

# welding aluminium

Welding uses an intense heat source to cause localised melting and fusion of the parent metal of the joint. Filler metal may or may not be used.

A wide variety of processes are used to weld aluminium, some common, others highly specialised.

## Arc Welding

- T.I.G. (Tungsten Inert Gas)
- M.I.G. (Metal Inert Gas)
- Pulse Arc (lower than normal currents)
- Stud (attaching studs and fasteners to metal)
- Atomic Hydrogen (intense heat - rare)
- Carbon Arc (rarely used)
- Metal Arc (not good quality - repairs)

## Oxy-Gas Welding

- Standard oxy-fuel techniques (oxy acetylene/oxy hydrogen)

## Resistance Welding

- Spot
- Seam
- Flash Butt
- Resistance Butt
- Projection
- Percussion

(Applicable to all aluminium alloys but more particularly to the heat-treatable alloys which are difficult to weld by the fusion process)

## Specialised Welding

- Pressure
- Ultrasonic
- Friction
- Thermit
- Induction and resistance seam
- Electron Beam
- Laser Beam
- Plasma Arc

(All applicable to the joining of aluminium but very limited application)

Welding is a widely accepted method of joining aluminium and the techniques are well known in the engineering and manufacturing industries.

The most commonly used basic welding processes are tungsten inert gas (T.I.G.) and metal inert gas (M.I.G.). As the names suggest, both processes are inert-gas-shielded systems which shroud the weld area from the air to prevent reformation of oxide film.

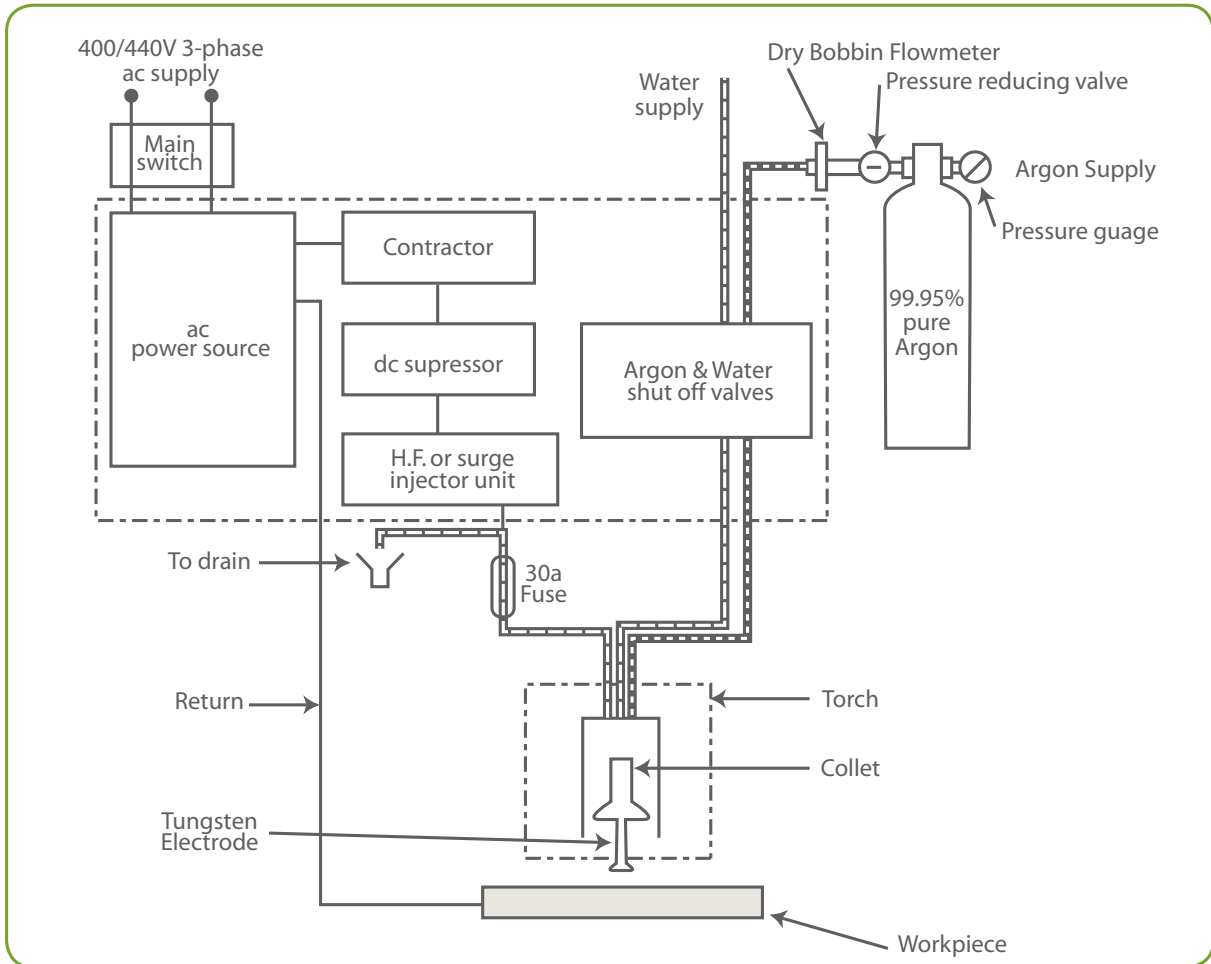
## Metal Thickness Capacity of TIG and MIG Welding Systems

