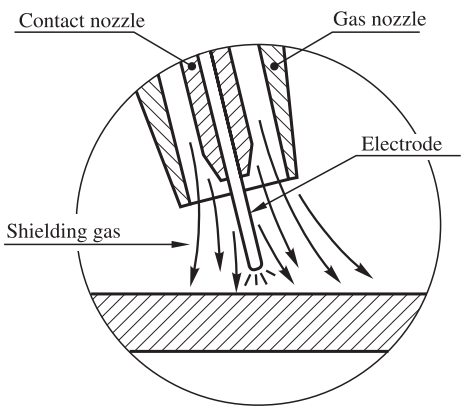
MAG Welding with Solid Wire - Methods and Equipment

MIG/MAG Welding

Generally

Gas Metal Arc Welding or welding with shielding gas, as it is often called, is a welding arc process which utilizes the heat of an electric arc established between a continuoually feeded wire and the workpiece. During this process the wire will melt and the weld metal is transferred to the workpiece.



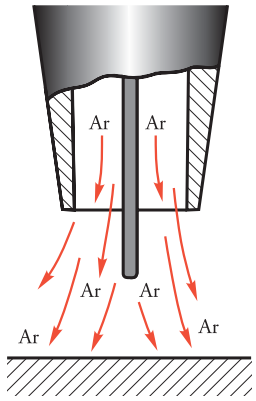
Shielding gas nozzle

The weld pool is always protected by a shield of gas in order to protect both the melting wire and the weld pool from the oxygen and nitrogen in the air. If these gases enter into the shielding gas atmosphere, it may cause porosities in the weld. Exterior disturbances such as draugths from open doors and windows may cause the shielding gas to blow away. Also ventilating air currents may influence on the welding place and the shielding gas.

The shielding gas is usually divided into two sub-methods according to the applied type of shielding gas.

MIG Welding

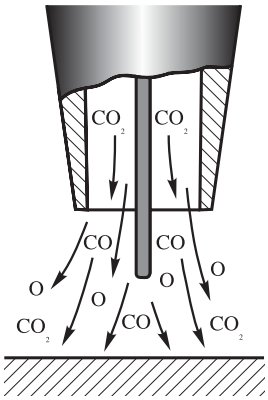
MIG welding is welding in an atmosphere of inert gas, which means welding with a shielding gas that does not react with other substances. Inert gases are for instance argon and helium of which argon is more used within the European region. Usually, the process is called MIG welding even
when the inert gas is mixed with small quantities of O_2, CO_2, H_2 or similar substances.



Argon shielding gas

MAG Welding

MAG welding is welding in an atmosphere of reacting gases, or as it is also called: shielded by an active gas. This means that the gas is separated in the arc and to a smaller or larger extent reacts with the weld pool. CO2 is mainly used as shielding gas which is why the process is also known as CO2 welding.



CO2 shielding gas

Advantages of MIG/MAG Welding

Every welding process has its pros and cons. The advantages of MIG/MAG welding are for instance as follows:

- The method is financially attractive due to a high welding speed and because a long arc time can be maintained as there is no frequent changing of electrode rods.
- The method provides the opportunity for rational welding of materials which are difficult to weld.
- Welding is possible in all positions.
- The arc and the weld pool is clearly visible.
- Usually only little aftertreatment of the weld is necessary.

Disadvantages of MIG/MAG Welding

Some of the disadvantages of MIG/MAG welding are as follows:

- The method is very vulnerable to draughts from ventilation systems, open doors and windows and the fans of aircooled welding machines.
- There is a risk of serious welding errors such as lack of fusion, etc. if the welder is not sufficiently skilled with a profound knowledge of the process and its welding parameters.
- The necessary, but costly, shielding of the welding place at outdoor jobs.
- Greater investments in welding equipment
- Greater expenses to maintenance to the welding equipment.

Applications

MIG/MAG welding is usually used with:

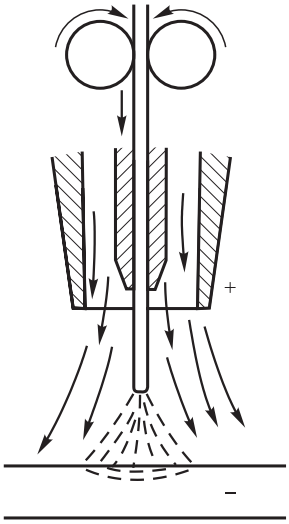
- Aluminium
- Ordinary mild steels
- Stainless steels
- Copper and copper alloys

In addition to the above metals this method is suited for magnesium, nickel and a number of other metals and their alloys.

Principle of Material Transfer

MIG/MAG welding is performed in two ways depending on the transfer of the metal; either spray transfer welding or dip transfer welding.

At spray transfer welding the voltage and current intensity are relatively high in relation to the diameter of the electrode. The material transfers as a lot of droplets which are flung from the arc like turbulent jets into the weld groove.



Material Transfer

Dip Transfer

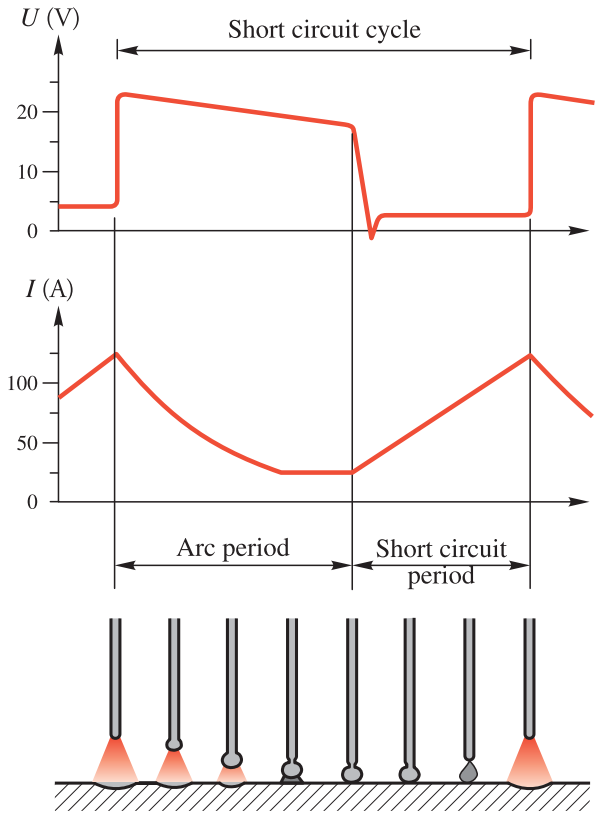
Dip transfer takes place with a comparatively thin wire, low current and arc voltage in relation to the diamater of the wire.

The heat input to the workpiece is moderate, and dip transfer welding is therefore suitable for welding in small plate thicknesses and for position welding as the weld pool is small and solidifies quickly.

During dip transfer welding the material is transferred in rather big drops which momentarily short-circuit the arc.

The number of short-circuits is approximately 20 to 200 times per second.

The below drawing shows a dip transfer cycle and the variations which the process imposes on the welding current and the voltage.



Dip Transfer Cycle

A droplet of melted material forms at the end of the wire. When it has grown big enough to establish contact with the weld pool, the arc short-circuits. In this moment the welding current increases drastically and the droplet is pinched off.
Afterwards the arc re-ignites.

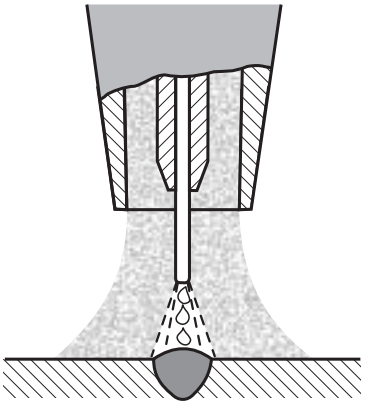
The short-circuit causes the formation of spatter and in addition the sound can provide an impression of whether the relation between voltage and current is adjusted correctly.

Spray Transfer Welding
Spray transfer welding is carried out with a comparatively high current and arc voltage in relation to the wire diameter.

The transfer of material takes place as many small droplets which are slung from the electrode into the weld pool.

There is no short-circuits of the arc. Spray transfer welding provides a stable arc.

The heat input to the workpiece is large which means that the weld pool is big and very fluid and therefore the method is only applicable for the vertical/down position.

