Sketch welding runs on diagram.

Complete the control data table below.

Weld current data		**Electrode data**	
Run	Run	Size	
1	7		
2	8	Type	
3	9		
4	10	Brand name	
5	11		
6	12	Electrode classification	
		Angles	Lead / Lateral
Material data		**Weld time**	
Type		Start	
Thickness		Finish	
		Units completed	
Assessment		**Complies**	**Does not comply**
Alignment and assembly			
Angular distortion			
Surface finish			
Weld size			
Surface defects			
Root penetration			
Name			**Exercise Number**

Skill practice 14

Assessment event 9 (practical)
Butt weld - steel sheet - flat

IF IN DOUBT ASK THE TEACHER

Suggested time Skill practice: 1 hour 10 minutes
Assessment: 20 minutes

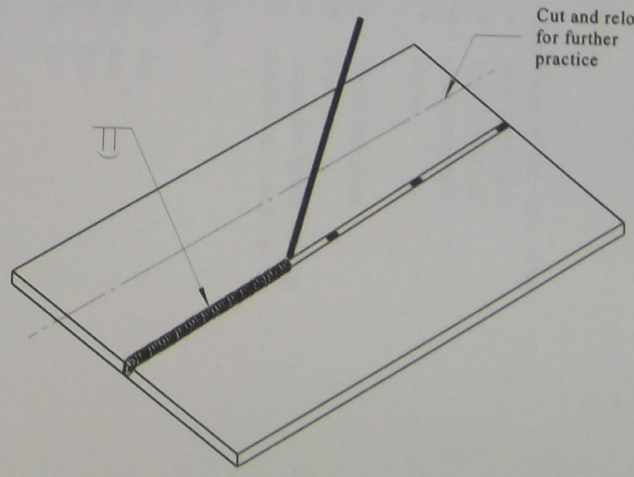
Objective To butt weld 1.6 and 3.0 mm low carbon steel sheet to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

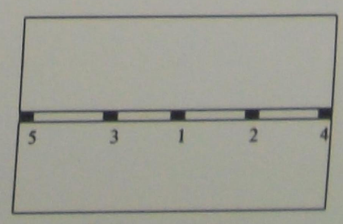
Method

1. Assemble and tack weld sheets using the sequence illustrated.
2. Position and weld approximately 50 mm of the joint.
3. Examine weld profile and penetration before completing the weld.
4. Complete the weld and submit for inspection.
5. Cut sheets and relocate for further practice as illustrated.
6. Evaluate the weld exercise and complete the procedure sheet.
7. For assessment, repeat the butt weld to the requirements given below.
8. Submit your weld and procedure sheet to the teacher.

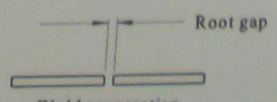


Requirements

- Correct alignment and assembly
- Smooth regular contour
- Angular distortion 0° to 5°
- Weld penetration for a minimum of 20% of the weld length.
- A maximum of two significant weld defects per 250 mm of weld length with an accumulative defect area of less than twice the square of the plate thickness.



Tacking sequence



Weld preparation

Material unit 2 pieces 50 x 3.0 x 150 mm low carbon steel sheet
2 pieces 50 x 1.6 x 150 mm low carbon steel sheet

Unit required 6

Economy Cut and relocate sheets for maximum use. Return all unused material to the store.

- rays given off
- electric shock
- fumes.

Skill practice 14
Assessment event 9 (practical)
Butt weld - steel sheet - flat

IF IN DOUBT ASK THE TEACHER

Suggested time Skill practice: 1 hour 10 minutes
Assessment: 20 minutes

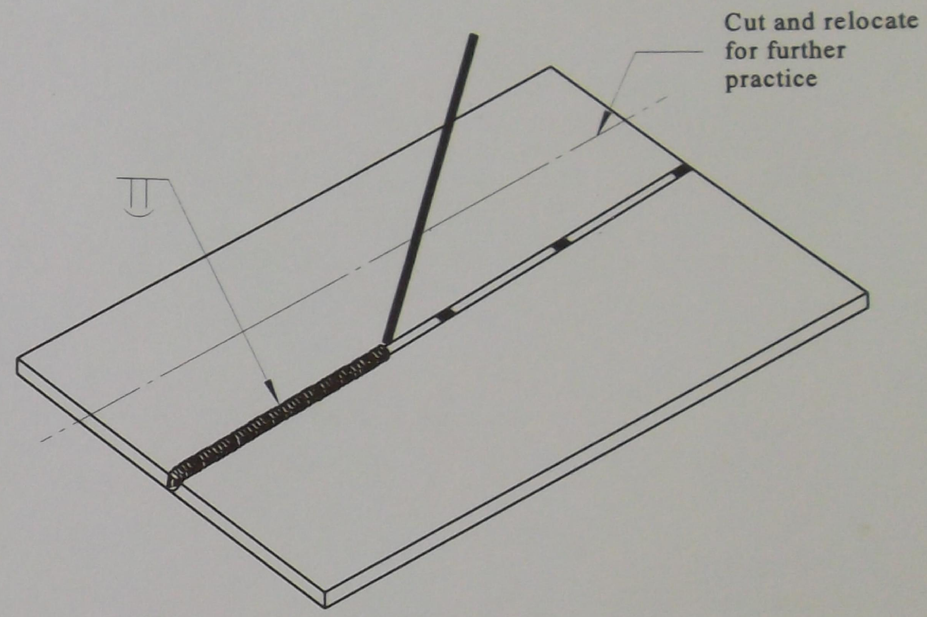
Objective To butt weld 1.6 and 3.0 mm low carbon steel sheet to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

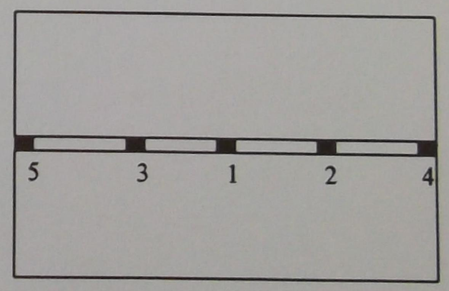
Method

1. Assemble and tack weld sheets using the sequence illustrated.
2. Position and weld approximately 50 mm of the joint.
3. Examine weld profile and penetration before completing the weld.
4. Complete the weld and submit for inspection.
5. Cut sheets and relocate for further practice as illustrated.
6. Evaluate the weld exercise and complete the procedure sheet.
7. For assessment, repeat the butt weld to the requirements given below.
8. Submit your weld and procedure sheet to the teacher.

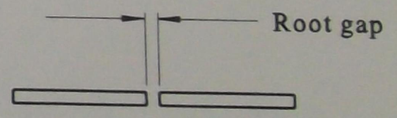


Requirements

- Correct alignment and assembly
- Smooth regular contour
- Angular distortion 0° to 5°
- Weld penetration for a minimum of 20% of the weld length.
- A maximum of two significant weld defects per 250 mm of weld length with an accumulative defect area of less than twice the square of the plate thickness.



Tacking sequence



Weld preparation

Material unit 2 pieces 50 x 3.0 x 150 mm low carbon steel sheet
2 pieces 50 x 1.6 x 150 mm low carbon steel sheet

Unit required 6

Economy Cut and relocate sheets for maximum use. Return all unused material to the store.

ANSWERS TO REVIEW QUESTIONS

Section 1

1. Any three of the following:
   - heat generated
   - rays given off
   - electric shock
   - fumes.

2.
   - burns the skin
   - arc-eye
   - stops the heart beating
   - problems breathing

3. 80%.

4. (a) d.c.
   (b) a.c.
   (c) d.c.
   (d) d.c.

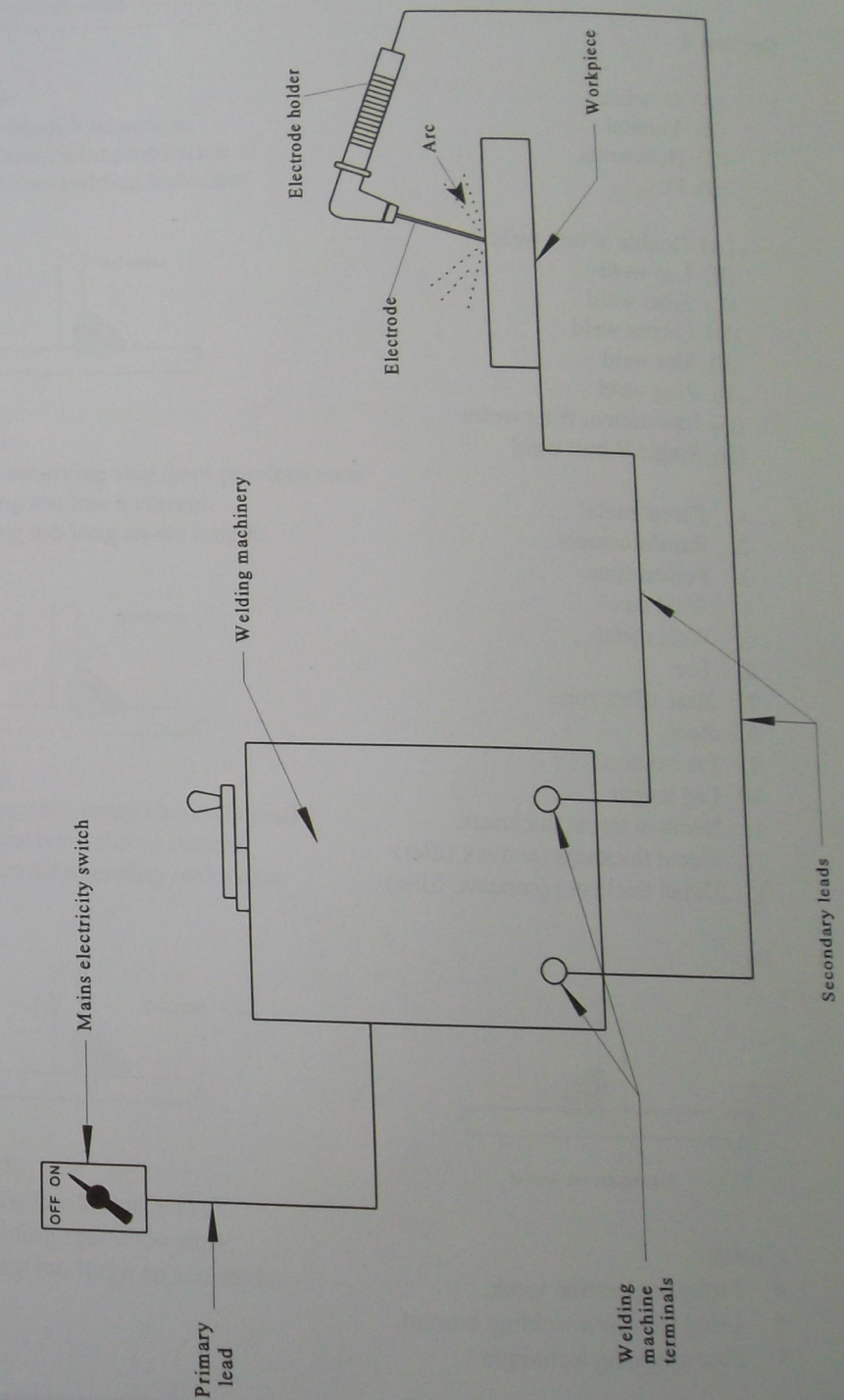
5. *Harmful rays*
   - ultra-violet
   - infra red

   Effects of harmful rays
   - burns the skin
   - arc eye

6.

	a.c. transformer sets	*d.c. motor generator sets*
Portability	These machines generally consist of static step-down transformers and they are considered as stationary types.	Most modern types have features that allow portability (especially the self contained types). They have an undercarriage fitted with wheels.
Power supply	The use of these machines is restricted to the location of the nearest alternating current power point.	Petrol or diesel engine driven machines can be used in any location.
Efficiency	70-90 per cent electrically efficient. A large number of multi operator sets give higher efficiency.	40-60 per cent electrically efficient but some modern types compare with alternating current efficiency.
Polarity	No polarity.	A choice of polarity is obtained by a simple reversal of a switch. (d.c.- or d.c.+).
Arc blow	Unaffected.	Arc blow occurs even in normal current and they are difficult to control above 300 amperes.
Maintenance	As there are no moving parts to be considered, maintenance costs are very low.	Revolving and wearing parts add to running costs.
Initial costs	Cheaper plant as less construction is involved.	More costly due to generator and motor construction.
Electrodes	Restricted to use of electrodes that are suitable for alternating current only.	Suitable for all types of electrodes.
Running costs	Cheaper running costs due to the use of an installed power supply.	Added costs due to the use of electric motors or internal combustion engines.
Voltage control	Constant open circuit voltage.	A variation of open circuit voltage is possible that permits a selection for electrode type and welding technique.
Arc length	Limited arc length.	Greater tolerance in arc length due to the characteristics of the machine.

7. A typical welding circuit.



8. Any one of the following:
   - porosity
   - spatter
   - cracking.

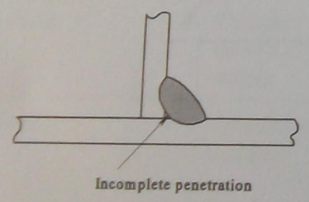
Section 4

1. (A) Overhead
   (B) Vertical
   (C) Horizontal
   (D) Flat.

2. (A) Double V butt weld
   (B) Lap weld
   (C) Fillet weld
   (D) Corner weld
   (E) Slot weld
   (F) Plug weld
   (G) Intermittent fillet welds
   (H) Single V butt weld

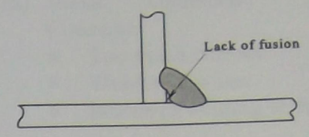
3. 1. Parent metal
   2. Reinforcement
   3. Fusion zone
   4. Weld face
   5. Weld metal
   6. Toe
   7. Heat affect zone
   8. Root
   9. Penetration
   10. Leg length
   11. Nominal throat thickness
   12. Throat thickness (convex fillet)
   13. Throat thickness (concave fillet)

4. (a)



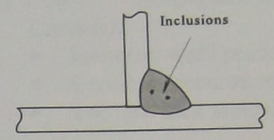
Cause(s):
- Faulty preparation work.
- Using too low a welding current.
- Poor operating technique

(b)



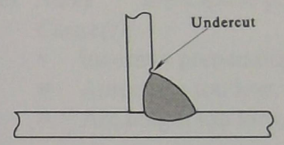
Cause(s):
- Not enough amperage.
- Incorrect joint preparation.
- Incorrect welding technique.

(c)



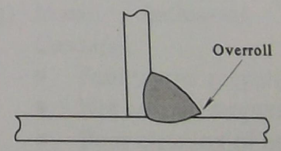
Cause(s):
- Not removing slag from previous runs.
- Using too low a current.
- Using too long an arc length.

(d)



Cause(s):
- Using the wrong electrode angle.
- Excessive welding current.
- Incorrect operating technique.

(e)



Cause(s):
- Using too low a current.
- Welding speed too slow.
- Using too large an electrode.

8. An
   -
   -
   -

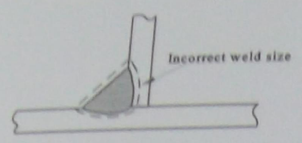
Section

1. (A
   (E
   (C
   (I

2. (
   (
   (
   (
   (

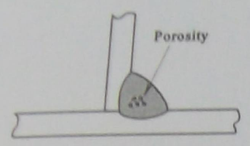
3.

(f)



Cause(s):
- Incorrect weld sequences (under or over welding).
- Poor fit-up.

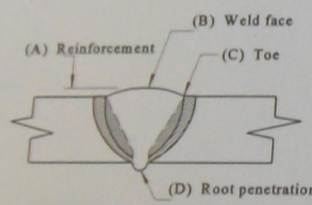
(g)



Cause(s):
- Using wet or damp electrodes.
- Welding over oily or greasy surfaces.
- Using wrong type of electrode.

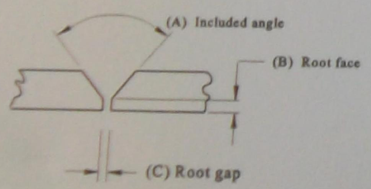
Section 14

1. (a) Weld parts



(b) Weld preparation

4.



(a) *Name:* Undercut
Cause(s):
- Too much current.
- Welding too fast.
- Incorrect welding technique.

(b) *Name:* Overroll
Cause(s):
- Electrode too large.
- Welding speed too slow.
- Incorrect electrode angle.

(c) *Name:* Misalignment
Cause(s):
- Incorrect weld procedure.
- Careless preparation.
- Too few tack welds.

(d) *Name:* Excess penetration
Cause(s):
- Incorrect preparation.
- Amperage too high.
- Incorrect welding technique.

(e) *Name:* Incomplete penetration
Cause(s):
- Incorrect preparation.
- Amperage too low.
- Arc length too long.

(f) *Name:* Lack of fusion
Cause(s):
- Not enough amperage.
- Incorrect joint preparation.
- Incorrect welding technique.

(g) *Name:* Inclusions
Cause(s):
- Faulty joint preparation.
- Not enough amperage.
- Poor cleaning of prior runs.

(h) *Name:* Porosity
Cause(s):
- Damp or old electrodes.
- Electrode incompatible with parent metal.

(i) *Name:* Cracking
Cause(s):
- Insufficient weld deposit.
- Insufficient pre-heat.
- Incorrect electrode.

SAMPLE ASSESSMENT (THEORY)

ssessment event 10 (theory)
o pass this assessment event, you are required to correctly answer eighteen questions.
uggested time: 1 hour

. The electrical supply required to power an alternating current (a.c.) welding transformer is:

- ☐ secondary current
- ☐ open circuit voltage
- ☐ welding supply
- ☐ primary supply.

. Alternating current (a.c.) welding machines are preferred to direct current (d.c.) machines because they:

- ☐ are cheaper to purchase
- ☐ operate at a lower open circuit voltage
- ☐ will run all electrode classifications
- ☐ are the only type suitable for site work.

. An electrical conductor is used to:

- ☐ resist current flow
- ☐ insulate cables
- ☐ carry current
- ☐ prevent shock.

. A person operating a welding machine will receive an electric shock if:

- ☐ the person forms part of the circuit
- ☐ the person is damp or wet
- ☐ a.c. current is used
- ☐ high current is used.

5. The most effective method of reducing your intake (breathing in) of dangerous fumes when welding coated materials is to:

- ☐ use a well ventilated workshop
- ☐ weld outdoors
- ☐ use a fan
- ☐ use a respirator.

