BOC
A Linde company

Shielding Gas

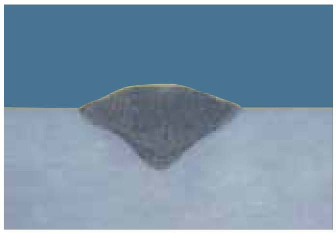
The Right Gas Working for You

Contents.

Can a shielding gas affect the weld quality?
Choosing the right gas.

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

17.1g

ARGOSHIELD® Heavy

8.6g

ARGOSHIELD Universal

5.5g

For many people, the sole role of the shielding gas is to protect the finished weld from the effects of oxygen and nitrogen in the atmosphere. What isn't widely understood is that selecting the right shielding gas for the job can bring many more benefits.

The choice of the shielding gas can affect:
- the weld metal properties, such as strength, corrosion resistance and toughness
- the weld bead shape and size
- the weld porosity and fusion
- welding speed and amount of spatter

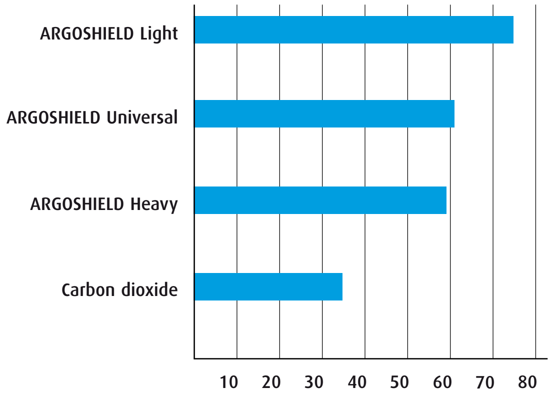
Weld metal properties

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

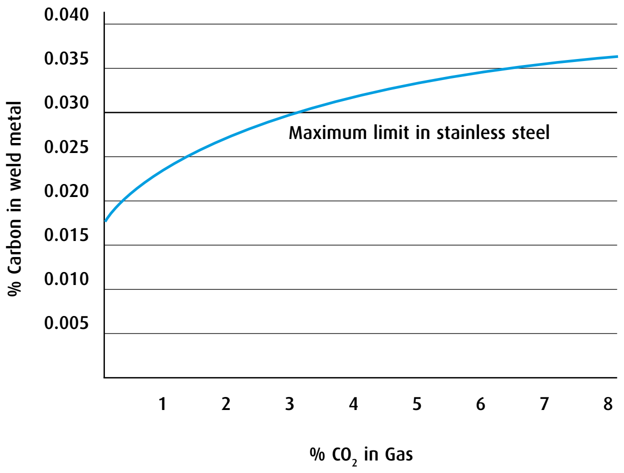
Adding oxygen and/or carbon dioxide to a shielding gas for MIG welding carbon steel increases its oxidation potential. In general, for a given welding wire, the higher the oxidation potential of a shielding gas, the lower the strength and toughness of the weld. This occurs because the oxygen and carbon 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.

When MIG welding stainless steel, the amount of carbon dioxide in the shielding gas has an effect on the corrosion resistance of the resulting weld metal. In particular, carbon transfer into the weld from the gas can produce unacceptably high carbon content 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 carbon pickup 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) also benefit from a limited CO_2 content because surface oxidation is greatly reduced.

Impact values at -20°C (joules)



% CO_2 in Gas



The addition of carbon dioxide and oxygen to argon for MIG welding carbon steels increases weld fluidity – allowing faster welding speed and improving the stability of metal transfer.

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 instances 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. Adding carbon dioxide to the shielding gas has a significant effect on the shape of the weld bead, making it wider and more rounded, so reducing the chances of fusion defects occurring.

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 occur. The addition of helium to the argon shielding gas 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 trapped gas more time to escape.

Another way in which the shielding gas can improve the weld quality is 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 reduces the surface tension of the weld metal, allowing the solidifying weld pool to sink and resulting in a weld with lower reinforcement.

Operational performance

There are many ways in which a shielding can improve welding-process performance. For example, the addition of hydrogen to argon when TIG welding-austenitic stainless steel results in a more fluid arc, which allows welding speeds to be significantly increased.

The use of carbon dioxide when MIG welding carbon steels can cause large amounts of spatter to be ejected from the weld pool. By using an argon/18-20% carbon dioxide mixture, the amount of spatter can be halved and by moving to an argon/12% carbon dioxide/2% oxygen mixture, this value can be halved again. Removing spatter after welding is both costly and can cause problems if the component is subsequently painted or coated, as the small marks left by the spatter show up as surface imperfections.

Which is the right process for you?
Welding processes.

MIG

The four most common welding processes are:

MIG (Metal Inert Gas) welding, also known as MAG (Metal Active Gas) welding and GMAW (Gas Metal Arc Welding). In Europe, the term 'MIG' is used only when a totally inert gas shield like argon is used, and 'MAG' when the shielding gas also contains active constituents, such as carbon dioxide or oxygen.

TIG (Tungsten Inert Gas) welding, also known as GTAW (Gas Tungsten Arc Welding).

FCAW (Flux Cored Arc Welding).

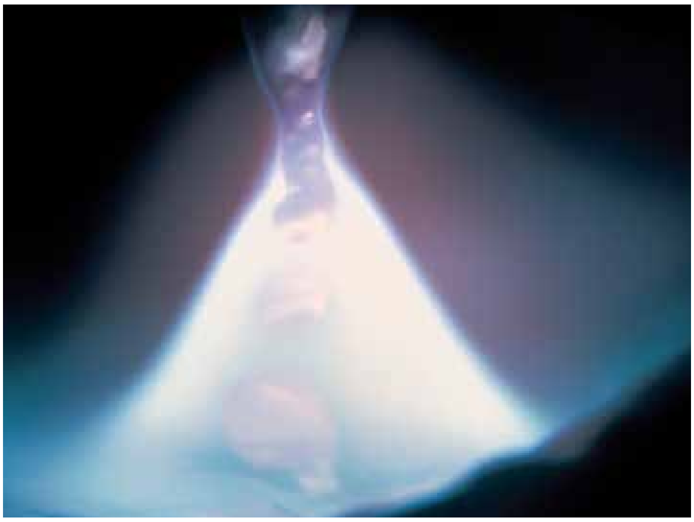
MMA (Manual Metal Arc) welding, also known as SMAW (Shielded Metal Arc Welding).

Each process has strengths and weaknesses; some can be automated, others cannot. But how does each compare?

