Undersized and oversized welds

Fillet and butt welded joints are designed to carry certain loads. These loads are calculated from tests carried out on similar joints. An allowance is made for safety.

It's necessary for the welding operator to deposit welds to the dimensions specified by the designer. The designer knows how the welds will behave in service and asks for weld deposits of a particular size to meet the conditions. If the operator then deposits an undersized weld, the weld may fail in service. If the weld is over reinforced, the joint will be less flexible and the metal structure beside it may fail. The rigidity of an oversized weld can also cause excessive stress loading on other sections of the weld.

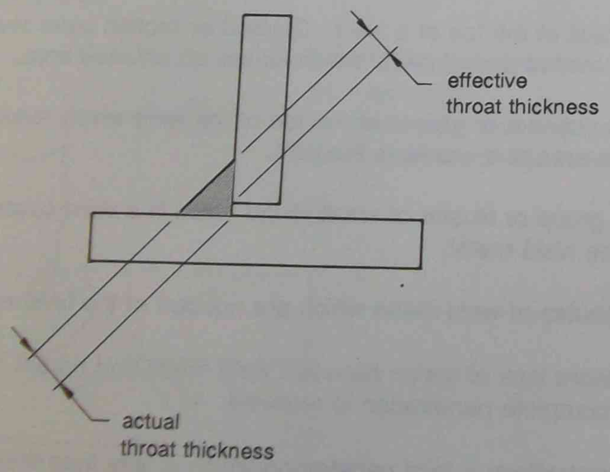
Examples: for a 6 millimetre fillet weld there should be a 6 millimetre leg length and a 4.2 millimetre throat thickness.

for a butt weld there should be an even curved reinforcement slightly above the alignment of the parent metals.

Where the size of the weld is not specified the deposit should be in proportion to the plate thickness, for example on 10mm plate a 10mm fillet weld.

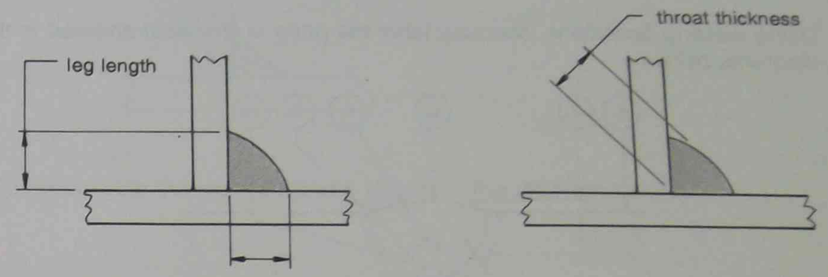
Butt welds should always be built up so that the weld section is at least equal to the thickness of the parent metal.

The assembly of parts for fillet welds also influences weld size. The parts should be close fitting so that there is fusion over the required area of the joint surfaces. In the diagram below there is a gap between the parts. The weld size is correct but the effective throat thickness is reduced.



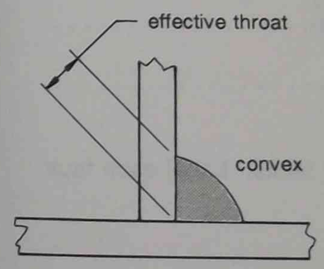
6. Fillet weld dimensions

The size of a fillet weld is determined by the following dimensions which are checked with a weld gauge.

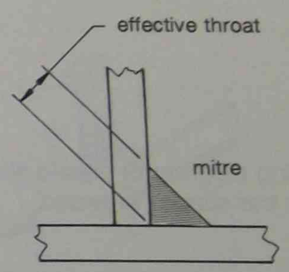


Note: The strength of the weld is determined by the effective throat thickness which for a mitre fillet should be 0.707 or 70% of the leg length.

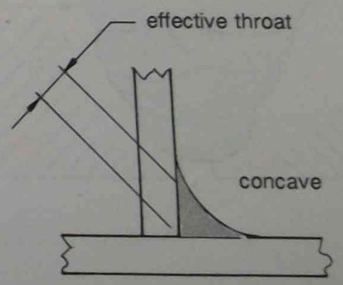
Convex



Mitre fillet



Concave fillet



Removing welding fumes using
a portable extractor system

Section 4: *Fillet weld single run - horizontal*

Task: To deposit single run fillet welds 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 have the skills to deposit single run fillets in the horizontal position as required by industry.

To pass: This is a skill practice exercise which is not assessed as part of this module. However you should try to reach the standards specified on the work sheet for this section as you'll use the skills you learn for later exercises that are formally assessed.

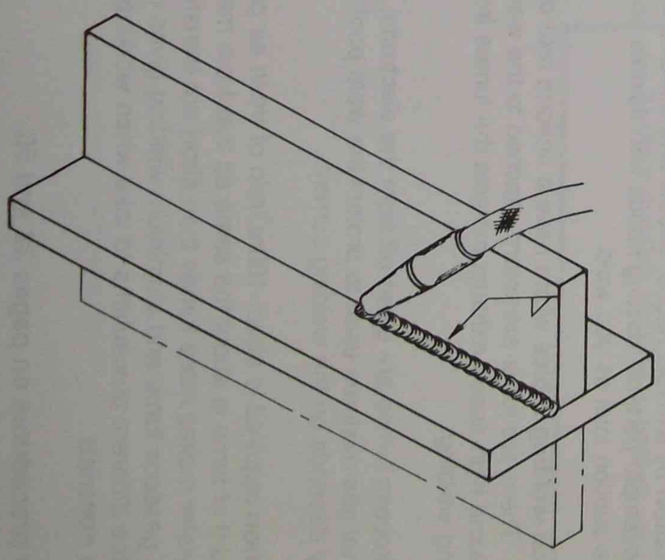
Safety

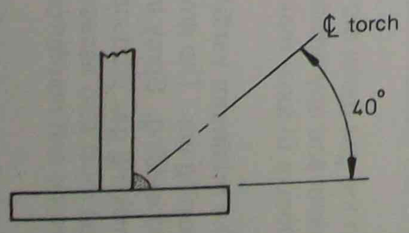
- Follow OH&S workshop procedures at all times. Your teacher will tell you what they are.
- Accidents happen more often in untidy workshops - clean up when you've finished a job.
- Always use adequate ventilation to remove harmful fumes.

PROCEDURE SHEET

SECTION 4: FILLET WELD - SINGLE RUN - 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		
Alignment and assembly						
Angular distortion						
Surface finish						
Weld size						
Surface defects						
Complete fusion						
Root penetration						
Undercut						
Name				Exercise No.		

SECTION 4: FILLET WELD - SINGLE RUN - HORIZONTAL





IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To develop the skills of electrode manipulation necessary to deposit a 6mm fillet weld to the requirements below

POSITION Horizontal

PROCEDURE Your teacher will demonstrate

METHOD

1. Wire brush the material to remove surface rust and loose mill scale
2. Tack both ends of the plate to ensure metal to metal contact
3. Complete about half the weld and examine appearance and profile before finishing the weld
4. Remove spatter and submit your exercise for inspection
5. Break the weld and resubmit your exercise for internal inspection
6. Relocate the plates for further practice using two new edges
7. Evaluate your weld exercise and complete the weld procedure sheet
8. Submit your work for assessment

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- a maximum of two significant weld defects per 250mm (or 225mm plate) of weld length with an accumulative area of less than twice the square of the plate thickness
- weld size 6^{+2}_{-0} mm
- complete fusion for the length of the weld joint
- undercut to be no greater than 1.5mm per 50% of the joint length

MATERIAL 2 pieces 75 x 6 x 225mm low carbon steel plate

UNIT 1

ECONOMY Consumables and materials are expensive - relocate plates as shown for maximum use

Control data

Wir

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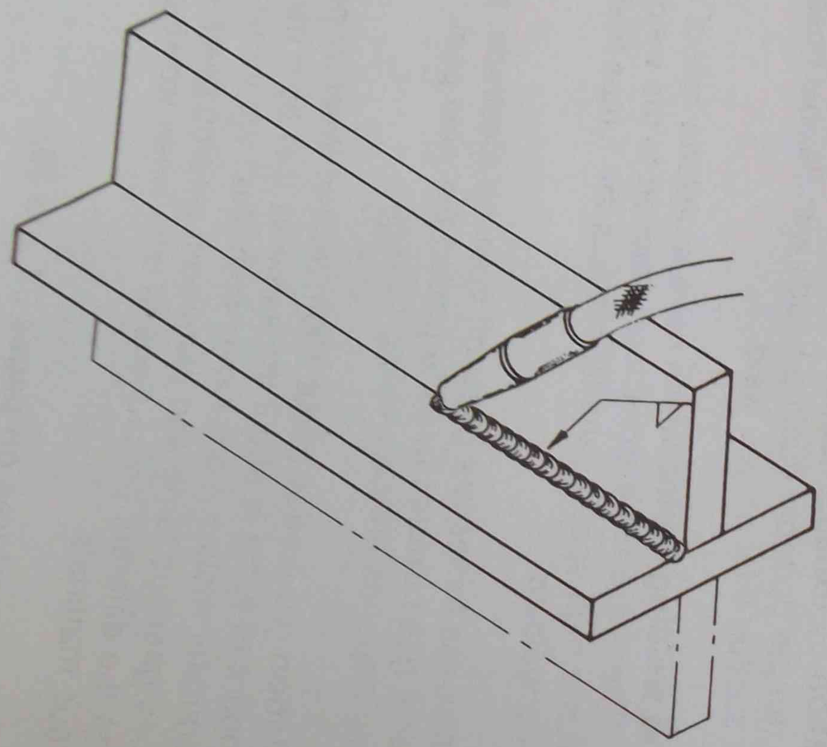
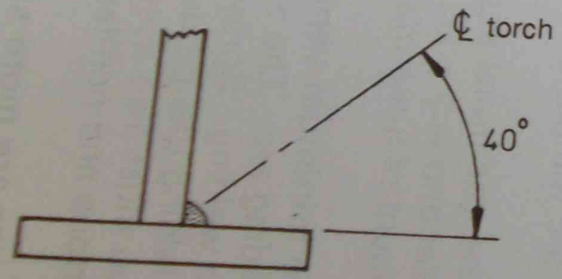
the standards specified. The skills you learn in this section
used for later exercises that are formally assessed.

SECTION 4: FILLET WELD - SINGLE RUN - HORIZONTAL





IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To develop the skills of electrode manipulation necessary to deposit a 6mm fillet weld to the requirements below

POSITION Horizontal

PROCEDURE Your teacher will demonstrate

METHOD

1. Wire brush the material to remove surface rust and loose mill scale
2. Tack both ends of the plate to ensure metal to metal contact
3. Complete about half the weld and examine appearance and profile before finishing the weld
4. Remove spatter and submit your exercise for inspection
5. Break the weld and resubmit your exercise for internal inspection
6. Relocate the plates for further practice using two new edges
7. Evaluate your weld exercise and complete the weld procedure sheet
8. Submit your work for assessment

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- a maximum of two significant weld defects per 250mm (or 225mm plate) of weld length with an accumulative area of less than twice the square of the plate thickness
- weld size 6^{+2}_{-0} mm
- complete fusion for the length of the weld joint
- undercut to be no greater than 1.5mm per 50% of the joint length

MATERIAL 2 pieces 75 x 6 x 225mm low carbon steel plate

UNIT 1

ECONOMY Consumables and materials are expensive - relocate plates as shown for maximum use

Safety procedures for gas metal arc welding: Part 2

DANGER

- The welding area should be **properly ventilated** and free from drafts that might affect the welding arc and shielding gas. Carbon tetrachloride, trichlorethylene or other chlorinated hydrocarbons should not be used for cleaning aluminium alloys before welding. Acetone and alcohol are recommended chemical cleaners but make sure surfaces are dry before welding. Do not weld in any area where there are fumes from such solvents.

- Do not weld near flammable or combustible materials. Degreasing aluminium alloys with acetone or other flammable solvents in a badly ventilated welding area creates a fire hazard.

- When gas metal arc welding with pure argon, ozone (O_3) is formed. Certain wavelengths of ultraviolet light emitted from the arcs produce O_3 at a high rate by transforming oxygen (O_2) to ozone (O_3). When welding aluminium and stainless steel in confined spaces, the reflecting metal surfaces can intensify the ultraviolet radiation. You should wear a **respirator** to protect you from toxic ozone.

- Natural ventilation may not be enough to control fumes when welding galvanised materials in confined spaces. You will need mechanical ventilation which can be:

General exhaust fans which help to reduce and dilute background fumes in the work area and direct fumes away from the operator.

Local exhaust ventilation by exhaust hoods, booths and extractors close to the fume source, for example portable ducting hoods with flexible hoses so that you can reposition the suction inlet as you weld.

Down draft ventilation welding tables which have a uniform rate of exhaust across the grille face. There are fume extractors attached to the welding gun near the arc. Low volume high speed exhaust extracts the fumes from around the arc without affecting welding.

In the gas metal arc process fumes are given off from the electrode, parent metal and any additional gas mixtures used to protect the weld pool. The amount of fume mainly depends on the welding current.

The **minimum ventilation** required is about 100m^2/min of fresh air per active welding arc. The amount of fume is about the same as that from manual metal arc welding. Spray transfer makes more fumes than short arc transfer. The shielding gas produces gaseous fume and aluminium welding gives off ozone. You must also assess the different precautions to take when working with ferrous and non-ferrous materials.

There are more safety procedures on pages 32 and 56.

TAFE

Section 5: Fillet weld - 3 run 2 layer - horizontal

Task: To deposit a multiple run horizontal fillet 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 have the skills to deposit multiple run fillets in the horizontal position as required by industry.

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

DANGER

Safety

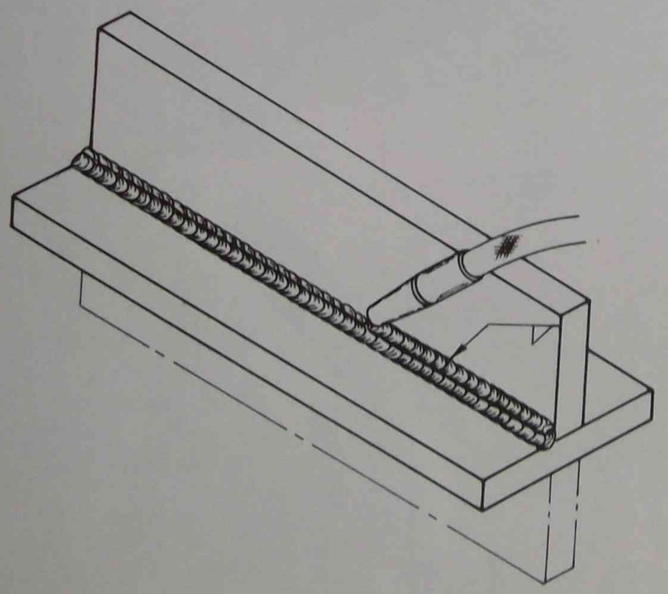
- Use an appropriate shade filter to protect your eyes
- Wear suitable clothing to protect your body

TAFE

PROCEDURE SHEET

SECTION 5: FILLET WELD - 3 RUN 2 LAYER - HORIZONTAL						
Sketch						
Machine type:						
		Control data				
Run	Wire speed	Amperage reading	Voltage control	Voltage reading	Transfer mode	
1						
2						
3						
4						
Electrode wire			Material data			
Size Ømm:			Type:			
Type:			Thickness:			
Classification:						
Shielding gas			Weld time			
Type:			Start:			
Flow rate: Litres/min:			Finish:			
			Units completed:			
Assessment		Complies		Doesn't comply		
Alignment and assembly						
Angular distortion						
Surface finish						
Weld size						
Surface defects						
Complete fusion						
Root penetration						
Undercut						
Name				Exercise No.		

SECTION 5: FILLET WELD - 3 RUN 2 LAYER - HORIZONTAL



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit a 3 run 2 layer fillet weld on low carbon steel using the gas metal arc welding process to the requirements listed below

POSITION Horizontal

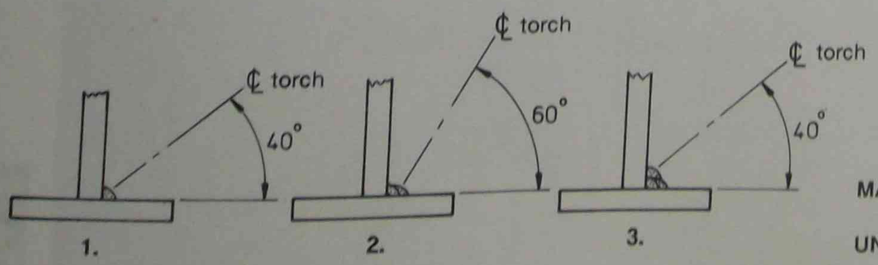
PROCEDURE Your teacher will demonstrate

METHOD

1. Set welding conditions and trial on scrap material
2. Wire brush the material to remove rust and loose scale
3. Assemble and tack weld both ends, ensuring metal to metal contact
4. Maintaining correct stickout and torch angle, deposit the first run
5. Critically examine the bead profile before placement of the second and third runs
6. Break the exercise and relocate for further practice
7. Flame cut and reposition for further practice
8. Evaluate your weld exercise and complete the procedure sheet

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- a maximum of two significant weld defects per 250mm (or 225mm plate) of weld length with an accumulative area of less than twice the square of the plate thickness
- weld size 10^{+2}_{-0} mm
- complete fusion for the length of the weld joint
- undercut to be no greater than 1.5mm per 50% of the weld length



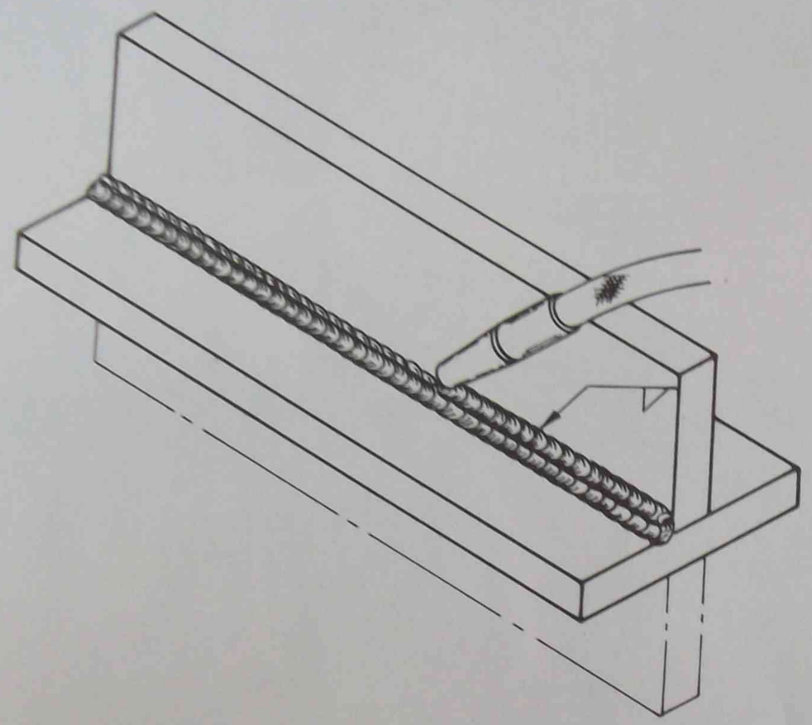
Layer sequence

MATERIAL 2 pieces 75 x 10 x 225mm low carbon steel plate

UNITS 3

ECONOMY Return all unused material to the store

SECTION 5: FILLET WELD - 3 RUN 2 LAYER - HORIZONTAL



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit a 3 run 2 layer fillet weld on low carbon steel using the gas metal arc welding process to the requirements listed below

POSITION Horizontal

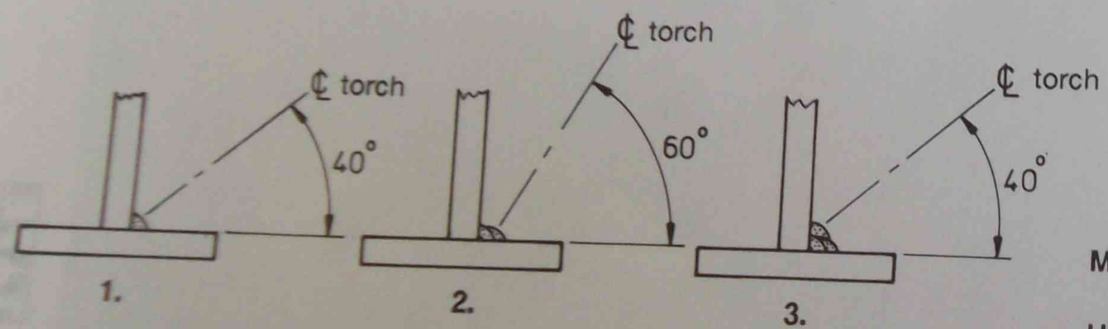
PROCEDURE Your teacher will demonstrate

METHOD

1. Set welding conditions and trial on scrap material
2. Wire brush the material to remove rust and loose scale
3. Assemble and tack weld both ends, ensuring metal to metal contact
4. Maintaining correct stickout and torch angle, deposit the first run
5. Critically examine the bead profile before placement of the second and third runs
6. Break the exercise and relocate for further practice
7. Flame cut and reposition for further practice
8. Evaluate your weld exercise and complete the procedure sheet

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- a maximum of two significant weld defects per 250mm (or 225mm plate) of weld length with an accumulative area of less than twice the square of the plate thickness
- weld size 10^{+2}_{-0} mm
- complete fusion for the length of the weld joint
- undercut to be no greater than 1.5mm per 50% of the weld length



Layer sequence

MATERIAL 2 pieces 75 x 10 x 225mm low carbon steel plate

UNITS 3

ECONOMY Return all unused material to the store

Depositing a fillet weld in the horizontal position

Section 6: Fillet weld - angle to plate - horizontal

Task: To deposit multiple run fillet welds on low carbon steel angle to 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 fillet weld flat and rolled steel structural sections in the horizontal position as required by industry.

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

DANGER

Safety

- Follow OH&S workshop procedures at all times. You teacher will tell you what they are.
- Untidy workshops can cause accidents. Make sure you clean up when you've finished a job.

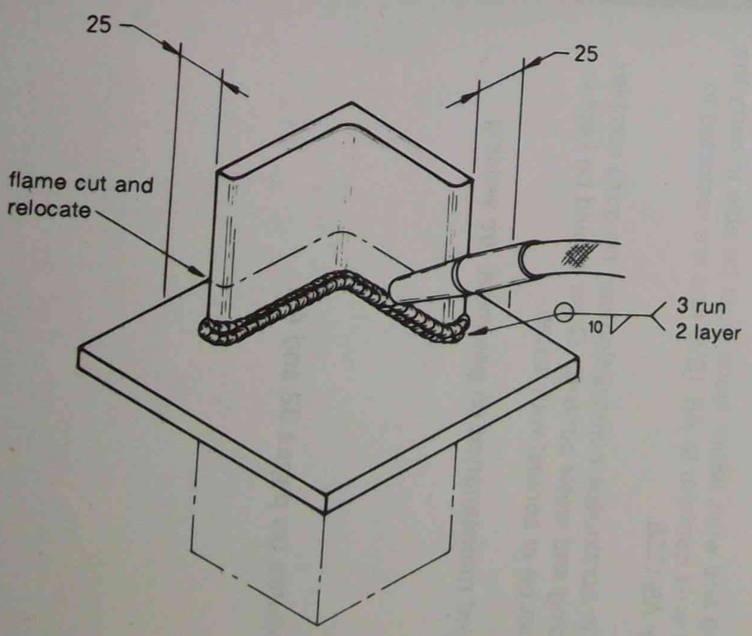
PROCEDURE SHEET

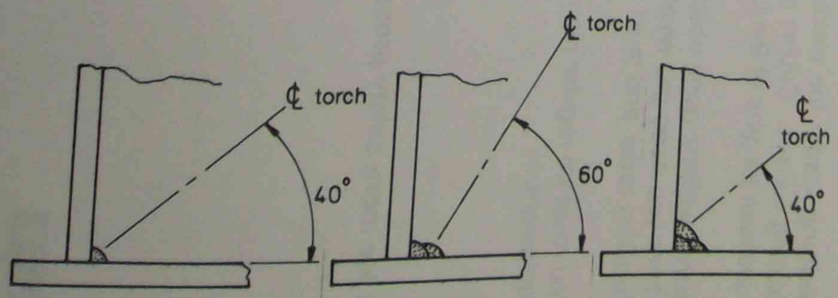
SECTION 6: FILLET WELD - ANGLE TO PLATE - HORIZONTAL						
Sketch						
Machine type:						
		Control data				
Run	Wire speed	Amperage reading	Voltage control	Voltage reading	Transfer mode	
1						
2						
3						
4						
Electrode wire Size Ømm: Type: Classification:				Material data Type: Thickness:		
Shielding gas Type: Flow rate: Litres/min:				Weld time Start: Finish: Units completed:		
Assessment		Complies			Doesn't comply	
Alignment and assembly						
Angular distortion						
Surface finish						
Weld size						
Surface defects						
Undercut						
Name					Exercise No.	

TAFE

April 1991

SECTION 6: FILLET WELD - ANGLE TO PLATE - HORIZONTAL





weld-layer sequence

IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE Deposit a 3 run 2 layer fillet weld using the gas metal arc welding process on angle section to plate

POSITION Horizontal

PROCEDURE Your teacher will demonstrate

METHOD

1. Assemble and tack weld the angle section to plate
2. Establish a weld procedure and finalise the first run
3. Submit the assembly for inspection
4. Using a three run, two layer technique complete the weld and submit for inspection
5. Mark out and flame cut the angle section to allow for further practice
6. Relocate the section on the opposite side of the plate and repeat the exercise
7. Evaluate your weld exercise and complete the weld procedure sheet
8. Submit your work for assessment

REQUIREMENTS

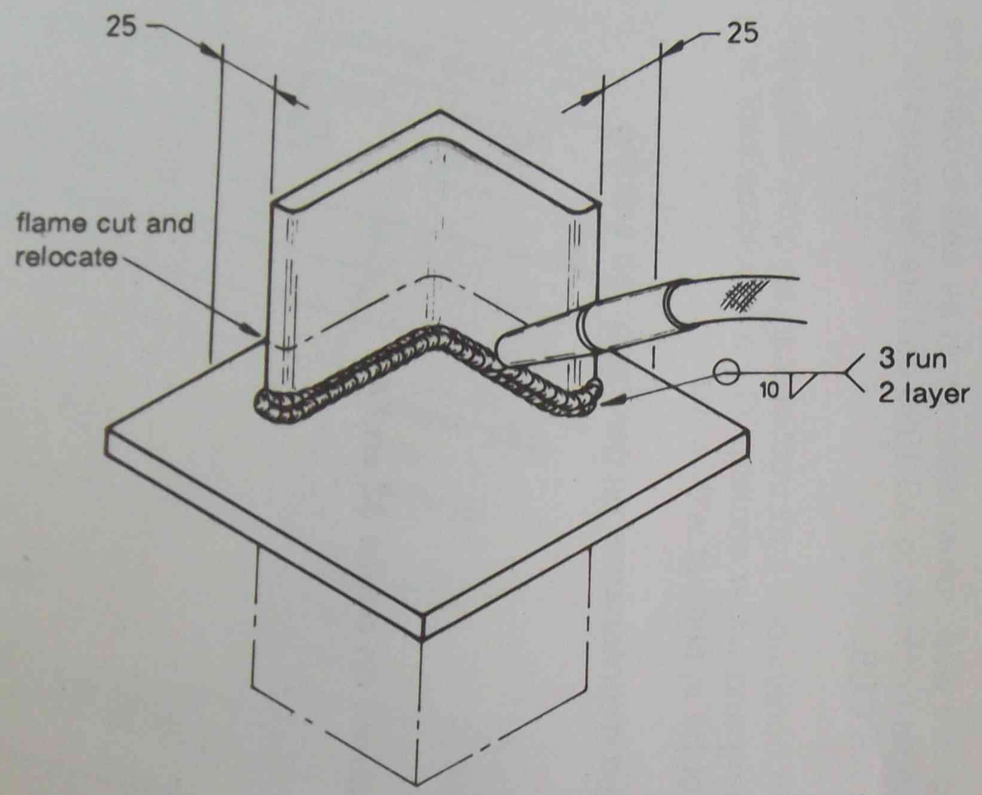
- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- a maximum of two significant weld defects per 250mm of weld length with an accumulative area of less than twice the square of the plate thickness
- weld size 10^{+2}_{-0} mm
- undercut to be no greater than 1.5mm per 50% of the weld length

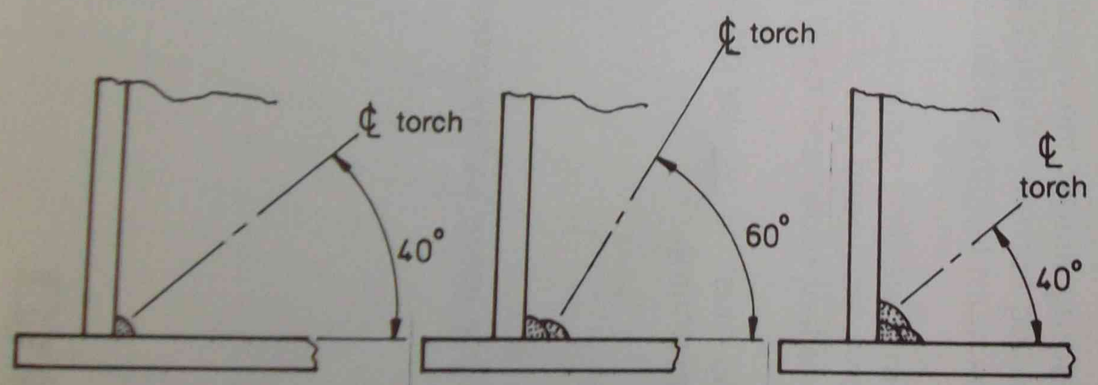
MATERIAL 1 piece 150 x 10 x 150mm low carbon steel plate
1 piece 75 x 75 x 10mm ASEA

UNITS 2

ECONOMY Return unused material to the store
Cut angle and reposition to gain maximum use from material

SECTION 6: FILLET WELD - ANGLE TO PLATE - HORIZONTAL





weld-layer sequence

IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE Deposit a 3 run 2 layer fillet weld using the gas metal arc welding process on angle section to plate

POSITION Horizontal

PROCEDURE Your teacher will demonstrate

METHOD

1. Assemble and tack weld the angle section to plate
2. Establish a weld procedure and finalise the first run
3. Submit the assembly for inspection
4. Using a three run, two layer technique complete the weld and submit for inspection
5. Mark out and flame cut the angle section to allow for further practice
6. Relocate the section on the opposite side of the plate and repeat the exercise
7. Evaluate your weld exercise and complete the weld procedure sheet
8. Submit your work for assessment

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- a maximum of two significant weld defects per 250mm of weld length with an accumulative area of less than twice the square of the plate thickness
- weld size 10^{+2}_{-0} mm
- undercut to be no greater than 1.5mm per 50% of the weld length

MATERIAL 1 piece 150 x 10 x 150mm low carbon steel plate
1 piece 75 x 75 x 10mm ASEA

UNITS 2

ECONOMY Return unused material to the store
Cut angle and reposition to gain maximum use from material

Safety procedures for gas metal arc welding: Part 3

- **Welding machines**

Direct current machine - supply of direct current by generators (driven by electric motors, petrol or diesel engines).
Transformer/rectifier - supply of alternating and/or direct current as designed.

Arc welding machines should be manufactured and tested to AS 1966 or equivalent standard. They must show a clearly visible nameplate stating the operating conditions of the machine (eg 300 amps, 32 volts, 60% duty cycle).

Although welding machines can supply a wide range of current, they generally operate within the following ranges:

Arc Voltage 16 to 35 V
Open Circuit Voltage (OCV) 50-80V AC
Open Circuit Voltage (OCV) 115 DC

OCV is restricted by Australian Standards AS 1966, AS CC5 and AS MP17.

- **Wire feeders:** where wire feed equipment is used with continuous wire processors, it should be installed and maintained in a safe condition to the manufacturer's recommendations. Particular notice should be taken of the possibility of contact with high voltages and the need for suitable earthing.

- **Welding leads:** the welding and work return leads must be able to carry the welding current. Cables should conform to AS 1995 and are restricted to maximum lengths of 9m by AS CC5.

- **Guns:** welding guns used in continuous construction can be quite complex where you need gas shielding and water cooling. Guns should be kept in excellent order and must not be in contact with water.

- You must do regular planned **maintenance** on gas metal arc welding equipment.

There are more safety procedures on pages 32 and 48.

Section 7: *Effects of gas metal arc welding variables*

Task: To understand the effects of gas metal arc welding variables on welding. This section covers parts of learning outcomes 2 and 3 of the National Module Descriptor.

Why? So you can use this knowledge in a practical environment to set up and maintain ideal operating conditions for welding carbon steels.

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

Technical information

If you don't understand any part of this section, ask your teacher for help.

1. Variables

A variable is a change that can be made to the operating conditions of a welding process.

The variables in the gas metal arc welding process are:

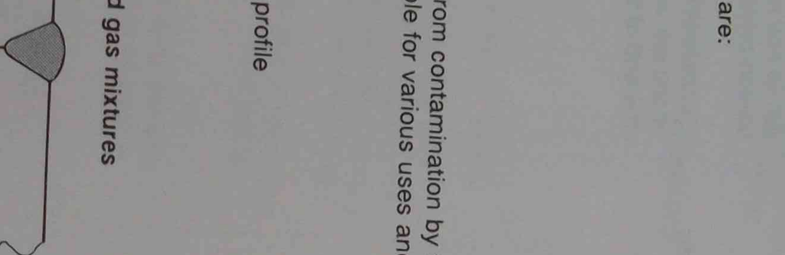
- *gas mixtures*
- *wire feed speed*
- *current density deposition rate (wire size)*
- *arc voltage*
- *stickout*
- *travel speed*

2. Gas mixtures

Shielding gases are used to protect the molten weld from contamination by the atmosphere during welding. Gas mixtures are available for various uses and conditions. They are used for:

- *welding light sheet structures*
- *welding heavy structural fabrications*
- *controlling spatter levels*
- *improving or obtaining a certain type of weld bead profile*
- *increasing the depth of weld penetration*
- *increasing the speed of welding*

Typical weld bead profiles produced by common gas and gas mixtures



Effects of shielding gases on weld bead shape
The recommended flow rates for gas mixtures for general workshop use range from 14 to 18 litres per minute.

***Note:** A heater is not required for a mixture of carbon dioxide and argon.*

Characteristics and uses of gas mixtures

Gas mixture %			Characteristics	Uses
carbon dioxide	oxygen	argon		
		99.99	▪ Limited penetration with a good surface finish ▪ Not recommended for welding carbon steels	Aluminium and non-ferrous materials
5	3	92	▪ Active gas addition that produces a rapid freezing with low spatter levels for positional welding, medium penetration	Light medium steels, for example motor vehicle repair, sheetmetal fabrications, light structural work
16	2.5	81.5	▪ Produces a hot arc with deep penetration ▪ High deposition rates ▪ For welding medium to heavy steel section ▪ Medium spatter levels	Medium to heavy sections, for example heavy structural steels, earthmoving equipment and machine bases
23		77	▪ A single active gas addition ▪ Hot arc with deep penetration ▪ Medium spatter levels ▪ For welding alloyed steels	Light to heavy sections, for example chrome, molybdenum steels, quench and tempered steels
100			▪ Welding grade CO2 gives a hot arc ▪ Deep penetration ▪ Because of levels and poor contour it's used where weld finishes are not critical	Medium to heavy sections, for example all low carbon steels and carbon steels and carbon - manganese steels.

Characteristics and uses of gas mixtures

Gas mixture %			Characteristics	Uses
carbon dioxide	oxygen	argon		
		99.99	▪ Limited penetration with a good surface finish ▪ Not recommended for welding carbon steels	Aluminium and non-ferrous materials
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16	2.5	81.5	▪ Produces a hot arc with deep penetration ▪ High deposition rates ▪ For welding medium to heavy steel section ▪ Medium spatter levels	Medium to heavy sections, for example heavy structural steels, earthmoving equipment and machine bases
23		77	▪ A single active gas addition ▪ Hot arc with deep penetration ▪ Medium spatter levels ▪ For welding alloyed steels	Light to heavy sections, for example chrome, molybdenum steels, quench and tempered steels
100			▪ Welding grade CO2 gives a hot arc ▪ Deep penetration ▪ Because of levels and poor contour it's used where weld finishes are not critical.	Medium to heavy sections, for example all low carbon steels and carbon steels and carbon - manganese steels.

3. Wire feed speed

Wire feed is controlled by the wire feed unit which is part of the gas metal arc welding plant. You can adjust the wire speed to increase or reduce the feed rate to suit a particular job.

Because of the characteristics of constant potential power sources the welding current output is directly proportional to the wire feed speed (increasing the wire feed speed automatically increases the amperage).

4. Current density deposition rate

The rate of metal transfer is proportional to the current and current density.

Current density is the current per cross sectional area of the electrode wire and is expressed as amperes per mm^2. At a given current there is much higher current density with 0.9mm diameter wire than with 1.2mm diameter wire.

$$\text{Current Density} = \frac{\text{Amperage}}{\text{Cross sectional area}}$$

Wire size in mm	Cross section area mm	Current amps	Current density Amps/mm^2	Deposition rate (kg/hr)
0.9	0.636	200	$\frac{200}{0.636} = 314.46$	higher
1.2	1.130	200	$\frac{200}{1.13} = 176.99$	lower

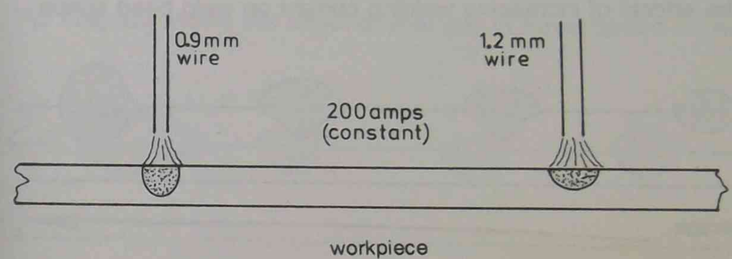
Note: The higher the current density the greater the deposition rate.

The metal deposition rate can be increased by using a thinner wire (giving a higher current density) at the same amperage
or
by using the same wire size but increasing the current.

However there are limitations on how much the current can be increased. Too much current vaporises the wire and practically no transfer takes place.

Machine capacity and duty cycles also determine the upper limit of current. High currents produce very fluid weld pools which make out of position work very difficult. Higher current density (or smaller diameter wire) also gives deeper penetration - see below.

Comparison of wire diameter to current density

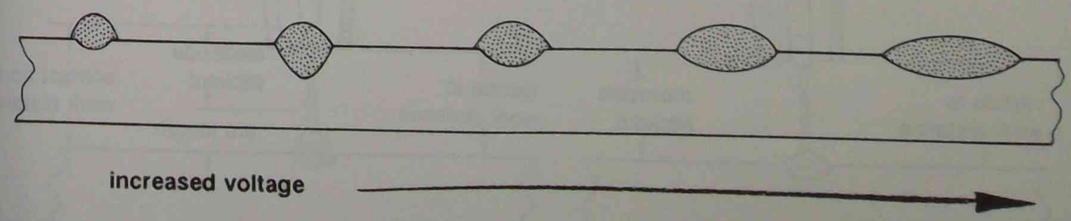


5. Arc voltage

Arc voltage controls the arc length. An increase of voltage increases the arc length and the width of arc at the work surface. It also increases the heat of the arc (if current is maintained) so there is a small increase in deposition rate, even though radiation heat losses are greater.

Increasing arc voltage:
- increases bead width
- increases arc heat
- reduces (flattens) bead height

The diagram shows the effect of arc voltage on weld bead shape and level of penetration:



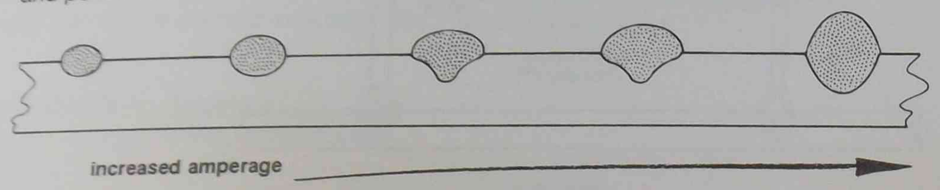
6. Welding current

Welding current is controlled by the wire feed speed. An increase in wire speed will give you:

- an increase in current
- increased penetration
- increased deposition
- increased bead size

It has only a minor effect on bead width. A change of wire size produces a change in current density for any selected current. Higher current densities (reducing wire size) give a more forceful arc and increase penetration and deposition rates.

