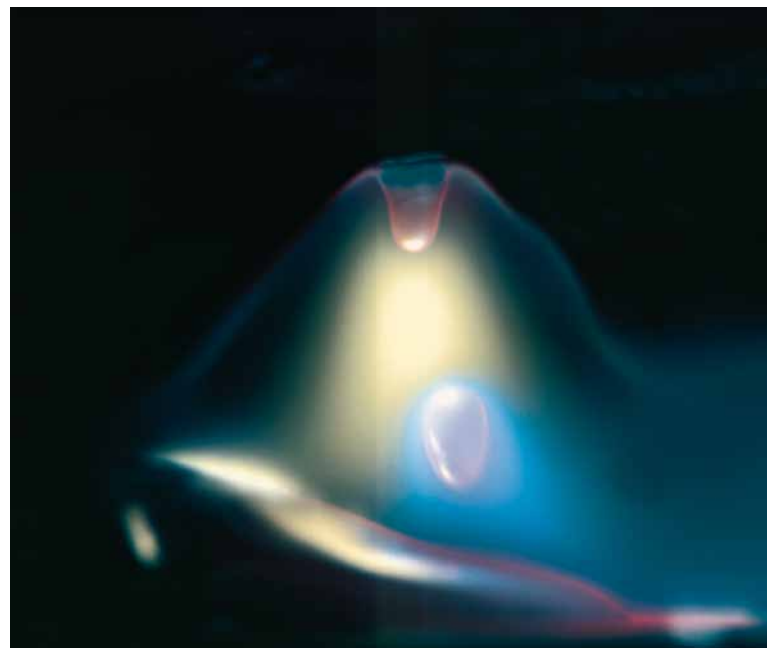
## What causes the sooty deposit when welding aluminium?

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 that 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. The use of an Alushield® shielding gas will also help reduce the coverage of aluminium oxide.

Pulsed Arc





# Our gases' capabilities grow with your requirements. Complex properties for specific uses.

An in-depth understanding of the 'internal properties' of gas components and their interaction in specialised mixtures is essential for successful use of process gases in specific welding applications. The welding arc itself, a highly efficient but complex tool, consists largely of different amounts of ionised gas and metal vapour. This means the physical properties of the gas have a direct and immediate impact on the arc. In addition, the process gases also contact the hot metal, a highly reactive area, in which the chemical and metallurgical effects of the gases also play an important role. The following criteria serve as examples only and do not claim to be complete.

## Dissociation and ionisation energy

Ionisation occurs directly in the case of the monatomic inert gases, Ar and He. Diatomic or polyatomic gases, such as  $H_2$  or  $CO_2$ , have to be initially dissociated in the arc, a process which requires additional energy. The less energy required for these processes, the easier it is to ignite the arc. If components that are comparatively difficult to ionise, such as He or  $CO_2$  are present, the welding voltage has to be increased accordingly. However, this additional electrical energy is released again in the form of recombination energy, which can both improve heat input and increase welding speed.

## Thermal conductivity

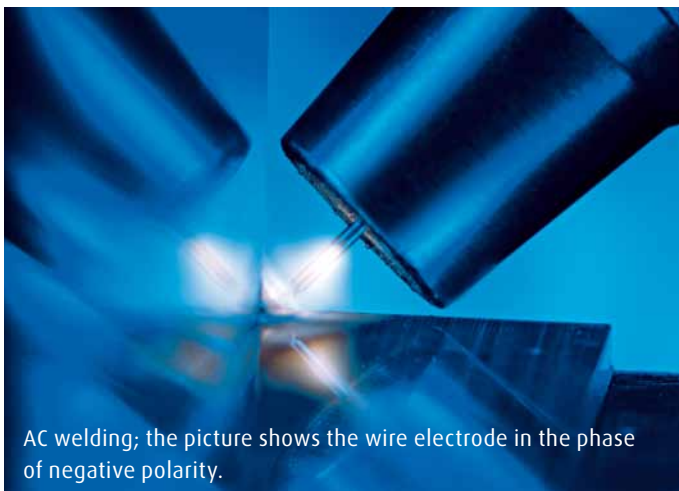
Some of the arc's heat is transferred to the workpiece via the plasma or gas flow. Especially at high temperatures, the two components He and  $H_2$  can significantly improve process efficiency. Good thermal conductivity has a positive effect on seam geometry, wetting, degassing of the molten pool – and on welding speed.

## Chemical reactivity and metallurgical impact

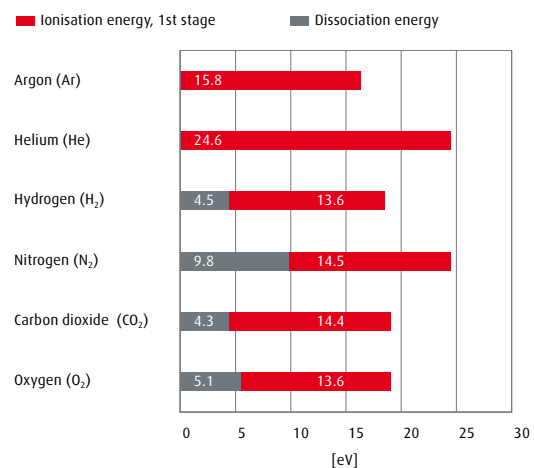
$CO_2$  and  $O_2$  are both active, oxidising gases. Especially at high temperatures, they react quickly with the materials present to form oxides. In appropriate quantities, metal oxides can improve arc stability. If larger percentages of active gases are present, for example, when GMA welding structural steel, the resulting increase in oxidation generates additional heat. The product of oxidation, otherwise known as 'slag' or 'silicate', is often found on the surface of the seam.  $O_2$  as a shielding gas component has a greater oxidising effect than the same quantity of  $CO_2$ . If quality demands require lower levels of these deposits, the active gas component in the Argoshield®/Stainshield® series can be reduced. However, this should only be done if requirements regarding fusion, penetration and the number of pores are taken into consideration. In the case of a higher  $CO_2$  content, carbon pickup may occur, depending on the material being welded.

## Thermal conductivity of the gases

Heat transfer from the arc to the base metal depends on the thermal conductivity of the different gases. Helium and hydrogen offer particularly high thermal conductivity values.



AC welding; the picture shows the wire electrode in the phase of negative polarity.





$N_2$  is considered a low-activity gas, i.e. whether or not reactions take place depends on the metal and the process conditions. An example of positive reactivity is the austenitising effect of Stainshield® Duplex gases when TIG welding fully austenitic materials or duplex steels. In contrast, the pore-forming or embrittling effect of  $N_2$  with GMA welding steel is detrimental.