6. A metal that generates dangerous fumes during welding is:

- ☐ cadmium
- ☐ low carbon steel
- ☐ silicon
- ☐ cast iron.

7. The filter lens used for general purpose MMAW is a shade:

- ☐ 4
- ☐ 6
- ☐ 8
- ☐ 10.

8. A duty cycle is specified for welding machines so that the operator will know the:

- ☐ maximum amperage of the machine
- ☐ maximum voltage of the machine
- ☐ maximum temperature range
- ☐ recommended output (amps) over 5 minutes.

9. The approximate operating current (amperage) for a 4.0 mm diameter general purpose electrode is:

- ☐ 90
- ☐ 100
- ☐ 120
- ☐ 140.

10. Arc voltage is measured when the welding machine is operating:

- ☐ at the positive terminals
- ☐ at the primary connection
- ☐ between the work and the work bench
- ☐ between the electrode and the workpiece.

11. E4112 and E4113 electrodes are classified as:

- ☐ cellulose
- ☐ rutile
- ☐ hydrogen controlled
- ☐ iron powder.

12. An alternating current (a.c.) welding machine is called a:

- ☐ transformer
- ☐ rectifier
- ☐ inverter
- ☐ generator.

13. An advantage of a direct current (d.c.) welding machine is:

- ☐ lower plant cost
- ☐ lower operating cost
- ☐ greater capacity
- ☐ the ability to run all electrodes.

14. List **four** major types of hazards associated with arc welding processes.

- _____
- _____
- _____
- _____

15. List **two** harmful rays given off by a welding arc.

- _____
- _____

16. State the names of **three** metals or metal coatings that produce harmful fumes during welding.

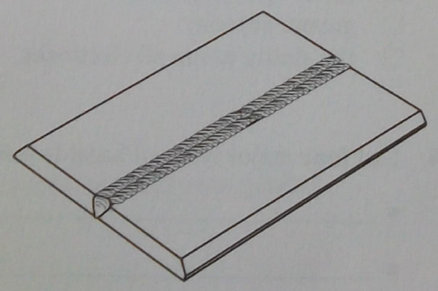
- _____
- _____
- _____

17. List **six** items of protective clothing used by welders.

- _____
- _____
- _____
- _____
- _____
- _____

18. The sketch illustrates a butt weld in the:

- ☐ flat position
- ☐ horizontal position
- ☐ vertical position
- ☐ overhead position.



19. The weld defect undercut can be caused by:

- ☐ too low a welding current
- ☐ too high a welding current
- ☐ too short an arc length
- ☐ alternating to direct welding current.

20. An outside corner weld joint is joined by using a:

- ☐ butt weld
- ☐ fillet weld
- ☐ plug weld
- ☐ slot weld.

21. Butt joints are preferred to fillet welds because they:

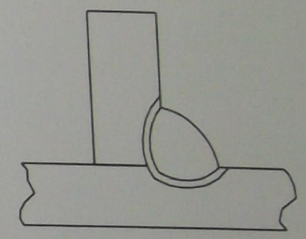
- ☐ have greater strength
- ☐ use less weld metal
- ☐ have easier joint preparation
- ☐ produce less distortion.

22. Slag inclusions are caused by:

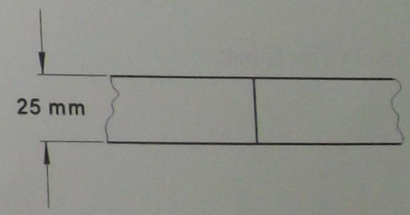
- ☐ failure to clean inter-pass runs
- ☐ excessive current
- ☐ excessive arc length
- ☐ excessive travel speed.

23. Indicate the following on the sketch.

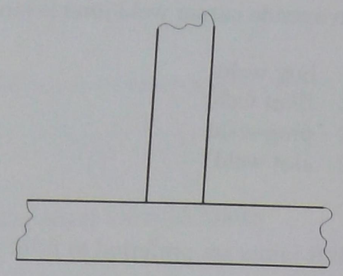
- Leg lengths
- Throat thickness
- Weld toe



24. On the sketch provided, draw and dimension an acceptable butt joint preparation.



25. On the sketch provided, draw a fillet weld and illustrate the following weld defects.



- Undercut
- Overroll
- Slag inclusion
- Lack of penetration
- Porosity

26. Sketch the following weld preparations.

(a) Single V butt.

(b) Open square butt

(c) Double U butt.

Answers to sample assessment (theory)

1. Primary supply.
2. Are cheaper to purchase.
3. Carry current.
4. The person forms part of the circuit.
5. Use a respirator.
6. Cadmium.
7. 10.
8. Recommended output (amps) over 5 minutes.
9. 140.
10. Between the electrode and the workpiece.
11. Rutile.
12. Transformer.
13. The ability to run all electrodes.
14.
    - Electric shocks
    - Fumes
    - Harmful rays
    - Confined spaces
15.
    - Ultra-violet
    - Infra-red
16.
    - Cadmium
    - Zinc
    - Paint and solvents

17. ▪ Overalls or work clothes
▪ leather apron and/or coat
▪ Welding gloves
▪ Spats
▪ Helmet
▪ Spats

18. Flat position.

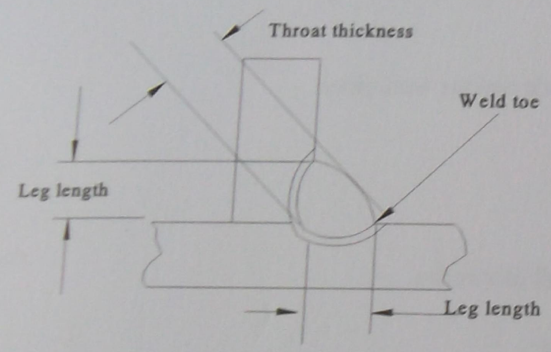
19. High a welding current.

20. Fillet weld.

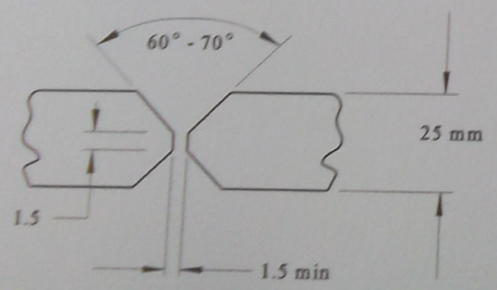
21. Have greater strength.

22. Failure to clean inter-pass runs.

23.



24.



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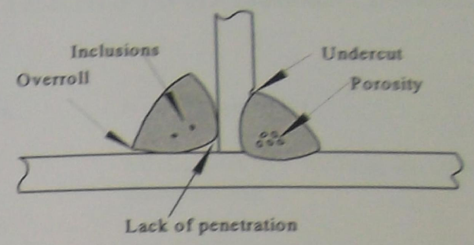
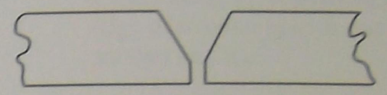
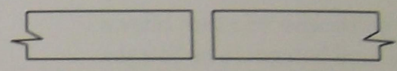


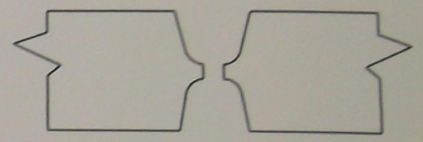
26. (a) Single V butt



(b) Open square butt



(c) Double U butt



Notes

TERMS AND DEFINITIONS

ambient temperature	room temperature
arc blow	a deflection of a welding arc commonly occurring with direct current
parent metal	metal to be joined
plug weld	a weld made by depositing a fillet weld around the edge of a round hole in one component to join it to another surface
pre-heating	the application of heat to the parent metal immediately prior to welding or cutting
slot weld	a weld made by depositing a fillet weld around the edge of an elongated hole in one component so as to join it to the surface of a touching component

NSW Module Resource Manual for the National Metal and Engineering Courses

Fabrication Stream

NF02 Gas Metal Arc Welding 1

Student Workbook

TAFE NSW

Contents

Introduction

Gas metal arc welding is a specialised welding process. This module, **Gas Metal Arc Welding 1 (GMAW1)**, includes:

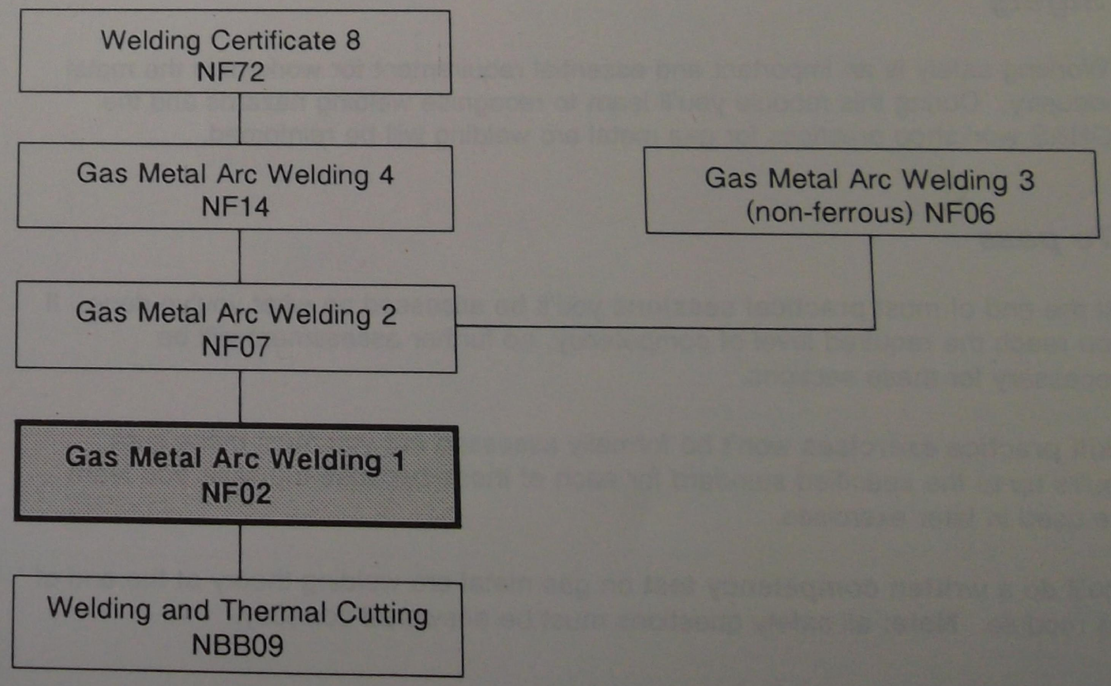
- the basic operating principles of gas metal arc welding
- descriptions of the types of joints used, possible weld defects and ways of correcting them
- an outline of the types of process variables and their effect on welding
- the theory of the gas metal arc spot welding process

The module is divided into nineteen sections that focus on the welding of low carbon steel sheet, plate and rolled structural sections commonly used in fabrication industries.

You must complete each related section before moving on to the next and study the theory before you attempt the practical work.

There are a number of practical exercises that teach you to weld in the flat, horizontal and vertical positions. You'll also learn to use these techniques in industrial situations.

The flow chart below shows where **Gas Metal Arc Welding 1** fits into the Metals and Engineering course.



Before enrolling for the Welding Certificate Module, you must meet the prerequisite requirements in Australian Standard AS 1796.

The Student Workbook

In this workbook you'll find:

- A student organiser allocating time for each session
- Background theory notes relating to the process
- Review questions
- Work and procedure sheets for the practical exercises
- Answers to the review questions
- Words you need to know
- Pages for your comments about the module.

Review questions

The **review questions** at the end of each theory section are there to help you understand and summarise what you are learning and to revise important points. They are not tests or exams, so your teacher won't be marking them. The answers to review questions are at the back of this workbook.

Words you need to know

There are also pages at the back of this workbook for the new words and terms you learn in this module. Some are explained for you to give you a start.

Safety

Working safely is an important and essential requirement for workers in the metal industry. During this module you'll learn to recognise welding hazards and the OH&S workshop practices for gas metal arc welding will be reinforced.

To pass

At the end of most **practical sessions** you'll be assessed on what you've done. If you reach the required level of competency, no further assessment will be necessary for these sections.

Skill practice exercises won't be formally assessed but you must make sure you're up to the specified standard for each of these because the skills you learn are used in later exercises.

You'll do a **written competency test** on gas metal arc welding theory at the end of this module. **Note:** all safety questions must be answered correctly.

Learning outcomes for Gas Metal Arc Welding as stated in the National Module Descriptor
1. Explain the operating principles related to the Gas Metal Arc welding process.
2. Identify the welding variables associated with the GMAW process.
3. Deposit a pad weld in the horizontal position. Spot weld. Deposit weld fillets in the flat, horizontal and vertical position; and butt weld in the flat, horizontal and vertical positions.
4. Set the variables and demonstrate the procedures for spot welding using the GMAW process.

Student organiser

This chart provides you with an overall picture of the content of this module. It's a record of your progress as you work through each section.

	Section	Assessed	Suggested hours
1.	Gas metal arc operating principles	▒	3.0
2.	Pad weld plate - horizontal		2.0
3.	Fillet and butt weld definitions and defects	▒	1.0
4.	Fillet weld - single run - horizontal	■	1.5
5.	Fillet weld - 3 run 2 layer - horizontal	■	2.0
6.	Fillet weld - angle to plate - horizontal		2.0
7.	Effects of gas metal arc welding variables	▒	2.0
8.	Corner fillet - horizontal		1.5
9.	Fillet weld - sheet steel - horizontal		2.0
10.	Fillet weld - sheet steel - horizontal and vertical		1.5
11.	Corner fillet - sheet steel - horizontal and vertical		1.5
12.	Butt weld - sheet steel - flat		2.0
13.	Butt weld - sheet steel - horizontal		1.5
14.	Butt weld - sheet steel - vertical		1.5
15.	Butt weld - 6mm plate - flat	■	2.0
16.	Butt weld - rolled steel section - flat		2.5
17.	Butt weld - 6mm plate - horizontal		2.0
18.	Butt weld - 6mm plate - vertical		2.5
19.	Gas metal arc spot welding theory	▒	1.0
	Competency test		1.0

▒ Theory sections - written assessment

■ Skill practice sections - no assessment

□ Skill competency sections - practical assessment

TAFE

Section 1: Gas metal arc operating principles

Task: To understand the operating principles of the gas metal arc welding process. This section covers learning outcome 1 of the National Module Descriptor.

Why? So you'll be able to identify machine and accessory parts and operate and adjust the gas metal arc welding equipment for a range of industrial uses.

To pass: Consists of short answer and multiple choice questions on the operating principles of the gas metal arc welding process. You'll be tested on this section at the end of this module.

Technical information

If you have any questions on this section, ask your teacher for help.

1. The gas metal arc welding process

The gas metal arc welding process is very popular in the fabrication and construction industries because of its advantages over other types of welding.

How the process works

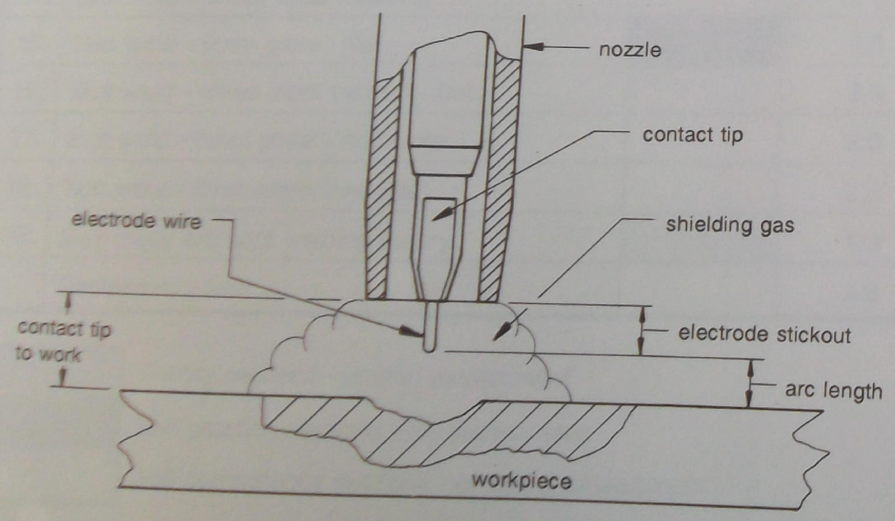
An electric arc is formed between a wire electrode and the workpiece. Once this is established, the wire electrode is fed at a set speed from a wire spool into the arc to form a weldpool. Both the weldpool and wire electrode are fully protected from atmospheric contamination by a shielding gas. The wire, shielding gas and electric current required to form the weld are activated semi-automatically by the operator.