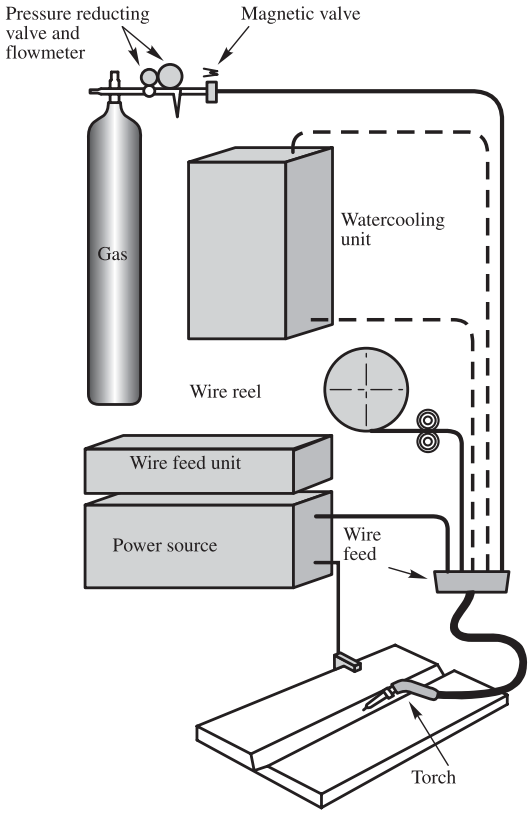


Spray Transfer Welding

Welding Equipment

Welding equipment for MIG/MAG welding consists in principle of:

- A shielding gas system with control
- A power source
- A wire feed unit
- A complete welding torch
- A reel of welding wire



Welding Methods

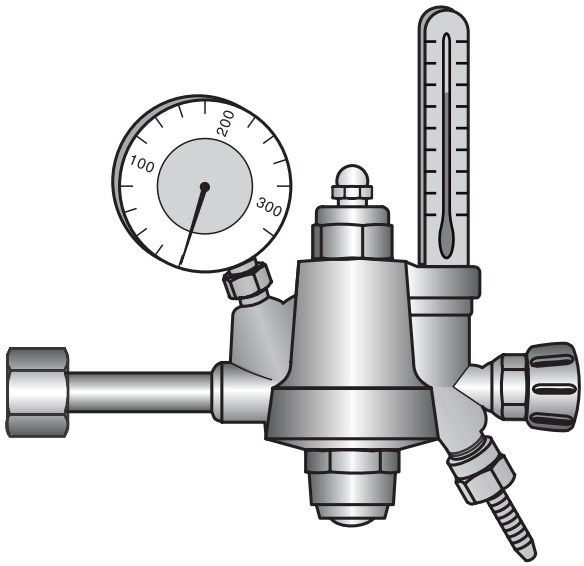
Older welding equipment can have quite a number of buttons and two to three connections for the earth cable. On such equipment the welder himself must adjust the welding parameters such as current, arc voltage and inductance, which demands a very skilled welder.

On the latest inverters these parameters are set by a small incorporated computer. The welder only has to adjust the welding current and the computer takes care of the rest. Furthermore, these new types of machines are programmable, and programs can be chosen during the actual welding process from a small remote control built-into the torch handle

Shielding Gas System

The shielding gas is supplied in cylinders of various dimensions and with a pressure of up to 150 kp/cm2.
The gas cylinder is fitted with a pressure reducing valve in order to decrease the high pressure inside the cylinder to a lower and less dangerous working pressure, before the gas flows into the hoses. After the pressure reducing valve (in connection with it) is a flowmeter indicating the gas consumption, usually in litres per minut.

The welding machine is equipped with a solenoid valve which controls the gas supply.

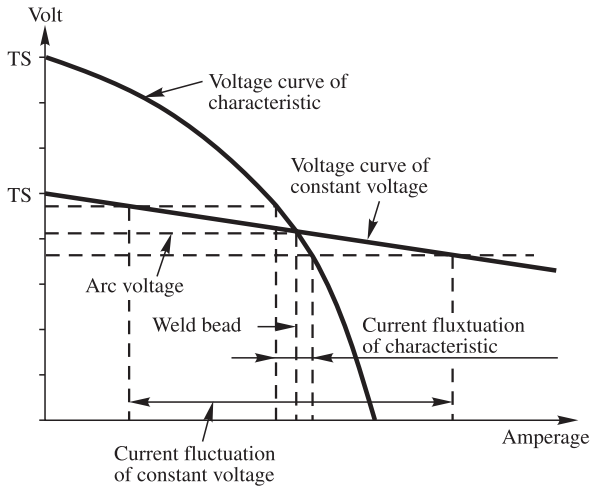


Welding Methods

Power Source

In order to obtain a stable arc the power source used for MIG/MAG welding must have a properly set or adjustable characteristic and an outlet for the appropriate inductance values. The static characteristic is the curve for voltage (V) versus current (A). A normal power source has a falling static characteristic, while a power source with an approximate flat characteristic is usually used for MIG/MAG welding.

If the welding result is to be good, the arc length should very as little as possible.



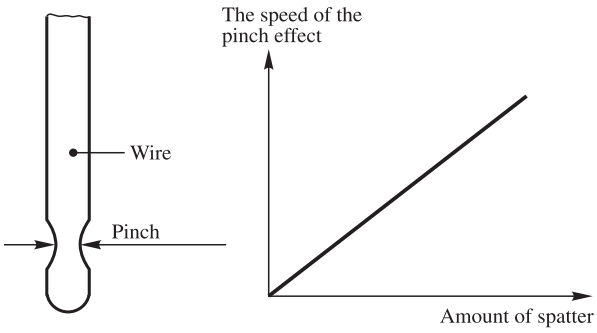
When in MIG/MAG welding the wire is feeded with a constant speed, it is rather simple to obtain the right welding conditions by means of a power source of the constant voltage type. If the arc length is shorter than the set value, that is if the arc voltage lowered, is current intensity will automatically increase dramatically and the wire will melt quicker than it is feeded.

If on the other hand the arc length is increased, the current intensity will automatically decrease and the wire is feeded quicker than it can melt. This means that the arc is kept constant even if the distance between the torch and the workpiece is changing for instance if the torch is not held regularly. Another advantage of the constant voltage power source is that there is a reduced risk of the wire burning up in the contact nozzle.

When welding is done by power sources of a falling characteristic, the current fluctuations

when the arc voltage changes are too small to adjust the arc length. It is therefore necessary that the wire feed unit is equipped with a motor which reacts to impulses from the arc so that the wire speed increases when the arc voltage increases

For dip transfer welding a welding rectifier with an approximately flat characteristic should be used in order for the wire to burn off quickly. Afterwards an inductor is often used in the welding current circuit. When the inductor is connected it has the effect that the speed of the current increase is slowed down at short-circuits and thereby less spatter is produced and a more stable arc is obtained because the pinch effect is reduced.



The speed of the pinch effect in relation to the amount of spatter

If the cable is connected to the first outlet, usually marked 1 or A, only few or none of the inductor windings are used. Consequently, the effect is small or non-existing and is called minimum inductance.

If the cable is connected to the last outlet the whole inductor is operating producing maximum inductance.

A power source with three outlets therefore has the possibility of minimum, medium or maximum inductance effect.

On modern power sources the inductance setting can be infinitely variable.

Wire Feed Unit

The wire feed speed is connected with the control of the wire feeding that is with the control system. For the actual mechanical feeding there are three different systems in principle.

Separate Wire Feed Unit

Method 1

The wire is pushed forward by the wire drive unit through the wire guide liner to the torch.

Wire Feed Unit in the Welding Torch

Method 2

The wire is pulled forward to the torch by a wire feed unit in the torch, figure A, Both the wire feed unit and the wire rolls are placed inside the welding torch (sigmette), figure B.

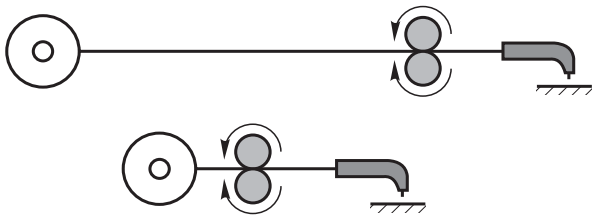


Figure A

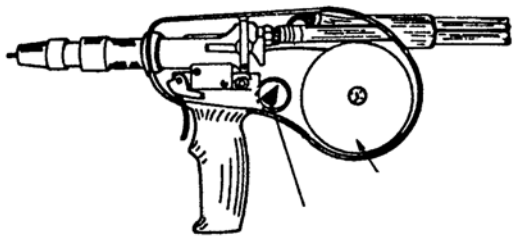
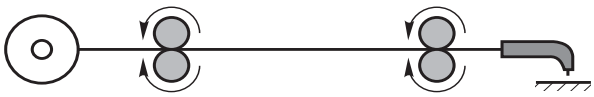


Figure B

Method 3
The wire is pushed forward by a wire feed unit in the welding machine and at the same time it is pulled through the wire liner by a wire feed unit in the welding torch, the so-called push-pull system, figure C.



Figur C

Advantages and Disadvantages
Method 1
Method 1 is the most frequently used of the three systems. It is a simple system and with regard to weight it offers the lightest torch. This system is not suitable for welding with very thin wire of soft materials.

Method 2
This system makes the welding torch heavy, but in return the welding cable is very flexible even when using very thin wires, and it is possible to use long welding cables to increase the working range.

The sigmette system with a small wire reel placed inside the welding torch is particularly suitable for welding with a soft wire in thin materials, e.g. 0.8 and 1.2 Al-wire. This system offers fine possiblities for welding in places otherwise hardly accessible.

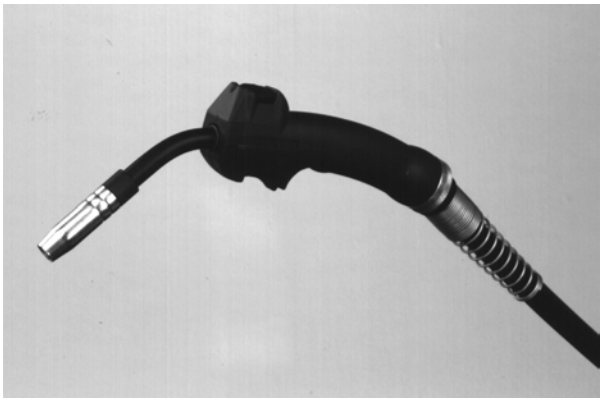
Method 3
If it is necessary to work in places at a long distance from the wire feed unit, as for instance fitting jobs at shipyards, the push-pull system is preferable, but also more expensive than the other two systems.

The Welding Torch

The welding torch can be either aircooled or watercooled. In general aircooled torches are used for all materials at low current intensities and also for welding of ordinary mild steels at higher current intensities. An aircooled torch will be rather heavy if it is to be used at higher current intensities.

Aircooled torch

Torch with integral fume exhaust



Aircooled ergonomical torch

Watercooled torches are lighter. They are mostly used for welding of metals and light metals at high current intensities. Is is important to notice that a watercooled torch will quickly burn off if the supply of water fails. Ususally this type of torch is fitted with some sort of protection which prevents welding if the torch is overheated (overheating protection) or if the water pressure fails (pressure protection).

