Smootharc TIG 200 ACDC
Operating manual

BOC
A Member of The Linde Group

Welcome to a better way of welding.

This operating manual provides the basic knowledge required for TIG welding, as well as highlighting important areas of how to operate the Smoothtarc TIG 200 ACDC machine.

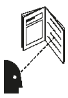
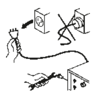
With normal use and by following these recommended steps, your Smoothtarc TIG 200 ACDC machine can provide you with years of trouble free service. BOC equipment and technical support is available through our national BOC Customer Service Centre or contact your local Gas & Gear outlet.

Please Note: This machine is to be used only by appropriately trained operators in industrial applications.

Contents.

1.0 Recommended safety guidelines and precautions

Diagram and safety explanation

	Electrical safety alert
	Welding electrode causing electric shock
	Fumes and gases coming from welding process
	Welding arc rays
	Read instruction manual
	Become trained
	Wear dry, insulated gloves
	Insulate yourself from work and ground
	Disconnect input power before working on equipment
	Keep head out of fumes
	Use forced ventilation or local exhaust to remove fumes
	Use welding helmet with correct shade of filter

Some safety precautions BOC recommends are as follows:

- Repair or replace defective cables immediately.
- Never watch the arc except through lenses of the correct shade.
- In confined spaces, adequate ventilation and constant observation are essential.
- Leads and cables should be kept clear of passageways.
- Keep fire extinguishing equipment at a handy location in the workshop.
- Keep primary terminals and live parts effectively covered.
- Never strike an arc on any gas cylinder.
- Never use oxygen for venting containers.

1.1 Health hazard information

The actual process of welding is one that can cause a variety of hazards. All appropriate safety equipment should be worn at all times, i.e. headwear, hand and body protection. Electrical equipment should be used in accordance with the manufacturer's recommendations.

Eyes
The process produces ultra violet rays that can injure and cause permanent damage. Fumes can cause irritation.

Skin
Arc rays are dangerous to uncovered skin.

Inhalation
Welding fumes and gases are dangerous to the health of the operator and to those in close proximity. The aggravation of pre-existing respiratory or allergic conditions may occur in some workers. Excessive exposure may cause conditions such as nausea, dizziness, dryness and irritation of eyes, nose and throat.

1.2 Personal protection

Respiratory
Confined space welding should be carried out with the aid of a fume respirator or air supplied respirator as per AS/NZS 1715 and AS/NZS 1716 Standards.

- You must always have enough ventilation in confined spaces. Be alert to this at all times.
- Keep your head out of the fumes rising from the arc.
- Fumes from the welding of some metals could have an adverse effect on your health. Don't breathe them in. If you are welding on material such as stainless steel, nickel, nickel alloys or galvanised steel, further precautions are necessary.
- Wear a respirator when natural or forced ventilation is insufficient.

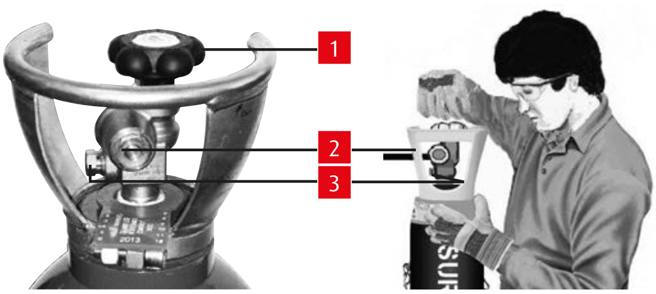
Eye protection
A welding helmet with the appropriate welding filter lens for the operation must be worn at all times in the work environment. The welding arc and the reflecting arc flash gives out ultraviolet and infrared rays. Protective welding screen and goggles should be provided for others working in the same area.

Recommended filter shades for arc welding

Less than 150 amps	Shade 10*
150 to 250 amps	Shade 11*
250 to 300 amps	Shade 12
300 to 350 amps	Shade 13
Over 350 amps	Shade 14

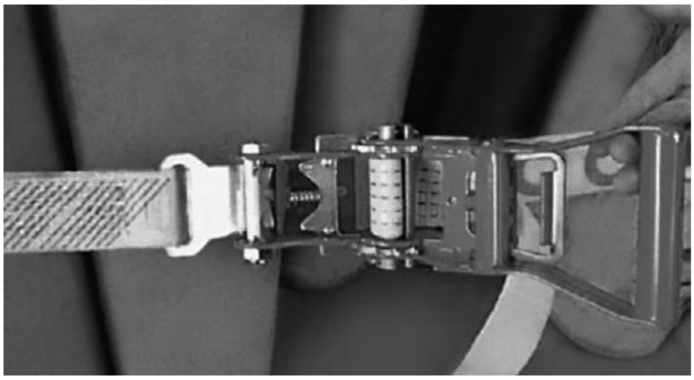
*Use one shade darker for aluminium.

Clothing
Suitable clothing must be worn to prevent excessive exposure to UV radiation and sparks. An adjustable helmet, flameproof loose-fitting cotton clothing buttoned to the neck, protective leather gloves, spats, apron and steel capped safety boots are highly recommended.



Back view of typical cylinder valve.

Operator wearing personal protective equipment (PPE) in safe position.



Cylinder safety diagram

1 Cylinder valve hand-wheel
2 Back-plug
3 Bursting disc

Ten points about cylinder safety

1. Read labels and Safety Data Sheet (SDS) before use
2. Store upright and use in well ventilated, secure areas away from pedestrian or vehicle thoroughfare
3. Guard cylinders against being knocked violently or being allowed to fall
4. Wear safety shoes, glasses and gloves when handling and connecting cylinders
5. Always move cylinders securely with an appropriate trolley. Take care not to turn the valve on when moving a cylinder
6. Keep in a cool, well ventilated area, away from heat sources, sources of ignition and combustible materials, especially flammable gases
7. Keep full and empty cylinders separate
8. Keep ammonia-based leak detection solutions, oil and grease away from cylinders and valves
9. Never use force when opening or closing valves
10. Don't repaint or disguise markings and damage. If damaged, return cylinders to BOC immediately

Cylinder valve safety
When working with cylinders or operating cylinder valves, ensure that you wear appropriate protective clothing – gloves, boots and safety glasses.

When moving cylinders, ensure that the valve is not accidentally opened in transit.

Before operating a cylinder valve
Ensure that the system you are connecting the cylinder into is suitable for the gas and pressure involved.

Ensure that any accessories (such as hoses attached to the cylinder valve, or the system being connected to) are securely connected. A hose, for example, can potentially flail around dangerously if it is accidentally pressurised when not restrained at both ends.

Stand to the side of the cylinder so that neither you nor anyone else is in line with the back of the cylinder valve. This is in case a back-plug is loose or a bursting disc vents. The correct stance is shown in the diagram above.

When operating the cylinder valve
Open it by hand by turning the valve hand-wheel anti-clockwise. Use only reasonable force.

Ensure that no gas is leaking from the cylinder valve connection or the system to which the cylinder is connected. DO NOT use ammonia-based leak detection fluid as this can damage the valve. Approved leak detection fluid, can be obtained from a BOC Gas & Gear centre.

When finished with the cylinder, close the cylinder valve by hand by turning the valve hand-wheel in a clockwise direction. Use only reasonable force.

Remember NEVER tamper with the valve.

If you suspect the valve is damaged, DO NOT use it. Report the issue to BOC and arrange for the cylinder to be returned to BOC.

1.3 Electrical shock

- Never touch 'live' electrical parts
- Always repair or replace worn or damaged parts
- Disconnect power source before performing any maintenance or service
- Earth all work materials
- Never work in moist or damp areas

Avoid electric shock by:

- Wearing dry insulated boots
- Wearing dry leather gloves
- Never changing electrodes with bare hands or wet gloves
- Never cooling electrode holders in water
- Working on a dry insulated floor where possible
- Never hold the electrode and holder under your arm

1.4 User responsibility

- Read the Operating Manual prior to installation of this machine
- Unauthorised repairs or modifications to this equipment may endanger the technician and operator and will void your warranty. Only qualified personnel approved by BOC should perform repairs
- Always disconnect mains power before investigating equipment malfunctions
- Parts that are broken, damaged, missing or worn should be replaced immediately
- Equipment should be cleaned periodically

BOC stock a huge range of personal protective equipment. This combined with BOC's extensive Gas and Gear network ensures fast, reliable service throughout the South Pacific.

STOP

PLEASE NOTE that under no circumstances should any equipment or parts be altered or changed in any way from the standard specification without written permission given by BOC. To do so, will void the Equipment Warranty.

Further information can be obtained from Weld Australia (WTIA) Technical Note No.7.

Health and Safety Welding
Published by WTIA,
PO Box 6165 Silverwater NSW 2128

Phone (02) 9748 4443

Switch on to electrical safety

for single-phase equipment

BOC welding machines are designed and manufactured to conform to IEC 60974 or AS 60974. This Standard not only covers the **machine** but also the **input cable** and **plug requirements** including the size of the plug that should be used.

X Rated duty cycle

I_1 Rated supply current

I_0 Rated no-load supply current

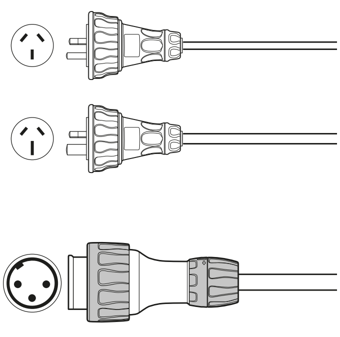
AS 60974-1

Formula in clause 3.33

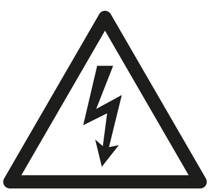
Maximum effective supply current

$$I_{1eff} = \sqrt{I_1^2 \times X + I_0^2(1-X)}$$

The I_{1eff} determines the correct plug, input cable and input current required for each machine.



	min–max cable size
$I_{1eff} \leq$ **10A**	1.5–2.5 mm²
$I_{1eff} \leq$ **15A**	1.5–4 mm²
$I_{1eff} \leq$ **25A**	2.5–6 mm²
$I_{1eff} \leq$ **32A**	4–10 mm² size must be indicated on the cable



Remember...

Before operating your welding machine, follow the instructions in the operating manual provided.
For more information refer to WTIA TN 22 – Welding Electrical Safety (Revised 2003) and WTIA TN 07 Health & Safety in Welding. If you have any queries please contact BOC **131 262** (AU), **1800 111 333** (NZ).

DO

✓ Use the **correct input current**, ✓ **cable** and ✓ **plug** in accordance with AS 60974-1 for your **safety** and to get the **maximum performance** from your welding machine.

How important is the correct input cable and plug on a welding machine?

The size of the plug depends on a formula that not only uses the maximum current draw but also the duty cycle of the power source. The use of any welding power source will not only cause the machine itself to heat up, but the input cable, plug and mains power circuit will increase in temperature as well. That's why it's important to understand input and output currents and to make sure that the input circuit is correctly rated to supply the required input draw. This allows the machine to operate at or near maximum output and protects the circuit board from tripping, overheating and/or catching fire.

Example

If the I_{1eff} rating on your machine is **27A** then you **must use a 32A plug** as a 15A is undersized for the welding current being used and may cause the cable to overheat.

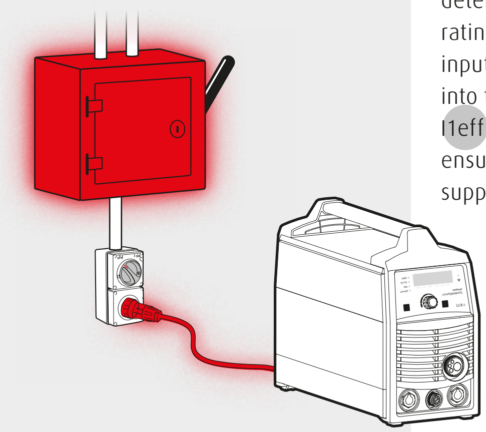
For your safety, BOC meets AS/NZS Standards for safe electrical compliance.

E4824 Regulatory Compliance Mark (RCM) and number

All BOC welding machines undergo an independent certification process to meet Australian and New Zealand regulations regarding electrical safety. The triangle-circle-tick (RCM) symbol signifies that BOC has taken the necessary steps to have the product comply with the electrical safety and/or electromagnetic compatibility (EMC) legislative requirements as specified by the Electrical Regulatory Authorities Council (ERAC). Depending on the machine, BOC may be required to have a 32A single phase plug to ensure that when the machine runs at its maximum output, the input supply plug and lead will not overheat. For your safety, please check for this symbol before buying any welding machine in Australia and New Zealand.

DON'T

✗ Don't risk damage to your machine or cause tripping and/or fire by using the wrong input current, cable or plug.
✗ Don't tamper with plugs or file down earth pins. Doing so will void warranty.



Check the rating plate on your machine.

All welding machines that comply with IEC 60974 or AS 60974 must have a rating plate similar to the one shown. Welding machines draw some current when idle (not welding) and a higher current when welding. Effective rated primary current (I1eff) combines the conductor heating due to these two levels of current. I1eff is the maximum rated effective supply current that determines the minimum plug and input cable rating as well as the minimum capacity of the input circuit that the machine gets plugged into to safely operate the machine. Look for the I1eff on the welding machine's rating plate and ensure that you have the correct input circuit to support this power draw.

Example of BOC rating plate

BOC Limited, 10 Julius Ave, North Ryde NSW 2113, Australia					
250 Multiprocess			E4824		
			AS/NZS60974-1 IEC/EN60974-10		
		50A/16.5V–230A/25.5V			
		X	25%	60%	100%
	U_0=63V	I_2	230A	190A	150A
		U_2	25.5V	23.5V	21.5V
		15A/10.6V–250A/20V			
		X	25%	60%	100%
	U_0=63V	I_2	250A	200A	160A
		U_2	20V	18V	16.4V
		15A/20.6V–220A/28.8V			
		X	25%	60%	100%
	U_0=63V U_r=17V	I_2	220A	170A	140A
		U_2	28.8V	26.8V	25.6V
1~(50/60Hz)	U_1~240V	MIG	I_{1max}=45A		I_{1eff}=26A
		TIG	I_{1max}=39A		I_{1eff}=23A
		MMA	I_{1max}=46A		I_{1eff}=27A
	S		IP21		Air cool

Always

✓ Inspect cables and plugs regularly. ✓ Contact a qualified electrician for advice and/or upgrade and, if needed, to replace any damaged plugs or cables.

What if I don't have a 240 volt 15 amp or 32 amp outlet?

If you don't have a suitable power outlet, you should contact a qualified electrician to advise whether the wiring in your building will cater for a 15 amp or 32 amp outlet. You may also need to upgrade your circuit breakers and possibly switchboard to suit. Failure to do this may cause an electrical fire in the building which may void insurances.