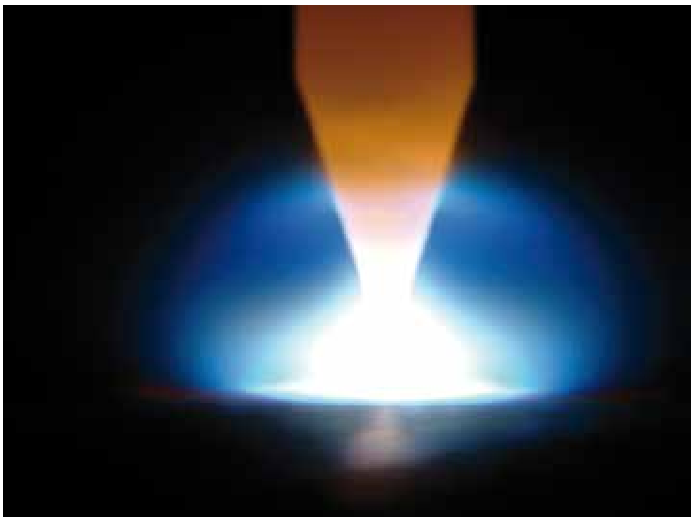
MIG versus MMA

- MIG is a high-productivity continuous process requiring little down time
- MIG can be used semi-automatically, automatically and robotically; MMA is manual
- MIG is suitable for a wide range of common materials. MMA electrodes are available primarily for ferrous materials and nickel alloys
- MIG requires a shielding gas; MMA requires no shielding gas
- MIG suffers from draughts affecting the gas shield. MMA is ideally suited to outside and site work because the electrode coating generates its own shielding gas
- MIG doesn't create a slag cover; MMA requires the slag to be removed
- Welding speeds are much quicker with MIG
- With MIG, about 98% of the consumable weight is converted into weld metal compared to about 65% for MMA

MIG



TIG



MIG versus TIG

- Skill levels for MIG welding are lower than those required for TIG
- Welding speeds for MIG are generally about double those for TIG
- Weld costs per unit length are much higher in TIG welding
- Generally, defect levels in TIG welds are lower than those for MIG, and TIG tends to be used for intricate work and where a high-quality finish is required

MIG versus FCAW

- FCAW is mainly limited to carbon and low-alloy steels and some types of stainless steel
- Positional welding can be easier using some flux-cored wires than with MIG
- MIG requires a shielding gas; some types of cored wire require a shielding gas but others don't
- Flux-cored wires are much less efficient, about 65–80% compared with 98% for MIG
- MIG and FCAW welding speeds are very similar
- MIG doesn't create a slag cover but FCAW requires the slag to be removed

TIG versus MMA

- TIG can be used manually or automatically whereas MMA is a manual process
- TIG can be used for all metals and alloys whereas MMA is limited. However for alloys where MMA electrodes are available, they can be tailored to suit the composition of the parent material
- TIG requires a separate shielding gas but MMA produces its own shielding gas
- TIG can suffer from draughts disrupting the gas shield. MMA is ideally suited to outside and site work as it generates its own shielding gas
- TIG doesn't create a slag cover and needs little post-weld cleaning but MMA requires the slag to be removed

MMA versus FCAW

- MMA is predominantly a manual process whereas FCAW can be used semi-automatically, automatically and robotically
- MMA electrodes and flux-cored wires cover very similar ferrous, stainless steel and hardfacing materials
- FCAW may be operated with or without a separate gas shield (depending on the type). MMA never requires a separate shielding gas
- Self-shielded cored wires are ideal for site work, as is MMA
- Welding speeds are much quicker with FCAW, so joint completion times are much faster.
- With MMA, only about 65% of the consumable weight is converted into weld metal compared with up to 80% for FCAW

Providing the right gas for you.
Product range.

Product range
ARGOSHIELD Light
ARGOSHIELD Heavy
SPECSHIELD® 20% CO_2
ARGOSHIELD Universal
Carbon Dioxide
SPECSHIELD 2.5% CO_2
STAINSHIELD® Heavy
STAINSHIELD Universal
STAINSHIELD Light
STAINSHIELD TIG
SPECSHIELD 5% H_2
SPECSHIELD 2.5% N_2
PURESHIELD® Argon
ALUSHIELD® Light
ALUSHIELD Universal
ALUSHIELD Heavy
SPECSHIELD 35% H_2

For any application, it is important to choose the right shielding gas. BOC provides an extensive shielding gas range to meet all requirements. To make the choice easier, the following pages present the attributes of each shielding gas for different materials, allowing you to select those that are most important for your application.

Our product range includes some shielding gases that have been tailored to offer added benefits. These have been specially developed to optimise the performance of the shielding gas in one or more respects.

BOC shielding gases provide you with a competitive advantage by reducing manufacturing costs through increasing production, reducing reject rates and improving quality.

All our products are proven mixtures offering the highest quality time and time again, meeting or exceeding ISO 14175:2008 standards.

For further information on the standards please refer to the BOC publication 'White Paper – ISO 14175:2008'.

Nominal composition (%)							ISO 14175:2008	Material/process
Ar	He	CO_2	O_2	H_2	N_2	NO		
93		5	2				M14 - ArCO - 5/2	MIG welding carbon steel
78		20	2				M26 - ArCO - 20/2	
80		20					M21 - ArC - 20	
86		12	2				M24 - ArCO - 12/2	
		100					C - C	
97.5		2.5					M12 - ArC - 2.5	MIG welding stainless steel
60	38	2					M12 - ArHeC - 38/2	
43	55	2					M12 - HeArC - 43/2	
13.5	85	1.5					M12 - HeArC - 13.5/1.5	
98				1.5			R1 - ArH - 2	TIG welding various materials
95				5			R1 - ArH - 5	
97.5					2.5		N2 -ArN - 2.5	
100							I1 - Ar	MIG and TIG welding various materials
70	30						I3 - ArHe - 30	
50	50						I3 - ArHe - 50	
25	75						I3 - ArHe - 75	
65				35			R2 - ArH - 35	Plasma cutting

The right gases for welding a wide range of steels.
Gases for carbon and low-alloy steels.

Steel forms the largest and most widely used group of structural and engineering alloys, and more steel is used in manufacturing than all other metals and alloys put together.

Steel is a term generally used to describe an extensive range of iron-carbon alloys. The carbon content may be up to about 2% but the majority of steels contain less than 1% carbon.

Simple steels, with carbon (and silicon and manganese) as the main alloying additions are often called carbon steels or carbon-manganese steels, whereas steels with small amounts of additional alloying additions (such as chromium, nickel and molybdenum) are called low alloy steels. Low-alloy steels are used in low- and high-temperature service and in creep- and wear-resisting applications.

MIG welding

MIG welding is the most common process for welding carbon and low-alloy steels. The high productivity obtained by this semi-automatic process makes it ideally suited to the construction and manufacturing of steel structures and components.

Argon-based gas mixtures are commonly used to weld carbon and low-alloy steels. These mixtures contain additions of active gases, oxygen and/or carbon dioxide to improve welding performance. How much of these active gases is added depends on the application.