Special attention should be paid to leaks that allow air to enter into the shielding gas. This can cause very serious welding errors.

Welding Wire

Welding wire is either delivered on wire reels or in coils for larger industrial installations. The wire must always be strictly concordant with the base material and the welding process.

In MIG welding there is no reaction between the welding wire and the shielding gas which means that concerning the chemical composition, the welding result only depends on the quality of the wire and the penetration into the parent material.

In MAG welding there is a reaction between the filler material, the shielding gas and the parent material. Usually, this reaction means that alloying elements are burned off in the arc. Wire for welding of e.g. steels are therefore over-alloyed with Si and Mn which partly burn off, that is they oxydize in the arc, and precipitate in a very hard almost resin-like slag scattered alongside the weld seam.

Regardless of the materials to be welded the basis of a good welding result is a clean wire free from grease and other polluting elements.

When the welding changes from for instance A1 alloys to welding in ordinary steel, the wire liner must also be exchanged in order to avoid the transfer of steel shavings to A1 alloys and vice versa.

Ergonomics

When welding in difficult positions it is often necessary for the welder to work in an akward and unhealthy working position. Such a working position may in the long run cause damages to the back or innjuries that demand medical treatment, and in the worst cases will disable the welder.

Therefore it is important to avoid working in straining positions and always consider the possibilities for making the working position as comfortable as possible.

A complete watercooled torch is often very heavy to carry and imposes a strain on the welder's back. A relief arm for the torch can be very useful to take the strain off the welder's back.

Relief arms exist in a number of models for fiiting either on the welding machine or on the ceiling, thus it should be possible to find a model suitable for almost any working situation.

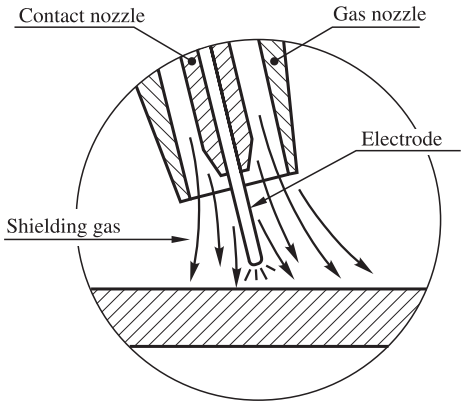
MAG Welding with Flux Cored Wire – Methods and equipment

MIG/MAG Welding – Flux Cored Wire

For many years the industry has wanted a semi-automatic arc welding process with continuously feeded wire without exterior coating and with a higher deposition rate than that of solid wire, known from the MAG welding process. If in addition a higher safety against welding errors could be obtained, so such a semi-automatic process could be used for welding in thicker dimensions, where traditionally coated electrodes were used, it would be even better.

In the early 1950s thin flux cored electrodes were developed on the basis of the MAG welding method. This type of wire can be used with the same welding equipment which is used for welding with solid wire.

By means of the wire flux it is possible to influence the physical conditions in the arc and the transfer of material, and also influence the metallurgic conditions. In this way some of the disadvantages and limitations of MAG welding with solid wire have been set up.



Flux cored wires for AC welding can be produced in the same way as coated electrodes.

The flux of the wire can contain elements which develop substantial amounts of gas and provides adequate shielding of the weld pool, thus eliminating the need for outer shielding gas.

It is possible to add alloying elements to the weld metal via the flux filling process which cannot be alloyed to a solid wire because it would destroy the drawing properties of the wire.

In the production of flux cored wires it has been a priority to seek to improve the transfer of material at higher current intensities than it is possible to utilize in MAG welding with solid wires.

The outer gas shielding is maintained. However, there is another version of this process called innershield welding where welding is carried out without use of shielding gas.

Welding with flux cored wire is in fact a special form of welding with shielding gas. It has the same limitations because of the need for an effecient gas shielding of the weld pool as the other welding methods with shielding gas, for instance it is still vital to keep a short distance between the gas nozzle and the workpiece.

Exterior disturbances around the welding place e.g. draugths from open doors and windows may cause the shielding gas to blow away. Also ventilating equipment in the shop og aircooled power sources can influence the welding place and the shielding gas.

The shielding gas is usually divided into two sub-methods according to the type of shielding gas.

MIG Welding

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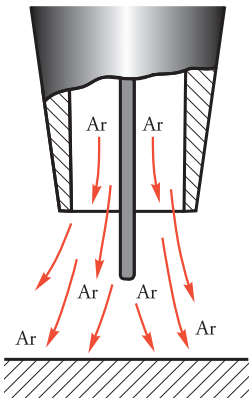

Argon Shielding Gas in MIG Welding

MAG Welding

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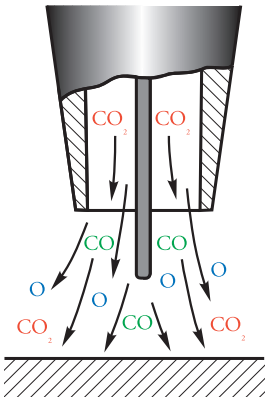

CO2 shielding gas when MAG welding

Advantages of MIG/MAG Welding with Flux Cored Wire

There is always advantages and disadvantages with any welding process. The advantages of welding with flux cored wire are as follows:

- The method is economical due to the high welding speed and because it is possible to maintain the arc in a long time as there is no need to change the electrode.
- The method offers the possibility to weld so-called difficult weldable materials in a rational way.
- Welding can be done in all positions
- The arc and the weld pool are completely visible.
- Usually there is only little after-treatment.
- The risk of serious welding errors is reduced compared to welding with solid wire.

Disadvantages of MIG/MAG Welding with Flux Cored Wire

Some of the disadvantages of MIG/MAG welding are as follows:

- The method is very vulnerable to draught from ventilation systems, open doors and windows as well as fans of aircooled welding machines.
- Risk of serious welding errors such as lack of fusion if the welder is not trained to have a profound knowledge of the welding process and its parameters.
- Increased costs for coverage of the welding place at outdoor jobs.
- Increased investments in welding equipment.

Application area

MIG/MAG welding with flux cored wire is now used for every job for which previously coated electrodes were used, e.g. at shipyards and other heavy industries working in material thicknesses more than 6 mm.

Today flux cored wire is used with ordinary mild steels and heat-resistant, acid-resistant and stainless steels.

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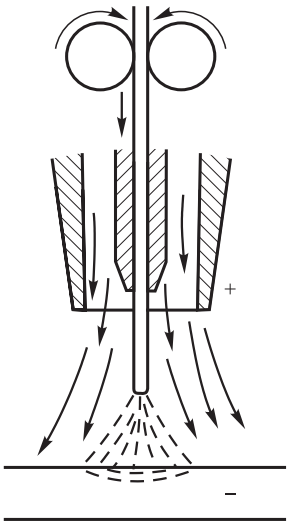

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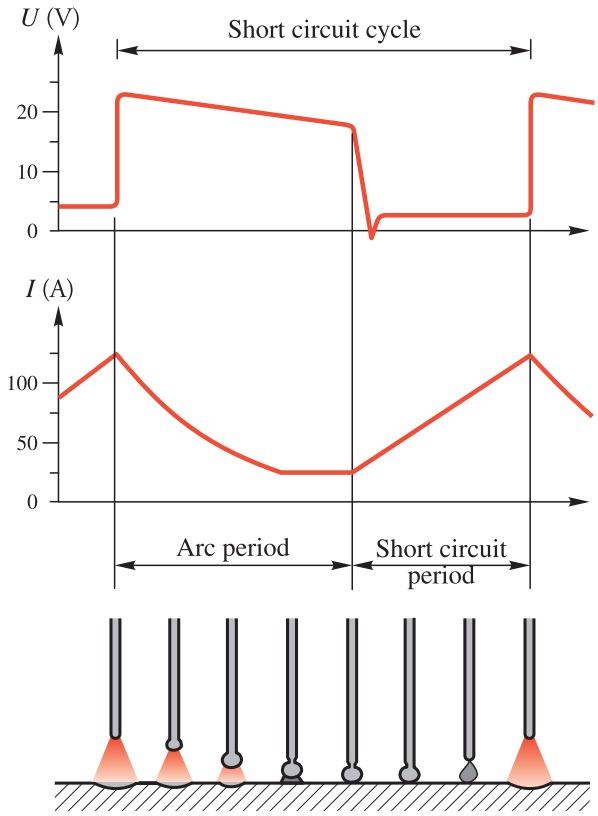

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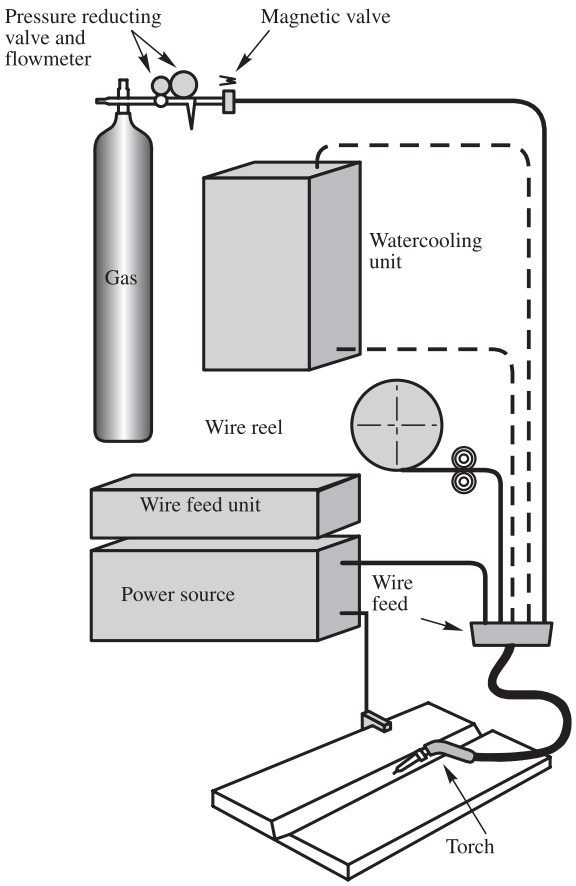

