Types of shielding gases for GMAW

Objectives: At the end of this lesson you shall be able to
- **state the different types of shielding gases used in Gas Metal Arc Welding (GMAW) process**
- **state the effects of different shielded gases and gas mixtures on ferrous and non-ferrous metals**
- **select the inert gas or gas mixtures for welding different metals using different modes of metal transfer**
- **explain why a gas heater is used in CO_2 welding plant.**

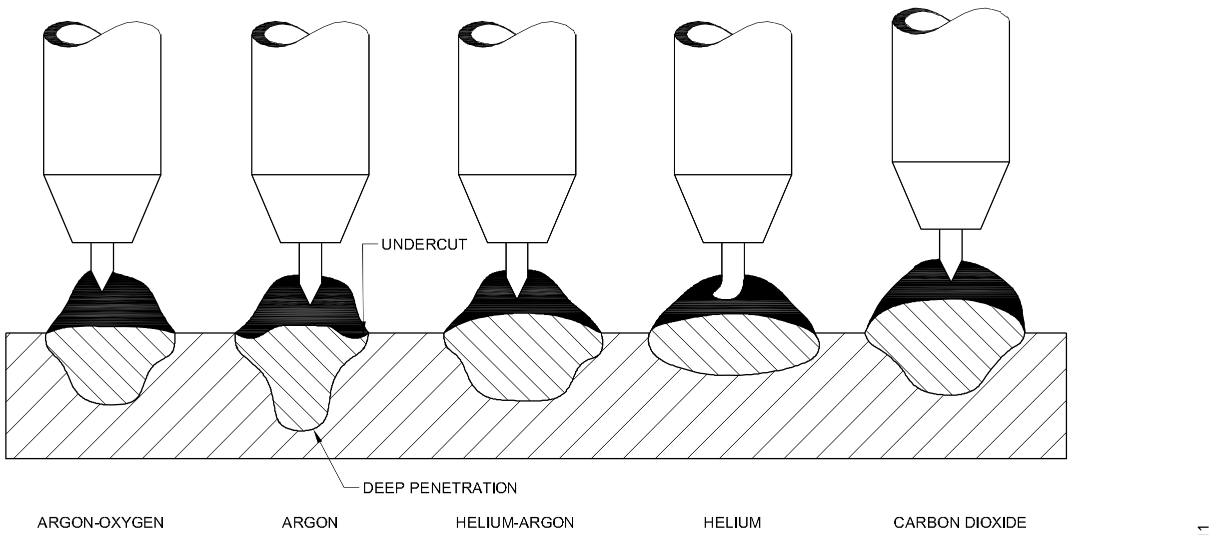
There are three types of shielding gases used for GMAW. They are inert gases, reactive gases and gas mixtures.

Inert gases: Pure argon and helium gas are excellent for protecting the arc, metal electrode and weld metal from contamination. Argon and helium are generally used for GMAW of non ferrous metals. Helium has very good conductivity and conducts heat better than argon. Therefore helium is choosen for welding thicker metals as well as high conductivity metals like copper and aluminium.

For thinner metal welding, lower conductivity argon is the better choice. Also argon is often used for welding out of position because of its lower thermal conductivity. Argon gas is 10 times heavier than helium gas, hence less argon gas is required to provide a good shield as compared to helium gas.

The weld bead contour and penetration are also affected by the gas used. Welds made with argon generally have deeper penetration. They also have a tendency to under cut at the edges. Welds made with helium have wider and thicker beads. Fig.1 shows the shape of welds made with various gases and gas mixtures.

Fig 1



GMAW BEAD SHAPES AND DEPTH OF PENETRATION FOR VARIOUS GASES AND GAS COMBINATIONS. THESE SHAPES ARE TYPICAL FOR DCEP (DCRP).

Argon used with the gas metal arc spray transfer process tends to produce deeper penetration through the center line of the bead. Spray transfer occurs more easily in argon than in helium.

Reactive gases and gas mixtures used in GMAW

Carbondioxide: Carbondioxide (CO_2) has a higher thermal heat conductivity than argon. This gas requires a higher voltage than argon. Since it is heavy, it covers the weld well. Therefore less gas is needed.

CO_2 gas is cheaper than argon. This price difference will vary in various locations. Beads made with CO_2 have a very good contour. The beads are wide and have deep penetration and no undercutting.

The arc in a CO_2 atmosphere is unstable and a great deal of spattering occurs. This is reduced by holding a short arc. Deoxidizers like aluminium, manganese or silicon are often used.

The deoxidizers remove the oxygen from the weld metal. Good ventilation is required when using pure CO_2. About 7-12 percent of the CO_2 becomes CO (carbon monoxide) in the arc. The amount increases with the arc length.

A 25% higher current is used with CO_2 than with argon or helium. This causes more agitation of the weld puddle, hence entrapped gases raises to the surface of the weld, so low weld porosity.

Argon carbondioxide: CO_2 in argon gas makes the molten metal in the arc crater more fluid. This helps to eliminate undercutting when GMA welding carbon steels.

CO_2 also stabilizes the arc, reduces spatter and promotes a straight line (axial) metal transfer through the arc.