2.0 Package contents

Package Contents
Power source
Work return lead
TIG torch
Regulator
Gas hose
Operator’s manual

Optional Accessories	Part No.
Foot control	340050-00018

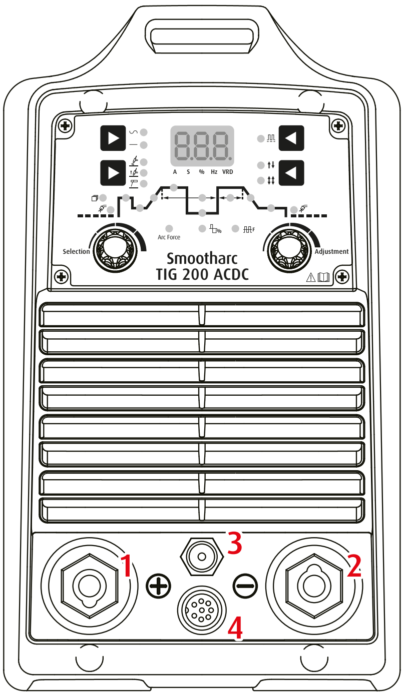
3.0 Technical specifications

Specifications

Part No.	BOCTIG200ACDC		
Rated input voltage	Single phase, AC230V +15%/-20%		
Frequency	50/60Hz		
Rated input power	5.7 Kw		
Rated max. input current	25 A		
Rated efficient input current	14 A		
		TIG	MMA
Open load voltage		60 V	13.2 V (VRD)
Rated duty cycle @40°C (30%)		210A	170A
Welding current range	3–210 A		10–170 A
MMA ARC-force current			0–100 A
MMA hot start current			0–100 A
Pre-gas time		0.01–9.99 s	
Up-slope time		0–10 s	
Down-slope time		0–15 s	
Post-gas time		0.1–60 s	
TIG mode ARC-starting type		HF/LIFT	
Arc strike current		40–100 A	
Arc starting current		3–210 A	
Base current	3–210 A		
Crater filling current	10–210 A		
AC frequency	10–250 Hz		
Pulse frequency	0.2–500 Hz		
Clean ratio	-40–40%		
Insulation class	F		
Maximum argon flow		20 L/min	
Weight	11.5 Kg		
Dimension (L×W×H)	430×160×300 mm		
Standards	AS/NZS 60974-1, IEC/EN 60974-10		

4.0 Connections

Front Connections of TIG 200 ACDC



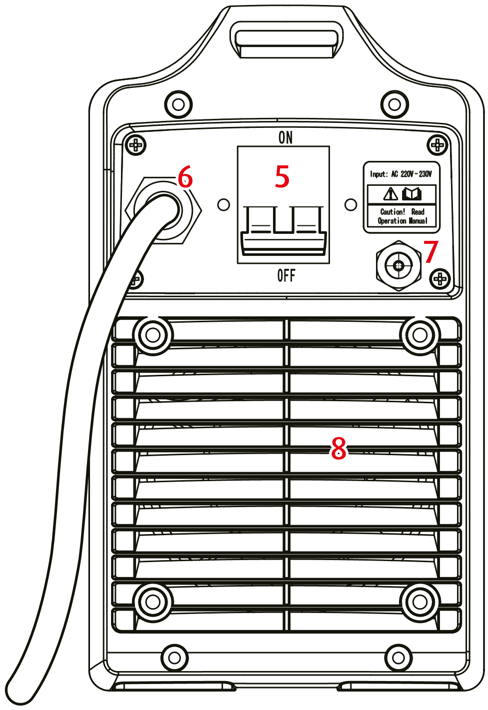
1 Welding cable quick socket (+)
In TIG mode, connect with work piece;
In MMA mode, connect with electrode holder.

2 Welding cable quick socket (-)
In TIG mode, connect with TIG torch;
In MMA mode, connect with work piece.

3 Gas outlet
Connect with TIG torch gas connector.

4 Control socket
Connect with TIG torch, foot pedal, or control cable of automation system.

Back Connections of TIG 200 ACDC



5 Power switch
Use this switch to supply single phase 230V AC power for welding machine. When switch is ON, control panel will light up, and the fan begins to run.

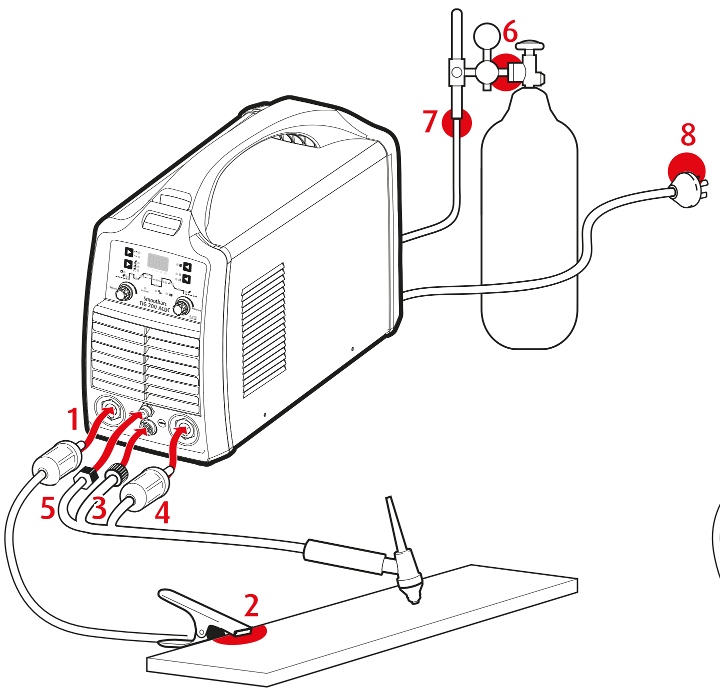
6 Power supply cable
Comes with a 15A plug.

7 Gas inlet
Connect gas regulator via gas hose.

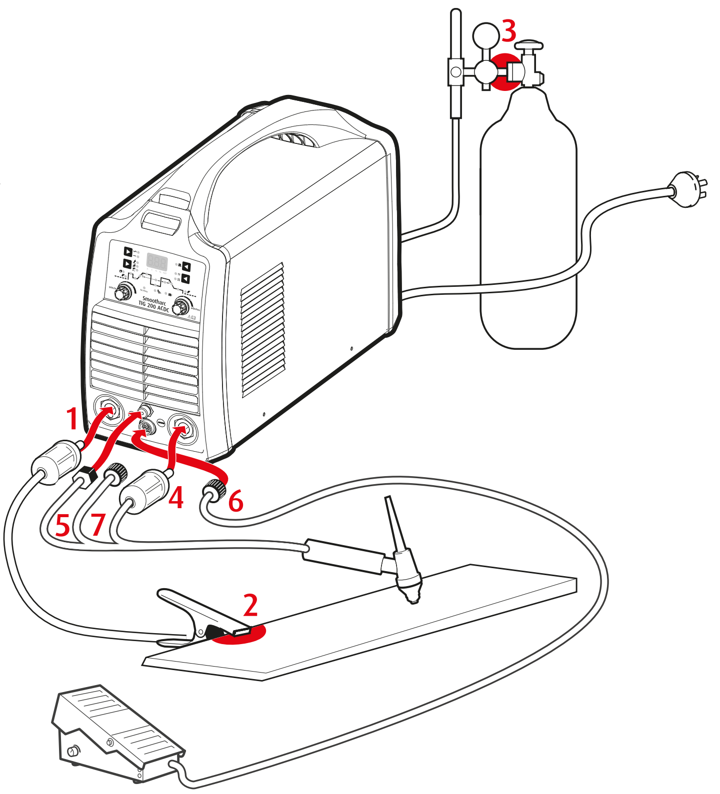
8 Fan
Cools down power source.

5.0 Smootharc TIG 200 ACDC installation

Installation for TIG setup



Installation for TIG setup using foot control



Foot pedal

5.1 Installation for TIG welding

1. Plug the work return lead into output socket ⊕, and tighten firmly.
2. Connect work return clamp to the work piece.
3. Plug the 8-pin plug of TIG torch into the welding machine control socket.
4. Connect the dinse plug of the TIG torch to negative ⊖ of the front panel, and fasten it clockwise.
5. Connect securely the gas lead of the TIG torch to the gas output terminal.
6. Connect gas regulator to gas cylinder.
7. Connect one end of gas hose to gas outlet of gas regulator. Fasten the hose clamp. Connect the other end to gas inlet on rear panel of welding machine.
8. Connect with single phase 230V power supply. Turn power switch ON (switch located on back of welding machine).

5.2 Optional Foot Pedal

Foot pedal switch can be used for arc start control and welding current regulation. Welding current will switch automatically to foot pedal control after the control plug is connected to welder's control cable socket. When the pedal is used, the welder begins to work at the welding current in accordance with pressure on the pedal. The maximum current value is preset by the potentiometer on the foot pedal.

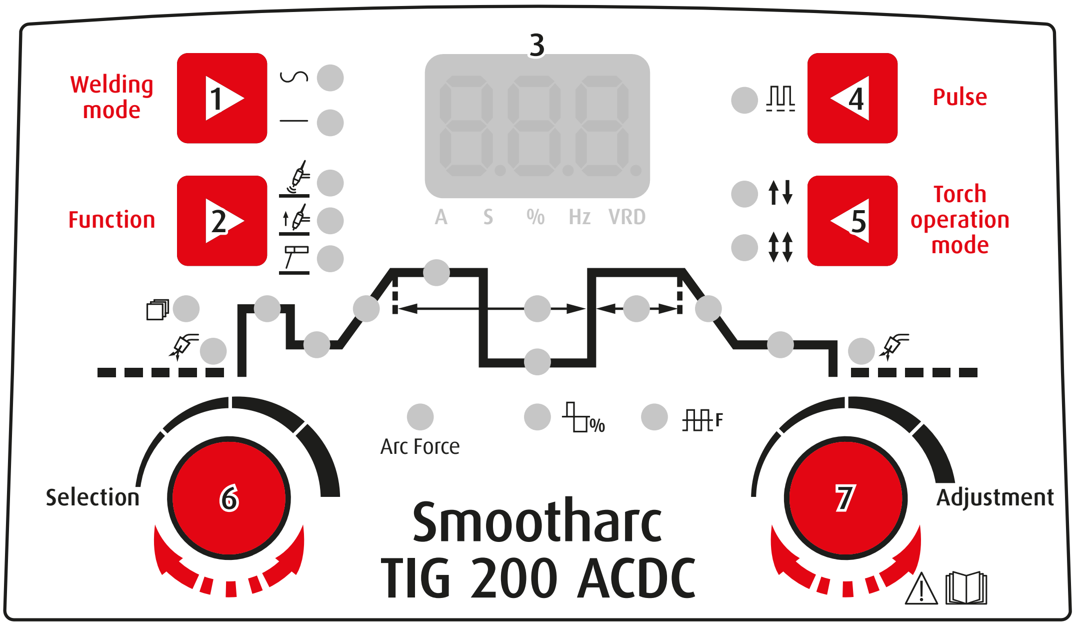
PLEASE NOTE The foot control pedal is sold separately
Part No. 340050-00018

5.3 Installation for TIG setup with optional foot control

1. Plug the work return lead into output socket ⊕, and tighten firmly.
2. Connect work return clamp to the work piece.
3. Connect the gas cylinder to the regulator. Select correct shielding gas for the application.
4. Connect the dinse plug of the TIG torch to negative ⊖ of the front panel, and fasten it clockwise.
5. Connect securely the gas lead of the TIG torch to the gas output terminal.
6. Connect the electical lead of the foot control to the 8-pin torch/foot contol socket and fasten the nut.
7. The 8-pin plug of the TIG torch should now hang free.

6.0 Control panel

Control Panel of TIG 200 ACDC



6.1 Function switches

1 AC/DC selection button: select between AC, DC, mixed waveform on TIG mode. Select between AC, DC on MMA mode.

> IMPORTANT! When both AC and DC lights are ON this means the machine is on mixed waveform TIG mode.

2 Function selection button: select between HF TIG, Lift TIG, MMA.

3 Digital display screen.

4 Pulse selection button: On TIG mode, to switch between constant current and pulse.When the indicator light is ON, it's in pulse mode. When the indicator light is OFF, it's in constant current mode.

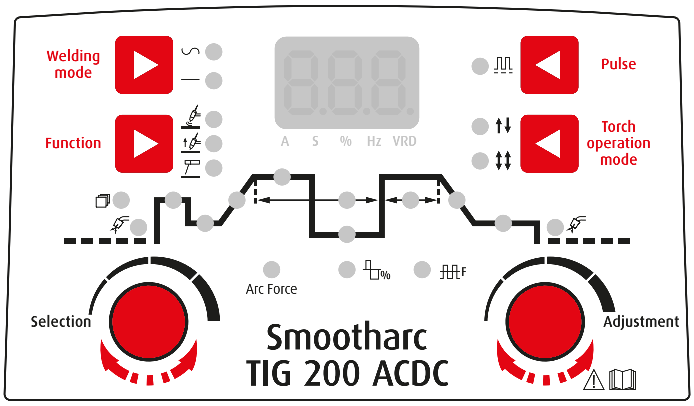
5 Operating mode selection button: on TIG mode, select between 2T, 4T.

6 Parameter selection knob: rotate clockwise to select from left to right, anti-clockwise to select from right to left.

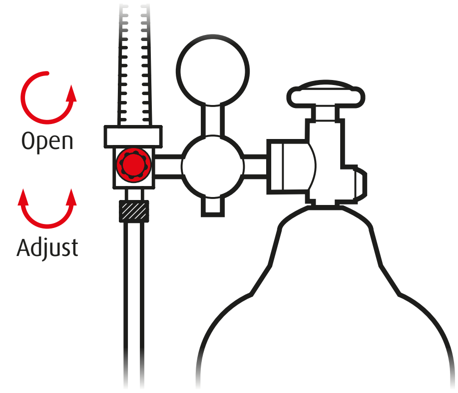
7 Parameter adjustment knob: adjust selected parameter. Rotate clockwise to increase value, anti-clockwise to decrease value. Press this button to rotate for quick adjustment.

7.0 Operation for TIG welding

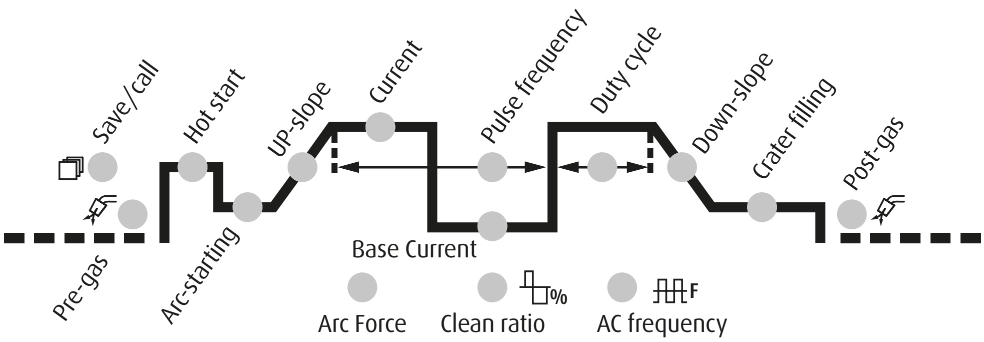
Control panel



Gas Regulator



TIG welding parameters

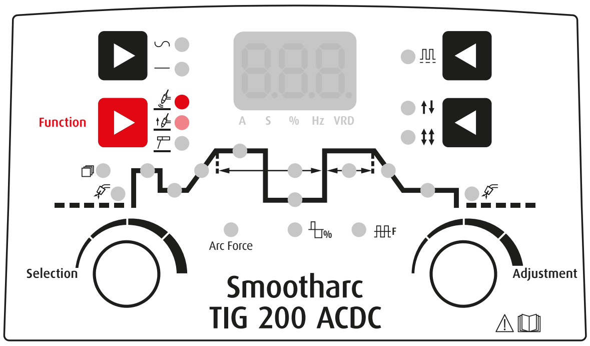


7.1 Operation for TIG welding

1. Press the bottom left button to select function: HF TIG, Lift TIG, MMA.
2. Press the top left button to select welding mode: AC, DC, Mixed waveform on TIG mode.
3. Press the bottom right button to select torch operation mode: 2T, 4T.
4. Press the top right button to select pulse
5. Adjust the left knob, to select TIG welding parameters
6. Adjust the right knob, to adjust selected welding parameter value
7. Open gas valve of gas regulator
8. Press parameter selection knob and pulse selection button at the same time for 3 second to enter into gas test mode. Adjust flow meter knob of gas regulator to suitable value.
9. Press torch switch and start welding.

