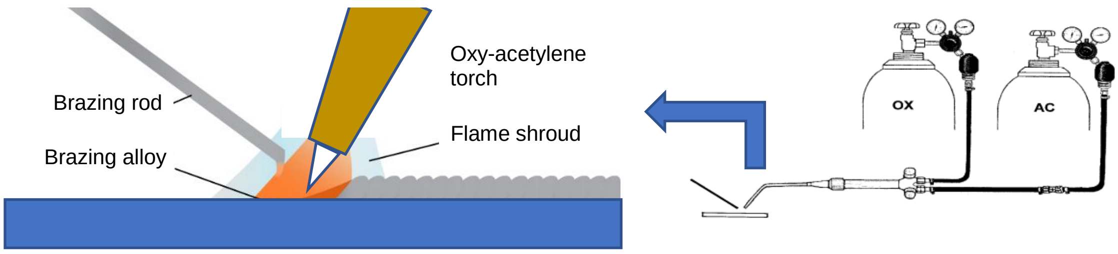
TIG & MIG Brazing for maintenance work onboard

By Leif Andersen, TE Andersen Consulting.

Traditionally, brazing processes have used an oxy-acetylene torch to melt the filler metal, but in TIG and MIG brazing, a standard TIG torch or MIG gun is used to run a brazing rod/ wire. TIG brazing, and specially MIG brazing may not be a familiar process to many doing maintenance welding onboard, and in some cases, it may even be considered a new technology. It is actually no stranger in the welding world. TIG and MIG is a welding process that has been around for years but unfortunately not been actively promoted onboard vessels by ship chandlers.

The great thing about all brazing is that we do not bring the base material to its melting point. It is heated to what we refer to as its bonding temperature. This is the minimum temperature to which the base material must be heated to form an alloy of the filler metal/consumable and the base material. When adding the brazing rod and flux we obtain a surface alloying. Brazing is a mechanical bonding. Welding is a chemical bonding which involves structural changes in the base material. So, in brazing the base material is therefore not affected to the same degree as in welding.

Traditional Brazing using an Oxy-acetylene torch



This article will provide the basics of TIG and MIG brazing and its filler metals/ consumables including advantages and disadvantages, where this process can be used, and how to properly set up a welding power source for TIG/ MIG brazing.

Most vessels will have an electric arc welding machine onboard that can perform Manual Metal Arc (MMA) welding, also referred to as stick electrode welding. It is quite common that these machines will also be fitted with a mode nob that can switch the machine over to perform Tungsten Inert Gas (TIG) welding. If this is the case, TIG brazing is an option instead of using oxy- acetylene for many repair applications. Welding machines that can perform Metal Inert Gas (MIG) welding is not so common onboard the average vessel. If available it gives the possibility to perform MIG brazing.