Welding System	Thickness of Parent Metal (mm)		Welding Equipment
	min	max	
TIG	1.2	9.5 <sup>1</sup>	Composite unit (350A) with Transformer (350A), High Frequency or Surge Injector unit, Suppressor and Welding Torches
MIG 0.5kg	1.6	8.0 <sup>2</sup>	Composite unit (250A) with Wire Feed unit and Welding Gun for 0.5kg Spool
MIG 5kg	4.8	None	Composite unit (250A) with Wire Feed unit and Welding Gun for 5kg Spool

1. Although the TIG process can weld thicker material, it is not normally used for aluminium greater than 9.5mm in thickness for economic reasons.
2. In theory there is no upper limit to metal thickness for 0.5kg MIG, but it is more economical to use 5kg MIG for aluminium greater than 8.0mm in thickness.

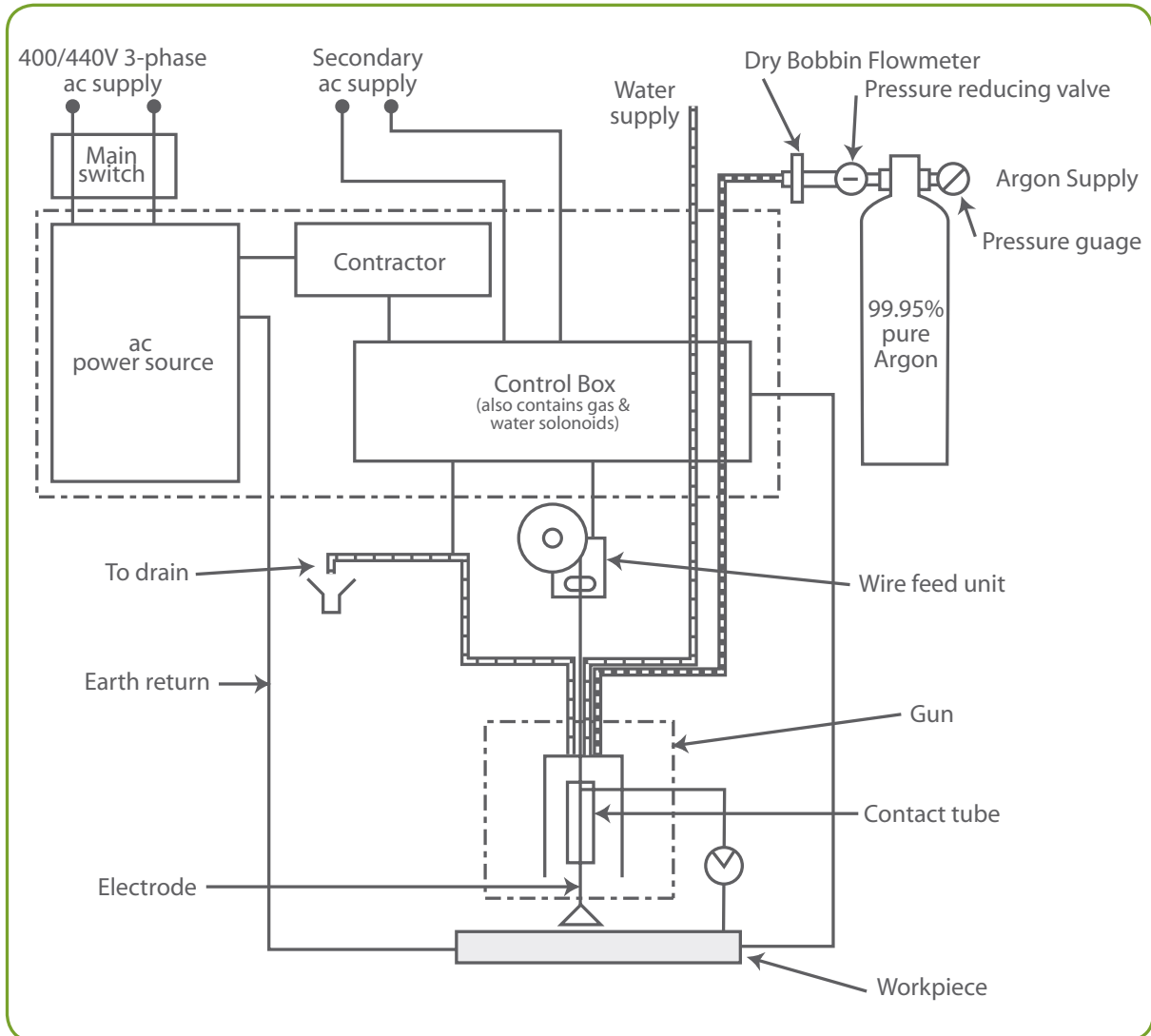
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## A Typical TIG (GTAW) Welding System