Gases for carbon and low-alloy steels

	Welding speed	Spatter control	Reduced slag island	Porosity control	Fusion	Penetration	Ease of use	Optimum thickness range (mm)
ARGOSHIELD Light	••	•••	•••	•	•	•	••	0.6 to 4
SPECSHIELD 20% CO_2	•	•	•	•••	•••	•••	••	4 to 12+
ARGOSHIELD Universal	•••	•••	••	•••	••	••	•••	4 to 8
ARGOSHIELD Heavy	•	•	•	•••	•••	•••	••	8 to 12+

The greater the number of dots, the better the gas performs.

ARGOSHIELD Light
This three component shielding gas is designed predominantly for welding thinner materials. The addition of oxygen increases arc stability minimising the amount of spatter. This makes the product ideal for welding components that are painted or powder coated after welding. The faster welding speeds achievable with this gas coupled with a low heat input also help to reduce welding distortion.

Again this product can suffer from lack of sidewall fusion and inter-run porosity when welding thicker materials.

SPECSHIELD 20% CO_2
SPECSHIELD 20% CO_2 produces welds with very good penetration and sidewall fusion, especially when welding thicker materials. This mixture performs very well in both dip and spray but is on the upper limit of CO_2 content for pulse welding.

The high CO_2 content helps cope with surface contamination such as oil, moisture or rust reducing pre-weld cleaning so reducing the cost of manufacture.

The higher CO_2 content produces more spatter and slag islands which can represent a considerable additional cost. Welding sheet material is more difficult with this gas as it is easier to burn though.

ARGOSHIELD Universal
This three component mixture designed for maximum performance and ease of use giving it a high welder acceptance so reducing the instances of weld defects.

Ideal for semi-automatic, automatic and robotic applications, the gas produces smooth flat welds with good penetration and sidewall fusion as well as low spatter reducing the need for rework and increasing productivity.

Welding speeds are high over a wide range of welding conditions making it the first choice product when productivity and low levels of distortion are important.

ARGOSHIELD Heavy
This three component mixture produces welds with good penetration and sidewall fusion ideal for welding thicker materials were weld strength is key. The addition of oxygen to the mixture reduces surface tension, lowering reinforcement levels and chances of undercut while improving arc stability.

Alloy flux-cored and metal-cored arc welding

	Welding speed	Spatter control	Porosity control	Fusion	Penetration	Ease of use
Carbon dioxide	••	•	••	•••	•••	••
SPECSHIELD 20% CO_2	••	••	••	•••	•••	•••

The greater the number of dots, the better the gas performs.

Flux-cored and metal-cored arc welding

Flux-cored arc welding and metal-cored arc welding processes are similar to MIG welding, except that the welding wires are tubular and contain flux powders and/or metal powders rather than being solid.

Consumable manufacturers blend their wires to suit one or two shielding gas mixtures; check which are recommended before commencing welding.

Carbon dioxide
This gas is suitable for use with many brands of flux-cored wire. Generally produces more spatter and particulate fume.

SPECSHIELD 20% CO_2
For use with flux-cored wires recommended for use with 'mixed gas'. In general it gives lower fume and spatter levels than pure carbon dioxide. Lower fume levels can improve the workplace environment as well as improve the well being of the workforce.

TIG welding

	Welding speed	Ease of arc striking	Porosity control	Fusion	Penetration	Ease of use	Thickness range (mm)
PURESHIELD Argon	•	•••	••	••	•	•••	0 to 8
ALUSHIELD Light	•••	••	•••	•••	•••	••	1.6 to 10+
ALUSHIELD Universal	•••	•	•••	•••	•••	•	3 to 10+

The greater the number of dots, the better the gas performs.

TIG welding

TIG welding is not commonly used for carbon steels, but it is used more for welding low-alloy steels where high-precision joints and excellent surface finish are more important than high productivity. Since the TIG process uses a non-consumable tungsten electrode, which is susceptible to damage by oxidising gases, gases for TIG welding these steels are usually limited to pure argon or argon/helium mixtures.

PURESHIELD Argon
Argon is the most common gas for TIG welding both carbon and low alloy steels. Arc initiation is easy but welding speeds are relatively slow.

ALUSHIELD Light & ALUSHIELD Universal
The addition of helium to argon creates a more fluid weld with better penetration, improved fusion and faster welding speeds. The higher helium mixtures should be used on thicker section materials. These mixtures are widely used on automatic welding stations where high welding speeds are the primary concern.

The right gases for all types of stainless steel.
Gases for stainless steels.

Stainless steel is usually defined as an iron-chromium alloy containing at least 10.5% chromium. It often contains other elements such as silicon, manganese, nickel, molybdenum, titanium and niobium. Most widely used as corrosion-resistant engineering materials, it finds applications in aggressive environments and at elevated temperatures.

Stainless steel is normally categorised into four main groups, and each group is further sub-divided into specific alloys. The main groups are austenitic, ferritic, martensitic and duplex.

- Austenitic stainless steels form the most widely used group, accounting for around 70% of all stainless steels fabricated. They are used in applications such as chemical processing, pharmaceuticals manufacturing, food and brewing, and liquid gas storage. The weldability of these grades is usually extremely good.
- Ferritic stainless steels are not as corrosion-resistant or as weldable as austenitic stainless steels. They have high strength and good high-temperature properties and are used for exhausts, catalytic converters, air ducting systems and storage hoppers.
- Martensitic stainless steels are high-strength and are more difficult to weld than other types of stainless steel. They are used for vehicle chassis, railway wagons, mineral-handling equipment and paper and pulping equipment.
- Duplex stainless steels combine the high strength of ferritic steels and the corrosion-resistance of austenitic steels. They are used in corrosive environments such as offshore and petrochemical plants, where the integrity of the welded material is critical.

Gases for MIG welding

	Welding speed	Spatter control	Reduced surface oxide	Porosity control	Fusion	Penetration	Ease of use	Thickness range (mm)
SPECSHIELD 2.5% CO_2	•	••	••	••	••	•	••	1 to 8
STAINSHIELD Heavy	••	•••	•••	•••	•••	•••	•••	3 to 15+
STAINSHIELD Universal	•••	•••	•••	•••	•••	•••	••	1 to 12
STAINSHIELD Light	••	•••	•••	•••	•••	•••	•	1 to 5

The greater the number of dots, the better the gas performs.

MIG welding

MIG welding using solid wire is an important process for joining stainless steels, usually with argon or argon/helium-based mixtures. These gases also contain small amounts of an oxidising gas such as oxygen or carbon dioxide to stabilise the arc. Carbon pickup can also be a problem and this limits the amount of carbon dioxide that can be used for low carbon grade ('L' grade) stainless steels to about 3%.