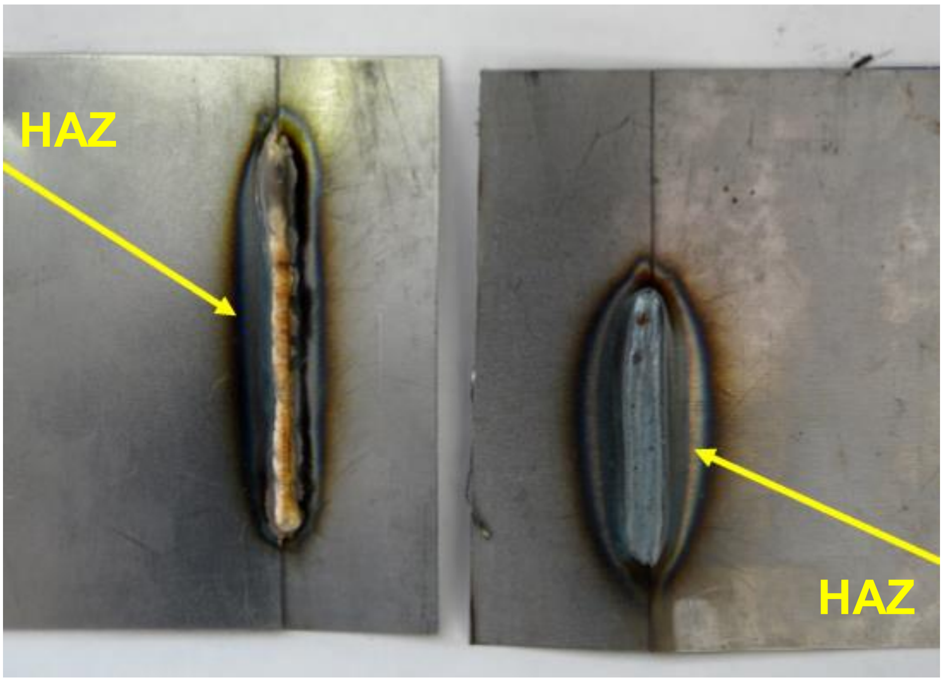
TIG/MIG brazing versus TIG/MIG welding

Rods and wires that are used for TIG and MIG brazing have a general melting temperature of 1060 °C (1940°F). Steel and typical steel rods and wires used for TIG and MIG welding have a general melting temperature of 1650°C (2800°F). Therefore, lower settings (amperage and voltage) can be used for TIG and MIG brazing, putting less heat into the base material. Less heat means less distortion and less structural changes to the material being welded/brazed.

Using less heat also is advantageous for galvanized steels. Welding galvanized steels involves burning away the protective zinc coating. Zinc will typically melt at 420°C (740°F) and vaporize at 910°C (1670°F). The immediate weld zone, either using MIG steel wire or MIG braze wire, will vaporize the zinc coating. The adjacent weld zone area is where a difference can be seen. The higher temperature of 1650°C (2800°F) that is needed to melt the steel wire causes more zinc to vaporize away from the adjacent weld zone. Vaporized zinc appears as a white ash substance. Zinc has a good flow characteristic by nature. By limiting the amount of vaporization through lower heat input, the zinc coating can, re-flow itself and re-solidify closely or directly next to a MIG braze joint, improving the corrosion protection.

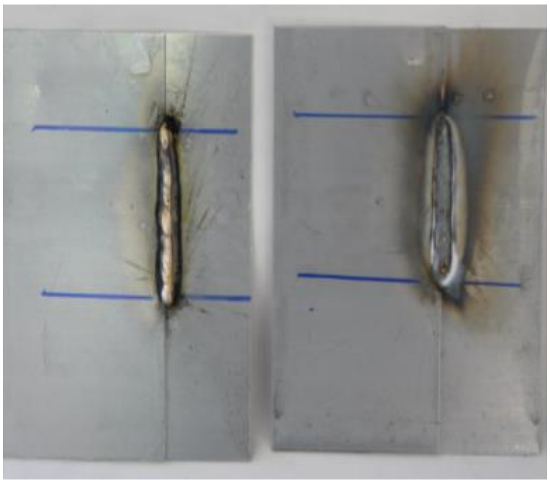
Compere the heat affected zone between MIG brazing and MIG welding on steel plates 0.7 mm (0.027“).

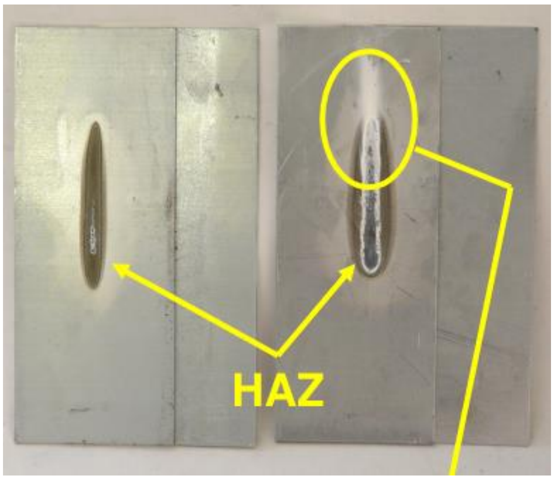
MIG braze MIG weld



MIG brazing verses MIG welding on Galvanized steel plates 1.1mm (0.043“)