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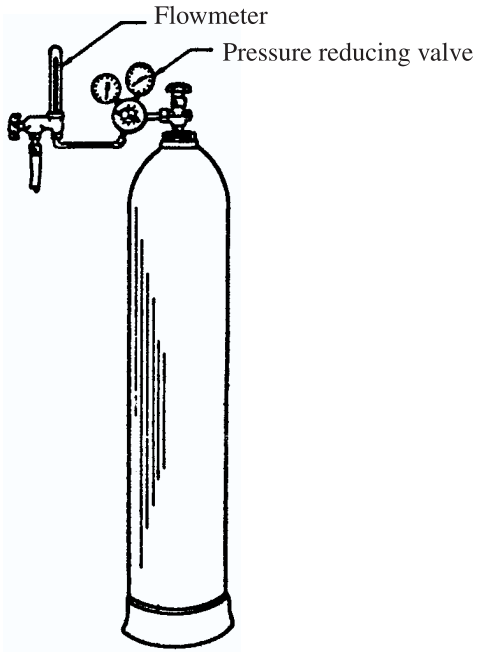

Gas cylinder with equipment

Power Source

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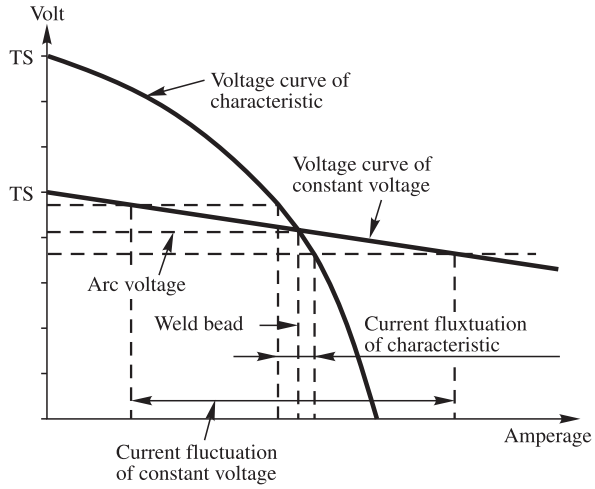

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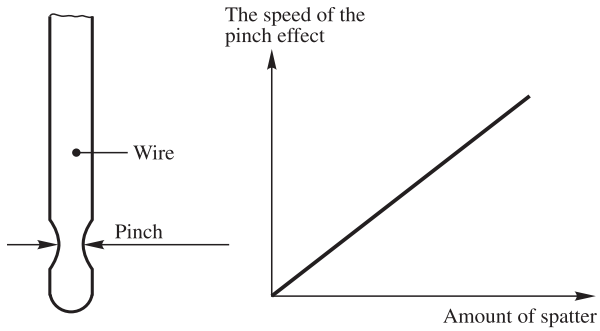


The speed of the pinch effect in relation to th amount of spatter

If the cable is connected to the first outlet usually marked 1 or A only few or none of the inductor windings are used. Consequently the effect is small or non-existing and is called minimum inductance.

If the cable is connected to the last outlet the whole inductor is operating producing maximum inductance.

A power source with three outlets therefore has the possibility of minimum, medium or maximum inductance effect.

On modern power sources the inductance setting can be infinitely variable.

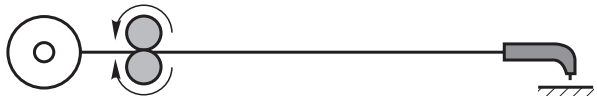
Wire Feed Unit

The wire feed speed is connected with the control of the wire feeding that is with the control system. For the actual mechanical feeding there are two different systems in principle.

Separate Wire Feed Unit

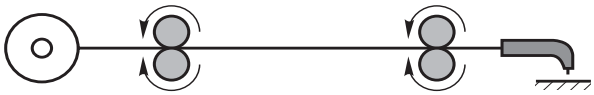
Method 1

The wire is pushed forward by the wire drive unit through the wire guide liner to the torch.



Method 2

The wire is pushed forward by a wire feed unit in the welding machine and at the same time it is pulled through the wire liner by a wire feed unit in the welding torch, the so-called push-pull system, figure C.



Figur C

Advantages and Disadvantages

Method 1

Method 1 is the most frequently used of the three systems. It is a simple system and with regard to weight it gives the lightest torch. This system is not suitable for welding with very thin wire of soft materials.

Method 2

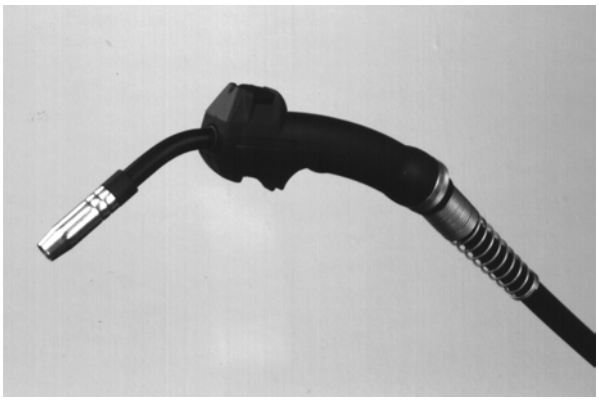
If it is necessary to work in places at a long distance from the wire feed unit, as for instance fitting jobs at shipyards, the push-pull system is preferable, but also more expensive than the other system.

The Welding Torch

The welding torch can be either aircooled or watercooled. In general aircooled torches are used for all materials at low current intensities and also for welding of ordinary mild steels at higher current intensities. An aircooled torch will be rather heavy if it is to be used at higher current intensities.

Aircooled torch

Torch with integral fume exhaust



Aircooled ergonimical torch

Watercooled torches are lighter. They are mostly used for welding of metals and light metals at high current intensities. Is is important to notice that a watercooled torch will quickly burn off if the supply of water fails. Ususally this type of torch is fitted with some sort of protection which prevents welding if the torch is overheated (overheating protection) or if the water pressure fails (pressure protection).

Particular attention should be paid to leaks that allow air to enter into the shielding gas. This can cause very serious welding errors.

Welding Wire

Welding wire is either delivered on wire reels or in coils for larger industrial installations. The wire must always be strictly concordant with the base material and the welding process.

In MIG welding there is no reaction between the welding wire and the shielding gas which means that concerning the chemical composition, the welding result only depends on the quality of the wire and the penetration into the base material.

In MAG welding there is a reaction between the filler material, the shielding gas and the base material. Usually this reaction means that alloying elements are burned off in the arc. Wire for welding of for instance steels are therefore over-alloyed with Si and Mn which partly burn off, which means oxydize in the arc, and precipitate in a very hard almost resin-like slag scattered alongside the weld seam.

Regardless of the materials to be welded the basis of a good welding result is a clean wire free from lubricates and other contaminations.

When the welding changes from for instance A1 alloys to welding in ordinary steel, the wire liner must also be exchanged in order to avoid the transfer of steel shavings to A1 alloys and vice versa.

Ergonomics

When welding in difficult positions it is often necessary for the welder to work in an akward and unhealthy working position. Such working position may in the long run cause damages to the back or innjuries that demand medical treatment, and in the worst cases disable the welder.

Therefore it is important to avoid working in straining positions and always consider the possibilities for making the working position as comfortable as possible.

A complete watercooled torch is often very heavy to carry and imposes a strain on the welder's back. A relief arm for the torch can be very useful to take the strain off the welder's back.

Relief arms exist in a number of models for fiiting either on the welding machine or on the ceiling, thus it should be possible to find a model suitable for almost any working situation.

Welding Equipment - Welding Errors

Errors in MAG Welding

Welding equipment for welding with shielding gas are built of a considerably larger number of components than welding machine for MMA welding with coated electrodes. Today welding machines for MAG welding is filled with electronics for instance for programming of the welding parameters.

All these advanced electronic components help to ease the everyday life of the welder, and the modern welding machines also reduce the risk for welding errors, but at the same time the electronics make the modern welding machine more fragile and sensitive than the welding rectifiers we use for welding with coated electrodes.

In the following section we will describe some of the many components of the MAG welding machine, the more common errors in these components and of course the welding errors they bring about.
the welder is able to see if the wire has been deformed. If the wire is deformed, it will appear from the contact nozzle in a spiral.

The Welding Machine

The heart of the welding machine - the electronics - is not the field of the welder. If errors occur in this field, it is often necessary to call assistance from the aftersales service of the manufacturer.

For safety reasons the welder should not interfere with the mains voltage supply of the welding machine or other electric components inside the case of the welding machine.

Instead the welder can help and not least prevent errors is by treating his welding equipment carefully.

Wire Feeding

When the wire is fed through the contact nozzle it looks very simple, but in fact the wire passes thought a number of individual parts which must be in order to achieve a fine welding result.

The wire rolls should be adjusted so that the grooves fit the actual wire size, and the pressure of the rolls on the wire should be correct. If the pressure is too small the rolls will slide on the wire and the wire speed will be irregular.

The welder will register this error during the welding process as a lack of wire feeding and irregular wire speed. The weld will get a poor appearance and lack fusion and porosities will also be likely consequences.

This error can be precluded if the welder controls the pressure of the wire rolls on the wire before welding begins. If the wire can be held back with two fingers so the rolls slide on the wire, the pressure is correctly set.