Gas metal arc welding equipment

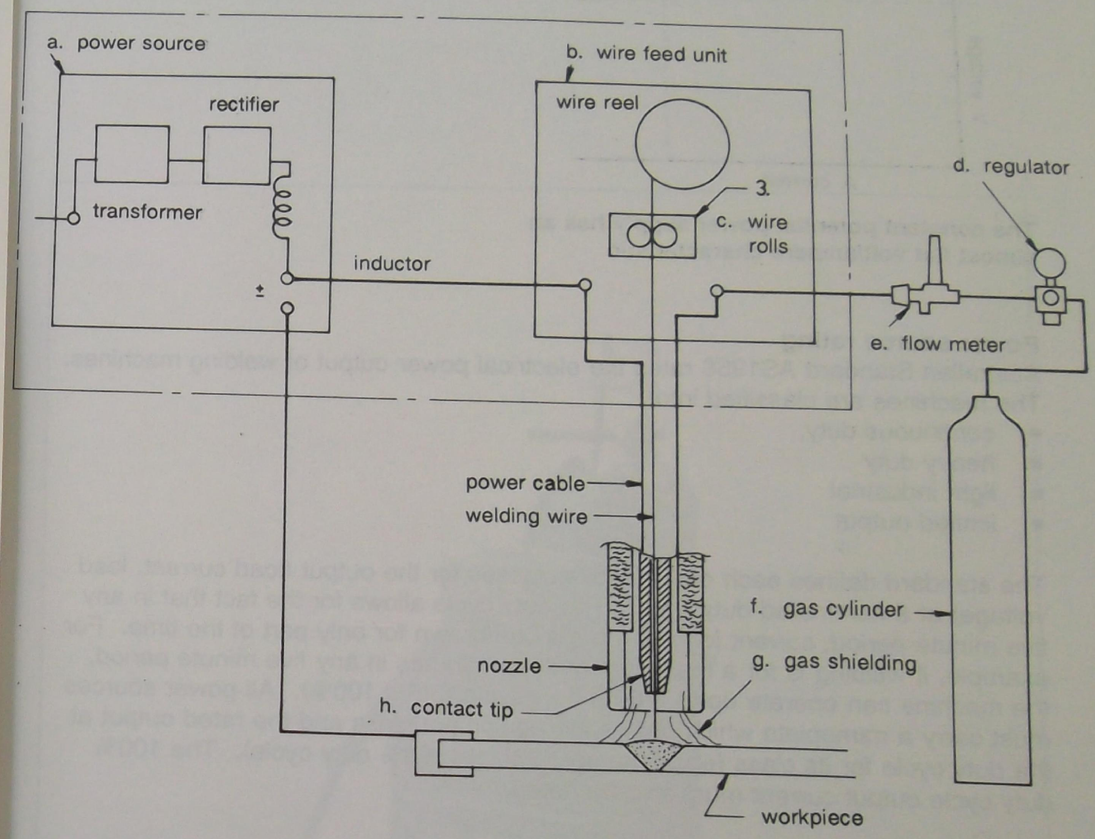
The equipment for gas metal arc welding consists of:

a. power source (transformer/rectifier)
b. wire feed unit (designed to allow the wire to feed freely and evenly)
c. wire rolls
d. regulator (adjusts and maintains constant gas flow)
e. flow meter (adjusts and maintains constant gas flow rate)
f. gas cylinder
g. gas shielding (protects weld from atmospheric contamination)
h. contact tip

Gas metal arc welding process



Gas metal arc welding plant

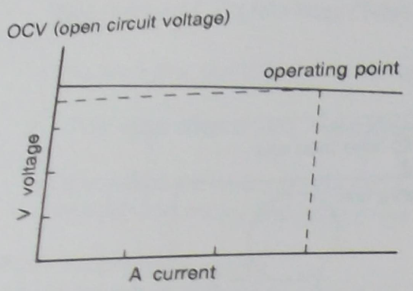


2. Power source

The gas metal arc welding heat is generated by the flow of current through the gap between the end of the wire electrode and the workpiece. A voltage forms across this gap which varies with the length of the arc. To produce a uniform weld, the welding voltage and arc length must be maintained at a constant value by:

- feeding the wire into the weld zone at the same rate at which it melts
  or
- melting the wire at the same rate it is fed into the weld zone (manual metal arc welding).

The constant voltage (potential) power supply was developed for gas metal arc welding because of the need for better arc control. The constant potential (CV) welding power supply has a relatively flat volt/ampere characteristic. This means that a preset voltage level can be held across its range.



The constant potential power supply has an almost flat volt/ampere characteristic

Power source rating

Australian Standard AS1966 rates the electrical power output of welding machines. The machines are classified into:

- continuous duty,
- heavy duty
- light industrial
- limited output

The standard defines each of the above classes for the output (load current, load voltage) at a nominated duty cycle. The duty cycle allows for the fact that in any five minute period, current for welding may be drawn for only part of the time. For example, if welding is for a maximum of three minutes in any five minute period, the machine can operate up to a 60% duty cycle (3/5 x 100%). All power sources must carry a nameplate which shows the equipment class and the rated output at the duty cycle for its class (eg 300 amps, 32 volts, 60% duty cycle). The 100% duty cycle output current must also be noted.

Gas metal arc welding machine

Photograph courtesy CIG

3. Short arc (dip transfer) metal transfer

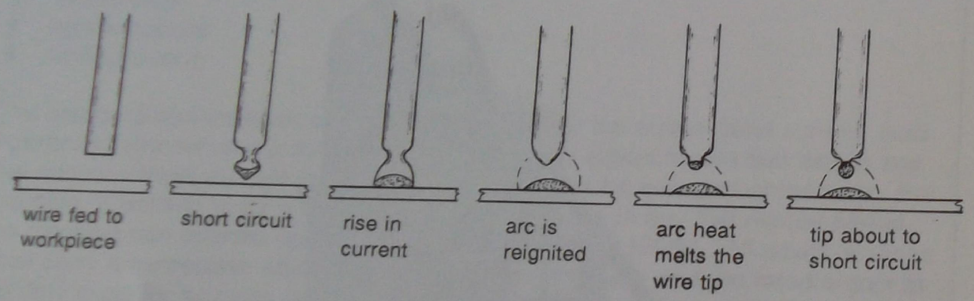
Short arc metal transfer uses both low currents and voltages which keep the heat input to the workpiece to a minimum. This transfer mode minimises the degree of distortion and is used for sheet metal and positional welds (vertical, overhead, etc).

Once an arc is struck between the wire and the workpiece, a molten pool is formed. The end of the wire electrode dips in the weld pool and causes a short circuit. There is a rapid rise in temperature at the tip of the wire which melts off and forms part of the weld. The wire is fed at a constant rate and this action is repeated up to 200 times per second.

Typical weld conditions

Volts: 15 to 24
Amps: 60 to 210
Stickout: 6mm to 15mm

Short arc (dip transfer) sequence



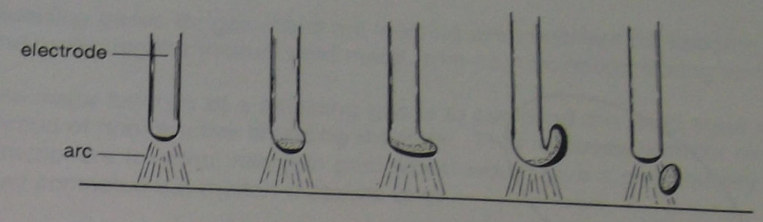
4. Globular metal transfer

Globular metal transfer is between the dip and spray transfer modes. The metal crosses the arc in large irregular shaped globules. It has better deposition rates than dip transfer but causes spatter and doesn't look as good as full spray transfer.

Typical weld conditions

Volts: 20 to 28
Amps: 200 to 280
Stickout: 12mm to 22mm

Globular transfer sequence



5. Spray arc metal transfer

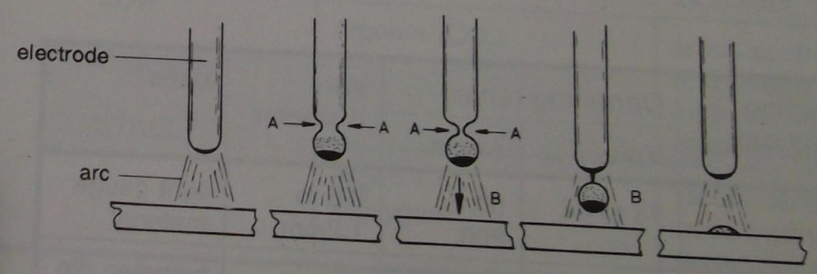
Spray arc transfer uses higher voltage and a greater current density than dip transfer. After the arc is struck the higher current available causes the filler wire to melt off before touching the workpiece. The molten metal crosses the gap in spray form. Each droplet is about the same size as the wire diameter.

Because this method uses higher current densities it has higher deposition rates than other transfer modes. The weld pool is both large and very fluid. This method is only used for downhand welding.

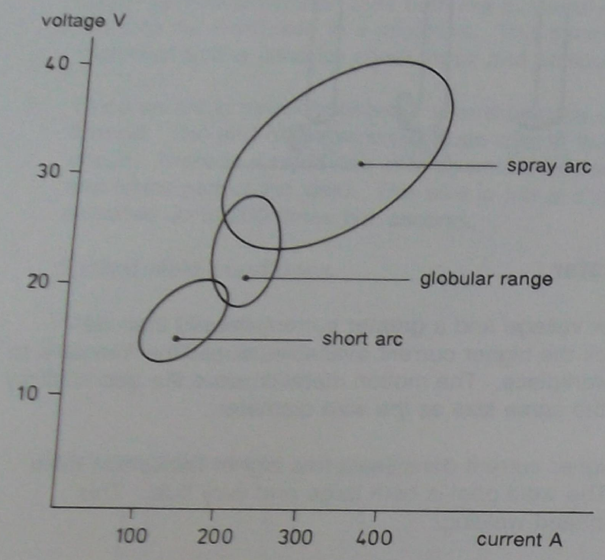
Typical weld conditions

Volts: 24 to 40
Amps: 200 and upwards
Stickout: 15mm to 30mm

Spray transfer sequence



Working range for the different types of arc



By carefully selecting wire speed and voltage, it's possible to set parameters to operate effectively within the three modes of transfer shown above. However, if welding parameters are set outside the three circles, your welding conditions will become erratic and uncontrollable.

Summary of gas metal arc transfer modes

Transfer method	Welding positions	Operating range		Wire diameter	Uses
		Volts	Amps		
Short arc (dip)	all	13 to 23	60 to 200	0.6 to 1.2mm	light gauge material
Globular	flat or horizontal (fillets)	20 to 26	200 to 280	All	between dip and spray
Spray	flat or horizontal (fillets)	24 to 40	210 to 410	0.8 to 1.6mm	material over 5mm

6. Shielding gas

Shielding gases for gas metal arc welding are important for keeping the arc stable and protecting the molten weld metal from contamination during welding.

The major function of a shielding gas is to surround the weld zone with a protective shroud of non-reactive shielding medium. This removes harmful elements from the atmosphere (oxygen, nitrogen gas) which would give a poor quality weld deposit if they contacted the molten metal.

Typical shielding gases

Typical shielding gases used for this process include:
argon/oxygen/carbon dioxide
carbon dioxide (CO_2)
argon/carbon dioxide mixtures

The recommended flow rate for argon and argon mixtures is 14 L/min (14 litres per minute) and 18 L/min (18 litres per minute) for CO_2 when used with a heated regulator.

Post flow of the shielding gas is needed to protect the solidifying weld metal from contamination from oxygen, nitrogen and water vapour in the atmosphere.

Comparison of shielding gases

Metal	Gas	Remarks
LOW CARBON STEEL	Carbon dioxide (CO_2)	low cost, high heat input, but accompanied by spatter
	Argon + (CO_2)	argon controls spatter and shields arc CO^2 improves heat input and reduces cost
	Argon + CO_2 + oxygen	recommended when good mechanical properties are essential

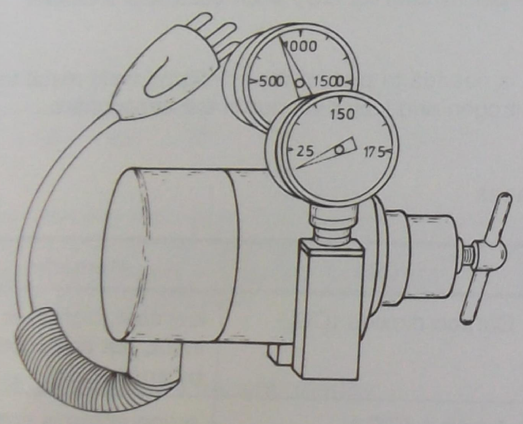
7. Wire electrodes

Electrode wires are drawn to specified sizes during manufacture. The general chemical compositions of wires must be compatible with the parent material they are intended to join. Electrodes also contain deoxidisers such as silicon, manganese and aluminium to remove oxides from the weld pool and produce sound quality welds.

Electrode diameters are matched with a range of operational current to produce the required deposition rates and welds of quality.

Common electrode wire diameters include 0.6, 0.8, 0.9, 1.0, 1.2 and 1.6mm (solid wire sizes).

Electrically heated regulator/flow meters are used with CO_2 gases. The heater stops the regulator freezing.



8. Air and water cooled guns

The gas metal arc welding process generates a high level of heat at the welding gun. The design of the guns and the cooling action of the shielding gas disperses the heat into the surrounding atmosphere. These guns are air cooled.

Water cooled guns are used with higher current densities. These have water flowing through the gun body to cool the welding unit. Higher welding currents can be used with this type of gun design without any increase in the gun's size or weight. The disadvantages of water cooling include the higher cost of the gun and the need for a constant water supply.

9. Wire feed roll tension

Most wire feed systems consist of two feed rolls. One is a driven roll with a groove machined into its circumference, the other a pressure roll that puts physical pressure on the wire. When the drive roll rotates, the wire is fed through the rolls into the gun.

With the wire feed running, adjust the feed roller pressure so that the wire reel can be stopped by slight pressure. If the roller pressure is too light the wire will feed erratically. Too high a pressure will cause twisting of the consumable wire and flaking of the protective copper coating which will clog the wire liner.

10. Burn back control

Welding automatically stops when the operator releases the trigger mounted on the gun. An electrical contact mechanism sends a signal back to the wire feed control unit to **shut down** the welding current, shielding gas and wire feed. If all this happened at the same time the end of the wire would stick to the workpiece. Modern wire feed units have a built-in **burn back control** so that the wire stops feeding just before the welding current shuts off. This action prevents the wire from sticking to the work.

11. Inching control

This operates the wire feed motor and feeds the electrode through the torch and contact tip without activating the welding current. It is used when installing a new reel of wire.

12. Comparison of gas metal arc welding (solid wire) and manual metal arc welding

Item	Gas metal arc welding	Manual metal arc welding
Capital cost	Higher: more complete for a given output size of welding plant	Lower: relatively simple equipment
Deposition rates	Higher current densities result in higher deposition rates Increased arcing times (longer weld lengths)	Lower: length of run that can be deposited dependent on electrode length
Consumable costs	Higher: electrodes by weight are classed as similar but additional costs of gases must be considered	Lower: allow for higher wastage of consumables as ends are not consumed
Operator appeal	Good: less cleaning control of variables less stopping thin gauge materials greater control	Good: more portable less maintenance ease of machine control
Deposited metal	Good: standard wires considered as hydrogen controlled giving higher mechanical properties	Good: greater selection of electrodes available

13. Operating maintenance

Cables and liners

- Check cables to make sure they are not being crushed, kinked or burned.
- Check O rings on the cable for gas leaks.
- Cut liners to the proper length to prevent any resistance to the wire feed.
- Remove all burrs or other obstructions.
- If the liner has been in use for some time see that all wire shavings, dirt and foreign material are removed.
- Do not over tighten locking screws to position the liner or they will crush it.

Contact tip

Check the contact tip for:

- excessive wear
- spatter build up
- correct size for wire being used
- screwed or tightened tip
- correct fit in the gas diffuser

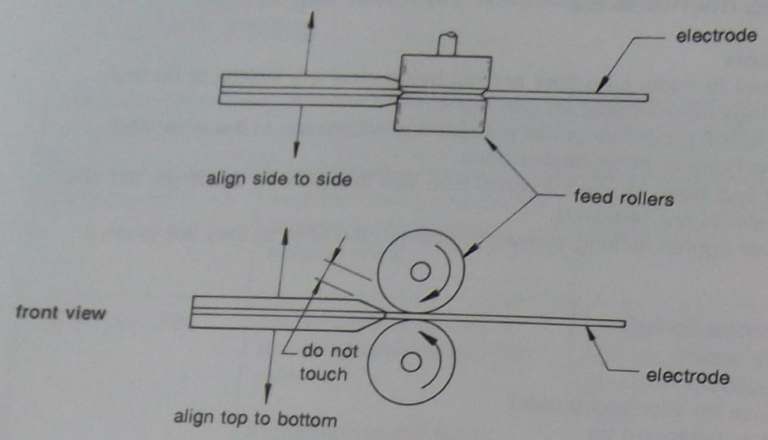
Shrouds and gas diffusers

Clean frequently to prevent spatter build up. Spatter build up will cause bridging or block the flow of shielding gas. An approved spatter release (spray or gel) will prolong their life.

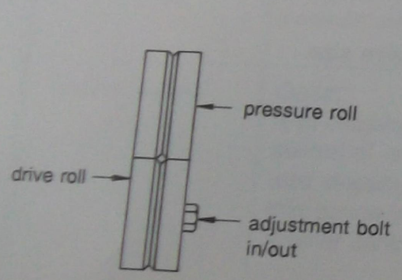
Roller selection

Check the roller size to see that it matches the wire size.

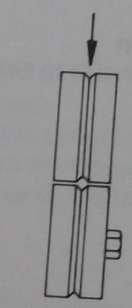
Feed roller and conduit alignment



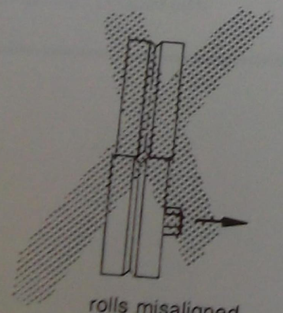
Adjustment of roller alignment



correct adjustment
both rolls aligned
with pressure roll
at correct tension



loose wire
adjust pressure
roll down



rolls misaligned
adjust drive roll
outward

14. Correcting weld and machine faults

Fault	Possible cause	Remedy
Undercutting	Speed too slow for current: torch angle too low voltage too high excessive current	Increase speed: raise torch angle reduce voltage reduce current
Lack of penetration	Current too low Stickout too great Joint preparation too narrow Gap too small	Increase current Shorten stickout Widen preparation Open gap
Lack of fusion	Voltage too low	Increase voltage
Spatter (excessive)	Voltage too high Voltage too low Incorrect shielding gas Insufficient inductance Blocked gas nozzle	Reduce voltage Increase voltage Check selection Increase inductance (if possible) Clean nozzle regularly and spray with anti-spatter
Irregular weld shape	Current too high for voltage Excessive stickout Wire wander Incorrect shielding gas Travel speed too low Excessive gas flow	Reduce current Contact tip closer to work Replace contact tip Check selection Increase speed Set to 14 L/min
Welding cracking	Dirty workpiece eg grease, paint, scale, rust Weld beads too small Weld too deep Using wrong type of wire Highly restrained weld Excessive voltage Lack of preheat	Clean and degrease before welding Slow speed down Reduce current, voltage and increase speed Revise setting up procedure Decrease voltage Preheat
Porosity	Insufficient shielding gas Dirty workpiece Arc voltage too high Air retained in gas shielding systems Excessive gas flow rates Spatter blocking gas nozzle Using incorrect type of wire	Set to 14 L/min (Argonshield) more if in windy position Clean work thoroughly Reduce voltage Check gas connections Purge gas lines Set 14 L/min Clean nozzle and spray regularly with *Spattergard* Check selection

Fault	Possible cause	Remedy
Cold weld	Incorrect machine settings Incorrect shielding gas Bad electrical connections Faulty diode	Increase heat input Replace gas Check and tighten connection Only a qualified electrician can test and replace faulty diodes (see *Instruction Manual*)
Jerky wire	Worn, dirty contact tip Worn, kinked or dirty conduit liner Wire spool runs too tightly Incorrect machine settings	Replace contact tip Clean or replace line Adjust brake (see *Instruction Manual*) Adjust machine parameters

Note: Most wire feeding problems are caused by faulty contact tips and conduit liners. If you have feeding problems, check these two items first and replace if necessary.