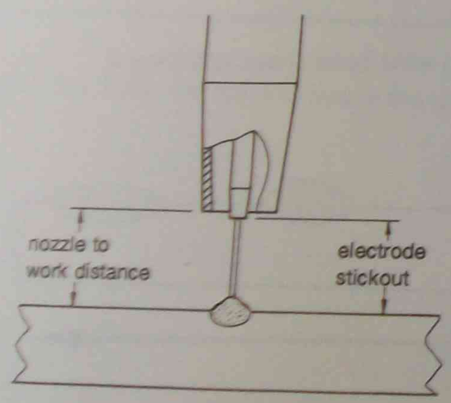
The diagram shows the effects of increasing welding current on weld bead shape and penetration:



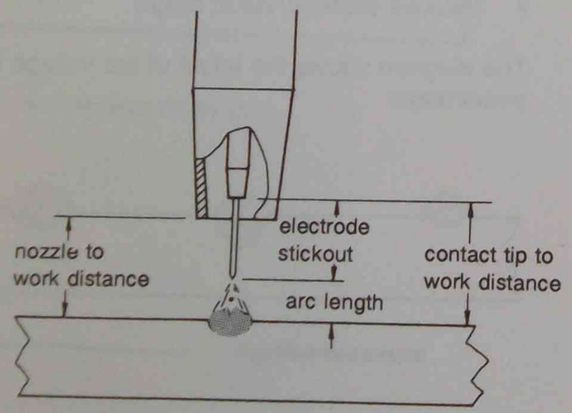
7. Stickout

Electrical stickout is the term used to describe the distance of the wire from the contact tip to the workpiece. An increase in stickout increases the preheat of the wire, reduces heat to the arc pool, slows the melting of the parent metal and decreases penetration.

Variations of stickout can be used by the operator to control the heat input to the workpiece. For example, an increase in stickout automatically reduces the heat input by lowering the current. This can be used to overcome the difficulties of bridging root gap openings from poor fit-ups.



short arc electrode stickout



spray arc electrode stickout

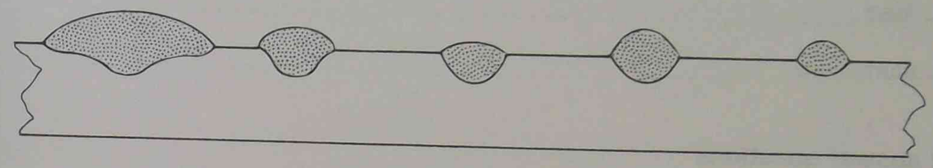
8. Travel speed

This variable contributes to the rate of heat input and amount of deposited metal per metre of weld. A smaller bead is produced as travel speed increases. At very low speeds there is a small increase in penetration, its effect reaches a maximum of some 400-500mm per minute and decreases after that.

Travel speed influences:

- bead height and width
- heat input rate/metre
- deposition rate (volume of metal)

The diagram shows the effect of changes in travel speed on weld profiles:



Review questions

These questions will help you revise what you've learnt in Section 8. The answers are on page 120.

Multiple choice question

1. Circle the appropriate answer **a, b, c, d.**

   Argon is the most suitable shielding gas for gas metal arc welding which of the following metals?

   a. steel

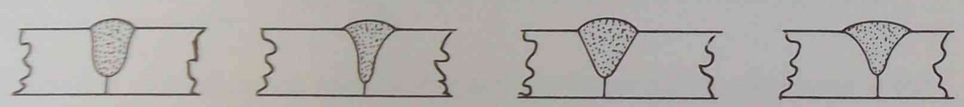
   b. cast-iron

   c. lead

   d. aluminium

Short answer questions

2. Shielding gases have varying effects on weld bead shape and depth of penetration. In the space provided list the shielding gas used for each profile shown below:



a. ..... b. ..... c. ..... d. .....

3. When welding with a gas metal arc what effect would increasing the electrode stickout have on the amperes (current) and volts?

   a. Current: .....

   b. Volts: .....

4. Using the following equation provide the current density for 1.0mm diameter wire.

   $$\text{Current Density} = \frac{\text{Amperage}}{\text{Cross sectional area}}$$

Wire size	Cross sectional area mm^2	Amperes	Current density
1.0	0.785	220	

5. Briefly describe the effect on the weld if the gas flow is too high:

   .....

   .....

Notes

Section 8 Corner fillet - horizontal

Task: To deposit a multiple run corner fillet 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 deposit corner fillet welds on low carbon steel plate as required by industry.

To pass: You'll be expected to deposit safely a multiple run fillet weld on low carbon steel plate in the horizontal position to the requirements specified on the work sheet for this section.

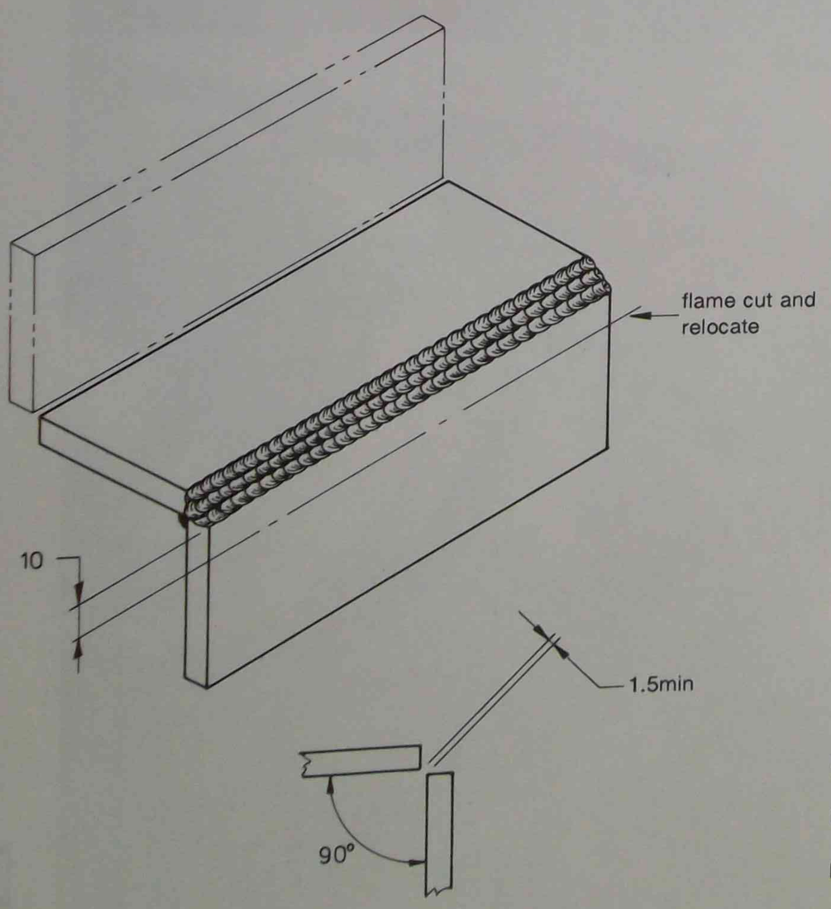
Safety

- Follow OH&S procedures in the workshop.
- Wear approved protective clothing. Don't wear clothes made from nylon material.

PROCEDURE SHEET

SECTION 8: CORNER FILLET 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	
Alignment and assembly						
Angular distortion						
Surface finish						
Weld size						
Surface defects						
Full radius						
Undercut						
Name					Exercise No.	

SECTION 8: CORNER FILLET WELD - HORIZONTAL



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit multiple run corner welds in the horizontal position using fillet welding techniques to the requirements below

POSITION Horizontal

PROCEDURE Your teacher will demonstrate

METHOD

1. Assemble and tack plates using a suitable spacer to maintain root gap
2. Position the plates and deposit approximately 50mm of the root run
3. Examine the bead shape and penetration before continuing the weld
4. Completely fill the remainder of the weld in a logical weld sequence
5. Seal the reverse side with a 6mm horizontal fillet weld
6. After inspection, flame cut the plate and relocate as shown
7. Evaluate your weld exercise and complete the weld procedure sheet
8. Submit your work for assessment

REQUIREMENTS

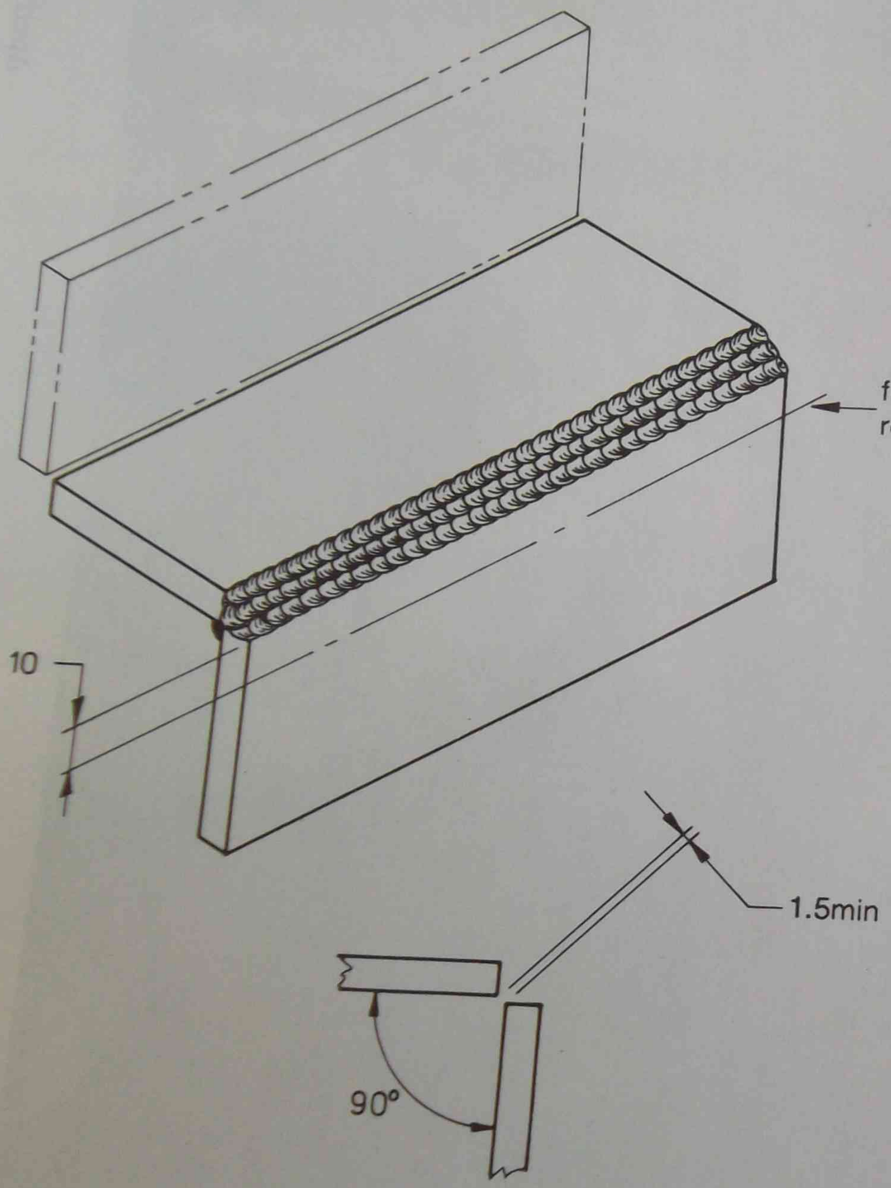
- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- a maximum of two significant weld defects per 250mm (or 225mm plate) of weld length with an accumulative area of less than twice the square of the plate thickness
- weld size 8^{+2}_{-0} mm
- undercut to be no greater than 1.5mm per 50% of the weld length

MATERIAL 2 pieces 50 x 10 x 225mm low carbon steel

UNITS 2

ECONOMY Return unused material to the store
Flame cut material for maximum use as shown

SECTION 8: CORNER FILLET WELD - HORIZONTAL



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit multiple run corner welds in the horizontal position using fillet welding techniques to the requirements below

POSITION Horizontal

PROCEDURE Your teacher will demonstrate

METHOD

1. Assemble and tack plates using a suitable spacer to maintain root gap
2. Position the plates and deposit approximately 50mm of the root run
3. Examine the bead shape and penetration before continuing the weld
4. Completely fill the remainder of the weld in a logical weld sequence
5. Seal the reverse side with a 6mm horizontal fillet weld
6. After inspection, flame cut the plate and relocate as shown
7. Evaluate your weld exercise and complete the weld procedure sheet
8. Submit your work for assessment

REQUIREMENTS

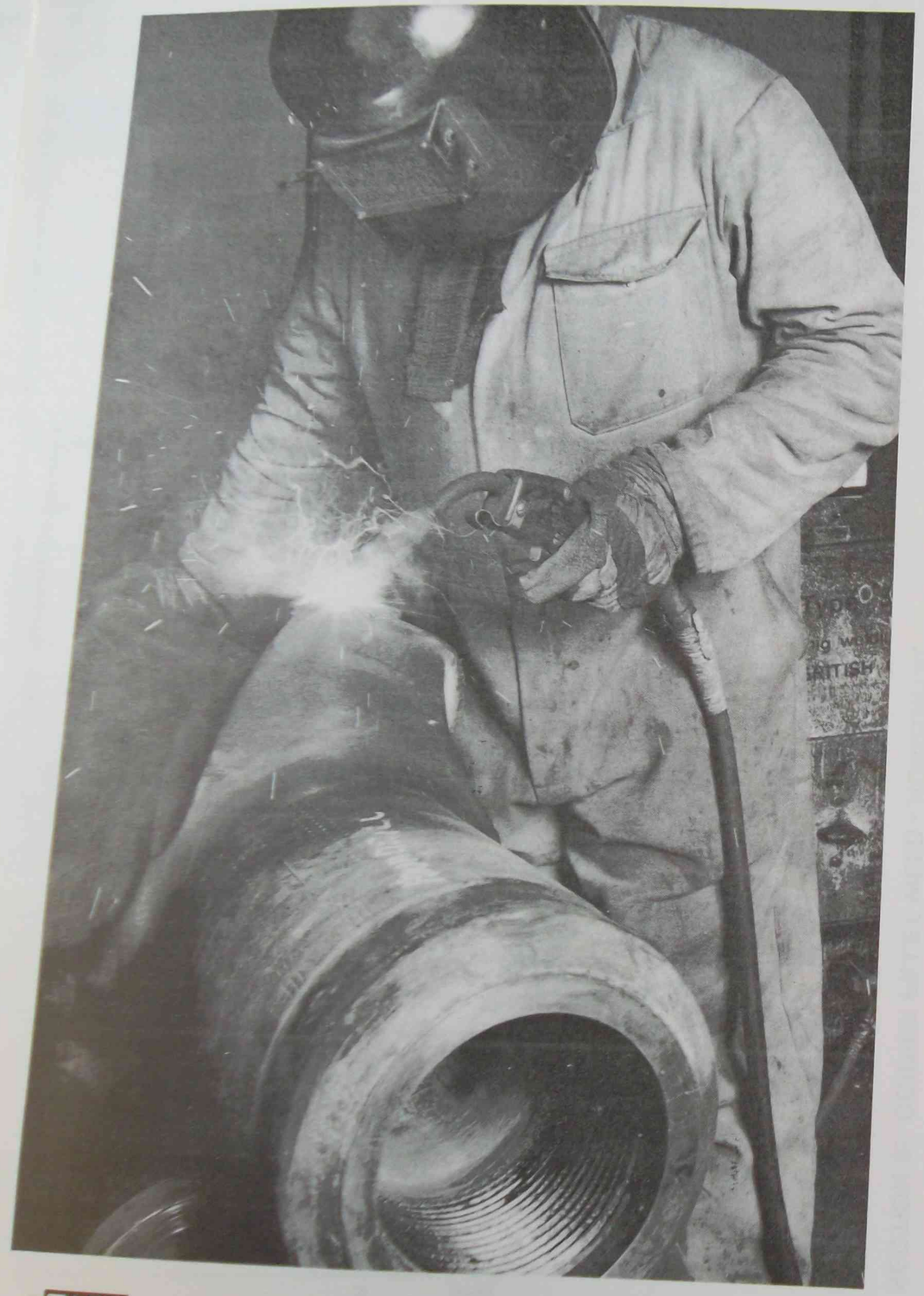
- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- a maximum of two significant weld defects per 250mm (or 225mm plate) of weld length with an accumulative area of less than twice the square of the plate thickness
- weld size 8^{+2}_{-0} mm
- undercut to be no greater than 1.5mm per 50% of the weld length

MATERIAL 2 pieces 50 x 10 x 225mm low carbon steel

UNITS 2

ECONOMY Return unused material to the store
Flame cut material for maximum use as shown

An industrial use of gas metal arc welding



Section 9: Fillet weld - sheet steel - horizontal

Task: To deposit single run fillet welds on low carbon sheet steel in the horizontal position. This section covers part of learning outcome 3 of the National Module Descriptor.

Why? So you'll be able to deposit fillet welds on sheet steel sections as required by industry.

To pass: You'll be expected to deposit safely a single run fillet weld on low carbon sheet steel to the requirements specified on the work sheet for this section.

Safety

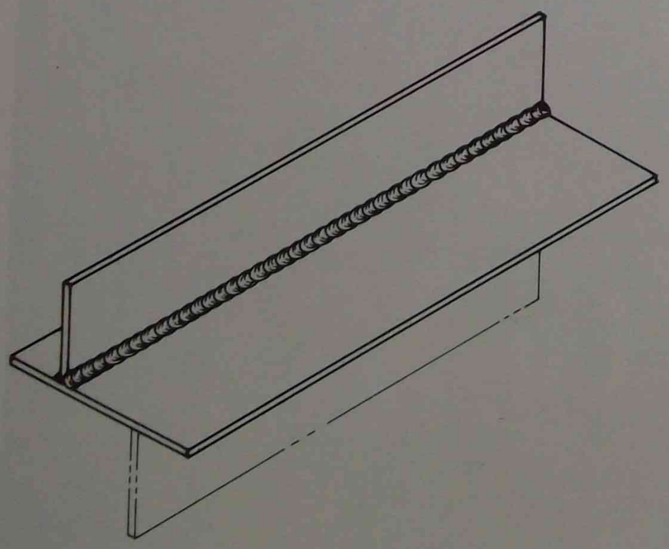
- Follow OH&S procedures in the workshop
- Don't put plastic lighters in your pockets - they can **explode**
- Clean up your area when you've finished working

PROCEDURE SHEET

SECTION 9: FILLET WELD - SHEET STEEL - HORIZONTAL					
Sketch					
Machine type:					
	Control data				
Run	Wire speed	Amperage reading	Voltage control	Voltage reading	Transfer mode
1					
2					
3					
4					
Electrode wire			Material data		
Size Ømm:			Type:		
Type:			Thickness:		
Classification:					
Shielding gas			Weld time		
Type:			Start:		
Flow rate: Litres/min:			Finish:		
			Units completed:		
Assessment			Complies		Doesn't comply
Alignment and assembly					
Angular distortion					
Surface finish					
Weld size					
Surface defects					
Undercut					
Name			Exercise No.		

SECTION 9: FILLET WELD - SHEET STEEL - HORIZONTAL

IF IN DOUBT ASK YOUR TEACHER



OBJECTIVE To deposit single run fillet welds in the horizontal position on low carbon steel sheet to meet the requirements listed below

POSITION Horizontal

PROCEDURE Your teacher will demonstrate

METHOD

1. Wire brush the material
2. Assemble and tack sheets
3. Deposit fillet weld along the weld joint
4. Critically evaluate the weld before welding the other side
5. Add an additional sheet (side 2) and repeat the process
6. Repeat the exercise on 1.6mm and 1.2mm sheet and submit assemblies for assessment
7. Document welding parameters on your procedure sheet

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness
- weld size to equal to the sheet thickness $^{+2}_{-0}$ mm
- undercut to be no greater than 1mm per 50% of the weld length

MATERIAL

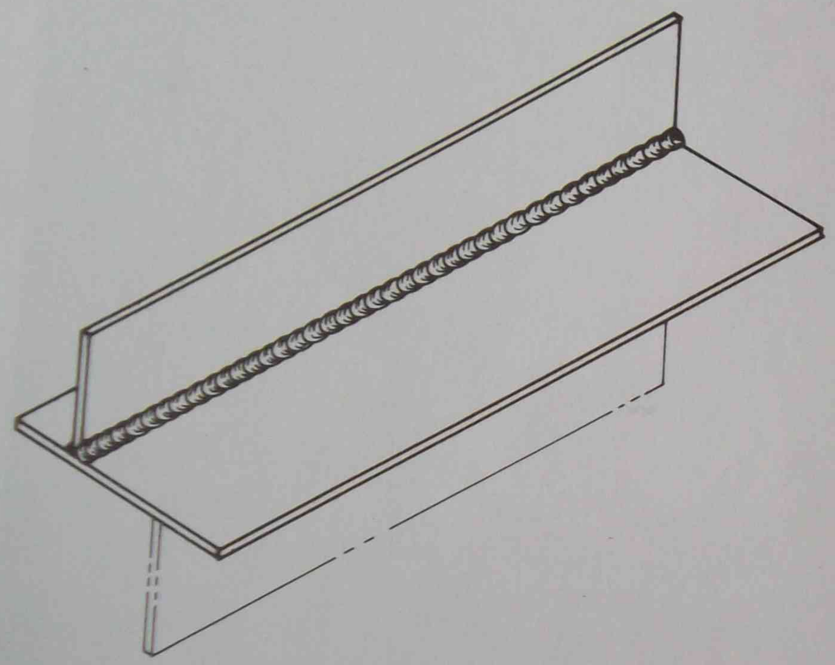
2 pieces low carbon steel 75 x 3 x 225mm sheet
2 pieces low carbon steel 25 x 3 x 225mm sheet
2 pieces low carbon steel 75 x 1.6 x 225mm sheet
2 pieces low carbon steel 25 x 1.6 x 225mm sheet
2 pieces low carbon steel 75 x 1.2 x 225mm sheet
2 pieces low carbon steel 25 x 1.2 x 225mm sheet

UNITS 2

ECONOMY Use stock fully and remember to turn cylinders off after you've finished

SECTION 9: FILLET WELD - SHEET STEEL - HORIZONTAL

IF IN DOUBT ASK YOUR TEACHER



OBJECTIVE

To deposit single run fillet welds in the horizontal position on low carbon steel sheet to meet the requirements listed below

POSITION

Horizontal

PROCEDURE

Your teacher will demonstrate

METHOD

1. Wire brush the material
2. Assemble and tack sheets
3. Deposit fillet weld along the weld joint
4. Critically evaluate the weld before welding the other side
5. Add an additional sheet (side 2) and repeat the process
6. Repeat the exercise on 1.6mm and 1.2mm sheet and submit assemblies for assessment
7. Document welding parameters on your procedure sheet

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness
- weld size to equal to the sheet thickness $^{+2}_{-0}$ mm
- undercut to be no greater than 1mm per 50% of the weld length

MATERIAL

2 pieces low carbon steel 75 x 3 x 225mm sheet
2 pieces low carbon steel 25 x 3 x 225mm sheet
2 pieces low carbon steel 75 x 1.6 x 225mm sheet
2 pieces low carbon steel 25 x 1.6 x 225mm sheet
2 pieces low carbon steel 75 x 1.2 x 225mm sheet
2 pieces low carbon steel 25 x 1.2 x 225mm sheet

UNITS

2

ECONOMY

Use stock fully and remember to turn cylinders off after you've finished

Fillet welding using the gas metal arc welding process

Section 10: Fillet weld - sheet steel - horizontal and vertical

Task: To deposit single run fillet welds on low carbon sheet steel in the horizontal and vertical position. This section covers part of learning outcome 3 of the National Module Descriptor.

Why? So you'll be able to deposit fillet welds on sheet steel section as required by industry.

To pass: You'll be expected to deposit safely a single run fillet weld on low carbon sheet steel to the requirements specified on the work sheet for this section.

DANGER

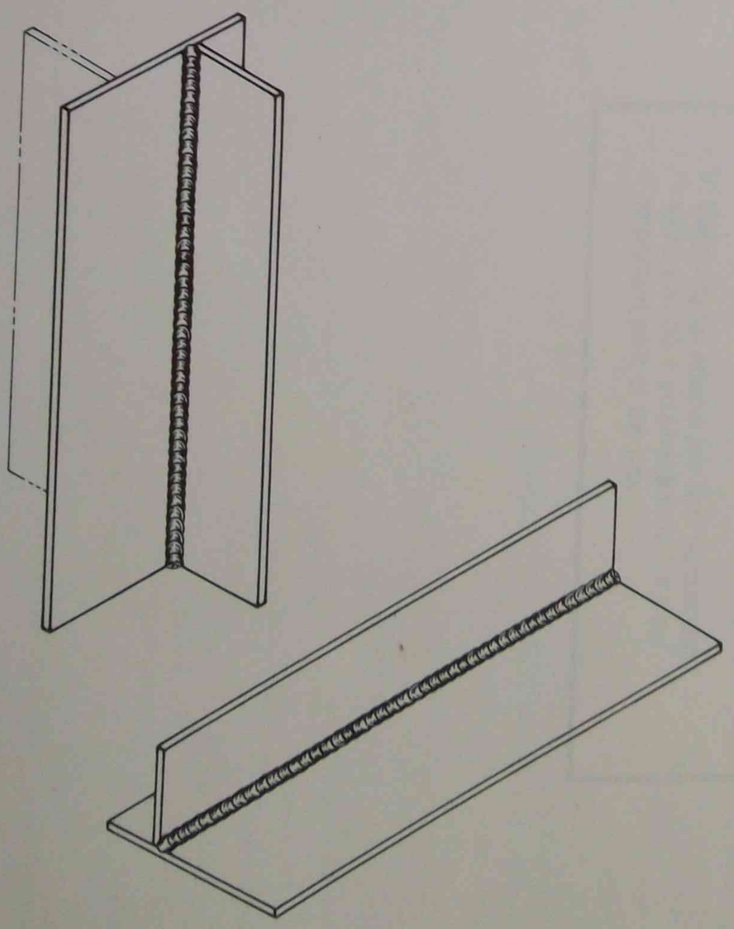
Safety

- Follow OH&S procedures at all times
- Wear correct footwear in the workshop area - no joggers
- Wear clothing made from fire-resistant fibres such as wool and cotton not from nylon material
- Don't wear clothing that has come into contact with any flammable substances such as petrol, diesel, oil or solvents.

PROCEDURE SHEET

SECTION 10: FILLET WELD - SHEET STEEL - HORIZONTAL AND VERTICAL						
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	
Alignment and assembly						
Angular distortion						
Surface finish						
Weld size						
Surface defects						
Undercut						
Name				Exercise No.		

SECTION 10: FILLET WELD - SHEET STEEL - HORIZONTAL AND VERTICAL



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit single run fillet welds on low carbon sheet steel to meet the requirements listed below

POSITION Vertical down and horizontal

PROCEDURE Your teacher will demonstrate

METHOD

1. Wire brush the material to remove surface rust and loose mill scale
2. Assemble and tack plates
3. Deposit fillet weld along the weld joint
4. Critically evaluate the weld before welding the other side
5. Add an additional sheet (side 2) and repeat the process
6. Repeat the exercise and submit assemblies for assessment
7. Complete your procedure sheet

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness
- weld size equal to the sheet thickness 3^{+2}_{-0} mm
- undercut to be no greater than 1mm per 50% of the weld length

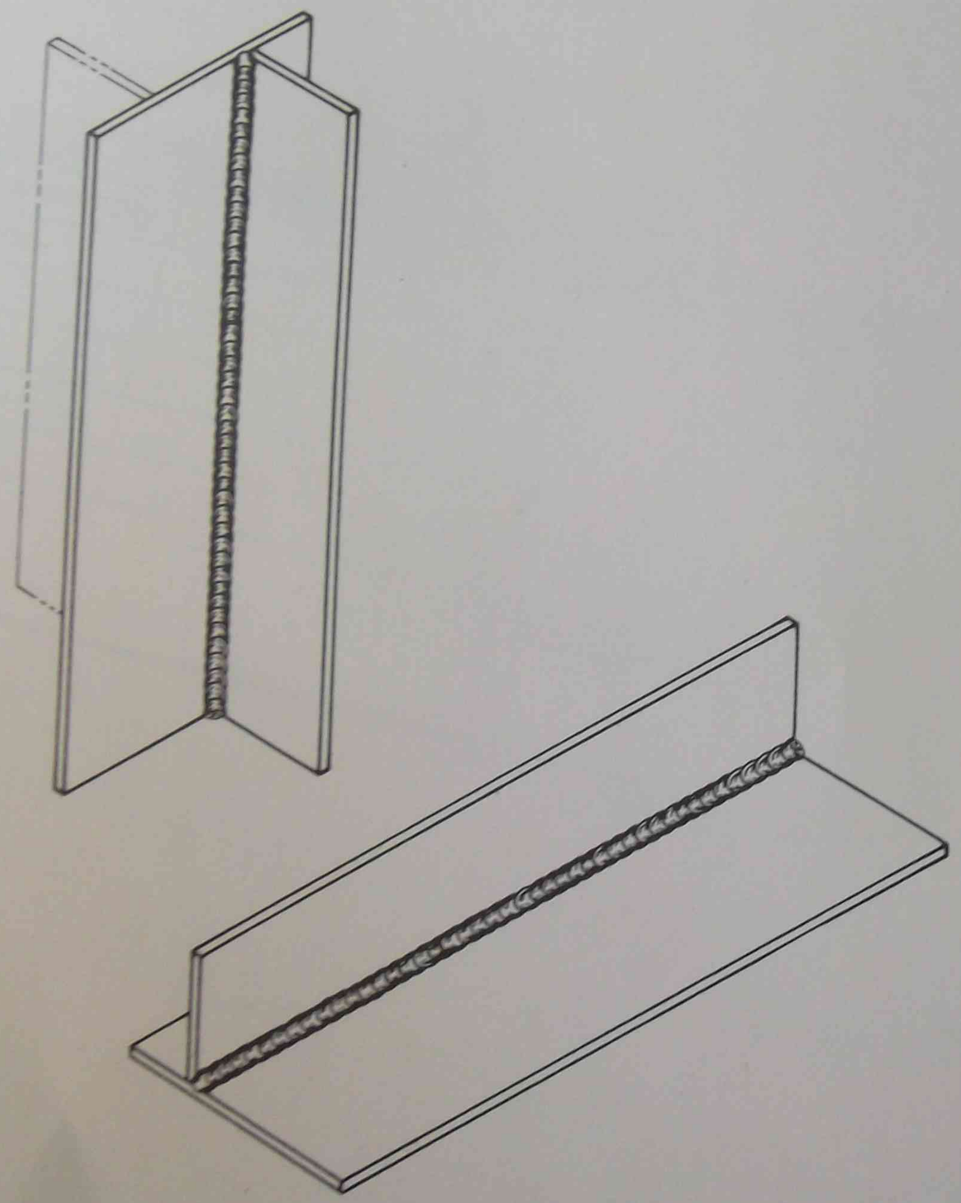
MATERIAL

2 pieces low carbon steel 75 x 3 x 225mm sheet
2 pieces low carbon steel 25 x 3 x 225mm sheet
2 pieces low carbon steel 75 x 1.6 x 225mm sheet
2 pieces low carbon steel 25 x 1.6 x 225mm sheet

UNITS 2

ECONOMY Use stock fully and remember to turn shielding gas cylinders off after you've finished

SECTION 10: FILLET WELD - SHEET STEEL - HORIZONTAL AND VERTICAL



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE	To deposit single run fillet welds on low carbon sheet steel to meet the requirements listed below
POSITION	Vertical down and horizontal
PROCEDURE	Your teacher will demonstrate
METHOD	1. Wire brush the material to remove surface rust and loose mill scale 2. Assemble and tack plates 3. Deposit fillet weld along the weld joint 4. Critically evaluate the weld before welding the other side 5. Add an additional sheet (side 2) and repeat the process 6. Repeat the exercise and submit assemblies for assessment 7. Complete your procedure sheet
REQUIREMENTS	▪ correct alignment and assembly ▪ smooth regular weld contour ▪ angular distortion 0° to 5° ▪ a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness ▪ weld size equal to the sheet thickness 3^{+2}_{-0} mm ▪ undercut to be no greater than 1mm per 50% of the weld length
MATERIAL	2 pieces low carbon steel 75 x 3 x 225mm sheet 2 pieces low carbon steel 25 x 3 x 225mm sheet 2 pieces low carbon steel 75 x 1.6 x 225mm sheet 2 pieces low carbon steel 25 x 1.6 x 225mm sheet
UNITS	2
ECONOMY	Use stock fully and remember to turn shielding gas cylinders off after you've finished

otes

Section 11: Corner fillet - sheet steel - horizontal and vertical

Task: To deposit corner fillet welds on low carbon sheet steel in the horizontal and vertical positions. This section covers part of learning outcome 3 of the National Module Descriptor.

Why? So you'll be able to deposit fillet welds on sheet steel sections as required by industry.

To pass: You'll be expected to deposit safely single run fillet welds on low carbon sheet steel to the requirements specified on the work sheet for the section.

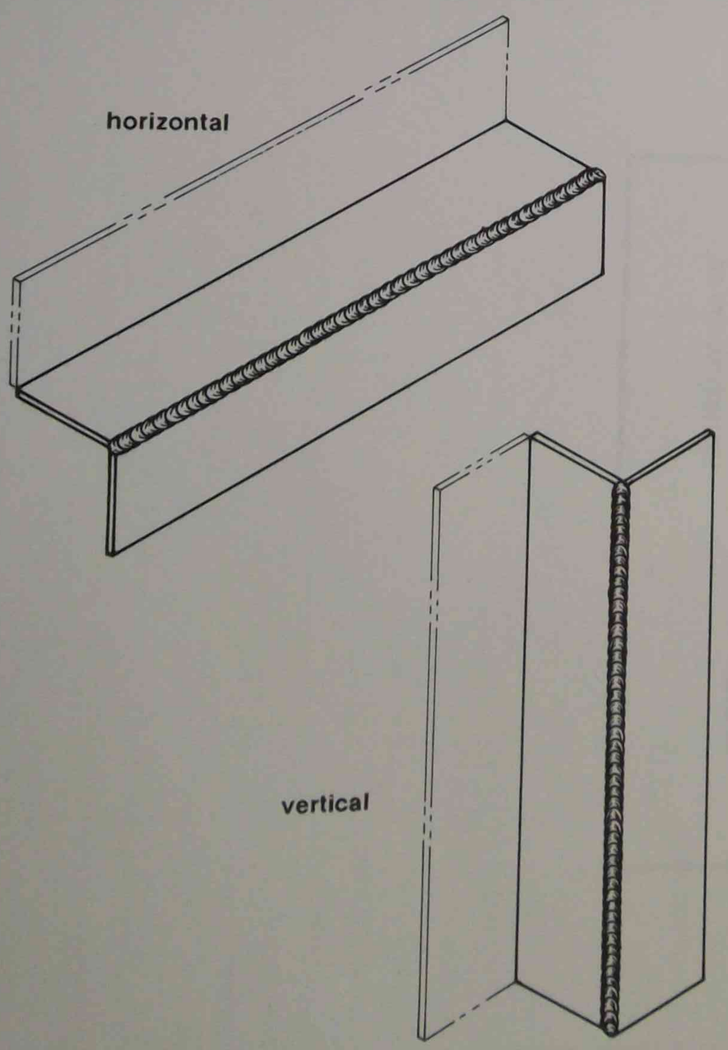
Safety

- Follow OH&S workshop procedures at all times.
- Cleaning up after a job isn't something extra you do if you have time - it's an important part of the job.

PROCEDURE SHEET

SECTION 11: CORNER FILLET - SHEET STEEL - HORIZONTAL AND VERTICAL						
Sketch						
Machine type:						
		Control data				
Run	Wire speed	Amperage reading	Voltage control	Voltage reading	Transfer mode	
1						
2						
3						
4						
Electrode wire				**Material data**		
Size Ømm:				Type:		
Type:				Thickness:		
Classification:						
Shielding gas				**Weld time**		
Type:				Start:		
Flow rate: Litres/min:				Finish:		
				Units completed:		
Assessment	Complies	Doesn't comply				
Alignment and assembly						
Angular distortion						
Surface finish						
Weld size						
Surface defects						
Undercut						
Name				Exercise No.		

SECTION 11: CORNER FILLET - SHEET STEEL - HORIZONTAL AND VERTICAL



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit single run outside corner fillet joints to the requirements listed below

POSITION Horizontal and vertical down

PROCEDURE Your teacher will demonstrate

METHOD

1. Wire brush the material to remove surface rust and loose mill scale
2. Assemble and tack plates
3. Deposit a corner weld in the horizontal position
4. Critically evaluate the weld before repeating the exercise
5. After you achieve the reuqired standard repeat the exercise in the vertical position
6. Submit your items for assessment
7. Document welding parameters on your weld procedure sheets

REQUIREMENTS

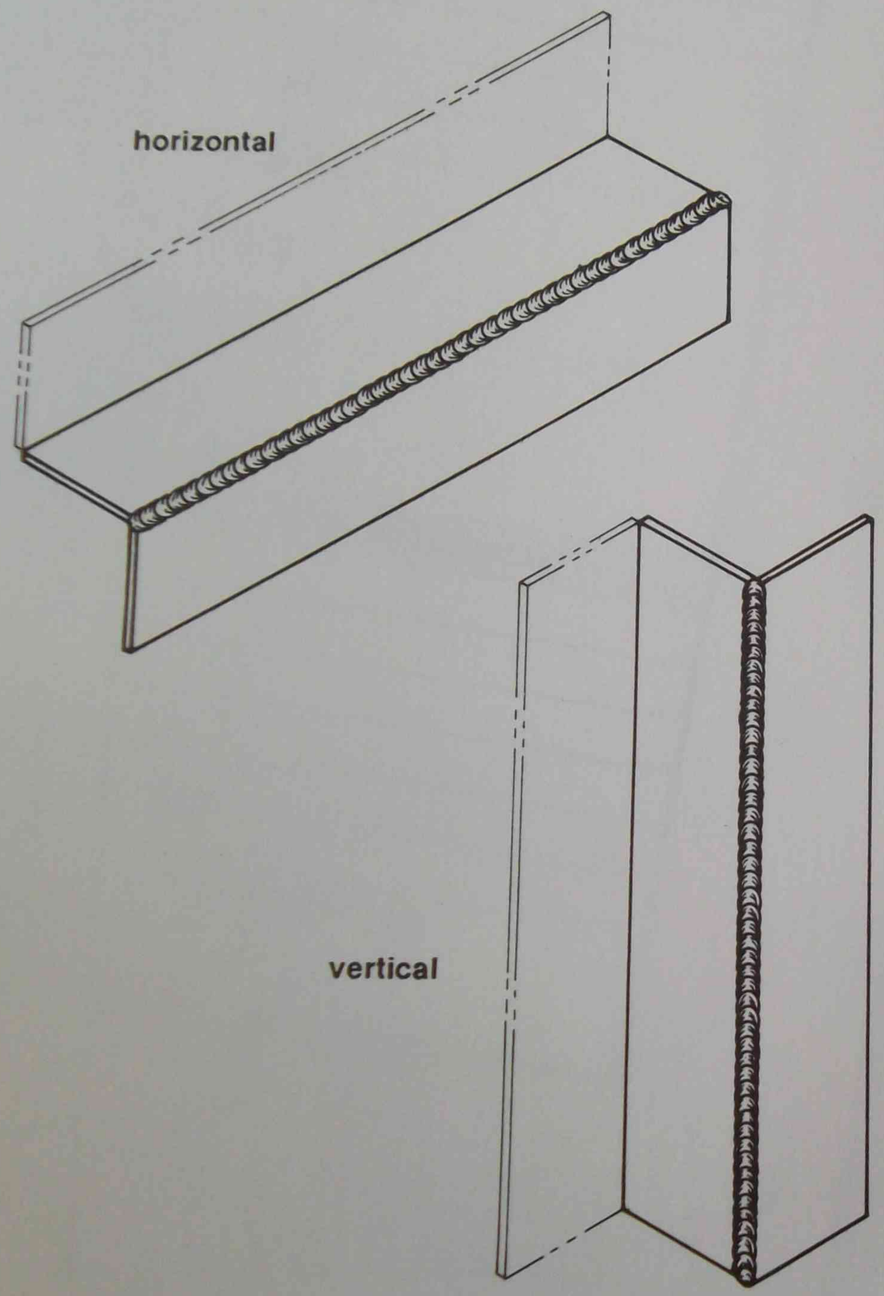
- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness
- weld size to equal to the sheet thickness 3^{+2}_{-0} mm
- undercut to be no greater than 1mm per 50% of the weld length

MATERIAL 8 pieces low carbon steel 25 x 3 x 225mm sheet

UNITS 4

ECONOMY Fully use material and return any unused pieces to the store

SECTION 11: CORNER FILLET - SHEET STEEL - HORIZONTAL AND VERTICAL



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE	To deposit single run outside corner fillet joints to the requirements listed below
POSITION	Horizontal and vertical down
PROCEDURE	Your teacher will demonstrate
METHOD	1. Wire brush the material to remove surface rust and loose mill scale 2. Assemble and tack plates 3. Deposit a corner weld in the horizontal position 4. Critically evaluate the weld before repeating the exercise 5. After you achieve the reuqired standard repeat the exercise in the vertical position 6. Submit your items for assessment 7. Document welding parameters on your weld procedure sheets
REQUIREMENTS	▪ correct alignment and assembly ▪ smooth regular weld contour ▪ angular distortion 0° to 5° ▪ a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness ▪ weld size to equal to the sheet thickness 3^{+2}_{-0} mm ▪ undercut to be no greater than 1mm per 50% of the weld length
MATERIAL	8 pieces low carbon steel 25 x 3 x 225mm sheet
UNITS	4
ECONOMY	Fully use material and return any unused pieces to the store

Notes

Section 12: Butt weld - sheet steel - flat

Task: To deposit single run butt welds on low carbon sheet steel in the flat position. This section covers part of leaning outcome 3 of the National Module Descriptor.