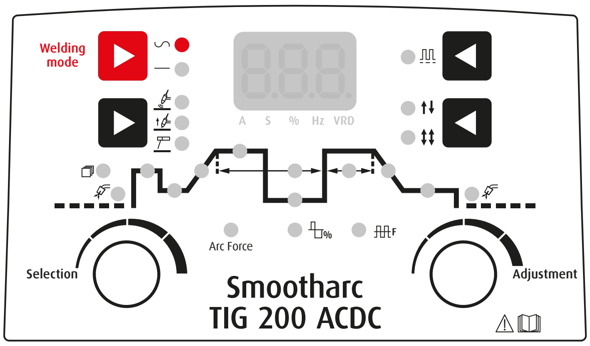
8.0 Operation for AC TIG welding

1. Select TIG function



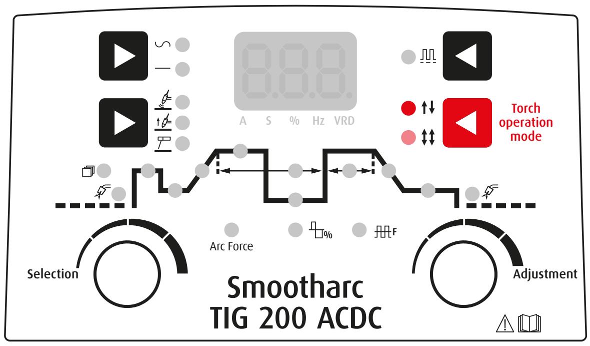
1 Press the bottom left button to select function: HF TIG, Lift TIG

2. Select AC welding mode



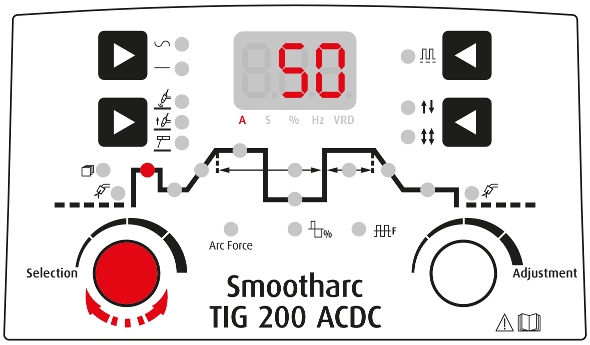
2 Press the top left button to select welding mode: AC

3. Select Torch operation mode



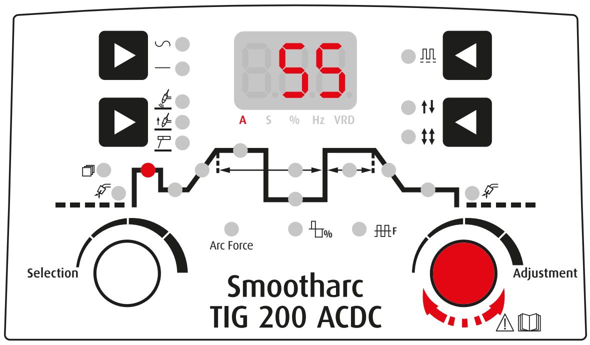
3 Press the bottom right button to select torch operation mode: 2T, 4T

4. Select Hot start



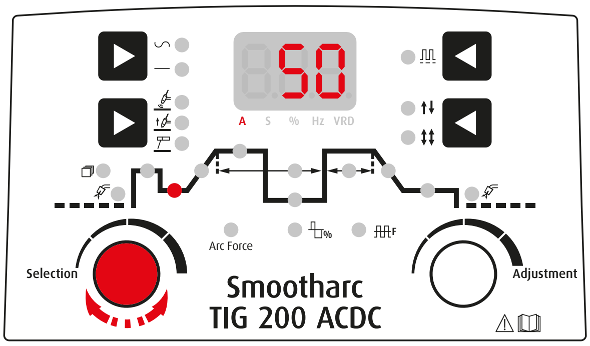
4 Rotate the left knob to select “Hot start”

5. Adjust Hot start



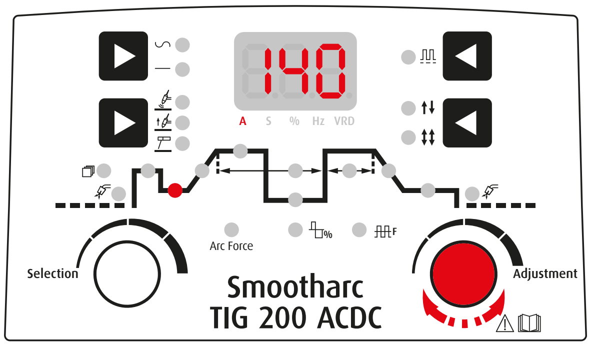
5 Rotate the right knob to adjust “Hot start” current

6. Select ARC-starting



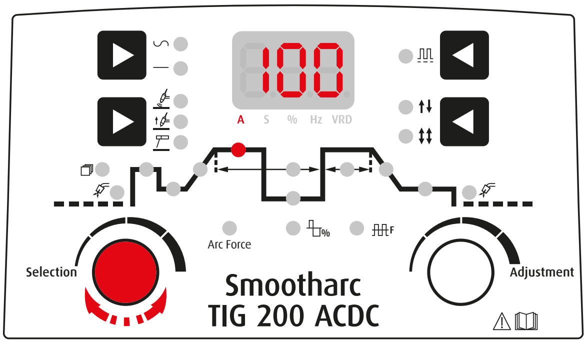
6 Rotate the left knob to select “ARC-starting”

7. Adjust ARC-starting



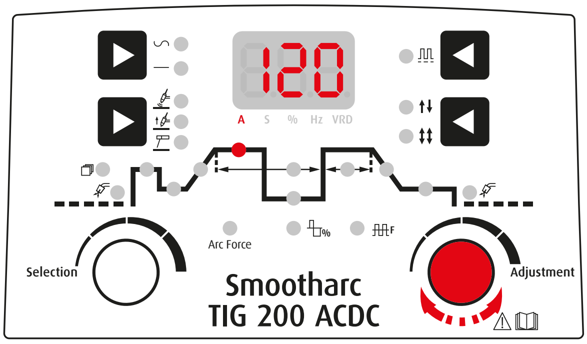
7 Rotate the right knob to adjust “ARC-starting” current

8. Select Current



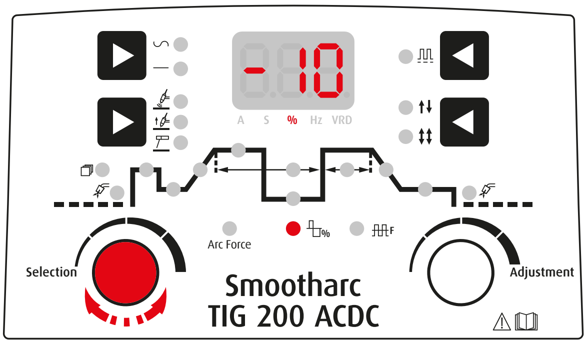
8 Rotate the left knob to select "Current"

9. Adjust Current



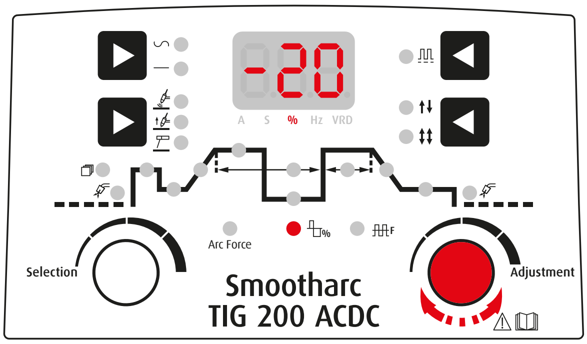
9 Rotate the right knob to adjust welding current according to work piece thickness

10. Select Clean Ratio



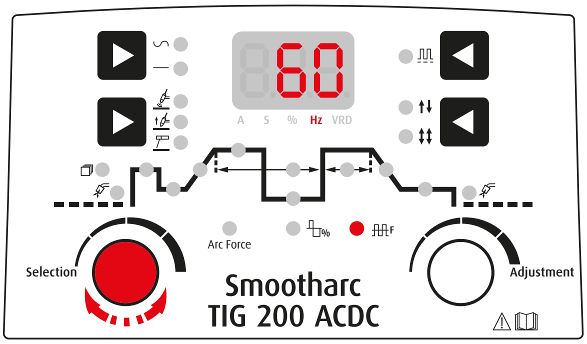
10 Rotate the left knob to select "Clean Ratio"

11. Adjust Clean Ratio



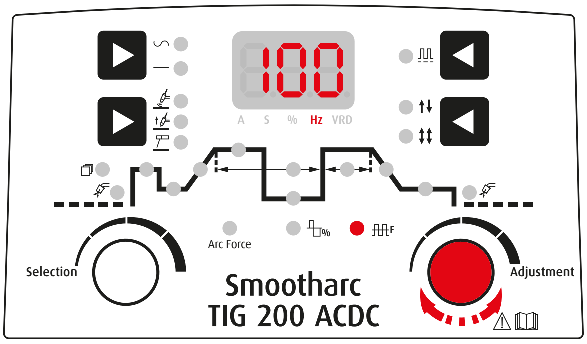
11 Rotate the right knob to adjust clean ratio. The higher the ratio is, the better the cleaning effect is, however it will shorten the life of the electrode.

12. Select AC frequency



12 Rotate the left knob to select "AC frequency"

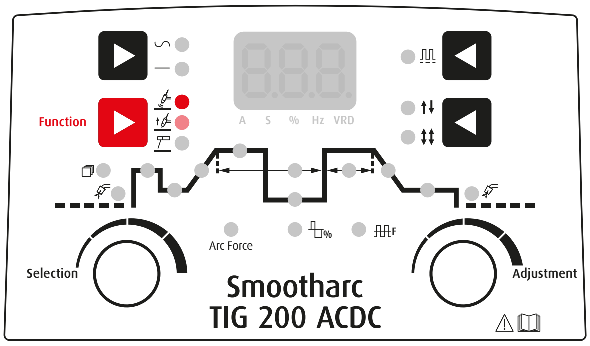
13. Adjust AC frequency



13 Rotate the right knob to adjust working frequency on AC mode

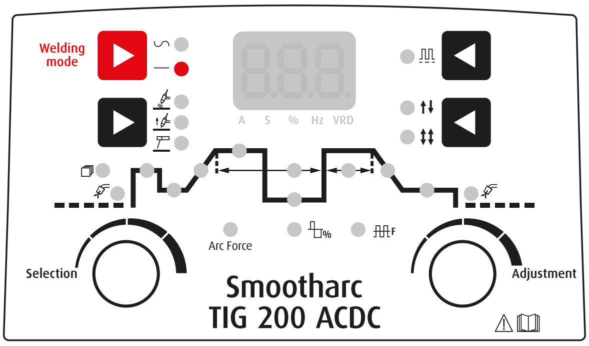
9.0 Operation for DC Pulse TIG welding

1. Select TIG function



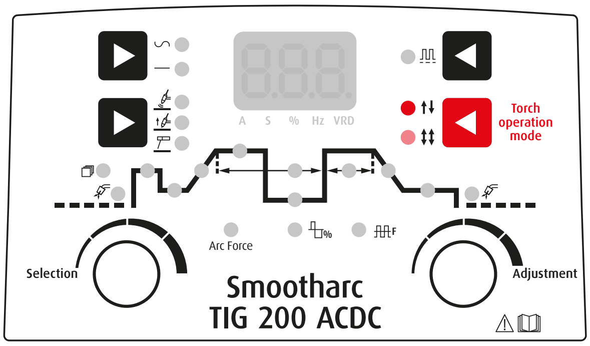
1 Press the bottom left button to select function: HF TIG, Lift TIG

2. Select DC welding mode



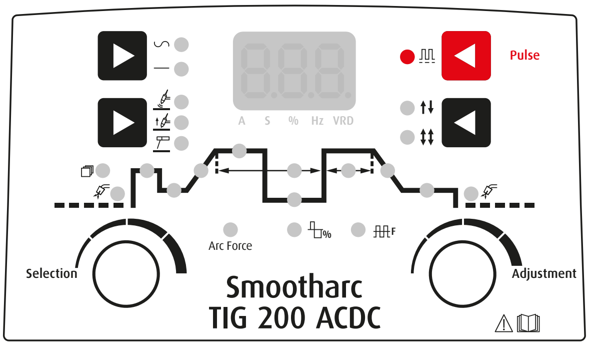
2 Press the top left button to select welding mode: DC

3. Select Torch operation mode



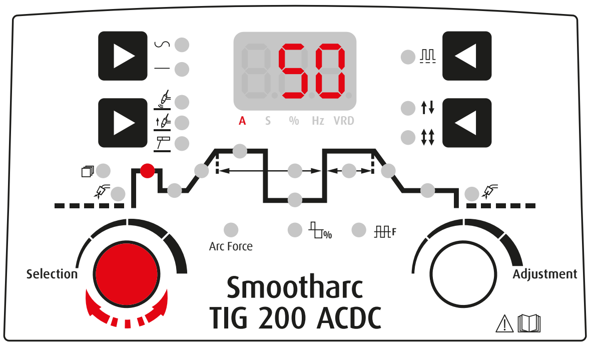
3 Press the bottom right button to select torch operation mode: 2T, 4T

4. Select Pulse



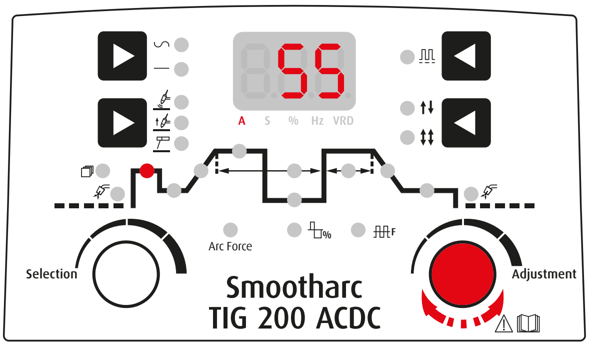
4 Press the top right button to select pulse

5. Select Hot start



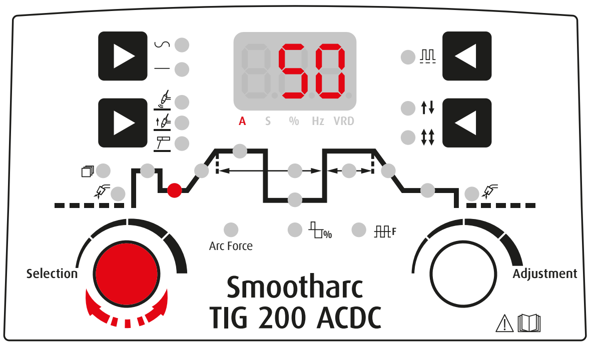
5 Rotate the left knob to select "Hot start"

6. Adjust Hot start



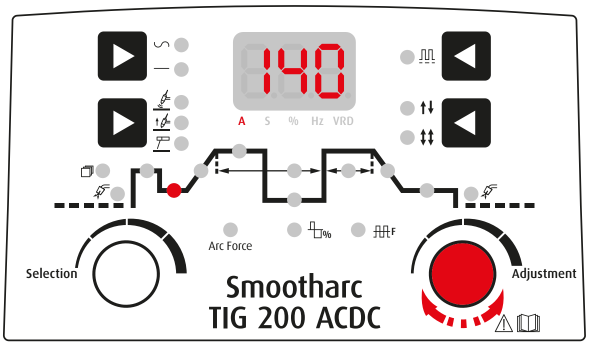
6 Rotate the right knob to adjust "Hot start" current

7. Select ARC-starting



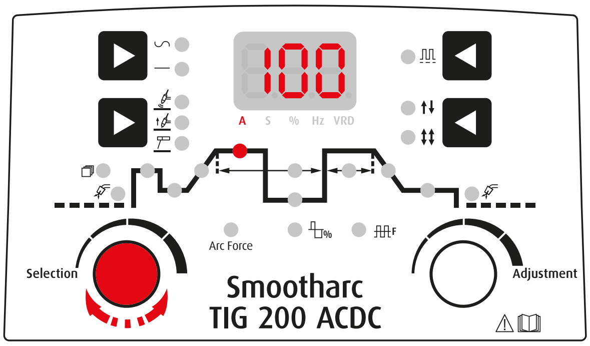
7 Rotate the left knob to select "ARC-starting"