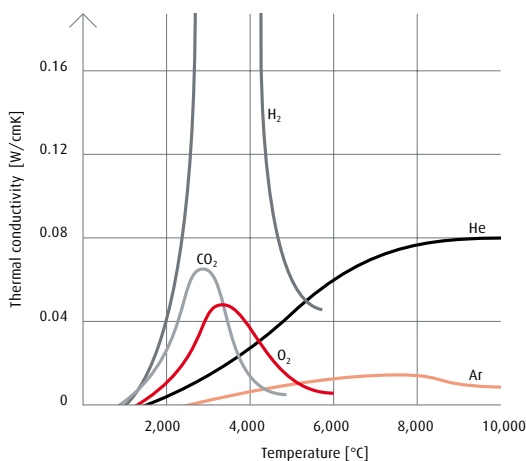
$H_2$  is unique as a particularly effective reducing component for arc welding. It can be used, for example, in TIG/PAW welding and forming of austenitic stainless steels with Argoplas® 5 gas, in other words, in cases in which it is important to prevent oxidation of very expensive and sensitive metals. Owing to their superior thermal conductivity and additional recombination energy, Argoplas® 5 gas permits much higher TIG/PAW welding speeds than argon. Unfortunately, these extremely beneficial properties cannot be used for welding all metals. For example,  $H_2$  leads to pore formation in aluminium and to cracks in ferritic steels. Thus,  $H_2$ 's compatibility with a given material always has to be tested.

Ar and He are the inert gases used in welding. Since they do not react with any metal, they can be used with all metals that can be fusion welded. Other relevant properties

- Relative density: influences the position-dependent effectiveness of the shielding gas
- Heat transfer coefficient: He can transfer heat to a metal surface much more effectively than Ar

## Dissociation and ionisation energy of the gas components

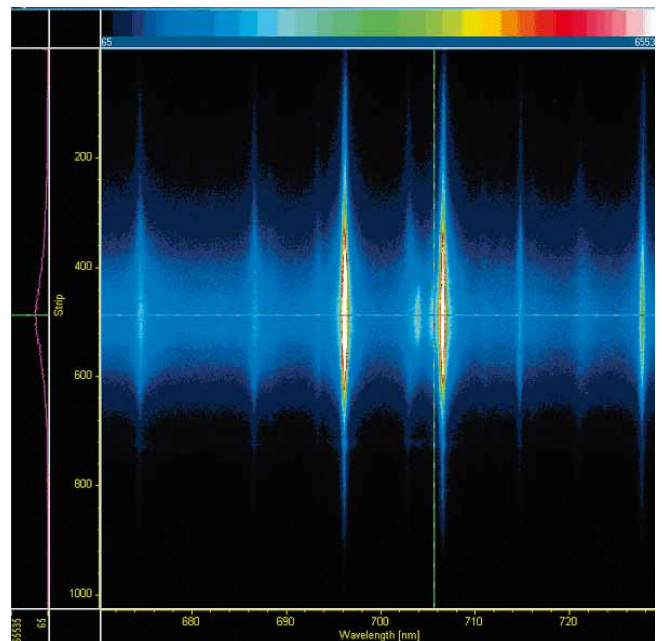
Parameters for ignition properties, welding voltage and arc energy



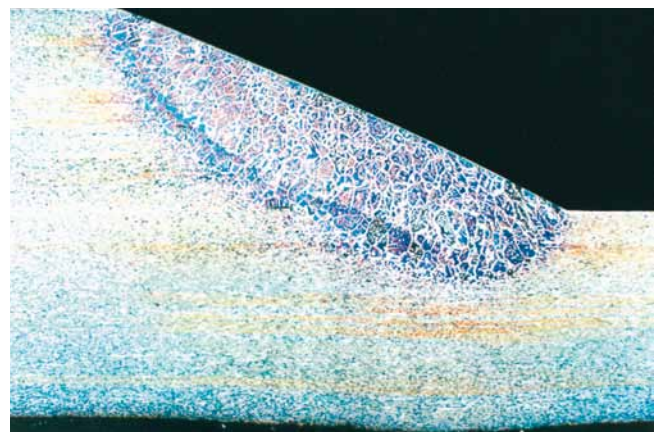
## Purity levels and mixing accuracies

Shielding gases are standardised in AS 4882 and ISO 14175. These standards specify, amongst other things, the minimum quality requirements of the components and mixtures. However, depending on the material, process, method and quality requirements, higher qualities may be necessary. In this case, please contact the specialists at BOC.

Use of scientific research methods to investigate plasma-physical processes in the arc: section of a spectral analysis of the MIGp welding process of aluminium with Alushield®.



Metallurgy via process gases: control of austenite-ferrite ratio when TIG welding duplex steels with Stainshield® Duplex.



# Proven under toughest conditions.

## Argoshield®: GMA welding of structural steel.

The collective term 'structural steel' refers to unalloyed and low-alloyed steels, fine-grained structural steels that are suitable for welding, including tubular and mild steels, unalloyed high-grade steels, as well as other alloyed steels that are not classified as stainless steels. The choice of the most suitable shielding gas depends mainly on the type of filler metal, the material thickness and surface condition of the base metals, the degree of mechanisation, working position, arc type and the requirements of the welded joint.

GMA welding with solid-wire electrodes and gas mixtures, consisting of Argon, CO<sub>2</sub> and O<sub>2</sub>, such as Argoshield® Universal, is by far the most common method for joining structural steels. Owing to their unbeatable advantages in terms of quality and economy, gas mixtures are now much more widely used than pure CO<sub>2</sub>. Thus, the general rule of thumb applies to how much active gas, CO<sub>2</sub> or O<sub>2</sub>, should be used: as little as possible and as much as necessary. Due to the increasing degree of mechanisation and the greater use of pulse techniques, mixed gases with a reduced CO<sub>2</sub> or O<sub>2</sub> content are becoming increasingly popular.

However, a lower level of active gases results in lower heat input, which can jeopardise fusion penetration and welding performance. In this respect, helium ad mixtures have proven effective in many applications.

A Helium content of 20–40% can improve heat transfer from the arc to the component, however, without the known disadvantages of the oxidising components. The increased efficiency of Argoshield® 100 gas can be used either for achieving higher welding speeds or for improving quality, such as better gap bridging or for reducing the risk of lack of fusion.

The shielding gas for metal-cored wires is selected according to the same criteria as those for solid-wire electrodes. These cored wires are flexible with regard to special alloying components and are characterised by a generally soft arc. Thanks to the powder filling, the power required for melting is lower than at comparable melt-down rate with solid-wire electrodes; this can also lead to a lower heat input.

Slag-forming flux-cored wires offer advantages for certain tasks. For example, when welding out of position, a quickly solidifying slag can act as a backing. By carefully defining the filling composition, the chemical and metallurgical reactions in the weld pool can be affected. As a rule, Argoshield® 52 or CO<sub>2</sub> is used; lower levels of CO<sub>2</sub> are not recommended since penetration can become critical.