Why? So you'll be able to deposit butt welds on sheet steel sections as required by industry.

To pass: You'll be expected to deposit safely single run butt welds on low carbon sheet steel to the requirements on the work sheet for this section.

Safety

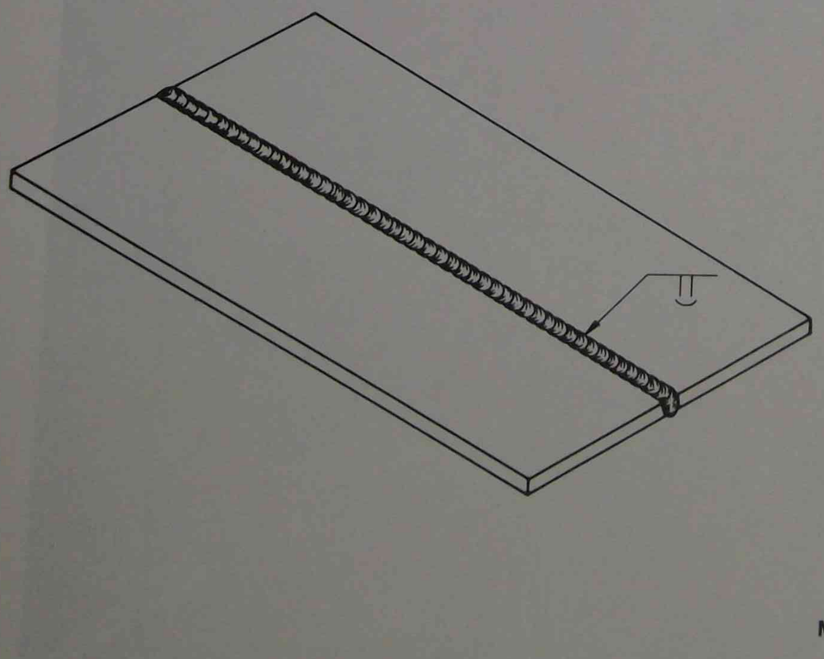
- Follow OH&S workshop procedures at all times.
- Wear approved protective clothing. Don't wear clothes made from nylon material in the workshop.

PROCEDURE SHEET

SECTION 12: BUTT WELD - SHEET STEEL - FLAT						
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**		
Alignment and assembly						
Angular distortion						
Surface finish						
Surface defects						
Root penetration						
Undercut						
Name				**Exercise No.**		

SECTION 12: BUTT WELD - SHEET STEEL - FLAT

IF IN DOUBT ASK YOUR TEACHER



OBJECTIVE To deposit single run butt welds on low carbon steel sheet to the requirements listed below

POSITION Flat

PROCEDURE Your teacher will demonstrate

METHOD

1. Assemble and tack weld the 3mm material to form an open square butt joint
2. Dress the tack welds before beginning the weld
3. Deposit half of the joint length before stopping to assess weld profile and penetration
4. Cut and relocate for further practice
5. After adequate practice repeat the procedure using 1.6mm and 1.2mm thick material
6. Repeat procedures
7. Evaluate the weld and document welding parameters on your procedure sheet
8. Submit your work for assessment

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- root penetration to be a minimum of 20% of the weld length
- a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness
- undercut to be no greater than 1mm per 50% of the weld length

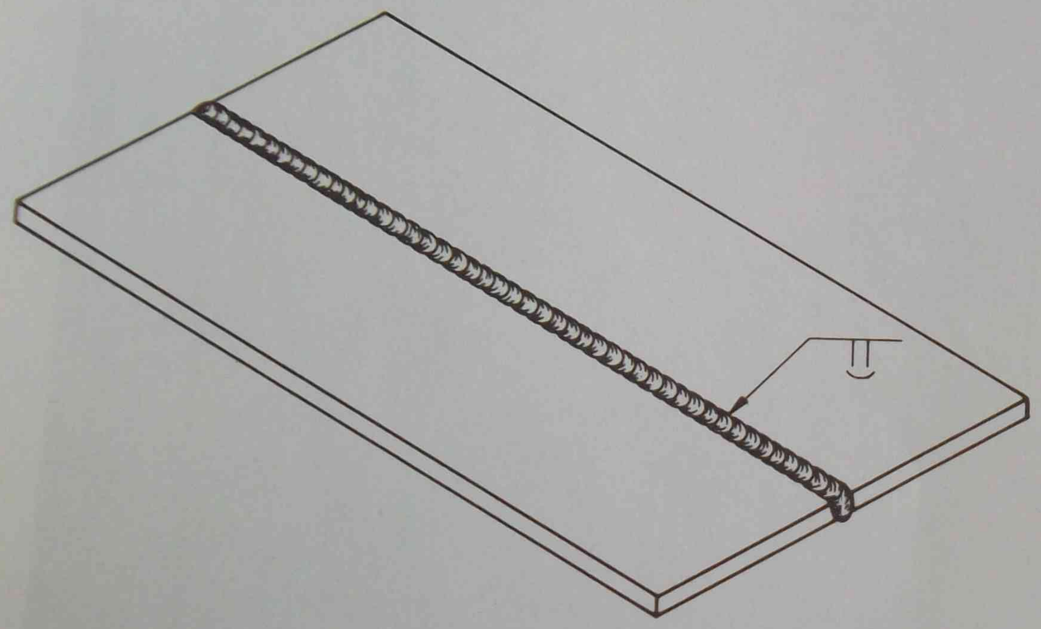
MATERIAL

3 pieces 50 x 3 x 225mm low carbon steel sheet
3 pieces 50 x 1.6 x 225mm low carbon steel sheet
3 pieces 50 x 1.2 x 225mm low carbon steel sheet

UNITS 2

ECONOMY Cut and relocate material for maximum use
Return all unused material to the store

SECTION 12: BUTT WELD - SHEET STEEL - FLAT



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE	To deposit single run butt welds on low carbon steel sheet to the requirements listed below
POSITION	Flat
PROCEDURE	Your teacher will demonstrate
METHOD	1. Assemble and tack weld the 3mm material to form an open square butt joint 2. Dress the tack welds before beginning the weld 3. Deposit half of the joint length before stopping to assess weld profile and penetration 4. Cut and relocate for further practice 5. After adequate practice repeat the procedure using 1.6mm and 1.2mm thick material 6. Repeat procedures 7. Evaluate the weld and document welding parameters on your procedure sheet 8. Submit your work for assessment
REQUIREMENTS	▪ correct alignment and assembly ▪ smooth regular weld contour ▪ angular distortion 0° to 5° ▪ root penetration to be a minimum of 20% of the weld length ▪ a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness ▪ undercut to be no greater than 1mm per 50% of the weld length
MATERIAL	3 pieces 50 x 3 x 225mm low carbon steel sheet 3 pieces 50 x 1.6 x 225mm low carbon steel sheet 3 pieces 50 x 1.2 x 225mm low carbon steel sheet
UNITS	2
ECONOMY	Cut and relocate material for maximum use Return all unused material to the store

Welding sheet metal using the gas metal arc welding procedure

Section 13: Butt weld - sheet steel - horizontal

Task: To deposit single run butt welds on low carbon sheet steel in the horizontal position. This section covers part of learning outcome 3 of the National Module Descriptor.

Why? So you'll be able to deposit butt welds on sheet steel sections as required by industry.

To pass: You'll be expected to deposit safely single run butt welds on low carbon sheet steel to the requirements specified on the work sheet for this section.

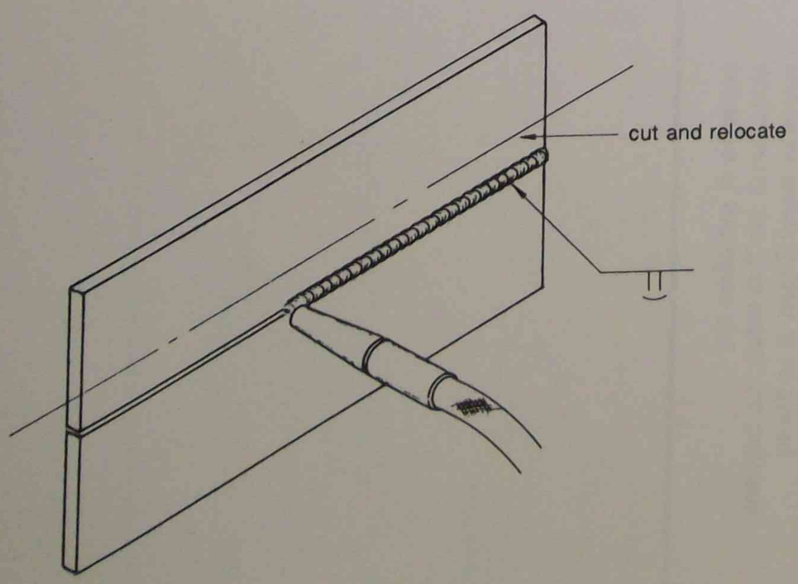
Safety

- You must follow OH&S 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 the bay **clean** at the end of the session.
- **Turn off** bay power points at the end of the session.

PROCEDURE SHEET

SECTION 13: BUTT WELD - SHEET STEEL - HORIZONTAL						
Sketch						
Machine type:						
		Control data				
Run	Wire speed	Amperage reading	Voltage control	Voltage reading	Transfer mode	
1						
2						
3						
4						
Electrode wire				**Material data**		
Size Ømm:				Type:		
Type:				Thickness:		
Classification:						
Shielding gas				**Weld time**		
Type:				Start:		
Flow rate: Litres/min:				Finish:		
				Units completed:		
Assessment		Complies		Doesn't comply		
Alignment and assembly						
Angular distortion						
Surface finish						
Surface defects						
Root penetration						
Undercut				Exercise No.		
Name						

SECTION 13: BUTT WELD - SHEET STEEL - HORIZONTAL



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit single run butt welds on low carbon steel sheet to the requirements listed below

POSITION Horizontal

PROCEDURE Your teacher will demonstrate

METHOD

1. Assemble and tack weld the 3mm material to form an open square butt joint
2. Deposit half of the joint length before stopping to assess weld profile and penetration
3. Make any procedural changes necessary and complete the weld
4. Cut and relocate for further practice
5. After adequate practice repeat the procedure using 1.6mm thick material
6. Evaluate the weld and document welding parameters on your procedure sheet
7. Submit your work for assessment

REQUIREMENTS

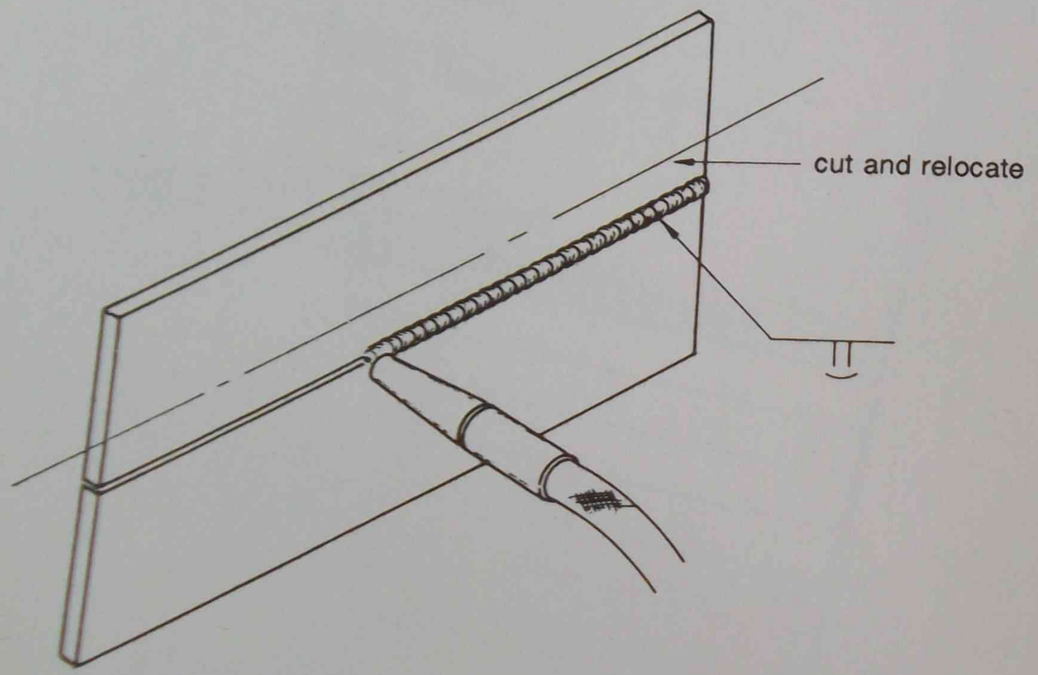
- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- root penetration to be a minimum of 20% of the weld length
- a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness
- undercut to be no greater than 1mm per 50% of the weld length

MATERIAL 3 pieces 50 x 3 x 225mm low carbon steel sheet
3 pieces 50 x 1.6 x 225mm low carbon steel sheet

UNITS 2

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

SECTION 13: BUTT WELD - SHEET STEEL - HORIZONTAL



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit single run butt welds on low carbon steel sheet to the requirements listed below

POSITION Horizontal

PROCEDURE Your teacher will demonstrate

METHOD

1. Assemble and tack weld the 3mm material to form an open square butt joint
2. Deposit half of the joint length before stopping to assess weld profile and penetration
3. Make any procedural changes necessary and complete the weld
4. Cut and relocate for further practice
5. After adequate practice repeat the procedure using 1.6mm thick material
6. Evaluate the weld and document welding parameters on your procedure sheet
7. Submit your work for assessment

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- root penetration to be a minimum of 20% of the weld length
- a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness
- undercut to be no greater than 1mm per 50% of the weld length

MATERIAL 3 pieces 50 x 3 x 225mm low carbon steel sheet
3 pieces 50 x 1.6 x 225mm low carbon steel sheet

UNITS 2

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

Section 14: Butt weld - sheet steel - vertical

Task: To deposit single run butt welds on low carbon sheet steel in the vertical position. This section covers part of learning outcome 3 of the National Module Descriptor.

Why? So you'll be able to deposit butt welds on sheet steel sections as required by industry.

To pass: You'll be expected to deposit safely a single run butt weld on low carbon sheet steel to the requirements specified on the work sheet for this section.

Safety

- Follow OH&S workshop procedures at all times.
- Protect your skin and eyes. A darker shade of welding filter is required when using the gas metal arc process because of the open arc.

N

PROCEDURE SHEET

SECTION 14: BUTT WELD - SHEET STEEL - VERTICAL						
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			
Alignment and assembly						
Angular distortion						
Surface finish						
Surface defects						
Root penetration						
Undercut						
Name		Exercise No.				

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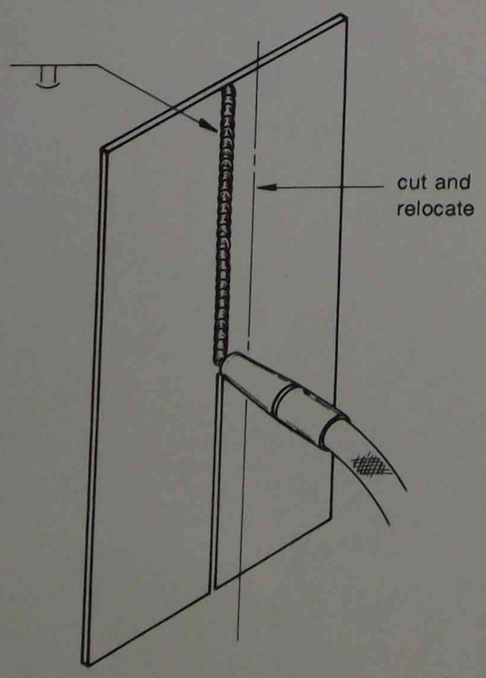
SECTION 14: BUTT WELD - SHEET STEEL - VERTICAL

IF IN DOUBT ASK YOUR TEACHER



OBJECTIVE To deposit single run butt welds on low carbon steel sheet to the requirements listed below

POSITION Vertical down

PROCEDURE Your teacher will demonstrate

METHOD

1. Assemble and tack weld the 3mm material to form an open square butt joint
2. Deposit half of the joint length before stopping to assess weld profile and penetration
3. Make any changes necessary and complete the weld
4. Cut and relocate for further practice
5. After adequate practice repeat the procedure using 1.6mm thick material
6. Evaluate the weld and document welding parameters on your procedure sheet
7. Submit your work for assessment

REQUIREMENTS

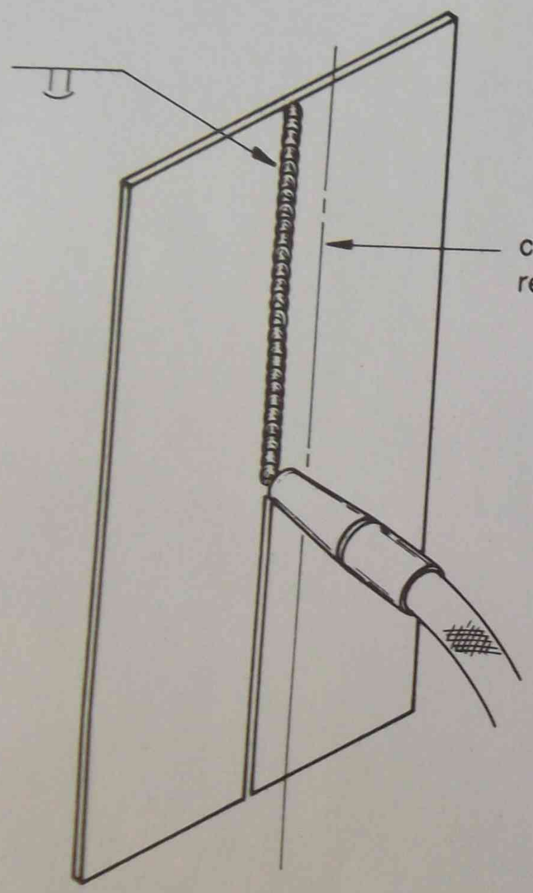
- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- root penetration to be a minimum of 20% of the weld length
- a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness
- undercut to be no greater than 1mm per 50% of the weld length

MATERIAL 2 pieces 50 x 3 x 225mm low carbon steel sheet
2 pieces 50 x 1.6 x 225mm low carbon steel sheet

UNITS 2

ECONOMY Cut and relocate material for maximum use
Return all unused material to the store

SECTION 14: BUTT WELD - SHEET STEEL - VERTICAL



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE

To deposit single run butt welds on low carbon steel sheet to the requirements listed below

POSITION

Vertical down

PROCEDURE

Your teacher will demonstrate

METHOD

1. Assemble and tack weld the 3mm material to form an open square butt joint
2. Deposit half of the joint length before stopping to assess weld profile and penetration
3. Make any changes necessary and complete the weld
4. Cut and relocate for further practice
5. After adequate practice repeat the procedure using 1.6mm thick material
6. Evaluate the weld and document welding parameters on your procedure sheet
7. Submit your work for assessment

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- root penetration to be a minimum of 20% of the weld length
- a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness
- undercut to be no greater than 1mm per 50% of the weld length

MATERIAL

2 pieces 50 x 3 x 225mm low carbon steel sheet
2 pieces 50 x 1.6 x 225mm low carbon steel sheet

UNITS

2

ECONOMY

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

The gas metal arc welding process
in use in the motor transport industry

Section 15: Butt weld - 6mm plate - flat

Task: To deposit multiple run butt welds on low carbon steel plate in the flat position. This section covers part of learning outcome 3 of the National Module Descriptor.

Why? So you'll be able to deposit butt welds on steel plate sections as required by industry.

To pass: Section 16 is a skill practice exercise that is not assessed as part of this module. However you should try to reach the standards specified on the work sheet for this section. You'll use the skills you learn for later exercises that are formally assessed.

DANGER

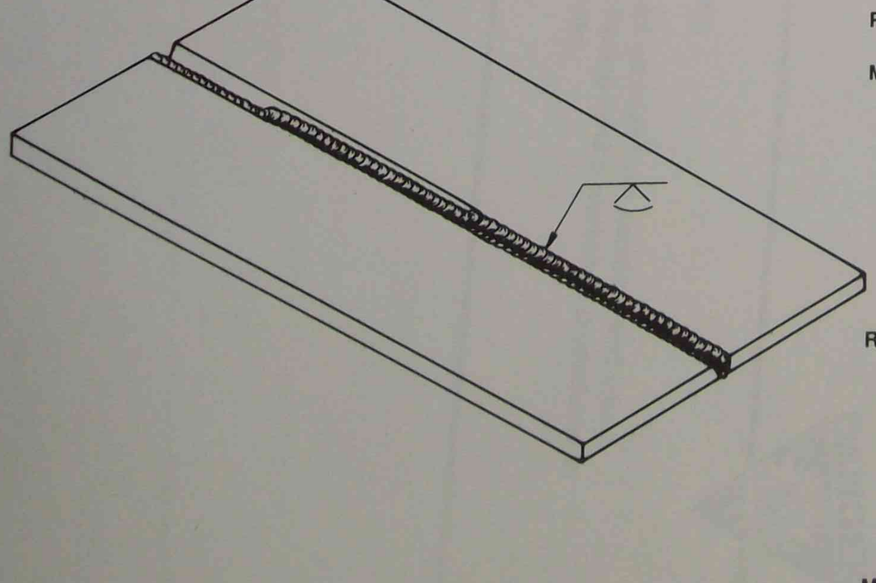
Safety

- Follow OH&S workshop procedures at all times
- Wear approved safety clothing

PROCEDURE SHEET

SECTION 15: BUTT WELD - 6MM PLATE - FLAT						
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		
Alignment and assembly						
Angular distortion						
Surface finish						
Surface defects						
Root penetration						
Undercut						
Name				Exercise No.		

SECTION 15: BUTT WELD - 6mm PLATE - FLAT



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit single run butt welds on 6mm low carbon steel sheet to the requirements listed below

POSITION Flat

PROCEDURE Your teacher will demonstrate

METHOD

1. Use a suitable spacer to maintain root gap before tacking plates
2. Check root gap and preset plates to counteract distortion
3. Complete half of the root run
4. Make any necessary procedural adjustments and complete the weld
5. Finish the weld joint using a logical weld sequence
6. Flame cut the assembly and reposition for further practice
7. Submit your work for assessment and complete your procedure sheet

REQUIREMENTS

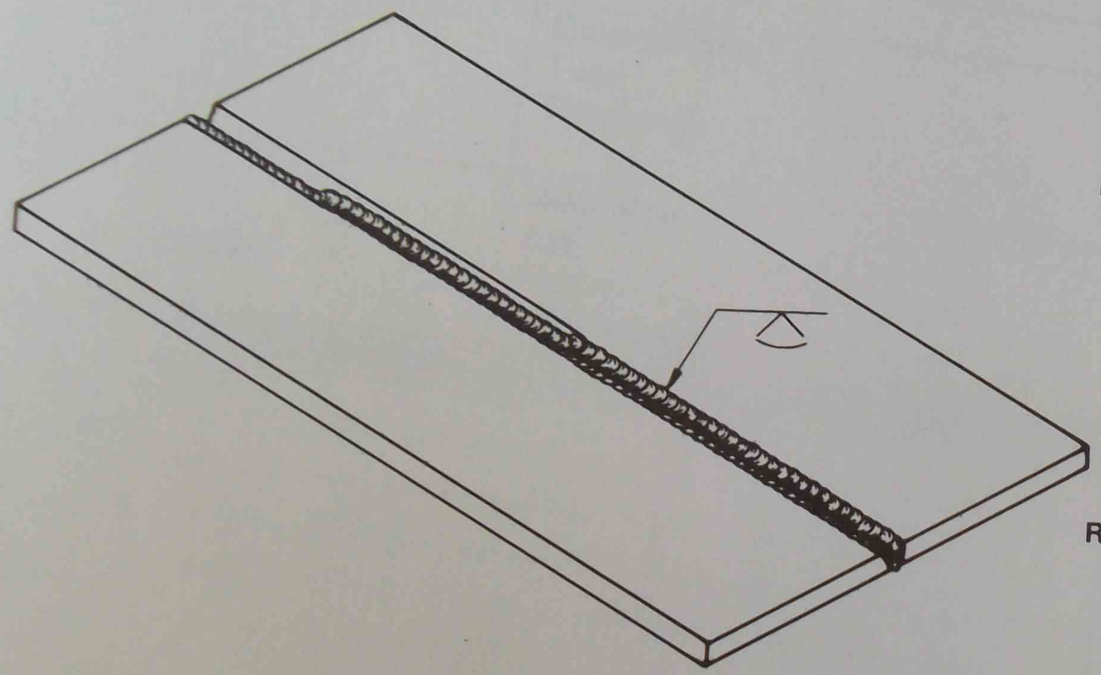
- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- root penetration to be a minimum of 20% of the weld length
- a maximum of two significant weld defects per 220mm (or 225mm plate) of weld length with an accumulative area of less than twice the square of the plate thickness
- undercut to be no greater than 1mm per 50% of the weld length

MATERIAL 2 pieces 75 x 6 x 225mm low carbon steel plate

UNITS 4

ECONOMY Return all unused material to the store

SECTION 15: BUTT WELD - 6mm PLATE - FLAT



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE	To deposit single run butt welds on 6mm low carbon steel sheet to the requirements listed below
POSITION	Flat
PROCEDURE	Your teacher will demonstrate
METHOD	1. Use a suitable spacer to maintain root gap before tacking plates 2. Check root gap and preset plates to counteract distortion 3. Complete half of the root run 4. Make any necessary procedural adjustments and complete the weld 5. Finish the weld joint using a logical weld sequence 6. Flame cut the assembly and reposition for further practice 7. Submit your work for assessment and complete your procedure sheet
REQUIREMENTS	▪ correct alignment and assembly ▪ smooth regular weld contour ▪ angular distortion 0° to 5° ▪ root penetration to be a minimum of 20% of the weld length ▪ a maximum of two significant weld defects per 220mm (or 225mm plate) of weld length with an accumulative area of less than twice the square of the plate thickness ▪ undercut to be no greater than 1mm per 50% of the weld length
MATERIAL	2 pieces 75 x 6 x 225mm low carbon steel plate
UNITS	4
ECONOMY	Return all unused material to the store

Notes

Section 16: Butt weld - rolled steel section - flat

Task: To deposit multiple run butt welds on low carbon steel rolled structural section in the flat position. This section covers part of learning outcome 3 of the National Module Descriptor.

Why? So you'll be able to deposit butt welds on rolled steel sections as required by industry.

To pass: You'll be expected to deposit safely a multiple run butt weld on a low carbon steel angle section to the requirements specified on the work sheet for this section.

Safety

Protect yourself from accident and injury by following OH&S workshop procedures at all times.

PROCEDURE SHEET

SECTION 16: BUTT WELD - ROLLED STEEL SECTION - FLAT					
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
Alignment and assembly		
Angular distortion		
Surface finish		
Surface defects		
Root penetration		
Undercut		
Name		Exercise No.

IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To prepare, assemble and deposit multiple run butt welds on low carbon steel rolled sections to the requirements listed below

POSITION Flat

PROCEDURE Your teacher will demonstrate

METHOD

1. Flame cut and dress angle edge preparation as illustrated
2. Assemble, align and tack weld angle sections
3. Fully weld the first side of the angle
4. Complete the butt weld in the flat position
5. Evaluate the weld exercise and complete the procedure sheet
6. Submit your work for assessment
7. Document welding parameters on your weld procedure sheet

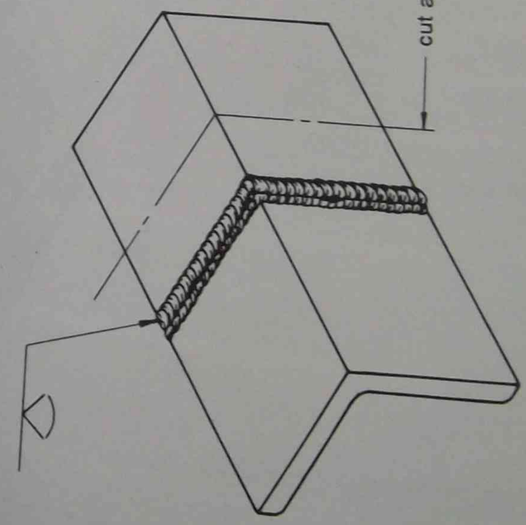
REQUIREMENTS

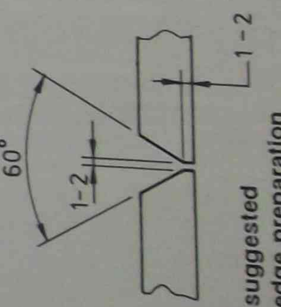
- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- root penetration to be a minimum of 20% of the weld length
- a maximum of two significant weld defects per 250mm (or 225mm material) of weld length with an accumulative area of less than twice the square of the material thickness
- undercut to be no greater than 1.5mm per 50% of the weld length

MATERIAL 2 pieces 75 x 75 x 10mm 75mm long ASEA

UNITS 2

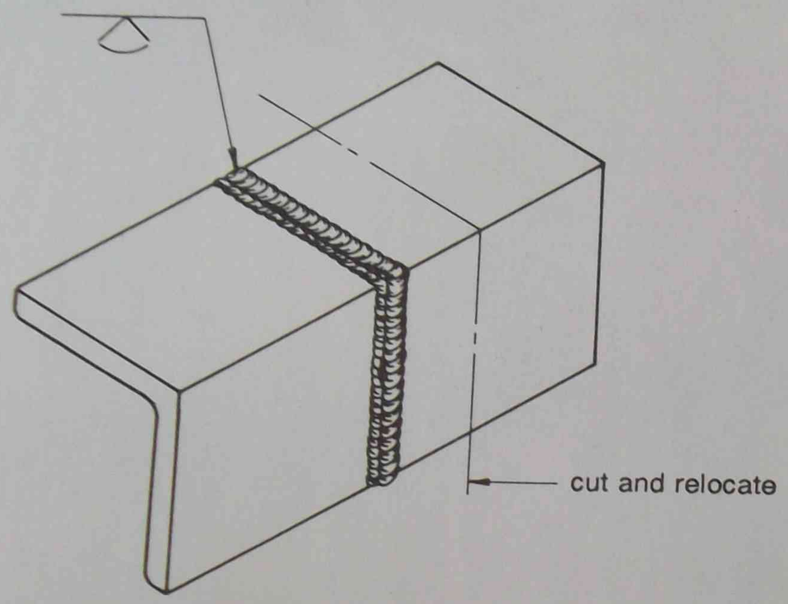
ECONOMY Return all unused material to the store

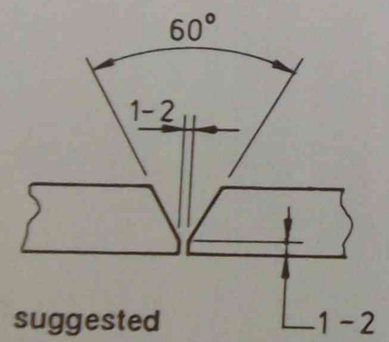




suggested edge preparation

SECTION 16: BUTT WELD - ROLLED STEEL - FLAT





suggested
edge preparation

IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE	To prepare, assemble and deposit multiple run butt welds on low carbon steel rolled sections to the requirements listed below
POSITION	Flat
PROCEDURE	Your teacher will demonstrate
METHOD	1. Flame cut and dress angle edge preparation as illustrated 2. Assemble, align and tack weld angle sections 3. Fully weld the first side of the angle 4. Complete the butt weld in the flat position 5. Evaluate the weld exercise and complete the procedure sheet 6. Submit your work for assessment 7. Document welding parameters on your weld procedure sheet
REQUIREMENTS	▪ correct alignment and assembly ▪ smooth regular weld contour ▪ angular distortion 0° to 5° ▪ root penetration to be a minimum of 20% of the weld length ▪ a maximum of two significant weld defects per 250mm (or 225mm material) of weld length with an accumulative area of less than twice the square of the material thickness ▪ undercut to be no greater than 1.5mm per 50% of the weld length
MATERIAL	2 pieces 75 x 75 x 10mm 75mm long ASEA
UNITS	2
ECONOMY	Return all unused material to the store

The gas metal arc welding process
in use on sheet steel

Section 17: Butt weld - 6mm plate - horizontal

Task: To deposit a single multiple run V butt 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 deposit butt welds on steel plate sections as required by industry.

To pass: You'll be expected to deposit safely a multiple run butt weld on low carbon steel plate sections to the requirements specified on the work sheet for this section.

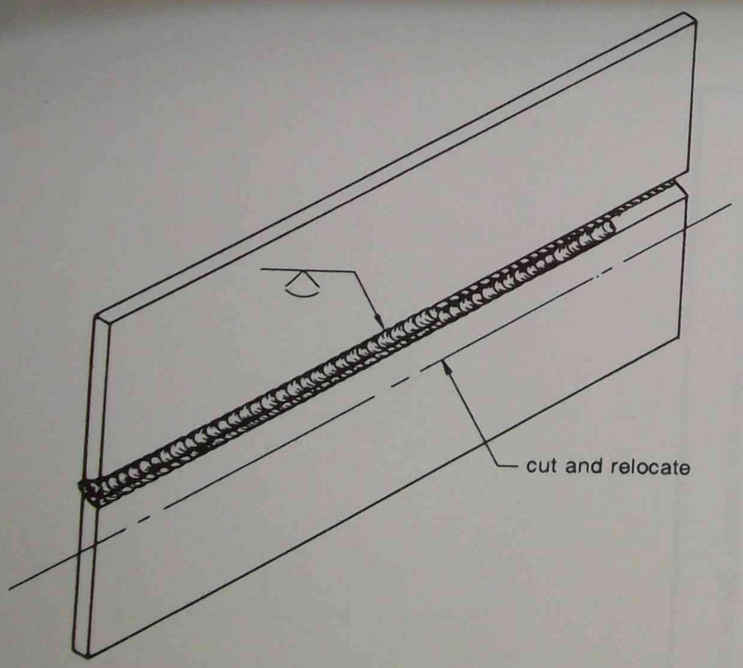
DANGER

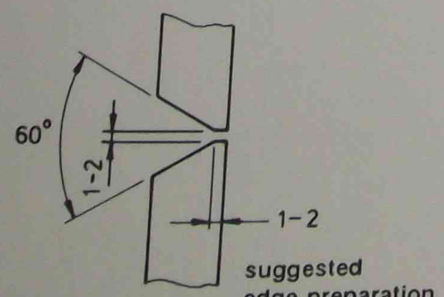
Safety

- Follow OH&S procedures at all times.
- Make sure you wear approved protective clothing.

PROCEDURE SHEET

SECTION 17: BUTT WELD - 6MM PLATE - HORIZONTAL						
Sketch						
Machine type:						
		Control data				
Run	**Wire speed**	**Amperage reading**	**Voltage control**	**Voltage reading**	**Transfer mode**	
1						
2						
3						
4						
Electrode wire			**Material data**			
Size Ømm:			Type:			
Type:			Thickness:			
Classification:						
Shielding gas			**Weld time**			
Type:			Start:			
Flow rate: Litres/min:			Finish:			
			Units completed:			
Assessment		**Complies**		**Doesn't comply**		
Alignment and assembly						
Angular distortion						
Surface finish						
Surface defects						
Root penetration						
Undercut						
Name				**Exercise No.**		





suggested edge preparation

IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit multiple run butt welds on 6mm low carbon steel plate to the requirements listed below

POSITION Horizontal

PROCEDURE Your teachers will demonstrate

METHOD

1. Use a suitable spacer to maintain root gap before tacking plates
2. Check root gap and preset plates to counteract distortion
3. Complete half of the root run and inspect
4. Make any necessary procedural adjustments and complete the weld
5. Finish the weld joint using a logical weld sequence
6. Flame cut the assembly and reposition for further practice
7. Submit your work for assessment and complete your procedure sheet

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- root penetration to be a minimum of 20% of the weld length
- a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness
- undercut to be no greater than 1.5mm per 50% of the weld length

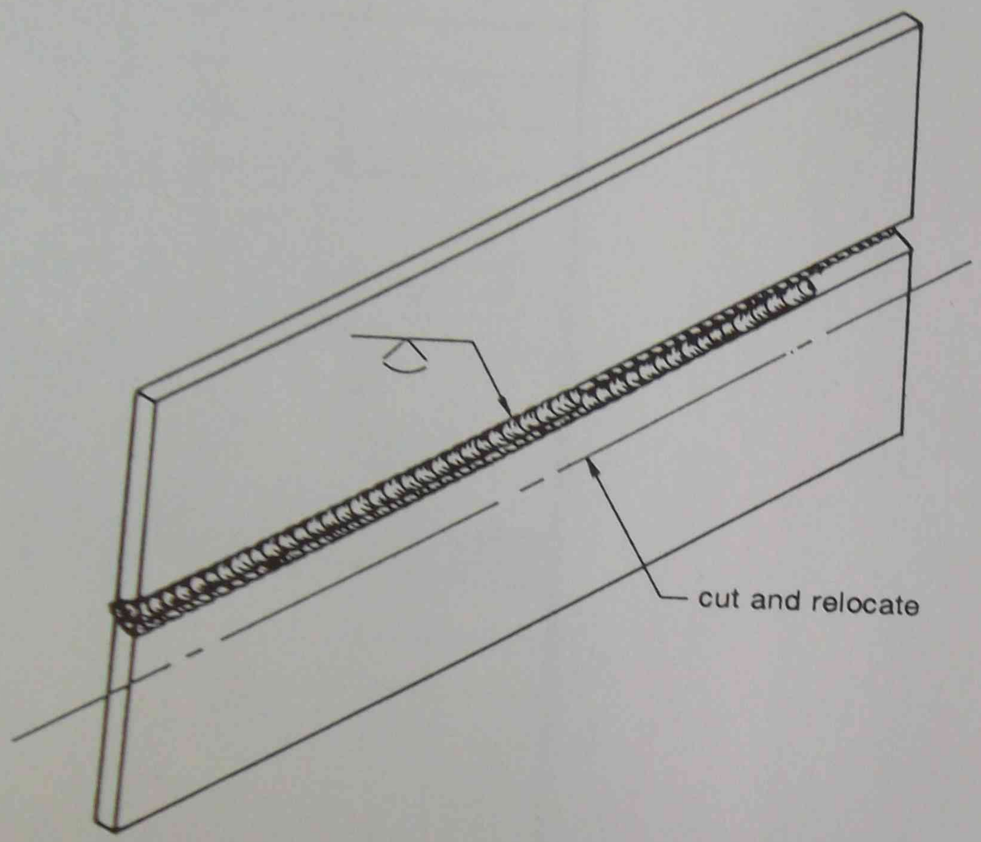
MATERIAL 2 pieces 75 x 6 x 225mm low carbon steel plate

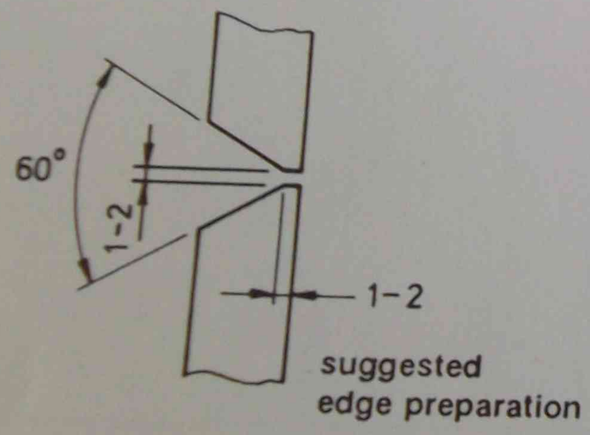
UNITS 4

ECONOMY Return all unused material to the store

on the work sheet for this section.