8. Adjust ARC-starting



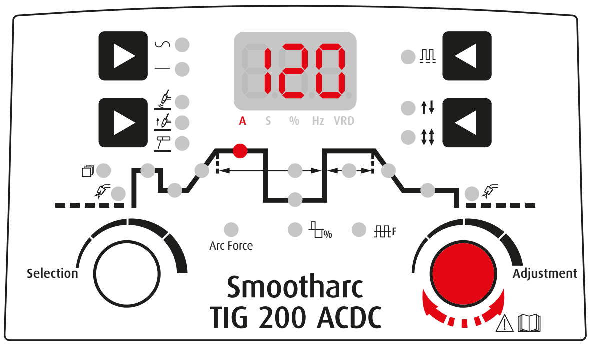
8 Rotate the right knob to adjust "ARC-starting" current

9. Select Current



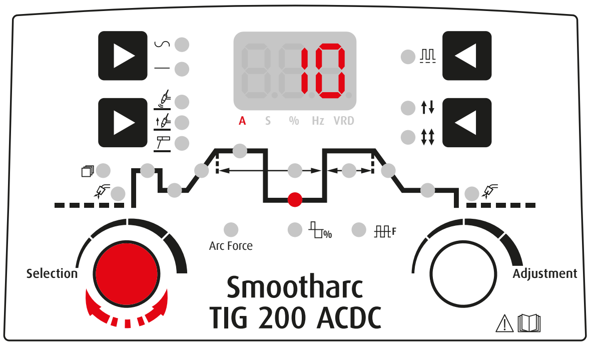
9 Rotate the left knob to select “Current” (peak current)

10. Adjust Current



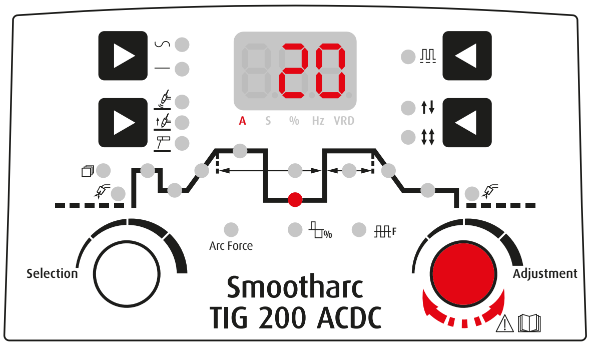
10 Rotate the right knob to adjust welding current (peak current)

11. Select Base Current



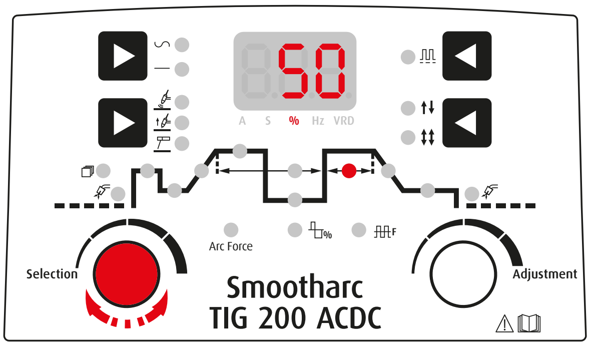
11 Rotate the left knob to select “Base Current”

12. Adjust Base Current



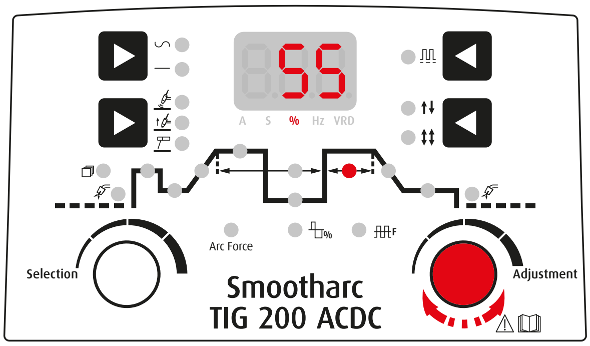
12 Rotate the right knob to adjust base current

13. Select Duty Cycle



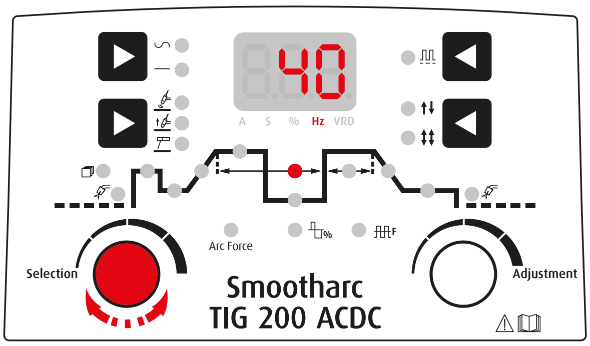
13 Rotate the left knob to select “Duty Cycle”

14. Adjust Duty Cycle



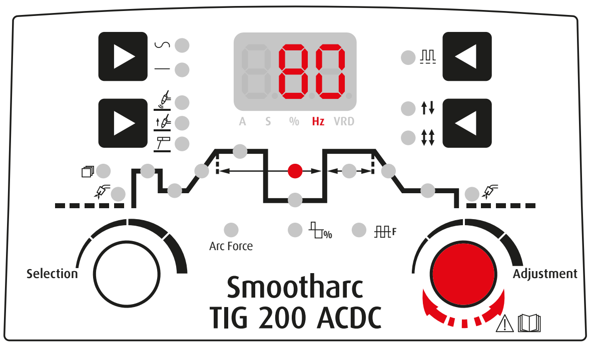
14 Rotate the right knob to adjust duty cycle. The higher the duty cycle is, the higher the welding current is

15. Select Pulse frequency



15 Rotate the left knob to select “Pulse frequency”

16. Adjust Pulse frequency



16 Rotate the right knob to adjust pulse frequency. The higher the frequency is, the higher the required welding speed is.

10.0 TIG Torch Operation Mode

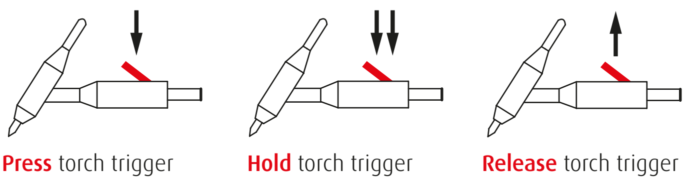
10.1 2T operation mode (HF TIG)

1. Press and hold torch trigger to start welding
   - Open solenoid valve. Shielding gas will flow out to expel air from torch hose (pre-gas time depends on the hose length). Then HF ignition device works and arc starts.
   - Output current continuously increases from initial current to welding current.
2. Release torch trigger to stop welding
   - Release torch trigger. Welding current will continuously decrease at a certain rate and time until it reaches zero.
   - The solenoid valve will continue to operate for a period of time (post-gas time), allowing the shielding gas to protect the tungsten electrode and molten pool. Then the solenoid valve closes, gas stops and welding finishes.

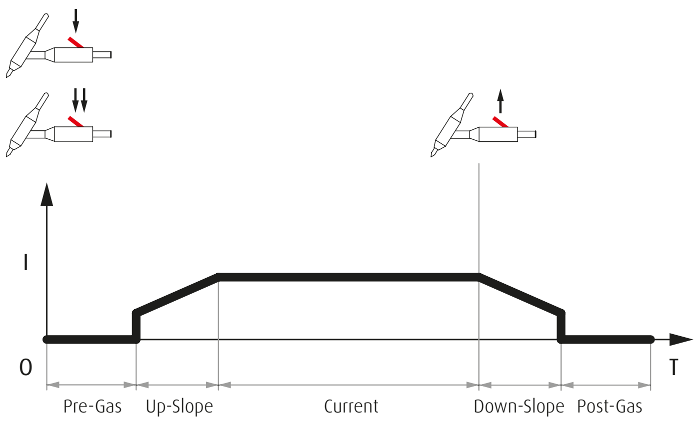
10.2 4T operation mode

1. Press and hold torch trigger to start welding
   - Open solenoid valve. Shielding gas will flow out to expel air from torch hose (pre-gas time depends on the hose length). Then HF ignition device switches on and arc starts.
   - Output current starts at initial current and time of initial current. Output depends on the time that torch trigger is pressed and held.
2. Release torch trigger
   - Output current increases from initial current to welding current. This time is called up slope time.
   - If the initial current is not required, the torch trigger does not need to be held. Quickly press torch trigger to start arc, then quickly release it and output current will increase to welding current.
3. Press and hold torch trigger again when the welding completes
   - Welding current will continuously decrease at a certain rate until it reaches to crater-fill current. This time is called down slope time.
   - Time of crater-fill current depends on the time that the torch trigger is pressed and held.
4. Release torch trigger
   - The output current is continuously lowered to zero and arc is extinguished. The solenoid valve will continue to work for the selected period of time (post-gas time), allowing the shielding gas to protect the tungsten electrode and molten pool. Then the solenoid valve closes, gas stops and welding completes.

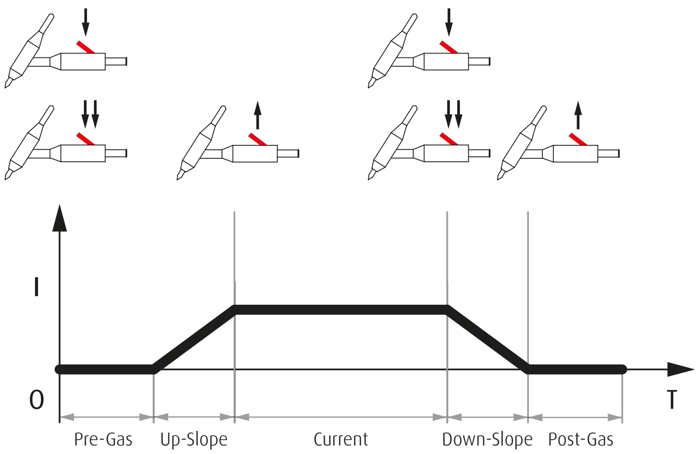
TIG torch operation modes



2T operation mode

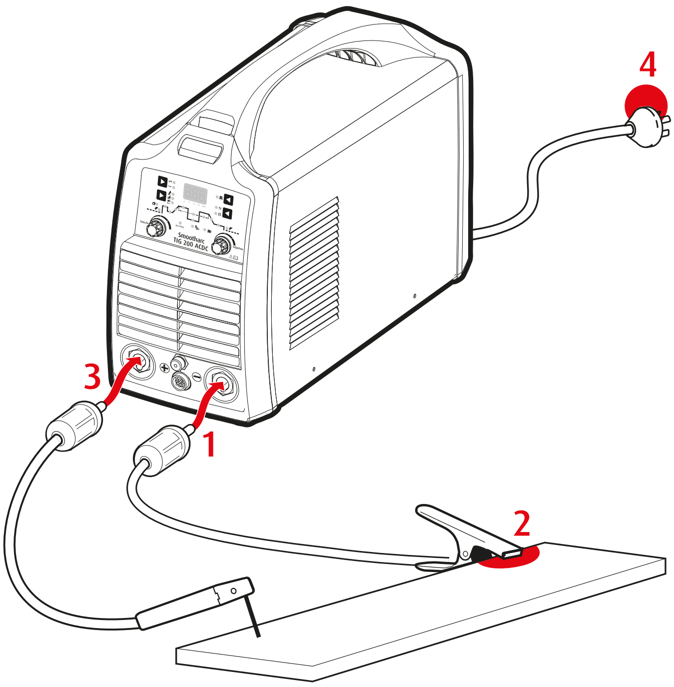


4T operation mode

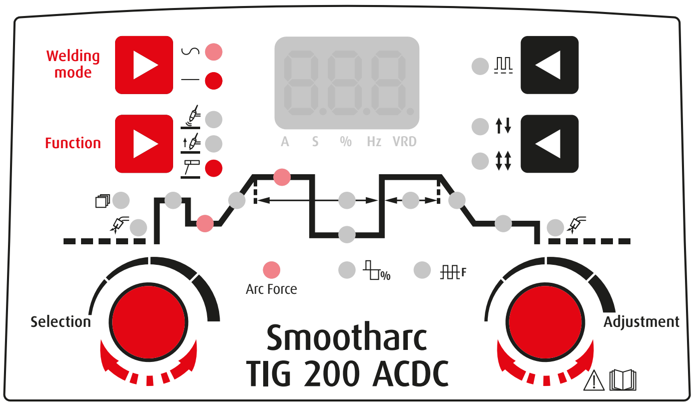


11.0 Installation & Operation for MMA use

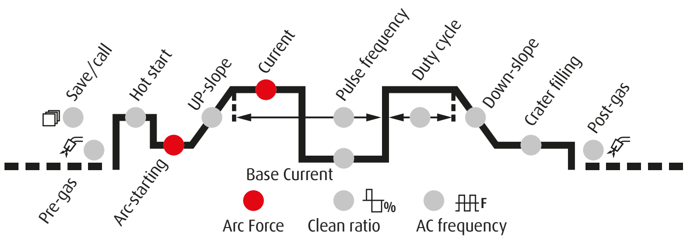
Installation for MMA process



Control panel use in MMA function



Adjustable welding parameters in MMA DC mode



11.1 Installation and Operation for MMA welding

1 Plug the work return lead into output socket ⊖, and tighten firmly.

2 Connect the work return clamp to the work piece.

3 Plug an electrode holder* into output socket ⊕, and tighten firmly.

4 Connect with single phase 230V power supply. Turn power switch ON (switch located on back of welding machine).

5 Press the bottom left button to select function: MMA

6 Press the top left button to select welding mode: AC, DC on MMA mode. On DC mode, ARC-starting, ARC-force and Current are adjustable. Rotate parameter selection knob to choose these parameters. Rotate parameter adjustment knob to adjust these parameters.

7 Rotate parameter adjustment knob, to adjust welding current value in MMA mode.

8 Start welding.

* Electrode holder not included in this package.

12.0 Troubleshooting and fault finding

IMPORTANT: Only authorised repair agents with valid certifications should carry out repairs and internal servicing.

Troubleshooting

No	Trouble	Causes	Remedy
1	Indicator lights of display board do not light up. Fan does not run. No output when machine switches on.	1. Power switch is damaged 2. No electricity on the electricity grid 3. Open circuit in power supply cable	1. Check power switch 2. Check power supply on the electricity grid 3. Check the connection of power supply cable
2	Indicator lights of display board light up. There is no E04 on display screen but welding machine does not have output.	1. Over-current protection 2. Output cable is not well connected 3. Main control board is damaged	1. Turn off the machine, and turn on after one minute 2. Check connection of output cable 3. Check and repair
3	Circuit breaker on the switchboard trips while welding	1. Following devices may be damaged: MOSFET, output diode, etc. 2. Input rectifier bridge is damaged	Check and replace
4	Welding current is unstable	1. Display board is damaged 2. Main control board is damaged 3. Bad connection within the welding machine, especially at connectors	Check and replace
5	Welding current is not adjustable	1. Display board is damaged 2. Main control board is damaged 3. Foot pedal is damaged	Check and replace
6	Display E04 (overheat protection)	1. Welding current is too high 2. Environmental temperature is too high 3. Temperature relay is damaged	1. Change on open load mode and cool down 2. Change on open load mode and cool down 3. Replace
7	Display E02 (Switch is abnormal)	1. Torch trigger or foot pedal switch is often on 2. Control wiring harness plug of the display board is damaged or not well connected 3. Main control board is damaged	1. Check 2. Check connection 3. Check and replace main control board

Error code display

Code	Trouble	Causes	Remedy
E10	Torch trigger is normally closed	1. Torch trigger (foot pedal switch) keeps pressing when on open load mode 2. Torch trigger cable has short circuited	1. Release trigger or check trigger 2. Check cable connection 3. Replace
E13	Arc stabilising circuit is over current protection	1. Arc stabilising circuit has a problem	1. Check and repair
E16	Fan is abnormal	1. Fan motor is locked- rotate 2. Fan is damaged	1. Check and repair 2. Check and replace
E19	Overheat protection	1. Machine internal is too hot 2. Temperature relay is damaged	1. Wait for machine to cool down 2. Replace

13.0 Periodic maintenance

WARNING

Only authorised repair agents should carry out repairs and internal servicing

Modification of the 15A primary input plug or fitment of a lower rated primary input plug will render the warranty null and void.