SPECSHIELD 2.5% CO_2
This mixture of argon and 2.5% carbon dioxide is a general purpose gas mixture for MIG welding stainless steels. It gives a good wetting action and produces smooth welds with little or no spatter and low surface oxidation. This reduces the need to use aggressive chemical cleaning agents after welding.

Some carbon pickup in the weld can occur but levels should not exceed those required for welding low carbon grades in the weld metal.

STAINSHIELD Heavy
This three component shielding gases containing argon, helium and carbon dioxide it is best suited for spray and pulse welding on thicker materials. The welds produced have low surface oxidation, excellent corrosion resistance, good fusion and low reinforcement levels. All these features help to reduce the number of rejects keeping costs low.

High welding speeds makes this product idea for both manual, mechanised and robotic welding. This can lead to significant improvements in productivity as well as keeping distortion low.

STAINSHIELD Universal
This argon, helium and carbon dioxide mixture produces welds with very good low temperature toughness values as well as excellent corrosion resistance coupled with good penetration and low levels of porosity. All these features can improve productivity, lower costs while producing welds of the highest quality.

The shielding gas operates well in dip, pulse and spray transfer producing welds with very low surface oxidation. This mixture is suitable for welding a wide range of material thicknesses at high speeds again helping to improve productivity.

STAINSHIELD Light
This high helium containing mixture is idea for pulse and dip transfer welding. The high droplet frequency reduces spatter while increasing fusion characteristics making it idea for welding in all positions.

Gases for Flux-cored and Metal-cored arc welding

	Welding speed	Spatter control	Porosity control	Fusion	Penetration	Ease of use	Thickness range (mm)
Carbon dioxide	••	•	••	•••	•••	••	0 to >25
SPECSHIELD 20% CO_2	••	••	•••	••	•••	•••	0 to >25

The greater the number of dots, the better the gas performs.

Flux-cored and metal-cored arc welding

Flux-cored arc welding of stainless steels is becoming increasingly popular as high-quality tubular wires become available. As with steel-cored wires, check the wire manufacturer's recommendations to ascertain which shielding gases are suitable.

Carbon dioxide

This gas is used with suitable stainless steel wires, large levels of fume can be generated together with high spatter levels.

SPECSHIELD 20% CO_2

For use with flux-cored wires recommended for use with 'mixed gas'. In general it gives lower fume and spatter levels than pure carbon dioxide. Lower fume levels can improve the workplace environment as well as improve the well being of the workforce.

Gases for TIG welding

	Types of stainless steel	Welding speed	Porosity control	Fusion	Penetration	Ease of use	Thickness range (mm)
PURESHIELD Argon	all	•	•	••	•	••	0 to 3
STAINSHIELD TIG	austenitic	••	•••	•••	••	•••	0 to 8
SPECSHIELD 5% H_2	austenitic	•••	•••	•••	•••	••	1 to 10+
ALUSHIELD Light	all	•••	•••	•••	•••	••	0 to 10
ALUSHIELD Universal	all	•••	•••	•••	•••	•	3 to 10+
SPECSHIELD 2.5% N_2	duplex	••	••	••	••	••	0 to 10

The greater the number of dots, the better the gas performs.

TIG welding

TIG welding is a very common process for welding stainless steels where high-quality welds with good surface finish are very important.

There is a greater number of shielding gas mixtures that can be used for TIG welding stainless steel than for steel but not all gas mixtures are suitable for all types, i.e. hydrogen-containing mixtures are suitable for welding only austenitic types.

PURESHIELD Argon
Argon is the simplest gas for TIG welding stainless steels and nickel alloys. Argon produces a clean welding arc, and is suitable for all grades of stainless steel. However the arc is relatively cold and can suffer from fusion and porosity problems as the material being welded gets thicker.

STAINSHIELD TIG
This argon/hydrogen mixture is the preferred gas mixture for manual welding of austenitic stainless steels. It gives a fluid weld pool and produces a very clean bright weld reducing clean up time and costs.

Welders find this product very easy to use and with the better fusion and lower defect rates the gas produces productivity is increased and costs reduced.

SPECSHIELD 5% H_2
This gas mixture has a higher hydrogen content than STAINSHIELD TIG and tends to be used for welding thicker section joints and although it can be used manually it is best suited to automatic TIG welding of austenitic stainless steels.

SPECSHIELD 5% H_2 gives good weld penetration and fusion improving productivity and lower costs. These attributes can also lead to a reduction in size of weld preparation further lowering production costs.

ALUSHIELD Light
This shielding gas mixture is suitable for TIG welding all grades of stainless steel with good welding speeds and penetration.

SPECSHIELD 2.5% N_2
This mixture of argon and nitrogen is specifically designed for welding duplex stainless steels. The nitrogen in the gas mixture helps to balance the weld metal microstructure improving the in-service corrosion performance, particularly pitting corrosion resistance.

ALUSHIELD Universal
This shielding gas mixture is suitable for TIG welding all grades of stainless steel allows higher welding speeds and better penetration than ALUSHIELD Light.

The right gases for welding non-ferrous materials.
Gases for aluminium, copper and titanium alloys.

Gases for aluminium, copper and titanium alloys

	Welding speed	Spatter control	Porosity control	Fusion	Penetration	Ease of use	Thickness range for MIG (mm)	Thickness range for TIG (mm)
PURESHIELD Argon	•	•	•	•	•	••	1 to 4	0 to 3
ALUSHIELD Light	••	••	••	••	•••	•••	1 to 6	1 to 6
ALUSHIELD Univiersal	•••	•••	•••	•••	•••	••	3 to 10	3 to 9
ALUSHIELD Heavy	•••	•••	•••	•••	•••	•	6 to 12+	6 to 12+

The greater the number of dots, the better the gas performs.

There is a wide range of aluminium, copper and titanium alloys, and these are used in a variety of industries such as aerospace, automotive, power generation and petrochemical.

These non-ferrous alloys can exhibit a wide range of mechanical, electrical and corrosion-resistant properties, depending on the alloy system, but they all have one property in common – they oxidise very easily during welding, and are sensitive to moisture and impurity pickup by the weld. Because of this they are not as easy to weld as the steel alloys, and good welding technique/procedures, together with good housekeeping and cleanliness in and around the welding area, are essential in order to weld these materials successfully.

MIG/TIG

Both MIG and TIG welding are widely used for welding these non-ferrous alloys. The choice of process is similar to that for other alloys in that MIG tends to be used for high-productivity and TIG for high-precision welding.

The choice of shielding gas for welding these materials is very simple in that only the inert gases are suitable as the major ingredients for shielding gas mixtures. Consequently the most common gas mixtures for both MIG and TIG welding aluminium, copper and titanium alloys are pure argon, pure helium and mixtures of the two.