### Competence Line®

Argoshield® Light

Argoshield® Universal

Argoshield® Heavy

Argoshield® 40

Argoshield® 54

Argoshield® MCW

Argoshield® 52

Carbon Dioxide

### Performance Line®

Argoshield® 100

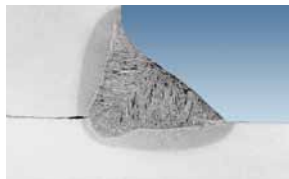


## Influence of gas components on penetration and seam surface: as an example, a fillet weld on a T-joint, sheet thickness 10 mm

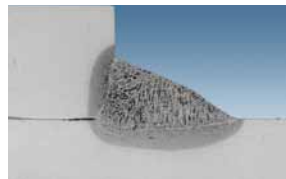
Fully mechanised GMA-robot weldments with constant travel and wire feed speed



Argoshield®MCW



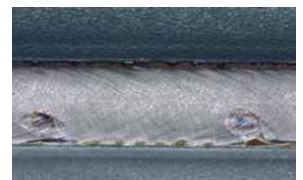
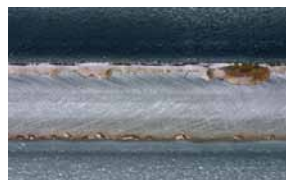
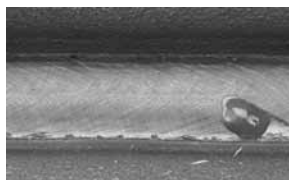
Argoshield®Heavy



Argoshield®40



Argoshield®100



### Effect of shielding gas composition on the GMA process and result

Criteria ↓	Gas components →			
	Ar + CO <sub>2</sub>	Ar + CO <sub>2</sub> + He Performance Line®	Ar + O <sub>2</sub>	CO <sub>2</sub>
Penetration in flat position welding	Good	Good	Adequate; good with thin sheets	Good
Penetration in out-of-position welding	Safer with more CO <sub>2</sub>	Safer with more CO <sub>2</sub>	Can be critical due to very liquid weld pool	Very safe
Avoidance of lack-of-fusion	Good	Improved by He content	Adequate, risk with weld pool flowing ahead	Adequate
Degree of oxidation ('slag formation')	Decreases with decreasing CO <sub>2</sub> content	Decreases with decreasing CO <sub>2</sub> content	Higher than comparable gases containing CO <sub>2</sub>	High
Pore formation in the weld seam	Becomes lower with increasing CO <sub>2</sub> content	Becomes lower with increasing CO <sub>2</sub> content	Most sensitive	Very low
Gap bridging	Becomes lower with decreasing CO <sub>2</sub> content	Improved by He content	Good	Poor
Spatter ejection	Decreases with decreasing CO <sub>2</sub> content	Decreases with decreasing CO <sub>2</sub> content	Low spatter	Heaviest
Notch effect at weld toe	Low	Lowest	Increases with sheet thickness	High
Heat transfer, heat input	Increases with rising CO <sub>2</sub> content	Increases with rising CO <sub>2</sub> or He content	Lowest	High
Arc types that are particularly recommended	Short arc, Spray arc, Pulsed arc (max. 25 % CO <sub>2</sub> )	Short arc, Spray arc (also high-performance) Pulsed arc (also high-performance)	Spray arc Pulsed arc	Short arc

# Special material properties require special gases.

## Stainshield®: GMA welding of stainless steels.

The shielding gases used for stainless steels differ from those used in GMA welding of unalloyed steels since they contain much less active gases, such as oxygen and carbon dioxide. This is necessary to prevent excessive oxidation of the passive layer responsible for the corrosion resistant properties of these metals. It is important to remember that the oxidation properties of oxygen are much greater than those of CO<sub>2</sub>. However, welding in an inert atmosphere, for example, with argon, is not recommended either since the pure argon arc is unstable and penetration is significantly decreased.

The carbon content of the weld metal is a key factor in ensuring resistance to intergranular corrosion. In stainless steels with particularly low carbon contents, referred to as ELC steels, the carbon content also of the weld metal should not exceed 0.03%. To prevent unacceptably high carbon pickup from the shielding gas, the CO<sub>2</sub> content of the above-mentioned products should be limited to a maximum of 2.5%. If welding is performed correctly, this prevents sensitisation to intergranular corrosion. The graph on the right illustrates the tendency of various shielding gases to cause the carburisation or decarburisation of the weld metal.

These guidelines apply if a solid wire or a metal-cored wire is used as filler metal. However, if a slag-forming flux-cored wire is used, the shielding gas recommended by the manufacturer should be used. An Argon/Carbon Dioxide shielding gas is usually recommended for these wires, e.g. Argoshield® 52, since the slag that forms prevents oxidation or carbon pickup.

### Application instructions

Austenitic and ferritic stainless steels are highly suitable for welding in the short and spray arc. The spray arc range starts at wire feed speeds about 20 % lower than in welding of unalloyed steels. The pulse technique offers certain advantages for welding high-alloyed materials, particularly with solid wire. It guarantees stable, almost spatter-free metal transfer throughout the performance range.

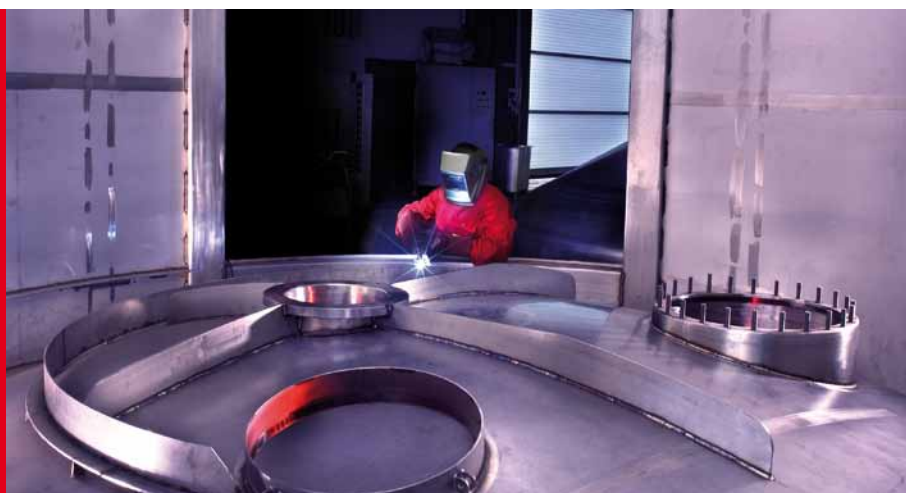
Due to their helium content, Linde's Performance Line® process gases offer improved heat input and a higher arc temperature. Consequently, it is possible to further increase the productivity of the GMA process. However, even if the welding speed is not increased, highly viscous materials, such as high-alloy CrNiMo steels and nickel-based alloys, also benefit from a higher energy input; fluidity and thus also wetting are improved considerably.