SECTION 17: BUTT WELD - 6mm PLATE - HORIZONTAL





suggested
edge preparation

IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit multiple run butt welds on 6mm low carbon steel plate to the requirements listed below

POSITION Horizontal

PROCEDURE Your teachers will demonstrate

METHOD

1. Use a suitable spacer to maintain root gap before tacking plates
2. Check root gap and preset plates to counteract distortion
3. Complete half of the root run and inspect
4. Make any necessary procedural adjustments and complete the weld
5. Finish the weld joint using a logical weld sequence
6. Flame cut the assembly and reposition for further practice
7. Submit your work for assessment and complete your procedure sheet

REQUIREMENTS

- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- root penetration to be a minimum of 20% of the weld length
- a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness
- undercut to be no greater than 1.5mm per 50% of the weld length

MATERIAL 2 pieces 75 x 6 x 225mm low carbon steel plate

UNITS 4

ECONOMY Return all unused material to the store

Notes

Section 18: Butt weld - 6mm plate - vertical

Task: To deposit multiple run single V butt welds on low carbon steel plate in the vertical position. This section covers part of learning outcome 3 of the National Module Descriptor.

Why? So you'll be able to deposit butt welds on steel plate sections in the vertical position as required by industry.

To pass: You'll be expected to deposit safely a multiple run butt weld on low carbon steel plate sections to the requirements specified on the work sheet for this section.

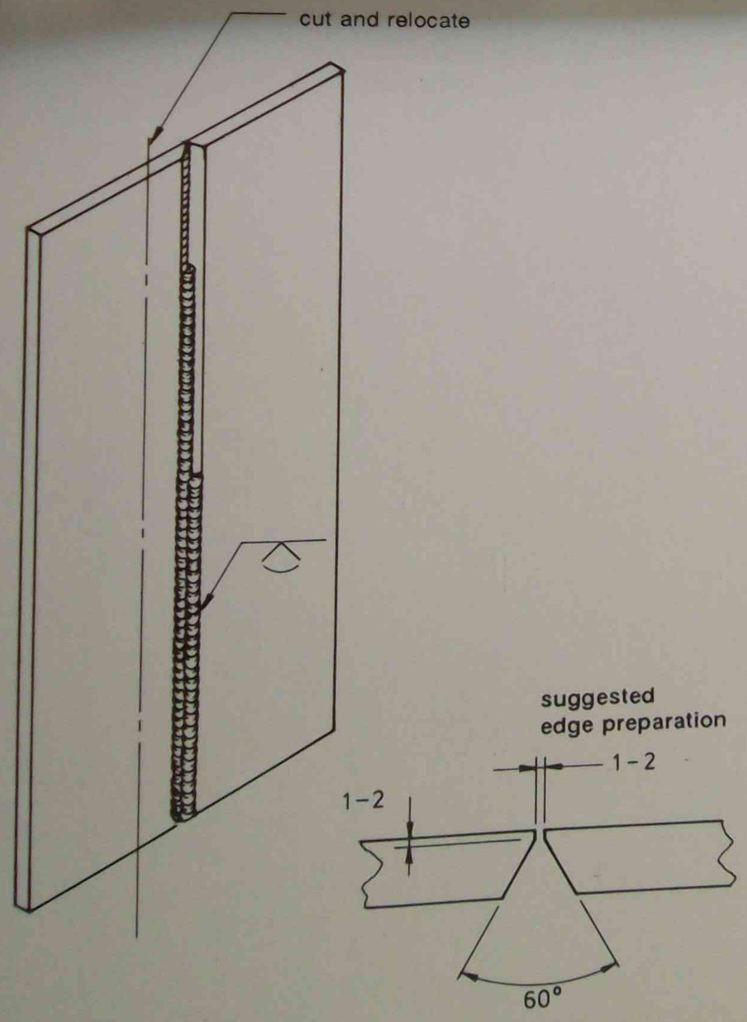
Safety

- Follow OH&S workshop procedures at all times.
- Make sure your work area is clean and tidy.
- Only use approved anti-spatter gel or spray.

PROCEDURE SHEET

SECTION 18: BUTT WELD - 6MM PLATE - VERTICAL						
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			
Alignment and assembly						
Angular distortion						
Surface finish						
Surface defects						
Root penetration						
Undercut						
Name			Exercise No.			

SECTION 18: BUTT WELD - 6mm PLATE - VERTICAL



IF IN DOUBT ASK YOUR TEACHER

OBJECTIVE To deposit multiple run butt welds on 6mm low carbon steel plate to the requirements listed below

POSITION Vertical up

PROCEDURE Your teacher will demonstrate

METHOD

1. Use a suitable spacer to maintain root gap before tacking plates
2. Check root gap and preset plates to counteract distortion
3. Complete half of the root run and inspect
4. Make any necessary procedural adjustments and complete the weld
5. Finish the weld joint using a logical weld sequence
6. Flame cut the assembly and reposition for further practice
7. Document welding parameters on your procedure sheet

REQUIREMENTS

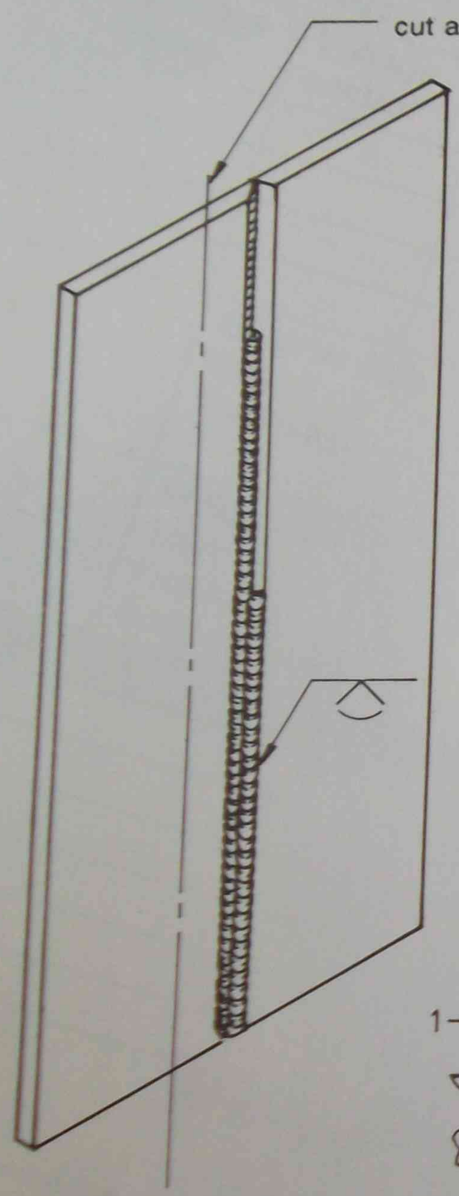
- correct alignment and assembly
- smooth regular weld contour
- angular distortion 0° to 5°
- root penetration to be a minimum of 20% of the weld length
- a maximum of two significant weld defects per 250mm (or 225mm sheet) of weld length with an accumulative area of less than twice the square of the sheet thickness
- undercut to be no greater than 1mm per 50% of the weld length

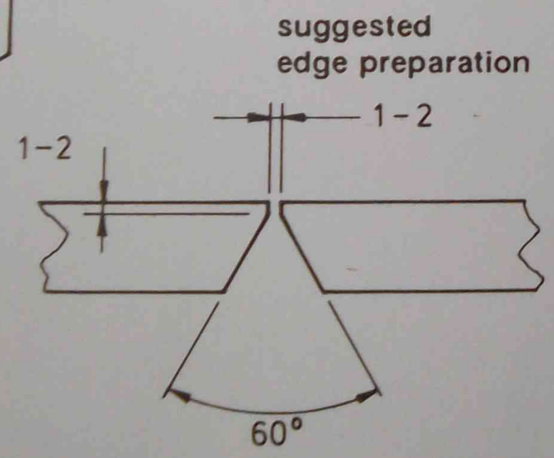
MATERIAL 2 pieces 75 x 6 x 225mm low carbon steel plate

UNITS 4

ECONOMY Return all unused material to the store

SECTION 18: BUTT WELD - 6mm PLATE - VERTICAL





IF IN DOUBT ASK YOUR TEACHER

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POSITION Vertical up

PROCEDURE Your teacher will demonstrate

METHOD

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MATERIAL 2 pieces 75 x 6 x 225mm low carbon steel plate

UNITS 4

ECONOMY Return all unused material to the store

otes

April 1991

Section 19: Gas metal arc spot welding theory

Task: To develop an understanding of the theoretical aspects of the gas metal arc spot welding process.

Why? To use your knowledge in a workshop environment to spot weld safely and competently.

To pass: You'll be expected to answer a series of questions on this topic at the end of this module.

Technical information

1. Spot welding

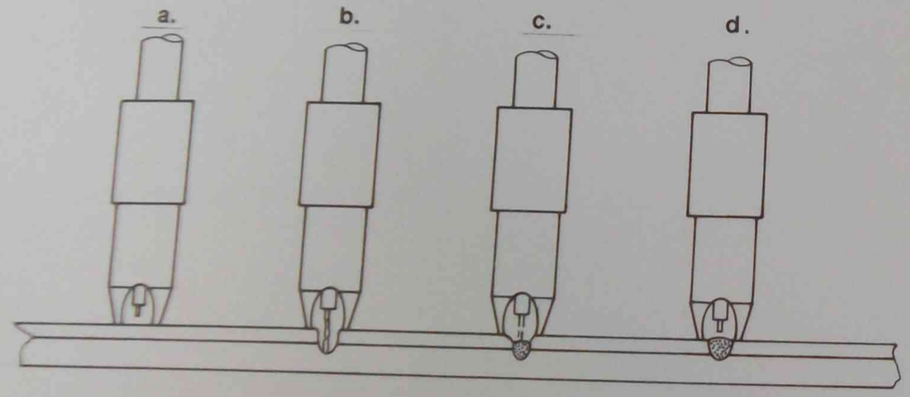
Gas metal arc welding is used to make high quality arc spot welds with either standard or specialised equipment. The process is used on awkward spaces and in cases where you mustn't damage the other side of the surface being welded. It's an excellent process for auto body repair.

Gas metal arc spot welds are produced from only one side of the joint. The weld starts on the surface of one material and burns through to the other material. Fusion between the sections leaves a small nugget on the metal surface.

Advantages:

- Welds can be made between thin and thick materials
- The weld can be made when you have access to only one side of the material's surface
- The weld can be made when there is paint on the interfacing surfaces
- The arc spot weld can also be used to assemble parts for welding at a later time.

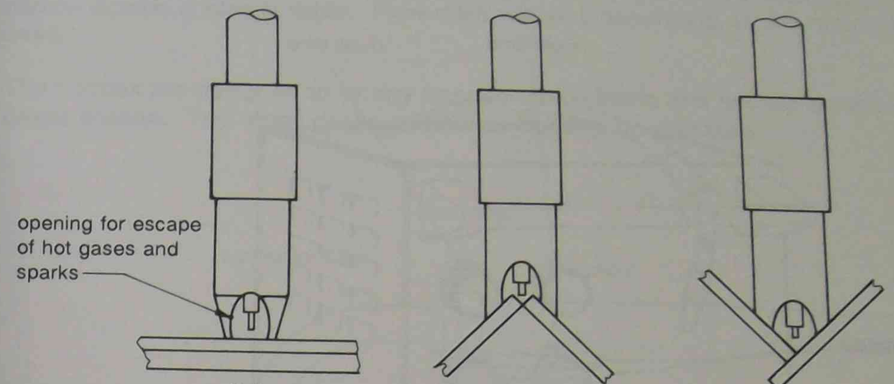
Typical sequence of operation



There are four steps in the gas metal arc spot weld sequence:

a. the arc starts
b. a hole is burnt through the first plate
c. the hole is filled with weld metal
d. the wire feed stops and the arc burns the wire back.

Specially designed nozzles provide flash protection, part alignment, and arc alignment.



A timing device controls the weld and burn back time. You must set the amperage, voltage, and length of welding time correctly to make a weld. The burn back time is a short period at the end of the weld when the wire feed stops but the current doesn't. The wire is burned back so it doesn't stick onto the weld.

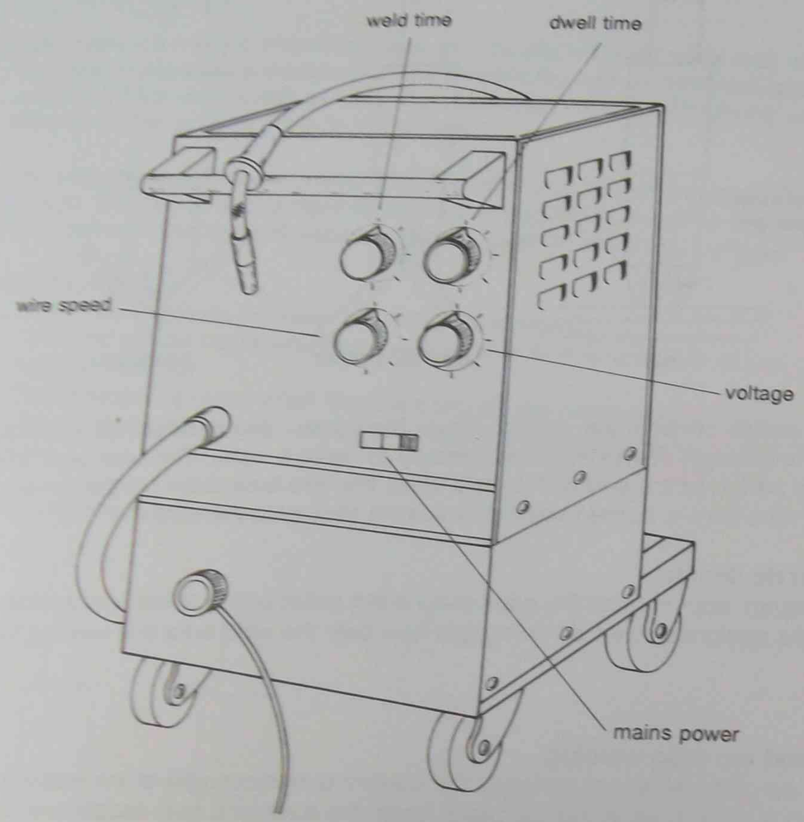
Spot nozzle design

The drawings above show the gaps around the outlet orifice of the spot nozzle. These are designed to let shielding gas flow over the weld area and welding fumes escape.

Gas metal arc plug welding

Where top plate thickness exceeds the current output capacity of the machine, drill or punch a small hole in the top plate, lower the torch and spot nozzle over the hole and spot weld as normal.

2. Equipment for gas metal arc spot welding



Voltage: A multi position switch for selecting the required welding voltage.

Wire speed: A variable control for selecting the wire speed and welding current.

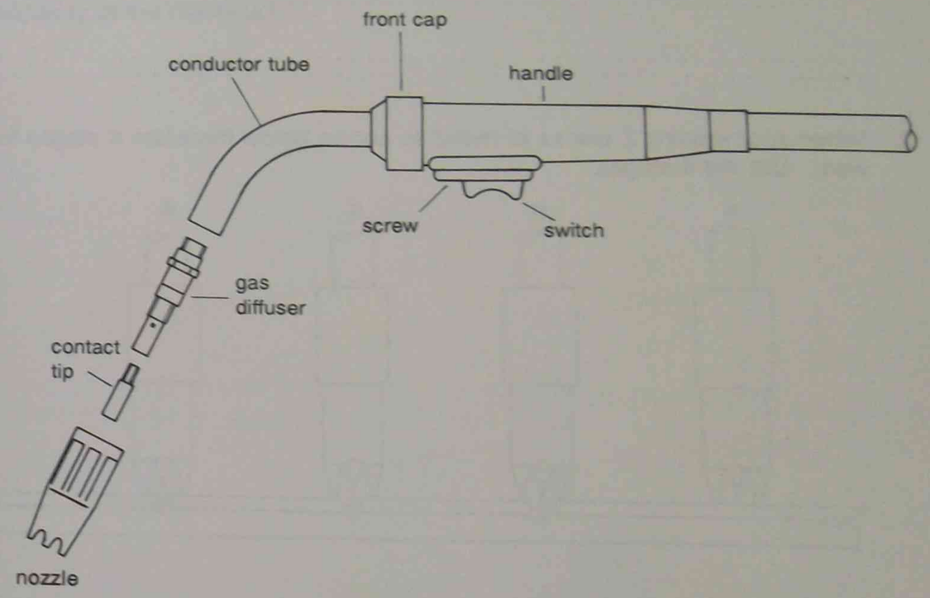
Weld time: The weld time control determines the duration of the weld time when **spot** or **stitch** welding. Make sure this control is in the **off** position for continuous welding.

Dwell time: The dwell time control adjusts the weld **off** time when **stitch** or **interval** welding. Make sure this control is in the **off** position for continuous welding.

3. Shielding gases

Gas mixtures such as argon/carbon dioxide are normally used but welding grade carbon dioxide is also suitable. Flow rates will vary depending on the nozzle being used.

The nozzles are designed to let any trapped atmospheric and excess shielding gases escape. This stops gases and fumes building up pressure.



4. Recommended spot welding procedure

Steps

1. Select the most appropriate spot welding nozzle for the torch and the job.
2. Fit the correct diameter consumable wire.
3. Select voltage setting.
4. Set wire feed to achieve current conditions.
5. Set weld time to appropriate arc on time.
6. Trial weld and increase or decrease voltage, wire feed and time to get the penetration and bead shape you want.

Review questions

These questions will help you revise what you've learnt in Section 19. The answers are on page 120.

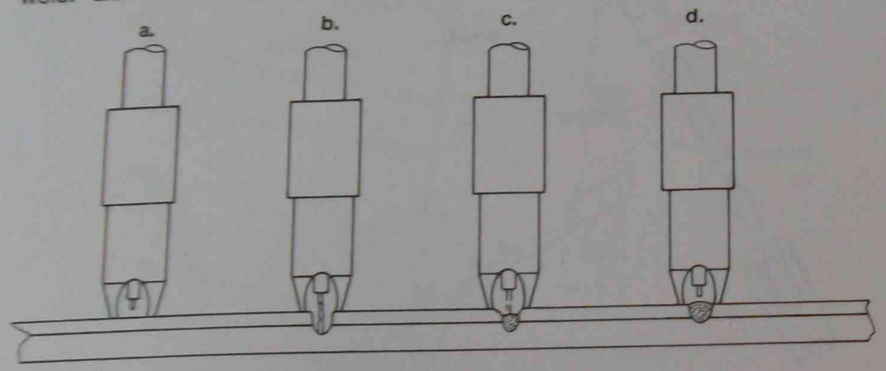
Short answer questions

1. Briefly describe the gas metal arc spot welding process:

   .....

   .....

2. When spot welding 2 pieces of metal as shown below there are 4 stages to the weld. List the 4 stages:



   a. .....

   b. .....

   c. .....

   d. .....

3. Spot welding nozzles are a special design - they have openings at the end. Briefly explain the reason for the openings:

   .....

   .....

4. Generally the power source/wire feed unit has 4 function control knobs. List the functions of these knobs:

   a. ..... b. .....

   b. ..... c. .....

5. What can be done about the problem of the top plate being too thick for the capacity of the machine?

   .....

   .....

Notes

Answers to review questions

Section 1: Gas metal arc operating principles

1. a. power
   b. wire feed unit
   c. wire rolls
   d. regulator
   e. flow meter
   f. gas cylinder
   g. gas shielding
   h. contact tip

2. (in any order)

   a. short arc
   b. globular
   c. spray arc

3. spray arc

4. To break down the high cylinder pressure to a safe operating pressure.

5. globular

6. increase the electrode stickout

7. The electrode would get poor current pickup, there would be reduced penetration and the electrode would wander in the arc.

8. a. To help prevent rust which would introduce oxides into the weld and to give better current pick-up.

   b. i. silicon
      ii. manganese

9. Operates the wire feed motor to feed the wire through the torch and contact without inducing current into the electrode.

Section 3: Fillet and butt weld definitions and defects

1. a. parent metal
   b. toe
   c. weld face
   d. penetration or fusion zone
   e. root
   f. weld metal
   g. reinforcement
   h. heat affected zone (HAZ)

2. a. porosity
   b. undercut
   c. lack of penetration
   d. spatter
   e. lack of fusion
   f. overroll

3. mitre

4. a. overhead
   b. horizontal
   c. flat
   d. vertical

Section 7: Effects of gas metal arc welding variables

1. aluminium

2. a. CO_2 (carbon dioxide)
   b. Ar/CO_2(argon/carbon dioxide)
   c. Ar/CO_2/0_2 (argon/carbon dioxide/oxygen)
   d. Argon

3. a. current would decrease
   b. volts would be increased

4. current density = 280.25

5. It becomes turbulent and the gas could mix with the atmosphere and contaminate the weld making it porous.

Section 19: Gas metal arc spot welding theory

1. The spot weld starts on the top surface and burns through to the lower surface. There is fusion between the two surfaces and a small nugget is left on the top surface.

2. a. The arc starts
   b. A hole is burned through the top plate
   c. The hole is filled with weld metal
   d. The wire feed stops and the arc burns the wire back

3. Allows the shielding gas to flow over the weld area and hot gases, fumes and sparks to escape.

4. a. voltage
   b. wire feed speed
   c. weld time
   d. dwell time

5. Drill or punch a hole.

Notes

Words you need to know

ASEA	Australian Standard Equal Angle
burn back:	fusing of the wire electrode to the contact tip
CO_2	carbon dioxide gas
contact tip:	a short tube fitted to a GMAW gun to pass electrical current onto the wire
current density:	the current for a given filler wire diameter
deposition rate	the weight of metal deposited in a unit of time
duty cycle:	percentage of time, for a test period during which power supply can be operated at its rated output without overloading
dwell time:	the period of time the nozzle remains on the job after welding to protect the cooling weld
flowmeter:	a gas flow measuring device connected to the regulator to adjust operating flow rates
globular transfer:	metal transfer which takes places as globules of a diameter larger than that of the electrode
GMAW:	gas metal arc welding
inching:	automatically feeding the wire electrode without welding
inert gas:	shielding gas consisting of argon or helium or a mixture of the two
liner:	supply conduit that the wire electrode feeds through
rectifier:	a power source developed to supply direct current (DC) for welding from an alternating (AC) mains power supply
short arc transfer:	metal transfer in which fused particles of wire electrode are detached in rapid succession during the repeated short circuiting contacts the weld pool

Words you need to know

spatter the metal particles which are expelled during welding on to the surface of the parent metal or a weld and which do not form a part of the weld

spray transfer: metal transfer which takes place as a rapidly projected stream of droplets of a diameter no larger than that of the wire electrode

stickout: the length the wire electrode projecting past the contact tip during welding

variables: operating conditions such as volts, wire speed, travel speed gas flow rate, that are adjustable before and during welding

weld time: total time involved between the start and finish of welding current during the making of one weld

TAFE NSW

Module Resource Manual

NF01

Manual Metal Arc Welding 1

Student Workbook

Third Edition

Manufacturing &
Engineering
Educational Services
Consortium

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PO Box 218 Bankstown NSW 2200

First edition January 1991
Second edition August 1994
Third edition December 1997

CONTENTS

Notes

Student organiser

This chart provides you with an overall picture of the content of this module. Use it as a guide as you work through each section.

No	*Section*	*Suggested time*
1	Introduction to welding and theory cutting processes	2 hrs 30 mins
2	Brazing theory	1 hr
3	Brazing Skill practice 1 Assessment event 1 (practical)	 1 hr 45 mins 15 mins
4	Braze welding theory	1 hr
5	Braze welding Skill practice 2 Assessment event 2 (practical)	 1 hr 45 mins 15 mins
6	Oxyacetylene welding theory	1 hr 30 mins
7	Oxyacetylene welding - beads on sheet Skill practice 3	 1 hr 30 mins
8	Oxyacetylene welding - outside corner Skill practice 4	 1 hr 30 mins
9	Oxyacetylene welding - fillet weld Skill practice 5 Assessment event 3 (practical)	 1 hr 15 mins 15 mins
10	Flame cutting theory	1 hr 30 mins
11	Flame cutting and heating Skill practice 6 Skill practice 7 Assessment event 4 (practical) Skill practice 8 Assessment event 5 (practical) Assessment event 6 (practical)	 1 hr 45 mins 15 mins 15 mins 15 mins 30 mins
12	Flame gouging theory	30 mins
13	Flame gouging Skill practice 9 Assessment event 7 (practical)	 45 mins 15 mins
14	Manual metal arc welding theory	1 hr 30 mins
15	Manual metal arc welding - beads on plate Skill practice 10	1 hr
16	Manual metal arc welding - pad weld Skill practice 11	1 hr 30 mins

No	*Section*	*Suggested time*
17	Manual metal arc welding - fillet weld Skill practice 12 Assessment event 8 (practical)	 1 hr 45 mins 15 mins
18	Gas metal arc welding theory	1 hr 30 mins
19	Gas metal arc welding - beads on plate Skill practice 13	 1 hr
20	Gas metal arc welding - pad weld Skill practice 14	 1 hr 30 mins
21	Gas metal arc welding - fillet weld Skill practice 15 Assessment event 9 (practical)	 1 hr 45 mins 15 mins
22	Hazardous locations and situations Assessment event 10 (theory)	2 hrs 30 mins 1 hr

Assessment

☐ To pass this module you must show competency in relation to the underpinning knowledge (theory), as well as demonstrate that you can safety carry out basic welding, heating, flame cutting and gouging tasks.

☐ The assessment scheme for this module comprises seven practical tests and one theory test.

The practical tests included in this workbook are based on material covered in the following module sections.

Section 3 Brazing
Section 5 Braze welding
Section 9 Oxyacetylene welding - fillet weld
Section 11 Flame cutting and heating
Section 13 Flame gouging
Section 17 Manual metal arc welding - fillet weld
Section 21 Gas metal arc welding - fillet weld

The theory test included in this workbook is based on material covered in the following module sections.

Section 1 Introduction to welding and thermal cutting processes
Section 2 Brazing theory
Section 4 Braze welding theory
Section 6 Oxyacetylene welding theory
Section 10 Flame cutting theory
Section 12 Flame gouging theory
Section 14 Manual metal arc welding theory
Section 18 Gas metal arc welding theory
Section 22 Hazardous locations and situations

☐ A complete assessment schedule will be supplied to you by your teacher, before you start this module.

MODULE SECTIONS

Section 1: Introduction to welding and thermal cutting processes

SUGGESTED DURATION	PREAMBLE
2 hours 30 minutes	This section provides an overview of the welding and thermal cutting processes used in the fabrication industry.

Objectives

At the end of this section you will be able to:

- ☐ recognise a range welding and thermal cutting processes
  - manual metal arc welding (MMAW)
  - gas metal arc welding (GMAW)
  - oxyacetylene welding (OAW)
  - gas tungsten arc welding (GTAW)
  - submerged arc welding (SAW)
  - resistance welding
  - fuel gas cutting
  - plasma cutting

- ☐ state typical industrial applications for welding and thermal cutting processes
  - light fabrication
  - heavy fabrication
  - general engineering
  - vehicle industry
  - building industry.

Introduction to welding and thermal cutting processes

Welding is a process that uses heat to join a range of materials. In the metal industry welding and thermal cutting processes are applied to a diverse range of material shapes and thickness. For example, these processes are used in the construction of steel frames for multistory buildings and motor vehicle bodies.

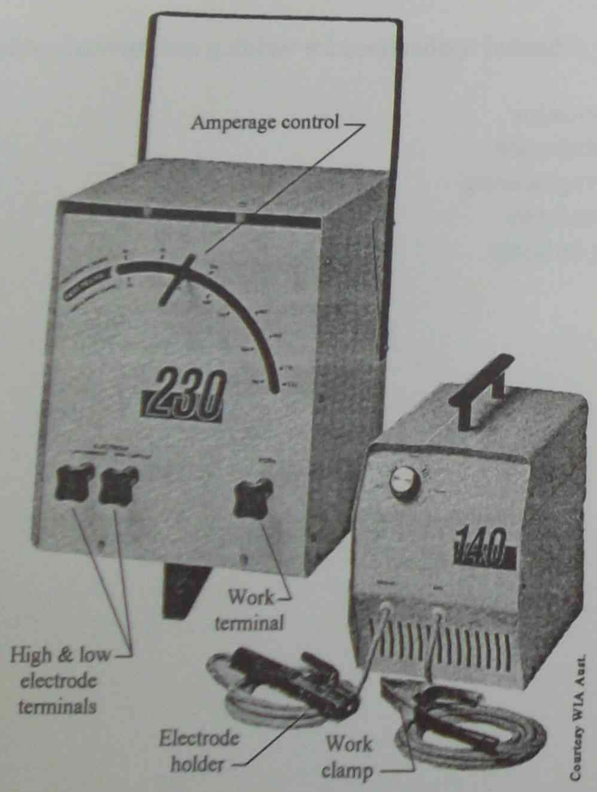
There are a variety of welding and thermal cutting processes available. Each has its own practical uses, advantages and limitations. Following are brief descriptions of common welding and thermal cutting processes used in the fabrication, engineering and related metal industries.

Manual metal arc welding (MMAW)

The process
Manual metal arc welding is an electric arc welding process.

An arc is struck on the job with a flux covered electrode. The heat of the arc melts the electrode and the parts which form the weld joint. Fumes from the electrode flux coating shield the weld area from the atmosphere as the flux melts to form a protective slag coating.

Uses
Manual metal arc welding is used in all general fabrication and pressure vessel industries.



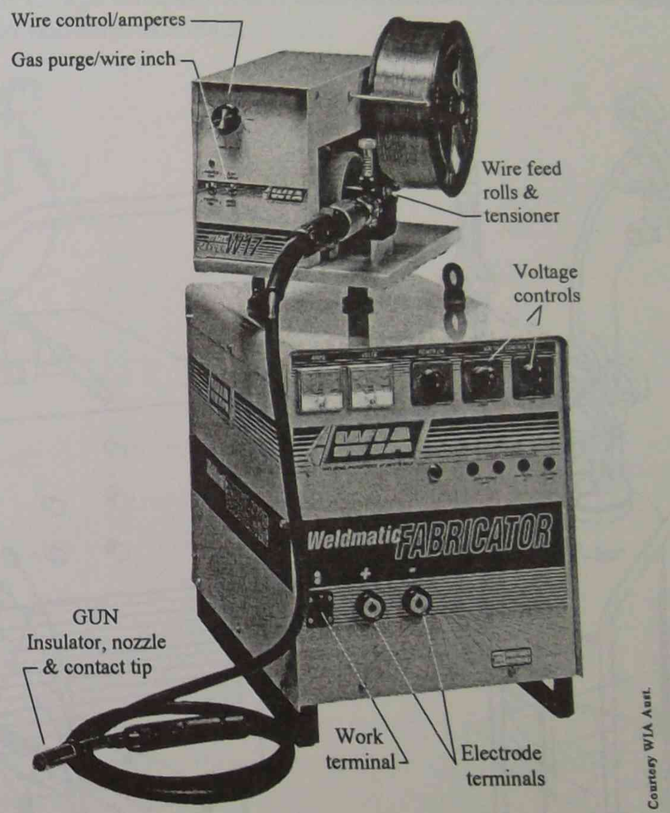
Manual metal arc welding equipment

Gas metal arc welding (GMAW)

The process
An arc is struck between the work and a continuous wire electrode fed through a torch which is supplied with a shielding gas.

Gas metal arc welding is usually a semi-automatic process but it can easily be made automatic which saves labour and consumables. It's important to use the right filler wire and shielding gas. You can weld a wide range of steels and non-ferrous metals by this method.

Uses
This versatile process is used in all light and heavy fabrication industries including the motor vehicle industry. This process is becoming more popular and in many cases is replacing manual metal arc welding.



Gas metal arc welding equipment

Introduction to welding and thermal cutting processes

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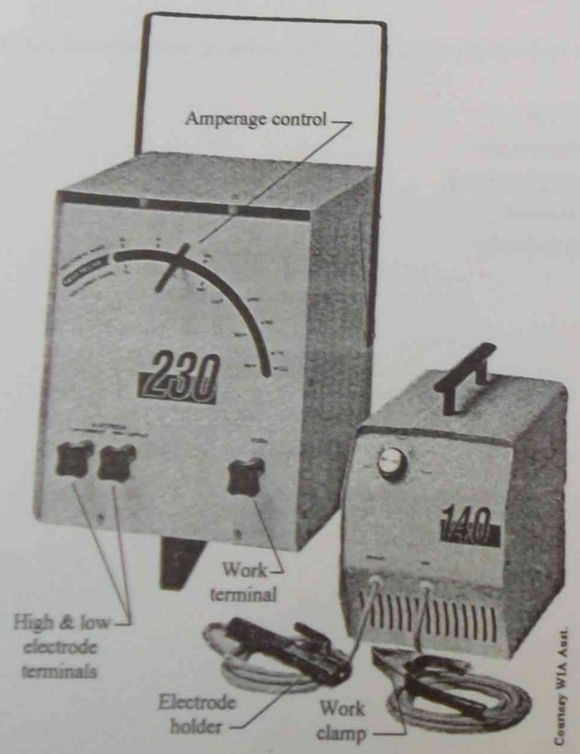

Manual metal arc welding equipment

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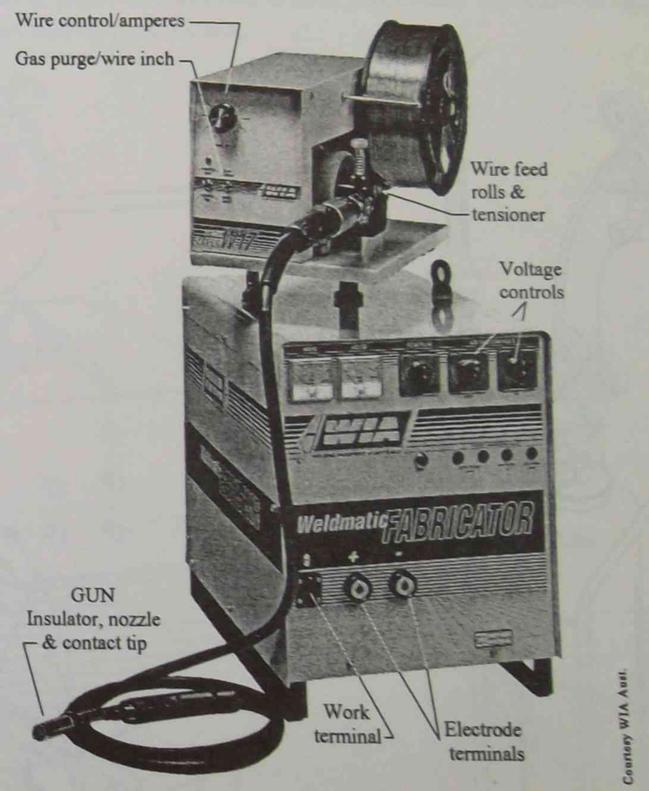


Gas metal arc welding equipment

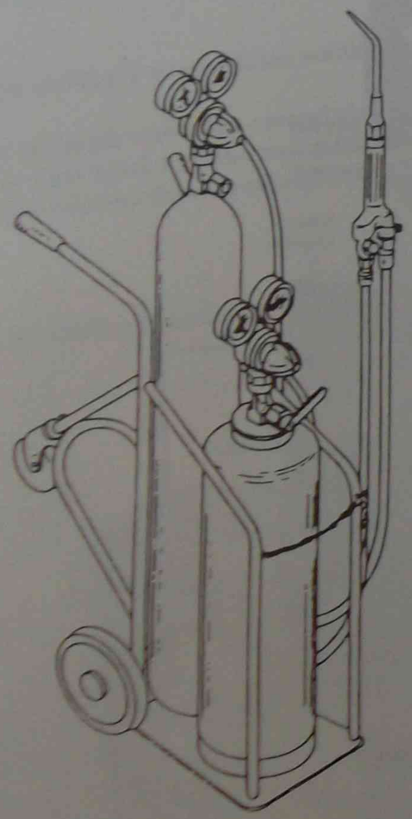
Oxyacetylene welding (OAW)

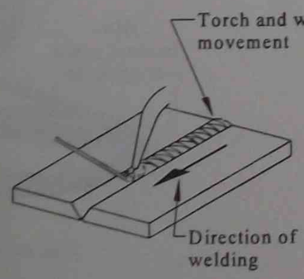
The process
The oxyacetylene welding process uses the heat from a gas flame to fuse or bond the parts together. This is called combustion.

Oxyacetylene welding is a manual skill which needs to be practised. It can be done with or without filler metal and can be used on materials of thin to medium thickness. You can't weld thicker metals economically by this method.

On the plus side, oxyacetylene equipment is fairly cheap and you can move it easily to where welding, brazing and heating are needed. However the process is slow and can sometimes cause more distortion in the metals being welded because of the greater heat.

Uses
Oxyacetylene welding is used in general engineering and in the light fabrication and vehicle industries.





Oxyacetylene welding (OAW)

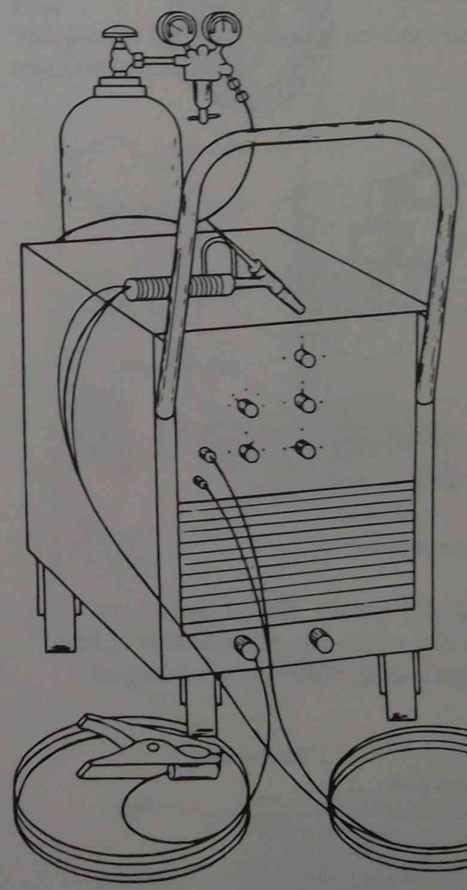
Gas tungsten arc welding (GTAW)

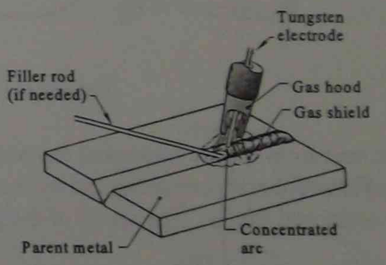
The process
Gas tungsten arc welding is a fusion process. The heat is generated by an electric arc between a tungsten electrode and the work rather than by a flame.

The tungsten electrode is used to carry the current which produces the arc and is not consumed to form part of the weld. A hand held filler rod can be used to supply additional weld metal.

Argon is the inert gas most commonly used in Australia as the shielding medium to protect the weld from contamination by nitrogen and oxygen in the atmosphere. An inert gas will not combine with other elements.

Uses
The gas tungsten arc process is used mainly in light fabrication and general engineering. It welds most metals to high standards and is used particularly for stainless steel, aluminium and other non-ferrous metals.





Gas tungsten welding equipment

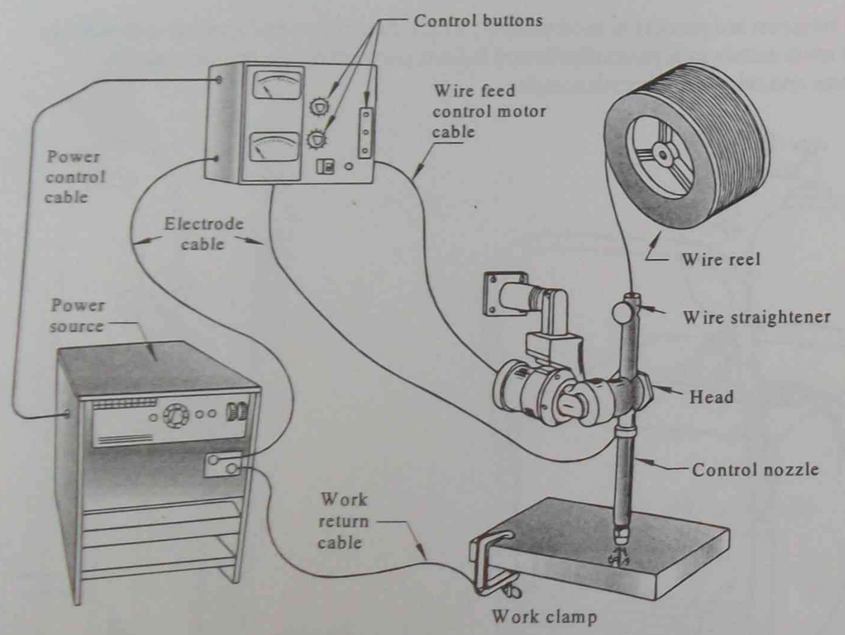
Submerged arc welding (SAW)

The process

Submerged arc welding uses a bare metal wire electrode. The arc is protected by a separate supply of loose flux. Some of this flux melts and forms a slag-cover over the weld. During welding the bare metal wire electrode is fed automatically into the blanket of flux. There are minimum fumes, no visible arcing and the equipment is easy to use.