Small additions, (usually less than 0.05%) of oxidising gases have been shown to be beneficial additions to argon/helium mixtures for welding aluminium. However, these are specialised applications and require welding engineering assessments. Titanium is very sensitive to oxygen and nitrogen and may even require special low-impurity products.

PURESHIELD Argon
Best suited for welding thin sections. When used for MIG welding it can give welds with high levels of reinforcement, poor fusion and porosity when welding thicker sections. When MIG or TIG welding copper some level of preheating is normally required.

ALUSHIELD Light
This mixture of argon/30% helium is used for both MIG and TIG welding thin to medium section thicknesses. Fusion and penetration profiles are improved over pure argon as are its gap bridging capabilities reducing the chances of burn through. The addition of helium also helps to lower the levels of porosity reducing defect rates.

Preheating will still be required for welding most thicknesses of copper but temperatures will be lower than for argon.

ALUSHIELD Universal
A 50% mixture of argon and helium it is used for manual and semi-automatic MIG and TIG welding. It produces a more fluid weld pool than ALUSHIELD Light, and so tends to be used on thicker components. Fusion and penetration are excellent reducing defect rates, improving productivity while reducing costs.

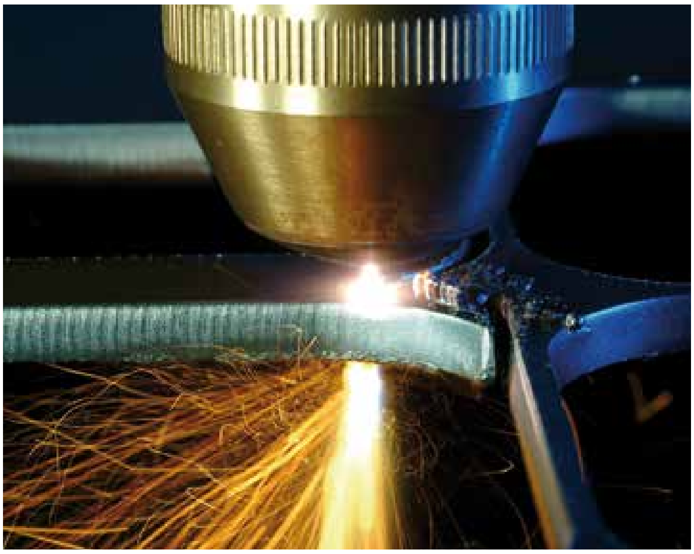
The high energy available means that little or no preheating is required when welding thicker aluminium sections or copper and that in some cases weld preparations can be reduced in size further reducing cost.

ALUSHIELD Heavy
A blend of 70% helium and 30% argon this mixture is most commonly used for automatic MIG and TIG welding of thick section joints. It produces a very fluid weld pool with excellent fusion and penetration and is ideal for welding very thick aluminium sections and copper.

The fluid weld pool can both increase welding speeds as well as reduce defect levels minimising the number of rejects created. Smaller weld preparations will also further improve the economic advantage of using such a shielding gas.

The right gases for plasma processes.
Plasma welding and cutting.

Plasma cutting



Gases for plasma welding

	Materials	Welding speed	Fusion	Penetration	Thickness range (mm)
PURESHIELD Argon	all	•	••	•	0 to 3
ALUSHIELD Light	all	•••	•••	•••	0 to 6
STAINSHIELD TIG/ SPECSHIELD 5% H_2	austenitic stainless steel	•••	•••	•••	0 to 8

The greater the number of dots, the better the gas performs.

Plasma welding

Plasma welding is a precision process involving a restricted welding arc, and it is used for welding a wide range of materials. There are many gas mixtures that can be used for plasma welding, but as with other welding processes, it is important to choose a plasma shielding gas that does not adversely affect the welding process or the weld metal produced.

PURESHIELD Argon
Argon is a standard shielding gas that can be used for plasma welding of all materials.

ALUSHIELD Light
This mixture can be used for plasma welding of all materials usually in thicker sections.

STAINSHIELD TIG/SPECSHIELD 5% H_2
These mixtures are primarily used for plasma welding of austenitic stainless steels. The thicker the section of material to be welded, the higher the hydrogen content in the plasma shielding gas.

Plasma cutting

Plasma cutting is used for cutting all metals and their alloys. In plasma cutting there are two gas streams: one to generate the plasma and the second to blow away the molten metal from the cut face. In some machines, one gas is used for both tasks but in others, separate gases are used.

The choice of both the plasma and shielding gas depends on the material being cut and the condition of the cut surface required. Choosing the wrong gas mixtures can create metallurgical defects close to the cut face that can affect welding.

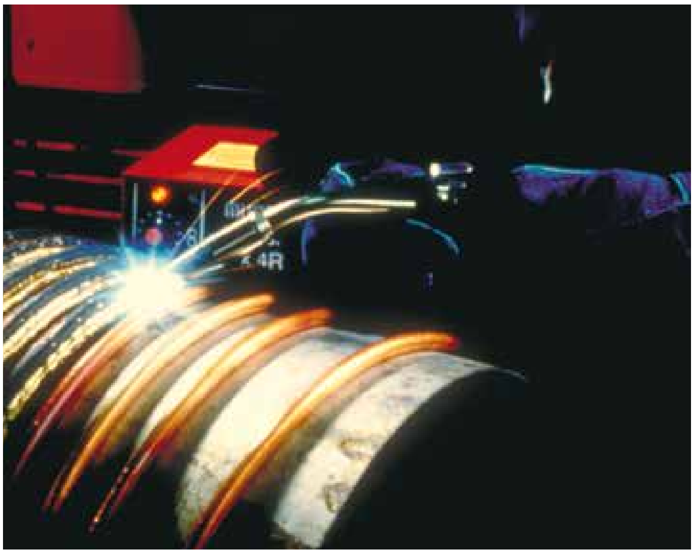
SPECSHIELD 35% H_2
Used primarily for plasma cutting aluminium and stainless steel as the plasma gas it produces a smoother cut face at higher speeds than other mixtures. It is often used in combination with nitrogen or carbon dioxide secondary gas.

The right gases for MIG brazing.
MIG brazing.

Gases for MIG brazing

	Welding speed	Spatter control	Bead appearance	Capillary action	Ease of use
PURESHIELD Argon	•	•	•	•	•
SPECSHIELD 2.5% CO_2	••	••	••	•	••
ALUSHIELD Light	•••	••	••	•••	••
STAINSHIELD Heavy	•••	•••	•••	•••	•••

MIG brazing



MIG brazing

MIG brazing is a variation of the MIG welding process using copper-alloy filler wires rather than wires with similar compositions to the parent material. In MIG brazing, because no fusion takes place between the parent material and the filler wire, the strength of the joint relies on the level of capillary action of the filler.