15. Advantages of gas metal arc welding

Some important advantages of the process are:

- No flux coating on the electrode, therefore, no slag to remove
- Low spatter levels
- Continuous electrode eliminates stops and starts
- High deposition rates
- Low level smoke and fumes with solid wires
- Open arc, better visibility for the operator
- Maximum control of weld deposit
- Metal recovery about 98% with gas mixtures (manual metal arc welding 80% max)
- Low hydrogen quality weld metal
- Radiographic sound weld deposit with high physical values

Added advantages of short arc (dip) transfer:

- Weld in all positions
- Gaps easily bridged in butt welds
- Minimum distortion due to low heat input
- Weld appearance
- Ability to weld light gauge metals (0.5mm)

16. Limitations of gas metal arc welding

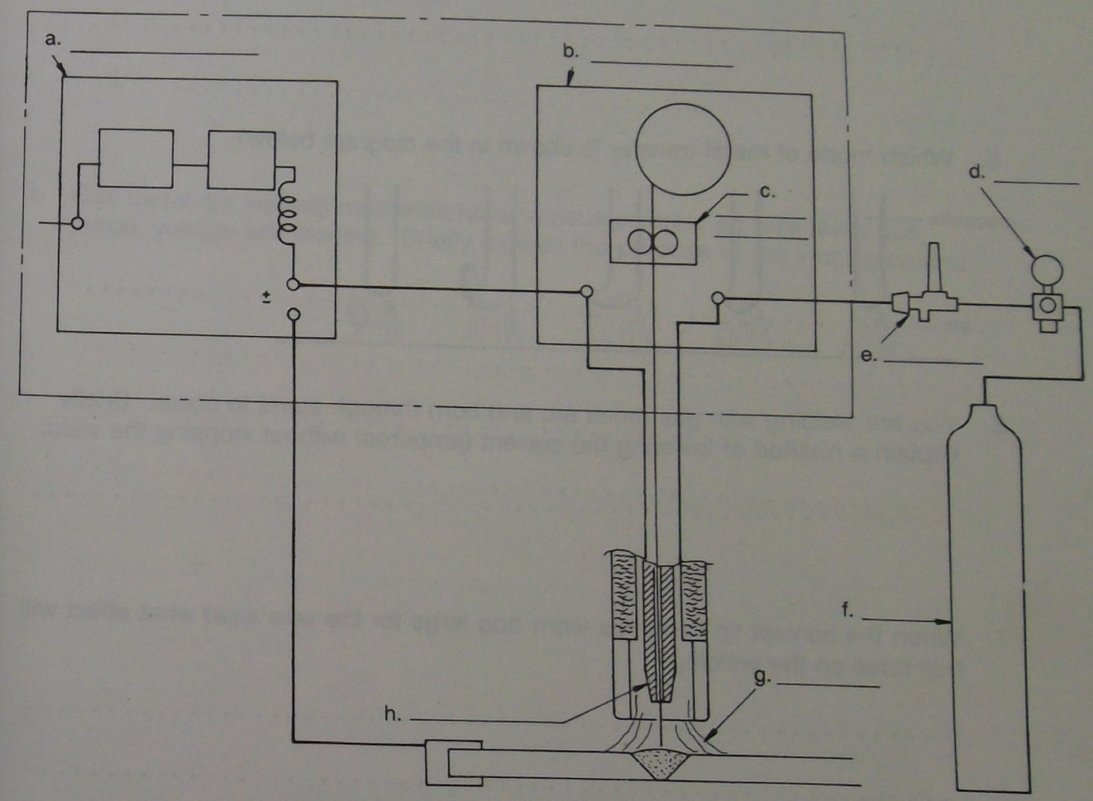
- Gas cover is blown away by the slightest breeze
- Welding over oxides can lead to weld faults
- Degree of expertise required for setting welding parameters
- Requires knowledge of equipment trouble shooting

Review questions

These questions are to help you revise what you've learnt in Section 1. The answers are on page 119.

Short answer questions

1. Label the 8 pieces of equipment on the diagram below:



2. List the 3 modes of metal transfer used in gas metal arc welding:

   a. .....

   b. .....

   c. .....

3. Of the three modes of metal transfer listed in the previous answer which would you use for the highest deposition rates?

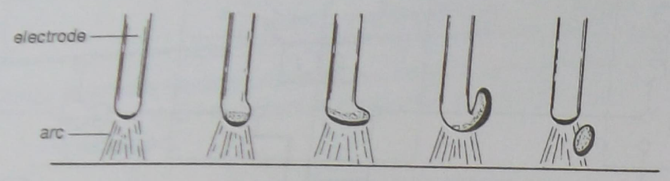
.....

4. The main function of the gas regulator is:

.....

.....

5. Which mode of metal transfer is shown in the diagram below?



.....

6. You are welding with gas metal arc and burn through starts to occur. Briefly explain a method of lowering the current (amperes) without stopping the weld:

.....

7. When the contact tip becomes worn (too large for the wire size) what effect will this have on the welding?

.....

.....

8. Carbon steel welding electrodes for gas metal arc welding are copper coated and double deoxidised.

a. Briefly explain the purpose of the copper coating:

.....

.....

b. List the deoxidisers used in the electrode wire:

i. .....

ii. .....

9. Gas metal arc welding machines have various controls eg wire feed, gas purge, voltage and inching. Briefly explain the purpose of the inching control:

.....

.....

.....

.....

Notes

Section 2: Pad weld - horizontal

Task: To build up a pad weld on low carbon steel plate in the horizontal position. This section covers part of learning outcome 3 of the National Module Descriptor.

Why? So you'll be able to rebuild worn or defective steel structures as required by industry.

To pass: You'll be expected to safely deposit a pad weld on low carbon steel in the horizontal position to the specifications on the work sheet for this section.

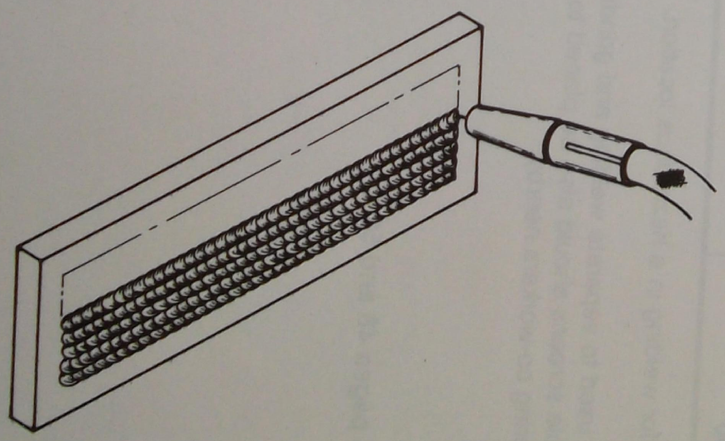
Safety

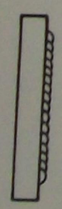
- You must follow Occupational Health and Safety workshop procedures - your teacher will tell you what they are.
- Be careful of small diameter wires. Their ends are sharp and may pierce your skin.
- **Weld** only on the striker plate.
- Leave your bay **clean** at the end of the session.
- **Turn off** bay power points at the end of the session.

PROCEDURE SHEET

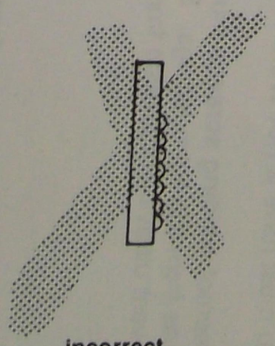
SECTION 2: PAD WELD - HORIZONTAL						
Sketch						
Machine type:						
			Control data			
Run	Wire speed	Amperage reading	Voltage control	Voltage reading	Transfer mode	
1						
2						
3						
4						
Electrode wire Size Ømm: Type: Classification:			Material data Type: Thickness:			
Shielding gas Type: Flow rate: Litres/min:			Weld time Start: Finish: Units completed:			
Assessment			Complies		Doesn't comply	
Surface finish						
Weld size						
Surface defects						
Name					Exercise No.	

SECTION 2: PAD WELDING - HORIZONTAL





correct bead placement



incorrect bead placement

IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit a pad weld on low carbon steel plate using the gas metal arc welding process to the requirements below

POSITION Horizontal

PROCEDURE Your teacher will demonstrate

MODE OF ARC TRANSFER Short arc, 16-24 volts and 60-200 amps used for all positional work

METHOD

1. Set welding conditions on scrap metal, before doing the pad weld exercise
2. Mark a rectangular outline of the required pad weld on the plate
3. Complete the exercise as shown
4. Clean up the pad weld and submit for inspection
5. Turn the plate over and repeat the exercise
6. Evaluate your weld exercise and complete the weld procedure sheet
7. Submit your work for assessment

REQUIREMENTS

- smooth regular pad deposit 3mm high $^{+2}_{-1}$ mm
- a maximum of four significant surface defects per unit area of 40 x 150mm with an accumulative defect area not exceeding the square of the plate thickness

MATERIAL 1 piece 75 x 10 x 225mm low carbon steel plate

UNIT 1

ECONOMY Use scrap metal for setting equipment and opposite side of plate for further practice

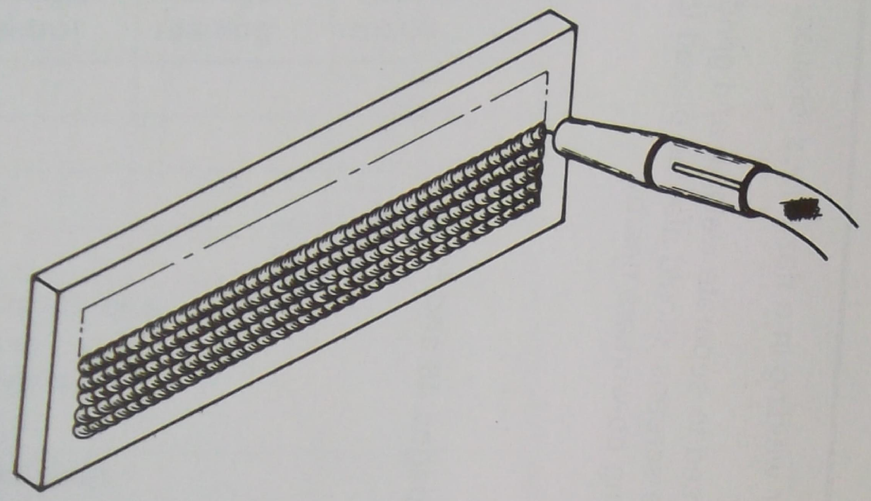
	C
e speed	Ampe readi

tres/min:

	Co

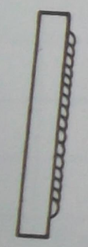
To pass: Consists of short answer and multiple choice questions on fillet and butt weld terms and defects. You'll be tested on this

SECTION 2: PAD WELDING - HORIZONTAL

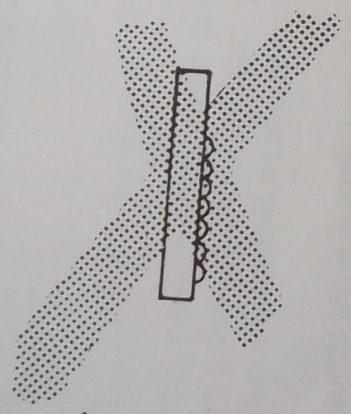


IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE	To deposit a pad weld on low carbon steel plate using the gas metal arc welding process to the requirements below
POSITION	Horizontal
PROCEDURE	Your teacher will demonstrate
MODE OF ARC TRANSFER	Short arc, 16-24 volts and 60-200 amps used for all positional work
METHOD	1. Set welding conditions on scrap metal, before doing the pad weld exercise 2. Mark a rectangular outline of the required pad weld on the plate 3. Complete the exercise as shown 4. Clean up the pad weld and submit for inspection 5. Turn the plate over and repeat the exercise 6. Evaluate your weld exercise and complete the weld procedure sheet 7. Submit your work for assessment
REQUIREMENTS	▪ smooth regular pad deposit 3mm high $^{+2}_{-1}$ mm ▪ a maximum of four significant surface defects per unit area of 40 x 150mm with an accumulative defect area not exceeding the square of the plate thickness
MATERIAL	1 piece 75 x 10 x 225mm low carbon steel plate
UNIT	1
ECONOMY	Use scrap metal for setting equipment and opposite side of plate for further practice



correct bead placement



incorrect bead placement

Safety procedures for gas metal arc welding: Part 1

- **Protective clothing and equipment** must be worn to protect you from electric shock, harmful radiation, fumes and hot metal (AS 1558, 1973)

- **Filter lenses** must be worn to protect your eyes (AS 1336 and AS 1338). The shade numbers in the following table are the minimum. If you feel any discomfort, you should use darker filters (higher shade numbers). If the surface temperature of the filter rises above 100°C, for example when welding preheated sections, you should use filters made of solid glass or glass laminates with dyed inserts.

Gas metal arc welding gives off more infrared radiation than other processes and causes a rise in filter temperature. To avoid this discomfort you can put an auxiliary heat absorbing filter between the cover glass and the filter glass.

Gas metal arc welding process	Approx range of welding current	Recommended filter
Aluminium	250	12
Stainless steel	250 - 350	13
Other material	up to 150	10
	150 - 250	11
	250 - 300	12
	300 - 400	13
	over 400	14

- You must have a **Hot Work Permit** for welding in a hazardous location.

- Fireproof **welding screens** must be used to separate welding and grinding areas from the surroundings. Suitable screens should also be placed to prevent ultraviolet radiation from injuring co-workers nearby.

There are more safety procedures on pages 48 and 56

Section 3: Fillet and butt weld definitions and defects

Task: To understand the terms used to describe fillet and butt weld joint configurations and be able to identify gas metal arc welding defects. This section covers part of learning outcome 3 of the National Module Descriptor.

Why? So you'll be able to use this knowledge in a workshop environment and identify gas metal arc welding faults.

To pass: Consists of short answer and multiple choice questions on fillet and but weld terms and defects. You'll be tested on this section at the end of this module.

Technical information

Talk to your teacher about anything in this section that isn't clear.

1. Introduction

Metal fabricators must know the general terms used in the trade to describe welded joints and structures. This section contains the universal names of specific fillet and butt weld locations. It's vital that you learn their correct names and know where they're located so that you can use this trade language in the workplace.

This section is also an introduction to gas metal arc welding defects. Although we aim to produce fault free welds, defects can and often do occur. It's important for you (the welder) to be able to name and identify faults so that you can take steps to correct them.

2. Weld joints

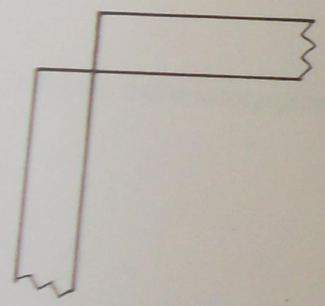
The fabrication industry uses a variety of weld joints for a range of welded structures. Selection of the joint depends on:

- the shape of the structure
- the thickness of the material
- the strength and flexibility required from the joint
- general appearance.

Common welded joints used in industry are:

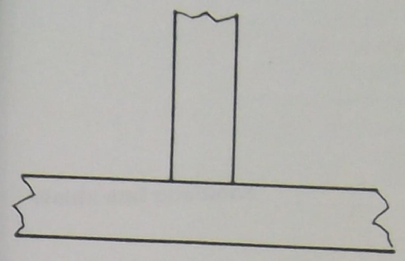
- corner fillet joints
- Tee fillet joints
- butt joints
- plug and slot joints

Corner fillet joint



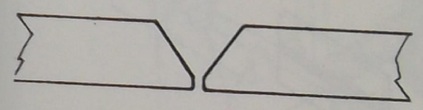
This type of weld joint is often used for hopper construction. The plate edges come together easily during fabrication and make a strong, watertight weld.

Fillet joint



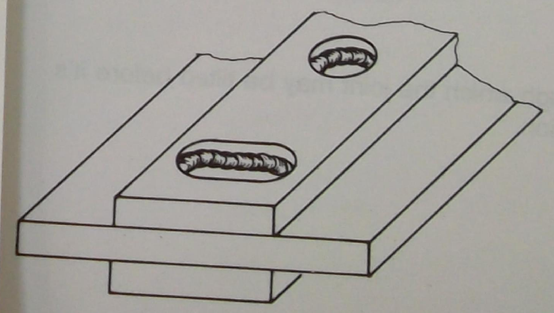
This is one of the most common welded joints used in the construction industry. It's easily fabricated and you can quickly deposit a weld that looks good.

Butt joint



This weld is a single V butt joint commonly used on materials between 5 to 12mm thick. Whether or not the section has to be bevelled for full fusion depends on the thickness of the material. This type is the strongest of all the welded joint designs.

Plug/slot joint



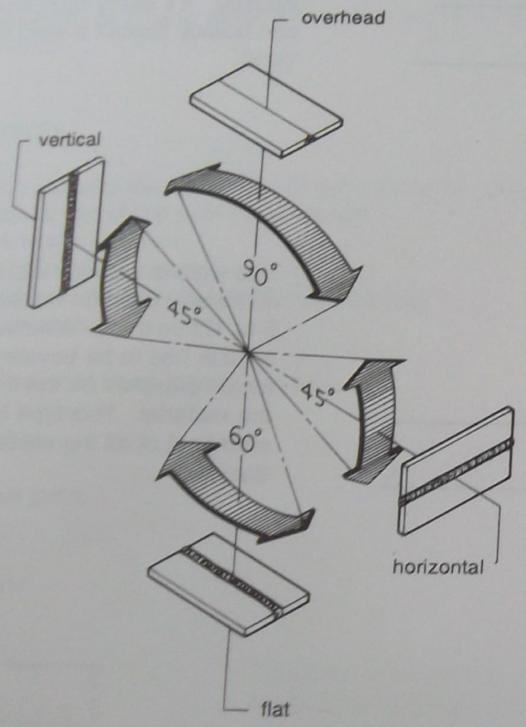
This special type of joint is used to fasten large flat plate sections together without buckling.