The working environment or amount of use the machine receives should be taken into consideration when planning maintenance frequency of your Smootharc welder.

Preventative maintenance will ensure trouble-free welding and increase the life of the machine and its consumables.

13.1 Power source

- Check electrical connections of unit at least twice a year. Repair or replace broken/damaged cables.
- Clean oxidised connections and tighten.
- Inner parts of machine should be cleaned with a vacuum cleaner and soft brush.
- Do not use any pressure-washing devices.
- Do not use compressed air as pressure may pack dirt even more tightly into components.

14.0 Warranty information

14.1 Terms of warranty

The Smootharc machine has a limited warranty that covers manufacturing and material defects only. The warranty is affected on the day of purchase and does not cover any freight, packaging and insurance costs. Verbal promises that do not comply with terms of warranty are not binding on warrantor.

14.2 Limitations on warranty

The following conditions are not covered under terms of warranty: loss or damage due to or resulting from natural wear and tear, non-compliance with operating and maintenance instructions, connection to incorrect or faulty voltage supply (including voltage surges outside equipment specs), incorrect gas pressure overloading, transport or storage damage or fire or damage due to natural causes (e.g. lightning or flood). This warranty does not cover direct or indirect expenses, loss, damage of costs including, but not limited to, daily allowances or accommodation and travelling costs.

Modification of the 15A primary input plug or fitment of a lower rated primary input plug will render the warranty null and void.

NOTE
Under the terms of warranty, welding torches and their consumables are not covered. Direct or indirect damage due to a defective product is not covered under the warranty. The warranty is void if changes are made to the product without approval of the manufacturer, or if repairs are carried out using non-approved spare parts. The warranty is void if a non-authorised agent carries out repairs.

14.3 Warranty period

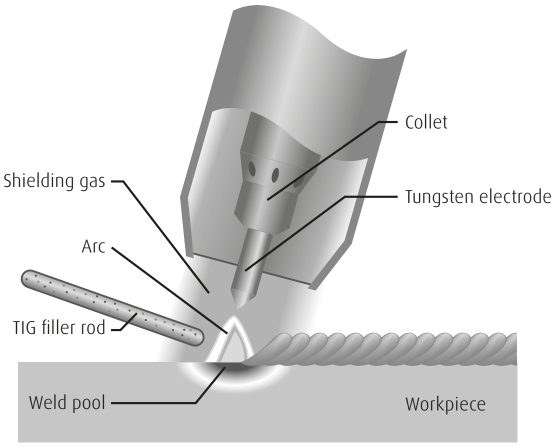
The warranty is valid for 18 months from date of purchase provided the machine is used within the published specification limits.

14.4 Warranty repairs

A BOC approved service provider must be informed within the warranty period of any warranty defect. The customer must provide proof of purchase and serial number of the equipment when making a warranty claim. Warranty repairs may only be carried out by approved BOC service providers. Please contact your local BOC Gas & Gear for a directory of BOC approved service providers in your area.

15.0 Gas tungsten arc welding (GTAW/TIG)

Schematic of the TIG welding process



15.1 Introduction

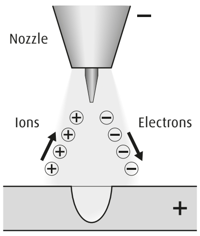
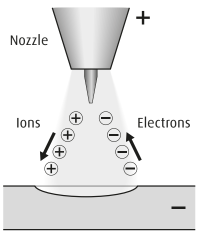
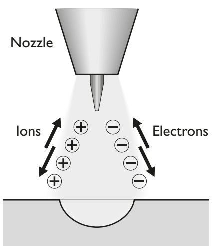
The Tungsten Inert Gas, or TIG process, uses the heat generated by an electric arc struck between a non-consumable tungsten electrode and the workpiece to fuse metal in the joint area and produce a molten weld pool. The arc area is shrouded in an inert or reducing gas shield to protect the weld pool and the non-consumable electrode. The process may be operated autogenously, that is, without filler, or filler may be added by feeding a consumable wire or rod into the established weld pool.

15.2 Process

Direct or alternating current power sources with constant current output characteristics are normally employed to supply the welding current. For DC operation the tungsten may be connected to either output terminal, but is most often connected to the negative pole. The output characteristics of the power source can have an effect on the quality of the welds produced.

Shielding gas is directed into the arc area by the welding torch and a gas lens within the torch distributes the shielding gas evenly over the weld area. In the torch the welding current is transferred to the tungsten electrode from the copper conductor. The arc is then initiated by one of several methods between the tungsten and the workpiece.

15.3 Process variables

Process variable	Explanation	Usage
DCEN		
Narrow bead, deep penetration  	When direct-current electrode-negative (straight polarity) is used: · Electrons strike the part being welded at a high speed · Intense heat on the base metal is produced · The base metal melts very quickly · Ions from the inert gas are directed towards the negative electrode at a relatively slow rate · Direct current with straight polarity does not require post-weld cleaning to remove metal oxides	For a given diameter of tungsten electrode, higher amperage can be used with straight polarity. Straight polarity is used mainly for welding: · Carbon steels · Stainless steels · Copper alloys The increased amperage provides: · Deeper penetration · Increased welding speed · A narrower, deeper, weld bead
DCEP		
Wide bead, shallow penetration  	The DCEP (reverse polarity) are different from the DCEN in following ways: · High heat is produced on the electrode rather on the base metal · The heat melts the tungsten electrode tip · The base metal remains relatively cool compared to using straight polarity · Relatively shallow penetration is obtained · An electrode whose diameter is too large will reduce visibility and increase arc instability	· Intense heat means a larger diameter of electrode must be used with DCEP · Maximum welding amperage should be relatively low (approximately six times lower than with DCEN)
Alternating Current with High-Frequency		
Average bead, Average penetration  	Welding with alternating current combines both direct-current characteristics: · In the positive phase, cleaning action occurs in the weld puddle. · During the negative phase, heat is concentrated in the weld puddle. · The above causes increased penetration.	

15.4 Shielding gas selection

Material	Shielding gas	Benefits
Aluminium Alloys	Argon	Used with high frequency AC good stable arc good cleaning action
	Argon/Helium	Used with high frequency AC good cleaning action higher welding speed increased penetration
Aluminium Bronze	Argon	Reduces penetration during surfacing minimising dilution
Brass	Argon	Stable arc Low fume
Cobalt-based alloys	Argon	Stable and easy to control arc
Copper-nickel (Monel)	Argon	Stable and easy to control arc Can be used for copper-nickel to steel
Deoxised copper	Helium	Increased heat input Stable arc Good penetration
	Helium(75%)/ Argon(25%)	Stable arc Lower penetration
Nickel alloys (Inconel)	Argon	Stable arc Manual operation
	Helium	High speed automated welding
Steel	Argon	Stable arc Good penetration
	Helium	High speed automatic welding Deeper penetration Small concentrated HAZ
Magnesium Alloys	Argon	Used with continuous high frequency AC Good arc stability Good cleaning action
Stainless steel	Argon	Good penetration Good arc stability
	Helium	Deeper penetration
Titanium	Argon	Stable arc
	Helium	High speed welding

15.5 Welding wire selection

The following table includes the recommended welding consumable for the most commonly welded materials.

Base material	BOC Consumable
C-Mn and low carbon steels	BOC Mild steel TIG wire
Low Alloy steels	
1.25Cr/0.5Mo	Comweld CrMo1
2.5Cr/1Mo	Comweld CrMo2
Stainless Steel	
304/304L	Profill 308
316/316L	Profill 316
309/309-C-Mn	Profill 309
321/Stabilised grades	Profill 347
Aluminium	
1000 series	Comweld 1100
5000 series	Comweld 4043/4047/5356
6000 series	Comweld 4043/4047/5356

Filler rod diameter (mm)	Thickness of metal (mm)
2	0.5–2
3	2–5
4	5–8
4 or 5	8–12
5 or 6	12 or more

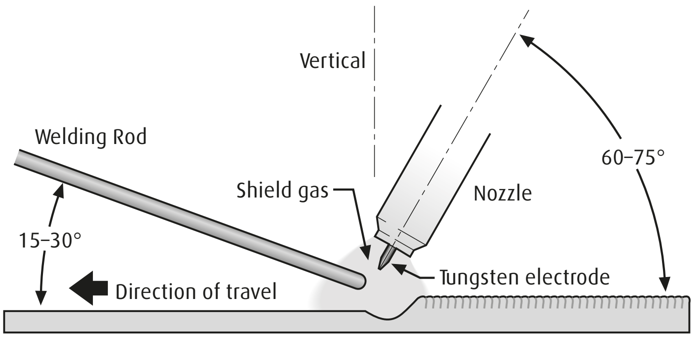
15.6 Non consumable tungstens

Tungsten Electrode Selector Chart

Thickness range	Desired results	Welding current	Electrode type	Shielding gas	Tungsten performance characteristics
Aluminium alloys and Magnesium alloys					
All	General purpose	ACHF	Pure (EW-P)	Argon	Balls easily. Low cost. Tends to spit at higher currents. Used for non-critical welds only.
			Zirconiated (EW-Zr)	Argon	Balls well. Takes higher current, with less spitting and with better arc starts and arc stability than pure tungsten.
			2% Thoriated (EW-Th2)	75% Argon/ 25% Helium	Higher current range and stability. Better arc starts, with lower tendency to spit. Medium erosion.
Only thin sections	Control penetration	DCRP	2% Ceriated (EW-Ce2)	Argon Helium	Lowest erosion rate. Widest current range. AC or DC. No spitting. Best arc starts and stability.
Only thick sections	Increase penetration or travel speed	DCSP	2% Thoriated (EW-Th2)	75% Argon/ 25% Helium	Best stability at medium currents. Good arc starts. Medium tendency to spit. Medium erosion rate.
			2% Ceriated (EW-Ce2)	Helium	Low erosion rate. Wide current range. AC or DC. No spitting. Consistent arc starts. Good stability.
Copper alloys, Cu-NI alloys and Nickel alloys					
All	General purpose	DCSP	2% Thoriated (EW-Th2)	75% Argon/ 25% Helium	Best stability at medium currents. Good arc starts. Medium tendency to spit. Medium erosion rate.
			2% Ceriated (EW-Ce2)	75% Argon/ 25% Helium	Low erosion rate. Wide current range. AC or DC. No spitting. Consistent arc starts. Good stability.
Only thin sections	Control penetration	ACHF	Zirconiated (EW-Zr)	Argon	Use on lower currents only. Spitting on starts. Rapid erosion rates at higher currents.
Only thick sections	Increase penetration or travel speed	DCSP	2% Ceriated (EW-Ce2)	75% Argon/ 25% Helium	Low erosion rate. Wide current range. AC or DC. No spitting. Consistent arc starts. Good stability.
Mild Steels, Carbon Steels, Alloy Steels, Stainless Steels and Titanium alloys					
All	General purpose	DCSP	2% Thoriated (EW-Th2)	75% Argon/ 25% Helium	Best stability at medium currents. Good arc starts. Medium tendency to spit. Medium erosion rate.
			2% Ceriated (EW-Ce2)	75% Argon/ 25% Helium	Low erosion rate. Wide current range. AC or DC. No spitting. Consistent arc starts. Good stability.
			2% Lanthanated (EWG-La2)	75% Argon/ 25% Helium	Lowest erosion rate. Widest current range on DC. No spitting. Best DC arc starts and stability.
Only thin sections	Control penetration	ACHF	Zirconiated (EW-Zr)	Argon	Use on lower current only. Spitting on starts. Rapid erosion rates at higher currents.
Only thick sections	Increase penetration or travel speed	DCSP	2% Ceriated (EW-Ce2)	75% Argon/ 25% Helium	Low erosion rate. Wide current range. No spitting. Consistent arc starts. Good stability.
			2% Lanthanated (EWG-La2)	Helium	Lowest erosion rate. Highest current range. No spitting. Best DC arc starts and stability.

15.7 Welding techniques

TIG Welding techniques

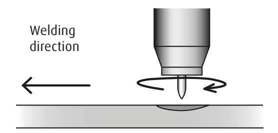


The suggested electrode and welding rod angles for welding a bead on plate are shown above. The same angles are used when making a butt weld. The torch is held 60–75° from the metal surface. This is the same as holding the torch 15–30° from the vertical.

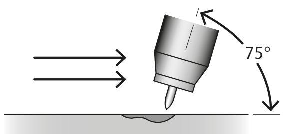
Take special note that the rod is in the shielding gas during the welding process.

15.8 Torch movement during welding

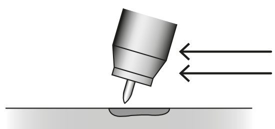
Tungsten Without Filler Rod



Form pool

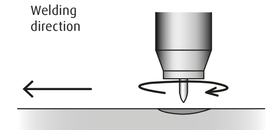


Tilt torch

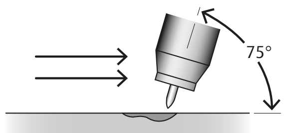


Move torch to front of pool. Repeat.

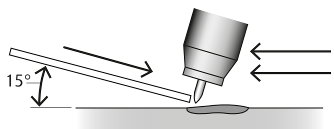
Tungsten With Filler Rod



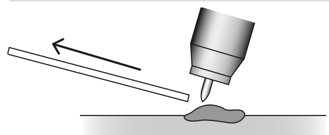
Form pool



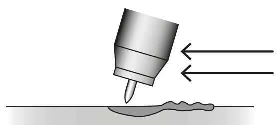
Tilt torch



Add filler metal

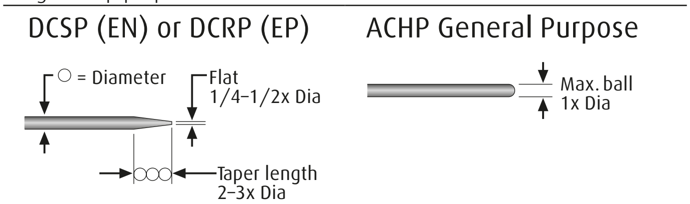


Remove rod



Move torch to front of pool. Repeat.

Tungsten tip preparation



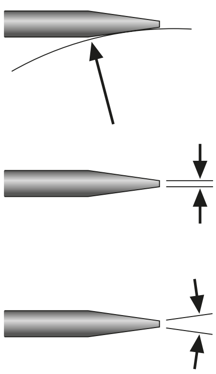
Ball tip by arcing on clean metal at low current DCRP (EP) then slowly increase current to form the desired ball diameter. Return setting to AC.

Tungsten grinding

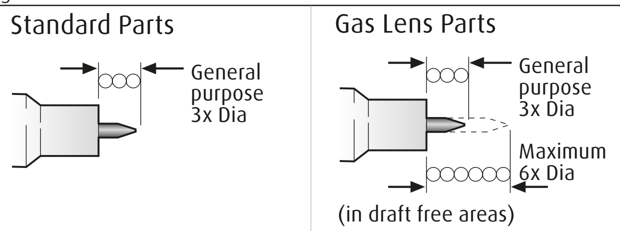
Shape by grinding longitudinally (never radially). Remove the sharp point to leave a truncated point with a flat spot. Diameter of flat spot determines amperage capacity (See below).

The included angle determines weld bead shape and size. Generally, as the included angle increases, penetration increases and bead width decreases.

Use a medium (60 grit or finer) aluminium oxide wheel.