MIG braze MIG weld MIG braze MIG weld





Front Back Zinc burning off

MIG brazing produces smaller heat effected zone (HAZ) and less damage to the galvanizing

TIG/MIG brazing disadvantages to consider: Generally, silicon bronze wire (that is most common to use) is more expensive than mild steel wire. Additionally, for MIG brazing, because of the composition, the wire is softer than a mild steel filler metal and occasionally can cause bird nesting/ backlash or other feeding issues if recommendations and advices are not followed.

TIG/MIG brazing versus Oxy-Acetylene brazing

The filler rods in TIG/MIG brazing are quite different from conventional oxy-acetylene brazing rods. As the TIG/MIG torch provides a protective argon gas shroud, there is no need for the addition of flux, as with the long-established oxy-acetylene brazing process. The arc from the TIG/MIG torch is more concentrated and will not to the same extent as oxy-acetylene brazing spread out and cause distortion to the base material. The brazing speed and deposition rate will also be much higher when doing TIG/MIG brazing. Oxy-Acetylene equipment is heavy, cumbersome and time consuming to move to different repair locations onboard. Total weight for 2 X 40L cylinders plus regulators, hoses and torch can reach 120 Kg (264 lbs). A modern inverter welding machine can be down to 24 Kg (52 lbs) plus a 10L argon cylinder 18 Kg (39 lbs) giving a total 42 Kg (92 lbs). So only 1/3 of the weight compared to oxy-acetylene brazing equipment.

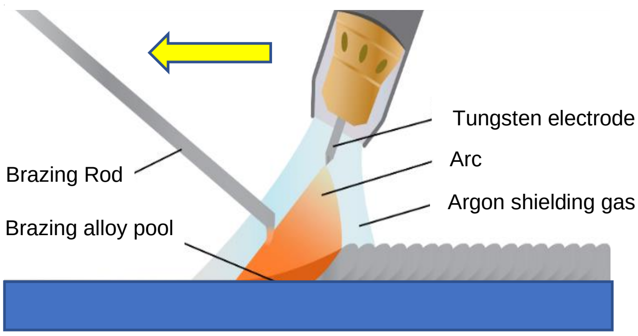
TIG/MIG brazing disadvantages to consider: Smaller pipe assemblies and intricate work involving capillary phosphor and silver joints will be better performed using oxy- acetylene brazing.

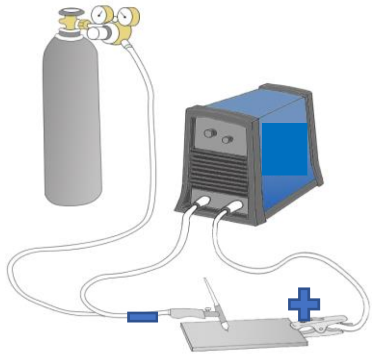
TIG brazing

TIG (Tungsten Inert Gas) welding also referred to as Gas tungsten arc welding (GTAW), is an arc welding process that uses a non-consumable Tungsten (Wolfram) electrode to produce a brazing/ weld pool.

In practice, the heat source is the TIG arc but run on a low current so as not to melt the base material with a suitable filler rod fed into the arc. Irrespective of the filler rod used, argon is the recommended shielding gas.

Brazing technic: Point the torch slightly in the direction of travel.