For austenitic-ferritic stainless steels, referred to as duplex steels, the same gases are recommended as for austenites. If duplex steel is used in a particularly corrosive environment, argon-oxygen mixtures are not suitable. Due to their higher oxidation properties, these gas mixtures would unnecessarily reduce the potential for corrosion resistance.

Competence Line®  
Stainshield®  
Stainshield® Light

Performance Line®  
Stainshield® Heavy  
Stainshield® 66  
Stainshield® 69

Stainshield® Heavy  
(source: EWM)

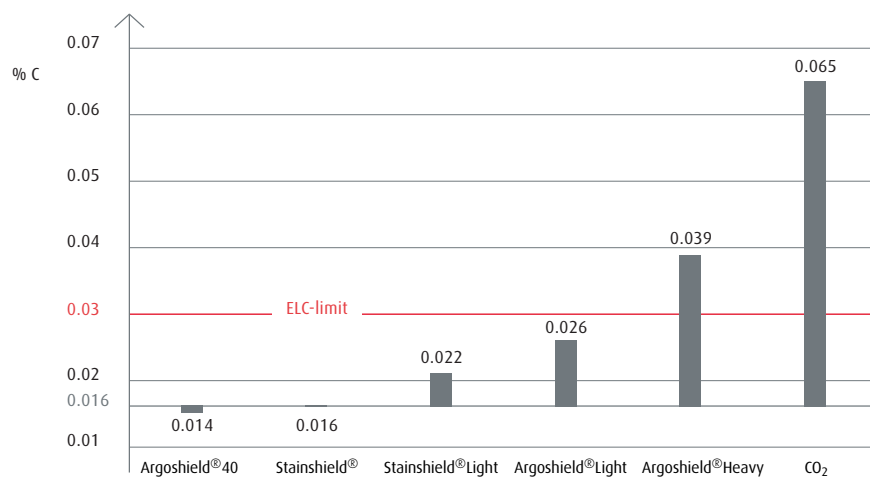


## Shielding gases at a glance

	Stainshield® Light	Stainshield®	Stainshield® Heavy
Degree of oxidation	Good	Good	Very good
Wetting properties	Good	Good	Very good
Welding speed	Good	Limited	Very good
Interpass weldability	Good	Good	Good
Spatter	Good	Good	Good
Arc stability	Good	Good	Good
Penetration	Good	Limited	Very good

## Carbon pick-up and loss with different shielding gases

Carbon content of the wire electrode: 0.016 %



## Impact of gases on surface oxidation

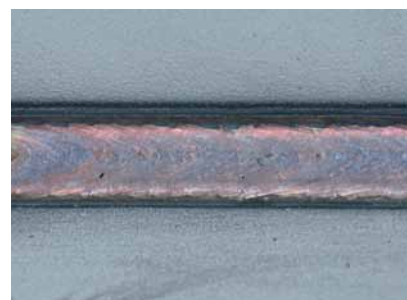
GMA fillet welds on stainless steel 304, sheet thickness 8 mm, mechanised welding



Stainshield®



Stainshield® Light



Stainshield® Heavy



# Quality, visible not only in the arc behaviour. Alushield®: MIG welding of aluminium alloys.

MIG welding of aluminium can be performed in the short, spray or pulsed arc. The advantages of the pulsed technique are that spatter formation is reduced and a wire electrode with the next largest diameter can be used. The thicker wire is easier to feed and, at identical melt-down rate, has a smaller surface area. Consequently, fewer impurities and less moisture are introduced into the weld seam via the wire.

The pulsed arc method can be further subdivided into direct current pulse and alternating current pulse since power equipment designed for both types of processes are now available. Welding with pulsed AC enables targeted distribution of the arc energy between the work-piece and the wire electrode. This technology expands the range of application of classical MIG welding of aluminium to include thinner components. It is also much easier to bridge gaps and to use thicker wire electrodes.

Argon is by far the most frequently used shielding gas for MIG welding of aluminium. It has impressive all-round properties and can be used for all types of arcs and in all positions. Further improvement can be achieved by using Alushield®.

Performance Line® gases are used in cases in which higher quality seams and increased welding performance are required. All gases in the Alushield® series contain helium, which makes the arc hotter, broader and more stable.

## Benefits of using Alushield®

- Reduced porosity
- Improved penetration, prevents lack of fusion
- Higher welding speeds
- Better gap bridging
- Less/no preheating of thick-walled components
- The more uniform heat input and better directional stability, facilitates the welding of components of different thermal conductivity, for example, thick-thin joins or cast nodes
- Reduced notch effect and better distribution of forces thanks to wider, flatter seams

The performance-enhancing effect of helium components and the arc-stabilising benefits of oxygen doping are effectively combined in the Alushield® series gases.

Competence Line®  
Argon

Performance Line®  
Alushield® Light  
Alushield® Universal  
Alushield® Heavy

Alushield® Heavy (source: EWM)



## Note on MIG welding with shielding gases containing helium (Alushields)

### Arc voltage

A higher helium content requires a higher arc voltage at identical arc length.

### Seam geometry

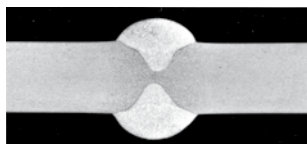
A greater helium content results in a broader and flatter seam at the same welding speed. The 'argon finger' is less pronounced and fusion penetration is rounder and deeper. This is advantageous, particularly in the case of dynamic loads.

### Shielding gas volume

Helium is lighter than air. This has to be taken into account both when measuring throughout and when adjusting the minimum shielding gas volume.

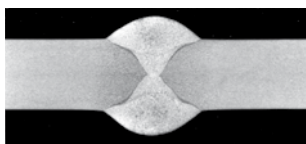
## GMA Welding of Aluminium Argon versus Alushield® Shielding Gases

Argon



280 A / 25 V

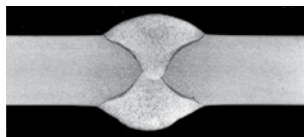
Alushield® Light



282 A / 27 V

Alushield® Light is 27% Helium with a balance of Argon

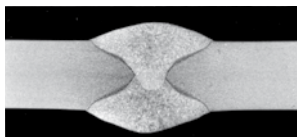
Alushield® Universal



285 A / 30 V

Alushield® Universal is 50% Helium with a balance of Argon

Alushield® Heavy



285 A / 34 V

Alushield® Heavy is 25% Argon with a balance of Helium

Parent metal	EN AW-5754 [AlMg3]	t = 10 mm
Filler metal	ISO 18273 - S Al 5183 (Al Mg4.5Mn)	Ø = 1.6 mm
Wire feed speed	9.7 m/min	
Welding speed	62 cm/min	

Alushields® are superior in most cases with regards to economics and quality.