3. Weld positions

You may be required to weld in many different positions. Some common weld positions are:

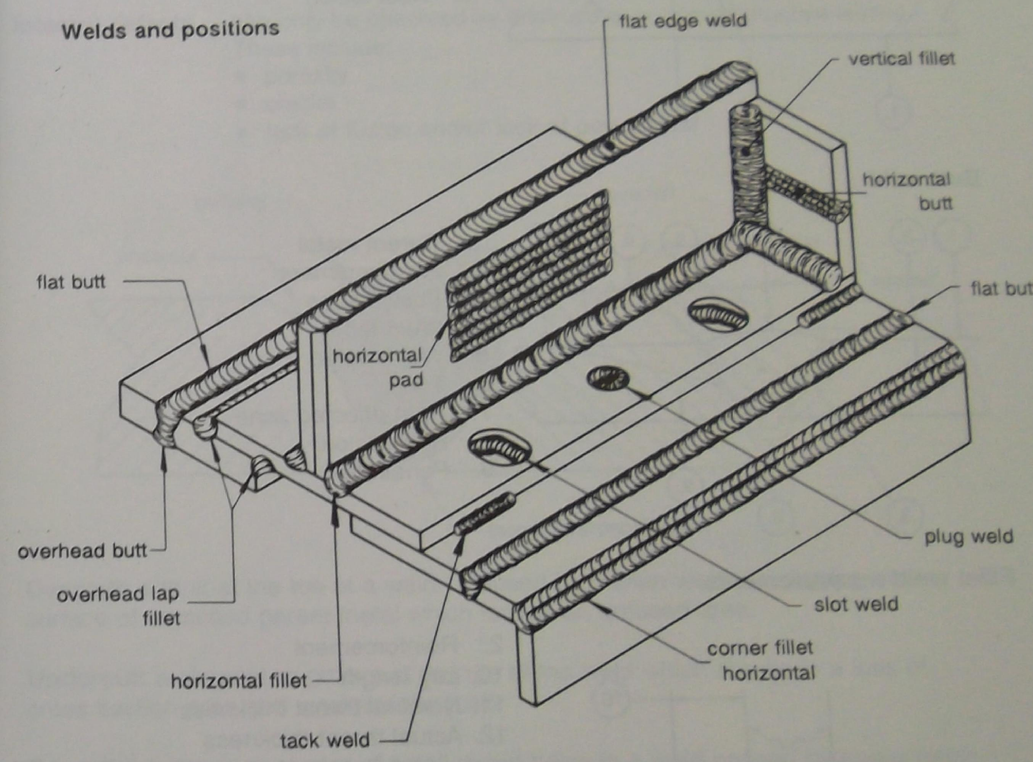
- flat
- vertical
- horizontal
- overhead

Weld positions



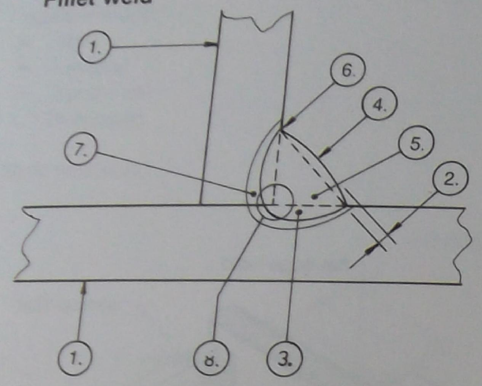
Note: The angles shown are those through which the joint may be tilted before it's considered to have changed position.

Welds and positions



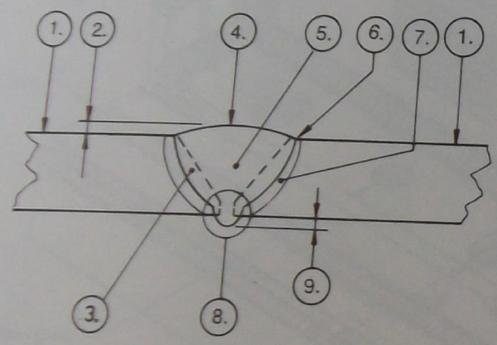
4. Definitions of fillet and butt welded structures

Fillet weld



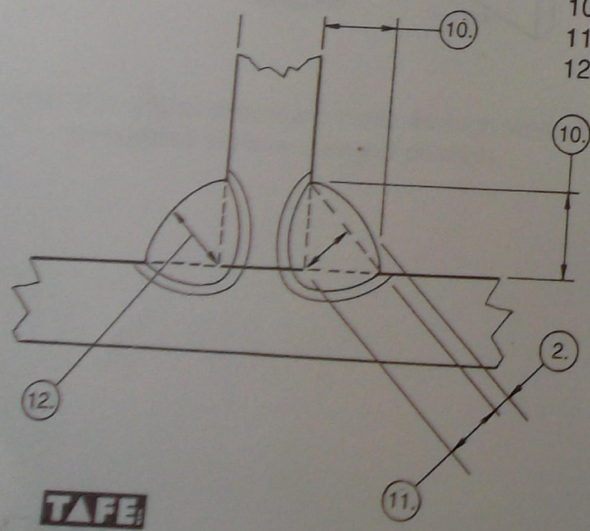
1. Parent metal
2. Reinforcement
3. Fusion zone
4. Weld face
5. Weld metal
6. Toe
7. Heat affected zone
8. Root fusion

Butt weld



1. Parent metal
2. Reinforcement
3. Fusion zone
4. Weld face
5. Weld metal
6. Toe
7. Heat affected zone
8. Root fusion
9. Penetration

Fillet weld measurements



2. Reinforcement
10. Leg length
11. Nominal throat thickness
12. Actual throat thickness

5. External and internal weld defects

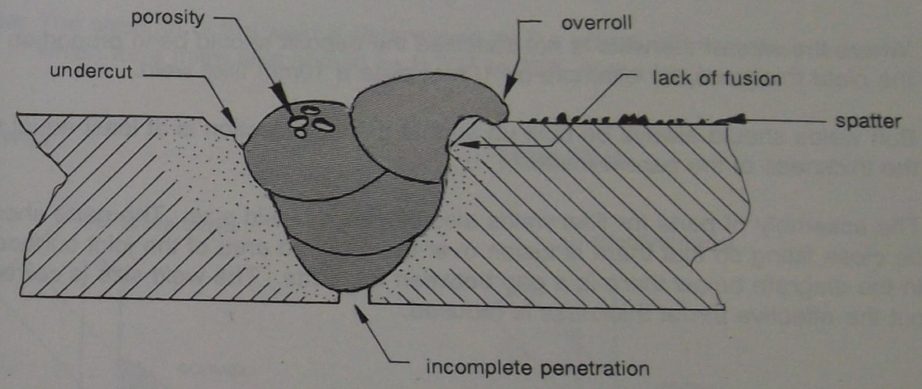
Weld defects can be either **external** or **internal**.

External defects can be identified by looking at the finished weld. Some examples are:

- undercut or overroll (overlap)
- plate misalignment
- lack of or excessive penetration
- weld craters, blowholes and spatter
- shape and size of the finished weld

Internal defects can only be observed by destructive or non-destructive testing. These include:

- porosity
- cracks
- lack of fusion and/or lack of penetration



Overroll: a fault at the toe of a weld. Caused by molten weld overflowing onto a surface of unmelted parent metal which leaves an unfused area.

Undercut: a channel or groove at the toe of the weld which results in a loss of cross section area and weakens the joint.

Porosity: a group or cluster of small round holes in a weld caused by gases being trapped in the weld metal.

Spatter: globules of weld metal which are not part of the finished weld.

Lack of fusion: lack of fusion between weld metal and parent metal at the root of weld when complete penetration is required.

Lack of penetration: a joint penetration which is less than that specified.

Review questions

Small containers that have held flammable substances are extremely dangerous if they are welded or cut. List **three** of the flammable substances that are classified as dangerous.

- _____
- _____
- _____

List **two** treatments that will remove flammable substances from small containers.

- _____
- _____

ANSWERS TO REVIEW QUESTIONS

Section 1

1. To shield the weld from the atmosphere.

2. A continuous wire electrode.

3. Oxygen and acetylene.

4. (a) Gas tungsten arc welding.
   (b) Light fabrication, general engineering.

5. Submerged arc welding.

6. (a) Resistance or spot welding.
   (b) Light fabrication, vehicle or transport industries.

7. To keep the surface of the metal at the required ignition temperature (815°C).

8. (a) Plasma arc cutting.
   (b) Any two of the following:
   - Stainless steel
   - aluminium
   - cast iron
   - alloy steels
   - carbon steels

Section 2

1. *Eyes* - protective goggles
   Body - close-fitting work clothes
   gloves
   safety shoes
   Ventilation - open, well vertilation area or forced air exhaust system

2. Any three of the following:
   - steel
   - copper
   - stainless steel
   - brass

3. - oxygen and acetylene
   - oxygen and LP gas

4. Lap joint.

5. ▪ greater strength
▪ greater cost
▪ greater temperature

Section 4

1. ▪ different joint preparations
▪ filler metal
▪ welding techniques

2. ▪ copper
▪ zinc

3. Cleaning the metal's surface during welding.

4. ▪ copper
▪ steel
▪ cast iron

5. Any one of the following:
▪ repairing machinery
▪ maintenance work
▪ leak-proof joints on small tanks
▪ constructing furniture from hollow sections

6 Any two of the following *advantages:*
▪ requires much less heat input
▪ causes less distortion
▪ joins a wide range of dissimilar metals including ferrous and non-ferrous

Any two of the following *disadvantages:*
▪ high consumable costs
▪ loss of strength at moderately high temperatures (above 260°C)
▪ will corrode if in contact with ammonia

7. Any two of the following:
▪ fumes
▪ heat
▪ poisonous fluxes

Section 6

1. Any four of the following:
▪ welding tips
▪ welding torch
▪ regulators
▪ gas cylinders
▪ hoses

2 (a) black
(b) crimson

3. Any two of the following:
▪ light fabrication
▪ repairs
▪ farm machinery
▪ general maintenance

4. ▪ carburising
▪ neutral
▪ oxidising

5. By the flame covering the weld zone.

6. Any three of the following:
▪ shade 5 or 6 lens - Australian Standards approved
▪ a shirt and trousers of tough flame-resistant material
▪ firm fitting leather shoes or boots
▪ leather gloves
▪ head covering

Section 10

1. 815°C

2 ▪ release a high speed jet of oxygen on the heated section
▪ by controlling the direction of the blowpipe nozzle and combining it with the oxidising action, cut through the metal

3. Any two of the following:
▪ acetylene
▪ coal gas
▪ LP gas
▪ hydrogen

4. Oxygen.

5. Any five of the following:
   - overalls
   - oxy-goggles
   - leather gloves
   - leather apron
   - steel-capped boots
   - spats

6. *Type 41:* acetylene taper seat
   No. 12 : nozzle size or ϕ 1.2 cutting jet hole

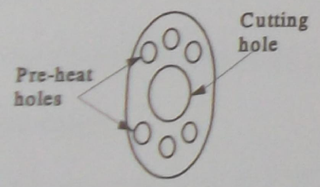
7. Nozzle size: 8
   Acetylene: 100 kPa
   Oxygen: 200 kPa

8. - metal composition
   - cutting nozzle size and condition
   - gas pressures
   - size of preheat flame
   - distance of nozzle from job

Section 12

1. - acetylene
   - LPG

2.



3. (a) Higher.
   (b) 813°
   (c) 30°

Section 14

1 - flux coating
  - corewire

2. 6000°.

3. Any four of the following:
   - adjustable helmet
   - flame resistant overalls
   - leather gloves
   - safety boots
   - safety glasses
   - skull cap or hat

4. - rays - ultraviolet and infrared
   - Effects - damage to eyes and skin

5. Any three of the following:
   - wear dry insulated boots
   - wear dry leather gloves
   - never change electrodes with bare hands or wet gloves
   - never cool electrode holders by immersion in water
   - work on a dry insulated floor where possible
   - never hold the electrode and holder under your arm

Section 18

1. To stop contamination from the atmosphere.

2. Any three of the following:
   - structural
   - boilers and pressure vessels
   - earth moving equipment
   - light fabrication (sheet metal)
   - general engineering

3. Eyes - head shield with correct lens shade
     safety glasses
   Body - overalls
     gloves
     head covering (cap or hat)
   Feet - solid boots or shoes
     spats

4. - natural ventilation
   - respirator
   - forced ventilation

5. Contact tip.

Section 22

1. Any three of the following:
   - alcohol distilleries
   - oil refineries
   - paint factories
   - explosives manufacturers
   - coal crushers
   - flour mills
   - plastics manufacturers
   - saw mills
   - wheat silos
   - clothing factories
   - paper mills

2. Obtain a work permit.

3 (a) A confined working space is a location with restricted ventilation and/or access.

(b) Any three of the following:
   - tanks and containers (road and rail tankers)
   - bins and silos (quarries, grain handlers, mines)
   - ship hull compartments
   - ducts and chutes
   - pipelines (large diameters)

4.
   - make sure there is adequate ventilation
   - have an assistant outside the location watching you work
   - have rescue apparatus on hand
   - leave gas cylinders outside the location in a well ventilated position
   - light blowpipes outside the location, wherever practicable, and remove them from the location when not in use
   - use low current electrical hand tools and lighting

5. Any three of the following:
   - petroleum products
   - acids
   - bitumen
   - flammable solids

6.
   - steaming
   - boiling

SAMPLE ASSESSMENT (THEORY)

Assessment event 10 (theory)

Suggested time: 1 hour
To pass this assessment event you must correctly answer 3 of the 5 questions in each part.

Tick the correct box.

Part 1

1. An inert shielding gas used in gas tungsten arc welding is:

   ☐ oxygen
   ☐ nitrogen
   ☐ hydrogen
   ☐ argon.

2. The welding process which uses a continuous electrode is:

   ☐ manual metal arc welding
   ☐ oxyacetylene welding
   ☐ gas metal arc welding
   ☐ gas tungsten arc welding.

3. Spot welding is used for:

   ☐ light fabrication
   ☐ heavy fabrication
   ☐ bridge repair
   ☐ flame cutting.

4. Manual metal arc welding uses:

   ☐ shielding gas mixtures
   ☐ flux covered electrodes
   ☐ continuous bare wire electrodes
   ☐ liquid flux.

5. The welding process which uses a loose flux mixture to protect the arc is:

   ☐ oxyacetylene welding
   ☐ manual metal arc welding
   ☐ submerged arc welding
   ☐ gas tungsten arc welding.

Part 2

1. Brazing flux:

   - ☐ assists the filler metal to flow
   - ☐ cleans the joint surfaces
   - ☐ prevents oxides from forming while brazing
   - ☐ does all of the above.

2. A safety problem when brazing can be:

   - ☐ poor lighting
   - ☐ poor ventilation
   - ☐ a change from LPG to acetylene fuel gas
   - ☐ an attempt to join unlike metals.

3. When brazing, the molten filler metal is drawn between the close-fitting parts of a joint with:

   - ☐ gravitational pull
   - ☐ the creation of a vacuum
   - ☐ capillary action
   - ☐ the melting of the parts being joined.

4. Brazing is often used instead of soldering because it is:

   - ☐ stronger
   - ☐ cheaper
   - ☐ a lower temperature process
   - ☐ softer.

5. The major element in brazing filler metal is:

   - ☐ copper
   - ☐ tin
   - ☐ aluminium
   - ☐ iron.

Part 3

1. The flame setting used for braze welding is:

   - ☐ neutral
   - ☐ slightly carburising
   - ☐ slightly oxidising.

2. A braze welded joint strength is achieved through:

   - ☐ the weld metal thickness
   - ☐ capillary action
   - ☐ the lower welding temperature
   - ☐ the thickness of the filler rod.

3. Braze welding is not suitable for:

   - ☐ welding steel
   - ☐ maintenance applications
   - ☐ service temperatures above 500°C
   - ☐ copper sheet less than 1.6 mm.

4. The element contained in a braze welding filler rod is:

   - ☐ iron
   - ☐ aluminium
   - ☐ lead
   - ☐ zinc.

5. The flux is added during the braze welding process by:

   - ☐ an inert gas
   - ☐ the filler rod
   - ☐ neither of the above because flux isn't needed.

Part 4

1. The temperature of the oxyacetylene welding flame is approximately:

   - ☐ 1300°C
   - ☐ 2500°C
   - ☐ 3100°C
   - ☐ 3900°C.

2. With oxyacetylene welding:

   - ☐ the parts are melted and fused together
   - ☐ filler rods should *not* be used
   - ☐ only non-ferrous metals can be joined
   - ☐ an inert gas is used.

3. The colour of an oxygen cylinder is:

   - ☐ black
   - ☐ red
   - ☐ silver
   - ☐ green.

4. Oxyacetylene welding is often preferred to other welding processes because it:

   - ☐ welds faster
   - ☐ is more versatile
   - ☐ is easier to use
   - ☐ has no distortion problems.

5. The shade of the filters used for general oxyacetylene welding is:

   - ☐ 3
   - ☐ 5
   - ☐ 7
   - ☐ 10.

1. One function of the flux on an electrode is to:

   - ☐ insulate the core wire
   - ☐ form a protecti...

Part 5

1. In oxy-fuel gas flame cutting, the *cutting* oxygen is needed to:

   - ☐ increase the flame temperature
   - ☐ reduce the metal's ignition temperature
   - ☐ oxidise the heated metal
   - ☐ keep the metal from overheating.

2. Conventional flame cutting requires a metal's oxide layer to:

   - ☐ melt below the melting point of the metal
   - ☐ melt above the melting point of the metal
   - ☐ be non-existent
   - ☐ melt at the same temperature as the metal.

3. The method that produces the most accurate and consistent flame cut surface is:

   - ☐ free hand cutting
   - ☐ guided cutting
   - ☐ machine guided cutting.

4. Flame cutting is unsuitable for:

   - ☐ low carbon steel
   - ☐ structural steel sections
   - ☐ brass
   - ☐ steel castings.

5. To successfully flame cut a metal, it must:

   - ☐ be heated above its melting point
   - ☐ have an ignition point above the melting point
   - ☐ be less than 50 mm thick
   - ☐ have a high iron content.

Sample assessment (theory)

Part 6

1. A common fuel gas used for flame gouging is:

   - ☐ hydrogen
   - ☐ oxygen
   - ☐ argon
   - ☐ acetylene.

2. Flame gouging is used on:

   - ☐ low carbon steel
   - ☐ stainless steel
   - ☐ non-ferrous metals
   - ☐ cast iron.

3. In comparison with fuel gas cutting, the gouging process relies upon a:

   - ☐ low velocity high volume oxygen stream
   - ☐ high velocity low volume oxygen stream
   - ☐ high velocity high volume oxygen stream
   - ☐ low velocity low volume oxygen stream.