If the pressure on the wire is too large, the wire will almost be rolled, thus deformed and destroyed. By letting the wire pass through the contact nozzle without short-circuiting the wire,

When the depth and the diameter of the groove fit the welding wire and the pressure of the rolls is correct, the wire should be fed evenly with the speed set by the welder on the operation panel. However, if this is not the case it could be that the wire rolls are worn and need to be exchanged.

Furthermore, the quality of the wire feed unit is of crucial importance for a welding process without problems. the wire rolls should be strong and the transmission between wire motor and rolls should be properly made gear transmission A wire feed unit with 4-roll drive works better than a single wire unit with two rolls. Furthermore, the 4-roll drive has more possibilities of application.

Wire Guiding
Another risk of errors in the wire feed unit is the capillary tube. In the first place it must be firmly fixed and adequately near the wire rolls. If the distance between the wire rolls and the capillary tube is too large, the wire may tie knots in the gap between the two components.

Furthermore, it is important that the capillary tube is aligned with the groove in the wire roll, and that the diameter of the capillary tube fits the chosen wire diameter.

The Complete Torch

The torch is a unit consisting of the wire liner, protection hose, wires for control current and maybe hoses for cooling water to the welding torch. This is a point where many errors or disturbances may appear.

Always avoid sharp bends on the hoses as they may cause the wire feeding to be irregular and the wire liner to break.

Avoid too long hoses and cables, The thinner the wire the shorter the torch hoses. If longer hoses are necessary, you should use an extra wire feed unit (an intermediary station) to make sure that the wire is kept tight all the way from the wire feed unit to the contact nozzle.

The wire liner should be blown regularly with compressed air to clean out dirt which can prevent the wire from being fed evenly.

If the welder spent only 15 minutes every week to check and clean the welding equipment, a lot of time and money could be saved on operation stops.

Most operation disturbances of a MAG machine could be prevented by the welder by treating the equipment with care.

If the welding machine is watercooled, hoses, connections and packings should be checked for leaks at regular intervals.

If a watercooled welding machines has not been in operation for some time and the packings have dried up, they should be exchanged before welding starts.

The Welding Torch

Often welding errors due to errors in the welding equipment are caused by errors in the welding torch and particularly the contact nozzle.

When welding in position a lot of spatter can stick to the contact nozzle causing irregular wire feeding, porosities and in the worst case lack of fusion.

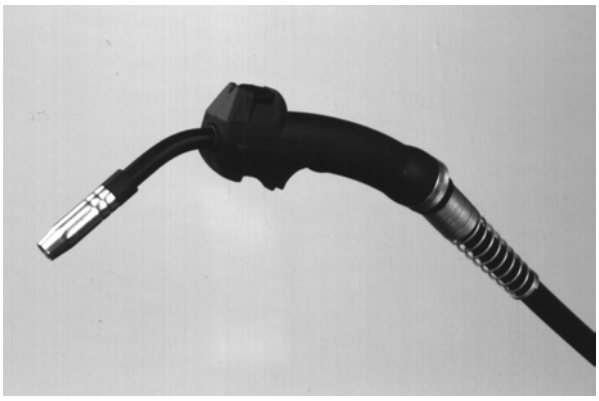
The contact nozzle also wears and the hole will become so large that the current transfer deteriorate.

This also causes irregular wire feeding, porosities and lack of fusion.

Depending on the type of the torch an insulator is fitted in the gas cup or a gas diffuser is fitted on the torch right under the swan neck. The insulator or the diffuser take care that the shielding gas is evenly distributed all around the contact nozzle to ensure an effective shielding of the weld pool. If the insulator or the diffuser is defective it immediately causes welding errors such as porosities, long porosities and in the worst case lack of fusion. Therefore the welder should check the diffuser and insulator every day.

Another important thing to check is the wire liner.

Apart from the liner which runs from the wire feed unit through the cable to the torch handle there is a small piece of liner inside the swan neck of the welding torch. This piece of liner needs cleaning as regularly as the long wire liner and should also be exchanged regularly.



Aircooled ergonomical torch

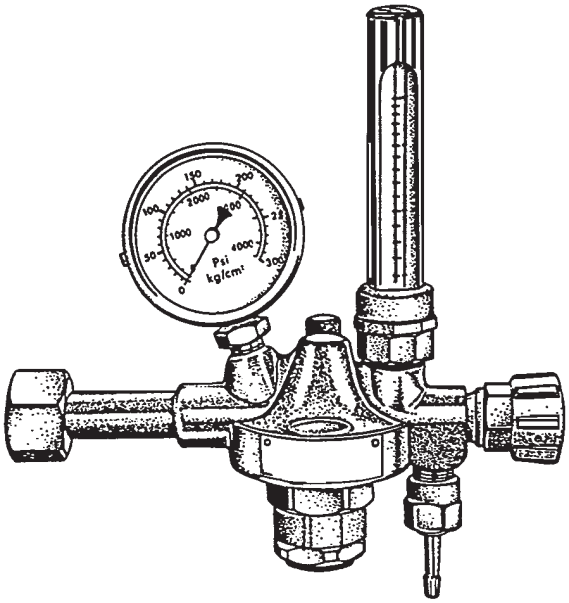
The Pressure Reducing Valve

The pressure reducing valve should be suitable for the applied shielding gas and functionable, so the content of the cylinder and the outflow quantity can be read with reasonable certainty.

An often occurring deficiency of the pressure reducing valve is that it tends to freeze. When it freezes the gas flow to the welding torch is reduced or stopped which causes a weld with many porosities and long porosities.

Therefore the pressure reducing valve and the gas flow should be controlled regularly. The gas flow can be controlled by a small flowmeter which is held on the torch while the gas flows and then the actual gas flow is indicated on the meter.

Remember to interrupt the wire feeding when you make this check.



Pressure reducing valve with flowmeter.

Other Error Possibilities by Equipment or Welder

Errors such as porosities or lack of fusion are always caused by defective welding equipment or wrong welding technique and lack of reflection on the welder's part.

If there is not adequate supply of shielding gas to the weld porosities will appear in the weld. Often the porosities are caused by an empty cylinder which the welder ought to have noticed before the errors occurred.

If the cylinder is adequately full and the flowmeter on the pressure reducing valve shows adequate gas flow, but there are porosities in the weld surface like those similar to lack of shielding gas, it may be that the solenoid valve of the welding machine is stuck.

Check the solenoid valve and its possible cable connections.

It is important always to take the weather into consideration when MAG welding is carried out. Draught removes all shielding gas from the weld pool and the weld becomes filled with porosities. Make sure the welding place is carefully protected from draught and wind. Even through the gap of a weld groove there may be draught under certain conditions.

Take care not to lie down the welding torch too much when welding. If the torch is lying too much there will be an injector effect in the gas nozzle causing atmospheric air to be sucked into the torch.

If the welding equipment has been checked and is OK, and there continues to be porosities in the weld, it may be caused by impurities in the shielding gas. However, this error is rather rare, but it may happen and can be controlled at the gas supplier's.

Finally, it is important that the workpieces are free of lubricants, grease, primer and similar substances as they may cause porosities and lack of fusion.

Other Interior Welding Errors

In the previous sections only errors such as porosities and lack of fusion has been mentioned. These are also the most common errors of MAG welding, but other errors such as slag inclusions may occur.

Cracks

Cracks may appear in the base metal for instance if the cooling time is too long or too thick layers are welded. If a Welding Procedure Specification (WPS) has been made for the welding job, it is important that it is observed in order to avoid cracks. It is also a good idea to weld several thin passes than a few thick passes as it reduces the toughness of the fusion zone and thereby the risk of cracks and breaks.

When welding in low-alloyed materials or materials which usually require preheating, there is a certain risk of hydrogen cracks, and therefore a WPS in which the risk of hydrogen cracks is calculated according to DS 316/EN 1011 should be used.

Geometric Errors

All welding errors, both interior and exterior, influence the geometry of the weld and is therefore called geometric errors. However, by geometric errors are often meant exterior errors such as undercuts, excess weld metal, lack of filling, penetration errors, etc.

All these errors and their tolerances are described in DS/EN 25817 and will not be mentioned further in this book.

Welders' Errors

There are many other possibilities for errors that those mentioned here, but the most important types of errors and their causes have been described on the last few pages. However, the weaker link of the chain is often the welder, and the more experienced the welder, the fewer errors in the weld.

The biggest risk at MAG welding is the fact that the welding parameters can be set so low, that there will be no penetration into the base material although the weld pool flows nicely and the machine sounds all right. Many welding errors can be avoided by increasing current and voltage to increase the heat of the material and thereby obtain a better penetration into the base material, and also by choosing the correct inductance level on the welding machine. Remember, that when the welding machine "hums like an angry bee" you are welding is the dip transfer area and in this area it is only possible to weld bottom runs in butt welds with full penetration or weld in very thin material thicknesses.

It is also very important for the welder to be familiar with his welding machine in order to make the correct adjustments.

On some welding machines it is difficult to trim the machine correctly as there is a wealth of regulation buttons, but on the newer welding machines the regulation of welding parameters is more simple, and the most frequently used welding data can be programmed in the memory of the machine.

The geometric welding errors which can be controlled visually are described in details in the DS/EN 25817. All geometric welding errors both exterior and hidden interior errors are defined in the DS/EN 26520.

MAG Welding - Setting of Welding Parameters

Setting of the Welding Parameters

When being an inexperienced MIG/MAG welder it can be a problem to adjust the welding machine to weld with optimum welding data. The problem is that there are several variable parameters that must suit each other correctly if a satisfactory welding result is to be achieved.

The following section is a description of the significance of the individual welding parameters and a method to get started on the welding job.

Types of transfer

There are several forms of material transfer by the arc in MIG/MAG welding. The transfer is separated in dip transfer welding, spray transfer welding, droplet transfer (mix-arc) and pulse welding.