# The somewhat 'colder' joint. Shielding gases for arc brazing.

Gas metal arc brazing (GMA brazing) is an alternative method for joining primarily thin ( $t < 3.0 \text{ mm}$ ) sheets that have been coated for corrosion protection. This method offers considerable advantages over GMA welding since an alloy metal with a lower melting point than the base metal is used as filler metal.

- Lower heat input
- Less burn-off of the coating
- Corrosion-resistant, copper-based filler metal
- Much less spatter formation
- Almost no seam corrosion
- Reduced distortion
- Good gap bridging

The right choice of shielding gas can further boost these positive properties. In addition to the shielding gas, other key factors influencing the quality of the join are the base metal, the type and thickness of the coating, and the alloy used for the filler metal.

Both short and pulsed arc GMA brazing are possible. Pulsed arc brazing can be further classified as DC pulsed and AC pulsed brazing since power sources enabling brazing with an alternating current have now been available for some time. AC pulsed brazing enables an accurate distribution of energy between the workpiece and the wire electrode. This is even gentler on the coating and results in even better gap bridging.

The shielding gas has a varying effect on the final brazing result, depending on the type of solder used and the base metal or its surface condition. Argon is the universal shielding gas for GMA brazing since it can be used with all solders, for all types of arcs and in all positions. It offers impressive all-round properties and a low heat input. The disadvantages of argon are somewhat unstable arc and a tendency towards porosity. Although the very small gas pockets do not have a negative effect on the strength of the join, they appear when the seam is being polished. This results in extensive finishing work, particularly in visible areas.

When brazing coated sheets with SG-CuSi3, the result can be improved by adding active components. Stainshield®, in particular stabilises the arc and reduces porosity. The slightly increased heat input in comparison with argon translates into higher process speeds and improved wetting.

When brazing with CuAl alloys, the amount of active component content in the shielding gas has to be restricted. However, here too, adding specific quantities of inert helium can also improve the final results. Products in the Alushield® series improve seam appearance, offer outstanding flow and wetting properties and, owing to a much higher brazing speed, also result in a lower heat input.

Performance Line® shielding gases are also the gases of choice for soldering stainless steel. Since no zinc vapours are produced that disturb the arc, the above mentioned advantages are even more pronounced.

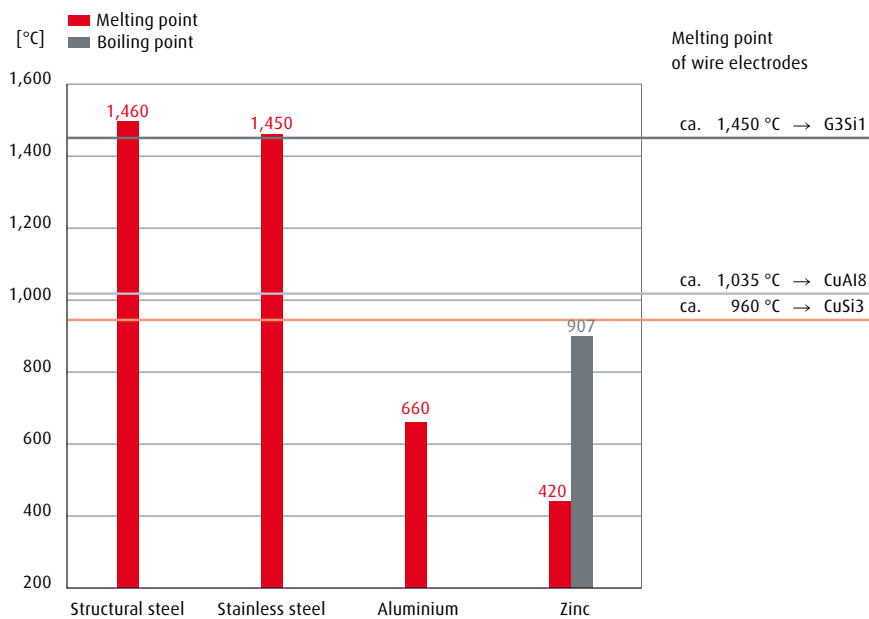
Tungsten inert gas (TIG) or plasma arc (PA brazing) brazing are also possible. Since the tungsten electrode cannot be used with gases with a high active-component content, only inert argon or gases in the Alushield® series can be used.

Competence Line®  
Argon  
Stainshield®

GMA brazing with Alushield® Universal  
(source: EWM)



## Low melting point of the copper solder enables lower heat input and thus lower Zn vaporisation with coated sheets

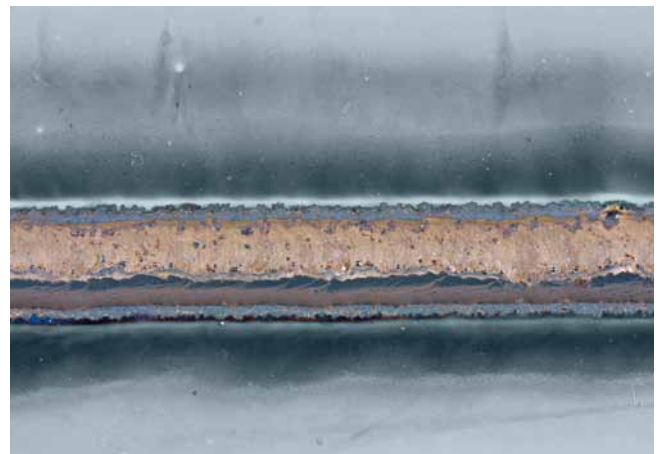


## Improvement in process stability, seam appearance, and wetting

with robotic GMA brazing of coated sheets with SG-CuSi3 using Stainshield®



Argon



Stainshield®

# For top quality requirements. Stainshield® and Alushield®: TIG welding.

In TIG welding, the arc burns between the workpiece and a non-consumable tungsten electrode. To protect the electrode and molten pool from oxidation, both are purged with an inert shielding gas, generally argon. This welding process is suitable for all fusion-weldable metals. The type of current, polarity and shielding gas used depends on the base metal. TIG welding can be carried out both with and without filler metal.

## Application advice

The addition of hydrogen or helium is especially beneficial to heat distribution and heat transfer in the arc, particularly with TIG welding. The Performance Line® offers a broad range of specialty gases that, owing to their hydrogen or helium content, enable a distinct increase in productivity.

Agroplas® 5 is primarily recommended for TIG welding of austenitic stainless steels and some nickel-based alloys. The hydrogen content in the gas permits more energy to be exchanged in the arc. This, in turn, results in deeper penetration and/or greater welding speeds. The hydrogen content may be as much as 15%, although the realistic upper limit for manual

welding is 5%. As a rule, gases with a higher hydrogen content are only recommended for mechanised welding, since it is more difficult to control the heat and the pool is very fluid. Gases containing hydrogen must not be used to weld aluminium alloys or steels sensitive to hydrogen since this can lead to greatly increased porosity or embrittlement.