Note: Composite TIG welding units include all the necessary auxiliaries. The argon and water shut off valves are usually controlled by solenoids, but may also be manually operated. The main power cable, fuse and torch can be air or water cooled.

A Typical MIG (GMAW) Welding System



1. The a.c. supply is 110v for 0.5kg MIG and 220v for 5kg MIG welding.
2. Composite MIG welding units have the contactor and control box built in.
3. The filler wire feed unit is integral with the gun in 0.5kg MIG and independent of it in 5kg MIG systems.
4. A voltage pick-up lead is required for 0.5kg MIG.
5. The main power cable and gun of 5kg MIG can be water cooled.
6. Arc voltage in MIG welding processes is measured with a voltmeter connected between the contact tube and the workpiece.

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## Preparation

Cleanliness and removal of the oxide film are most important. The proposed weld area must be degreased using methylated spirits, acetone, etc. Oxides, grease or oil films left on the edges to be joined will cause unsound welds and the mechanical efficiency of the weld will be adversely affected. The joint must be wiped dry.

After degreasing, the joint is cleaned with stainless steel wire brushes, or a chemical etch cleaner to remove the oxide film. Welding should be carried out as soon as possible.

The majority of T.I.G. and M.I.G. welding is done manually, however, they are ideal processes for mechanising. This leads to improvements in terms of increased welding speed, more consistent penetration, bead shape and general appearance and a greater degree of repeatability which is essential for volume production welding work.

The chief differences between the T.I.G. and M.I.G. processes are in the electrodes and the characteristics of the power used. In T.I.G. welding, the electrode is tungsten (non-consumable), which is used to maintain the arc; an appropriate aluminium filler material is added separately as required. Argon is fed to the torch through a flexible tube so that the whole of the arc and the weld pool are shrouded with argon, effectively preventing oxidation.

Conventional T.I.G. welding of aluminium is performed with AC current.

In M.I.G. welding, the electrode is aluminium filler wire fed continuously through the gun or torch from a reel into the weld pool as fast as it is consumed; the arc is struck between the tip of this wire and the metal being welded. For welding aluminium, the gas may be argon, helium, or a mixture of both, which is fed through the torch to provide a protective shroud. The current supply is DC (reverse polarity) with the electrode positive.

The choice of correct fill composition is of fundamental importance when fusion welding the various aluminium alloys. As well as the important consideration of corrosion resistance and the strength required of the weld, the filler metal must be compatible with the alloy to be welded. Weld cracking may result from using incorrect filler alloys.