The choice of type of transfer depends on:

- The thickness of the material
- The type of weld
- The welding position
- The size and type of the welding machine

Dip Transfer Welding

Definition
In dip transfer welding the transfer of material takes place as an interplay between the formation of a droplet of welding wire and its short-circuiting. When the arc is established a droplet forms on the end of the wire. This droplet will grow and eventually get into contact with the weld pool and then short-circuit. This means that the droplet is pinched off at a speed of 80 to 200 short-circuits per second. This issue is further described in the section “Welding Methods and Equipment”.

Wire Dimension at Dip Transfer Welding
When welding within the dip transfer area relatively thin wires between 0.8 and 1.0 mm are used. When welding in very thin base materials such as motorcar body sheets also very thin wires of 0.6 mm are used, but also 1.2 mm wires can be used in the dip transfer area. As dip transfer welding is only applied on materials of smaller dimensions, welding with other dimensions of wire is not possible.

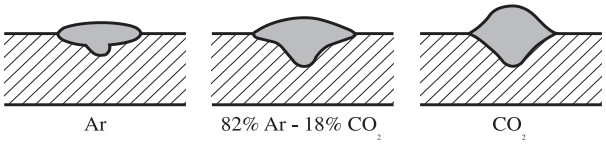
Areas of Application
Dip transfer welding is only suited for welding in ordinary steel. If the method is used on aluminium or stainless steels there will be produced a substantial amount of spatter from the weld pool, and the risk of lack of fusion will be very high. Dip transfer welding is particularly used on plate thicknesses < 5 mm and for welding of bottom runs in thicker materials, even very large plate dimensions.
Dip transfer welding is also suitable for position welding for instance when the bottom run is welded vertically-downwards while the remaining runs are welded vertically-upwards.

Welding parameters
At dip transfer welding with 0.8 mm electrode the welding current will be between 50 and 90 A, while the voltage is between 16 and 18 V. The stick-out should be some 15 mm. Both CO_2 and mixed gas are applicable with a gas flow of 8 to 12 l/min. When welding with a 1 mm wire the current should be around 80 and 150 A while the typical arc voltage should be around 17 to 20 V.

Penetration
The penetration in the dip transfer area is somewhat larger with CO_2 than with mixed gas (at the same wire feeding). The reason is that the weld pool of the mixed gas is shorter due to the higher short-circuit frequency and the lower arc voltage (2 to 3 V) than that of CO_2.

As the mixed gas due to its stable arc has a much larger tolerance than CO_2 for the variations of welding parameters, for instance the current intensity, it is easy to increase the wire speed and compensate for the smaller penetration and at the same time increase the weld speed.

Welding with mixed gases usually offers higher welding speed than welding with CO2, due to the fact that the mixed gas arc is more stable and therefore allows higher wire speed.



Spray Transfer Welding

Definition
Spray transfer welding or spray arc welding is welding where the wire is transferred as spray, hence the name Spray Arc. The transfer takes place as a large amount of very fine drops without short-circuits. The best result is obtained when the arc “snarls” a bit.

Welding parameters
The welding current at spray transfer welding is very high, between 140 A with a 0.8 mm wire and some 390 A with a 1.6 mm wire. The voltage will be between 23 and 24 V with the same wire diameters.

Wire Dimensions
Usually 1.0 and 1.2 mm wires are used for spray transfer welding, but wire of 0.8 and 1.6 mm are also applicable.

Shielding gas
Mixed shielding gases with a large content of argon are always used for spray transfer welding, e.g. 82/18. Due to the large droplets welding with CO2 would make it impossible to control the weld pool.

Application Area
Spray transfer welding can be used with all metals. However, with ordinary steel the only welding position is underhand welding. The method is used with material thicknesses more than 3 mm and up to even very large thicknesses. Spray transfer welding is a very heat welding process, but due to the speed it only causes small deformations.

Mixed Transfer Welding
When welding in the mixed transfer area the transfer of material takes place as rather large droplets. The mixed transfer welding lies between dip transfer and spray transfer welding and the transfer of material takes place in the form of very large droplets mostly without short-circuits.

Welding Parameters
The welding current lies between 110 and 130 A with 0.8 and 1.6 mm wire respectively.

With the same wire dimensions the voltage lies between 18 and 28 V.

Concerning the choice of shielding gas both mixed gas and CO2 are applicable, but if a smooth surface is required, the best choice would be mixed gas, e.g. a 82/12. The gas flow should be between 8 and 12 l/min.

Application Area
Welding in the mixed transfer area is often used for welding of bottom runs in heavy plates and for filling of V-grooves. The method can also be used for welding of fillet welds for instance in inward corners and vertical/downward.

Welding Data
When welding MIG/MAG it is very important that the welding data are correct as otherwise very serious and even potentially dangerous welding errors may occur.

The correct welding data are set by the individual welder as they depend on the welding speed among many other things. The personal influence is however, fairly limited why we in the following have made some tables of recommended welding data. The general idea is that the individual welder can start with the indicated data and then adjust the parameters to make them fit his particular welding.

It is our hope that the tables will be of help in the workshop.

Tables of Welding Data for Fillet and Butt Welds in Steel

Recommended welding data - MIG/MAG welding - Fillet Welds

Plate thickness, mm	1	1,5	2	3	5	8	10	12
Type of weld	◺	◺	◺	◺	◺	◺	◺	◺
Welding position	1 KP 2 KP	1 KP 2 KP	1 KP 2 KP	1 KP 2 KP	1 KP 2 KP	1 KP 2 KP	1 KP 2 KP	1KP 2 KP
Number of runs	1	1	1	1	1	1	2	3
Wire diameter, mm	0,8	0,8	0,8	0,8	1,0	1,0	1,0	1,0
Shielding gas	80/20	80/20	80/20	80/20	80/20	80/20	80/20	80/20
Wire speed, m/min.	4,5	7,0	8,0	7,5	10,0	11,0	12,0 8,5	15,0
Current, A	90	125	140	200	225	235	240 210	265
Voltage, V	18,5	21	21	22	28	32,5	33 28	34
Gas consumption, l/min.	12	12	12	12	12	12	12	12

Recommended welding data - MIG/MAG welding - Fillet Welds

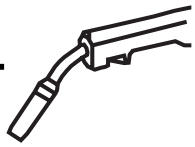
Plate thickness, mm	1	1,5	2	3	5	8	10	12
Designation acc. DS/ISO2553 **Type of weld**	◺	◺	◺	◺	◺	◺	◺	◺
Designation acc. DS 889 Welding position	3 KP 1/f	3 KP 1/f	3 KP 1/f	3 KP 1/f	3 KP 1/f	3 KP 1/f	3 KP 1/f/l/s	3KP 1/f/l/s
Number of runs	1	1	1	1	1	1	2	2
Wire diameter, mm	0,8	0,8	0,8	1,0	1,0	1,0	1,0	1,0
Shielding gas	80/20	80/20	80/20	80/20	80/20	80/20	80/20	80/20
Wire speed, m/min.	4,5	6,3	7,8	6,0	7,0	4,5	7,0 4,5	8,0 4,5
Current, A	90	120	145	175	185	140	185 140	210 140
Voltage, V	16,5	19,5	20,5	21,5	22,5	19,5	22 20	23 20
Gas consumption, l/min.	12	12	12	12	12	12	12	12

Recommended Welding Data - MIG/MAG Welding - Butt Welds

Plate thickness, mm	1	1,5	2	3	5	5	8	10	12
Designation acc. DS/ISO 2553 – Type of weld	||	||	||	||	||	V	V	V	V
Welding position	1 P	1 P	1 P	1 P	1 P	1 P	1 P	1 P	1 P
Groove gap, mm	0	0.5	1.5	2	2	2	2	2	2
Open angle, degrees	-	-	-	-	50	50	50	50	50
Number of runs	1	1	1	1	2	2	2	3	3
Wire diameter, mm	0.8	0.8	0.8	1.0	0.8	1.0	1.0	1.0	1.0
Current, A	80	100	110	125	118 100	125 112	175 175	175 210	185 220
Voltage, V	21	20	19.5	19.5	21 22	18 24	22.5 24	22.5 24	24 27.5
Gas consumption, l/min	12	12	12	12	12	12	12	12	12

Recommended Welding Data - MIG/MAG Welding - Butt Welds

Plate thickness, mm	1	1,5	2	3	5	5	8	10	12	Notes
Designation acc. DS/ISO 2553 – Type of weld	||	||	||	||	||	V	V	V	V	
Welding position	3 P 1/f	3 P 1/f	3 P 1/f	3 P 1/f	3 P 1/f 1/s	3 P 1/f 1/s	3 P 1/f 1/s	3 P 1/f 1/s	3 P 1/f 1/s	
Groove gap, mm	0	0,5	1,5	2	2	2	2	2	2	
Open angle, degrees	-	-	-	-	50	50	50	50	50	
Number of runs	1	1	1	1	2	2	3	3	4	
Wire diameter, mm	0,8	0,8	0,8	1,0	0,8	1,0	1,0	1,0	1,0	
Shielding gas	80/20	80/20	80/20	80/20	80/20	80/20	80/20	80/20	80/20	
Wire speed, m/min.	4.0	5.0	5.5	4.0	7.0 3.7	4.0 2.5	6.5 3.0	7.0 3.8	7.5 4.5	Intermediary and top runs welded in the same position
Current, A	80	100	110	125	125 80	130 80	170 100	180 115	200 135	
Voltage, V	20	19.5	19	19	20.5 19.5	18 18.5	20.5 20	21.5 20.5	22 20.5	
Gas consumption, l/min.	12	12	12	12	12	12	12	12	12	



Recommended Welding Data - MIG/MAG Welding - Wire Speed

Amperage	Wire Diameter ø (mm)							
	Mild Steel			Stainless Steel			Aluminium	
	0.8	**1.0**	**1.2**	**0.8**	**1.0**	**1.2**	**1.2**	**1.6**
75	3.5			6.0				
100	5.0			8.0	4.0			
125	70	4.0	2.5	10.5	5.0	3.0		
150	9.0	5.0	3.5	13.5	6.0	4.0	6.0	
175	11.5	6.0	4.5	17.0	7.5	5.0	7.0	4.4
200	14.0	7.5	5.5		9.0	6.0	8.5	5.0
225	19.0	10.0	6.5		10.5	7.5	10.0	5.6
250		13.0	7.5		13.0	9.0	11.5	6.3
275		16.0	9.0		15.5	11.0	13.0	6.9
300		19.0	11.0		19.0	14.0	14.5	7.5
325			13.0			19.0	16.0	8.1
350			15.0					8.7
375			19.0					9.3
400								10.0

Parameters for MAG Welding of Fillet Welds with Flux Cored Wire

Setting of the Welding Machine

Being an inexperienced MIG/MAG welder it can be a problem to adjust the welding machine to weld with optimum welding data. The problem is that there are several variable parameters that must suit each other correctly if a satisfactory welding result is to be achieved.