Since helium (like argon) is an inert gas, the gas mixtures in the Alushield® series can also be used for aluminium alloys, all types of steel, and for gas-sensitive metals.

The gas in Stainshield® Duplex was developed especially for TIG welding duplex steels or fully austenitic materials. The addition of nitrogen causes the austenisation of the weld metal, which is particularly beneficial when TIG welding duplex steel without filler metal. These gases have also proven valuable for low-ferrite welding of high-alloy metals in the chemical industry.

Competence Line®  
Argon

Performance Line®  
Agroplas® 5  
Stainshield® Duplex  
Alushield® Light  
Alushield® Universal

TIG – the arc method for top quality results, also in the aerospace industry

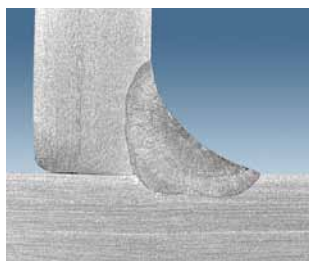


## Shielding gases at a glance

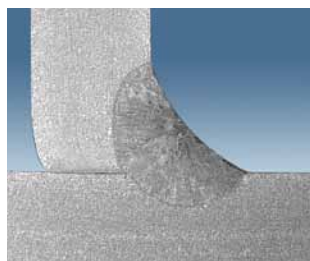
Competence Line®	Performance Line®	Material	Comments
Argon		All fusion-weldable metals	Suitable for universal use, minimum purity requirement with highly reactive materials 4.8
	Alushield® Light Alushield® Universal Alushield® Heavy	Al and Al alloys Cu and Cu alloys	Higher heat input due to addition of He — Better penetration — Higher welding speed
	Helium	Al and Al alloys	TIG direct-current welding with electrode with negative polarity
	Argoplas® 5	Austenitic stainless steels Ni-base metals	Addition of H <sub>2</sub> results in hotter arc Better penetration Higher welding speed Cleaner seams due to reducing action
	Stainshield® Duplex	Duplex and super duplex steels	Control of the austenite-ferrite ratio in the weld metal

## Argoplas® 5 improves speed of welding and penetration

Manual welding of stainless steel 1.4301, sheet thickness 4 mm



TIG DC, argon,  $v_s = 13$  cm/mm



TIG AC, Argoplas®,  $v_s = 18$  cm/mm

## TIG Welding of Stainless Steel Argon versus Argoplas® 5



### Competence

Welding gas: Argon  
Welding speed: 35 cm/min, mechanised welding  
Parent material: 304,  $t = 4$  mm  
Filler metal: 308LSi



### Performance

Welding gas: Argoplas® 5  
Welding speed: 55 cm/min, mechanised welding  
Parent material: 304,  $t = 4$  mm  
Filler metal: 308LSi

# Greater power density thanks to a constricted arc. Stainshield® and Alushield®: plasma welding.

Plasma arc welding (PA welding) differs from TIG welding in that the arc is constricted by means of an additional, water-cooled nozzle. At the same time the electrode is moved backwards to the inside of the burner. This constricted arc has a much greater power density than a TIG arc.

Two gas flows are required for PA welding: inner plasma gas and shielding gas. Argon is generally used as the plasma gas. In rare cases, argon with a H<sub>2</sub> content of up to 5% is also used, but it must be compatible with the metal. The shielding gas is selected according to the same criteria as for TIG welding. Argon is a very good all-round gas that can be used with all materials.

Performance Line® shielding gases are generally used to increase welding performance. Alushield® gases are suitable for all materials. Argoplas®5 gas has been optimised for high-alloy stainless steels.

Depending on the type of method and performance range, PA welding can be further classified into micro-plasma welding (0.1–50 A, t = 0.05–2.5 mm), plasma thick-sheet welding (50–350 A, t = 2.5–10 [12] mm) and plasma keyhole welding (from 60 A, t > 2 mm).

## Metals suitable for plasma welding

- Unalloyed/low-alloy steels
- High-alloyed steels: CrNi and CrNiMo (good for keyhole methods due to high viscosity of the melt)
- Ni, nickel-based alloys
- Titanium and its alloys
- CuNi alloys, Cu
- Aluminium and its alloys

## Applications of this welding method include

- Chemical equipment manufacture
- Aerospace industry
- Vessel construction
- Food industry
- Automotive industry

Competence Line®  
Argon

Performance Line®  
Alushield® Light  
Alushield® Universal  
Argoplas® 5

Plasma-spirally-welded aluminium  
pipes (Source: Linde Engineering)





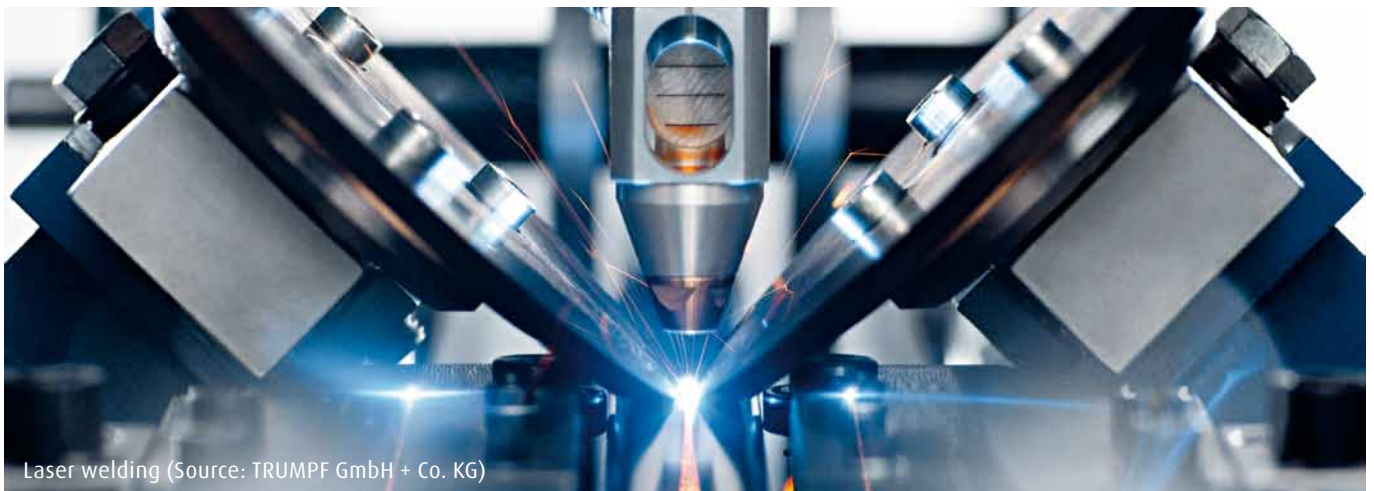
# Where precision and speed meet. Process gases for laser welding.