Tungsten extension



Tungsten electrode tip shapes and current ranges

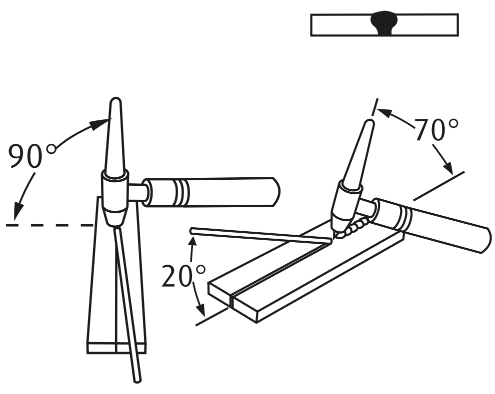
Thoriated, ceriated, and lanthanated tungsten electrodes do not ball as readily as pure or zirconiated tungsten electrodes, and as such are typically used for DCSP welding. These electrodes maintain a ground tip shape much better than the pure tungsten electrodes. If used on AC, thoriated and lanthanated electrodes often spit. Regardless of the electrode tip geometry selected, it is important that a consistent tip configuration be used once a welding procedure is established. Changes in electrode geometry can have a significant influence not only on the weld bead width, depth of penetration, and resultant quality, but also on the electrical characteristics of the arc. Below is a guide for electrode tip preparation for a range of sizes with recommended current ranges.

Tungsten electrode tip shapes and current ranges

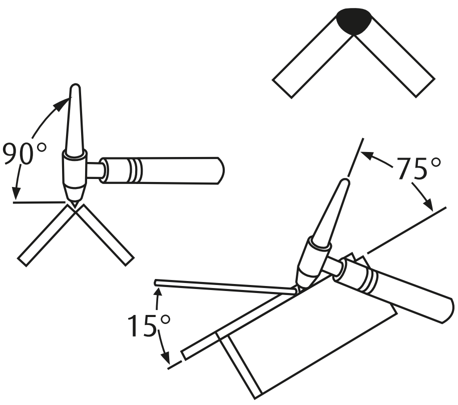
Electrode diameter (mm)	Diameter arc tip (mm)	Constant included angle, (degrees)	Current range (A)
1.0	0.125	12	2–15
1.0	0.250	20	5–30
1.6	0.500	25	8–50
1.6	0.800	30	10–70
2.3	0.800	35	12–90
2.3	1.100	45	15–150
3.2	1.100	60	20–200
3.2	1.500	90	25–250

15.9 Positioning torch tungsten for various weld joints

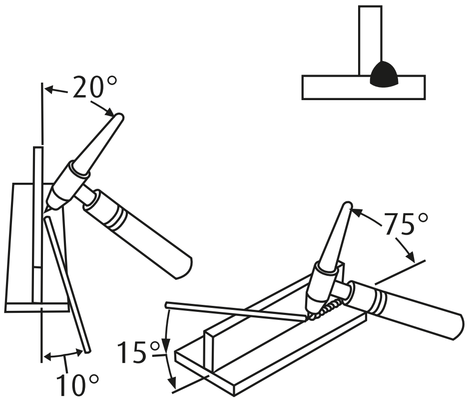
Butt Weld and Stringer bead



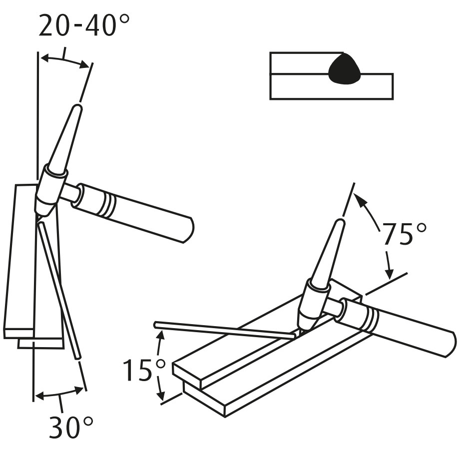
Corner Joint



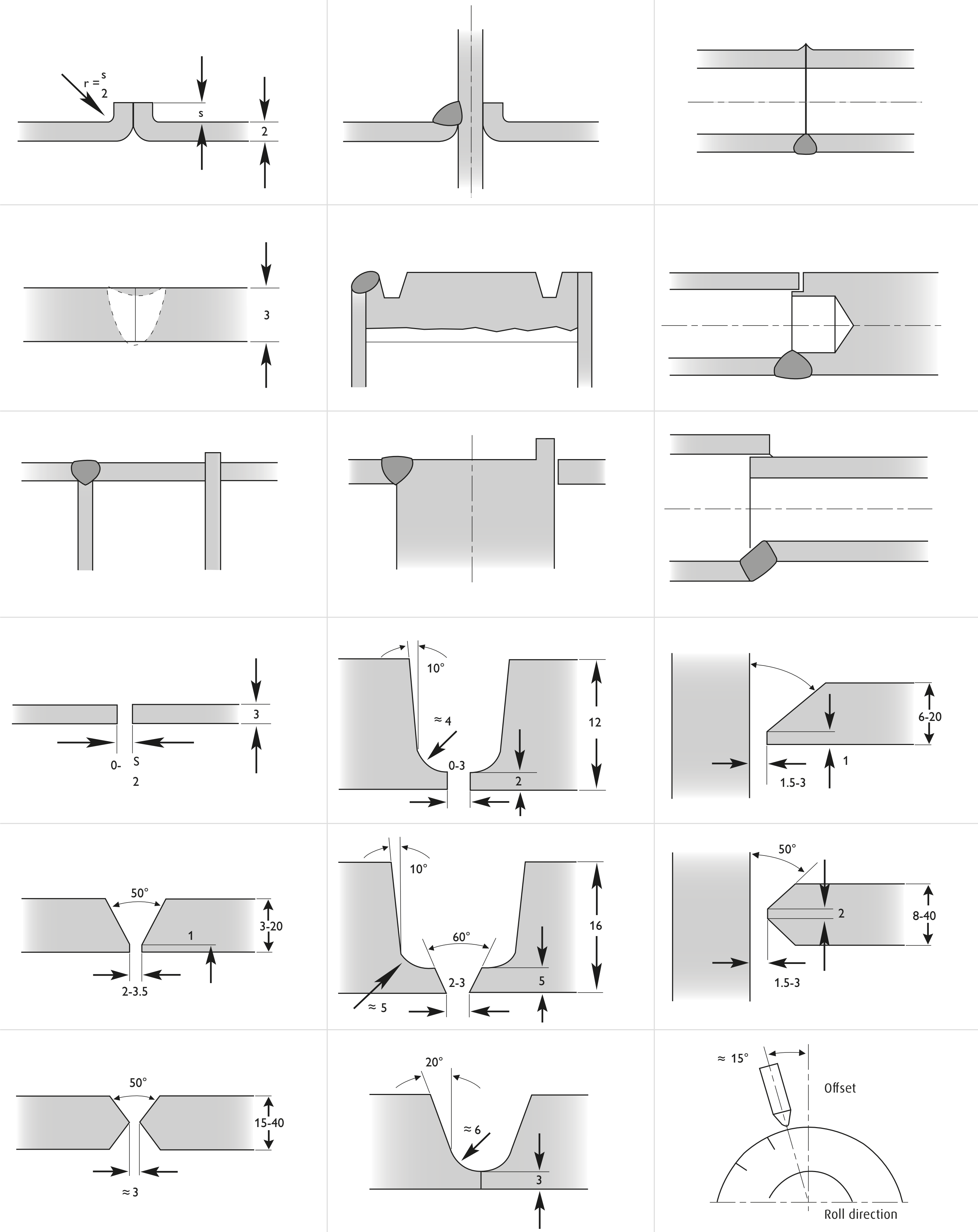
'T' Joint



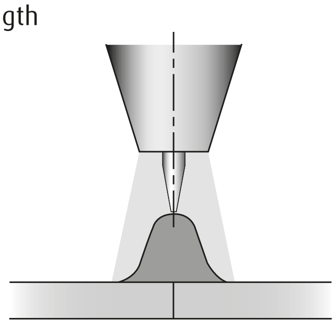
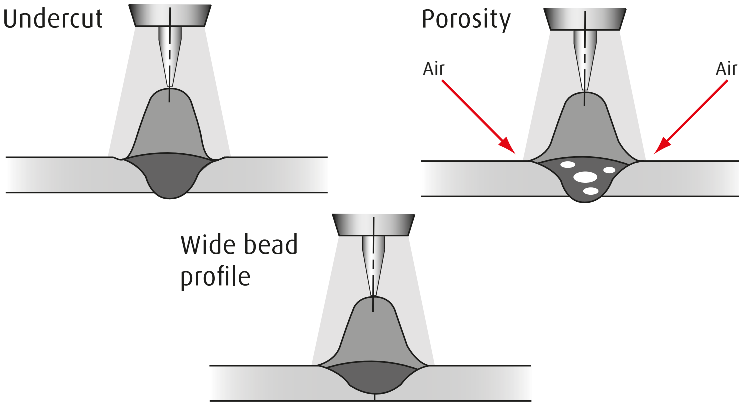
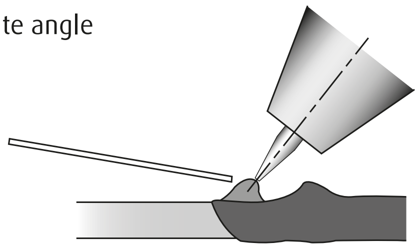
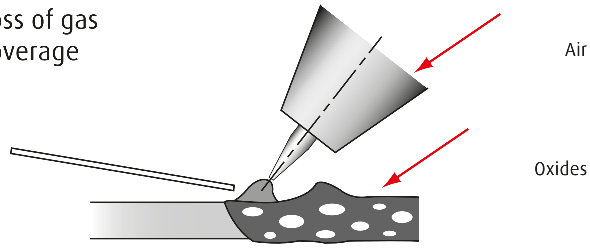
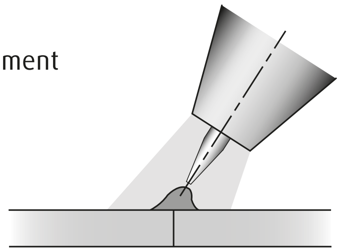
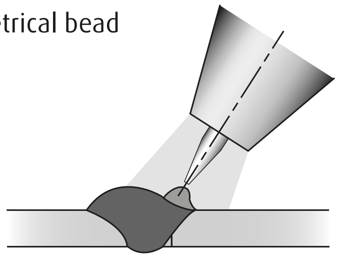
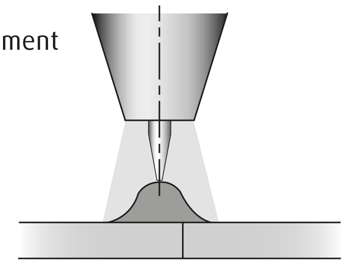
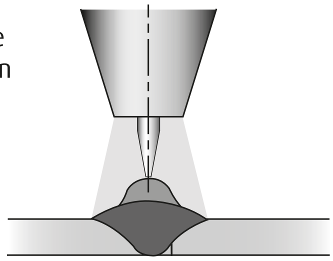
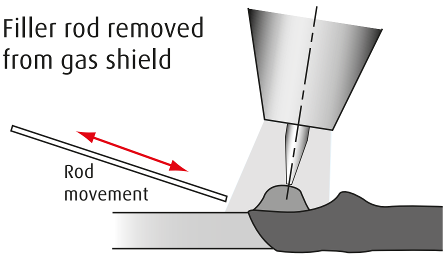
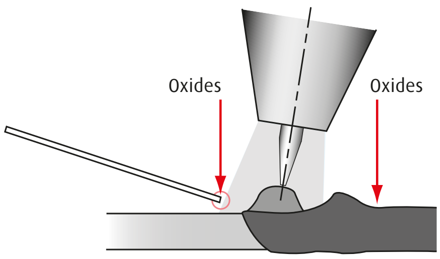
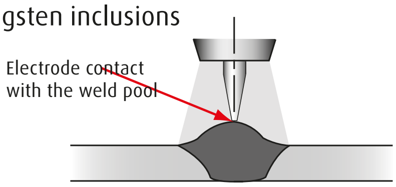
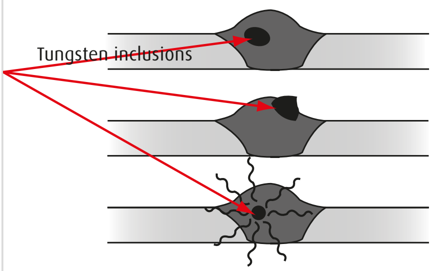
Lap Joint



15.10 Joint preparation



All measurements in mm

Condition	Result
Long arc length 	
Acute angle 	Loss of gas coverage 
Angular mis-alignment 	Unsymmetrical bead profile 
Mis-alignment 	Incomplete penetration 
Filler rod removed from gas shield 	
Tungsten inclusions 	

16.0 TIG welding of materials

16.1 Application summary

Material	Type of current	Polarity
C-Mn steel	Direct current (-)	DC negative
Alloyed steel	Direct current (-)	DC negative
Copper and Cu alloys	Direct current (-)	DC negative
Nickel and Ni alloys	Direct current (-)	DC negative
Titanium and Ti alloys	Direct current (-)	DC negative
Aluminum and Al alloys	Alternating current (~)	
	Direct current (-) with Helium	DC negative
Magesium and Mg alloys	Alternating current (~)	

16.2 C-Mn steel

TIG welding may be used for welding carbon steel but because deposition rates are low, it is usually only used for welding sheet and thin sections for high quality applications, small components, and root passes of multipass butt joints in plate and pipe.

Standard DC TIG equipment is normally suitable and DCEN polarity is usually chosen to provide good workpiece heating.

Only inert or reducing gases should be used for TIG welding and pure argon is normally recommended as the shielding gas for steel.

Filler rods are usually selected to match the chemical composition and the mechanical properties of the parent plate. The weldability of the steel may impose restrictions on the choice of filler rod.

Steels with carbon contents above about 0.3% are hardenable, and fast cooling will produce a hard HAZ and this is liable to result in hydrogen cracking. This form of cracking can be prevented by use of preheat and suitable welding procedures.

C-Mn steel welding parameters

Plate thickness (mm)	0.8	1	1.5	2	1	1.5	2
Joint type	Fillet	Fillet	Fillet	Fillet	Butt	Butt	Butt
Number of passes	1	1	1	1	1	1	1
Tungsten electrode (mm)	1.6	1.6	1.6	2.4	1.6	1.6	2.4
Consumable size (mm)	1.5	1.5	2	2.5	1.5	2	2.5
Current (A)	70	90	110	130	80	120	140
Welding speed (cm/min)	30	30	30	25	20	20	20
Gasflow (l/min)	5	5	6	6	6	7	7

Shielding gas: Argon, Consumable ER70S-6, Position: Downhand, Polarity: DC–

16.3 Alloyed steel

TIG welding may be used for welding alloy steels but because deposition rates are low, it is usually only used for welding sheet and thin sections for high quality applications, small components, and root passes of multipass butt joints in plate and pipe.

Standard DC TIG equipment is normally suitable and DCEN polarity is usually chosen to provide good workpiece heating. Tungsten electrodes with additions of thorium oxide, cerium oxide, or lanthanum oxide are used for welding steel and they give good arc stability.

Only inert or reducing gases should be used for TIG welding and pure argon is normally recommended as the shielding gas for welding alloy steel.

Filler rods are usually selected to match the chemical composition and the mechanical properties of the parent plate. The weldability of the steel may impose restrictions on the choice of filler rod.

Alloy steels with high carbon equivalents are hardenable, and fast cooling will produce a hard HAZ and this is liable to result in hydrogen cracking. This form of cracking can be prevented by use of preheat and suitable welding procedures.

16.4 Stainless steel

TIG is a high quality process ideally suited for welding of stainless steels, particularly thin sheet up to about 5 mm thick where weld integrity and good surface finish are critical. The process has a high degree of controllability resulting in clean, smooth, high quality welds with good penetration and strength with very low defect rates.

Standard TIG equipment is suitable and stainless steels are TIG welded using DCEN polarity.