Argon-Oxygen: Argon-oxygen gas mixtures are used on low alloy carbon and stainless steels. A 1-5 percent oxygen mixture will produce beads with wider, less finger shaped, penetration. Oxygen also improves the weld contour, makes the weld pool more fluid and eliminates undercutting.

Oxygen seems to stabilize the arc and reduce spatter. The use of oxygen will cause the metal surface to oxidise slightly. This oxidization will generally not reduce the strength or appearance of the weld to an unacceptable level. If more than 2% oxygen is used with low alloy steel, a more expensive electrode wire with additional deoxidisers must be used.

The desirable rate of gas flow will depend on the type of electrode wire, speed and current being used and the metal transfer mode.

As a rule small weld pools 10 L/min

medium weld pools 15 L/min

and large spray weld pools 20-25 L/min

Too much gas flow can be just as bad as not having enough. The reason being that if the gas flow is too high it will come out of the MIG Torch.

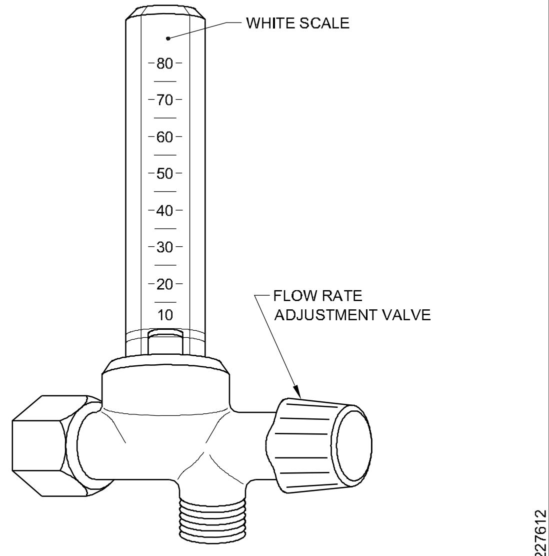
Suggested gases and gas mixtures for use in GMAW spray transfer

Metal	Shielding gas	Advantages
Aluminium	Argon 75% Helium 25% argon	0.1 in.(2.5mm) thick; best metal transfer and arc stability; least spatter 1-3 in.(25-76mm) thick; higher heat input than argon
Copper, nickel and alloys	Argon	Provide good wetting;good control of weld pool for thickness up to 1/8 in.(3.2mm)
Magnesium	Argon	Excellent cleaning action
Carbon Steel,	Argon 5-8% CO_2	Good arc stability; produces a more fluid and controllable weld pool; good coalescence and bead contour, minimizes undercutting ; permits higher speeds compared with argon.
Low alloy Steel	Argon 2% oxygen	Minimizes undercutting; provides good toughness
Stainless Steel	Argon 1% oxygen Argon 2% oxygen	Good arc stability; produces a more fluid and controllable weld pool, good coalescence and bead contour, minimizes under cutting on heavier stainless steels Provides better arc stability, coalescence and welding speed than 1% oxygen mixture for thinner stainless steel materials
Aluminium copper, magnesium, nickel and their alloys	Argon and argon helium	Argon satisfactory on sheet metal argon-helium preferred on thicker sheet metal
Carbon steel	Argon 20-25% CO_2 CO_2	Less than 1/8 in.(3.2mm) thick; high welding speeds without melt through; minimum distortion and spatter; good penetration Deeper penetration; faster welding speeds;minimum cost
Stainless Steel	90% helium 7.5% argon 2.5% CO_2	No effect on corrosion resistance small heat affected zone; no undercutting; minimum distortion; good arc stability

CO_2 gas cylinder and regulator: The shielding gas required for GMAW/CO_2 welding is supplied from a gas cylinder through an outlet valve and regulator.

Gas flow meter: It is a unit which has graduations marked on the glass tube. A flow rate adjustment valve fixed to the flow meter controls the rate of flow of inert gas/CO_2 gas to the welding gun in litre per minute. Fig. 2.

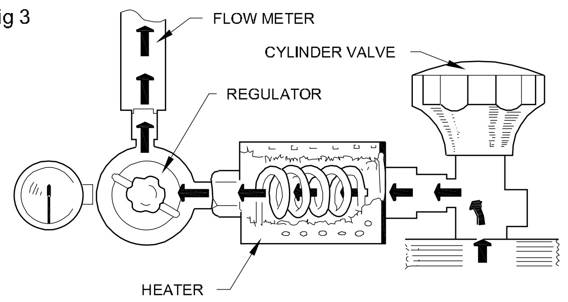
Fig 2



FLOW METER

Gas Preheater for CO_2 welding (Fig 3): Carbondioxide is filled in cylinders in liquid form. i.e., the CO_2 at room temperature and high pressure condenses into liquid form. Therefore while welding the liquid CO_2 has to be in gaseous form as they enter into the welding torch. CO_2 liquid boils and expands into gas as it passes through the regulator. This causes the gas to cool. If moisture is present in the regulator inlet, it will condense and freeze in the regulator, causing blocking of the gas passage. Therefore to avoid cooling a gas heater is connected to the cylinder to increase the temperature of the gas leaving the cylinder. Hence a uniform gas flow is maintained during welding.