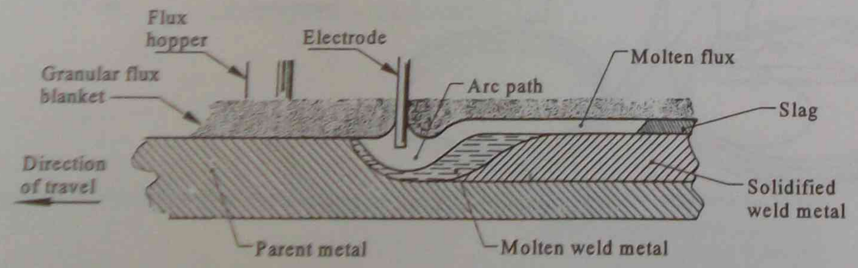
Uses

Submerged arc welding is popular in the heavy metal fabrication industry because it gives welds of high quality. It is used to make pipes, pressure vessels, boilers, road and railroad tankers and other structures that require welding in a straight and continuous line.



Submerged arc welding equipment

The heat from the arc melts and fuses the base and filler metals. The arc is protected from atmospheric contamination by the blanket of flux which also prevents weld spatter, arc noise and fumes. The speed of the process helps to keep distortion to a minimum.



Resistance welding

Spot welding process

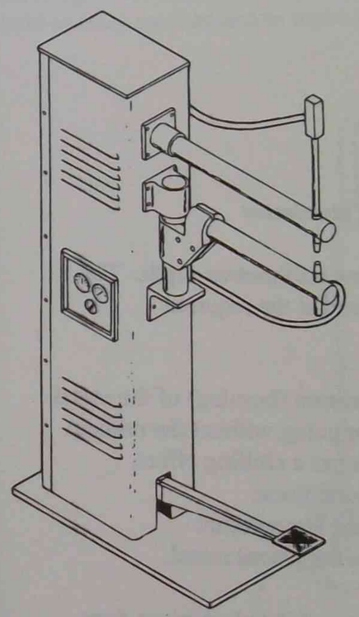
The spot welding process uses the heat resulting from resistance to an electric current passing through the metals being joined.

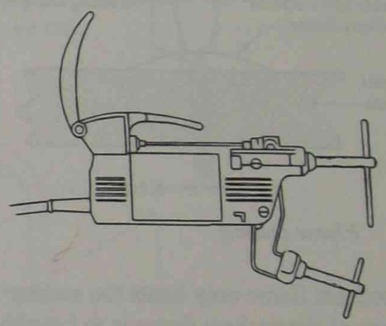
The spot welding machine produces a small round weld, called a weld nugget, to join two overlapping pieces of metal. The materials to be welded are clamped together between two copper alloy electrodes and a current is passed between the electrodes, for a controlled time. The current heats the metals at their junctions and they are joined by the force of the electrodes being squeezed together.

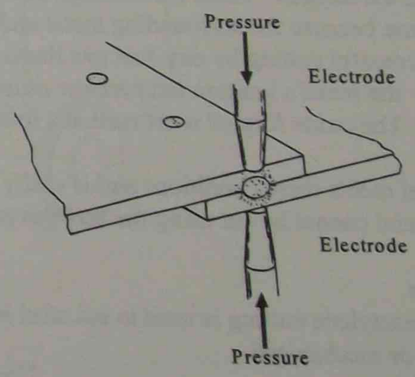
Spot welding may be used on materials from 0.025 mm to 6 mm thick but most spot welding is done with materials of less than 3 mm thickness.

Uses

This process is commonly used on sheet metal in the light fabrication, vehicle and transport industries.







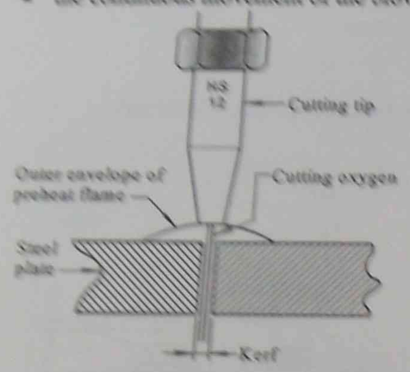
Spot welding equipment

Fuel gas cutting

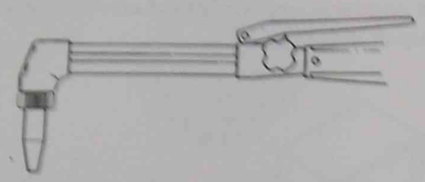
Chemistry of oxy-fuel gas cutting

The oxy-fuel gas cutting process depends on the chemical reaction of heated iron or steel coming in contact with pure oxygen. The reaction is called oxidisation.

Process
The cutting process involves:
- heating the steel to its ignition temperature (815˚C)
- oxidisation of the steel in the path of the oxygen jet
- removal of the slag by pressure from the oxygen stream
- the continuous movement of the blowpipe.



Flame cutting



Cutting attachment

The preheat flame only heats the surface of the metal to a few millimetres depth. The purpose of the preheat flame is to keep the surface of the metal at the required temperature (ignition point 815°C).

The remaining thickness of the metal is heated by the combustion (burning) of the metal and the oxygen. There isn't enough heat to keep the reaction going without the preheat flame because the surrounding metal and the cutting oxygen has a chilling effect.
Successful cutting by oxy-fuel gas flames depends on two conditions:
- the metal's ignition temperature must be below its melting temperature
- The oxide formed must melt at a lower temperature than the parent metal.

Steel meets these conditions and is easily cut with this process whilst aluminium does not and cannot be cut using the fuel gas process.

Uses
Oxyacetylene cutting is used to cut steel in all industries. The machine can be hand-held or mechanised.

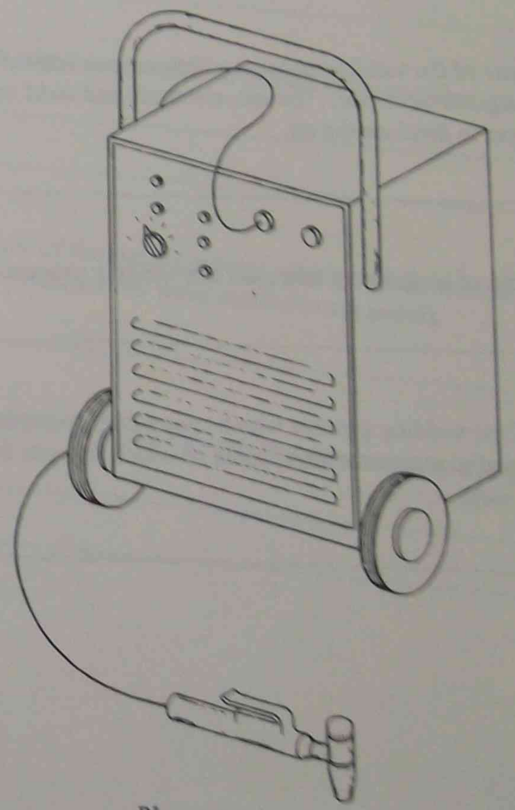
Plasma cutting

The process
The plasma cutting process is more versatile than the oxy-fuel gas cutting process and will cut non-ferrous and ferrous metals. It uses an electric current to ionise the gas to cut the metal, rather than a flame and oxygen to oxidise the metal.

In a plasma torch, the electric arc is made by:
- the tungsten electrode and the nozzle of the torch **OR**
- the tungsten electrode and the surface of the work.

Plasma cutting equipment
Plasma cutting is a thermal process used on all metals that can be melted by a hot plasma arc. Some of these metals are stainless steel, aluminium, cast iron, alloy steels and low carbon steel. Plasma cutting is good for a wide range of shapes which includes straight lines, bevel preparations and profiles.

Uses
Both light and heavy industry use the plasma cutting process. The units are either hand-held or fully mechanised to move around the shape to be cut.



Plasma cutting equipment

Review questions

These questions will help you revise what you've learnt in Section 1.

1. State a reason why a flux is used on manual metal arc welding electrodes.

_____

_____

2. List the type of electrode used in metal arc welding process.

_____

_____

3. State the name of the gases used in the OAW process.

_____

_____

4 (a) State the name of the welding process which uses an intense arc between the work and tungsten electrode. The arc, electrode and weld zone are protected by an inert gas to displace the air.

_____

(b) State the name of an industry that uses this welding process.

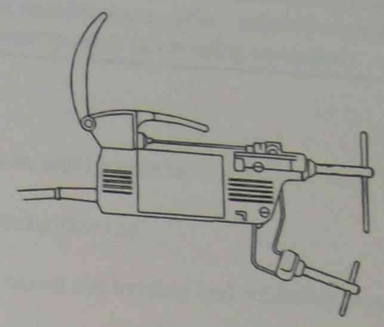
_____

5. State the name of the welding process which uses a continuous bare metal electrode enveloped in a granular flux, some of which fuses to form a removable slag covering the weld.

_____

Review questions

6. (a) State the name of the welding process that uses the machine shown below.



_____

(b) State the names of **two** industries which use this process.

- _____
- _____

7. Give the reason why a pre-heat flame is used when oxy-fuel gas cutting.

_____

_____

8 (a) State the name of the cutting process which uses an electric arc created between the torch and the work surface to cut metals.

_____

(b) State the names of **two** of the metals that can be cut by this process.

- _____
- _____

Notes

Section 2: Brazing theory

SUGGESTED DURATION	PREAMBLE
1 hour	This section enables you to select suitable consumables, joint types and equipment to carry out brazing operations.

Objectives

At the end of this section you will be able to:

- ☐ describe the brazing process
- ☐ compare and contrast the brazing and soldering processes in terms of:
  - appearance
  - strength
  - cost
  - applications
- ☐ list the equipment and consumables required for brazing
  - welding plant
  - flux
  - filler material
- ☐ state the metals suitable for brazing
  - ferrous
  - non-ferrous
- ☐ list common industrial uses for brazing
  - copper fittings
  - electrical connections
- ☐ list the hazards of the brazing process
  - heat
  - poisons (flux solvents)
- ☐ list the safety equipment required for the brazing process
  - eye
  - body
  - ventilation
  - respiratory.

Brazing process

Brazing is more like soldering than welding. Capillary action draws the molten filler metal between two close fitting surfaces and joins them. Lap joints and prepared fillet joints similar to soldering are recommended.

Brazing is much stronger and more expensive than soft soldering and is done at temperatures above 450°C.

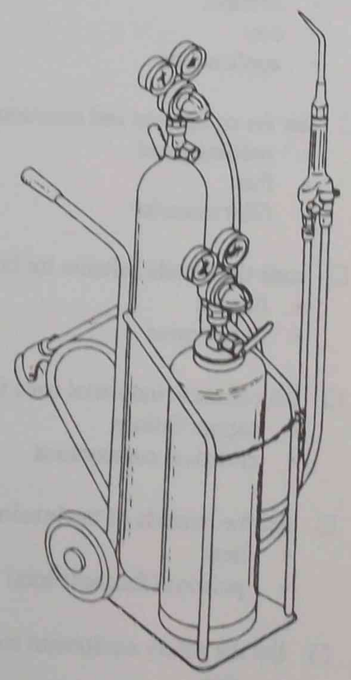
Silver brazing
Silver brazing is also called silver soldering and is used for joining steel, copper, bronze and brass.

For silver brazing you need a filler metal made of silver and copper alloy and a commercially prepared flux. Silver brazing alloy melts at a lower temperature than other alloys used for brazing.

Common heating gas mixtures

- *Oxygen and acetylene*
  This type of flame is suitable for most torch brazing. The equipment is portable and quite cheap. The flame heat can be controlled over a wide temperature range.

- *Oxygen and LP gas*
  Both industrial and hand held units are available. Hand held units are ideal for small and difficult to reach areas.



Portable oxyacetylene welding plant suitable for braze welding

Safety

Hoses should be checked regularly for gas leaks.

Brazing fluxes
Fluxes are used for most brazing operations for the following reasons.
- To assist the filler alloy to flow freely
- To clean the surfaces to be joined
- To prevent oxides forming while brazing

Fluxes are available in a number of forms. The most common fluxes are powder, liquid or paste. Manufacturers' information leaflets will help you to select the most suitable flux for a particular job.

Safety

- You must have adequate ventilation when brazing. This is particularly important when the flux contains fluorides or when the brazing alloy contains cadmium.

- Don't let flux contact your skin.

Brazing alloys

Brazing alloys are available in many combinations. You must choose the most suitable alloy.

Points to think about when choosing the most suitable alloy.
- Mechanical strength of the joint
- Materials involved
- Finish required
- Cost
- Your level of skill
- Colour of joint - matching the workpieces if required

Filler metals come in three main groups.
- Copper base alloys
- Silver base alloys
- Phoshorus copper based alloy

Silver alloys are free flowing. They can enter small openings and provide strong neat looking joints.

Brazing

Brazing is
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Brazing is
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Silver braz
Silver brazi
and brass.

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other alloys

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Metals suitable for brazing

Most ferrous and non-ferrous metals used in industry can be joined with either copper or silver alloys. You can braze metals that are not alike, eg. copper to steel.

Examples of metals commonly brazed are given below.

- Steel - most grades and alloys
- Copper
- Stainless steel
- Brass

Industrial uses of brazing

Brazing is commonly used for:

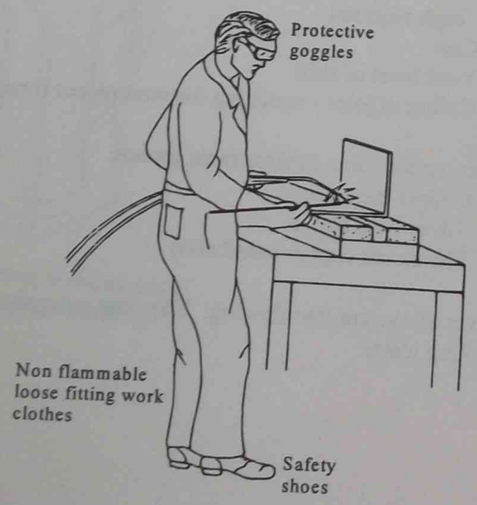
- electrical connections
- copper pipes and fittings
- furniture
- auto fittings
- plumbing (phoshorus copper based alloy).

Hazards of brazing

Ventilation
Fluxing agents contain toxic (poisonous) chemicals and it's important that adequate ventilation is maintained throughout the brazing operation.

Flux
Avoid flux contacting your skin.

Chemicals
Be very careful when using acids. Always wear protective clothing, gloves and goggles when working with chemicals and make sure you're in a well ventilated area. These precautions are for your safety. Don't take risks.



Protective clothing

Review questions

These questions will help you revise what you've learnt in Section 2.

1. List the safety equipment you need for brazing. Use the following headings as a guide.

   Eyes

   _____

   _____

   Body

   _____

   _____

   Ventilation

   _____

   _____

2. List **three** of the metals which can be joined by the brazing process.

   - _____
   - _____

3. State the name of **two** common heating gas mixtures used for brazing.

   - _____
   - _____

4. State a weld joint recommended for brazing.

   _____

   _____

NBB09 Welding
Student Workbook

Review questions

5. Compare brazing to soldering by ticking the appropriate box for the following.

	Greater than soldering	Less than soldering
☐ Strength	☐	☐
☐ Cost	☐	☐
☐ Temperature	☐	☐

Section 3: Brazing

SUGGESTED DURATION	PREAMBLE
1 hour 45 minutes	This section enables you to use the brazing process to safely join copper and copper alloys.

Objectives

At the end of this section you will be able to:

- ☐ use the brazing process to bond copper and galvanised sheet in the horizontal position to the following requirements
  - neat and adequate fluxing of the surfaces to be bonded
  - correct alignment and assembly
  - penetration and bonding for the length of the joint
  - adequate but not excessive addition of filler rod
- ☐ record the brazing procedure
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Follow all Occupational Health & Safety workshop procedures.
- Keep flux away from your eyes, mouth and skin.
- Avoid breathing welding fumes.
- Wash your hands thoroughly when you've finished your exercise.

Skill practice 1
Assessment event 1 (practical)
Brazing

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 1 hour 45 minutes
Assessment: 15 minutes

Objective To bond materials by brazing (copper/silver alloy) to the requirements given below.

Position As illustrated.

Procedure Before beginning the exercise, you must attend a demonstration by your teacher.

Method

1. Straighten the copper material and remove oxides from the bonding surfaces with a wire brush or abrasive cloth.
2. Apply flux to both bonding surfaces and assemble members.
3. Heat plates evenly with the outer envelope of a soft flame.
4. When the flux indicates correct temperature, apply the brazing alloy allowing sufficient filler material to just penetrate the joint.
5. Take the assembly to be inspected by your teacher.
6. Repeat the exercise on brass and record the information on the procedure sheet.
7. Remove flux by wire brushing the effected areas in hot water.
8. For assessment, repeat the brazing to the requirements given below.

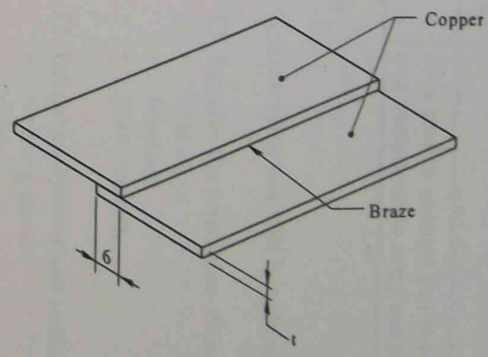
Requirements

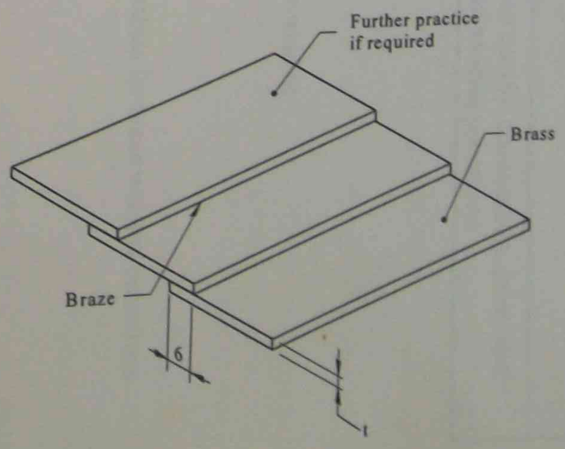
- Correct alignment with penetration for the length of the joint
- Minimum filler metal addition with adequate fluxing

Material unit 2 pieces copper 30 x 1.6 x 50 mm
2 pieces brass 30 x 1.6 x 50 mm

Unit required 1

Economy Return all unused material to the store.





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Skill practice 1
Assessment event 1 (practical)
Brazing

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 1 hour 45 minutes
Assessment: 15 minutes

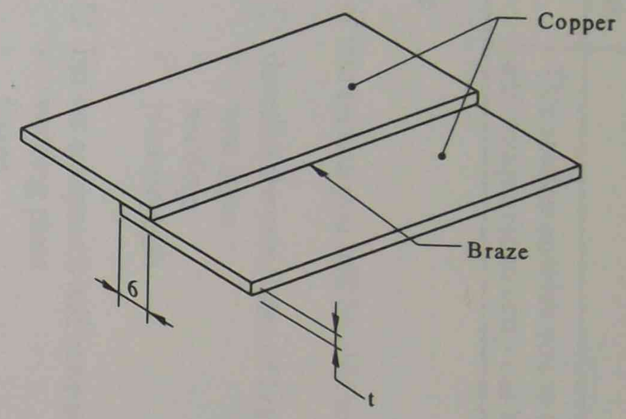
Objective To bond materials by brazing (copper/silver alloy) to the requirements given below.

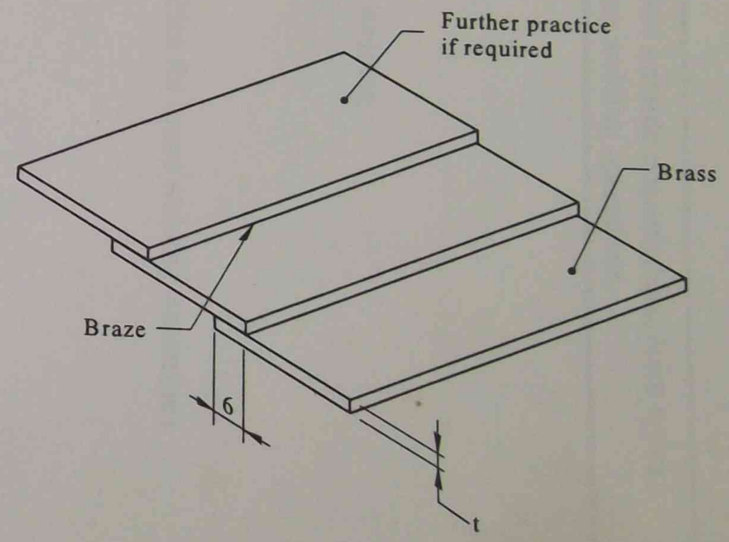
Position As illustrated.

Procedure Before beginning the exercise, you must attend a demonstration by your teacher.

Method

1. Straighten the copper material and remove oxides from the bonding surfaces with a wire brush or abrasive cloth.
2. Apply flux to both bonding surfaces and assemble members.
3. Heat plates evenly with the outer envelope of a soft flame.
4. When the flux indicates correct temperature, apply the brazing alloy allowing sufficient filler material to just penetrate the joint.
5. Take the assembly to be inspected by your teacher.
6. Repeat the exercise on brass and record the information on the procedure sheet.
7. Remove flux by wire brushing the effected areas in hot water.
8. For assessment, repeat the brazing to the requirements given below.





Requirements

- Correct alignment with penetration for the length of the joint
- Minimum filler metal addition with adequate fluxing

Material unit 2 pieces copper 30 x 1.6 x 50 mm
2 pieces brass 30 x 1.6 x 50 mm

Unit required 1

Economy Return all unused material to the store.

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Notes

6.

Section 4: Braze welding theory

SUGGESTED DURATION	PREAMBLE
1 hour	This section enables you to select suitable consumables, joint types and equipment to carry out braze welding operations.

Objectives

At the end of this section you will be able to:

- ☐ describe the principles of braze welding
  - heat input
  - bonding
  - joint strength
- ☐ list the equipment and consumables for braze welding operations
  - welding plant
  - fluxes
  - filler materials
- ☐ state the metals suitable for braze welding
  - steel
  - cast iron
  - copper
- ☐ list common industrial uses for brazing welding
  - maintenance repairs
  - tanks
  - furniture
- ☐ list the hazards of the brazing welding process
  - heat
  - poisons (fluxes)
- ☐ list the safety equipment for the brazing welding process
  - eye
  - body
  - respiratory
- ☐ outline the technique for braze welding low carbon steel
  - flame adjustments
  - flux application
  - welding technique.

Braze welding process

Braze welding uses an oxyacetylene flame, a flux to clean the surface, and a filler rod made from a copper/zinc alloy. The filler rod melts at a much lower temperature than the parts to be joined, and the parent metal is not melted.

Braze welding is different from brazing in that it uses different joint preparations, filler metal and welding technique. The weld preparations for braze welding are like the ones used for fusion welding. They allow for full thickness welds and give strong joints. The bond strength comes from the filler metal penetrating into the metal's grain boundaries and sticking to the surface of the joint preparation.

Braze welding technique

The parts are first heated using a slightly oxidising flame. The flux is added to the heated end of the filler rod and applied to the joint during welding.

Advantages of braze welding

- requires much less heat input and causes less distortion than fusion welding
- braze welding is able to join a wide range of dissimilar metals including non-ferrous and ferrous, eg copper, steel, cast iron.

Disadvantages of braze welding

- higher consumable costs
- loss of strength at moderately high temperatures (above 260°C)
- will corrode if in contact with ammonia.

Uses of braze welding

Braze welding is used for repairing machinery and fittings in maintenance work.
Other uses include making leakproof joints on small tanks and constructing furniture from hollow sections.
Braze welding is ideal for repairing broken or worn cast iron components.

Safety when braze welding

Safety precautions

- Have enough ventilation
- Don't let fluxes touch your skin
- Use flame and other equipment carefully
- Observe Occupational Health & Safety procedures

Safety clothing

Wear the right clothing for the work you have to do. For example, for bench work wear:

- overalls
- work boots
- non-flammable under-clothing
- oxy-welding goggles with standard filter lens.

Review questions

These questions will help you revise what you've learnt in Section 4.

1. State the differences between braze welding and brazing.

   _____

   _____

2. State the names of the **two** main metals that make up the alloy filler rod for braze welding.

   - _____
   - _____

3. Give a reason why flux is used in braze welding.

   _____

   _____

4. List **three** metals suitable for braze welding.

   - _____
   - _____
   - _____

5. Name a use for braze welding.

   _____

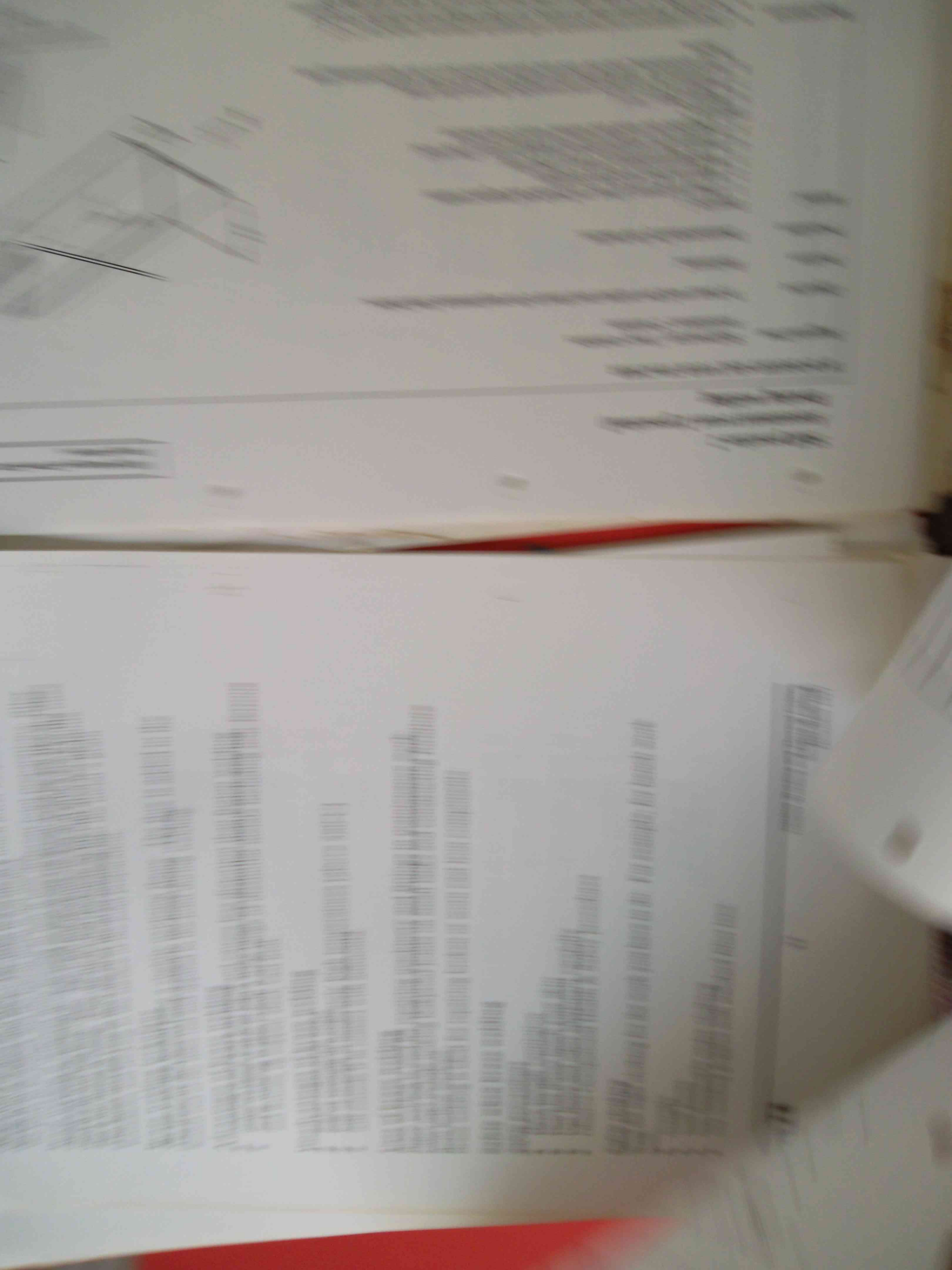
6. Compare braze welding with oxyacetylene fusion welding by listing **two** advantages and disadvantages of braze welding.

   Advantages

   - _____
   - _____

   Disadvantages

   - _____
   - _____



Review questions

List **two** potential hazards associated with the braze welding process.

_____

_____

Section 5: Braze welding

SUGGESTED DURATION	PREAMBLE
1 hour 45 minutes	This section enables you to safety braze weld low carbon steel sheet.

Objectives

At the end of this section you will be able to:

- ☐ braze weld low carbon steel sheet in the horizontal position to following requirements
  - correct alignment and assembly with angular distortion of 0° to 5°
  - no melting of the parent metal
  - adequate tinning and bonding of the joining surfaces
  - a maximum of two significant surface defects per weld length with an accumulative defect area not exceeding 10 mm square per 150 mm weld length
- ☐ record the braze welding procedure
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Follow all Occupational Health & Safety workshop procedures.
- Wear the proper eye protection.
- Wear suitable protective clothing.
- Keep your work area tidy.

Procedure sheet
Braze welding

Sketch		
Gas data		**Consumables data**
Regulator		Filler type
Pressure O_2	C_2H_2	Filler size
Flame type		Flux
Weld tip size		
Material data		**Weld time**
Type		Start
Thickness		Finish
		Units completed
Assessment	**Complies**	**Does not comply**
Alignment		
Distortion		
Tinning and bonding		
Surface finish		
Surface defects		
Name	**Exercise Number**	

Skill practice 2
Assessment event 2 (practical)
Brazing welding

IF IN DOUBT ASK YOUR TEACHER

Suggeted time Skill practice: 1 hour 4 minutes
Assessment: 15 minutes

Objective To braze weld low carbon steel sheet to the requirements listed below.

Position Horizontal.

Procedure Demonstrated by the teacher.

Method

Exercise 1
1. Clean weld zone of rust, mill scale and organic matter.
2. Align and tack weld the assembly.
3. Weld approximately 50 mm of the joint.
4. Examine the weld profile and tinning action of the weld.
5. Complete the weld and submit work to the teacher.

Exercise 2
6. Repeat Steps 1 to 4.
7. Evaluate the weld project and complete the procedure sheet.
8. For assessment, join the first and second exercises to the requirements given below.

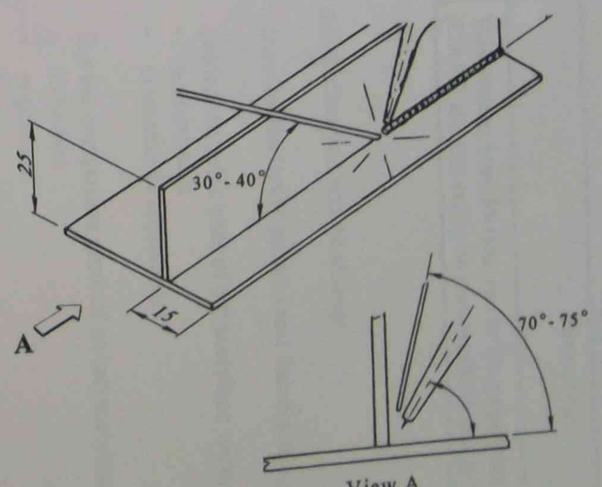
Requirements
- Correct alignment and assembly with angular distortion limited to 0°-5°
- No melting or parent plate or excessive loss of filler metal alloying elements
- Adequate tinning and bonding of the deposited alloy to the parent material
- A maximum of two significant surface defects per weld length with an accumulative defect area not exceeding 10 mm square per weld

Material unit 2 pieces 50 x 1.6 x 150 mm low carbon steel sheet
2 pieces 25 x 1.6 x 150 mm low carbon steel sheet

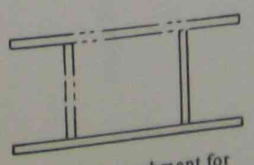
Unit required 2

Filler material 1.6 mm diameter manganese bronze and copper/brass flux.

Economy Join exercises 1 and 2 for maximum use of material. Return all unused material to the store.



View A


Method of attachment for maximum material use.

Skill practice 2
Assessment event 2 (practical)
Brazing welding

IF IN DOUBT ASK YOUR TEACHER

Suggeted time Skill practice: 1 hour 4 minutes
Assessment: 15 minutes

Objective To braze weld low carbon steel sheet to the requirements listed below.

Position Horizontal.

Procedure Demonstrated by the teacher.

Method

Exercise 1
1. Clean weld zone of rust, mill scale and organic matter.
2. Align and tack weld the assembly.
3. Weld approximately 50 mm of the joint.
4. Examine the weld profile and tinning action of the weld.
5. Complete the weld and submit work to the teacher.

Exercise 2
6. Repeat Steps 1 to 4.
7. Evaluate the weld project and complete the procedure sheet.
8. For assessment, join the first and second exercises to the requirements given below.

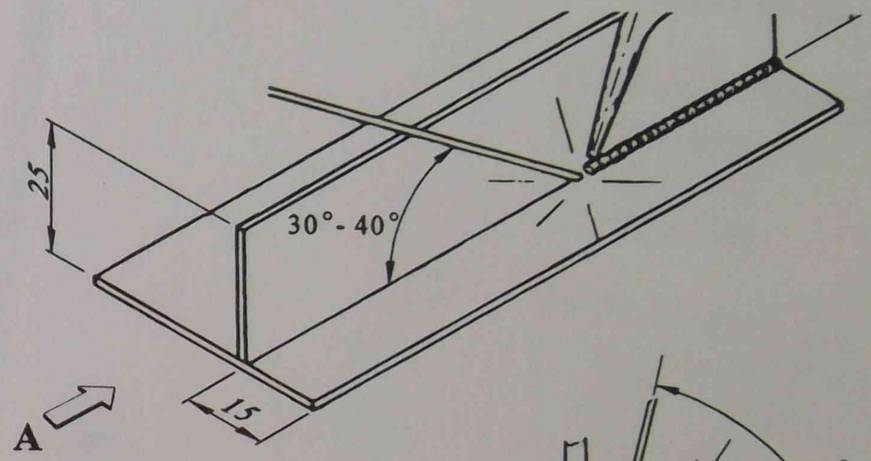
Requirements
- Correct alignment and assembly with angular distortion limited to 0°-5°
- No melting or parent plate or excessive loss of filler metal alloying elements
- Adequate tinning and bonding of the deposited alloy to the parent material
- A maximum of two significant surface defects per weld length with an accumulative defect area not exceeding 10 mm square per weld

Material unit 2 pieces 50 x 1.6 x 150 mm low carbon steel sheet
2 pieces 25 x 1.6 x 150 mm low carbon steel sheet

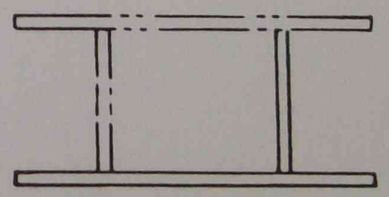
Unit required 2

Filler material 1.6 mm diameter manganese bronze and copper/brass flux.

Economy Join exercises 1 and 2 for maximum use of material. Return all unused material to the store.



View A



Method of attachment for maximum material use.

Notes

Section 6: Oxyacetylene welding theory

SUGGESTED DURATION	PREAMBLE
1 hour 30 minutes	This section introduction you to the principles of oxyacetylene welding (OAW) and the safety requirements of this process.

Objectives

At the end of this section you will be able to:

- ☐ describe the OAW process and flame settings
- ☐ outline the principles of oxyacetylene welding
  - heat process
  - consumable application
- ☐ list the component parts of an oxyacetylene welding plant
  - cylinders
  - regulators
  - hoses
  - welding torch
- ☐ compare the OAW process to arc welding in relation to:
  - deposition rate
  - portability
  - versatility
- ☐ list the common uses for OAW
  - maintenance repair
  - tubular furniture
  - farm uses
- ☐ list the hazards of the OAW process
  - heat
  - gases
  - fumes
- ☐ list the protective clothing available for OAW operators
  - eyes
  - body
  - feet
- ☐ describe the need for adequate ventilation when using the OAW process.

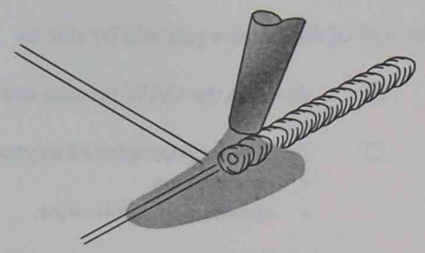
Oxyacetylene welding process

Oxyacetylene welding is a manual process which combines oxygen and acetylene gases to give a high temperature flame for welding.

The edges of the parts to be joined are melted and fused together to form a high strength joint. Additional weld metal can be added from a hand held filler rod.

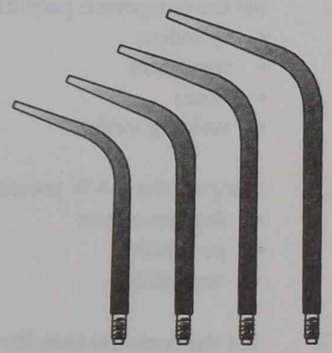
You must protect the molten puddle with the flame to prevent the atmosphere from contaminating the molten weld pool.

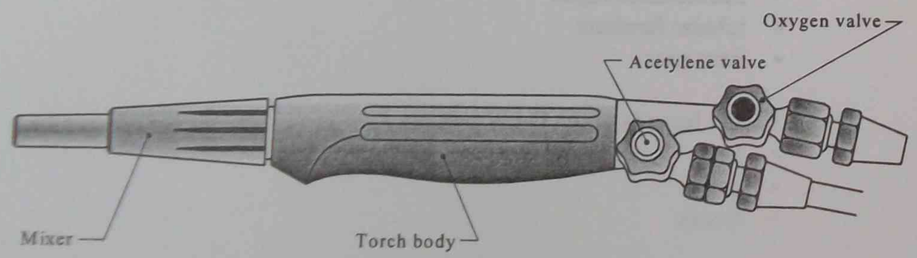
The hot end of the filler rod and weld are protected from the atmosphere by the covering flame.



Equipment

Welding tips come in sizes to suit different metal thicknesses. They screw into the mixer which is on the end of the welding torch.