4. The flame process is used extensively to:

   - ☐ prepare single bevel weld joints
   - ☐ pre-heat weld joints
   - ☐ remove defective welds
   - ☐ trim plate edges.

5. The angle of the gouging nozzle to the plate surface is normally:

   - ☐ 5°
   - ☐ 10°
   - ☐ 20°
   - ☐ 30°.

Sample assessment (theory)

Part 7

1. One function of the flux on an electrode is to:

   - ☐ insulate the core wire
   - ☐ form a protective slag
   - ☐ carry the electric current
   - ☐ reduce radiation.

2. An increase in welding current (amps) will:

   - ☐ make it more difficult to strike an arc
   - ☐ reduce welding speed
   - ☐ cause the electrode to stick
   - ☐ increase the melting rate of the electrode.

3. Welders should:

   - ☐ inspect all cables for damage
   - ☐ always have good ventilation
   - ☐ wear safety glasses
   - ☐ do all of the above.

4. The temperature of the electric arc in manual metal arc welding is approximately:

   - ☐ 160°C
   - ☐ 800°C
   - ☐ 2400°C
   - ☐ 6000°C.

5. Manual metal arc welding:

   - ☐ is used for welding low carbon steel
   - ☐ is used for welding aluminium
   - ☐ can be used as a fully automatic process
   - ☐ uses a continuous electrode.

Part 8

1. Gas metal arc welding:

   - ☐ is completely manually controlled
   - ☐ uses a tungsten electrode
   - ☐ uses a flammable gas shield
   - ☐ is a semi-automatic process.

2. The welding current in gas metal arc welding is supplied to the electrode by the:

   - ☐ feed rolls
   - ☐ wire spool
   - ☐ work
   - ☐ contact tip.

3. Excessive fumes generated by gas metal arc welding:

   - ☐ are not harmful
   - ☐ will contaminate the weld
   - ☐ will require fume extraction
   - ☐ contain flammable gases.

4. The shielding gas mixture used for gas metal arc welding low carbon steel is:

   - ☐ oxygen/nitrogen
   - ☐ nitrogen/acetylene
   - ☐ acetylene/oxygen
   - ☐ argon/CO_2.

5. The electrode (wire) diameter range used for gas metal arc welding is:

   - ☐ 0.3 to 1.0 mm
   - ☐ 0.6 to 1.6 mm
   - ☐ 1.0 to 3.0 mm
   - ☐ 1.6 to 6.0 mm.

4. Is more versatile

Part 9

1. When working in a confined space, the electrical equipment must be:

   - ☐ low voltage
   - ☐ high voltage
   - ☐ high amperage
   - ☐ low resistance.

2. When welding is required at a saw mill:

   - ☐ fireproof gloves must be worn
   - ☐ all timber must be removed
   - ☐ the area is classed as a hazardous location
   - ☐ an assistant is required.

3. When working in a confined space:

   - ☐ an assistant is required
   - ☐ milk must be consumed to overcome fumes
   - ☐ table salt must be available
   - ☐ gas cylinders should be inside.

4. Before attempting to work in a hazardous location you must:

   - ☐ work with a mate
   - ☐ isolate the power
   - ☐ obtain a work permit
   - ☐ work only at weekend.

5. Which one of the following is a confined space?

   - ☐ fabrication workshop
   - ☐ building site
   - ☐ ship
   - ☐ foundry.

Answers to sample assessment (theory)

Part 1

1. Argon.
2. Gas metal arc welding.
3. Light fabrication.
4. Flux covered electrodes.
5. Submerged arc welding.

Part 2

1. Does all of the above.
2. Poor ventilation.
3. Capillary action.
4. Stronger.
5. Copper.

Part 3

1. Slightly oxidising.
2. The weld metal thickness.
3. Service temperatures above 500°C.
4. Zinc.
5. The filler rod.

Part 4

1. 3100°C.
2. The parts are melted and fused together.
3. Black.
4. Is more versatile.
5. 5.

Part 5

1. Oxidise the heated metal.
2. Melt below the melting point of the metal.
3. Machine guided cutting.
4. Brass.
5. Have a high iron content.

Part 6

1. Acetylene.
2. Low carbon steel.
3. Low velocity high volume oxygen stream.
4. Remove defective welds.
5. 30°.

Part 7

1. Form a protective slag.
2. Increase the melting rate of the electrode.
3. Do all of the above.
4. 6000°C.
5. Is used for welding low carbon steel.

Part 8

1. Is a semi-automatic process.
2. Contact tip.
3. Fume extraction.

ment (the

. Argon/CO_2

. 0.6 to 1.6 mm

art 9

Low voltage.

The area is classed as a hazardous location.

An assistant is required.

Obtain a work permit.

Ship.

TERMS AND DEFINITIONS

⌀	the symbol for diameter
acetone	a flammable and volatile liquid used as a solvent to dissolve and stabilise acetylene under pressure
acetylene	a highly combustible gas composed of carbon and hydrogen (C_2H_2) and used as a fuel gas in oxyacetylene welding and cutting
alloy	a mixture of two or more metals in solid solution
arc	an electric current crossing a gap between an electrode and the work
automatic welding	welding in which the means of making the weld are controlled by a machine
backfire	a loud popping noise caused when the blowpipe flame goes out suddenly and re-lights from the hot work
backhand welding	(rightward, backward) welding with the blowpipe flame pointing in the opposite direction to that in which the weld progresses - the opposite of forehand welding
backing strip	material (such as metal, carbon) used to support and protect the root of a butt weld
blowhole	a cavity in the weld metal caused by a bubble of gas becoming trapped in the solidifying metal
blowpipe (torch)	the hand held device used to mix the fuel gas and oxygen, control the flame and direct it to where it's required
bonding	the joining of two or more metals
braze welding	a welding process in which the parent metal isn't melted, but the joint design is similar to fusion welding - the filler metal is a non-ferrous alloy with a melting point lower than that of the metal being joined.
brazing	a joining process more like soldering than welding in which the molten filler metal is drawn by capillary action between two closely adjacent surfaces to be joined - the filler metal is a non-ferrous metal or alloy with a melting point lower than that of the metal being joined

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capillary action	the flow of molten filler metal between the properly fitted surfaces of the joint
celsius (C)	a temperature scale that registers the freezing point of water as 0°C and the boiling point as 100°C under normal atmospheric pressure
clear lens	a clear glass used to protect the filter in goggles and welding helmets
combustion	the process of burning
conduction	the transmission of electric current or heat through a medium
consumable	material that is used for making welds eg electrodes, filler metals, fluxes, gases
cutting attachment	an attachment to a welding torch handle which converts it to a cutting torch
cutting torch	equipment used in oxygen-fuel gas cutting designed to control the gases for preheating and the oxygen for cutting
cutting oxygen	the jet of oxygen from the central opening of the cutting nozzle which oxidises the preheated metal and allows the cutting action to take place
de-oxidising	the process of removing oxygen particularly from the weld area
deposition rate	the volume of metal deposited in a specified time
diameter	the distance from one side of a circle to the other measured through the centre of the circle
downhand welding	see flat position
ductility	the ability to be permanently bent or deformed without fracture
ferrous	a metal that contains iron
filter (lens)	a coloured lens, usually made of glass, designed to protect a welder's eyes from glare and harmful radiation
flashback	the burning back of the flame into the torch or into one of the gas lines

flat position	welding from above the joint when the weld face is nearly horizontal
flux	a chemical powder or paste which dissolves oxides, cleans the metal and prevents further oxidisation during welding
flux inclusion	a cavity in the weld metal containing flux caused by a quantity of flux becoming trapped as the metal hardens
forehand welding	(leftward, forward) welding with the blowpipe flame pointing in the direction of the weld, that is towards the unfinished seam - the opposite of backhand welding
freehand flame cutting	the cutting process in which the operator both holds and guides the hand cutting torch
fusion weld	a joining of pieces of metal at faces made plastic or liquid by heat pressure or both - filler metal may be used
hazardous locations	the meaning of the term "hazardous locations" is specific and additional to general OH&S issues related to welding & thermal cutting in the workshop. For a full definition of the term, refer to Australian Standard AS 1674 Part 1
horizontal welding	welding in a position in which the line of the weld is horizontal but the surface of the work is vertical
ignition temperature	the temperature at which a material will ignite (burn) eg. 815°C for iron
kerf	the space left during flame cutting by the removal of metal
manual	working by hand
non-ferrous	a metal that does not contain iron
overhead welding	welding in which the filler metal is deposited from the underside of the joint and the face of the weld is approximately horizontal
oxide	a compound of oxygen with another element or substance - rust and mill scale are examples of iron oxides
oxidisation	the process of forming an oxide eg. a section of rusting steel
oxygen	a colourless and odourless gas which supports combustion - oxygen makes up about one-fifth of the atmosphere
parent metal	the metal parts being welding

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oxidisation	the process of forming an oxide eg. a section of rusting steel
oxygen	a colourless and odourless gas which supports combustion - oxygen makes up about one-fifth of the atmosphere
parent metal	the metal parts being welding

portability	able to be moved easily
preheat	heat applied before welding or cutting begin - used to prevent distortion, cracking and unwanted hardening
radiation	the transfer of heat through space by wave motion - all bodies that are at a higher temperature than their surroundings radiate heat
semi-automatic welding	welding in which some of the welding variables are automatically controlled but manual guidance is also necessary
shielding	a process in which gases produced during welding exclude the harmful elements in the atmosphere
slag	a fused, non-metallic residue produced from some welding processes
slag inclusion	non-metallic material trapped in a weld
tack weld	a short weld used for assembly purposes only
tip	the generally detachable part of a blowpipe from which gas or gases emerge for welding
toxic	poisonous
vertical welding	welding in a position in which the axis of the weld is almost vertical
volatile	evaporating rapidly
weld pool	the metal pool created while making the weld - it can consist of filler metal, plate material or a mixture of both
weld contamination	the oxidisation of the weld pool or the generation of gas from organic materials which cause weakening of the weld.
weld metal	metal in a welded joint which has been melted in making the weld - the weld metal includes the filler and parent metals

NSW Module Resource Manual for the National Metal and Engineering Courses

Fabrication Stream

NF03
Gas Tungsten Arc Welding 1

Student Workbook

TAFE

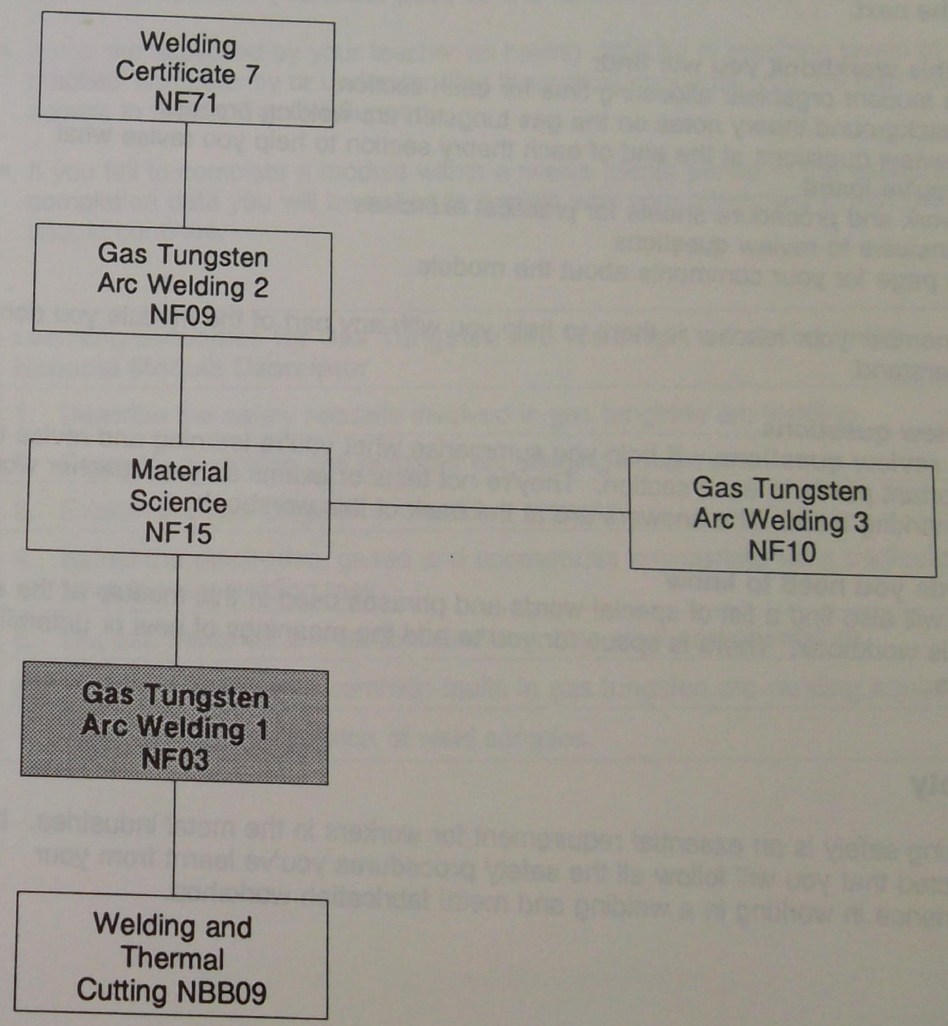
Contents

Introduction

NF03 - Gas Tungsten Arc Welding (GTAW1) is the first of a series of three modules on this process.

The flow chart shows where **Gas Tungsten Arc Welding** fits into the Metals and Engineering course.

Before enrolling in **NF71 - Welding Certificate 7**, students must meet the prerequisites in Australian Standard **AS1796**.



Gas Tungsten Arc Welding 1 contains thirteen sections designed to give you:

- an understanding of the principles of this process and the hazards of using it
- the knowledge to choose appropriate welding parameters, tungsten electrodes, shielding gases and filler rods for welding ferrous and non-ferrous materials
- a description of typical gas tungsten arc welding faults and the steps to take to correct them
- the knowledge to assemble gas tungsten arc welding equipment safely and competently
- practice in depositing fillet and butt welds on low carbon steel, stainless steel and aluminium sections.

You must reach the specified competency in each related section before moving on to the next.

In this workbook you will find:

- a student organiser allocating time for each section
- background theory notes on the gas tungsten arc welding process
- review questions at the end of each theory section to help you revise what you've learnt
- work and procedure sheets for practical exercises
- answers to review questions
- a page for your comments about the module.

Remember your teacher is there to help you with any part of the module you don't understand.

Review questions

The **review questions** will help you summarise what you're learning and revise the important points in each section. They're not tests or exams so your teacher won't be marking them. The answers are at the back of this workbook.

Words you need to know

You will also find a list of special words and phrases used in this module at the end of this workbook. There is space for you to add the meanings of new or unfamiliar terms.

Safety

Working safely is an essential requirement for workers in the metal industries. It's expected that you will follow all the safety procedures you've learnt from your experience in working in a welding and metal fabrication workshop.

To pass

At the end of most **practical sessions** you'll be assessed on what you've done. **Skill practice exercises** won't be formally assessed but you must make sure you're up to the specified standard for each of these. Your results for practical exercises will be shown by your teacher on your procedure sheets.

At the end of the module you'll do a **written competency test** on the theory sections.

To pass this module you must pass all the formal competency tests.

- If you are assessed by your teacher as having difficulty in reaching levels of practical competency or understanding theoretical concepts, you will then have access to Metals Tutorial Support.
- If you fail to complete a module within a twelve month period of the expected completion date you will be asked to explain why your enrolment in that module should continue.

Learning outcomes for Gas Tungsten Arc Welding 1 as stated in the National Module Descriptor
1. Describe the safety hazards involved in gas tungsten arc welding.
2. Correctly assemble gas tungsten arc welding equipment.
3. Explain the gas tungsten arc welding process.
4. Select the electrodes, gases and accessories appropriate for a particular gas tungsten arc welding task.
5. Deposit welds on low carbon steel/stainless steel and aluminium.
6. Diagnose and rectify common faults in gas tungsten arc welding equipment.
7. Perform visual inspection of weld samples.

Student organiser

This chart gives you an overall picture of the content of this module. It's a record of your progress as you work through each section.

	Section	Suggested hours	Assessed
1	Gas tungsten arc welding - process and hazards	2	
2	Lines of fusion and stringer beads - sheet steel - flat	4	
3	Butt weld - stainless steel sheet - flat (temporary backing)	3	
4	Butt weld - steel tube - flat (rotated)	3	
5	Power sources, polarity and tungsten electrodes	2	
6	Gases and filler rods	1	
7	Corner fillet weld - stainless steel sheet - flat	3	
8	Fillet weld - stainless steel sheet - horizontal	3	
9	Gas tungsten arc weld faults	1	
10	Stringer beads - aluminium sheet - flat	3	
11	Butt weld - aluminium sheet - flat (temporary backing)	3	
12	Corner fillet - aluminium sheet - flat	3	
13	Fillet weld - aluminium sheet - horizontal	4	
	Competency test	1	

Total 36 hours

Theory sections - written assessment

Skill practice section - no assessment

Skill competency section - practical assessment

Section 1 Gas tungsten arc welding - process and hazards

Task To understand how gas tungsten arc welding works and the hazards of the process.

This section covers learning outcomes 1, 2 and part of 3 of the National Module Descriptor.

Why So you will be able to use this process safely and competently.

To pass At the end of the module you will do a competency test on this topic. This consists of multiple choice and short answer questions.

Safety

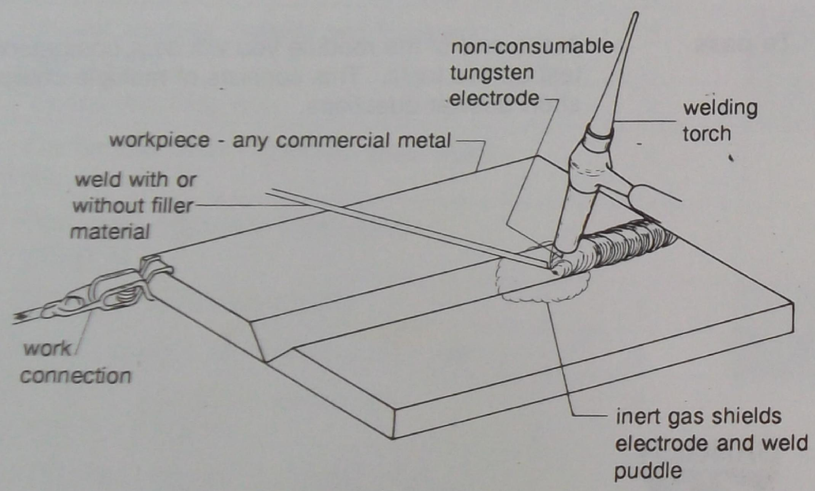
- Always wear protective clothing.
- Never leave hot metal objects unattended around the workshop.
- Read and learn the safety notes on pages 14 and 15 of this section.

