BOC SHIELDING GAS INFORMATION

Shielding Gases and Their Properties

The purpose of a shielding gas in the GMA or GTA welding process is to shield the weld pool and molten filler wire from atmospheric Oxygen and Nitrogen, to stabilise the arc, provide the desired depth of penetration, and in GMAW, facilitate the required form of metal transfer. These functions are affected by such factors as:

- material to be welded
- weld position
- process chosen
- weld economics
- material thickness
- type of wire
- metal transfer mode
- finish required.

The main gases used in the formulation of a shielding gas are:

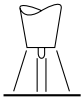
- Argon
- Carbon Dioxide
- Oxygen
- Helium
- Hydrogen.

These gases form the basis of the mixtures used in the Argoshield™ range designed to best meet the needs of the welding industry. While carbon dioxide and argon can be used in their pure form as shielding gases in most applications, a specific mixture of gases will offer improvements in welding productivity and help to reduce the total weld cost.

Argon

Argon is a chemically inert gas, heavier than air, with an ionisation potential of 15.7 eV giving easy arc starts and a stable welding arc. Argon produces a constricted arc column and has a low thermal conductivity which facilitates easy arc initiation.

The result is a relatively narrow weld bead with deep central penetration of the weld deposit into the base metal giving the 'finger' or 'wine glass' penetration profile. In GMA welding (spray or pulse transfer mode), the main force in the arc is axial to the filler wire and accelerates the molten droplet smoothly across the arc. This allows for virtually spatter-free welding in spray transfer mode.



GMAW Argon arc column

Argon is used as a GMA welding shielding gas for many non-ferrous metals. It does not, however, provide suitable metal transfer characteristics for steel. There is a marked tendency for the filler metal not to flow out to the toes of the weld causing a very uneven weld shape. This poor weld bead shape is due to low arc energy, low heat input and rapid cooling rate and the high surface tension of liquid iron in argon atmospheres.

Argon is one of the gases available in the Argoshield™ range and is a standard GTA welding shielding gas. Argon forms 0.8% of air by volume and is produced in the air separation process in addition to oxygen and nitrogen.

Penetration profile of Argon shielded GMA weld on Carbon steel

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Carbon Dioxide

Carbon dioxide, or CO_2, as it is commonly known, is not chemically inert. When energised and subjected to arc temperatures above 6000°C, its molecules dissociate at the top of the arc to form excited species of oxygen and carbon monoxide:

$$2CO_2 = 2CO + O_2$$

Carbon Dioxide arc column

These molecules recombine at the bottom of the arc and in so doing, release a disruptive force upward into the arc causing a stuttering, unstable arc and welding spatter. The oxygen superheats the transferring molten filler metal creating a deep penetrating, fluid weld pool and promoting the deposition of convex weld beads.

Because the CO_2 shielded arc is highly oxidising, it is useful for coping with surface contaminants such as rust, paint and primers. Carbon dioxide can be used for mild and carbon manganese steel welding, where it gives a narrow, peaked weld bead with deep penetration. The normal spray transfer of fine metal droplets does not occur in the CO_2 arc. Globular and dip transfer arc modes only are used with CO_2.

Because it is oxidising and not inert, CO_2 cannot be used to weld readily oxidisable metals such as aluminium, copper, magnesium or nickel, or for GTA welding. It is not suitable for stainless steels because of carbon pick-up which can give a 200-300% increase in carbon content in the weld metal.

Penetration profile of Carbon Dioxide on Carbon steel

In addition, because of the oxidising characteristics of CO_2 in GMA welding of steel, it is recommended that filler wires with a high manganese and silicon level or triple de-oxidised wires are used.

Oxygen

Although oxygen itself is not used as a shielding gas, it is a vital component in shielding gas mixtures. When used as a low percentage (i.e. 1-7%) additive to argon or argon/ CO_2 mixtures, oxygen can be very beneficial in improving arc characteristics and reducing the surface tension of the weld metal. It is an active gas which dissociates in the arc intensifying the arc plasma, thereby increasing the heat input and travel speed, and improving weld penetration and edge wetting. It promotes the spray transfer mode in GMA welding of steels to give a virtually spatter-free, high productivity process.