The correct joint design is important to ensure adequate penetration. Backing strips should be used where feasible; the backing bar may be of steel, stainless steel, copper or aluminium.

For the T.I.G. process, the joint design and root openings required are determined by the thickness of the aluminium to be jointed and the structural requirements of the weldment.

For the M.I.G. process, the square butt joint is satisfactory up to 6mm. For thicker material either a single-vee or double-vee bevel may be necessary.

**The four primary conditions which must be correct for a good weld are:**

- Volts
- Amps
- Gas Flow
- Arc Travel Speed

Each job requires a particular set of welding conditions depending on the type and position of weld and the thickness of the metal.

## Filler Wire

Alloys in the 5000 and 6000 series can be welded readily to a wide range of other aluminium alloys. The table that follows shows the preferred weld filler wire for such combinations of parent metals and, where appropriate, gives an alternative filler wire which can be used when the finished component is to be anodised and a close colour match is required between the weld area and the parent metal. Alloys in the 2000 series are not shown in the table since they are not recommended for fusion welding using the TIG and MIG processes.

## Filler Metal Selection Chart for the Welding of Wrought Alloys<sup>1,2</sup>

The following table is extracted from "Successful Welding of Aluminium" published by WTIA (Welding Technology Institute of Australia) and should be used as a guide only.

First alloy subgroup	Second alloy subgroup						
	Itself (or same subgroup)	7005	6006 <sup>3</sup> 6061 6082	5154A 5454	5083 5086	5052 5251	5005 5050A
1050 <sup>4</sup>	1100 <sup>7</sup>	5356 <sup>7</sup>	4043	4043 <sup>9</sup>	5356 <sup>7</sup>	4043 <sup>9</sup>	4043 <sup>9</sup>
5005 5050A	4043 <sup>8,9</sup>	5356 <sup>9</sup>	4043 <sup>6</sup>	5356 <sup>6</sup>	5356 <sup>9</sup>	4043 <sup>9</sup>	4043 <sup>9</sup>
5052 5251	5356 <sup>5,6,7</sup>	5356 <sup>9</sup>	5356 <sup>6,7</sup>	5356 <sup>6</sup>	5356 <sup>9</sup>		
5083	5183 <sup>9</sup>	5183 <sup>9</sup>	5356 <sup>9</sup>	5356 <sup>9</sup>			
5086	5356 <sup>9</sup>	5356 <sup>9</sup>	5356 <sup>9</sup>	5356 <sup>9</sup>			
5154A 5383	5356 <sup>5,6,8</sup> 5183 <sup>9</sup>	5356 <sup>6</sup> 5183 <sup>9</sup>	5356 <sup>6,7</sup> 5356 <sup>9</sup>	5356 <sup>6</sup> 5356 <sup>9</sup>	5356 <sup>9</sup>		
5454	5554 <sup>7,9,11</sup>	5356 <sup>6</sup>	5356 <sup>6,7</sup>				
6060 <sup>3</sup> 6061 6082	4043 <sup>6</sup>	5356 <sup>6,7</sup>					
7005	5356 <sup>9,10</sup>						

1. Service conditions such as immersion in fresh or salt water, exposure to specific chemicals, or a sustained high temperature (over 65°C) may limit the choice of filler metals. Filler metals 5356, 5183, 5556 and 5654 are not recommended for sustained temperature service over 65°C.
2. Recommendations in the main body of this table are the preferred choice and apply for most applications.
3. Other alloys in this group include: 6005A, 6101, 6106 and 6261.
4. Other alloys in this group include: 1080A, 1150, 1350 and 3203.
5. 5654 filler is used for welding base metal alloys for low-temperature hydrogen peroxide service (less 65°C).
6. 5183, 5356, 5554, 5556 and 5654 may be used. 5554 is only 5xxx series filler alloy listed suitable for service temperature over 65°C.
7. 4043 may be used.
8. Filler metal with the same analysis as the base metal may be used.
9. 5183, 5356 or 5556 may be used.
10. 5039 is preferred but not readily available.
11. 5554 is only 5xxx series filler alloy listed suitable for service temperatures over 65°C.