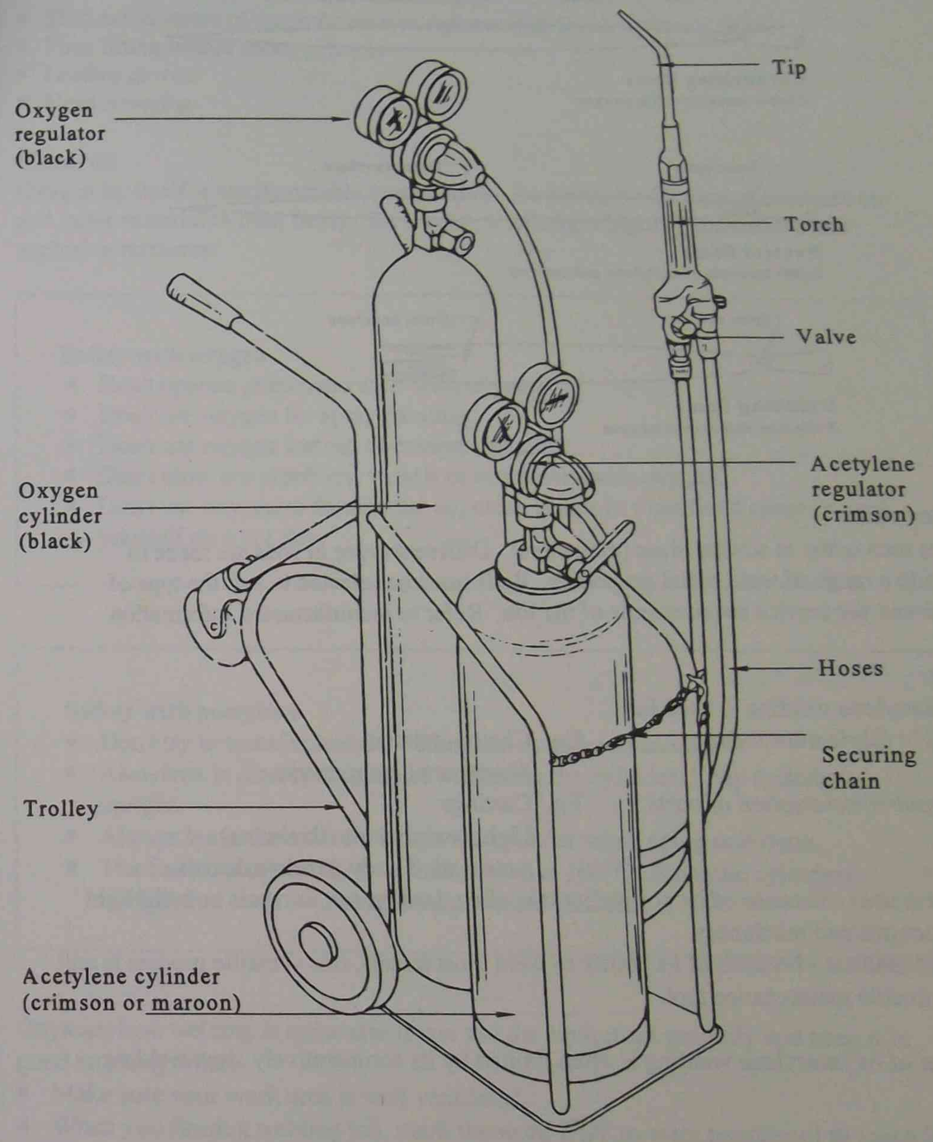




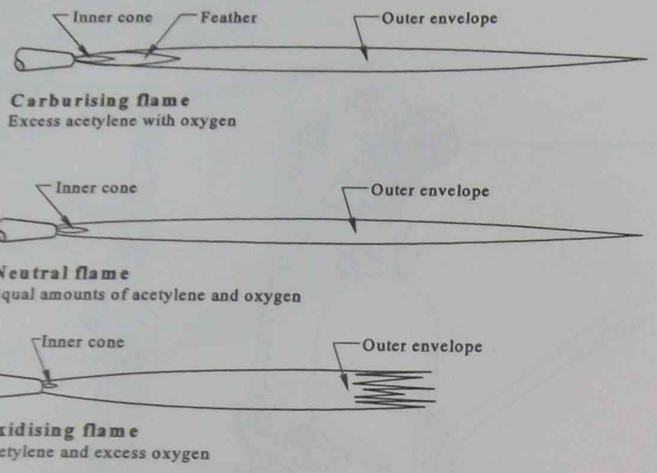
The table opposite shows the gas pressures suitable for the various tip sizes.

Tip size	Oxygen pressure kPa	Acetylene pressure kPa
8	50	50
10	50	50
12	50	50
15	50	50
20	50	50
26	50	50
32	100	100

Oxyacetylene welding equipment



Oxyacetylene welding - flame adjustments



Filler rods

Filler rods come in several sizes (diameters). Different types of rods are made to provide a range of weld metal properties. Rods must be selected to suit the type of metal and the service requirements of the job. Refer to manufacturers' information.

Uses

Oxyacetylene welding is used for:

- *Light fabrication industry* Eg. Chairs - tubular
  Sheet metal components
- *Repairs/reclamation of parts* Eg. Castings
  Light components (thickness)
  Automotive body panels/exhausts
- *Farm uses* - because of its portability it is often used on site to repair or build light structures and machinery.
- *Maintenance* - because of its ability to weld most metals, this versatile process is still a valuable maintenance tool.

The use of oxyacetylene welding is often limited by its comparatively slow welding speed.

Protective clothing

You must protect yourself from the radiated heat and rays when welding with oxyacetylene. Wear the following protective clothing.

- Shade 5 or 6 lens - Australian Standards approved
- Shirt and trousers of tough flame-resistant material (thick cotton or wool)
- Firm fitting leather shoes or boots
- Leather gloves
- Head covering

Hazards

Oxygen by itself is not flammable or explosive. However, it will support combustion and cause material to burn freely. Be careful, it will form highly combustable and explosive mixtures.

Safety with oxygen

- Don't operate pneumatic tools with oxygen.
- Don't use oxygen for spray painting.
- Don't use oxygen instead of compressed air.
- Don't blow out pipelines, vessels or containers with oxygen.
- Don't use oxygen to freshen the air, clean fumes in a confined space or cool yourself on a hot day.

Safety with acetylene

- Don't try to transfer acetylene from one cylinder to another.
- Acetylene is dissolved in liquid acetone in the cylinder. Keep cylinder upright.
- Always leave the cylinder key in the cylinder when using acetylene.
- The fusible plugs on these cylinders melt at 100˚C. Store the cylinders upright in a cool, well ventilated protected location.

Oxyacetylene welding is quite safe if you use the equipment properly and keep it in good working order.

- Make sure your work area is well ventilated.
- When you finish a welding job, mark the work *HOT* to warn people not to touch it.
- The burning temperature of the combined oxygen and acetylene gases is about 3100˚C. Treat this flame with extreme caution.
- Report all faulty or damaged equipment to your supervisor.

Review questions

These questions will help you revise what you've learnt in Section 6.

1. List **four** essential component parts required to operate an oxyacetylene welding plant.

   - _____
   - _____
   - _____
   - _____

2. Cylinders are identified by shape and colour.

   (a) State the colour used for oxygen cylinders.

   _____

   (b) State the colour used for acetylene cylinders.

   _____

3. State **two** industrial uses for oxyacetylene welding.

   - _____
   - _____

4. List **three** types of flame setting.

   - _____
   - _____
   - _____

5. How is the atmosphere excluded from the weld pool during the oxyacetylene process?

   _____

   _____

Review questions

6. List **three** items of clothing you need to protect you when oxyacetylene welding.

   - _____
   - _____
   - _____

Notes

Section 7: Oxyacetylene welding - beads on sheet

SUGGESTED DURATION	PREAMBLE
1 hour 30 minutes	This section enables you to safely deposit weld beads on low carbon steel sheet using the oxacetylene welding (OAW) process.

Objectives

At the end of this section you will be able to:

- ☐ open and close down an oxyacetylene welding plant
- ☐ deposit weld beads on carbon steel sheet to the following requirements:
  - neutral flame setting
  - weld beads for 150 mm continuous length
- ☐ document the weld procedure
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Follow Occupational Health & Safety workshop procedures.
- Always wear close fitting welding goggles.
- Direct the flame away from regulators, hoses, clothes and other people.
- Make sure your equipment is in good working order.

Procedure sheet
Oxyacetylene welding - beads on sheet

Sketch		
	Gas data	**Consumables data**
	Regulator	Filler type
	Pressure 0_2 C_2H_2	Filler diameter
	Flame type	Angles Torch Wire
	Weld tip size	
	Material data	**Weld time**
	Type	Start
	Thickness	Finish
		Units completed
Remarks	**Complies**	**Does not comply**
Flame setting		
Continuous weld bead		
Name	**Exercise Number**	

Skill practice 3

Oxyacetylene welding - beads on sheet

IF IN DOUBT ASK YOUR TEACHER

Objective To create lines of fusion and to deposit continuous weld beads to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method

1. Set up equipment with all connections tight and set regulator pressures as demonstrated.
2. Position the sheet as shown in Exercise 1.
3. Light the torch and before starting to weld, revise:
   - Gas mixture
   - Torch angle
   - Distance of cone from molten pool (view A)
4. Appraise the finished line of fusion and repeat the exercise.
5. After adequate practice, add filler rod to produce continuous weld beads as shown in Exercise 2.
6. Evaluate the exercises and complete the procedure sheet.
7. Submit your work for evaluation.

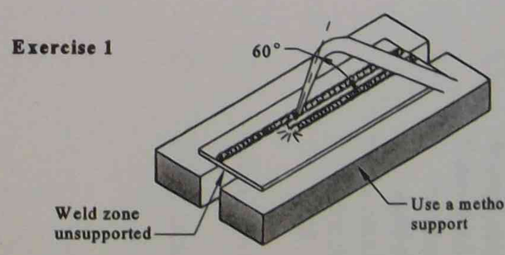
Points to watch
- Flame setting
- Torch and filler rod angles
- Distance of cone from molten pool
- Pool size and welding speed

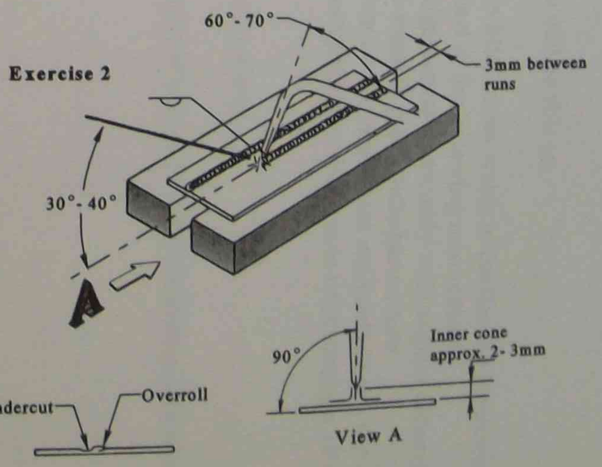
Requirements
- Neutral flame setting
- Weld beads for 150 mm continuous length

Material unit 1 piece 50 x 3 x 150 low carbon steel
1 piece 50 x 1.6 x 150 mm low carbon steel

Unit required 6

Economy Use both sides of sheets. Return unused material to the store.





Skill practice 5

Oxyacetylene welding – beads on sheet

IF IN DOUBT ASK YOUR TEACHER

Objective To create line of fusion and to deposit continuous weld beads to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method

1. Set up equipment with all connections right and set regulator pressures as demonstrated.
2. Position the sheet as shown in Exercise 1.
3. Light the torch and before starting to weld, revise:
   - Gas mixture
   - Torch angle
   - Distance of cone from molten pool (view A)
4. Appraise the finished line of fusion and repeat the exercise.
5. After adequate practice, add filler rod to produce continuous weld beads as shown in Exercise 2.
6. Evaluate the exercises and complete the procedure sheet.
7. Submit your work for evaluation.

Points to watch

- Flame setting
- Torch and filler rod angles
- Distance of cone from molten pool
- Pool size and welding speed

Requirements

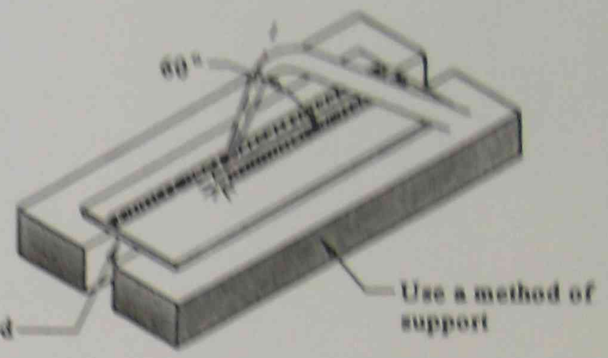
- Neutral flame setting
- Weld beads for 150 mm continuous length

Material unit 1 piece 50 x 3 x 150 low carbon steel
1 piece 50 x 1.6 x 150 mm low carbon steel

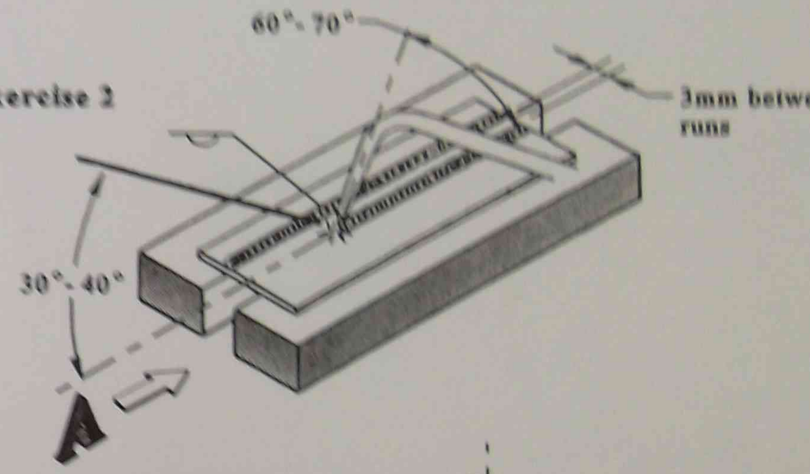
Unit required 6

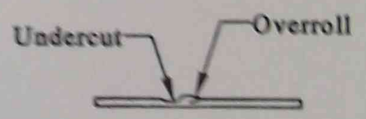
Economy Use both sides of sheets. Return unused material to the store.

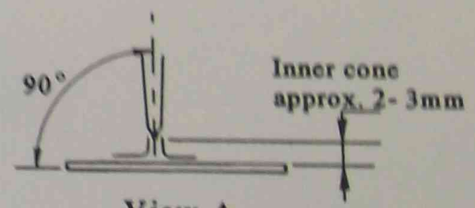
Exercise 1



Exercise 2







View A

Notes

Section 8: Oxyacetylene welding - outside corner

SUGGESTED DURATION	PREAMBLE
1 hours 30 minutes	This section enables you to safety deposit outside corner fillet welds in the flat and horizontal positions.

Objectives

At the end of this section you will be able to:

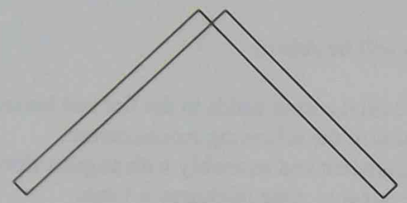
- ☐ deposit outside fillet corner welds in the flat and horizontal positions on 3 mm thick sheet to the following requirements:
  - correct alignment and assembly with angular distortion 0°-5°
  - weld size equal to plate thickness ± 1 mm
  - a maximum of two significant weld defects per 150 mm weld length with the accumulative defect area not exceeding 10 mm square per weld
- ☐ record the weld procedure
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Follow Occupational Health & Safety workshop procedures.
- Wear the proper eye protection - make sure your goggles are a good fit and have shade 5 or 6 lenses.
- Direct the flame away from regulators, hoses, clothes and other people.

Procedure sheet
Oxyacetylene welding - outside corner

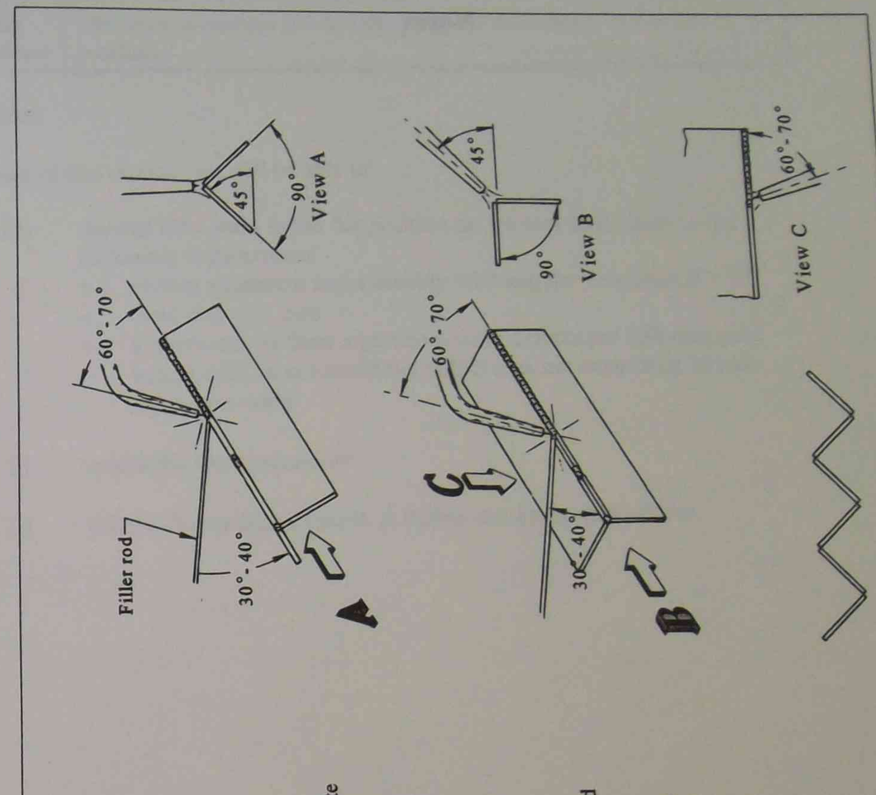
Sketch



Gas data		**Consumables data**	
Regulator		Filler type	
Pressure 0_2	C_2H_2	Filler diameter	
Flame type		Angles Torch	Wire
Weld tip size			
Material data		**Weld time**	
Type		Start	
Thickness		Finish	
		Units completed	

Remarks	**Complies**	**Does not comply**
Alignment		
Distortion		
Weld size		
Surface defects		

Name	**Exercise Number**



Skill practice 4

Oxyacetylene welding - outside corner

IF IN DOUBT ASK YOUR TEACHER

Objective To deposit outside corner welds to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method
1. Assemble and tack two sheets to form a corner joint ensuring correct fit and alignment.
2. Weld approximately 50 mm in a horizontal position.
3. After examination of the weld profile and penetration, complete the weld.
4. After inspection, add an additional section and repeat the exercise.
5. When a sufficient level of proficiency is reached, repeat the exercise.
6. Add additional sections as illustrated for further practice.
7. Evaluate the exercise and complete the procedure sheet.
8. Submit your work for evaluation.

Requirements
- Correct alignment and assembly with angular distortion limited to 0° - 5°
- Weld size equal to plate thickness ±1 mm
- A maximum of two significant surface defects per weld length
- A maximum of two significant surface defects per weld length with an accumulative defect area not exceeding 10 mm square per weld

Material unit 2 pieces low carbon steel 50 x 3 x 150 mm.

Unit required 6

Economy Align and tack plates as directed. Join all filler rod short ends and return all unused material to the store.

Skill practice 4

Oxyacetylene welding - outside corner

IF IN DOUBT ASK YOUR TEACHER

Objective To deposit outside corner welds to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method

1. Assemble and tack two sheets to form a corner joint ensuring correct fit and alignment.
2. Weld approximately 50 mm in a horizontal position.
3. After examination of the weld profile and penetration, complete the weld.
4. After inspection, add an additional section and repeat the exercise.
5. When a sufficient level of proficiency is reached, repeat the exercise.
6. Add additional sections as illustrated for further practice.
7. Evaluate the exercise and complete the procedure sheet.
8. Submit your work for evaluation.

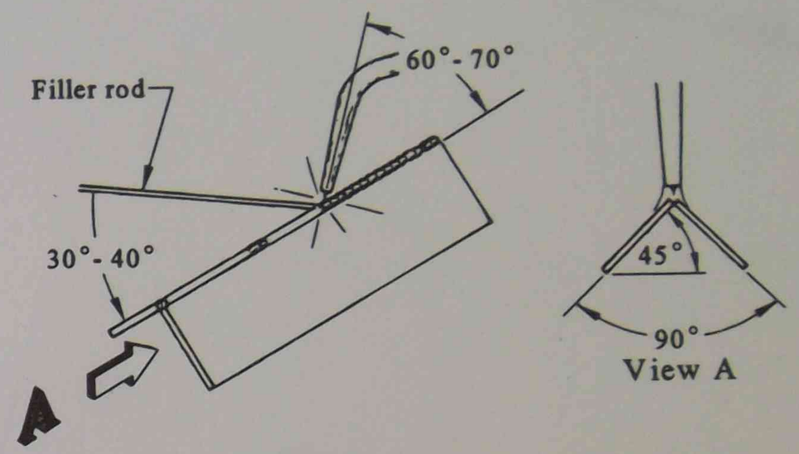
Requirements

- Correct alignment and assembly with angular distortion limited to 0°–5°
- Weld size equal to plate thickness ±1 mm
- A maximum of two significant surface defects per weld length with an accumulative defect area not exceeding 10 mm square per weld

Material unit 2 pieces low carbon steel 50 x 3 x 150 mm.

Unit required 6

Economy Align and tack plates as directed. Join all filler rod short ends and return all unused material to the store.



Notes

Section 9: Oxyacetylene welding - fillet weld

SUGGESTED DURATION	PREAMBLE
1 hour 15 minutes	This section enables you to safety deposit fillet welds in the flat position.

Objectives

At the end of this section you will be able to:

- ☐ deposit fillet weld in the flat position on 1.6 mm thick sheet to the following requirements
  - correct alignment and assembly with angular distortion 0°- 5°
  - weld size 3^{+2}_{-1} mm
  - a maximum of three significant weld defects per 150 mm weld length with an accumulative defect area not exceeding 10 mm square per weld
- ☐ record the weld procedure
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Follow Occupational Health & Safety workshop procedures.
- Wear the proper eye protection.
- Direct the flame away from regulators, hoses, clothes and other people.
- Mark your finished work **HOT** to warn others not to touch it.
- At all times observe safety procedures when handling or using oxygen and acetylene.

Procedure sheet
Oxyacetylene welding - fillet weld

Sketch		
Gas data Regulator Pressure 0_2 C_2H_2 Flame type Weld tip size		**Consumables data** Filler type Filler diameter Angles Torch Wire
Material data Type Thickness		**Weld time** Start Finish Units completed
Assessment	**Complies**	**Does not comply**
Alignment		
Weld size		
Weld defects		
Name	**Exercise Number**	

Skill practice 5
Assessment event 3 (practical)
Oxyacetylene welding - fillet weld

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 1 hour 15 minutes
Assessment: 15 minutes

Objective To weld deposit fillet welds to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

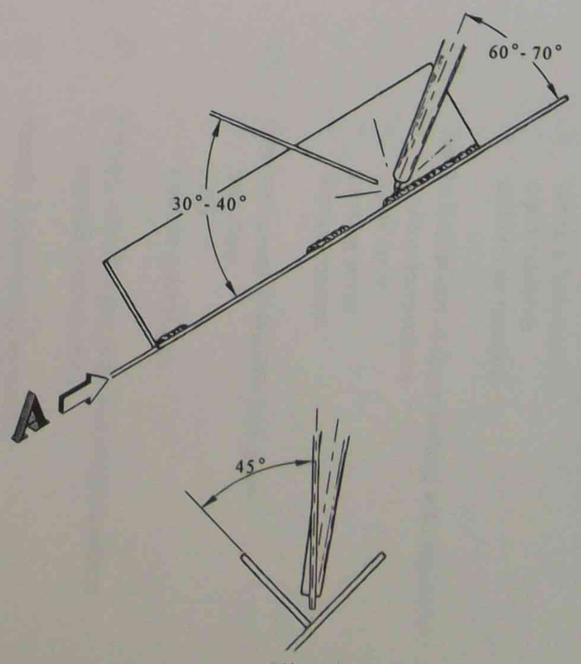
Method
1. Wire brush sheet to remove rust or scale from the fusion zone.
2. Align sheets at 90°.
3. Tack weld and check alignment, adjust if necessary to 90°.
4. Weld approximately 50 mm and check bead profile and penetration.
5. Complete the weld.
6. Submit your work for evaluation and complete the procedure sheet.
7. For assessment, repeat the fillet weld to the requirements given below.

Requirements
- Correct alignment and assembly
- Weld size 3^{+2}_{-1} mm
- A maximum of 3 significant weld defects per 150 mm weld length with an accumulative defect area not exceeding 10 mm square per weld

Material unit 2 pieces 25 x 1.6 x 150 mm low carbon steel
2 pieces 50 x 1.6 x 150 low carbon steel

Unit required 2

Economy Align and tack plates as directed. Join all filler rod ends and return all unused material to the store.



View A

SUGGESTED DURATION	PREAMBLE
1 hour 30 minutes	This section introduces you to oxy-fuel gas f

Unit 10: Flame cutting theory

Skill practice 5
Assessment event 3 (practical)
Oxyacetylene welding - fillet weld

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 1 hour 15 minutes
Assessment: 15 minutes

Objective To weld deposit fillet welds to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method

1. Wire brush sheet to remove rust or scale from the fusion zone.
2. Align sheets at 90°.
3. Tack weld and check alignment, adjust if necessary to 90°.
4. Weld approximately 50 mm and check bead profile and penetration.
5. Complete the weld.
6. Submit your work for evaluation and complete the procedure sheet.
7. For assessment, repeat the fillet weld to the requirements given below.

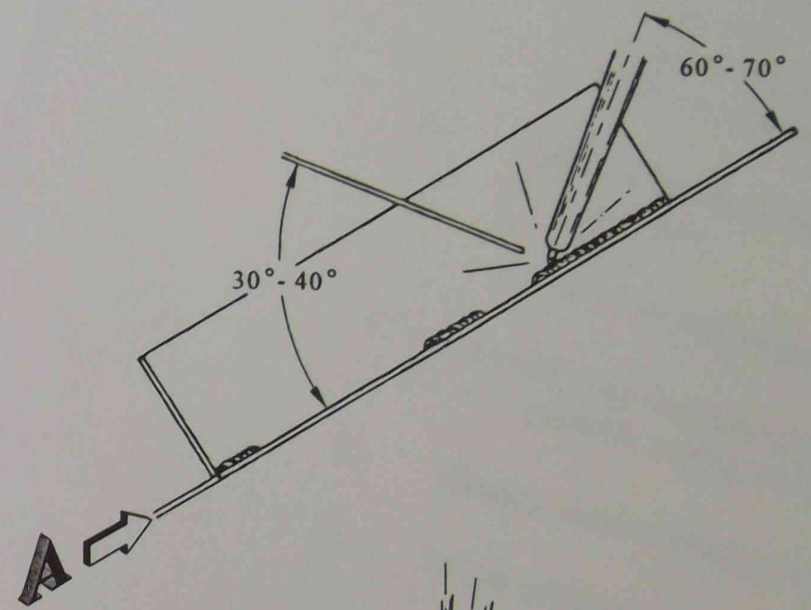
Requirements

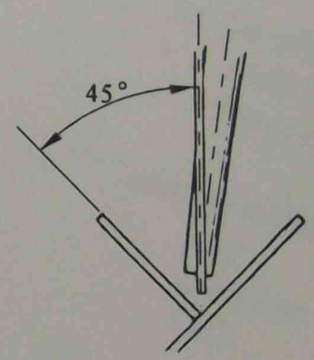
- Correct alignment and assembly
- Weld size 3^{+2}_{-1} mm
- A maximum of 3 significant weld defects per 150 mm weld length with an accumulative defect area not exceeding 10 mm square per weld

Material unit 2 pieces 25 x 1.6 x 150 mm low carbon steel
2 pieces 50 x 1.6 x 150 low carbon steel

Unit required 2

Economy Align and tack plates as directed. Join all filler rod ends and return all unused material to the store.





View A

Notes

Section 10: Flame cutting theory

SUGGESTED DURATION	PREAMBLE
1 hour 30 minutes	This section introduces you to oxy-fuel gas flame cutting, safely requirements and the equipment used.

Objectives

At the end of this section you will be able to:

- ☐ describe the basic principles of flame cutting
  - ignition temperature
  - rapid oxidation
  - exothermic reaction
- ☐ list the limitations of flame cutting with regard to:
  - ignition temperature
  - oxide layer
  - melting point
  - ferrous content
- ☐ state the names of suitable fuel gases
  - acetylene
  - LPG
  - town or natural gas
- ☐ identify oxy-fuel gas plant and supply systems
  - portable cutting plant
- ☐ identify flame cutting apparatus
- ☐ list the advantages of flame cutting apparatus
  - multi-purpose blowpipe
  - flame cutting attachment
- ☐ identify different types of flame cutting nozzles
  - size
  - acetylene
  - LPG
- ☐ use appropriate text or manufacturers' information to select the equipment and gas pressures necessary to flame cut steel from 6 to 12 mm thick

- ☐ identify the conditions that give a satisfactory flame cut surface
  - nozzle condition
  - gas pressures and flame setting
  - nozzle height
  - cutting speed
  - material surface condition
- ☐ list the flame cutting methods
  - freehand
  - guided
  - machine
- ☐ discuss the safety factors of flame cutting and flame gouging
  - cylinder location
  - equipment maintenance
  - protective clothing
  - molten oxide stream.

Cutting torches
There are two main types of manual flame cutting tool

Flame (thermal) cutting process

The flame cutting process used for cutting iron and steel depends on a chemical reaction between heated iron and oxygen.

The theory of the flame cutting reaction
When a piece of iron or steel is heated to a temperature of 815°C (the *ignition temperature)* the material will burn to form a lower melting point substance called iron oxide.

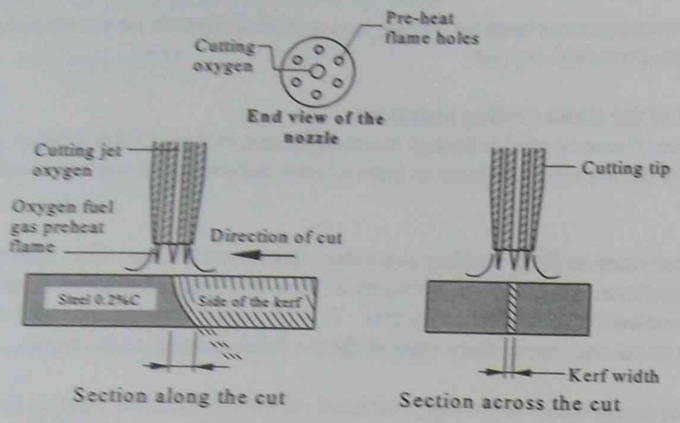
The chemical reaction from burning generates a great deal of heat. This heat enables the cutting to continue. Once the metal begins to burn, the heat generated will lead to a spread of oxidisation through the material. This important property of flame cutting allows you to cut and pierce thick steel without overall heating of the metal.

The *ignition temperature* is the temperature at which the chemical reaction begins. The ignition temperature for low carbon steel is 815°C. This is well below its melting temperature which is about 1,450°C.

The steps of the flame cutting action
1. Use the flame to raise a small section of the metal to ignition temperature.
2. Release a high speed jet of oxygen on the heated section.
3. By controlling the direction of the blowpipe nozzle and combining it with the oxidising action, cut through the metal. The width of the cut through the steel is called the *kerf.*

The cutting action is a function of the high speed jet of oxygen. The purpose of the flame is to heat the metal to its ignition temperature so that the cutting can begin. Theoretically, once the cutting begins, the flame shouldn't be necessary. However, heat is lost from the work through conduction, so it's necessary to keep the pre-heat flame going while you're working.

The most common gas combinations used for pre-heat are oxyacetylene and oxy-LPG (Liquefied petroleum gas).



Flame cutting

Limitations

Because flame cutting depends on a chemical reaction (oxidisation) between heated iron and oxygen, you can normally only use it on metals which are basically iron. Non-ferrous metals (such as copper, brass, aluminium) cannot be flame cut.

For a metal is to be readily flame cut, it needs to have:

- an ignition temperature below its melting point so that the metal can be cut without being melted by the flame
- a higher melting point than the oxide or slag that forms from the cutting action.

Cutting equipment

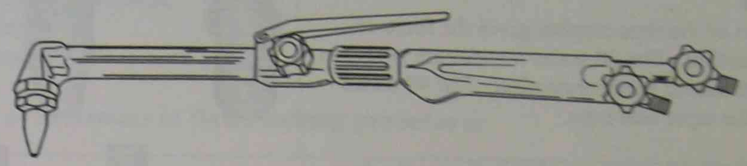
The portable flame cutting plant is the same as for oxyacetylene welding except for the cutting torch or cutting attachment connected to the hoses. The plant consists of the following components.

- Oxygen cylinder
- Acetylene cylinder
- Gas regulators
- Hoses
- Cutting torch
- Cutting nozzle
- Cylinder trolley

Cutting torches

There are two main types of manual flame cutting torches:

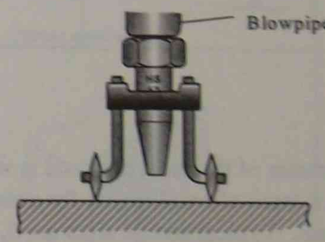
- Multiple-purpose cutting torches that are heavy duty cutting and gouging units
- Cutting attachments that are used with a normal welding blowpipe - these units are cheaper and more versatile than the multi-purpose unit but is not as robust and does not have the thickness cutting capacity.



Blowpipe attachment with handle

Cutting technique

The torch can be hand guided (free hand) for normal industrial use. However there are aids (such as a roller guide attachment) to steady the cutting torch movement and improve the quality of the cut.



Roller guide attachment

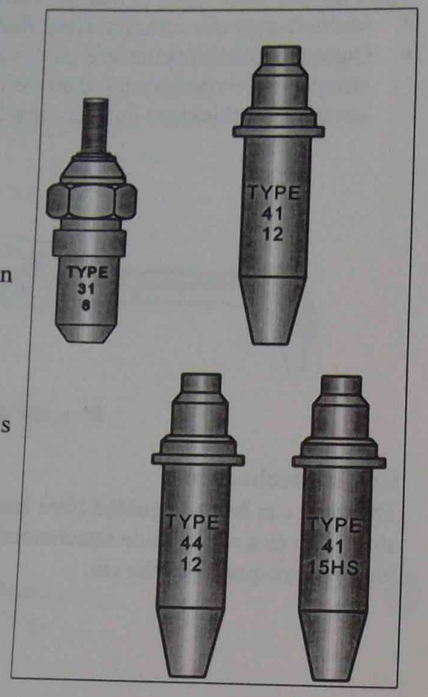
Cutting nozzles

Cutting nozzles are designed for different thicknesses and applications. Each nozzle is stamped to indicate the size, type of fuel gas and process.

Oxyacetylene cutting nozzles

Nozzle identification

Every cutting nozzle or tip is stamped for easy identification. The stampings indicate the type of nozzle, the size of nozzle and special process identification.



Nozzle type

The first part of the type number gives the form of nozzle connection. The 30 series nozzles are screw-in type with a threaded inlet connection. The 40 series nozzles are the taper seat type.

The second part of the type number indicates the fuel gas used. If the type number ends in a '1' the nozzle is used with acetylene, if it ends in '4' it is used with LP gas.

Gas number identification

1 Acetylene
2 Low pressure acetylene
3 Coal gas
4 LP gas
5 Hydrogen

Size of nozzle

The size number tells you the diameter of the main bore and is stamped underneath the type number. The size number is a tenth of a millimetre for example, a size 12 nozzle has a main bore diameter of 1.2 mm. Typical nozzle sizes are 6, 8, 12, 15 and 20.

Machine cutting

Flame cutting machines are an essential piece of equipment in engineering workshops that make machine parts or structural steel components. These machines have great advantages over manual cutting, especially for accurately cutting thick sections or for cutting multiple items, as they hold the blowpipe rigidly at the correct distance from the work with an even cutting speed.

Safety

Be careful when flame cutting and/or gouging as the cutting stream can shower hot metal sparks to great distances. The protective clothing you need for flame cutting and/or gouging is the same as for welding.

- Overalls
- Oxy goggles (shade 5 filter)
- Leather gloves
- Leather apron
- Steel capped boots
- Spats

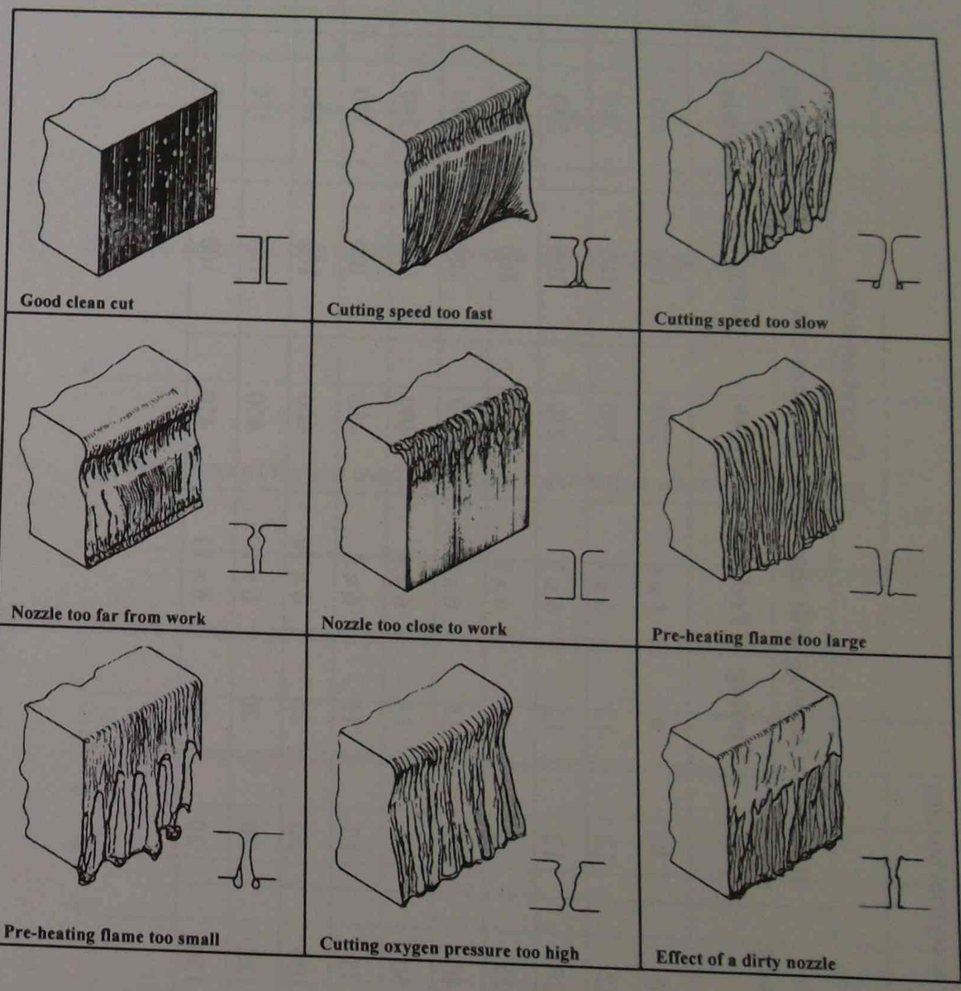
Keep all equipment in good order and report any faulty or damaged equipment to your supervisor.

Cut quality

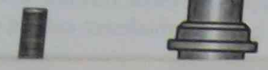
Factors which will affect the quality of the cut are:

- metal composition
- surface cleanliness - free from such thing as paint, oil, grease
- cutting nozzle size and condition
- gas pressures
- size of preheat flame
- cutting speed
- distance nozzle is from job.

Effects of variations in flame cutting procedures



nozzle, the size of nozzle and special process identification.



Reference chart: Recommended flame cutting operating data

Type 41 - Taper seat acetylene nozzles

Plate thickness mm	Nozzle size	Cleaning drill size		Operating Pressure kPa		Cutting speed mm/min	Consumption	
		Cutting	Preheat	Oxygen	Acetylene		Acetylene L/min	Oxygen L/min
6	8	8	5 x 6	200	100	450	3.5	17.5
12	12	12	6 x 7	200	100	380	4	38
20	12	12	6 x 7	250	100	340	4.5	42
25	15	15	6 x 8	220	100	320	6	56
40	15	15	6 x 8	350	100	270	7	75
50	15	15	6 x 8	400	100	240	7.5	85
75	15	15	6 x 8	450	100	180	8	95
100	20	20	6 x 10	400	100	150	9	134
125	20	20	6 x 10	450	100	150	10	155
150	20	24	6 x 11	450	100	130	11	211

Section 11: Flame cutting and heating

Review questions

These questions will help you revise what you've learnt in Section 10.

1. State the ignition temperature of low carbon steel.

   _____

2. State **two** basic steps for flame cutting other than the one given below.

   - The flame is used to raise a small section of metal to ignition temperature.
   - _____
   - _____
   - _____
   - _____

3. State the names of **two** suitable fuel gases for oxy-fuel gas cutting.

   - _____
   - _____
   - _____

4. State the name of the gas used to support combustion when flame cutting.

   _____

5. List **five** items of personal protective clothing you need for flame cutting.

   - _____
   - _____
   - _____
   - _____
   - _____

Review questions

6. State the meaning of the numbers on a cutting nozzle.

   Type 41: _____

   No. 12: _____

7. Use the Reference Chart to find the recommended nozzle size and gas pressures for flame cutting 6 mm thick low carbon steel.