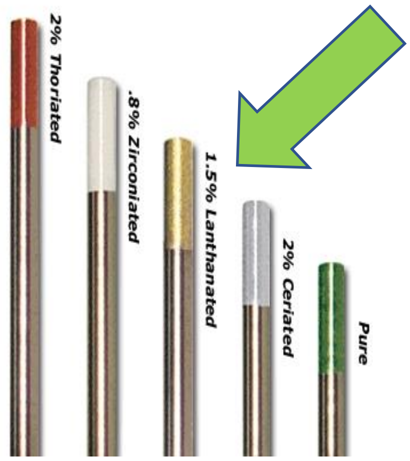


Weco Micro Pulse 302MFK set up for TIG welding/brazing.

Process Tips:

As for all brazing (Oxy-acetylene or TIG): Always remember that cleanliness of the work piece is a priority for first class results: remove any oxide or grease from the joint area.

TIG brazing is relatively straightforward. The TIG torch needs a Lanthanum alloyed tungsten electrode (color code gold) and DC current with the torch connected to minus polarity. NB. Thoriated TIG welding electrodes with 2% thorium oxide (color code red) are currently the most widely used electrodes worldwide. Thorium is however a radioactive element and as such represents a potential danger to health and environment. Thorium is a so-called “a-emitter,” but when enclosed in a tungsten matrix, the “a” radiation emitted externally is negligible. The danger to the welder arises when thorium oxide gets into the respiratory canals. This problem can occur during welding (vapors) as well as when grinding the electrode tip (grinding dust).



Recommendation: Tungsten electrodes alloyed with Lanthanum (color code gold) can be used for AC and DC welding.

The TIG torch should preferably be fitted with a gas lens diffuser. A typical gas lens is composed of a copper and or brass body with layered mesh screens of steel or stainless steel that helps evenly distribute the shielding gas around the tungsten and along the weld puddle and arc. Gas lenses can be used with all shielding gases and are available for both air- and water-cooled TIG torches. The most durable gas lenses-feature a porous metal filter that greatly improves laminar flow compared to mesh screen designs. The TIG torch alumina nozzle should be size 8. This because the brazing alloys molten pool need good protection towards oxidation.

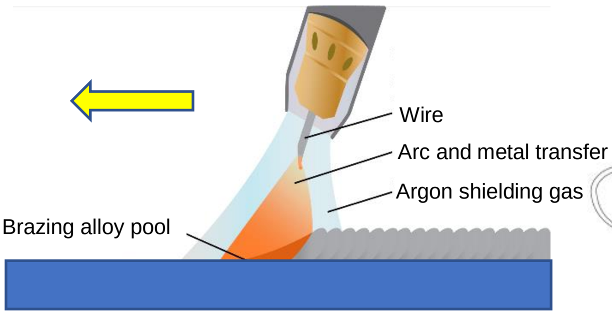
Whereas TIG welding with say 1.6mm (0.063”) silicon bronze rod would require 80-95 amps, TIG brazing will only require less than half that current, more in the order of 35-45 amps.

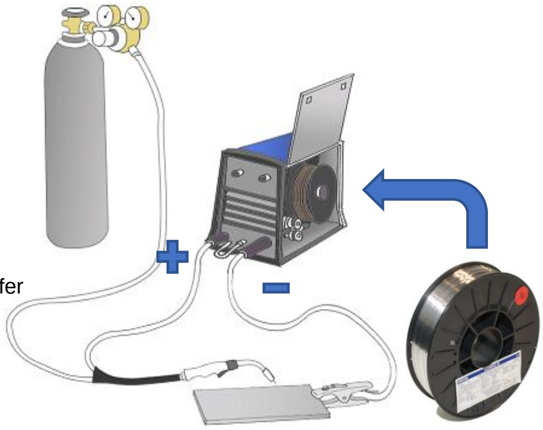
It is important for the operator to be comfortably positioned with regards to the parts being joined, so that the whole procedure can flow at a relatively fast rate. Maintaining torch and filler rod angles with respect to the workpiece is key to prevent breakdown of the inert gas envelope and avoid atmospheric contamination of the joint. The operator should always use a technique that only flows the filler rod and does not melt the base metal.