The process

Gas tungsten arc welding (also called TIG welding - tungsten inert gas) was developed during World War II as a better, faster method of welding corrosion resistant and difficult-to-weld metals such as aluminium, magnesium and their alloys. Gas tungsten arc welding is now used for a variety of jobs ranging from general maintenance to extremely critical metal joining in aerospace programs.

Gas tungsten arc welding is an extension of the basic electric arc welding process (manual metal arc welding).

Gas refers to the shielding material which surrounds the arc and molten pool.
Tungsten is the non-consumable electrode which conducts the electric current to the arc.
Arc indicates the welding is done by an electric arc rather than by gas combustion.

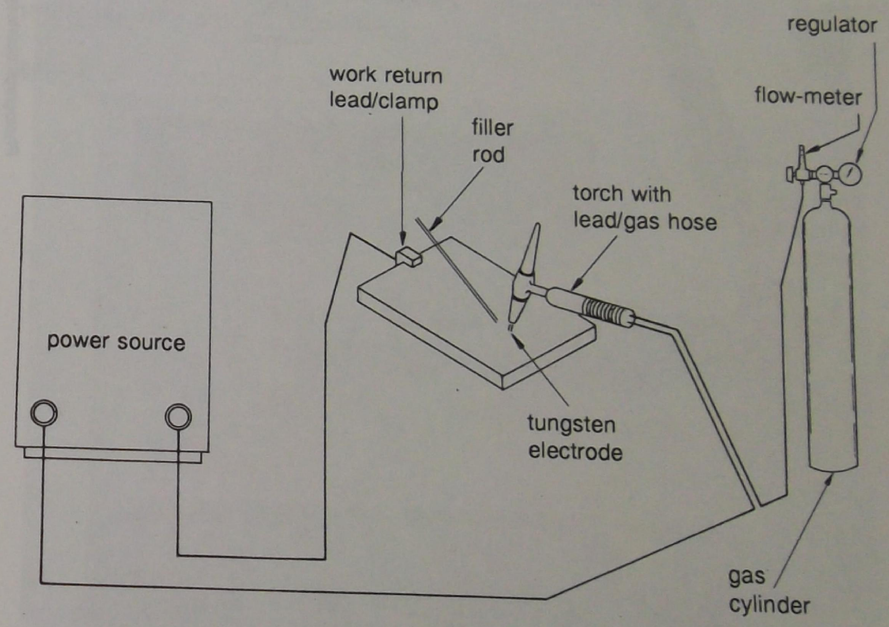


Gas tungsten arc is an electric arc process. The heat is produced by drawing an arc between a non-consumable tungsten electrode and the work (parent material). The weld zone, molten weld pool and electrode are shielded form atmospheric contamination. This inert gas shield is concentrated around the area of the arc by a ceramic gas nozzle. Filler material may or may not be used.

Temperatures in the arc area reach 10,000°C and higher depending on the gas shielding mixture. You will learn more about gas shielding mixtures in **Section 6**.

Equipment

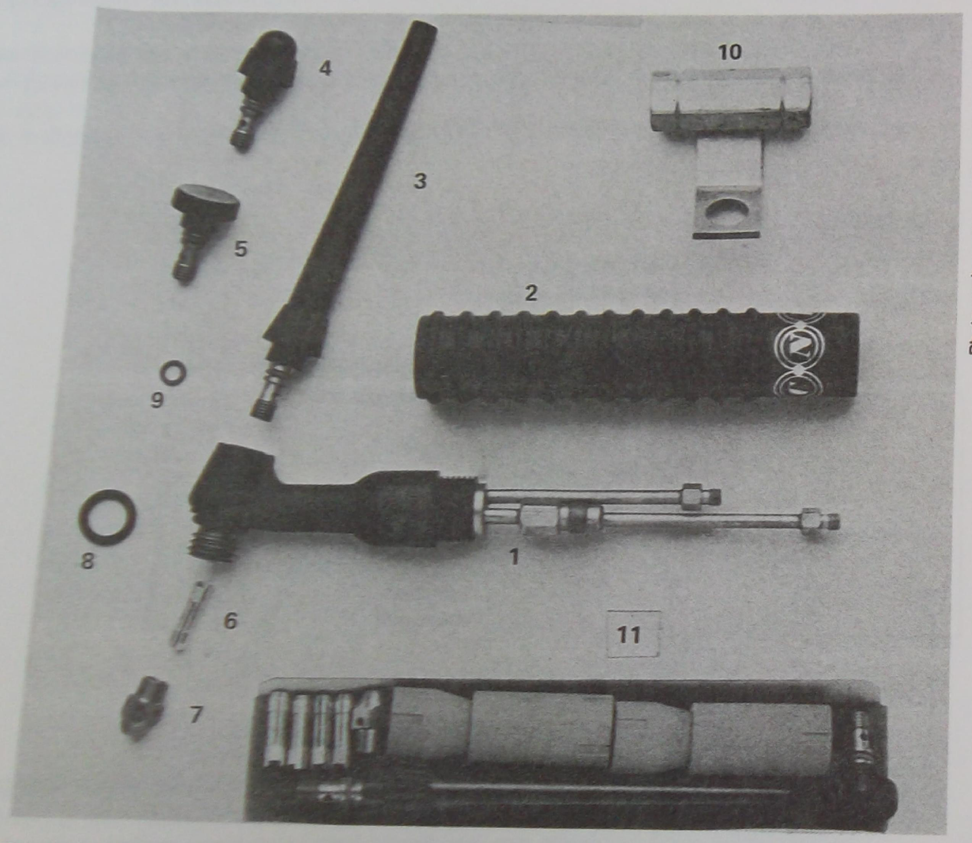
The basic components for the gas tungsten arc welding process are:
- power source
- torch with lead/gas hose
- work return lead/clamp
- gas cylinder
- regulator
- flow-meter
- tungsten electrode
- filler rod (if needed)



Power source attachments

- pulse unit — used for greater control of bead shape and penetration
- foot control — allows the operator to vary the amperage without adjusting the power source
- remote control — hand operated control to vary amperage or adjust pulse

gas tungsten arc welding torch



Photograph courtesy of Ceramic Nozzles Inc.

1. Torch body
2. Handle
3. Long black cap
4. Medium black cap
5. Short black cap
6. Collet
7. Gas diffuser
8. O ring
9. O ring
10. Power cable adaptor
11. Accessory kit

Gas tungsten arc welding torches

There are a large number of gas tungsten arc welding torches available: pencil types which allow access to hard-to-reach weld areas, torches with flexible heads and water cooled torches.

Torches are rated on their current carrying capacity:

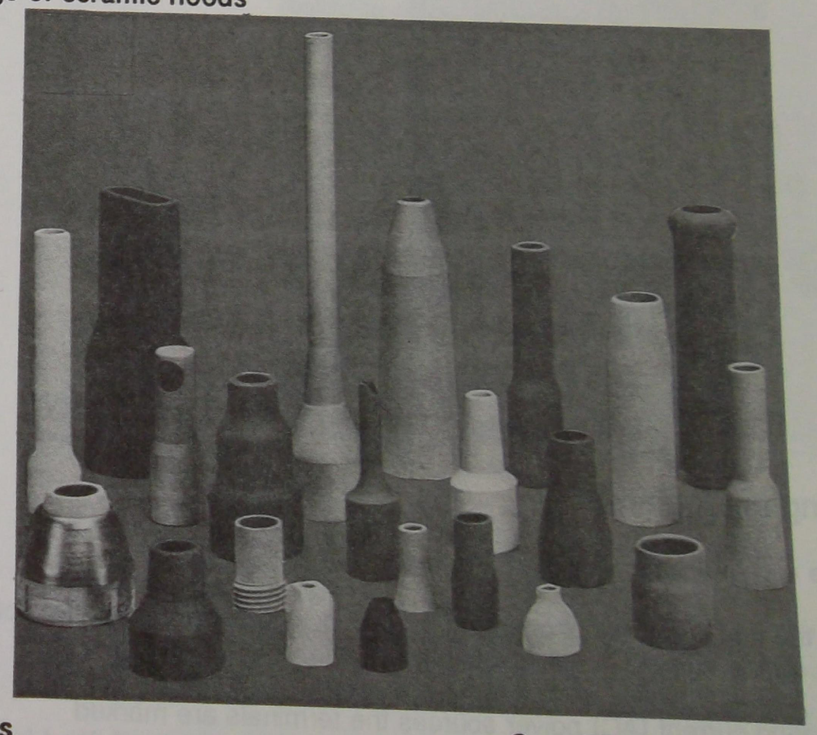
air cooled	2 - 200 amps
water cooled	2 - 500 amps

Gas hoods

ceramic (alumina or silicon carbide)
fused quartz transparent type
metal (generally water cooled)

Hoods come in various shapes and sizes to suit different metals and applications. Ceramic hoods are by far the most common but they become brittle in use and have to be replaced from time to time. Small mesh screens are available to fit gas hoods for very smooth gas flow.

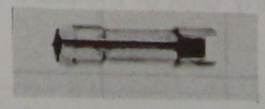
Range of ceramic hoods



Photograph courtesy of Ceramic Nozzles Inc.

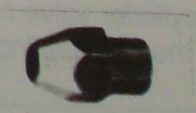
Collets

Collets are used to determine the length the electrode protrudes and to carry current. The collet size must suite the electrode diameter.



Gas diffuser

A gas diffuser is used to deliver gas evenly around the electrode.



General purpose gas tungsten arc welding plant

Photograph courtesy CIG

Assembling equipment

To assemble a gas tungsten arc plant for welding:

1. Connect the torch lead (electrode lead) and work return lead to the correct terminals on the power source and tighten securely.

   On alternating current (AC) power sources the terminals are marked **work/electrode.** On direct current (DC) power sources, the torch lead is attached to the **negative(-)** terminals and the work return lead to the **positive (+)** terminal.

2. Open the cylinder valve momentarily to blow out any dust or moisture which may be in the gas seating valve.

3. Screw the regulator into the cylinder valve and tighten. Attach the flow-meter to the outlet on the regulator and tighten.

4. Connect the gas hose from the torch to the flow-meter and tighten.

5. Now check all connections with a soapy water solution. If there are no gas leaks, re-open the cylinder valve and set the flow-meter at the required flow rate (five to ten litres per minute is recommended).

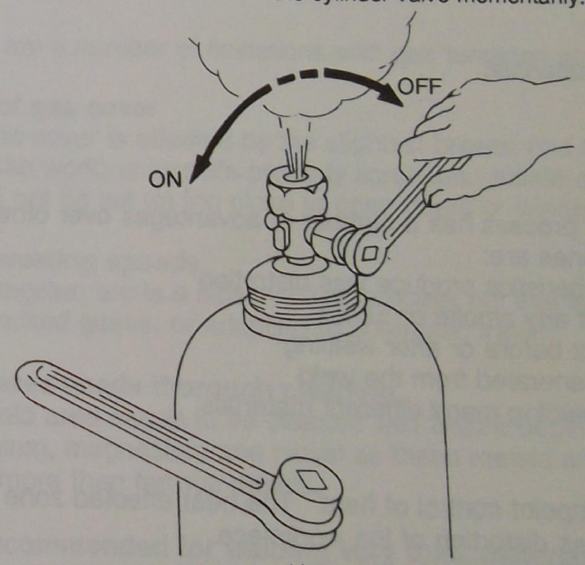
6. Check the tungsten electrode is the correct type for the metal being welded and that it is tight in the collet.

7. Attach the work return lead clamp to the base metal to be welded.

8. Switch on the power source.

9. Set the amperage for the job and begin welding.

Blow out the cylinder valve socket before connecting regulator, **cracking-open** the cylinder valve momentarily.



Use correct key to avoid unnecessary strain on the valve.

Uses

Some of the uses of gas tungsten arc welding include:
- welding thin metal sections
- welding pipe, tube and hollow sections
- welding ferrous and non-ferrous materials.

Because the process uses small diameter electrodes on low currents, a high concentrated, controlled arc is produced. This means thin materials can be easily welded.

Pipes and tube and hollow sections in a range of diameters, wall thickness and sizes are often welded. Some uses include:
- butt welds on pipe lines
- welding tubular frames for helicopters and aircraft
- motor cycle frames.

A wide range of ferrous and non-ferrous metals can be welded in all positions by this process. Industrial materials welded include:
- carbon and low alloy steels
- stainless steel and high alloy steels
- aluminium and magnesium alloys (light metals)
- copper and copper alloys
- nickel and nickel alloys
- titanium and other exotic materials.

Advantages

The gas tungsten arc welding process has a number of advantages over other forms of welding. The main ones are:
- the concentrated arc characteristics produce less distortion
- the process produces little if any smoke or fumes
- no slag or fluxes are present before or after welding
- no sparks and spatter are generated from the weld
- the process is suitable for welding many different materials.

Concentrated arc
The concentrated arc allows pinpoint control of heat. The heat affected zone (HAZ) is narrow and there is less distortion of the workpiece.

Because of the concentrated open arc, and harmful rays there are special safety precautions with the process. There is more information on these at the end of this section. Learn the precautions carefully and take note of what they say. Your health and safety and that of others working with you could depend on it.

Absence of smoke and fumes
Smoke and fumes are not produced by the gas tungsten arc process unless the metal contains coatings or elements such as lead or zinc. If the metal is contaminated by oil, grease, paint or other contaminants, smoke and fumes will be produced by the heat of the arc.

No flux or slag
As flux is not required for shielding the arc, there is no slag to obstruct the operator's view of the molten pool or to remove between runs in multi-pass welds.

No sparks and spatter
Unlike most other electric arc processes, the gas tungsten arc process doesn't have to transfer metal across the arc because it's added by a filler rod. This process is generally spark and spatter free.

Welding range
The process is capable of welding a wide range of ferrous and non-ferrous materials from everyday steel to exotic and highly expensive materials used for aerospace, nuclear and scientific research.

Limitations

There are a number of limitations with gas tungsten arc process. They include:

Loss of gas cover
The gas cover is affected by the slightest breeze and the process is not used in the field (site work) unless it's properly screened. Inside a factory, the equipment should not be set up too close to open doors or windows.

Slow welding speeds
Gas tungsten arc is a slow welding process but this is overcome to a degree by using mixed gases, or adapting to automatic travel.

Weld area needs thorough cleaning
The weld area needs to be cleaned well before beginning to weld, especially on aluminium, magnesium and nickel as these metals are affected by contaminants much more than ferrous metals.

Not recommended for welding very thick material
Gas tungsten arc welding is slow and uneconomical compared with some other processes such as gas metal arc welding or manual metal arc welding. The gas tungsten arc process isn't generally used for welding material thicker than 6mm.

Health and safely hazards

Because the gas tungsten arc welding process has a highly concentrated arc there are safety precautions which need to be strictly observed for the welding operator's, and other workers' health and wellbeing. Some of the hazards are:

- arc radiation
- electric shock/high frequency
- asphyxiation when working in confined spaces.

Arc radiation

The gas tungsten arc welding process gives off:

- ultraviolet rays
- infrared rays
- brightness (glare)

The rays of the concentrated arc can quickly **burn** unprotected skin. Protect your eyes with welding helmets fitted with the correct shade lenses. Protect other workers in the area from stray glare and arc flashes by screening your work.

Electric shock

Electric shock can be quite severe with all welding processes but with gas tungsten arc it is effectively increased by the **high frequency (HF)** which is used for a **non-touch** start. There is more information on high frequency in **Section 5**.

Asphyxiation

Welding in confined spaces (such as inside tanks, boilers and containers) produces high levels of ozone, nitrous oxide and other gases which can cause asphyxiation. These areas must be properly ventilated.

Review questions

These questions will help you revise what you've learnt in **Section 1**. The answers are on page 79. Remember your teacher will also help you with anything you haven't understood so far.

Multiple choice questions

Choose the correct answer and write the letter **a**, **b**, **c** or **d** in the box.

1. The piece of equipment for controlling the welding current when gas tungsten arc welding is the:

   a. tungsten electrode
   b. power source
   c. filler wire
   d. gas cylinder

2. Gas tungsten arc welding is **not** recommended for use on:

   a. thin metal sections
   b. tubes and pipe
   c. non-ferrous metals
   d. thick plate

3. Which of the following joints can be welded with the gas tungsten arc process?

   a. butt joint
   b. lap joint
   c. corner joint
   d. all of the above

4. Which of the following metals is not normally welded with the gas tungsten arc process?

   a. tungsten
   b. low carbon steel
   c. copper
   d. stainless steel

5. Non-consumable electrodes used for welding with this process are made from:

   a. magnesium
   b. zinc
   c. stainless steel
   d. tungsten

Short answer questions

6. When assembling a gas tungsten arc welding plant on direct current (DC), to which terminal is the electrode lead connected?

   _____

7. The gas tungsten arc process has advantages over other welding processes. List **three** of these advantages:

   - _____
   - _____
   - _____

8. List **two** limitations of the gas tungsten arc process:

   - _____
   - _____

Fill in the missing words in the following:

9. Gas refers to the _____ materials which surrounds the arc and molten pool.

10. _____ is the non-consumable _____ which conducts the electric current to the arc.

11. Arc indicates the _____ is done by an electric arc rather than by gas combustion.

Section 2 Lines of fusion and stringer beads - steel sheet - flat

Task To produce lines of fusion and deposit stringer beads on low carbon steel sheet in the flat position.

This section covers part of learning outcome 5 of the National Module Descriptor.

Why To develop the necessary manipulative skills to join a range of weld joint preparations.

To pass Section 2 is a skill practice exercise which is not assessed as part of this module. However, you should make every effort to reach the standard required. The skills you learn in this section are used later for exercises that are formally assessed.