   Nozzle size: _____

   Acetylene: _____

   Oxygen: _____

8. List the factors which will affect a flame cut finish. One of the factors is given.

   - Material's surface - it should be clean and free from such things as paint, oil, grease.
   - _____
   - _____
   - _____
   - _____

Section 11: Flame cutting and heating

SUGGESTED DURATION	PREAMBLE
2 hours 30 minutes	This section enables you to safely flame cut low carbon steel plate.

Objectives

At the end of this section you will be able to:

- ☐ open and close down a flame cutting plant
- ☐ use manual, guided and machine (straight line) cutting methods
- ☐ flame cut 6 mm and 10 mm thick low carbon steel plate to the following requirements
  - flame cut surfaces to exhibit a smooth profile free from excessive nicking and adhering slag
  - cutting accuracy to the marked line ± 2 mm
- ☐ record the flame cutting procedure
- ☐ heat and bend flat bar
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Follow all Occupational Health & Safety workshop procedures.
- Always wear safety goggles when flame cutting.
- Always use a flint gun or lighter to ignite the blow pipe. NEVER use matches.
- Turn the cutting torch off when you have finished a job or before putting the torch down.

Procedure sheet
Flame cutting - angle and roller guides

Sketch	
	as data
	gulator
	ssure O_2 C_2H_2
	me type
	tting nozzle size
	terial data
	e
	ckness
	narks
	uracy
	urface
	tion

	Weld time
	Start
	Finish
	Units completed
Complies	**Does not comply**
Exercise 1	
Exercise 2	
Exercise 1	
Exercise 2	**Exercise Number**

Skill practice 6

Flame cutting - angle and roller guides

IF IN DOUBT ASK YOUR TEACHER

Objective To connect a flame cutting plant and cut, 6 and 10 mm low carbon steel to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method
1. Mark out and prick punch the cutting line locations for Exercises 1 and 2.
2. Establish correct cutting techniques for Exercises 1 and 2 using scrap material.

Exercise 1: Flame cut 10 mm plate as illustrated, using:
a) an angle guide b) a roller guide.
Exercise 2: Flame cut 6 mm plate as illustrated, using:
a) an angle guide b) a roller guide.

3. Evaluate the work and complete the procedure sheet.
4. Submit your work to the teacher.

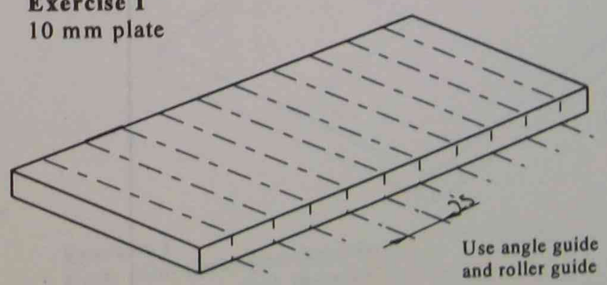
Requirements
- Assemble and activate oxyacetylene cutting plant
- Flame cut surfaces to exhibit a smooth profile free from adhering slag and excessive nicking
- Accuracy to be maintained to ±2 mm of marked line

Material unit **Exercise 1**: 1 piece 150 x 10 x 300 mm low carbon steel
Exercise 2: 1 piece 150 x 6 x 300 mm low carbon steel

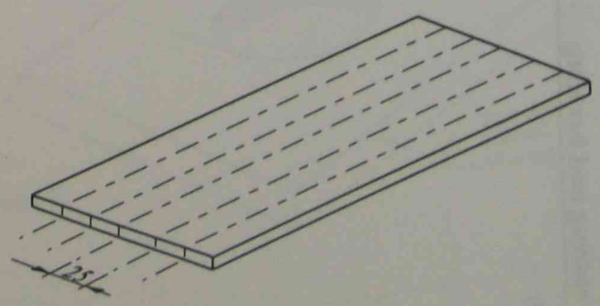
Unit required 1

Economy Practise flame cutting on scrap material.
Return all unused material to the store.

Exercise 1
10 mm plate



Exercise 2
6 mm plate



Skill practice 6

Flame cutting - angle and roller guides

IF IN DOUBT ASK YOUR TEACHER

Objective To connect a flame cutting plant and cut, 6 and 10 mm low carbon steel to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method

1. Mark out and prick punch the cutting line locations for Exercises 1 and 2.
2. Establish correct cutting techniques for Exercises 1 and 2 using scrap material.

Exercise 1: Flame cut 10 mm plate as illustrated, using:
a) an angle guide b) a roller guide.
Exercise 2: Flame cut 6 mm plate as illustrated, using:
a) an angle guide b) a roller guide.

3. Evaluate the work and complete the procedure sheet.
4. Submit your work to the teacher.

Requirements

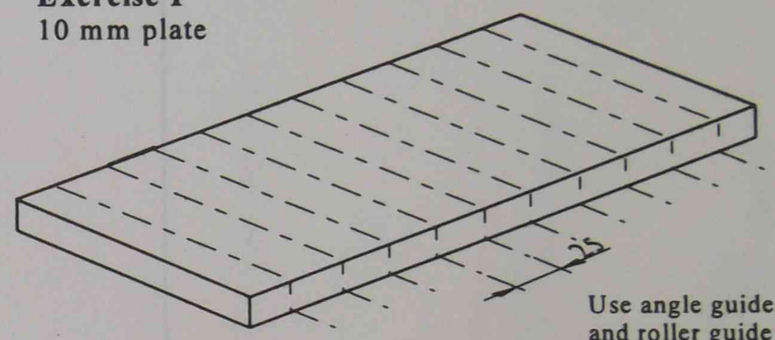
- Assemble and activate oxyacetylene cutting plant
- Flame cut surfaces to exhibit a smooth profile free from adhering slag and excessive nicking
- Accuracy to be maintained to ±2 mm of marked line

Material unit **Exercise 1**: 1 piece 150 x 10 x 300 mm low carbon steel
Exercise 2: 1 piece 150 x 6 x 300 mm low carbon steel

Unit required 1

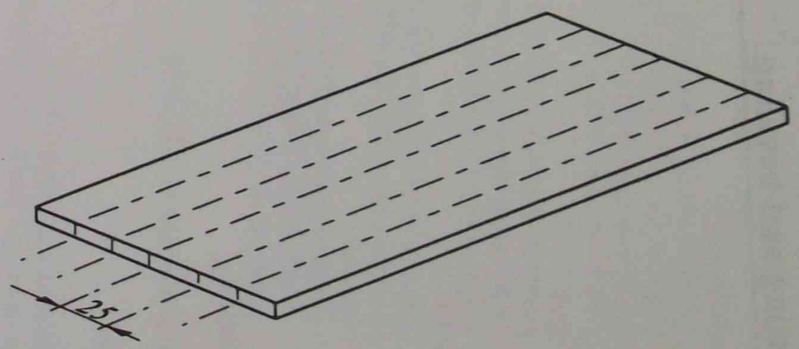
Economy Practise flame cutting on scrap material.
Return all unused material to the store.

Exercise 1
10 mm plate



Use angle guide
and roller guide

Exercise 2
6 mm plate



Use angle guide
and roller guide

Nozzle identification

Procedure sheet
Flame cutting and beveling

Sketch	
Gas data Regulator Pressure O_2 C_2H_2 Flame type Cutting nozzle size	**Weld time** Start Finish Units completed
Material data Type Thickness	

Assessment		**Complies**	**Does not comply**
Accuracy	Ex 1		
	Ex 2		
Cut surface condition	Ex 1		
	Ex 2		

Name	**Exercise Number**

Skill practice 7
Assessment event 4 (practical)
Flame cutting and beveling

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 45 minutes
Assessment: 15 minutes

Objective To connect a flame cutting plant and cut, bevel 10 mm low carbon steel to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method

Exercise1
1. Mark out and prick punch the cutting line locations.
2. Using scrap material, establish the correct cutting technique.
3. Using a circle cutting attchment, flame cut the circular flanges to the sizes shown.
4. Evaluate the work and complete the procedure sheet.
5. Submit completed work to the teacher.

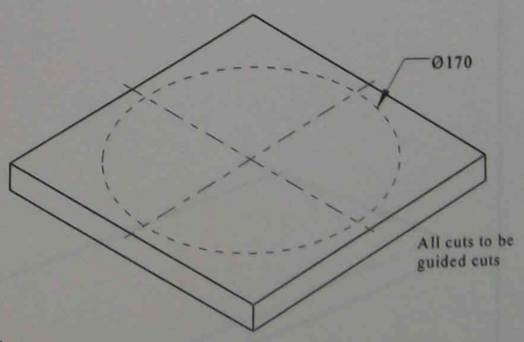
Exercise 2
1. Mark out and prick punch the cutting line locations.
2. Using scrap material, establish the correct cutting technique.
3. Using an appropriate cutting guide, flame cut two 45° bevel edges as illustrated.
4. Using free hand techniques, flame cut two 45° bevel edges as illustrated.
5. Using free hand techniques, cut the hole as shown.
6. Evaluate the work and complete the procedure sheet.
7. For assessment, repeat steps 1 to 5 of Exercise 2 to the following requirements.

Requirements
- Assemble and activate oxyacetylene cutting plant
- Flame cut surfaces to exhibit a smooth profile free from adhering slag and excessive nicking
- Accuracy to be maintained to ± 2 mm of marked line

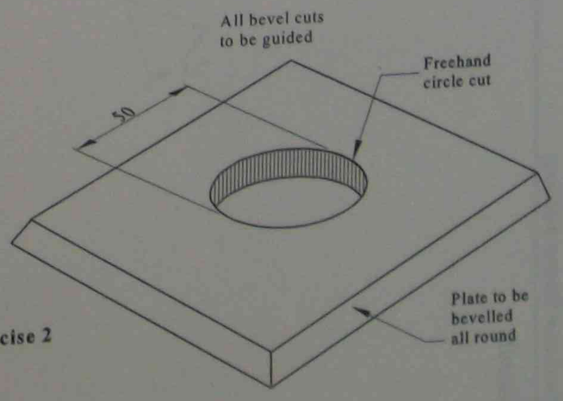
Material unit Exercise 1: 1 pieces 200 x 10 x 200 mm low carbon steel
Exercise 2: 2 piece 200 x 10 x 200 mm low carbon steel

Unit required 1

Economy Practise flame cutting on scrap material Return all unused material to the store.



Exercise 1
Note: Cut the largest diameter first and work inwards



Exercise 2

Skill practice 7
Assessment event 4 (practical)
Flame cutting and beveling

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 45 minutes
Assessment: 15 minutes

Objective To connect a flame cutting plant and cut, bevel 10 mm low carbon steel to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method

Exercise1

1. Mark out and prick punch the cutting line locations.
2. Using scrap material, establish the correct cutting technique.
3. Using a circle cutting attchment, flame cut the circular flanges to the sizes shown.
4. Evaluate the work and complete the procedure sheet.
5. Submit completed work to the teacher.

Exercise 2

1. Mark out and prick punch the cutting line locations.
2. Using scrap material, establish the correct cutting technique.
3. Using an appropriate cutting guide, flame cut two 45° bevel edges as illustrated.
4. Using free hand techniques, flame cut two 45° bevel edges as illustrated.
5. Using free hand techniques, cut the hole as shown.
6. Evaluate the work and complete the procedure sheet.
7. For assessment, repeat steps 1 to 5 of Exercise 2 to the following requirements.

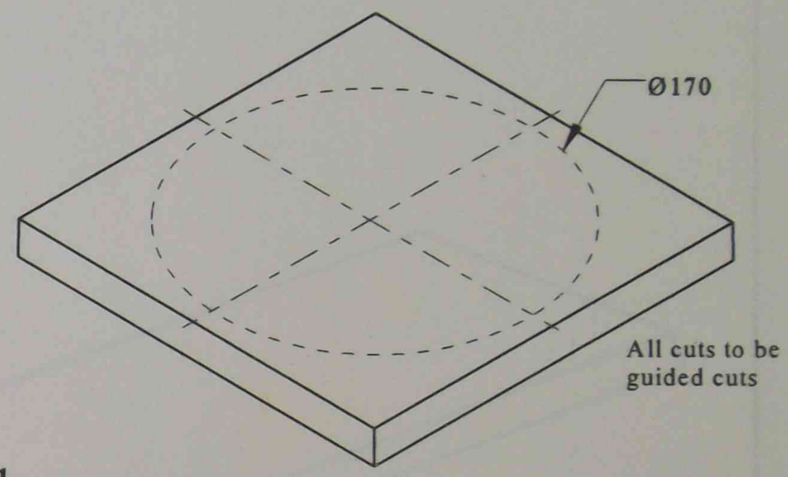
Requirements

- Assemble and activate oxyacetylene cutting plant
- Flame cut surfaces to exhibit a smooth profile free from adhering slag and excessive nicking
- Accuracy to be maintained to ± 2 mm of marked line

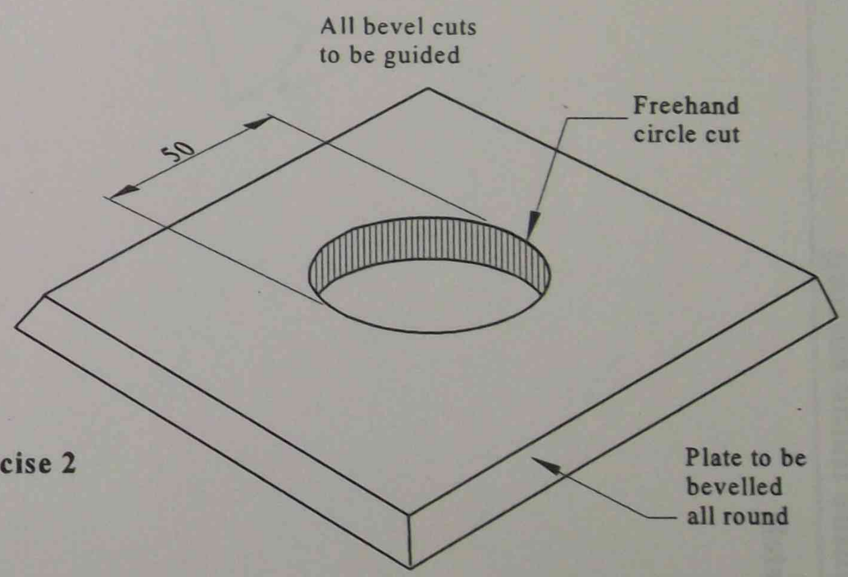
Material unit
Exercise 1: 1 pieces 200 x 10 x 200 mm low carbon steel
Exercise 2: 2 piece 200 x 10 x 200 mm low carbon steel

Unit required 1

Economy Practise flame cutting on scrap material Return all unused material to the store.



Exercise 1
Note: Cut the largest diameter first and work inwards



Exercise 2

Sketch	s data	Speed of cut
	gulator	45° bevel
	ssure O_2 C_2H_2	90° cut
	me type	
	ting nozzle size	
	terial data	Weld time
	e	Start
	kness	Finish
		Units completed
	ssment	Complies / Does not comply
	racy	
	urface	
	tion	
		Exercise Number

Skill practice 8
Assessment event 5 (practical)
Machine flame cutting

IF IN DOUBT ASK YOUR TEACHER

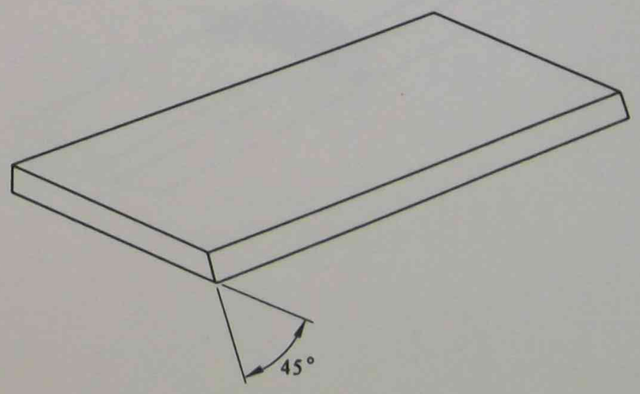
Suggested time Skill practice: 15 minutes
Assessment: 15 minutes

Objective To machine flame cut 10 mm low carbon steel to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method
1. Mark out the cutting line locations.
2. Using scrap metal, establish correct cutting techniques.
3. Flame cut 10 mm plate as illustrated, using the straight line machine with the nozzle set at 45°.
4. Evaluate your work and complete the procedure sheet.
5. For assessment repeat Steps 1 to 3 to the requirements given below.



Requirements
- Flame cut surfaces to have a smooth profile free from adhering slag and excessive nicking
- Accuracy to be maintained to ±2 mm of marked line

Material unit 1 piece 150 x 10 x 300 low carbon steel

Unit required 1

Economy Practise flame cutting on scrap material. Return all unused material to the store.

Skill practice 8
Assessment event 5 (practical)
Machine flame cutting

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 15 minutes
Assessment: 15 minutes

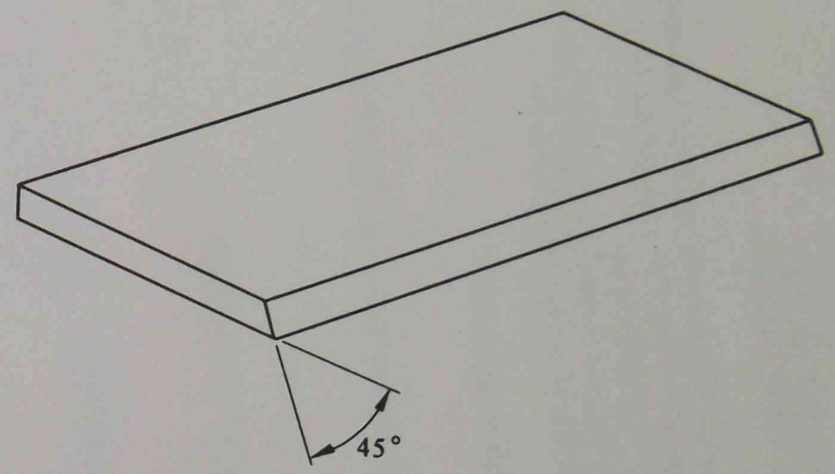
Objective To machine flame cut 10 mm low carbon steel to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method

1. Mark out the cutting line locations.
2. Using scrap metal, establish correct cutting techniques.
3. Flame cut 10 mm plate as illustrated, using the straight line machine with the nozzle set at 45°.
4. Evaluate your work and complete the procedure sheet.
5. For assessment repeat Steps 1 to 3 to the requirements given below.



Requirements

- Flame cut surfaces to have a smooth profile free from adhering slag and excessive nicking
- Accuracy to be maintained to ±2 mm of marked line

Material unit 1 piece 150 x 10 x 300 low carbon steel

Unit required 1

Economy Practise flame cutting on scrap material. Return all unused material to the store.

re sheet
and bending

	Speed of cut 45° bevel 90° cut
C_2H_2	
zle size	
ta	**Weld time** Start Finish Units completed
	Complies / **Does not comply**
	Exercise Number

Assessment event 6 (practical)

Heating and bending

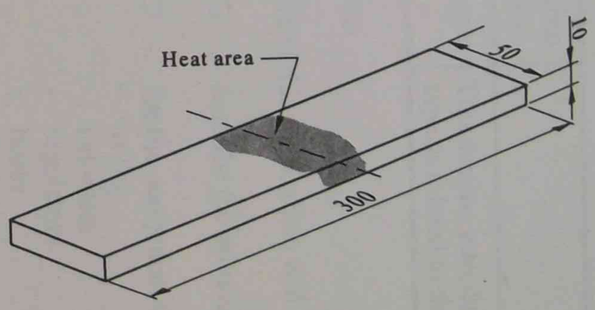
IF IN DOUBT ASK YOUR TEACHER

Suggested time 30 minutes

Objective To heat and bend low carbon steel flat bar to the requirements given below.

Procedure Demonstrated by the teacher.

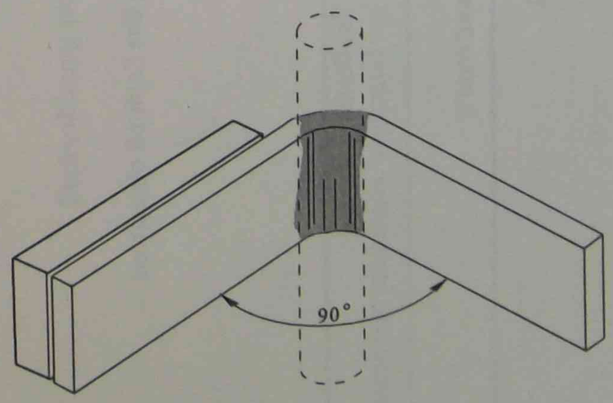
Mehtod
1. Mark areas to be heated using a scriber.
2. Heat the 1st mark as shown until bar is red right through for 10 mm each side of the mark.
3. Using the appropriate jig, bend the bar to 90°check and adjust.
4. Evaluate the exercise and submit for assessment.



Requirements
- Observe safety precautions
- All bends to be 90° ± 5°

Material unit 1 pieces 50 x 10 x 300 mm low carbon steel

Unit required 1



Notes

Steps in flame gouging

1. Hold the nozzle at an angle of 30°
ignition tem

Section 12: Flame gouging theory

SUGGESTED DURATION	PREAMBLE
30 minutes	This section introduces you to the principles, equipment and safety aspects related to the oxy-fuel gas gouging process.

Objectives

At the end of this section you will be able to:

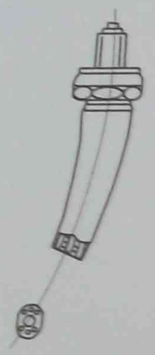
- ☐ describe the principles of fuel gas gouging operations
- ☐ list the equipment for industrial flame gouging
  - trolley
  - cylinders
  - regulators
  - hoses
  - torch
  - nozzle
- ☐ describe typical industrial uses for flame gouging
  - weld preparation
  - defect removal.

Safety

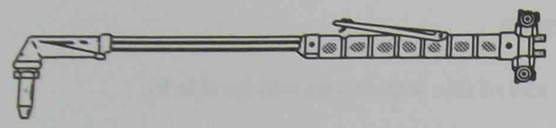
- Always use the recommended equipment for the job.
- Protect your skin and eyes.

Flame gouging principles

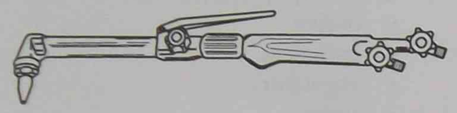
Flame gouging (also called flame machining) is a process used to groove metal surfaces instead of cutting them. The nozzles used for flame gouging have a much larger opening for the cutting oxygen than the standard cutting types. The cutting jet uses a greater volume of oxygen at a lower velocity (speed). There is oxidisation over a wider area of metal, but the cut in the steel is shallower.



Flame gouging nozzle

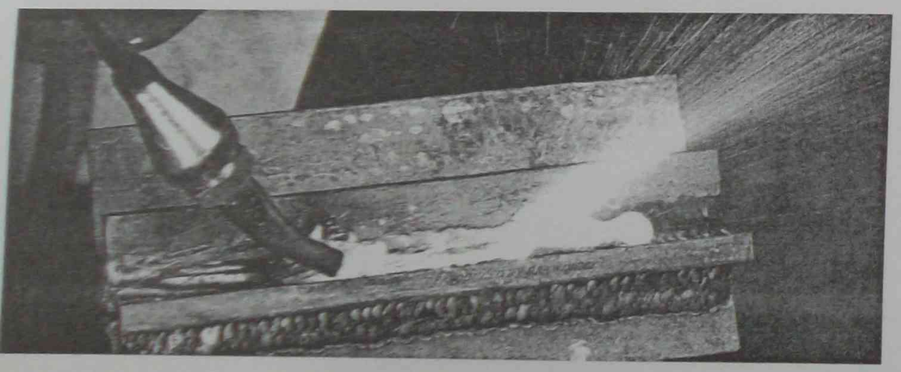


(a) Multi-purpose blowpipe



(b) Blowpipe attachment with handle

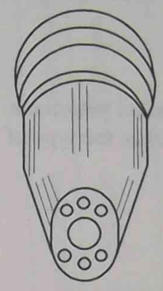
Many gouging nozzles are the bent type as shown in the illustration. Straight nozzles are also available.



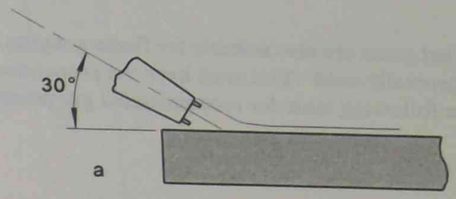
Gouging out a fillet weld

Steps in flame gouging

1. Hold the nozzle at an angle of 30° to the surface of the work and heat a spot on the metal to ignition temperature (815°C).
2. Reduce the angle of the gouging nozzle as you apply the cutting oxygen.
3. Move the nozzle in the direction you want to make the groove. The molten slag is blown from the groove onto the surface of the metal in front of the flame.



Flame gouging nozzle

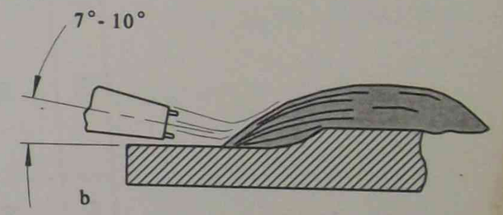


Angle of nozzle to surface of work

The width and depth of the groove are controlled by:

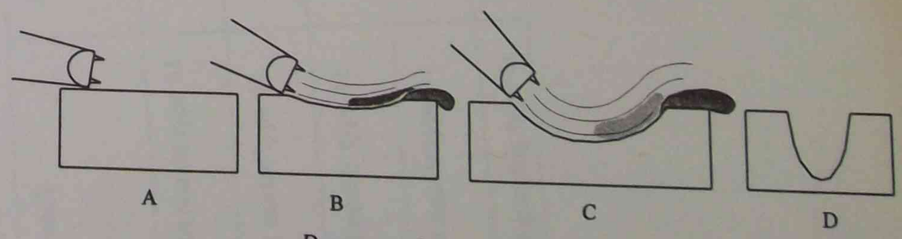
- size of nozzle
- cutting oxygen pressure
- angle of nozzle to work
- number of gouge passes made.

Note: The nozzle must not ride on the bottom of the groove.



Angle between nozzle and plate

The illustration below shows how to deep gouge. After pre-heating, open the cutting oxygen valve and reduce the angle of the nozzle slowly. Increase the angle until you get the depth of gouge you want. When you move the nozzle forward 25 mm, the angle is reduced and it increases again as the depth increases. Repeat this until you've made the gouge length you need.



Deep gouging

Uses

Flame gouging is used in welded construction and repair work for:

- edge preparation for butt welds
- the remvoal of metal from the underside of butt welds to prepare them for full penetration welding
- the removal of defective sections (for example cracks and slag inclusions) of welded joints to prepare them for rewelding.

Fuel gases

Flame cutting fuel gases are also suitable for flame gouging. Acetylene or liquiefied petroleum gas (LPG) are generally used. You must have the proper nozzle design that matches the type of fuel gas. See the following table for recommended gas pressures.

	Nozzle	*Nozzle size*	*Regulator pressure kPa*		*Speed mm/min*	*Gas consumption L/min*		*Dimensions groove*	
			Oxygen	Fuel gas		Total oxygen	Fuel gas	Width mm	Depth mm
Acetylene	C227 straight nozzle type 31	32GS (13)	500-560	70	300-500	80-85	18	8	3-6
	C151 bent nozzle type 41	32GB (13)	500-560	70	300-500	80-85	15	8	3-6
	C152 bent nozzle type 41	48 GB (19)	560-630	70	500-650	135-120	18	10-11	5-10
	C153 bent nozzle type 41	64GB (25)	630-700	70	550-800	180-210	20	13	5-11
	C209 deep gouging type 41	60 (24)	280-350	70	3000-16000	80-85	20	13-20	13-20

Review questions

These questions will help you revise what you've learnt in Section 12.

1. State the names of **two** common fuel gases.

   - _____
   - _____

2. Sketch and identify the end view of a gouging nozzle.

3. *Tick the correct box.*

   (a) The volume of oxygen used for flame gouging when compared to flame cutting is:

   - ☐ higher
   - ☐ lower
   - ☐ the same.

   (b) Before you can initiate the flame cutting/gouging action, the temperature of the plate must be raised to:

   - ☐ 750°
   - ☐ 216°
   - ☐ 815°
   - ☐ 425°.

   (c) The angle of the gouging nozzle to the plate surface is approximately:

   - ☐ 10°
   - ☐ 20°
   - ☐ 30°
   - ☐ 40°.

Section 13: Flame gouging

SUGGESTED DURATION	PREAMBLE
45 minutes	This section enables you to safely use the flame gouging process for efficient metal grooving of low cabron steel metal and welded products.

Objectives

At the end of this section you will be able to:

- ☐ set up and operate a flame gouging plant to groove low carbon steel plate to the following requirements
  - smooth gouge surface free from adhering slag
  - depth and width of the groove consistent with the gouging nozzle specification with the groove section 4 mm wide +3 -1 mm to the required size
- ☐ record the flame gouging procedure
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Always direct hot sparks and slag away from other people working in the area and away from flammable material.

Procedure sheet
Flame gouging - flat

Sketch			
Gas data		**Nozzle size**	
Regulator		Plot thickness	
Pressure 0_2	C_2H_2		
Flame type			
Weld tip size			
Material data		**Cutting time**	
Type		Start	
Thickness		Finish	
		Units completed	
Assessment		**Complies**	**Does not comply**
Alignment			
Weld size			
Weld defects			
Name		**Exercise Number**	

Skill practice 9
Assessment event 7 (practical)
Flame gouging - flat

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 45 minutes
Assessment: 15 minutes

Objective To flame gouge low carbon steel plate to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

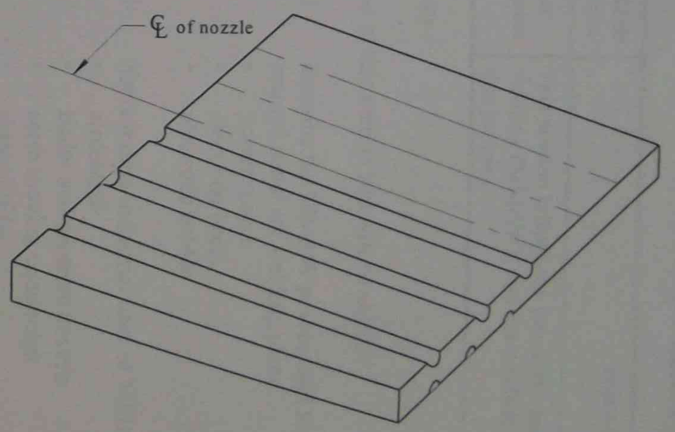
Method
1. Mark out the line of gouging on plate surface.
2. Gouge approximately 70 mm of the length before stopping to examine the quality of the cut.
3. Make any procedural changes necessary and complete the gouge.
4. Repeat the procedure for the other nominated locations.
5. Turn the plate over and repeat the exercise on the 10 mm wide grooves.
6. Complete the procedure sheet.
7. For assesment, repeat the groove to the requirement given below.

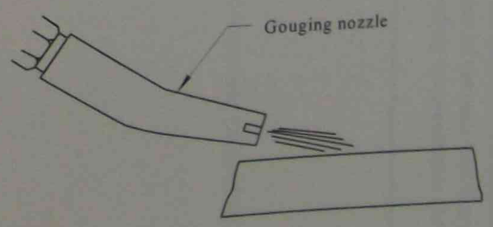
Requirements
- Smooth gouge surface free from adhering slag
- Depth and width of the groove consistent with the gouging nozzle specification with the groove section 4 mm wide +3 -1 mm to the required size

Material unit 1 piece of 150 x 10 x 150 mm low carbon steel

Unit required 2

Economy Gouge both sides of plate for maxium use. Return all unused material to the store.





Skill practice 9
Assessment event 7 (practical)
Flame gouging - flat

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 45 minutes
Assessment: 15 minutes

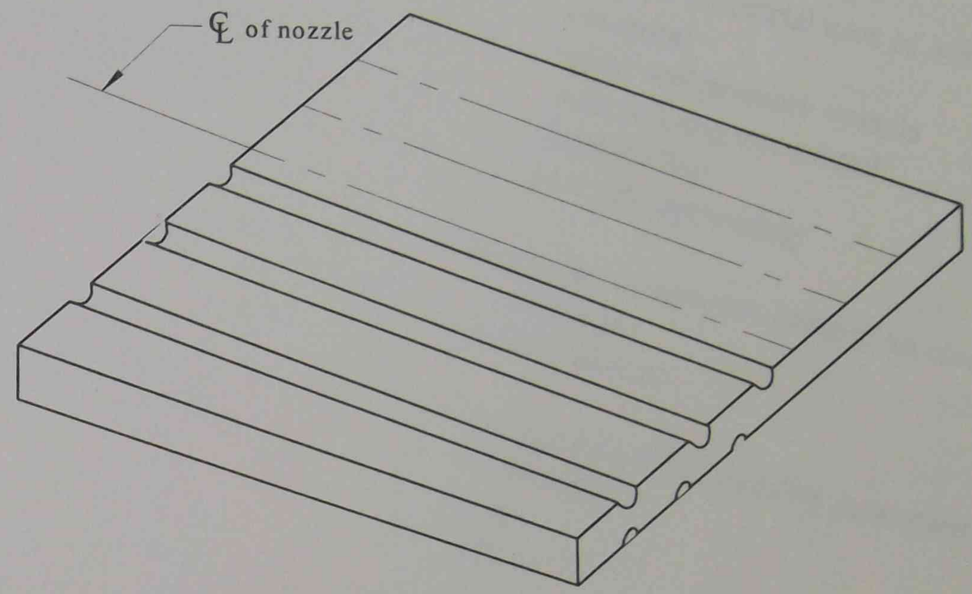
Objective To flame gouge low carbon steel plate to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

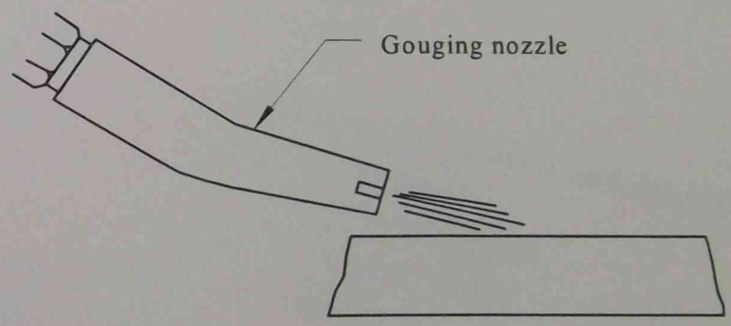
Method

1. Mark out the line of gouging on plate surface.
2. Gouge approximately 70 mm of the length before stopping to examine the quality of the cut.
3. Make any procedural changes necessary and complete the gouge.
4. Repeat the procedure for the other nominated locations.
5. Turn the plate over and repeat the exercise on the 10 mm wide grooves.
6. Complete the procedure sheet.
7. For assesment, repeat the groove to the requirement given below.



Requirements

- Smooth gouge surface free from adhering slag
- Depth and width of the groove consistent with the gouging nozzle specification with the groove section 4 mm wide +3 -1 mm to the required size



Material unit 1 piece of 150 x 10 x 150 mm low carbon steel

Unit required 2

Economy Gouge both sides of plate for maxium use. Return all unused material to the store.

Notes

Section 14: Manual metal arc welding theory

SUGGESTED DURATION	PREAMBLE
1 hour 30 minutes	This section introduces you to the basic principles of manual metal arc welding (MMAW), and the welding plant and safety requirements for this process.

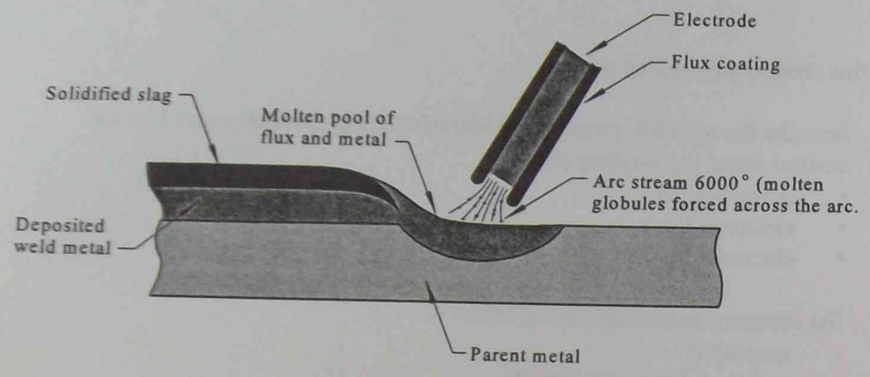
Objectives

At the end of this section you will be able to:

- ☐ describe the MMAW process and identify the component parts of an a.c. manual metal arc welding plant
  - power source
  - electrode leads
  - electrode holder
- ☐ list common industrial uses of MMAW
  - structural
  - boiler and pressure vessels
  - earth moving equipment
  - shipbuilding
  - general engineering
- ☐ identify the component parts of an electrode
  - core wire
  - flux coating
- ☐ list the hazards of arc welding processes
  - electricity
  - heat
  - fumes
- ☐ list the protective clothing available for MMAW operators
  - eyes
  - body
  - feet
- ☐ describe the methods of reducing/removing welding fumes from the breathing zone
  - natural ventilation
  - exhaust systems
  - respirators.

Manual metal arc welding process

A welding machine provides the electrical energy to make an arc between the electrode and the workpiece. There has to be a strong enough electric current (amps) to melt the surface of the workpiece and the end of the electrode. The machine has a control which changes the amount of current to suit different welding conditions.



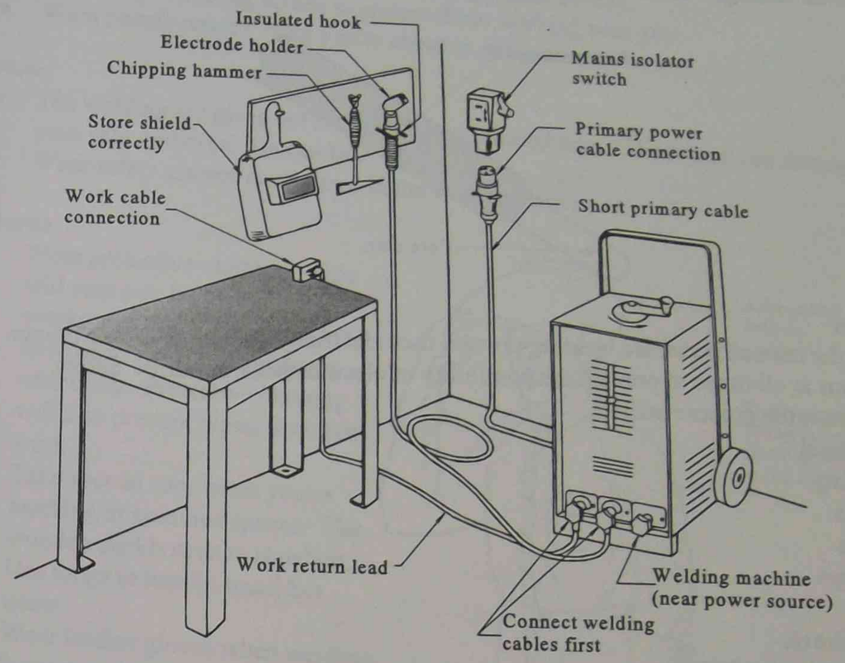
When the arc is formed, the temperature at the point of contact rises to about 6000°C. This intense heat is concentrated at the electrode end and the point of welding. It melts a small pool of metal in the workpiece and also melts the end of the electrode into globules of molten metal which are forced across the arc and into the weld pool on the work. The electrode flux coating melts, provides a gaseous shield around the arc and deposits a protective slag on the molten weld pool. The melting rate of the electrode metal depends on the amount of electric current used.

Uses

Manual metal arc welding is used for:

- structural steel work
- steel bridges
- pressure vessels
- tanks
- general fabrication
- earth moving equipment.

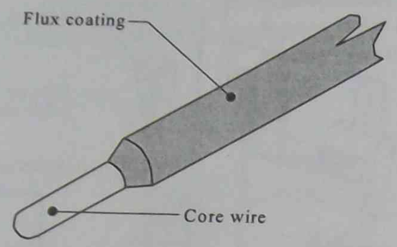
Equipment set-up



- Install the welding machine as near as possible to the mains power to keep the primary power cable short. *The primary power cables carry dangerously high voltages.*
- Inspect all cables for damage.
- Use welding cables that are fully insulated.
- Make sure the electrode holder is insulated from the bench. *Hang it on an insulated hook.*
- Switch off when not in use.