MIG brazing

MIG (Metal Inert Gas) process, also referred to as Gas Metal Arc Welding (GMAW) is a Wire Welding process. Wire Welding is a process where a wire from a reel is fed through a welding torch passing a contact tip supplying the welding current. The wire melts and is transferred to the pool through the arc. A shielding gas (Argon) is necessary to prevent oxygen oxidising the pool.

Brazing technic: Point the torch slightly in the direction of travel.





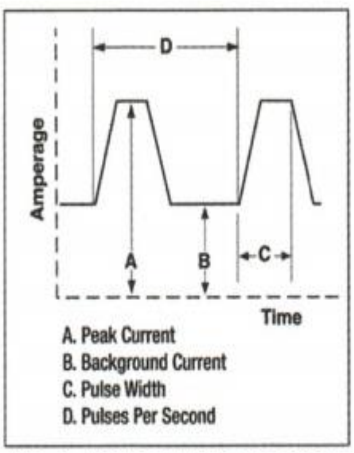
Weco Micro Pulse 302MFK set up for MIG welding/brazing.

MIG brazing can be performed using a standard MIG welding machine, equipped with a conventional torch or a spool gun.

Conventional MIG torch

Spool gun

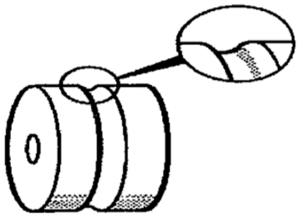
The brazing can be done with short-circuit transfer, and the arc characteristics will be like a mild steel filler metal arc. However, Pulse MIG equipment will give the best results when MIG brazing. Pulse equipment simply provides lower heat input into the base metal because it uses one molten drop of wire per pulse, which also results in virtually spatter-free deposit. Generally, this type of equipment has a computerized program that controls a number of different parameters.



Pulse transfer: A droplet of filler metal transfers from the wire to the workpiece during each pulse of current. Results in less spatter, faster brazing speed, less heat input.

Key components that must be correct to achieve the best results possible:

- Shielding gas: It is critical that 100% argon shielding gas is used with the brazing wire.



- Drive rolls: In order to avoid any abrasions to the wire when it is fed, U-groove drive rolls are recommended. Silicon bronze wire is softer than steel wire. Set the drive roll pressure slightly less than you would for steel wire.

- A Teflon, plastic-graphite, or carbon fibre liner is recommended due to the softness of the silicon bronze wire.

- Polarity: Polarity should be set to DC + polarity to the torch.
- Technique: Techniques used for MIG brazing are similar to aluminium MIG welding techniques. The welder should position himself to push the welding torch.

  The operator should also position himself so that he can see in front of the arc. The lower current and voltage settings used for MIG brazing typically cause the arc to be smaller than what the operator is used to seeing when MIG welding. Being able to see where the arc is and how the arc is reacting is very important for producing a successful brazing. Pushing the welding torch also aids with MIG brazing when working with coated metals. The zinc that is being vaporized from the arc needs to escape the joint. Pushing the welding torch allows vaporized zinc to escape more freely, as opposed to dragging the welding torch. Trapping vaporized zinc in the MIG brazed joint can lead to excessive, unwanted porosity.

Notes regarding the welding power source:

Pulse-control MIG brazing is a rather new feature added to MIG welding machines. Therefore, if a MIG welding machine is older than eight years, it most probably doesn’t have this feature. If to invest in a new power source it is recommended to purchase a dual-purpose machine that can do all welding processes: Manual Metal Arc (MMA) also known as Stick electrode welding, Tungsten Inert Gas (TIG) welding and Metal Inert Gas (MIG) welding.