The following section is a description of the significance of the individual welding parameters and a method to get started on the welding job.

Types of transfer

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The choice of type of transfer depends on the thickness of the material, the type of weld, the welding position and the size and type of the welding machine

Dip Transfer Welding

In dip transfer welding the transfer of material takes place as an interplay between the formation of a droplet of welding wire and its short-circuiting. When the arc is established a droplet forms on the end of the wire. This droplet will grow and eventually get into contact with the weld pool and then short-circuit. This means that the droplet is pinched off at a speed of 80 to 200 short-circuits per second.

Flux Cored Wire and Dip Transfer Welding

For welding fillet welds with flux cored wire a 1.2 mm wire is used, and as the welding takes place on rather heavy metal thicknesses (8 mm) it is not possible to weld with an adequate quality in the dip transfer area. In order to weld fillet welds of an adequate quality in 8 mm plates with 1.2 mm flux cored wire the welding parameters must be set to welding in the spray transfer area which means more than 200 A.

Areas of Application

Dip transfer welding is only suited for welding in ordinary steel with solid wire. If the method is used on aluminium or stainless steels there will be produced a substantial amount of spatter from the weld pool, and the risk of lack of fusion will be very high. Dip transfer welding is particularly used on plate thicknesses < 5 mm and for welding of bottom runs in thicker materials, even very large plate dimensions.
Dip transfer welding is also suitable for position welding for instance when the bottom run is welded in the dip transfer area while the remaining runs are welded in the mixed transfer area.

Welding parameters

When welding fillet welds in 8 mm plate thickness it will typically be within the spray transfer area, when welded in positions 1 KP and 2 KP2 as well as 2 KR and others. In the spray transfer area the current is set to more than 200 A. At position welding, which means welding in for instance positions PD and PF it will not be possible to control the weld pool within the spray transfer area, and therefore welding will usually take place in the mixed transfer area around 150 to 200 A. If a really skilled welder holds the torch, the welding current could sneak into the lower edge of the spray transfer area.

The stick-out should for all the above jobs be between 20 and 25 mm and the welding voltage between 21 and 30 V.

Apart from the above, the welding parameters should be set as specified in the WPS of the actual job, and the welder then trims his parameters within the allowed tolerances. If there is not a WPS available, the welder can use the data sheets delivered from the wire supplier for adjustment of his welding parameters.

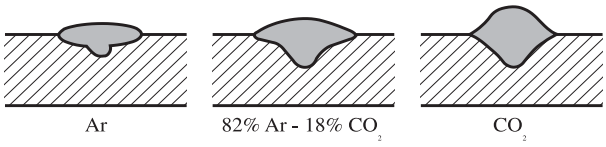
In order to avoid welding errors such as porosities and long porosities it is important to see to it that there is adequate gas shielding of the weld pool. the gasflow should be about 20 l/min. or more if there is draught in the workshop. Atmospheric air is the worst enemy of the weld metal, as the air

causes a massive formation of porosities. Therefore it is important to avoid welding with shielding gas in places where there is a risk of draught.

Penetration
The penetration in the dip transfer area is somewhat larger with CO2 than with mixed gas (at the same wire feeding). The reason is that the weld pool of the mixed gas is shorter due to the higher short-circuit frequency and the lower arc voltage (2 to 3 V) than that of CO2.

As the mixed gas due to its stable arc has a much larger tolerance than CO2 for the variations of welding parameters, for instance the current intensity, it is easy to increase the wire speed and compensate for the smaller penetration and at the same time increase the weld speed.

Welding with mixed gases usually offers higher welding speed than welding with CO2, due to the fact that the mixed gas arc is more stable and therefore allows higher wire speed.



Spray Transfer Welding

Definition
Spray transfer welding or spray arc welding is welding where the wire is transferred as spray, hence the name Spray Arc. The transfer takes place as a large amount of very fine drops without short-circuits. The best result is obtained when the arc “snarls” a bit.

Welding Parameters
At spray transfer welding the welding current is very high; between 200 and 300 A with a 1.2 mm flux cored wire. With a wire of the same diameter the voltage will lie between 22 and 26 V depending on the type of wire.

Current and voltage are very dependent on the type of wire and its make, and in each case the relevant welding parameters must be looked up in the manufacturer’s data sheets or in the WPS.

The data given in this theoretical instruction are therefore only intended as a guide and cannot be directly applied on actual workshop welding jobs.

Wire Dimension
In most cases 1.2 mm to 2.4 mm wire are used for spray transfer welding. When welding downhand horizontal and vertical fillet welds 1.6 and 2.4 mm wire will be used depending on the thickness of the base material, while preferring 1.2 mm wire for position welding.

Shielding gas
Mixed shielding gases with a large content of argon are always used for spray transfer welding, e.g. 82/18. Due to the large droplets welding with CO2 would make it impossible to control the weld pool.

Application Area
Spray transfer welding can be used with all metals. However, with ordinary steel the only welding position is underhand welding. The method is used with material thicknesses more than 3 mm and up to even very large thicknesses. Spray transfer welding is a very heat welding process, but due to the speed it only causes small deformations.

Mixed Transfer Welding

When welding in the mixed transfer area the transfer of material takes place as rather large droplets. The mixed transfer welding lies between dip transfer and spray transfer welding and the transfer of material takes place in the form of very large droplets mostly without short-circuits.

Welding Parameters
The welding current lies between 100 and 200 A with 1.2 mm wire. With the same wire dimension the voltage lies between 18 and 26 V.

Concerning the choice of shielding gas both mixed gas and CO2 are applicable, but if a smooth surface is required, the best choice would be a mixed gas, e.g. a 82/12. The gas flow should be between 15 and 25 l/min.

The shielding gas should always be chosen with due regard to the chosen wire, as the quality of the welding is very dependant on the type of shielding gas.

The recommended shielding gas for a particular type of wire is always indicated in the wire catalogue together with the data sheet of the wire in question.

Area of Application
Usually welding in the mixed transfer area will be used for welding of bottom runs in heavy plates and for filling of V-grooves. The method is also applicable for downhand and vertical/down welding of fillet welds for instance in inward corners.

Welding Data
When welding MIG/MAG with flux cored wire it is very important always to use the correct welding data, as otherwise very serious and even potentially dangerous welding errors may occur.

The correct welding data is set by the individual welder within the allowed tolerances indicated in the WPS or on the data sheet of the wire in question. It is very important for the metallurgy of the construction that the welder does not adjust the welding data beyond the allowed tolerances indicated on the WPS or similar instructions. Excessive adjustments may cause unintentional tension and hardness which will reduce the strength and lifetime of the construction.

Parameters for MAG Welding of Butt Welds with Flux Cored Wire

Welding Parameters

A welding parameter is a detail of the welding process which has influence on the welding performance and quality. A welding parameter may be the regulation of the welding voltage (V), setting of the welding current (A), the welding speed, the stick-out and if it leftward or rightward welding.

In addition to these parameters the shielding gas has a great influence of the welding performance and quality, and last but not least the wire influences on the welding quality.

The Function of the Wire Flux

Just as the manufacturers of coated electrodes, those producing flux cored wires each have their own recipes for the flux mixture which makes the welder prefer one brand to another, although the specification and properties of the wires should be identical.

The flux is mixed according to the area of application for which the flux cored wire is developed.

The function of the flux

The main function of the flux is to clean the weld metal for gases like oxygen and nitrogen which have a bad influence on the mechanical properties of the welding. In order to reduce the content of oxygen and nitrogen in the weld metal, silicon and manganese is added to the flux due to their deoxidizing and strength enhancing properties.

Slag

Elements such as calcium, potassium, silicon and sodium are added for the purpose of creating the slag which protects the weld pool against the atmospheric air during the solidification period.

Furthermore, the slag contributes to:

- form the surface to the correct profile
- hold the weld pool during position welding
- slow down the solidifying of the weld pool

Elements like potassium and sodium furthermore contribute to a soft arc and only little spatter.

Alloying Elements

The possibilities for alloying a flux cored wire are much better than for alloying a solid wire as the alloying elements can be added to the wire flux.

Common alloying elements are molybdenum, chromium, nickel, carbon, manganese, etc.

The elements increase the strength and the ductility and at the same increase the yield of the wire and improve its welding properties.

The combination of the flux determines whether the wire becomes sour (rutile) or basic.

The Function of the Shielding Gas

Most flux cored wires requires a shielding gas as does welding with solid wire. However, it is possible to purchase wires which produce so much gas from the flux that external shielding gas is not necessary. This method is called innershield welding.

For the types of wire which require external shielding gas either CO_2, mixed gas or pure argon can be used according to the type of material and the chemistry of the wire.