At high welding speeds, laser welding offers targeted heat input and low distortion. Mostly laser welding is performed without any additional material. However, in some cases this may be necessary due to metallurgical reasons or to bridge gaps. Steels, light-weight metals and thermoplastics are suitable for laser welding.

Different types of lasers are used for laser welding: CO<sub>2</sub> lasers or solid-state lasers (Nd:YAG, diode, fiber or disc lasers). Shielding gases are essential for high-quality welds, whatever the laser type. Whereas material considerations determine the choice of shielding gas when using solid-state lasers, when using CO<sub>2</sub> lasers, the interaction between the shielding gas and the laser beam also has to be taken into account.

Therefore, helium and gas mixtures containing helium are used when welding with CO<sub>2</sub> lasers. For example, Specshield® is used for laser welding low-alloy or galvanised steels. Argon and mixed gases of Specshield® quality is used with solid-state lasers.

The choice of shielding gas essentially depends on the arc process and on the material to be welded.



Laser welding (Source: TRUMPF GmbH + Co. KG)

# For top-quality workmanship. Gases for root protection.

When subjected to high temperatures and atmospheric oxygen, many metals tend to intense oxidation. The oxides generally appear as temper colour, for example, with stainless steel or titanium materials. Temper colours will greatly impair the corrosion resistance of such metals. Further more, severe oxidation will impair the formation of weld roots. Thus, in many cases, the root side has to be protected against oxygen in order to ensure optimum corrosion resistance. The careful exclusion of atmospheric oxygen can prevent oxidation and temper colours.

## Differentiating between two different purging methods

In the case of gas displacement, the backing gas pushes forward the air to be removed, with only little mixing occurring. This principle is conceivable, for example, for large vessels. With this method it is very important to take the relative density of the backing gas into account. In a – purely theoretical – ideal-case scenario, with this type of purging, only as much backing gas is used as that of the volume to be purged.

In the case of dilution purging, the backing gases distributed uniformly throughout the area and mixes with the air to be removed. The purging continues until the amount of residual oxygen has fallen below a certain threshold. The amount of shielding gas required is thus several times that of the purging volume.

## Two groups of gases are used for root protection

- Inert or low-activity gases, such as argon or nitrogen
- Inert or low-activity gases with added hydrogen

Thanks to the reducing action of hydrogen, root-shielding gases containing hydrogen offer greater protection against the formation of temper colours. However, they are not suitable for all metals. The type of gas used for root protection primarily depends on the type of metal of the component to be purged. Steels that are sensitive to hydrogen or highly reactive metals, such as titanium, are generally purged with argon. Austenitic stainless steels can be protected with root shielding gases containing hydrogen, for example, with gases from the 'Forming gas' + Argoplas® or the Stainshield® series.

## Application advice

Gases for root protection are standardised in ISO 14175.

- Group R (Ar-H<sub>2</sub> mixtures)
- Group I (Ar or Ar-He mixtures)
- Group F (N<sub>2</sub> or N<sub>2</sub>-H<sub>2</sub> mixtures)

### Competence Line®

Argon  
Nitrogen  
Argoplas® 5  
Forming gas

Welding with additional forming gas





Minimum purging times have to be observed to prevent the formation of temper colours. The required purging time depends on the geometry of the component and on the volumetric flow rate of the gas. The recommended value for required backing gas volume for pipelines, for example, is 2.5–3 times the geometric volume of the component, calculated from the supply point to the welding point. Depending on pipe diameter, a gas flow rate of 5–12 l/min is recommended. The use of a measuring device to measure the residual oxygen content is recommended.

To prevent the formation of temper colours, after welding, purging should continue until the component has cooled to a temperature of below approx. 220°C. If the root of the weld is not accessible after welding for reworking, a root shielding gas should be used when tacking the component since temper colours will not be dissolved by welding over the tack. In the case of Ti-stabilised stainless steels, gases containing N<sub>2</sub> cause a clearly visible yellowing of the root of the weld as a result of the formation of titanium nitride. With duplex and super-duplex steels, using root-shielding gases that contain nitrogen or pure nitrogen improves corrosion resistance.

## Safety information

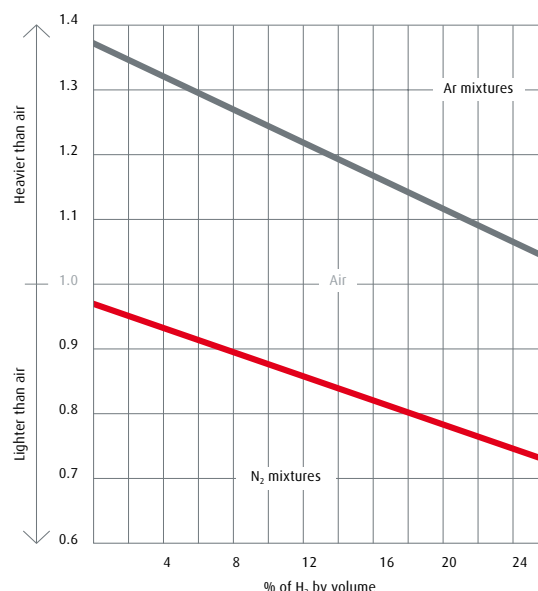
Root shielding gases with a hydrogen content of more than 4% can form explosive mixtures if they come into contact with air or oxygen. Users must take certain precautionary measures to prevent the formation of such gas mixtures. For safety reasons, BOC recommends burning-off if the hydrogen content in the root shielding gas is 10% or higher.

When forming large, closed components, adequate ventilation must be available before inspection to prevent the risk of suffocation. When working in small rooms, oxygen depletion should be taken into account.

## Root shielding gases for various materials

Shielding gas		Material
Argon		All fusion-weldable metals
Argoplas® 5	Ar-H <sub>2</sub> mixtures	Austenitic stainless steels
Forming gas	N <sub>2</sub> -H <sub>2</sub> mixtures	Austenitic stainless steels (not Ti-stabilised) Unalloyed steels (not high-strength fine-grained steels!)
Stainshield® series	Ar-N <sub>2</sub> mixtures	Austenitic stainless steels (not Ti-stabilised)
	N <sub>2</sub>	Duplex and super duplex steels

## Relative density of root shielding gases



TIG seam, root side, no root protection



TIG seam, root side, with root protection

For more detailed information on purging or BOC purging equipment, please request a copy of our technical publication 'Purging While Welding'.

# Practical solutions for extraordinary materials.

## Welding gases for special materials.

The group of so-called special metals is not clearly defined. In general, special materials are defined as materials that are not considered 'standard' materials, such as aluminium, structural steel or stainless steel. These special metals include nickel-based metals, copper or magnesium, as well as reactive metals such as titanium, tantalum and zirconium.