Recommended welding machine for TIG & MIG Brazing (& Welding):
Weco **Micro Pulse 302MFK.** This is a 3-phase robust designed Inverter for Synergic, Pulse Synergic and Double Pulse Synergic MIG/MAG welding, MMA and TIG Lift Arc welding. Easy to transport, compact and only 24 kg (52 lbs), it is a most suitable machine for maintenance and repair brazing and welding onboard.

Filler/Consumables for TIG and MIG brazing according to AWS A5.7 / A5.8:

There is a large number of consumables available for TIG and MIG brazing. The below mentioned consumables are therefore based on selecting what will be most in demand and useful for repair work onboard a vessel.

There are also added a number of suppliers/ manufacturers of TIG and MIG brazing alloys and the different alloys they offer. Make sure that the particular brand is according to the AWS specification in case changes have taken place.

The most common alloys for TIG and MIG brazing are Copper Silicon, Copper Aluminium and Copper Tin. These alloys are all rather thick flowing. TIG brazing can also be performed using Copper-phosphor, Copper-silver capillary brazing alloys.

It is recommended to treat rods and wires for TIG and MIG brazing similar to aluminium wires. With other words, with a high degree of cleanliness.

- Silicon bronze ERCuSi-A (EN ISO Cu6560/ CuSi3Mn1)

Copper silicon wires/rods contain from 2.8% to 4% silicon with about 1.5% manganese, 1% tin, and 1 % zinc. This filler wire is used for brazing of galvanized steel and for welding silicon bronzes and brasses. When TIG brazing with silicon bronze filler metal the molten metal bonds the base materials together, but does not provide fusion like mild steel filler metal. Because of this, silicon bronze can be used for brazing dissimilar materials together, such as cast iron to steel, stainless steel to steel, copper to carbon steel or stainless steel. Silicon bronze is more wear resistant than carbon steel so it is sometimes used as a wear resistant layer on journals or shafts. The low melting point of silicon bronze also provides a cooler process, putting less heat into the material that is being brazed. Reduction in heat input leads to less distortion and the ability to braze on heat sensitive materials without compromising the physical properties. It is an ideal process for joining thinner metals together, filling gaps, and sheet metal work such as HVAC (Heating, Ventilation and Air Conditioning).

SIF Sifmig 968 (ERCuSi-A) MIG brazing
SIF Sifsilcopper No 968 (ERCuSi-A) TIG brazing
CEWELD CuSi-A (ERCuSi-A) TIG/MIG brazing
OERLICON Copperfil CuSi3 (ERCuSi-A) MIG brazing
ESAB OK Autrod 19.30 (ERCuSi-A) MIG brazing
LINCOLN LNM CuSi3 (ERCuSi-A) MIG brazing
HARRIS Silicon bronze (ERCuSi-A) TIG/MIG brazing
VOESTALPINE BOHLER FONTARGEN A 202M (ERCuSi-A) MIG brazing
VOESTALPINE BOHLER FONTARGEN A 202W (ERCuSi-A) TIG brazing

- Aluminium bronze ERCuAl-A2 (EN ISO Cu6180/CuAl10Fe1).
- Aluminium bronze ERCuAl-A1 (EN ISO Cu6100/CuAl7).

Aluminium bronze wires/rods contain approximately from 6 to 11% aluminium and 1% iron. The ERCuAl-A1 contain 6 to 8.5% aluminium that gives a deposit with 47% elongation and 125 Hardness Brinell. ERCuAl-A2 contain 8 to 11% aluminium that gives a deposit with 28% elongation and 140Hardness Brinell. Use aluminium bronze in place of silicone bronze if you need more wear resistance surface than what silicone bronze provides. It's much harder than silicone bronze. Applications cover overlays on shafts, propellers, housings, couplings, bushings, valve seats, pumps, and other surfaces needing a bronze wearing surface. Aluminium bronze and Silicon bronze can be used to repair cast iron but aluminium bronze will make a stronger joint.