A thoriated tungsten electrode is normally used but health concerns have promoted use of ceriated or lanthanated instead. The filler rod used depends on the type of stainless being welded but, in general, is matching for austenitic grades, enriched in nickel for duplex grades, and may be matching or an austenitic type for ferritic and martensitic grades.

Shielding gas is conventionally pure argon, but other gases are available to provide specific properties and these include argon-hydrogen, argon-helium mixtures, argon-helium-hydrogen, and argon-nitrogen mixtures.

When welding pipes an inert gas purge is required inside the pipe to prevent oxidation on the underside of the weld. Gas purging may also be used to protect the root side of butt welds in plate or sheet materials too.

General welding parameters

Plate thickness (mm)	1	1.5	2	3	5	6	8	12
Tungsten electrode (mm)	1	1.6	1.6	1.6–2.4	2.4–3.2	3.2–4.0	4	4.8–6.4
Gas flow (l/min)	3–4	3–4	4	4–5	4–6	5–6	5–6	5–7
Current (A)	30–60	70–100	90–110	120–150	190–250	220–340	300–360	350–450
Consumable size (mm)	1	1.5	1.5–2.0	2.0–3.0	3.0–4.0	4.0–6.0	4.0–6.0	4.0–6.0

Polarity: DC–

16.5 Aluminium

TIG is a high quality process widely used for welding aluminium, particularly in section size up to about 6mm. The process may be operated with or without filler.

TIG welding of aluminium can be carried out using any of the three standard operating modes, alternating current (AC), direct current electrode negative (DCEN) and direct current electrode positive (DCEP).

AC is the most frequently used since with AC cleaning of the oxide film occurs on the electrode positive cycle and heating occurs on the electrode negative cycle. With aluminium the surface oxide film must be removed to allow full fusion to take place and AC TIG does this efficiently, allowing high quality joints to be made. High purity argon and argon-helium shielding gas mixtures can be used. The AC output may be conventional sine wave or square wave and many electronic power sources allow the AC waveform to be adjusted, and also provide facilities for pre- and post- gas flow and current slope-in and slope-out.

16.6 Balanced squarewave

The balance on squarewave machines can be adjusted to achieve the desired results. Greater amounts of EN create a deeper, narrower weldbead and better joint penetration. This helps when welding thick material and promote faster welding speeds. Greater amounts of EP removes more oxides from the surface but also have a shallower penetration.

Aluminium welding parameters

Plate Thickness (mm)	1	2	3	4	5	5	6	6
Joint type	Square butt	Square butt	Square butt	Square butt	Square butt	V-butt (70)	Square butt	V-butt (70)
Tungsten size (mm)	1.6	1.6	2.4	2.4	2.4	3.2	3.2	3.2
Consumable Size (mm)	1.6	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Current (A)	75	110	125	160	185	165	210	185
Welding speed (mm/min)	26	21	17	15	14	14	8	10
Gas flow (l/min)	5	6	6	8	10	12	12	12

Alternating current, Welding position: Downhand: Pure Aluminium

16.7 Copper and copper alloys

Cleanliness is important when welding copper, and all dirt, grease, and other contaminants must be removed before welding. Copper alloys containing aluminium will form a surface oxide film and this must also be removed before welding. Preheat will be required for unalloyed copper but some copper alloys can be TIG welded without preheat except on thick sections.

Standard DC TIG welding equipment is suitable for most copper and copper alloys, but aluminium bronze is normally TIG welded using AC current to break down the tenacious oxide film on the surface.

Pure argon, helium, or argon-helium mixtures are standard shielding gases for DC TIG welding copper and copper alloys. Alushield Heavy is ideal for TIG welding copper and some copper alloys, particularly in thicker sections. Pure argon is the shielding gas used for AC TIG welding.

TIG consumables are solid filler rods based on pure copper and several copper alloy compositions, including aluminium bronzes, silicon bronzes, and cupro-nickels. It is normal to try to use a filler material with a similar composition to that of the parent material but this is not always possible, and sometimes not desirable.

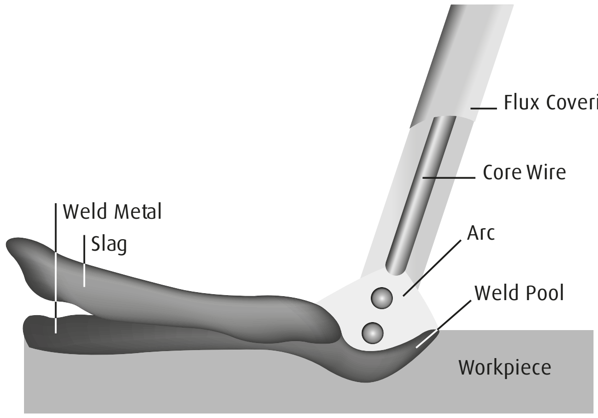
Porosity is the main welding problem encountered when TIG welding unalloyed copper and some copper alloys are prone to solidification cracking and porosity. Certain alloys are difficult to weld (brass will lose zinc if welding is attempted), and welding is not recommeded for those containing lead.

Copper and copper alloy welding parameters

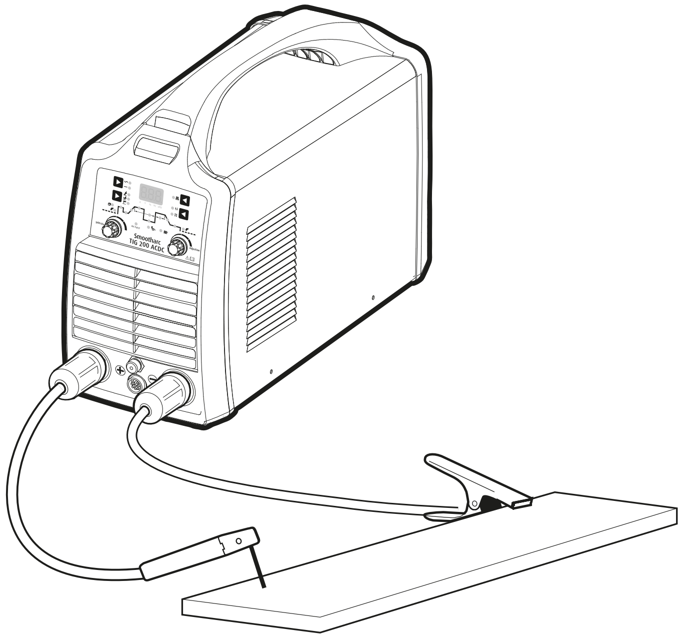
Plate thickness (mm)	1.5	3	5
Joint type	Square butt	Square butt	Square butt
Root gap (mm)	1.0	2.0	3.0
Layers	1	1	2
Tungsten size (mm)	1.6	3.2	4.0
Consumable size (mm)	2.0	3.0	4.0
Current (A)	120	185	270
Welding speed (cm/min)	0.29	0.25	0.15
Gasflow (l/min)	7	8	8

17.0 Manual Metal Arc Welding Process (MMAW)

TIG Welding techniques



Installation for MMA process



17.1 Process

Manual Metal Arc welding is the process of joining metals where an electric arc is struck between the metal to be welded (parent metal) and a flux-coated filler wire (the electrode). The heat of the arc melts the parent metal and the electrode which mix together to form, on cooling, a continuous solid mass.

Before arc welding can be carried out, a suitable power source is required. Two types of power sources may be used for arc welding, direct current (DC) or alternating current (AC).

The essential difference between these two power sources is that, in the case of DC, the current remains constant in magnitude and flows in the same direction. Similarly, the voltage in the circuit remains constant in magnitude and polarity (i.e. positive or negative).

In the case of AC however, the current flows first in one direction and then the other. Similarly, the voltage in the circuit changes from positive to negative with changes in direction of current flow. This complete reversal is called a 'half cycle' and repeats as long as the current flows. The rate of change of direction of current flow is known as the 'frequency' of the supply and is measured by the number of cycles completed per second. The standard frequency of the AC supply in Australia is 50 Hz (Hertz).

17.2 Welding Machine

The most important consideration when contemplating the use of arc welding for the first time is the purchase of a suitable welding machine.

BOC supplies a popular range of arc welding machines. Machines range from small portable welders that operate from standard 240 Volt household power to heavy-duty welders used by the largest steel fabricators.

Basic Welding Machine and Cables

The choice of welding machine is based mostly on the following factors:

- primary voltage, e.g. 240 Volt or 380 Volt
- output amperage required, e.g. 140 amps
- output required, e.g. AC or DC +/-
- duty cycle required, e.g. 35% @ 140 amps
- method of cooling, e.g. air-cooled or oil-cooled method of output amperage control, e.g. tapped secondary lugs
- or infinitely variable control.

For example, the Smootharc 175 Multiprocess connects to 240 Volt supply (15 amps Input), has an output of 175 amps DC @ 35% duty cycle.

Having decided on a welding machine, appropriate accessories are required. These are items such as welding cables, clamps, electrode holder, chipping hammer, helmet, shaded and clear lenses, scull cap, gloves and other personal protective equipment.

BOC stocks a huge range of personal protective equipment. This combined with BOC's extensive network ensures fast reliable service throughout the South Pacific.

17.3 Welding Technique

Successful welding depends on the following factors:

- selection of the correct electrode
- selection of the correct size of the electrode for the job
- correct welding current
- correct arc length
- correct angle of electrode to work
- correct travel speed
- correct preparation of work to be welded.

17.4 Electrode Selection

As a general rule the selection of an electrode is straight forward, in that it is only a matter of selecting an electrode of similar composition to the parent metal. It will be found, however, that for some metals there is a choice of several electrodes, each of which has particular properties to suit specific classes of work. Often, one electrode in the group will be more suitable for general applications due to its all round qualities.

The table (page 27) shows just a few of the wide range of electrodes available from BOC with their typical areas of application.

For example, the average welder will carry out most fabrication using mild steel and for this material has a choice of various standard BOC electrodes, each of which will have qualities suited to particular tasks. For general mild steel work, however, BOC Smootharc 13 electrodes will handle virtually all applications. BOC Smootharc 13 is suitable for welding mild steel in all positions using AC or DC power sources. Its easy-striking characteristics and the tolerance it has for work where fit-up and plate surfaces are not considered good, make it the most attractive electrode of its class. Continuous development and improvement of BOC Smootharc 13 has provided in-built operating qualities which appeals to the beginner and experienced operator alike. For further recommendations on the selection of electrodes for specific applications, see table page 27.

Electrodes and Typical Applications

Name	AWS Class.	Application
BOC Smootharc 13	E6013	A premium quality electrode for general structural and sheet metal work in all positions including vertical down using low carbon steels
BOC Smootharc 24	E7024	An iron powder electrode for high speed welding for H-V fillets and flat butt joints. Medium to heavy structural applications in low carbon steels
BOC Smootharc 18	E7018-1	A premium quality all positional hydrogen controlled electrode for carbon steels in pressure vessel applications and where high integrity welding is required and for free-machining steels containing sulphur
BOC Smootharc S 308L	E308L	Rutile basic coated low carbon electrodes for welding austenitic stainless steel and difficult to weld material
BOC Smootharc S 316L	E316L	
BOC Smootharc S 309L	E309L	Rutile basic coated low carbon electrode for welding mild steel to stainless steel and difficult to weld material

Electrode Size

The size of the electrode is generally dependent on the thickness of the section being welded, and the larger the section the larger the electrode required. In the case of light sheet the electrode size used is generally slightly larger than the work being welded. This means that if 1.5 mm sheet is being welded, 2.0 mm diameter electrode is the recommended size. The following table gives the recommended maximum size of electrodes that may be used for various thicknesses of section.

Recommended Electrode Sizes

Average Thickness of Plate or Section	Max. Recommended Electrode Dia.
≤1.5 mm	2.0 mm
1.5–2.0 mm	2.5 mm
2.0–5.0 mm	3.15 mm
5.0–8.0 mm	4.0 mm
≤8.0 mm	5.0 mm

Welding Current

Correct current selection for a particular job is an important factor in arc welding. With the current set too low, difficulty is experienced in striking and maintaining a stable arc. The electrode tends to stick to the work, penetration is poor and beads with a distinct rounded profile will be deposited.

Excessive current is accompanied by overheating of the electrode. It will cause undercut, burning through of the material, and give excessive spatter. Normal current for a particular job may be considered as the maximum which can be used without burning through the work, over-heating the electrode or producing a rough spattered surface, i.e. the current in the middle of the range specified on the electrode package is considered to be the optimum.

In the case of welding machines with separate terminals for different size electrodes, ensure that the welding lead is connected to the correct terminal for the size electrode being used. When using machines with adjustable current, set on the current range specified.
The limits of this range should not normally be exceeded.

The following table shows the current ranges generally recommended for BOC Smootharc 13.

Generally Recommended Current Range for BOC Smootharc 13

Size of Electrode (mm)	Current Range (Amp)
2.5	60–95
3.2	110–130
4.0	140–165
5.0	170–260

Arc Length

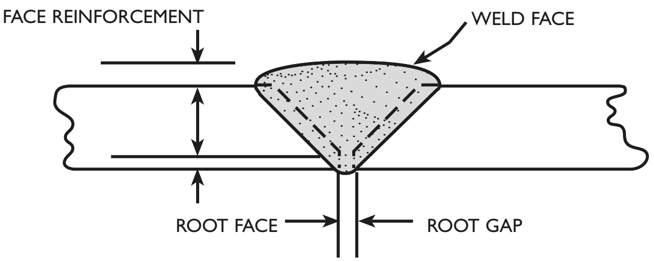
To start the arc, the electrode should be gently scraped on the work until the arc is established. There is a simple rule for the proper arc length; it should be the shortest arc that gives a good surface to the weld. An arc too long reduces penetration, produces spatter and gives a rough surface finish to the weld. An excessively short arc will cause sticking of the electrode and rough deposits that are associated with slag inclusions.

For downhand welding, it will be found that an arc length not greater than the diameter of the core wire will be most satisfactory. Overhead welding requires a very short arc, so that a minimum of metal will be lost. Certain BOC electrodes have been specially designed for ‘touch’ welding. These electrodes may be dragged along the work and a perfectly sound weld is produced.

Electrode Angle

The angle which the electrode makes with the work is important to ensure a smooth, even transfer of metal. The recommended angles for use in the various welding positions are covered later.

Butt Welding



Correct Travel Speed

The electrode should be moved along in the direction of the joint being welded at a speed that will give the size of run required. At the same time the electrode is fed downwards to keep the correct arc length at all times. As a guide for general applications the table below gives recommended run lengths for the downhand position.

Correct travel speed for normal welding applications varies between approximately 125–375 mm per minute, depending on electrode size, size of run required and the amperage used.

Excessive travel speeds lead to poor fusion, lack of penetration, etc. Whilst too slow a rate of travel will frequently lead to arc instability, slag inclusions and poor mechanical properties.

Run Length per Electrode – BOC Smootharc 13

Electrode Size (mm)	Electrode Length (mm)	Run Length (mm) Min. to Max.
4.0	350	175 to 300
3.2	350	125 to 225
2.5	350	100 to 225

Correct Work Preparation

The method of preparation of components to be welded will depend on equipment available and relative costs. Methods may include sawing, punching, shearing, lathe cut-offs, flame cutting and others. In all cases edges should be prepared for the joints that suit the application. The following section describes the various joint types and areas of application.

17.5 Types of Joints

Butt Welds

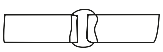
A butt weld is a weld made between two plates so as to give continuity of section. Close attention must be paid to detail in a butt weld to ensure that the maximum strength of the weld is developed. Failure to properly prepare the edges may lead to the production of faulty welds, as correct manipulation of the electrode is impeded.

Two terms relating to the preparation of butt welds require explanation at this stage. They are:

- Root Face: the proportion of the prepared edge that has not been bevelled.
- Root Gap: the separation between root faces of the parts to be joined.