Standard MIG equipment is suitable for MIG brazing and usually the only change required is to fit wire feed rollers suitable for the softer copper-based wires. The filler wire is usually either a copper-silicon (CuSi) alloy or copper-aluminium (CuAl – aluminium bronze) type.

PURESHIELD Argon
Argon is suitable for MIG brazing with both copper silicon (CuSi) and aluminium bronze (CuAl) filler materials. However the travel speeds are low and the weld bead appearance is not as good as with other gas mixtures with high levels of reinforcement.

SPECSHIELD 2.5% CO_2
The addition of a small amount of carbon dioxide to argon gives better results than pure argon for both filler types. The carbon dioxide helps stabilise the arc reducing spatter as well as producing a more even bead shape, however some surface discolouration can occur especially with aluminium bronze filler materials.

ALUSHIELD Light
The addition of helium to the shielding gas helps improve the fluidity of the weld pool producing a more even weld bead shape at faster welding speeds. The helium also helps with the capillary action improving the bond between the surfaces being joined. This shielding gas is often preferred when welding with aluminium bronze filler.

STAINSHIELD Heavy
This shielding gas produces very smooth weld beads with little reinforcement and virtually no spatter. Welding speeds are also very high as the fluid weld pool gives the welder better control.

The right gases to protect the other side of the weld.
Purging or root backing.

Shielding gas	Material
Argon	all materials
Nitrogen (oxygen free)	carbon and low-alloy steels (not high-strength fine-grained steels); austenitic, duplex and super-duplex stainless steels
STAINSHIELD TIG SPECSHIELD 5% H_2	austenitic stainless steels
SPECSHIELD 2.5% N_2	austenitic stainless steels (not Ti-stabilised) duplex and super-duplex stainless steels

Root runs on stainless steel pipe

When welding takes place, the temperature of both the parent material and filler rises above the temperature at which oxidation takes place. The shielding gas protects the front of the weld from atmospheric contamination but if no purging or root backing is carried out on the back of the weld, it will oxidise.

Purging is usually carried out when the welded material is going to be used for its corrosion-resisting qualities, such as stainless steels and some nickel alloys, or when the material will oxidise very easily during welding, such as with aluminium and titanium alloys. If root purging is not done, it can significantly reduce the working life of the component or in the worst case lead to its failure in service.

Purging is achieved by passing a dry stream of an inert, low-reactivity or reducing gas over the reverse side of the weld area to exclude the air, preventing oxidation from taking place. It is important to choose the purging gas with care. For some metals that oxidise very readily (such as titanium), it may be necessary to place the component in a chamber filled with the purge gas to ensure that oxidation does not take place.

Gases

The most common gases used for purging are argon and nitrogen, but mixtures of argon/hydrogen and nitrogen/hydrogen can be used if the material is not susceptible to nitrogen or hydrogen attack.

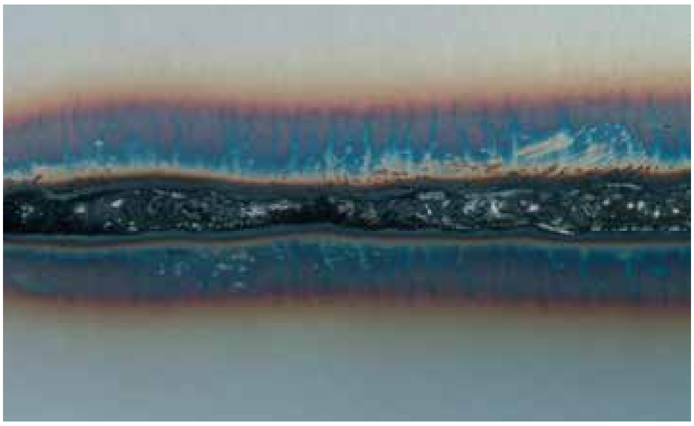
Argon is widely used for weld purging due to its inert nature. It will give satisfactory results on all materials because no compounds are formed.

Nitrogen is also widely used. However, care should be exercised because some materials (such as aluminium) are sensitive to nitride formation and this can reduce the corrosion-resistance characteristics. Also, nitrogen is an austenite stabiliser in stainless steels and adsorption into the weld areas could produce an unacceptable microstructure.

Hydrogen is added to argon primarily to improve its oxygen-scavenging characteristics. Gas mixtures such as STAINSHIELD TIG and SPECSHIELD 5% H_2 are frequently used in high-quality applications where only very low levels of oxidation can be tolerated. These mixtures are only used with materials that are not susceptible to hydrogen attack, such as austenitic stainless steels.

With root backing

Without root backing



Practical advice

In many applications, it is necessary to maintain a low oxygen concentration during welding. Just what level of oxygen can be tolerated depends largely on the material being welded and the type of service the component will undergo.

Technical advice should be sought if you are unsure of the oxygen level required but as a general guide the following may be useful:

- For carbon and many low-alloy steels, for most applications, back purging is not required.
- For carbon and low-alloy steels, when back or pipe purging is required, a value of 1% O_2 is often considered acceptable.
- For many applications with stainless steel, an oxygen level of 0.01% (100ppm) is satisfactory but some surface oxidation will occur.
- For stainless steels for extreme service conditions, a level of 20ppm O_2 may be necessary to prevent pitting corrosion or subsequent stress-corrosion cracking.
- For nickel alloys, between 25 and 50ppm O_2 may be stipulated.
- For reactive metals like titanium and zirconium, as little as 5 or 10ppm O_2 is normally required to prevent embrittlement.
- For semiconductor applications, impurity levels of 1ppm are generally required.
- The level of oxygen after purging can be estimated from flow-rate/flow-time charts available for different-purity purging gases, but it is more accurate to use an oxygen analyser.

Safety

When using purging gases containing more than 5% hydrogen, it is recommended to burn off the hydrogen to prevent build-up. However, hydrogen burns with a nearly invisible flame, and it is recommended that a wire mesh cage be fitted around the flare stack to prevent an operator accidentally coming into contact with the flame.

When purging, the volumes of inert or unreactive gases used tend to be quite high and this significantly increases the risk of asphyxiation in the areas around the welding station. It is therefore important always to check the working environment ensure to that there is adequate oxygen present to support breathing.

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 you will know the answer to, for others, the answer may not be what you were expecting. Some you may have been waiting years to have an answer to.

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 MIG welding steels?

While it is possible to MIG-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 MIG 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.

Can I use ARGOSHIELD for MAG welding stainless steel?

No - the CO_2 content in ARGOSHIELD (even ARGOSHIELD Light) is too high for welding austenitic stainless steels. When wishing to weld stainless steels, we should try to keep below 3% CO_2 level in the shielding gas.

Should I increase shielding gas flow rate if I increase the welding parameters?