Fig 3

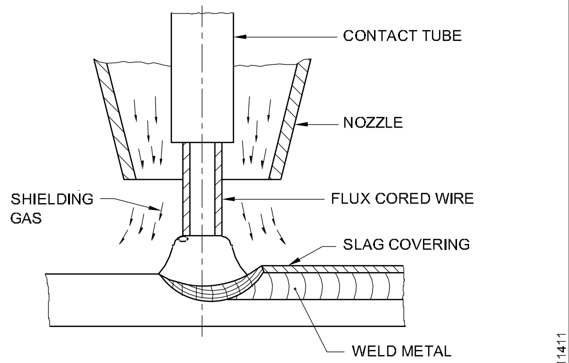


Flux Cored Arc Welding (FCAW)

Objectives: At the end of this lesson you shall be able to
- **explain the flux cored arc welding and narrow gap welding process**
- **explain the type of metal transfer in flux cord Arc welding**
- **classification of flux cored wires**

Flux Cored Arc Welding (FCAW) Fig.1 is an arc welding process in which the heat for welding is produced by an arc established between the flux cored tubular consumable electrode wire and the workpiece.

Fig 1



FLUX CORED ARC WELDING

There are two major versions of the process, namely self shielded type (in which the flux performs all the functions of shielding) and the 'gas shielded type', which requires additional gas shielding.

The gas shielded type FCAW is widely employed for welding of carbon steel, low alloy steel and stainless steel in flat, horizontal and overhead positions.

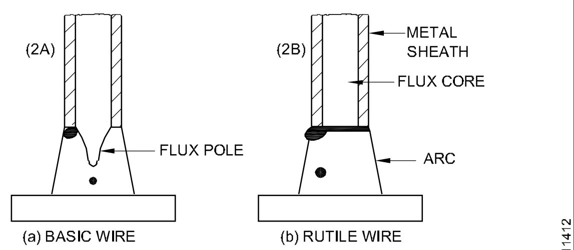
However, the self shielded type FCAW is mainly used for carbon steel welding and the quality of weld produced by this type is generally inferior to that of welds made with gas shielded type.

Equipment: The noticeable differences in the equipment used for GMAW and FCAW, are in the construction of welding torch and feed rollers.

The welding torch used for self shielded wire is very simple in construction as there is no need for the gas nozzle. Similarly the feed rollers used for flux cored wires have to ensure positive feeding of the wire without applying too much pressure on the soft tubular wire.

Metal transfer in FCAW: The metal transfer in FCAW differs significantly from GMAW process. FCAW process exhibits two distinctly different modes of metal transfer, namely large droplet transfer and small droplet transfer. However, both are classified as free flight transfer. The FCAW process does not produce a stable dip transfer as that of solid wire GMAW. The large droplet transfer occurs at the lower current voltage ranges. At higher current voltage ranges, the transfer mode changes to smaller droplet transfer. An important aspect to be observed during FCAW metal transfer is the presence of the 'flux pole' at the core of the arc column, protruding into the arc. The 'flux pole' appears only during welding with basic type flux cored wire. Fig.2(a) However, with rutile wire 'flux pole' does not occur and the metal transfer is of spray type. Fig.2(b)

Fig 2



APPEARANCE OF FLUX POLE

Classification of flux cored wires: The basic functions of the flux contained within the tubular wire include providing protective slag on the weld bead, introducing the required alloying elements and deoxygenerators into the weld pool and providing stability to the arc, besides producing the required shielding medium to protect the arc and weld pool.

Flux cored wires are now available for welding of plain carbon steel, low alloy steel and stainless steel and also for hard facing applications. These wires based on the nature of flux, may be classified as rutile gas shielded, basic gas shielded, metal cored and self shielded.

Rutile gas shielded wires have extremely good arc running characteristics, excellent positional welding capabilities and good slag removal and mechanical properties.

Basic gas shielded wires give reasonable arc characteristics, excellent tolerance to operating parameters and very good mechanical properties.

Metal cored wires contain very little mineral flux, the major constituent being iron powder and ferro alloys. These wires give smooth spray transfer in Argon/CO_2 gas mixtures. They generate minimum slag and are suitable for mechanised welding applications. Self shielded wires are available for general purpose down hand welding.

The flux cored wires are available in both seamless and folded types. The seamless type is generally coated with copper, whereas the folded type wires (i.e. close butt and overlapped type) are treated with special compounds.

Deposition rate and efficiency: Deposition rate is defined as the weight of metal deposited per unit time. The deposition efficiency is defined as the ratio of weight of weld metal effectively deposited to the weight of wire consumed.

In GMAW welding the deposition efficiency is generally between 93% to 97% and in FCAW the corresponding figure is between 80% to 86%. These values are determined by the spatter losses and slag formation. The low deposition efficiency in the case FCAW is due to the slag formation.

Generally the spatter loss can be minimised by using Argon/CO_2 mixed gas instead of CO_2 gas.