Helium

Helium is also inert but has a higher ionisation potential than argon, of 24.5 eV. As a result, helium arcs have a higher arc voltage than argon for a given arc length, translating into higher heat input and weld travel speeds.

The high thermal conductivity of helium produces a wide, low weld bead with good fusion and penetration. High flow rates are necessary to maintain a helium shield because the gas is lighter than air.

GMAW Helium arc column

BOC SHIELDING GAS INFORMATION

Helium cont.

High concentrations of helium are used in Argoshields' designed to weld thick sections of non-ferrous metals or metals where the high heat conductivity of the metal causes problems in maintaining weld pool fluidity. Welding speeds are very high with helium and its use can result in economical advantages over low cost gases, particularly in high conductivity materials.

Helium is a rare gas found in association with certain natural gas streams in low concentrations. It is costly to produce, store and transport as a liquid, because its boiling point is very low - 269°C.

Penetration profile of Helium shielded GMA weld on Carbon steel

Hydrogen

Hydrogen has a relatively low ionisation potential (13.5 eV), but a high thermal conductivity. This produces a higher arc energy for deeper penetration and weld pool fluidity. Because hydrogen is a reducing agent, its action helps to remove oxide films on the weld pool surface resulting in a cleaner weld bead.

Argon Based Mixtures

The characteristics of each gas used in a shielding gas mixture affect the way the gas will perform, including the shielding efficiency, arc stability and the shape and strength of the weld. Depending on the application, the right balance of gases in a mixture will produce a shielding gas with the optimum properties for the application and greater tolerance to voltage and current settings.

Argon is an excellent base for GMA welding shielding gas mixtures because it permits the use of spray transfer with all the commonly welded metals. However, when depositing flat or horizontal welds on steel or stainless steel, the quick freeze characteristics of an argon weld does not permit the molten metal to wet out the toes of the weld, causing undercutting at the edges of the weld bead. It is therefore necessary to add active gases to argon, such as oxygen or carbon dioxide, to increase the heat input for GMA welding of steels and stabilise the droplet size.

Argon + Oxygen Mixtures

Oxygen is added to argon to stabilise the arc, improve the weld bead profile and edge wetting and minimise the tendency to undercut ferrous welds. Discrete percentages of oxygen (i.e. 1-7%) prevent excessive losses of manganese and silicon, as well as increase the temperature of the molten metal transferred across the arc. The molten weld pool has a lower surface tension than with argon, wetting the parent metal to flatten the weld bead profile.

For stainless steels and other corrosion resistant steels (e.g. 3CR12) a mixture of 1-2% oxygen is recommended.

Above 5% oxygen, the surface of the weld bead becomes increasingly oxidised with consequent losses of manganese, silicon and chromium. Argon/oxygen welds have a flatter bead than argon or CO_2 and give a wine glass penetration pattern. Argoshield™ 40 is such an argon/oxygen mixture offering virtually spatter-free beads on sheet steel in spray mode.

Penetration profile of Argon + Oxygen shielded GMA weld on Carbon steel

BOC SHIELDING GAS INFORMATION

Argon Based Mixtures

Argon + Carbon Dioxide Mixtures

For mild and carbon manganese steels, argon/carbon dioxide mixtures can be used with the CO_2 conventionally ranging from 2-30% by volume. Ideally 25% CO_2 should not be exceeded for best results. With increasing CO_2 content to provide more heat and broader and deeper penetration, the spray transfer mode deteriorates. Argoshield™ 52 is a high CO_2 mixture offering excellent penetration. Argon/CO_2 mixtures are successfully used with flux-cored and metal-cored wires.

Penetration profile of Argon + Oxygen shielded GMA weld on Carbon steel

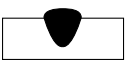
An argon/CO_2 weld shows deeper and fuller penetration than argon/carbon dioxide shielded and an argon/oxygen weld.