SIF Sifmig 328Brazing (ERCuAl-A1) MIG brazing
SIF Sifalbronze No 32 (ERCuAl-A2) TIG brazing
CEWELD CuAl8 (ERCuAl-A1) TIG/MIG brazing
OERLICON Copperfil CuAl8 (ERCuAl-A1) MIG brazing
ESAB OK Tigrod 19.40 (ERCuAl-A1) TIG brazing
LINCOLN LNM CUAL8 (ERCuAl-A1) MIG brazing
HARRIS Aluminum bronze A2 (ERCuAl-A2) TIG/MIG brazing
HARRIS Aluminum bronze A1 (ERCuAl-A1) TIG/MIG brazing
VOESTALPINE BOHLER FONTARGEN A 2115/8M (ERCuAl-A1) MIG brazing
VOESTALPINE BOHLER FONTARGEN A 2115/8W (ERCuAl-A1) TIG brazing

- Tin bronze (Phosphor bronze) ERCuSn-A (EN ISO Cu5180 A/CuSn6P)

Phosphor bronze is a copper-tin bronze containing approximately 5% tin and up to 0.35% phosphor added as a deoxidizer.

SIF Sifmig No 8 Brazing (ERCuSn-A) MIG brazing
CEWELD CuSn6 (ERCuSn-A) TIG/MIG
OERLICON Copperfil CuSn6 (ERCuSn-A) TIG
LINCOLN LNT CuSn6 (ERCuSn-A) TIG
HARRIS Phos bronze A (ERCuSn-A) TIG/MIG brazing
VOESTALPINE BOHLER UTP A32 (ERCuSn-A) TIG brazing
VOESTALPINE BOHLER FONTARGEN A 203/6M (ERCuSn-A) MIG brazing
VOESTALPINE BOHLER FONTARGEN A 203/6W (ERCuSn-A) TIG brazing

- Copper- phosphor- silver (Capillary brazing alloys) BCuP-

This capillary brazing alloys contain mostly copper and from 5 to 7% phosphor and some alloys also from 2 to 15% silver. They are in general thinner flowing than the previous mentioned bronzes and require a capillary joint in order to work to its full capacity. Traditionally these alloys are used in combination with an oxy acetylene torch but can with good result be used for TIG brazing. NB. Never use copper-phosphors brazing alloys to braze iron or nickel-based alloys or for parts working in sulphurous environment. The below mentioned consumables are Voestalpine Bohler Fontargen products according to AWS A5.8. There are a number of other manufacturers/ suppliers on the market.

VOESTALPINE BOHLER FONTARGEN :
A 2003 (BCuP-2) Cu 93%-P 7%
A 3002 (BCuP-6) Cu 91%-P 7%- Ag 2%
A 3005 (BCuP-3) Cu 89%-P 6%- Ag 5%
A 3015 (BCuP-5) Cu 80%- P 5%- Ag 15%

TIG brazing rods are available in sizes: 1mm (0.039”) – 1.6mm (0.063”) - 2mm (0.079”) – 2.5mm (0.098”) – 3.2mm (0.126”).
MIG brazing wires are available in sizes: 0.8mm (0.030”) – 1.0mm (0.039”) – 1.2mm (0.047”) – 1.6mm (0.063”).
Delivery form:

TIG brazing rods

MIG brazing
Standard wire reel

A MIG brazing Spool gun require a small size wire spool

Brazing parameters:

The most common error that operators do when setting the parameters for TIG and MIG brazing is setting the output of the welding machine too high and making too hot a pool. When MIG brazing use a lower wire speed (Amperage) setting than what is generally used for welding with steel wire. Also, use lower voltage settings. This requires the power source to deliver a stable arc in the low power range.