Under normal operating conditions there is no need to alter the shielding gas flow rate if the welding parameters are changed, in the majority of cases we would advise a flow rate of around 15 l/min as being adequate to cover the majority of applications, however, this is dependent upon local operating conditions and procedural requirements.

The following guidelines can also be followed as a more accurate form of calculating the shielding gas flow rate, one litre per minute of shielding gas should be used for each 1mm diameter of the welding torch nozzle. (e.g. a welding torch with an 18mm diameter nozzle will require a flow rate of 18l/min of shielding gas).

Why SPECSHIELD is recommended for FCAW welding and not ARGOSHIELD?

When using FCAW, the consumable manufacturers data sheet should be consulted for the recommended shielding gas to be used. Normally, this will be an argon/CO_2 blend, or pure CO_2. ARGOSHIELD is a three component argon/CO_2/ oxygen blend that is not normally recommended due its oxidising nature.

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.

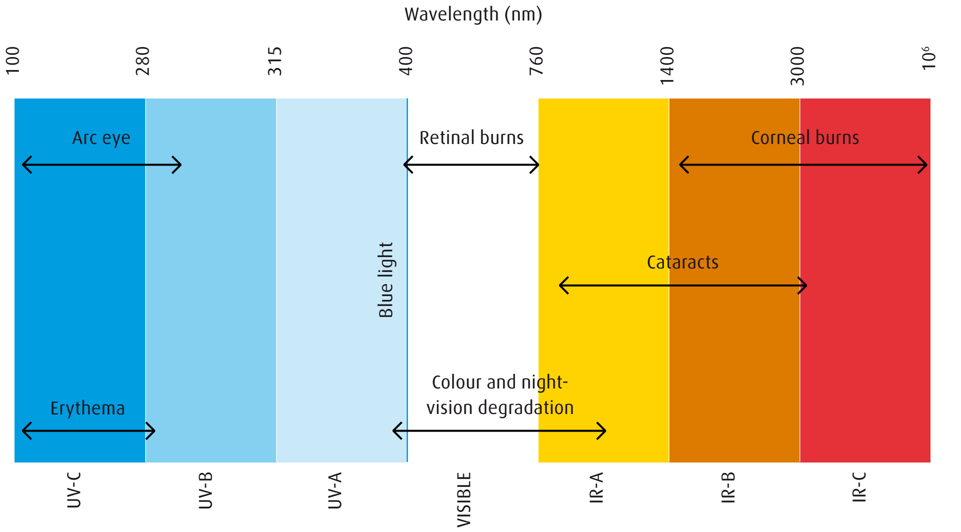
It is not always possible to eliminate this problem but altering the torch angle and ensuring correct shielding gas coverage can minimise the effect. Also, if the weld is cleaned immediately after welding, the oxide is much easier to remove than if it is left until the weld is cold.

Where can I receive expert advice on my welding processes, technique and gas use?

BOC have a team of technical experts on hand to provide welding advice via email, phone, or even a visit to your site. Contact your account manager for more details.

Hazards associated with welding.
Health and safety.

Electromagnetic radiation



The welding environment can be a hazardous place for the untrained and unobservant. Welding, cutting and allied processes present numerous occupational hazards to welders and others. Everybody has a responsibility to work safely and to not endanger themselves or any other person at work.

Being aware of the possible hazards and how best to avoid them is paramount in reducing the risk associated with these hazards. The main welding-related hazards encountered by welders include:

- electricity
- radiation
- heat, flames, fire, explosion
- noise
- welding fumes
- solvents

These are not the only hazards faced in the welding workshop and people working in this environment must always remain vigilant.

Electrical hazards

Touching live electrical equipment or components, including the electrode and the workpiece, can result in burn injuries or, more seriously, electric shock. Electric shock can kill by direct action on the body. It can also cause you to fall if working at height.

Radiation hazards

Arc welding and cutting emit electromagnetic radiation in the form of ultraviolet (UV), visible light and infrared (IR) radiation. The potential effect of radiation on the body depends on the type and intensity of the radiation, the distance you are from it and the duration of exposure.

Non-ionising radiation from welding/cutting processes can cause damage to the skin and eyes. UV radiation in particular can cause burns to unprotected skin and eyes (arc eye).

Radiation from electric welding arcs is usually apparent but arc flashes can occur without warning. The effects of IR and UV radiation are not normally felt until some time after exposure.

Heat, flames, fire and explosion

A burn is a hazard that welders face every working day because welding is a process that frequently involves heat, flames, molten metal and high-temperature welding arcs. Burns may occur to the skin, or, potentially very seriously, to the eyes.

Fire and explosion are serious hazards in the welding environment. Heat and flames can result in fire or even explosion in the presence of combustible materials, dust, flammable liquids, gases or vapours.

Noise

Noise is an everyday occurrence in an industrial workshop. All welding and cutting processes generate noise but some are much noisier than are others. Ancillary processes like grinding, chipping, gouging and hammering also generate varying levels of noise. Exposure to noise over a period of time can result in impairment or loss of hearing.

Welding fume

All welding processes generate welding fume but some produce very little fume while others produce much more. Welding fume consists of particulate fume – the cloud of smoke you can see rising, and gaseous fume, which you cannot see but can sometimes smell. In most cases, welding fume is formed close to the arc and near the welder, but some of the gaseous fume (i.e. ozone) can be generated well away from the arc.

The potential effect on the body of exposure to welding or cutting fume depends mainly on the amount of fume produced, what is in it and the length of time the worker is exposed to the fume. Whilst all components of welding or cutting fume may present a risk to health given a high enough concentration, some present a greater hazard than others.

Solvents

Solvents used in welding industry may be flammable, contain constituents that are flammable, or they may be non-flammable. The most frequently encountered flammable solvents are acetone, petroleum ether and white spirits.

Some solvents break down under the action of the welding arc to form toxic or irritant by-products, the most toxic of these being phosgene.

Precautions

Controls

Local fume extraction should be used to control the fumes and gases produced during welding to below their individual recognised exposure limits when measured in the welder's and co-workers' breathing zone. If this is not possible, would recommend the use of air-fed welding helmets (PAPR helmets).

In confined spaces where ventilation is not adequate, it may be necessary to use an air-fed breathing system. Where fume levels exceed the recognised exposure limits, respiratory protection may be required.

Personal protection

Due to the hazards associated with welding, cutting and other manufacturing processes, welders and co-workers in the vicinity should wear the correct protective clothing, hearing and eye protection as specified by local standards.

Providing you with the right gas.
Supply options.

Shielding gases can be supplied in various ways. We are happy to advise you on the best choice for your needs.

Cylinders

Cylinders are the most common way that our customers receive their shielding gases. In the cylinder, the gas is held at high pressure; this can be anywhere from 150 to 300 bar, dependent on the shielding gas composition and the pressure rating of the cylinder itself.