Argon + Oxygen + Carbon Dioxide mixtures

The further addition of Oxygen to an argon/CO_2 mixture flattens the weld bead and improves spray transfer characteristics, total heat input, weld bead profile and penetration.

Argon/oxygen/carbon dioxide mixtures allow the fullest flexibility in producing shielding gases best suited to different steel applications. The oxygen and CO_2 mixtures, such as Argoshield™ Light, are well suited to dip transfer welding of lighter section metal. In the spray transfer mode, they give an excellent arc with greater welder appeal and minimum spatter that is suitable for welding light and medium section steels.

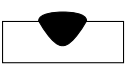
Low oxygen/high CO_2 mixtures, such as Argoshield™ Universal, are best suited to dip and spray transfer welding and display excellent weld bead profiles and penetration. They perform particularly well in all position welding of heavy steel sections. High CO_2 mixtures give spatter levels which are much lower than with carbon dioxide, but with comparable penetration and fusion performance. The addition of the oxygen reduces the droplet diameter and improves the stability of the transfer.



Penetration profile of Argon + Oxygen + Carbon Dioxide

Argon + Helium Mixtures

Argon/helium mixtures are usually used to obtain the most favourable characteristics of both gases in terms of heat input, weld speed, weld bead profile and penetration. The mixtures are normally used for heavier sections of non-ferrous metals such as aluminium, copper, magnesium and nickel. The heavier the metal thickness and the more heat conductive the metal, the greater the percentage of helium required in the mixture. Typical mixtures contain between 25% and 75% helium. Alushield Light and Alushield Heavy are argon/helium mixtures.



Penetration profile of Argon + Helium shielded weld on Carbon steel

Argon + Helium + Hydrogen

A mixture of argon/helium/hydrogen, as found in Argoshield™ 71T, produces a very hot arc making this mixture ideal for GTA welding of stainless and nickel steels. The relatively small amount of hydrogen does not cause damage to the tungsten electrode but is desirable to increase the speed of welding while offering cleaner weld beads by the reducing action of the hydrogen on the weld pool surface oxides. Hydrogen is also known to improve the weld tolerance of variations in austenitic stainless steel castings.

SHIELDING GAS INFORMATION

Mild and Medium Tensile Steels - Gas Metal Arc and Flux Cored Arc Welding

Shielding Gas	Filler Metals GMAW		Comments	Filler Metals FCAW	Comments
Argoshield 40	Autocraft LW1	Autocraft LW1-6	Clean, smooth finish	Metal-Cor XP*	
Argoshield Light	Autocraft LW1	Autocraft LW1-6	Clean, dip & spray transfer	Metal-Cor XP* Verti-Cor XP*	
Argoshield Universal	Autocraft LW1	Autocraft LW1-6	Higher penetration	Metal-Cor XP	Optimum shielding for penetration and travel speeds
				Verti-Cor XP Verti-Cor 3XP Supre-Cor 5	Smooth even transfer spatter and fine levels. Adequate penetration.
Argoshield 52	Autocraft LW1	Autocraft LW1-6	Higher CO_2 level, excellent dip and spray	Verti-Cor XP Verti-Cor 3XP Supre-Cor 5	Optimum shielding giving excellent edge fusion and penetration, low spatter and fume levels.
				Metal-Cor XP	Higher CO_2 contents with higher spatter levels.
Argoshield 54	Autocraft LW1	Autocraft LW1-6	High quality, triple mixture	Metal-Cor XP* Verti-Cor XP*	
Argoshield 100	Autocraft LW1	Autocraft LW1-6	Helium addition for higher travel speeds	Supre-Cor 5	Improved arc transfer, better fillet shapes & lower spatter levels
Welding CO_2	Autocraft LW1	Autocraft LW1-6	High penetration, low cost	Satin-Cor XP Verti-Cor ULTRA Verti-Cor ULTRA 3 Verti-Cor XP Verti-Cor 3XP Supre-Cor 5 Tensi-Cor 110TXP	Optimum shielding for economy and weld metal quality. Low cost shielding giving deep penetration characteristics.