### Reactive materials: Ti, Ta, Zr

Titanium, tantalum and zirconium are termed 'reactive' materials since they react readily with  $O_2$ ,  $N_2$  and  $H_2$ . These processes are promoted by the heat generated during welding. Picking up even tiny quantities of atmospheric gases can lead to the total embrittlement of the weld seam. This embrittlement cannot be reversed by heat treatment. Under the influence of heat, oxygen also causes greater surface oxidation, which severely affects the corrosion resistance of these materials. The use of appropriate gas protection during welding is the most important factor in protecting such valuable materials from these negative influences.

TIG welding, generally with pure argon as shielding gas, is the most common welding process used for such materials. Purity should be at least 4.5 (99.995 %). Inert He mixtures, such as Alushield®Light, can also be used for thicker walls and for improved penetration.

### Nickel metals

In the case of nickel alloys, the choice of a suitable shielding gas greatly depends on the type of alloy to be welded. A variety of nickel alloys are available on the market, which, depending on their area of application, vary greatly in terms of their metallurgical properties and suitability for welding. As a result, there are also a number of different recommended gases. Users should contact BOC if there is any doubt as to which gas to use.

### TIG welding

Many nickel alloys can be easily welded using argon-hydrogen mixtures, e.g. Argoplas®5. Other materials, for example, those that are particularly susceptible to hot cracks, are better processed with pure argon. However, for metallurgical reasons, some high-temperature nickel-based alloys require the addition of nitrogen to the shielding gas, e.g. Specshield®Ni. This product is not a stock item and needs to be made to order.

Competence Line®  
Argon

Performance Line®  
Stainshield® Duplex  
Alushield® Light  
Alushield® Universal  
Specshield® Ni

GMAp arc under Specshield® Ni



## GMA welding

The gases in the Specshield® Ni were specially developed for GMA welding of nickel-based materials. These patented gas mixtures are all doped with CO<sub>2</sub>. This minute amount of CO<sub>2</sub> stabilises the arc perceptibly without impermissibly altering the carbon content of the weld metal.

Specshield® Ni also contain hydrogen or helium, which improves flow properties and seam appearance and at the same time, maintains the material's corrosion resistance.

Specshield® Ni was developed especially for GMA welding of the high-temperature alloy 602CA. In addition to CO<sub>2</sub> doping, this gas contains helium and nitrogen. The latter clearly reduces the risk of hot cracking during welding.

## Copper metals

Copper and most copper alloys are characterised by very high thermal conductivity. To compensate for the rapid dissipation of welding heat, gases containing helium are recommended for use with these metals. Alushield® Light or Alushield® Universal are the gases of choice for both TIG and for MIG welding, particularly if preheating can be reduced as a result of their use. To prevent the risk of hydrogen brittleness when welding copper, shielding gases containing H<sub>2</sub> should not be used.

## Magnesium metals

Inert gas mixtures, namely argon, helium and their compounds, are used for gas-shielded arc welding of magnesium alloys. Argon can be used for all welding methods, apart from TIG direct current. However, Alushield® mixtures are generally recommended as shielding gas as they can reduce pore formation.

Only shielding gases with very high helium content (such as Alushield® Heavy), or pure helium, can be used for TIG DC welding of magnesium with the electrode at negative polarity. Otherwise, there will be not enough heat for welding. In the case of MIG welding, due to the high electrical resistance of magnesium and the associated heating of the free end of wire, the amount of energy that can be transferred in the wire is limited. This can be somewhat compensated for by using a welding gas that contains helium. In addition to the classical pulsed and short arc processes, MIG welding has recently also been carried out in the form of special pulsed or controlled short arc welding. Alushield® mixtures can also be used with these methods to reduce pore formation.

Production of a furnace roll made of Nicrofer®6025HT/alloy 602CA with Specshield®Ni. (Source: H. BUTTING GmbH & Co. KG)





Overview of  
the installation



# The GMA Arc Projector.

## Well known in the welding world.

For about 30 years, The Linde Group has been using the GMAW arc projector to demonstrate the benefits of using shielding gases in real arc time. Welders, welding specialists, welding engineers, sales teams and customers around the world recognise the arc projector and its incredible capabilities. BOC, a member of The Linde Group, is now proud to have exclusive access to this world-renowned projector.

The arc projector can simultaneously show an image of the GMA welding arc (optically magnified 80x) with the corresponding welding parameters, such as wire feed speed, voltage, stick-out, current, pulse frequency, shielding gas composition etc. As soon as the parameters are changed, you can observe how the arc is affected.

What's unique about the GMA arc projector is that it shows a real welding arc - not a simulation, still image or a pre-recorded video. This therefore significantly improves its credibility in live demonstrations, when specific changes to parameters are made.

The first generation of the arc projector used optical projection – a lens system together with a moving laser dot on a parameter table (current, voltage). The other parameters were indicated separately on numeric displays. This system has now been superseded with a new arc viewing system.

Additionally, the concept and look of the old projector was updated to coincide with the release of new technology features in the projector.

The new arc projector is designed to still work with an optical projection system, as it was found that even today's video cameras cannot cope with the extreme contrast and brightness of a welding arc. The optical projection simply offers the best possible image quality.

To show the welding parameters, the new arc projector uses a rugged and self-contained PC measuring system, combined with a standard beamer. The projector software is custom-made and proprietary, and is therefore adapted to the BOC shielding gas range.

The operator panel consists of a gas mixer for Ar/CO<sub>2</sub> mixes, 4 gas selection buttons, welding start/stop and several other controls. To operate the PC, there is a keyboard with an integrated mouse/trackball.

The arc projector can also

- demonstrate the influence of the stick-out on the amperage (to illustrate why you should always measure the wire feed speed, and not only the amps)
- show how to set up a pulsed arc and what the influencing parameters are
- guide a whole audience through various arc types and settings and the effects of shielding gases

In summary, the arc projector is able to display the significant difference that BOC shielding gases can make to your weld.

- Argoshield®
- Stainshield®
- Alushield®
- Specshield®

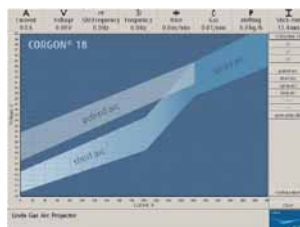
Operator Panel



Inside view of the projection chamber



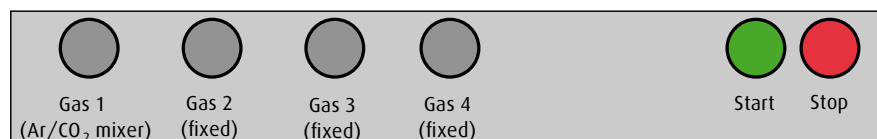
Parameter screen (beamer)



Welding arc screen (optical lens projection)



Operator Panel



For more information contact the  
**BOC Customer Service Centre** on:

**Australia**

**131 262**

[contact@boc.com](mailto:contact@boc.com)

[www.boc.com.au](http://www.boc.com.au)

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