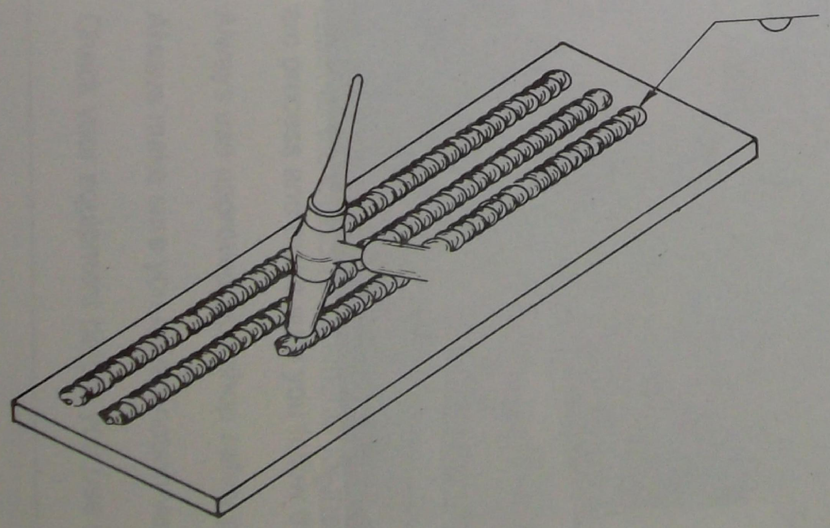
Safety

- Learn all the OH&S requirements for the gas tungsten arc process and make sure you follow them.
- Never use trichlorethylene for cleaning or degreasing weld surfaces. It gives off highly poisonous gases when heated.
- Always wear approved face and eye protection.
- Never play practical jokes when using electrical equipment.

PROCEDURE SHEET

Section 2 Lines of fusion and stringer beads - steel sheet - flat		
Welding data:		
Machine brand	**Weld current data** Run:	
Type of current:	1 amps	3 amps
Type of electrode:	2 amps	4 amps
Electrode size: Ø	**Material data** Type:	Classification:
Electrode profile		
Type of shielding gas:	Thickness:	
Flow rate l/min:	Surface cleaning:	
Type of filler rod:	Pre heat temperature:	
Size of filler rod: Ø	Ceramic hood size:	
Assessment	**Complies**	**Doesn't comply**
Correct assembly of equipment		
Complete fusion		
Smooth regular appearance		
Surface defects		
Name:		

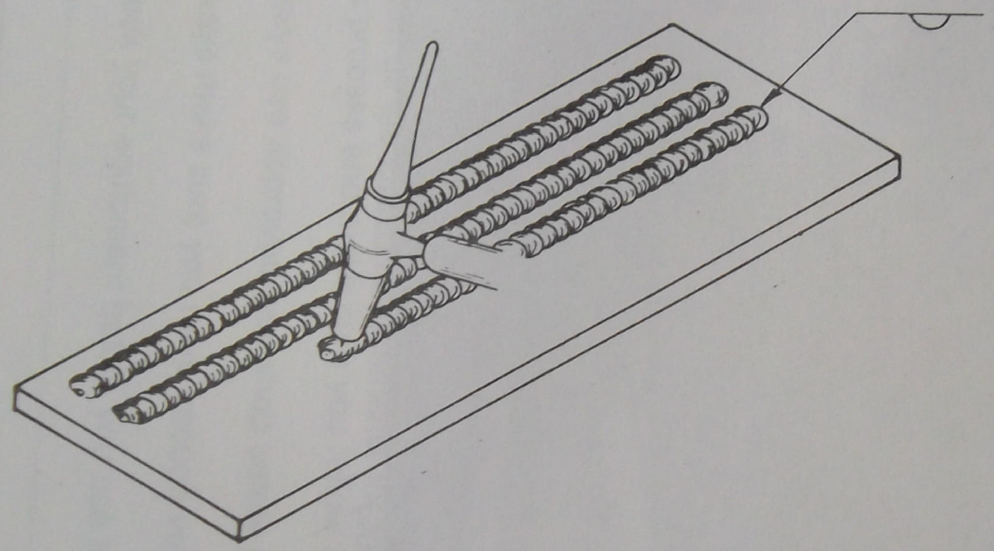
Section 2 Lines of fusion stringer beads
(Skill practice - no formal assessment)



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE	To develop the gas tungsten arc welding manipulative skills for welding different types of joints.
POSITION	Flat
PROCEDURE	Your teacher will demonstrate.
METHOD	1. Thoroughly clean weld surface and degrease if necessary. 2. Position sheet on support surface. 3. Complete bead exericse and show your work to your teacher. 4. Repeat exercise for further practice. Show your completed job for assessment. 5. Complete your procedure sheet.
REQUIREMENTS	▪ complete fusion of the parent metal ▪ smooth regular appearance ▪ beads to have no surface defects
MATERIAL	2 pieces 75 x 3 x 225mm low carbon steel sheet
UNITS	2
ECONOMY	Return unused material and filler rods to the store. Turn off the shielding gas when you're not using it.
Note	Students will be assessed on the correct assembly of equipment.

Section 2 Lines of fusion stringer beads
(Skill practice - no formal assessment)



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To develop the gas tungsten arc welding manipulative skills for welding different types of joints.

POSITION Flat

PROCEDURE Your teacher will demonstrate.

METHOD

1. Thoroughly clean weld surface and degrease if necessary.
2. Position sheet on support surface.
3. Complete bead exericse and show your work to your teacher.
4. Repeat exercise for further practice. Show your completed job for assessment.
5. Complete your procedure sheet.

REQUIREMENTS

- complete fusion of the parent metal
- smooth regular appearance
- beads to have no surface defects

MATERIAL 2 pieces 75 x 3 x 225mm low carbon steel sheet

UNITS 2

ECONOMY Return unused material and filler rods to the store. Turn off the shielding gas when you're not using it.

Note Students will be assessed on the correct assembly of equipment.

Photograph courtesy CIG

Gas tungsten arc welding

Section 3

Butt weld - stainless steel sheet - flat (temporary backing)

Task

To deposit single run butt welds on carbon and stainless steel sheet in the flat position.

This section covers part of learning outcome 5 of the National Module Descriptor.

Why

So you will be able to competently weld stainless steel sections together in the flat position as required by industry.

To pass

You will need to complete a single run butt joint on stainless steel sheet in the flat position to the requirements on the work sheet.

DANGER

Safety

- Learn all the OH&S requirements for the gas tungsten arc process and make sure you follow them.
- Always use approved workshop safety practices.
- Always make sure you have enough ventilation.
- Check your equipment before you use it.

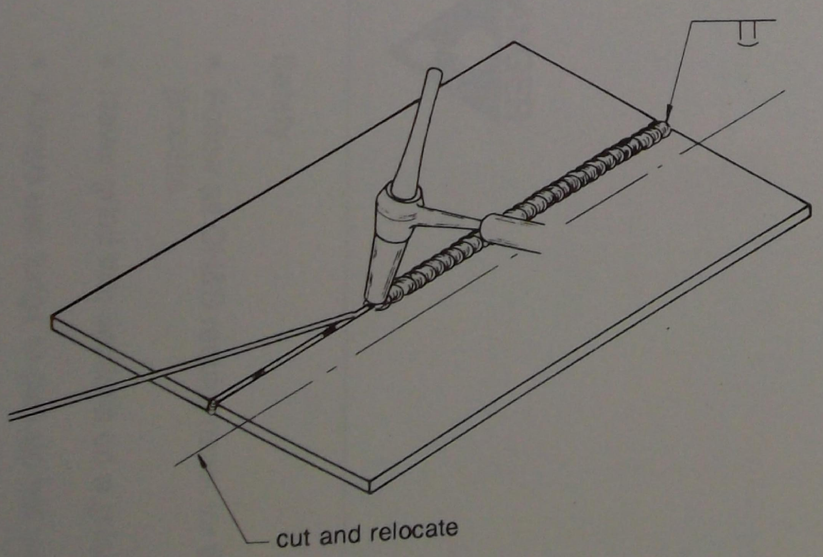
PROCEDURE SHEET

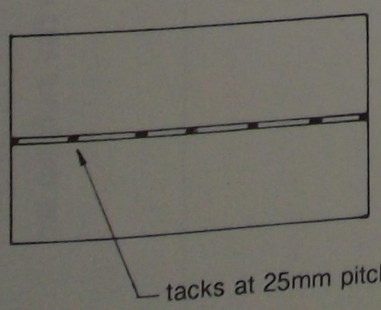
Section 3 Butt weld - stainless steel sheet - flat (temporary backing)

Welding data:	
Machine brand	**Weld current data**
Type of current:	Run: 1 amps 3 amps
Type of electrode:	2 amps 4 amps
Electrode size: Ø	
Electrode profile	**Material data** Type: Classification:
Type of shielding gas:	Thickness:
Flow rate l/min:	Surface cleaning:
Type of filler rod:	Pre heat temperature:
Size of filler rod: Ø	Ceramic hood size:

Assessment	**Complies**	**Doesn't comply**
Correct alignment, assembly and tacking		
Smooth regular contour		
Angular distortion		
Weld penetration		
Weld defects		
Name:		

Section 3 Butt weld stainless steel sheet - flat (temporary backing)
(Formal assessment to pass)





IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit a single run butt, weld on 1 to 1.6mm stainless steel using a temporary backing bar.

POSITION Flat

PROCEDURE Your teacher will demonstrate.

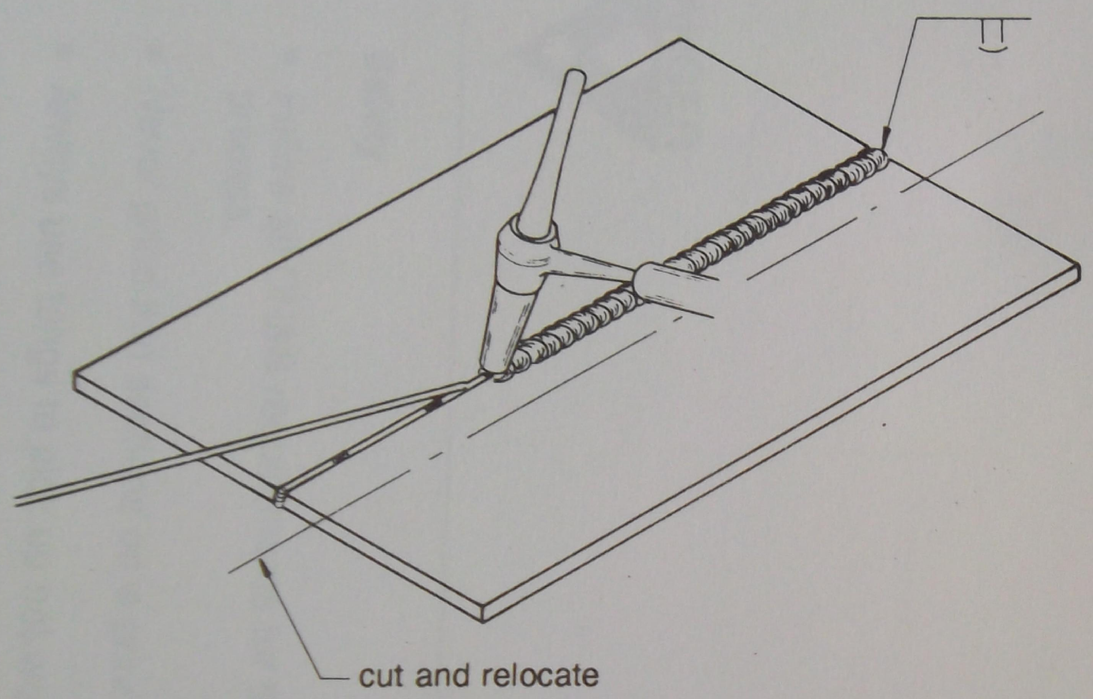
METHOD
1. Thoroughly clean weld surface and degrease if necessary.
2. Assemble and securely tack weld the workpiece.
3. Dress tack welds.
4. Complete welding exercise and show your work to your teacher.
5. Cut and relocate for further practice.
6. Repeat exercise and show your completed job for assessment.
7. Complete your procedure sheet.

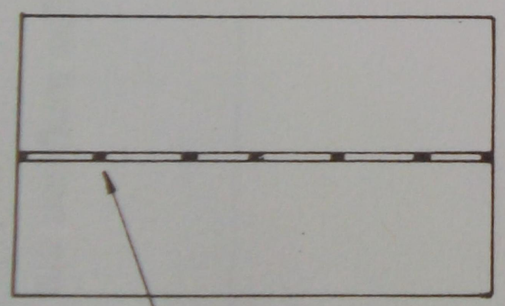
REQUIREMENTS
- correct alignment, assembly and tacking of the job
- smooth regular weld contour
- angular distortion 0° to 5°
- penetration to be no less than 20% of the total weld length
- to have no more than 2 significant defects per 150mm of weld length with an accumulated defect area of less than 4 times the square of the material thickness.

MATERIAL UNITS 4 pieces 75 x 1 to 1.6 x 150mm stainless steel sheet
2

ECONOMY Return unused material and filler rods to the store.
Turn off the shielding gas when you're not using it.

Section 3 Butt weld stainless steel sheet - flat (temporary backing)
(Formal assessment to pass)





IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit a single run butt, weld on 1 to 1.6mm stainless steel using a temporary backing bar.

POSITION Flat

PROCEDURE Your teacher will demonstrate.

METHOD

1. Thoroughly clean weld surface and degrease if necessary.
2. Assemble and securely tack weld the workpiece.
3. Dress tack welds.
4. Complete welding exercise and show your work to your teacher.
5. Cut and relocate for further practice.
6. Repeat exercise and show your completed job for assessment.
7. Complete your procedure sheet.

REQUIREMENTS

- correct alignment, assembly and tacking of the job
- smooth regular weld contour
- angular distortion 0° to 5°
- penetration to be no less than 20% of the total weld length
- to have no more than 2 significant defects per 150mm of weld length with an accumulated defect area of less than 4 times the square of the material thickness.

MATERIAL 4 pieces 75 x 1 to 1.6 x 150mm stainless steel sheet
UNITS 2

ECONOMY Return unused material and filler rods to the store.
Turn off the shielding gas when you're not using it.

lotes

Section 4 Butt weld - steel tube - flat (rotated)

Task

To deposit single run butt welds on low carbon steel tube in the flat position.

This section covers part of learning outcome 5 of the National Module Descriptor.

Why

So you will able to competently weld tubular sections in the flat position as required by industry.

To pass

You will need to complete a single run butt joint on a tubular steel section in the flat position to the requirements on the work sheet.

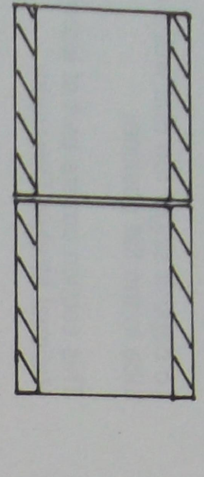
DANGER

Safety

- Follow all OH&S requirements for the gas tungsten arc process.
- Never grind thin sections on a grinding wheel.
- Always use tongs to pick up hot work.

CEDURE SHEET

tion 4 Butt weld - steel tube - flat (rotated)



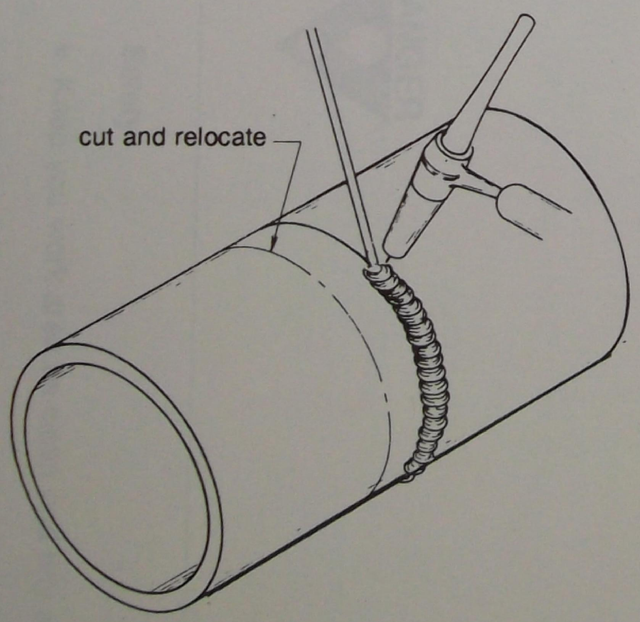
ng data:

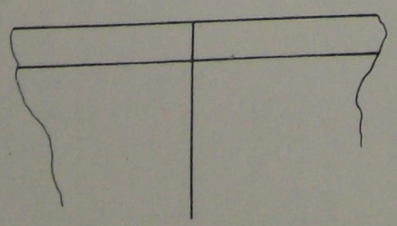
ne brand	**Weld current data**
current:	Run: 1 amps 3 amps
electrode:	2 amps 4 amps
e size: Ø	
e profile	**Material data** Type: Classification:
hielding gas:	Thickness:
l/min:	Surface cleaning:
er rod:	Pre heat temperature:
r rod: Ø	Ceramic hood size:

nt	Complies	Doesn't comply
nment, assembly and tacking		
ular contour		
ortion		
ation		

Section 4 Butt weld steel tube - flat (rotated)
(Formal assessment to pass)

IF IN DOUBT ASK YOUR TEACHER





Suggested joint preparation

OBJECTIVE To deposit a single run butt weld on low carbon steel tube.

POSITION Flat (rotate)

PROCEDURE Your teacher will demonstrate.

METHOD
1. Thoroughly clean weld surface and degrease if necessary.
2. Assemble and securely tack weld the workpiece.
3. Complete welding exercise and show your work to your teacher.
4. Cut and relocate for further practice.
5. Repeat the exercise and show your completed job for assessment.
6. Complete your procedure sheet.

REQUIREMENTS
- correct alignment, assembly and tacking of the job
- smooth regular weld contour
- angular distortion 0° to 5°
- penetration to be no less than 20% of the total weld length
- to have no more than 2 significant defects per 150mm of weld length with an accumulated defect area of less than four times the square of the material thickness.

MATERIAL 4 pieces Ø 50 x 1.2 x 150mm low carbon steel tube

UNITS 4

ECONOMY Return unused material and filler rods to the store. Turn off the shielding gas when you're not using it.

Notes

Section 5 Power sources, polarity and tungsten electrodes

Task

To understand the power sources, polarity and tungsten electrodes for welding steel, stainless steel and aluminium materials.

This section covers part of learning outcome 5 of the National Module Descriptor.

Why

So you can use this knowledge in a practical workshop environment and select appropriate operating variables.

To pass

At the end of the module you will do a competency test on this topic. This consists of multiple choice and short answer questions.

Safety

- Keep you work area as clean and tidy as possible.
- Make sure your work is cool before touching it.