** These shielding gases are not normally recommended due to higher Mn and Si recovery in the weld metal. For single pass fillet welds the results may be acceptable.*

SHIELDING GAS INFORMATION

Alloy Steels - Gas Metal Arc and Flux Cored Arc Welding

Shielding Gas	Filler Metals GMAW	Comments	Filler Metals FCAW	Comments
Argoshield 52	Autocraft Super Steel Autocraft Mn-Mo Autocraft CrMo1 Autocraft NiCrMo	Excellent penetration and usability for dip and spray transfer. Most suitable for dip transfer.	Supre-Cor 5	For alloy steels where full joint efficiency is not required
			Verti-Cor 80Ni 1 Verti-Cor 91 K2 Verti-Cor 111 K3	For alloy steels where higher joint strength is required
Stainshield	Autocraft Super Steel Autocraft Mn-Mo Autocraft CrMo1 Autocraft NiCrMo	Optimum choice for smooth transfer in spray mode, higher alloy recovery	N.R.	
Argoshield 100	Autocraft Super Steel Autocraft Mn-Mo Autocraft CrMo1 Autocraft NiCrMo	Helium addition for high travel speeds	Supre-Cor 5	Improved arc transfer, better fillet shapes & lower spatter levels. For alloy steels where full joint efficiency is not required

Stainless Steels - Gas Metal Arc and Gas Tungsten Arc Welding

Shielding Gas	Filler Metals GMAW	Comments	Filler Wires GTAW	Comments
Stainshield	Autocraft 308LSi, 316LSi, 309LSi,	Smooth, even transfer, excellent fillet shape, ideal for spray transfer	N.R.	
Stainshield Heavy	Autocraft 308LSi, 316LSi, 309LSi,	Excellent dip transfer, can also be used for spray For welding heavier section (›9mm) stainless steels.	N.R.	
Welding Argon	N.R.		Comweld 308L , 309L, 316L,	Low cost shielding for all general purpose applications. Also used as purge gas on pipe welding.

SHIELDING GAS INFORMATION

Aluminium Alloys - Gas Metal Arc and Gas Tungsten Arc Welding

Shielding Gas	Filler Metals GMAW	Comments	Filler Wires GTAW	Comments
Welding Argon	Autocraft AL1188 Autocraft AL4043 Autocraft AL5356	Excellent shielding for general purpose applications	Comweld AL1188 Comweld AL4043 Comweld AL4047 Comweld AL5356	Excellent shielding for manual applications
Alushield Light	Autocraft AL1188 Autocraft AL4043 Autocraft AL5356	Hotter arc to give broader & deeper penetration.	Comweld AL1188 Comweld AL4043 Comweld AL4047 Comweld AL5356	Hotter arc where more penetration is required.
Alushield Heavy	Autocraft AL1188 Autocraft AL4043 Autocraft AL5356	Hottest arc, high speed broadest, deepest penetration for heavy sections.	Comweld AL1188 Comweld AL4043 Comweld AL4047 Comweld AL5356	Hottest arc for heavier sections (›6mm) and mechanised applications.

Copper Alloys - Gas Metal Arc and Gas Tungsten Arc Welding

Shielding Gas	Filler Metals GMAW	Comments	Filler Wires GTAW	Comments
Welding Argon	Autocraft Deox. Copper Autocraft Silicon Bronze	For general purpose applications	Comweld Si. Bronze	For general purpose applications
Specshield Copper	Autocraft Deox. Copper Autocraft Silicon Bronze	For improved characteristics	N.R.	
Alushield Alushield Heavy	Autocraft Deox. Copper Autocraft Silicon Bronze	Hotter arc, reduces preheat temp. requirements. Higher travel speeds.	Comweld Si. Bronze	Hotter arc for mechanised applications. Higher travel speeds.