Due to the comparatively high current intensities of welding with flux cored wires, the manufacturers in most cases recommend a mixed gas consisting of approximately 80% argon and 20% CO_2. CO_2 is not suitable for welding with flux cored wires as this shielding gas will make it very difficult for welder to control the weld pool at the high intensities, which will cause welds of inferior quality. Furthermore, the arc characteristic improves by use of argon mixtures and so do the mechanical properties of the weld metal.

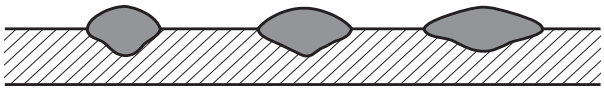
The Significance of the Welding Parameters

Arc Voltage

The arc voltage determines the length of the arc. The higher the arc voltage, the longer the arc.

The diffusion of heat is increased proportionally with the length of the arc, as the arc will spread over a larger area making the weld wider and flatter. If the arc voltage is too high, it will cause an unstable arc, a lot of spatter and a poor weld surface. If the voltage is too low, it will cause the weld to have too high a surface.

The below figure shows the weld profiles of three different arc voltages while all other parameters remained the same.



Arc voltage (V)	28	32	36
Current Intensity (A)	450	450	450
Welding speed (cm/min)	56	56	56
Wire speed (cm/min)	445	445	445
Stick-out (mm)	28	28	28
Electrode angle	5/0	5/0	5/0
Wire diameter (mm)	2,4	2,4	2,4

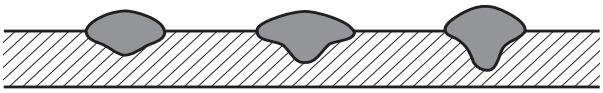
Current Intensity

As before mentioned welding with flux cored wires requires power sources with a flat characteristic for instance a power source of the inverter type which would be very suitable.

The power source yields the amount of current necessary to maintain the melting speed of the wire providing the set arc voltage. When all parameters is kept constant and the wire speed is increased it will automatically cause an increase of the current intensity and thus the deposition rate. In this way more weld metal and more heat are transferred per welded meter. The result is more welding fumes and deeper penetration.

By decreasing the wire speed the opposite result is achieved; less welding fumes and less deep penetration.

The below figure shows a drawing of the penetration profiles of three welds made with different current intensity and otherwise the same parameters.



Current Intensity (A)	400	450	500
Arc voltage (V)	32	32	32
Welding speed (cm/min)	56	56	56
Wire speed (cm/min)	378	445	520
Stick-out (mm)	28	28	28
Electode angle	5/0	5/0	5/0
Wire diameter (mm)	2,4	2,4	2,4

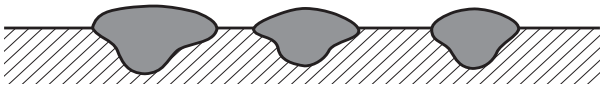
The influence of the current intensity on the penetration profile

Welding Speed
The speed between the workpiece and the wire is called the wire speed, and it has great influence on the penetration profile.

If all other parameters remain constant and the wire speed is increased, the deposition and the heat supply are reduced per meter weld. This results in a more narrow weld profile and an inferior penetration. Too high speed and thereby a higher current results in a more coarse surface where the slag sticks more. Furthermore, a too high wire speed may cause a penetration notch and thus an increased risk of breaks.

By maintaining a slow wire speed it works the opposite way. More weld material is being transferred and the heat input per meter weld is increased. The deposition rate is higher and the penetration profile wider. By continuing to slow down the wire speed you will reach to a point where the volume of the weld pool and the slag becomes so large that they will flow into the crater under the arc. This creates an insulating effect between the arc and the base material. Only a small amount of heat is transferred to the base material and the penetration profile will be wide but only with little deposition, which will create a serious risk of long systematic lacks of fusion.

The below drawing shows the penetration profiles of three welds, welded with different welding speed and otherwise identical parameters.



Welding speed (cm/min)	36	56	76
Current intensity (A)	450	450	450
Arc voltage (V)	32	32	32
Wire speed (cm/min)	445	445	445
Stick-out (mm)	28	28	28
Electrode angle	5/0	5/0	5/0
Wire diameter (mm)	2,4	2,4	2,4

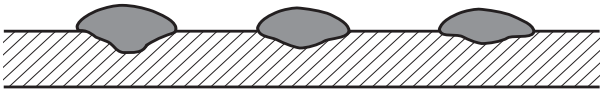
The influence of the welding speed on the penetration profile in butt welding

Stick-out
A large stick-out causes a higher electrical resistance in the wire. The power yields the same current in order to maintain a constant arc voltage and arc length for as long as the wire speed remains the same. The current intensity decreases resulting in a colder welding and thereby less penetration. A too short stick-out produces more spatter and the weld may arch and become too high.

A too long stick-out also produces more spatter and an unstable arc.

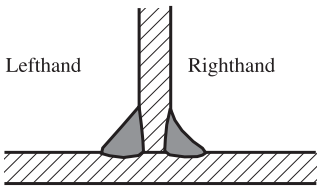
When the stick-out and the wire speed increase, the electrical resistance heating of the wire will result in an increase of the deposition rate.

The below drawing shows the importance of the stick-out on the penetration profile when all other parameters remain the same.



Stick-out (mm)	19	28	36
Current intensity (A)	470	450	430
Arc voltage (V)	32	32	32
Welding speed (cm/min)	22	22	22
Wire speed (cm/min)	445	445	445
Stick-out (mm)	28	28	28
Electrode angle	5/0	5/0	5/0
Wire diameter (mm)	2,4	2,4	2,4

The influence of the stick-out on the penetration profile in butt welding



At leftward welding the penetration profile is smaller than at rightward welding.

Basic Flux Cored Wires

Basic flux cored wires deposit a very crack-resistant weld metal with a low content of hydrogen, about 5 ml/100 g weld metal.

The basic flux cored wires are particularly suitable for welding of butt and fillet welds in heavy materials and tightly fixed constructions. The basic weld metal makes the electrode very suitable for welding of dynamically charged constructions and construction which are to operate at low temperatures.

Typical applications areas are cranes, contractor machinery, offshore constructions, bridges, etc. made of steel corresponding to Fe 510 D according to DS/EN 10025 or similar micro-alloyed steels and ship plates.

Basic flux cored wires are also suitable for welding of cast steel and free-cutting steel, and furthermore, it is very suitable for welding of bottoms runs with ceramic backing.

The basic flux cored wires can be welded in all positions. Choose a 1.2 mm wire for position welding, and for downhand welding choose 1.6 or 2.4 mm wires.

The shielding gas should always be the gas recommended by the wire manufacturer, as the wire may be approved for this type of gas exclusively, e.g. mixed gas 82/18.

Basic flux cored wires are available in dimensions from 1.0 mm to 2.0 mm.

The basic flux cored wires have fine mechanical properties, typically:

Tensile strength:	470 N/mm2	
Breaking strength:	540 N/mm2	
Elongation:	25%	
Impact resistance, charpy V:	+20°C	140 J
	0°C110 J	-20°C
	95 J-30°C	50 J

Rutile Flux Cored Wires

Rutile flux cored wires have very fine welding properties and they are very suitable for position welding. The weld will be smooth often with a self-releasing slag.

The rutile flux cored wires are used for welding of fillet and butt welds in construction steel and container plates corresponding to a quality up to Fe 510 D, DS/EN 10025 or similar micro-alloyed steels. Some of the rutile flux cored wires have very fine impact resistance values down to -60°C.

Rutile flux cored wires can be used in all welding positions. Electrode dimension 1.2 mm is particularly suited for position welding as it is possible to weld in different positions with the same current intensity and voltage settings. For downward welding in heavier plates, electrodes with a diameter of ø1,6 and ø2.4 mm are used.

Rutile flux cored wires are available in dimensions from ø1.0 to ø2.4 mm.

The shielding gas should be the mixture recommended by the manufacturer of the wire, e.g. Ar/CO2 82/18.

As previously mentioned the mechanical properties for flux cored wires are generally fine, typically as indicated in the below table:

Tensile strength:	540 N/mm2	
Breaking strength:	570 N/mm2	
Elongation:	24%	
Impact resistance, charpy V:	0°	80 J
	-20°	55 J

For rutile wires with improved impact resistance the picture is a bit different:

Tensile strength:	420-496 N/mm2	
Breaking strength:	500-620 N/mm2	
Elongation:	22%	
Impact resistance, charpy V:	-20°	80 J
	-60°	35 J

Metal Flux Cored Wires

The flux of the metal flux cored wires largely consists of iron powder and some filtering elements known from the solid wires such as silicon and manganese. A few wires has 2% nickel content which improves the impact resistance at low temperatures.

Metal flux cored wires are used for welding of butt and fillet welds in all positions. The metal fluxed wire welds very fast, and produces nice slag-free surfaces which means that welding can be done in several layers without deslagging after each welded layer.

The metal flux cored wires are used for welding of construction steels and container plates to a quality corresponding to Fe 510 d, DS/EN 10025.

The shielding gas should be the type recommended by the manufacturer of the wire, e.g. Ar/CO2 80/20.

Metal flux cored wires are available in diameters from 1.2 to 2.4 mm. However, there can be differences from supplier to supplier, some manufacturers can only deliver up to ø1.6 mm while others can deliver down to ø1.0 mm.

The metal flux cored wires have fine mechanical properties largely on level with the basic wires. Typically, the mechanical properties are as follows:

Tensile strength:	520 N/mm2	
Breaking strength:	580 N/mm2	
Elongation:	24%	
Impact resistance, charpy V:	+20°	100 J
	0°	95 J
	-20°	60 J
With nickel content:	-30°	90 J
	-60°	70 J