Weco Micro Pulse 302MFK Synergic parameters

MIG Short spray with CuSi3 Ø0.8mm (0.031") and 100% argon the parameters are:

Thickness mm	Amperage (A)	Voltage (V)	Wire speed (m/min)
0.6 (0.024")	42	12.0	4.0 (13.1 ft/min)
0.8 (0.031")	48	12.6	4.5 (14.7 ft/min)
1.0 (0.039")	54	13.1	5.1 (16.7 ft/min)
2.0 (0.079")	132	18.1	11.1 (36.4 ft/min)

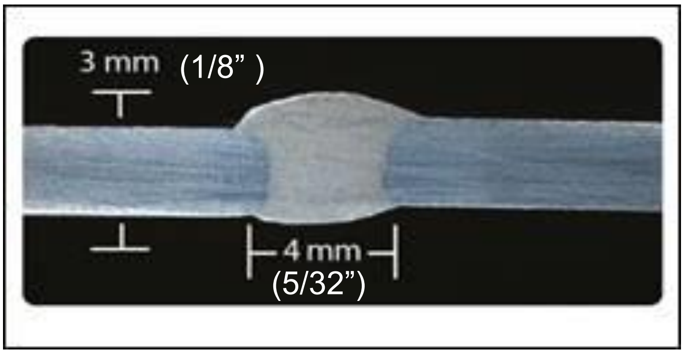
MIG Pulse with CuSi3 Ø0.8mm (0.031") and 100% argon the parameters are:

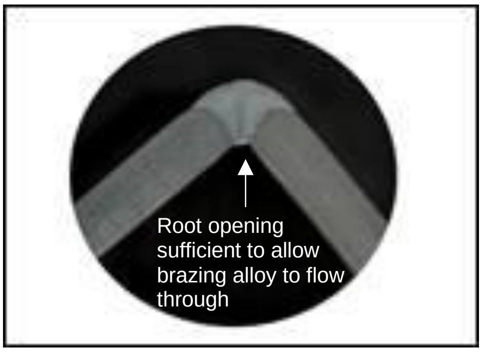
Thickness (mm)	Amperage (A)	Voltage (V)	Wire speed m/min
0.6 (0.024")	29	15.6	3 (9.8 ft/min)
0.8 (0.031")	33	15.7	3.5 (11.5 ft/min)
1.0 (0.039")	45	15.8	4.3 (14.1 ft/min)
2.0 (0.079")	93	19.0	8.5 (27.9 ft/min)

For TIG brazing the amperage setting will be more situation and operator depending from case to case.

Edge preparation

In TIG and MIG brazing it is important that the brazing alloy flows through the joint and grips the back edge of the assembly. For that to happen there is a need for sufficient root opening.





Special note:

The development of TIG, and specially MIG brazing, has been brought forward by the automotive industry. In the automotive industry the need to save weight, while at the same time meeting increasingly severe crash test standards, has led to the use of high strength manganese boron steels. Various advanced high-strength steel (AHSS) and ultra-high-strength steel (UHSS) grades are available for applications within the body structure. Dual-phase (DP) steels are advantageous for energy-absorption structures, while TRIP (transformation induced plasticity) steel is used for energy-absorption elements and sections such as front floor panels, where there is also a requirement for high formability. HSLA (high-strength, low-alloy) steel offers a combination of high strength and good weldability, complex-phase steels can be used for floor members and other areas where reinforcement is required. Martensitic steels have extremely high strength and are used for reinforcement of areas such as the B-pillar and tunnels. Other terms encountered in this field are boron steel and manganese-boron steel. The excellent physical material characteristics of these latest-generation steels are derived from heat treatment processes. It follows that the steels are more easily affected by heat, hence they cannot be readily MIG welded. Furthermore, the tendency for modern automotive steels to be zinc-coated means that the elevated temperatures encountered with welding burn off the zinc coating and adversely affect both the joint strength and the subsequent corrosion resistance of the steel. For these reasons MIG brazing is an advantage. Whereas welding requires the temperature to be raised to the melting point of the parent metal, brazing takes place at lower temperatures that minimise damage to the zinc coating and do not change the metallurgy of high- and ultra-high-strength steels.