Some shielding gases are also available in different sizes of cylinder to best suit your needs. However, the most common cylinder size is 50 litres, which holds about 10m^3 of gas, dependent on the pressure to which it is filled. So for a typical shielding-gas flow-rate of 15 litres per minute, this size of cylinder will last for about 11 hours of continuous welding.

Manifolded Cylinder Pallets (MCPs)

Cylinder bundles are ideal for customers who use high-productivity processes and don't want to waste time changing cylinders, or who have several welders using the same shielding gas from a pipeline. Cylinder bundles typically contain 12 to 15 of these 50-litre cylinders connected together. You simply connect to the bundle outlet as if it were a single cylinder.

All bundles are designed to be handled using a forklift truck and some products are also designed to be craned into place. Please check with your BOC representative which is suitable for you.

Liquid cylinders

Cryogenic liquid cylinders are ideal for customers with similar gas requirements to those using cylinder bundles but who don't have the space. These vacuum-insulated cylinders stand about the same height as a 50-litre cylinder and hold about the same amount of gas as a cylinder bundle. However in this case, the 'gas' is stored as a cryogenic (cold) liquid.

Although not available for shielding gas mixtures, liquid cylinders are available for a range of pure gases such as argon, oxygen, carbon dioxide and nitrogen. When used in conjunction with a mixing system, liquid cylinders can be used to produce many of the core shielding gas range.

Liquid cylinders are refilled on site by our CRYOSPEED® service.

Liquid tanks

Liquid tanks are best suited to customers who require large volumes of gas. These cryogenic tanks are fixed on concrete plinths at the customers' sites, and are filled periodically by liquid tanker trucks. The largest liquid tanks hold 75,000l of gas, which is enough to last one welder over 2.5 years. These vessels are best suited to large factories with more than about 25 welders or welding stations.

Again they are available for a range of pure gases such as argon, oxygen, carbon dioxide and nitrogen. A mixing system is required to create the required shielding gas and a pipeline is needed to deliver it to where the welding is taking place.

Mixing systems

Mixing systems are available in a range of capacities to suit your applications. These precision products can be supplied ready to produce a fixed composition or with the flexibility to make different gas mixtures either manually or by computer control.

Our trained engineers will be happy to size your installation for you, ensuring that you have the right package for your present and future needs.

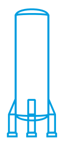
Cylinders

	Capacity (litre)	Content* (m^3)
Steel	~10	2.0 – 2.4
	~20	4.0 – 4.7
	~50	9.9 – 11.8
300bar	~33	8.61 – 10.07
	~55	13.05 – 5.50

Liquid	30 – 500	~106.8 – 141.6

*Volume of gas in the cylinder depends on the type of gas

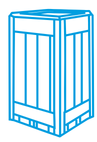
Liquid upright tanks



Content** (l)
~600 – 75,000

**Volume of liquid in the tank depends on its size

Manifold Cylinder Pallets (MCPs)



	Content* (m^3)
Steel	110 – 175
300bar	195.75 – 252.00

*Volume of gas in the bundle depends on the type of gas

Complementing the right gas.
Services.

BOC provides a broad range of services complementing your choice of gas. Our services portfolio has been developed to meet your needs as our customer. The portfolio can be broken down into four interlinked segments:

→ Administrative efficiency
→ Supply reliability
→ Quality and safety
→ Process know-how

Administrative efficiency

Not only do we deliver high-quality products as standard, but we make it simpler and easier for you to order your gas when you need it.
- BOC offers you a one-stop-shop for all your gas supplies, equipment needs, associated products and services you need for your business.
- You can call our customer service center, drop in to one of our 50+ local stores or browse our industry leading online shop 24/7 at boconline.co.uk/shop

Supply reliability

It is our goal is to eliminate all unscheduled interruptions to your delivery, ensuring you get the right gases when you want them.
- Extra delivery services – we know you can't always predict exactly when and how much gas you will need. Express and emergency delivery, delivery to point-of-use and cylinder connection are some of our service offers available to you. That's why we deliver when it suits your needs.
- Complete supply options – Whatever the process used we have a supply mode to meet your needs. Compressed gas cylinders, CRYOSPEED® and bulk cryogenic gases – We supply them all without any effort to you.

Quality and safety

Safety is a priority for BOC and most likely for you too. BOC can provide you with know-how in the safe use of your shielding gases.
- Safety training – these are practical courses designed for the users of gases and can be delivered face-to-face by our expert trainers at your site or accessed online, for quick and convenient access.
- Gas analysis – professional analysis of gas in the lab or on site guarantees the high and consistent quality you need in your processes.
- Preventive maintenance contracts – we offer a regular check of your gas-supply system, to ensure its safe operation and, if required, to maintain and repair the system.

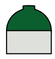
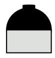
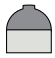
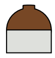
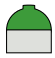
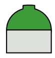
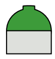
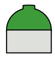
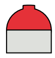
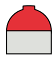
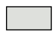
Process know-how

The BOC is part of a global solution-provider committed to the welding industry. With our outstanding global team of application engineers, we have high competence in all shielding gas processes.
- Application training – you can benefit from our experience in welding and cutting applications to ensure that the skill levels of your workers are as high as possible.
- Process consultation – our application engineers can look at your gas consumption and optimise it for your processes.

Know the right gas cylinder colours.

The cylinder label is the primary method of identifying for any gas; the cylinder colour should only be used a guide. If a cylinder does not have a cylinder label, it should not be used but should be returned immediately to the supplier.

Cylinder colours

	Gases
	Argon
	Nitrogen
	Carbon dioxide
	Helium
	Argon + carbon dioxide mixtures
	Argon + oxygen mixtures
	Argon + helium mixtures
	Argon + nitrogen mixtures
	Argon + hydrogen mixtures
	Nitrogen + hydrogen mixtures
	Cylinder body colour is not covered by the standard and can be any colour

BOC is a Linde company, the leading global gases and engineering business with a mission to make the world more productive.

We are the UK and Ireland's largest provider of industrial, medical and special gases as well as related equipment, engineering services and solutions to support them.

We produce, package and distribute thousands of different types of gases to our customers every day. Our unrivalled range includes atmospheric gases, high purity gases and mixtures, refrigerants and chemicals, for applications as diverse as cooling magnets in hospital MRI scanners to fuelling zero emissions vehicles and much more.

BOC offers tailored supply solutions for every size of customer; our cylinder customers enjoy a nationwide delivery and collection network; bulk customers the reassurance of 24/7 delivery; and for our high-demand customers we offer onsite production or dedicated pipeline supply.

And all of this is backed up by industry leading customer service, expert technical support and best-in-class levels of safety and environmental performance – the basis on which we have earned our reputation as a reliable and trusted partner.

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