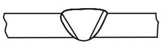
Various types of butt welds are in common use and their suitability for different thickness of steel are described as follows:

Square Butt Weld



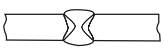
The edges are not prepared but are separated slightly to allow fusion through the full thickness of the steel. Suitable for plate up to 6 mm in thickness.

Single 'V' Butt Weld



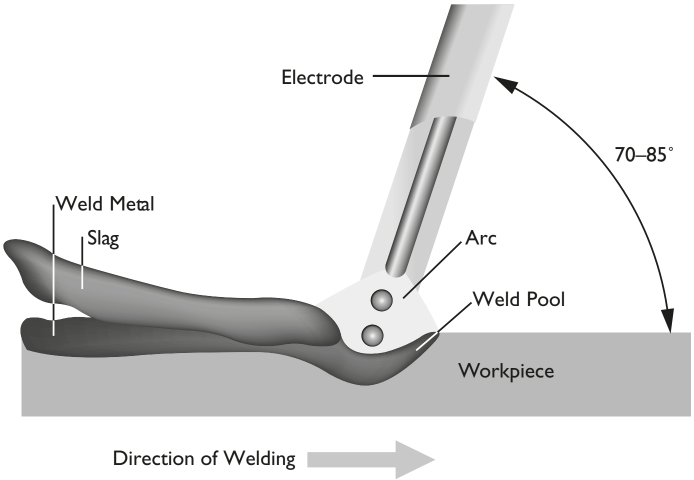
This is commonly used for plate up to 16 mm in thickness and on metal of greater thickness where access is available from only one side.

Double 'V' Butt Weld

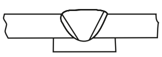


Used on plate of 12 mm and over in thickness when welding can be applied from both sides. It allows faster welding and greater economy of electrodes than a single 'V' preparation on the same thickness of steel and also has less of a tendency to distortion as weld contraction can be equalised.

Welding Progression Angle

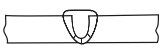


Butt Weld with Backing Material



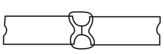
When square butt welds or single 'V' welds cannot be welded from both sides it is desirable to use a backing bar to ensure complete fusion.

Single 'U' Butt Weld



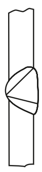
Used on thick plates an alternative to a single 'V' preparation. It has advantages as regards speed of welding. It takes less weld metal than a single 'V', there is less contraction and therefore a lessened tendency to distortion. Preparation is more expensive than in the case of a 'V', as machining is required. The type of joint is most suitable for material over 40 mm in thickness.

Double 'U' Butt Weld



For use on thick plate that is accessible for welding from both sides. For a given thickness it is faster, needs less weld metal and causes less distortion than a single 'U' preparation.

Horizontal Butt Weld



The lower member in this case is bevelled to approximately 15° and the upper member 45°, making an included angle of 60°. This preparation provides a ledge on the lower member, which tends to retain the molten metal.

General notes on Butt Welds

The first run in a prepared butt weld should be deposited with an electrode not larger than 4.0 mm. The angle of the electrode for the various runs in a butt weld is shown.

It is necessary to maintain the root gap by tacking at intervals or by other means, as it will tend to close during welding.

All single 'V', single 'U' and square butt welds should have a backing run deposited on the underside of the joint; otherwise 50% may be deducted from the permissible working stress of the joint.

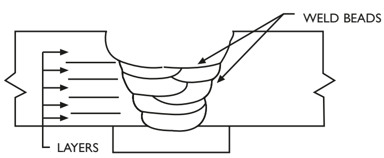
Before proceeding with a run on the underside of a weld it is necessary to remove any surplus metal or under penetration that is evident on that side of the joint.

Butt welds should be overfilled to a certain extent by building up the weld until it is above the surface of the plate. Excessive build-up, however, should be avoided.

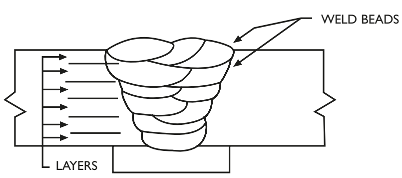
In multi-run butt welds it is necessary to remove all slag, and surplus weld metal before a start is made on additional runs; this is particularly important with the first run, which tends to form sharp corners that cannot be penetrated with subsequent runs. Electrodes larger than 4.0 mm are not generally used for vertical or overhead butt welds.

The diagrams following indicate the correct procedure for welding thick plate when using multiple runs.

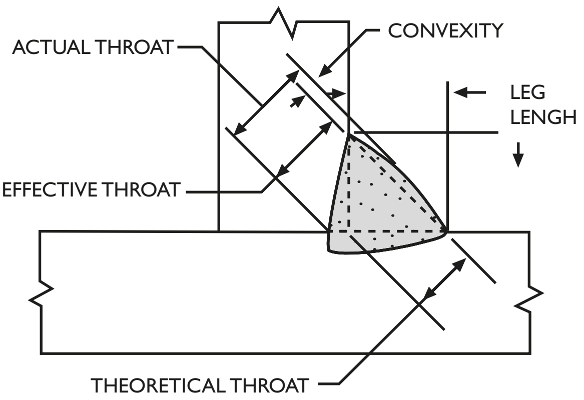
Electrode Angle for 1st and 2nd Layers



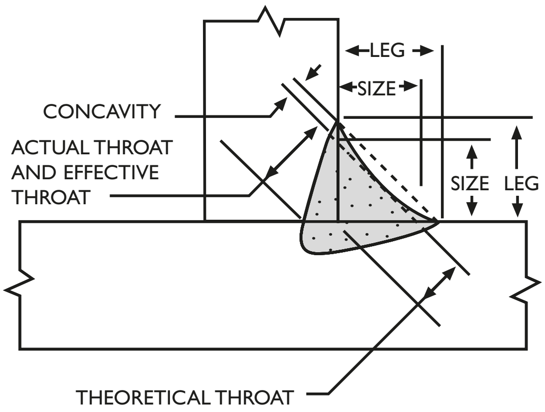
Electrode Angle for Subsequent Layers



Convex Fillet Weld



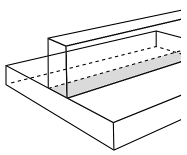
Concave Fillet Weld



17.6 Fillet Welds

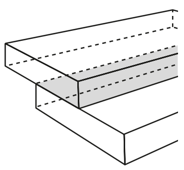
A fillet weld is approximately triangular in section, joining two surfaces not in the same plane and forming a lap joint, tee joint or corner joint. Joints made with fillet welds do not require extensive edge preparation, as is the case with butt welded joints, since the weld does not necessarily penetrate the full thickness of either member. It is important that the parts to be joined be clean, close fitting, and that all the edges on which welding is to be carried out are square. On sheared plate it is advisable to entirely remove any 'false cut' on the edges prior to welding. Fillet welds are used in the following types of joints:

'T' Joints



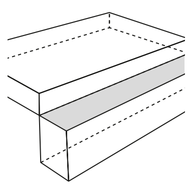
A fillet weld may be placed either on one or both sides, depending on the requirements of the work. The weld metal should fuse into or penetrate the corner formed between the two members. Where possible the joint should be placed in such a position as to form a "Natural 'V' fillet" since this is the easiest and fastest method of fillet welding.

Lap Joints



In this case, a fillet weld may be placed either on one or both sides of the joint, depending on accessibility and the requirements of the joint. However, lap joints, where only one weld is accessible, should be avoided where possible and must never constitute the joints of tanks or other fabrications where corrosion is likely to occur behind the lapped plates. In applying fillet welds to lapped joints it is important that the amount of overlap of the plates be not less than five times the thickness of the thinner part. Where it is required to preserve the outside face or contour of a structure, one plate may be joggled.

Corner Joints



The members are fitted as shown, leaving a 'V'-shaped groove in which a fillet weld is deposited. Fusion should be complete for the full thickness of the metal. In practice it is generally necessary to have a gap or a slight overlap on the corner. The use of a 1.0–2.5 mm gap has the advantage of assisting penetration at the root, although setting up is a problem. The provision of an overlap largely overcomes the problem of setting up, but prevents complete penetration at the root and should therefore be kept to a minimum, i.e. 1.0–2.5 mm.

The following terms and definitions are important in specifying and describing fillet welds.

Leg Length

A fusion face of a fillet weld, as shown below. All specifications for fillet weld sizes are based on leg length.

Throat Thickness

A measurement taken through the centre of a weld from the root to the face, along the line that bisects the angle formed by the members to be joined.

Effective throat thickness is a measurement on which the strength of a weld is calculated. The effective throat thickness is based on a mitre fillet (concave Fillet Weld), which has a throat thickness equal to 70% of the leg length. For example, in the case of a 20 mm fillet, the effective throat thickness will be 14 mm.

Convex Fillet Weld

A fillet weld in which the contour of the weld metal lies outside a straight line joining the toes of the weld. A convex fillet weld of specified leg length has a throat thickness in excess of the effective measurement.

Concave Fillet Weld

A fillet in which the contour of the weld is below a straight line joining the toes of the weld. It should be noted that a concave fillet weld of a specified leg length has a throat thickness less than the effective throat thickness for that size fillet. This means that when a concave fillet weld is used, the throat thickness must not be less than the effective measurement. This entails an increase in leg length beyond the specified measurement.

The size of a fillet weld is affected by the electrode size, welding speed or run length, welding current and electrode angle. Welding speed and run length have an important effect on the size and shape of the fillet, and on the tendency to undercut.

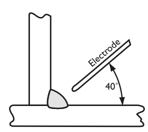
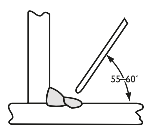
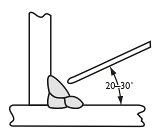
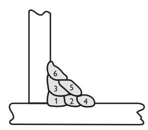
Insufficient speed causes the molten metal to pile up behind the arc and eventually to collapse. Conversely, excessive speed will produce a narrow irregular run having poor penetration, and where larger electrodes and high currents are used, undercut is likely to occur.

Fillet Weld Data

Nominal Fillet Size (mm)	Minimum Throat Thickness (mm)	Plate Thickness (mm)	Electrode Size (mm)
5.0	3.5	5.0–6.3	3.2
6.3	4.5	6.3–12	4.0
8.0	5.5	8.0–12 & over	4.0
10.0	7.0	10 & over	4.0

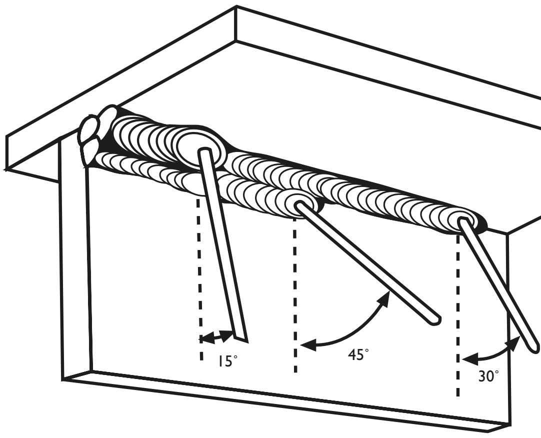
Selection of welding current is important. If it is too high the weld surface will be flattened, and undercut accompanied by excessive spatter is likely to occur. Alternatively, a current which is too low will produce a rounded narrow bead with poor penetration at the root. The first run in the corner of a joint requires a suitably high current to achieve maximum penetration at the root. A short arc length is recommended for fillet welding. The maximum size fillet which should be attempted with one pass of a large electrode is 8.0 mm. Efforts to obtain larger leg lengths usually result in collapse of the metal at the vertical plate and serious undercutting. For large leg lengths multiple run fillets are necessary. These are built up as shown below. The angle of the electrode for various runs in a downhand fillet weld is shown below.

Recommended Electrode Angles for Fillet Welds

1st Run	2nd Run
	
3rd Run	**Multi-run Fillet**
	

Multi-run horizontal fillets have each run made using the same run lengths (run length per electrode table). Each run is made in the same direction, and care should be taken with the shape of each, so that it

Recommended Angles for Overhead Fillet Welds



has equal leg lengths and the contour of the completed fillet weld is slightly convex with no hollows in the face.

Vertical fillet welds can be carried out using the upwards or downwards technique. The characteristics of each are: upwards – current used is low, penetration is good, surface is slightly convex and irregular. For multiple run fillets large single pass weaving runs can be used. Downwards – current used is medium, penetration is poor, each run is small, concave and smooth (only BOC Smootharc 13 is suitable for this position).

The downwards method should be used for making welds on thin material only. Electrodes larger than 4.0 mm are not recommended for vertical down welding. All strength joints in vertical plates 10.0 mm thick or more should be welded using the upward technique. This method is used because of its good penetration and weld metal quality. The first run of a vertical up fillet weld should be a straight sealing run made with 3.15 mm or 4.0 mm diameter electrode. Subsequent runs for large fillets may be either numerous straight runs or several wide weaving runs.

Correct selection of electrodes is important for vertical welding.

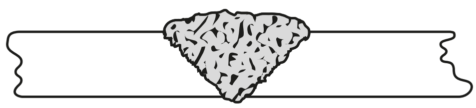
In overhead fillet welds, careful attention to technique is necessary to obtain a sound weld of good profile. Medium current is required for best results. High current will cause undercutting and bad shape of the weld, while low current will cause slag inclusions. To produce a weld having good penetration and of good profile, a short arc length is necessary. Angle of electrode for overhead fillets is illustrated above.

17.7 Typical Defects Due to Faulty Technique

Manual metal arc welding, like other welding processes, has welding procedure problems that may develop which can cause defects in the weld. Some defects are caused by problems with the materials. Other welding problems may not be foreseeable and may require immediate corrective action. A poor welding technique and improper choice of welding parameters can cause weld defects. Defects that can occur when using the shielded metal arc welding process are slag inclusions, wagon tracks, porosity, wormhole porosity, undercutting, lack of fusion, overlapping, burn through, arc strikes, craters, and excessive weld spatter. Many of these welding technique problems weaken the weld and can cause cracking. Other problems that can occur which can reduce the quality of the weld are arc blow, finger nailing, and improper electrode coating moisture contents.

Defects caused by welding technique

Slag Inclusions



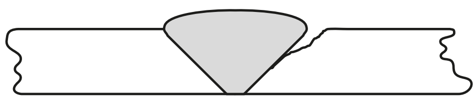
Slag inclusions occur when slag particles are trapped inside the weld metal which produces a weaker weld. These can be caused by:

- erratic travel speed
- too wide a weaving motion
- slag left on the previous weld pass
- too large an electrode being used
- letting slag run ahead of the arc.

This defect can be prevented by:

- a uniform travel speed
- a tighter weaving motion
- complete slag removal before welding
- using a smaller electrode
- keeping the slag behind the arc which is done by shortening the arc, increasing the travel speed, or changing the electrode angle.

Undercutting



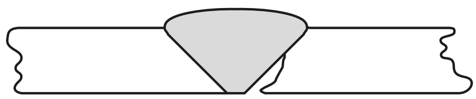
Undercutting is a groove melted in the base metal next to the toe or root of a weld that is not filled by the weld metal. Undercutting causes a weaker joint and it can cause cracking. This defect is caused by:

- excessive welding current
- too long an arc length
- excessive weaving speed
- excessive travel speed.

On vertical and horizontal welds, it can also be caused by too large an electrode size and incorrect electrode angles. This defect can be prevented by:

- choosing the proper welding current for the type and size of electrode and the welding position
- holding the arc as short as possible
- pausing at each side of the weld bead when a weaving technique is used
- using a travel speed slow enough so that the weld metal can completely fill all of the melted out areas of the base metal.

Lack of Fusion



Lack of fusion is when the weld metal is not fused to the base metal. This can occur between the weld metal and the base metal or between passes in a multiple pass weld. Causes of this defect can be:

- excessive travel speed
- electrode size too large
- welding current too low
- poor joint preparation
- letting the weld metal get ahead of the arc.

Lack of fusion can usually be prevented by:

- reducing the travel speed
- using a smaller diameter electrode
- increasing the welding current
- better joint preparation
- using a proper electrode angle.

For more information contact the
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