Electrodes

Electrode size is measured by the diameter of the corewire. You can use the manual metal arc welding process with welding current from about 40 amps to 400 amps depending on electrode size. Follow manufacturers' recommendations for flux types and current settings. These are always printed on the electrode packet.



Hazards

Because the manual metal arc welding process uses electricity, you need to take proper precautions at all times to prevent the possibility of electric shock or burns. Safety hazards from the process include:

- hot metal
- hot slag
- sparks
- fumes
- arc rays

Electric shock

Avoid electric shock by:

- wearing dry insulated boots
- wearing dry leather gloves
- never changing electrodes with bare hands or wet gloves
- never cooling electrode holders in water
- working on a dry insulated floor where possible
- never holding the electrode and holder under your arm.

If there is an accident, turn off the power to the circuit **first**. When this isn't possible, clear the victim from the electrical source using dry non-conducting material.

Ventilation and fumes

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

Protective clothing

Protect your eyes and skin from harmful arc radiations:

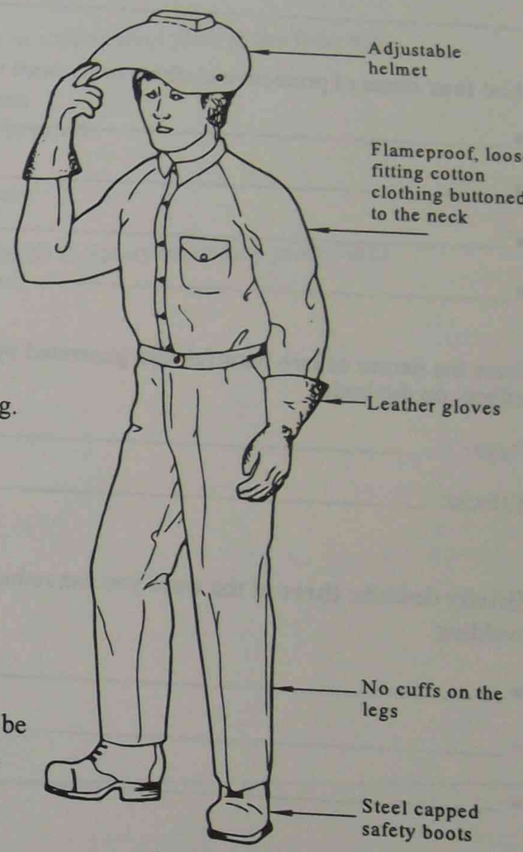
- Never watch the arc without wearing a welding shield. Protect your eyes. Wear a helmet with filters of the correct shade (eg. shade 10-13).
- Use a non-reflecting screen to protect those working near you.
- Warn people nearby when you're about to strike an arc.

Note:

- The welding arc gives out ultraviolet and infrared rays. These rays can damage your skin and eyes. Be careful.
- Wear safety glasses at all times in the work environment.

Burns

- Wear protective clothing. This will stop you being burnt by sparks and slag. You shouldn't have open pockets or trousers with cuffs. Protective clothing will also prevent burns from hot work.
- Take special care when you're working in confined spaces. Use wooden duckboards to stand on.
- Use tongs to handle small hot items.
- Wear leather gloves when welding. Inspect your gloves regularly for holes and thin patches. Don't depend on gloves to protect you when you're handling very hot items. Use tongs.
- Wear a skull cap and cape or jacket of chrome leather to protect you when welding in the overhead position.
- Write '*HOT*' on items which may be handled accidently before cooling.



Suitable protective clothing

Review questions

These questions will help you revise what you've learnt in Section 14.

1. State the names of the component parts that make up a MMAW electrode.

   - _____
   - _____

2. What is the approximate temperature of the electric arc in manual metal arc welding?

   _____

3. List **four** items of protective clothing to be worn when MMAW.

   - _____
   - _____
   - _____
   - _____

4. State the names of **two** harmful rays generated by the electric arc and give their effects on the body.

   Rays: _____

   Effects: _____

5. Briefly describe **three** of the ways you can reduce the risk of electric shock when welding.

   - _____
   - _____
   - _____

Section 15: Manual metal arc welding - beads on plate

SUGGESTED DURATION	PREAMBLE
1 hour	This section enables you to safely deposit weld beads on low carbon steel plate.

Objectives

At the end of this section you will be able to:

- ☐ set up and activate a manual metal arc welding plant
- ☐ deposit weld beads on low carbon steel plate to the following requirements:
  - bead height 3^{+2}_{-1} mm
  - smooth regular weld profile
- ☐ record the weld procedure
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Follow Occupational Health & Safety workshop procedures.
- Protect your eyes from the welding arc and wear the proper eye protection.
- Wear suitable protective clothing including dry leather gloves.

1. ...of the component parts that make up a MMAW electrode.

2.

3.

4.

5.

Procedure sheet
Manual metal arc welding - beads on plate

Sketch	
Weld current data Run 1 2 3 4 5 6	**Electrode data** Size Type Brand name Electrode Angles Lead 60°-80° Lateral 90°
Material data Type low carbon steel Thickness 10 mm	**Weld time** Start Finish Units completed
Remarks	**Complies** / **Does not comply**
Height of beads	
Restarts	
Spatter	
Name	**Exercise Number**

Skill practice 10

Manual Metal Arc Welding - beads on plate

IF IN DOUBT ASK YOUR TEACHER

Objective To deposit uniform weld beads to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method
1. Position the plate on the bench so that a right handed operator would weld across the body from left to right (left hand opposite direction).
2. Deposit a weld bead along the plate length, maintaining the angles shown with an arc gap of approximately 2 mm.
3. Deposit additional runs parallel to the plate edge approximately 6 mm apart.
4. When the top surface of the plate has been covered, turn the material over and repeat Steps 1 to 4.
5. Evaluate the weld exercise and complete the procedure sheet.
6. Submit your work for evaulation.

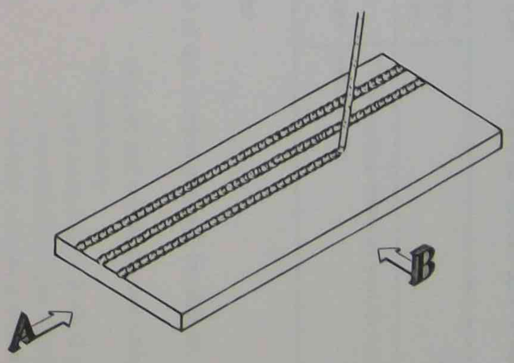
Points to watch
- Amperage setting and heat input
- Position of the plate on the bench
- Correct method of arc striking
- Correct arc length
- Correct welding speed and travel
- Electrode angles

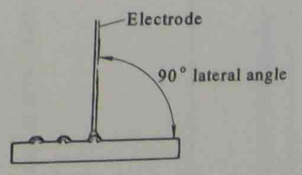
Requirements
- Beads to be uniform with consistent, even restarts, free from slag and splatter
- Bead height 3^{+2}_{-1} mm

Material unit 1 piece low carbon steel 75 x 10 x 225 mm

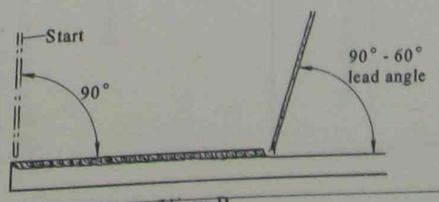
Unit required 1

Economy Materials and consumables are expensive. Use electrodes to 50 mm maximum stub length.





View A



View B

Skill practice 10

Manual Metal Arc Welding - beads on plate

IF IN DOUBT ASK YOUR TEACHER

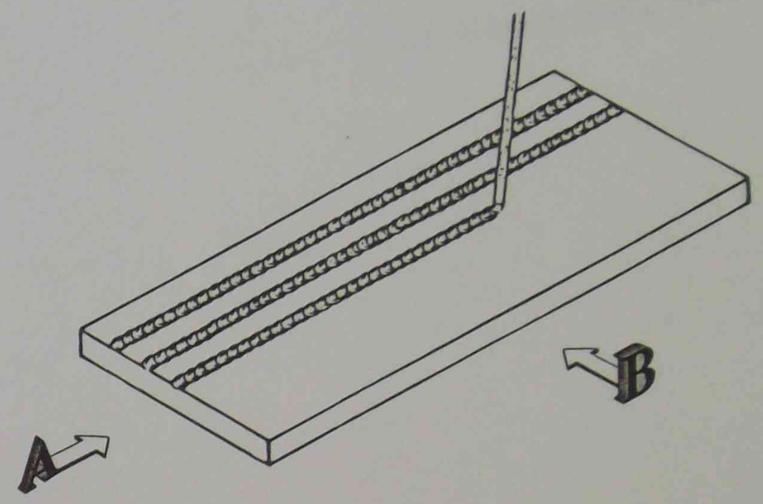
Objective To deposit uniform weld beads to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

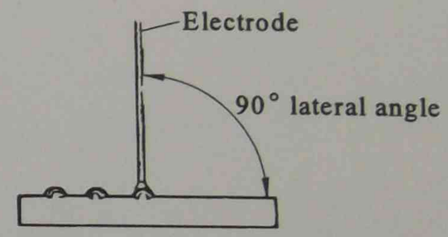
Method

1. Position the plate on the bench so that a right handed operator would weld across the body from left to right (left hand opposite direction).
2. Deposit a weld bead along the plate length, maintaining the angles shown with an arc gap of approximately 2 mm.
3. Deposit additional runs parallel to the plate edge approximately 6 mm apart.
4. When the top surface of the plate has been covered, turn the material over and repeat Steps 1 to 4.
5. Evaluate the weld exercise and complete the procedure sheet.
6. Submit your work for evaulation.



Points to watch

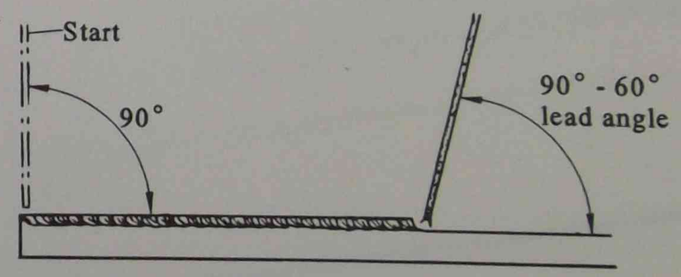
- Amperage setting and heat input
- Position of the plate on the bench
- Correct method of arc striking
- Correct arc length
- Correct welding speed and travel
- Electrode angles



View A

Requirements

- Beads to be uniform with consistent, even restarts, free from slag and splatter
- Bead height 3^{+2}_{-1} mm



View B

Material unit 1 piece low carbon steel 75 x 10 x 225 mm

Unit required 1

Economy Materials and consumables are expensive. Use electrodes to 50 mm maximum stub length.

Notes

Section 16: Manual metal arc welding - pad weld

SUGGESTED DURATION	PREAMBLE
1 hour 30 minutes	This section enables you to safely deposit pad welds on low carbon steel plate.

Objectives

At the end of this section you will be able to:

- ☐ deposit pad welds on low carbon steel plate to the following requirements
  - pad weld height 3 +2 -1 mm
  - a maximum of four significant surface defects in a unit area of 40 x 150 mm with an accumulative defect area not exceeding the square of the plate thickness
  - no adhering slag or spatter
- ☐ record the weld procedure
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Follow Occupational Health & Safety workshop procedures.
- Use an approved shade 10 welding glass filter.
- Wear suitable protective clothing to stop ray burn.

Procedure sheet
Manual metal arc welding - pad weld

Sketch			
Weld current data		**Electrode data**	
Run 1	Run 7	Size	
2	8	Type	
3	9	Brand name	
4	10	Electrode	
5	11	Angles Lead	Lateral
6	12	60°-80°	90°
Material data		**Weld time**	
Type low carbon steel		Start	
Thickness 10 mm		Finish	
		Units completed	
Remarks		**Complies**	**Does not comply**
Height of beads			
Restarts			
Spatter			
Name		**Exercise Number**	

Skill practice 11

Manual metal arc welding -pad weld

IF IN DOUBT ASK THE TEACHER

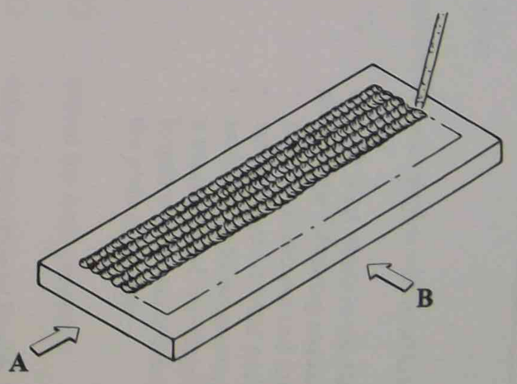
Objective To deposit a pad weld on low carbon steel plate to the requirements given below.

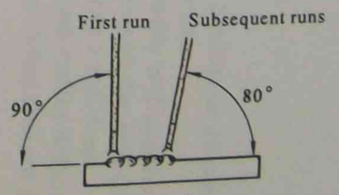
Position Flat.

Procedure Demonstrated by the teacher.

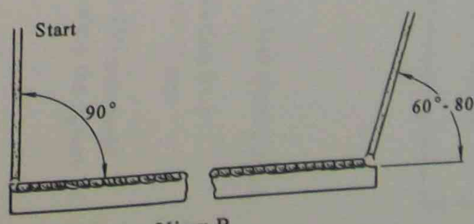
Method

1. Outline, with chalk, a rectangular shape 40 x 200 mm.
2. Position the plate on the bench.
3. Deposit weld beads along the plate length, maintaining the angles shown.
4. Remove all slag from individual weld beads before depositing subsequent runs. Each run must have a staggered stop and restart.
5. Build up the pad to the required dimensions and have your exercise inspected.
6. Evaluate the weld and complete the procedure sheet.
7. Submit your work for evaluation.





View A



View B

Points to watch

- Setting of amperage and heat input
- Position of the plate on the bench
- Correct method of arc striking
- Correct arc length
- Correct welding speed and travel
- Correct electrode angles

Requirements

- Pad weld height of 3 +2 -1 mm
- A maximum of four significant surface defects on a unit area of 40 x 150 mm with and accumulative area not exceeding the square of the plate thickness
- No adhering slag or splatter

Material unit 1 piece low carbon steel 75 x 10 x 225 mm

Unit required 1

Economy Use electrodes down to a stub length of 50 mm maximum.

Skill practice 11

Manual metal arc welding -pad weld

IF IN DOUBT ASK THE TEACHER

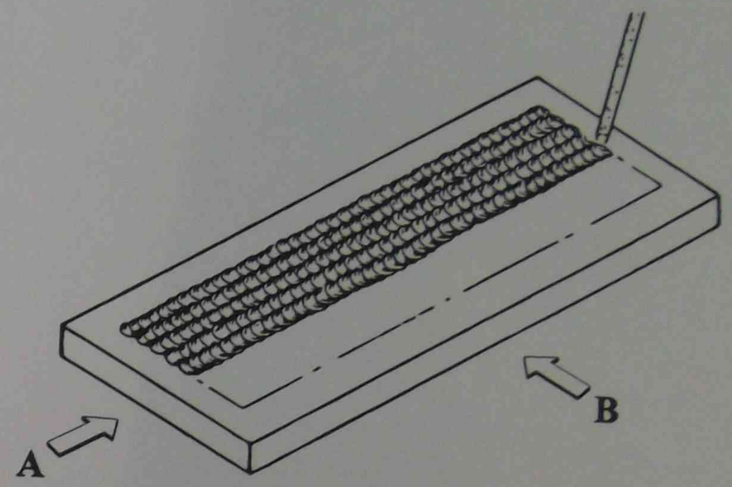
Objective To deposit a pad weld on low carbon steel plate to the requirements given below.

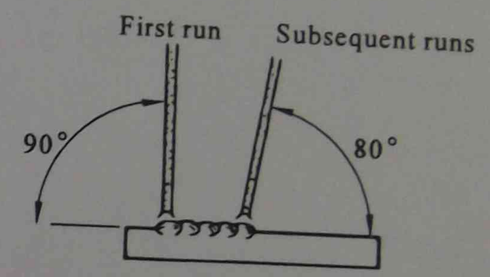
Position Flat.

Procedure Demonstrated by the teacher.

Method

1. Outline, with chalk, a rectangular shape 40 x 200 mm.
2. Position the plate on the bench.
3. Deposit weld beads along the plate length, maintaining the angles shown.
4. Remove all slag from individual weld beads before depositing subsequent runs. Each run must have a staggered stop and restart.
5. Build up the pad to the required dimensions and have your exercise inspected.
6. Evaluate the weld and complete the procedure sheet.
7. Submit your work for evaluation.





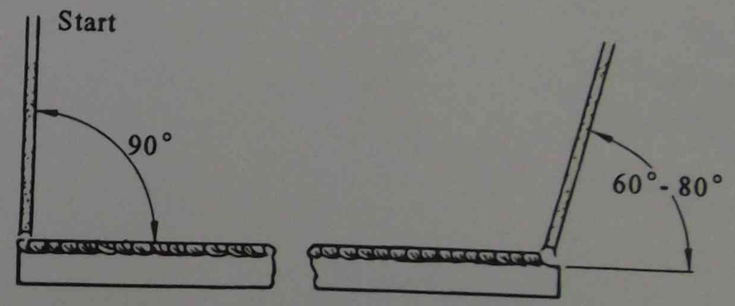
View A

Points to watch

- Setting of amperage and heat input
- Position of the plate on the bench
- Correct method of arc striking
- Correct arc length
- Correct welding speed and travel
- Correct electrode angles

Requirements

- Pad weld height of 3 +2 -1 mm
- A maximum of four significant surface defects on a unit area of 40 x 150 mm with and accumulative area not exceeding the square of the plate thickness
- No adhering slag or splatter



View B

Material unit 1 piece low carbon steel 75 x 10 x 225 mm

Unit required 1

Economy Use electrodes down to a stub length of 50 mm maximum.

Notes

Section 17: Manual metal arc welding - fillet weld

SUGGESTED DURATION	PREAMBLE
1 hour 45 minutes	This section enables you to safely deposit fillet welds in the flat position.

Objectives

At the end of this section you will be able to:

- ☐ deposit fillet welds in the flat position on 10 mm thick low carbon steel plate to the following requirements
  - correct alignment and assembly with angular distortion 0°-5°
  - smooth regular weld profile with the weld size 6 +2 -2 mm
  - undercut to be no greater than 1 mm deep
  - a maximum of two significant surface defects per 250 mm weld length with an accumulative defect area not exceeding the square of the plate thickness
- ☐ record the weld procedure
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Follow Occupational Health & Safety workshop procedures.
- Wear the proper eye protection.
- Wear suitable protective clothing.

Procedure sheet
Manual metal arc welding - fillet weld

Sketch	
Weld current data Run 1 Run 7 2 8 3 9 4 10 5 11 6 12	**Electrode data** Size Type Brand name Electrode Angles Lead Lateral
Material data Type Thickness	**Weld time** Start Finish Units completed
Assessment	**Complies** / **Does not comply**
Height of beads	
Restarts	
Spatter	
Name	**Exercise Number**

Skill practice 12
Assessment event 8 (practical)
Manual metal arc welding - fillet weld

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 1 hour 45 minutes
Assessment: 15 minutes

Objective To deposit a fillet weld to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

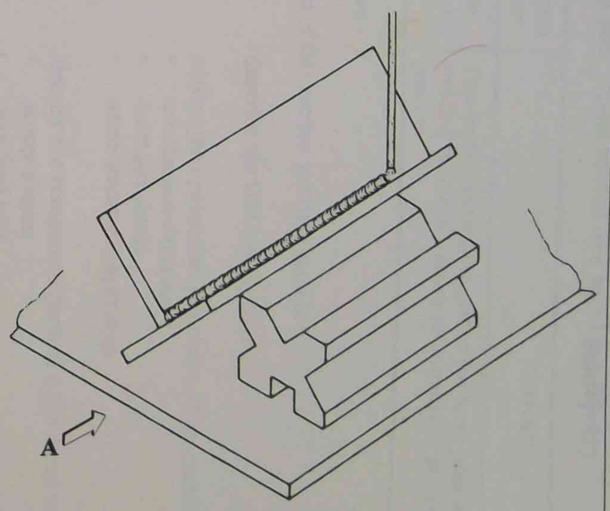
Method
1. Wire brush fusion faces to remove surface rust and mill scale.
2. Tack both ends of the plates, ensuring a close fit.
3. Complete approximately 50 mm of the weld and examine the weld profile.
4. Complete the weld and present to the teacher for inspection.
5. Break the weld and reposition for further practice.
6. Evaluate the weld exercise and complete the procedure sheet.
7. For assessment, repeat the fillet weld to the requirements given below.

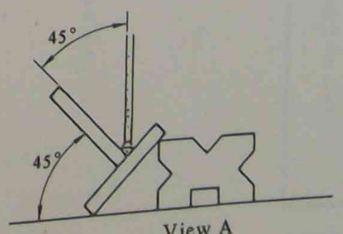
Requirements
- Correct alignment and assembly with angular distortion limited to 0°-5°
- Smooth regular weld profile with weld size 6 +2 -2 mm
- Undercut restricted to 1 mm depth for the length of welds
- A maximum of two significant surface defects per weld length with an accumulative defect area not exceeding the square of the plate thickness

Material unit 2 pieces low carbon steel 50 x 10 x 225 mm

Unit required 2

Economy Consumables are expensive. Use electrodes down to a stub length of 50 mm maximum.





View A

Skill practice 12
Assessment event 8 (practical)
Manual metal arc welding - fillet weld

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 1 hour 45 minutes
Assessment: 15 minutes

Objective To deposit a fillet weld to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method

1. Wire brush fusion faces to remove surface rust and mill scale.
2. Tack both ends of the plates, ensuring a close fit.
3. Complete approximately 50 mm of the weld and examine the weld profile.
4. Complete the weld and present to the teacher for inspection.
5. Break the weld and reposition for further practice.
6. Evaluate the weld exercise and complete the procedure sheet.
7. For assessment, repeat the fillet weld to the requirements given below.

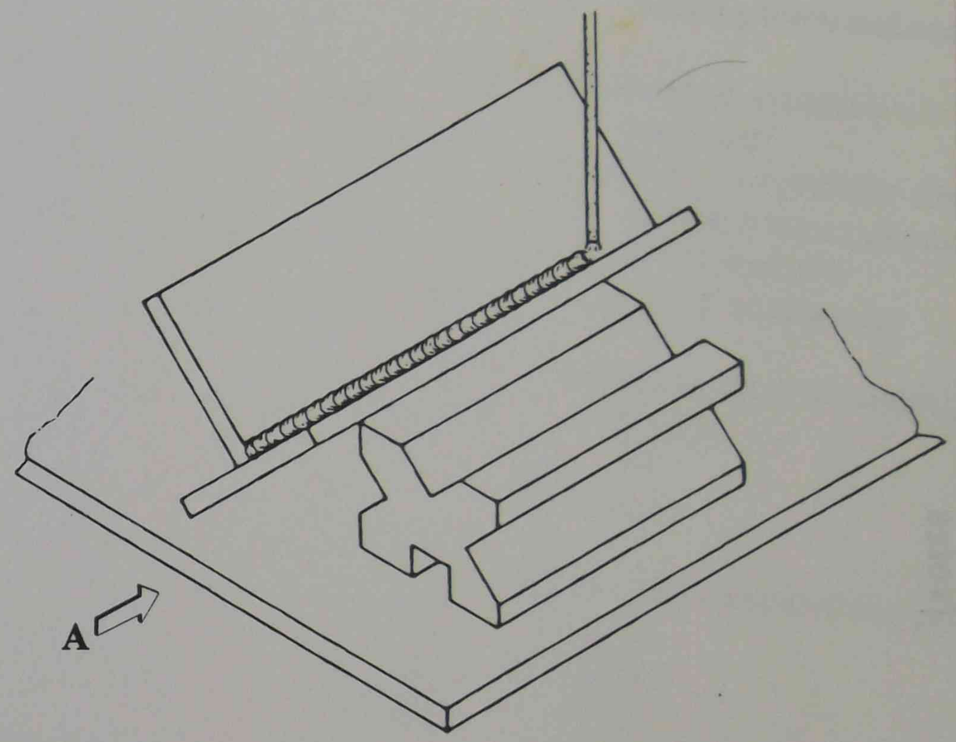
Requirements

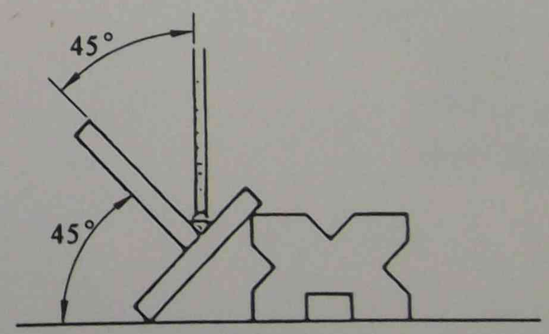
- Correct alignment and assembly with angular distortion limited to 0°-5°
- Smooth regular weld profile with weld size 6 +2 -2 mm
- Undercut restricted to 1 mm depth for the length of welds
- A maximum of two significant surface defects per weld length with an accumulative defect area not exceeding the square of the plate thickness

Material unit 2 pieces low carbon steel 50 x 10 x 225 mm

Unit required 2

Economy Consumables are expensive. Use electrodes down to a stub length of 50 mm maximum.





View A

Notes

Section 18: Gas metal arc welding theory

SUGGESTED DURATION	PURPOSE
1 hour 30 minutes	This section introduces you to the basic principles of gas metal arc welding (GMAW), safety requirements, and equipment for this process.

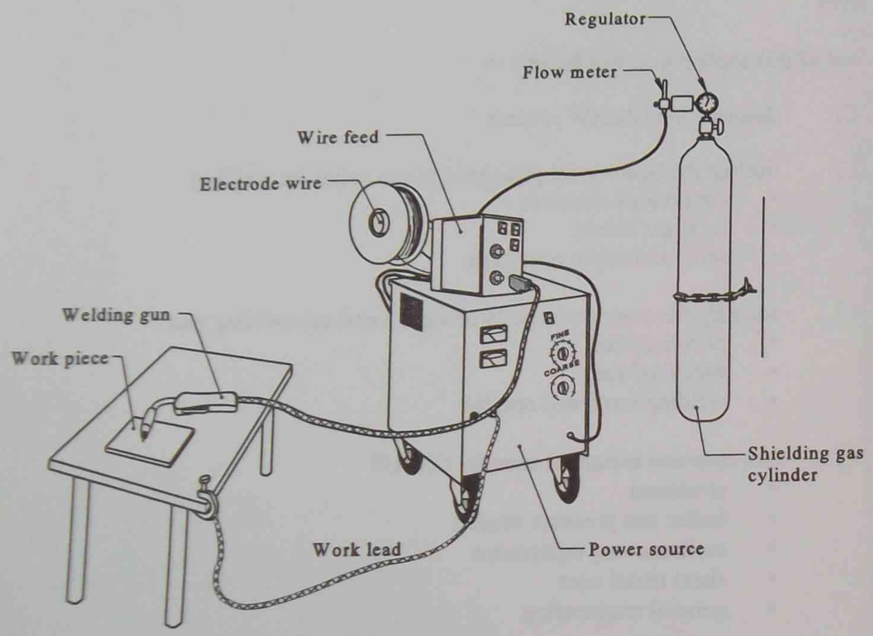
Objectives

At the end of this section you will be able to:

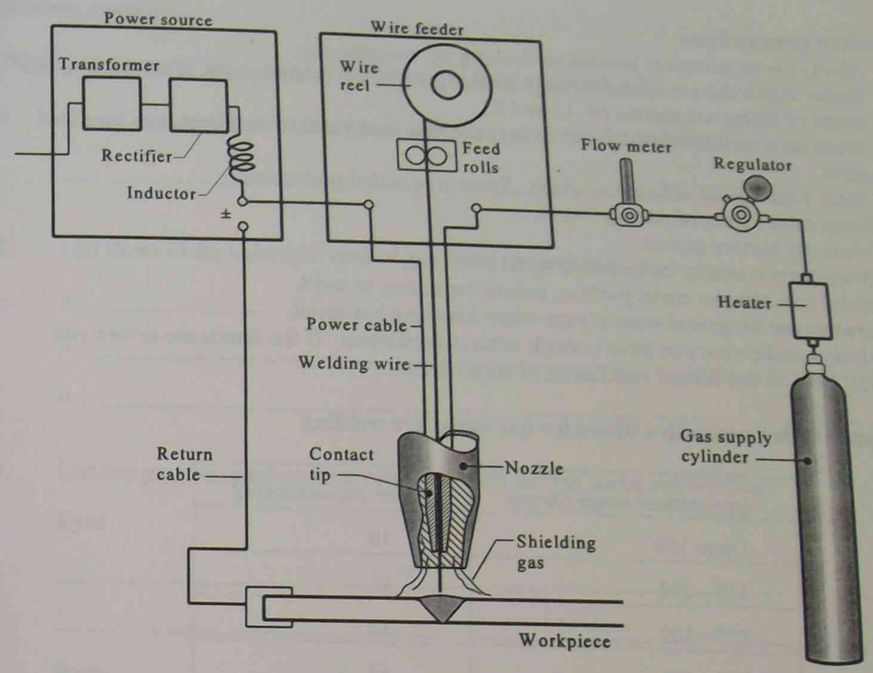
- ☐ describe the GMAW process
- ☐ outline the operational principles of gas metal arc welding
  - continuous electrode
  - inert gas shield
  - semi-automatic operation
- ☐ identify the component parts of a gas metal arc welding plant
  - power source
  - wire feed unit
  - welding torch and conduit
- ☐ list common industrial uses for GMAW
  - structural
  - boiler and pressure vessels
  - earth moving equipment
  - sheet metal uses
  - general engineering
- ☐ list the hazards of arc welding processes
  - electrical
  - heat
  - fumes
- ☐ list the protective clothing available for GMAW operators
  - eyes
  - body
  - feet
- ☐ describe how welding fumes can be removed or reduced from the breathing zone
  - natural ventilation
  - exhaust systems
  - respirators.

Gas metal arc welding (GMAW) process

Gas metal arc welding is a semi-automatic welding process which feeds a continuous wire electrode, through a torch, to the work. A shielding gas is given out around the wire and the weld pool to stop contamination from the atmosphere. Electric power is transferred to the wire at the contact tip. Machine settings are important to make sure that proper welding conditions are maintained for the job.



GMAW plant



Gas metal arc welding process

Electrode wires range from 0.6 mm diameter to 1.6 mm and are supplied on spools.

Shielding gases are selected to suit the job. They are usually argon/CO_2 mixtures for welding steel.

Uses

Gas metal arc welding is used widely in industry. You can make variations for different jobs by selecting different gases, consumable wires, machine types and settings.

GMAW is used in the following industries.

- Structural
- Boilers and pressure vessels
- Earth moving equipment
- Light fabrication (sheet metal)
- General engineering

Safety precautions

- Always wear adequate protective clothing eg. overalls, cap.
- Never watch the arc except through a filter glass of the correct shade. The usual range of filters are shades 10, 11 and 12.
- Work on a well-insulated floor. Where possible, use wooden duckboards or insulated mats.
- Wear well-insulated boots or shoes. Spats give added protection.
- Keep cables clear of passage ways.
- Wear dry leather gloves.
- Warn people nearby before striking an arc.
- Make sure screens are in position before beginning to weld.
- Always use tongs and wear gloves when handling hot metal.
- Always make sure you have enough natural ventilation. If the fumes are severe you may have to use forced ventilation or respirators.

Recommended protective filters for gas metal arc welding

Approximate range (amps)	*Filter recommended*
Up to 150	10
150 - 250	11
250 - 300	12
300 - 400	13
Over 400	14

Your helmet and filter should meet relevant code requirements.

4. Is more versatile.

Review questions

These questions will help you revise what you've learnt in Section 18.

1. Give a reason why shielding gas is used with gas metal arc welding.

   _____

2. List **three** of the industrial uses of gas metal arc welding.

   - _____
   - _____
   - _____

3. List the protective equipment you must have for gas metal arc welding.

   Eyes

   _____

   _____

   Body

   _____

   _____

   Feet

   _____

   _____

4. List **three** ways of protecting yourself from fumes when gas metal arc welding.

   - _____
   - _____
   - _____

5. State the name of the part of the welding torch where the welding current is transferred to the wire.

   _____

Notes

4. Is more versatile.

Section 19: Gas metal arc welding - beads on plate

SUGGESTED DURATION	PREAMBLE
1 hour	This section enables you to safey deposit weld beads using the gas metal arc welding process.

Objectives

At the end of this section you will be able to:

- ☐ operate a gas metal arc welding plant
- ☐ deposit weld beads on low carbon steel plate to the following requirements
  - bead height 3 +2 -1mm
  - smooth regular weld profile
- ☐ record the weld procedure
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Follow Occupational Health & Safety workshop procedures.
- Turn off your welding machine when you complete your work.
- Keep cables clear of passage ways.
- Always use tongs and wear gloves when handling hot metal.
- Cool your hot work, or attach a sign telling others it is hot.

Safety pre
- Always v
- Never wa
  range of l
- Work on
  mats.
- Wear wel
- Keep cabl
- Wear dry
- Warn peo
- Make sur
- Always us
- Always m
  may have

Recommend

our helmet

Procedure sheet
Gas metal arc welding - beads on plate

Sketch	
Electric output data Amps Volts open circuit Volts arc	**Consumables data** Wire type Wire diameter Gas type Flow rate
Electrode data Electrical stick out Wire feed rate Torch angles Lead Lateral	**Material data** Type Thickness
	Weld time Start Finish Units completed
Remarks	**Complies** / **Does not comply**
Bead height	
Surface finish	
Spatter	
Name	**Exercise Number**

Skill practice 13

Gas metal arc welding - beads on plate

IF IN DOUBT ASK YOUR TEACHER

Objective To deposit a bead weld on low carbon steel plate using the gas metal arc welding process to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

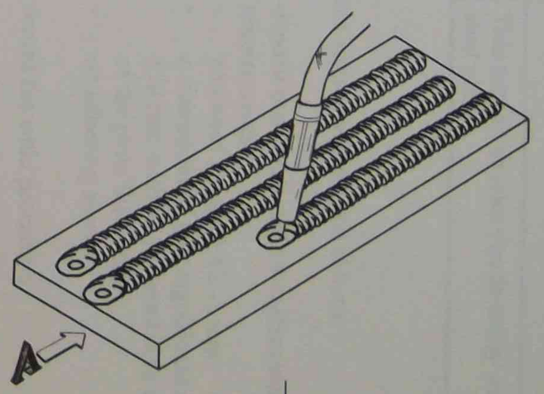
Method
1. Trial welding conditions on scrap material, to establish the weld procedure.
2. Deposit the weld as shown.
3. Clean up the bead weld and submit your work for inspection.
4. Turn the plate and repeat the exercise.
5. Evaluate the weld exercise and complete the procedure sheet.
6. Submit your work for evaluation.

Requirements
- Smooth regular weld profile free from splatter
- Bead height of 3 +2 -1 mm

Material unit 1 piece 100 x 12 x 225 mm low carbon steel

Unit required 1

Economy Use scrap material for setting equipment, and opposite side of the plate for further practice.



4. Is more versatile.

Skill practice 13

Gas metal arc welding - beads on plate

IF IN DOUBT ASK YOUR TEACHER

Objective To deposit a bead weld on low carbon steel plate using the gas metal arc welding process to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method

1. Trial welding conditions on scrap material, to establish the weld procedure.
2. Deposit the weld as shown.
3. Clean up the bead weld and submit your work for inspection.
4. Turn the plate and repeat the exercise.
5. Evaluate the weld exercise and complete the procedure sheet.
6. Submit your work for evaluation.

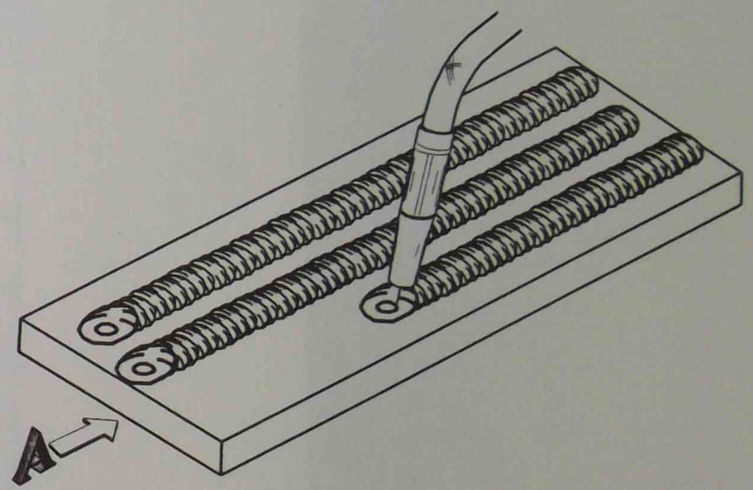
Requirements

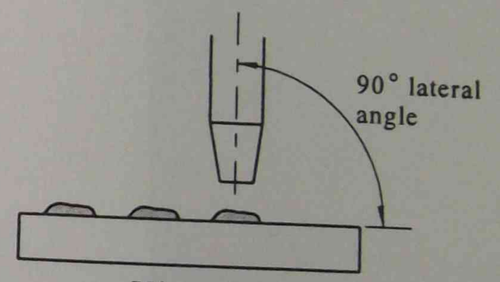
- Smooth regular weld profile free from splatter
- Bead height of 3 +2 -1 mm

Material unit 1 piece 100 x 12 x 225 mm low carbon steel

Unit required 1

Economy Use scrap material for setting equipment, and opposite side of the plate for further practice.





View A

Notes

4. Is more versatile

Section 20: Gas metal arc welding - pad weld

SUGGESTED DURATION	PREAMBLE
1 hour 30 minutes	This section enables you to safely deposit pad welds on low carbon steel plate.

Objectives

At the end of this section you will be able to:

- ☐ deposit pad welds on low carbon steel plate to the following requirements
  - pad weld height 3 +2 -1 mm
  - a maximum of four significant surface defects in a unit area of 40 x 150 mm with an accumulative defect area not exceeding the square of the plate thickness
  - no adhering spatter
- ☐ record the weld procedure
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Follow Occupational Health & Safety workshop procedures.
- Wear safety glasses in the welding workshop.
- Wear suitable protective clothing.
- Use tongs to handle hot work.
- Warn people nearby before striking an arc.
- Make sure screens are in position before beginning to weld.

Procedure sheet
Gas metal arc welding - pad weld

Sketch		
Electric output data Amps Volts open circuit Volts arc	**Consumables data** Wire type Wire diameter Gas type Flow rate	
Electrode data Electrical stick out Wire feed rate Torch angles Lead Lateral	**Material data** Type Thickness **Weld time** Start Finish Units completed	
Remarks	**Complies**	**Does not comply**
Spatter		
Surface finish		
Surface defects		
Pad weld height		
Name	**Exercise Number**	

Skill practice 14

Gas metal arc welding - pad weld

IF IN DOUBT ASK YOUR TEACHER

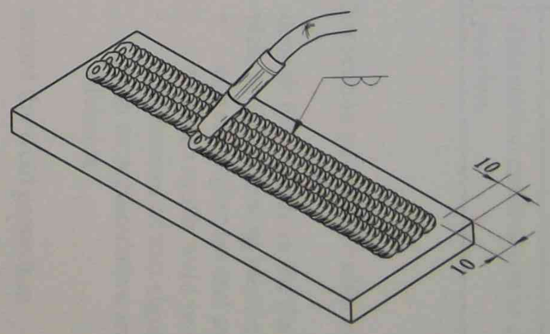
Objective To deposit a pad weld on low carbon steel plate using the gas metal arc welding process to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

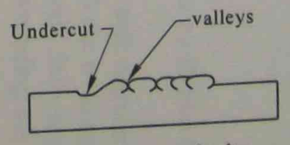
Method

1. Trial welding conditions on scrap material, to establish the weld procedure.
2. Mark a rectangular outline of the required bead weld on the plate.
3. Deposit the pad shape as shown.
4. Clean the weld and submit your work for inspection.
5. Turn the plate and repeat the exercise.
6. Evaluate the weld exercise and complete the procedure sheet.
7. Submit your work for evaluation.



Requirements

- Smooth regular weld profile free from splatter
- Pad height of 3 +2 -1 mm
- A maximum of four significant surface defects per unit area of 40 x 150 mm with an accumulative defect area not exceeding the square of the plate thickness



Common faults

Material unit 1 piece 100 x 12 x 225 mm low carbon steel

Unit required 1

Economy Use scrap material for setting equipment, and opposite side of plate for further practice.

4. Is more versatile

Skill practice 14

Gas metal arc welding - pad weld

IF IN DOUBT ASK YOUR TEACHER

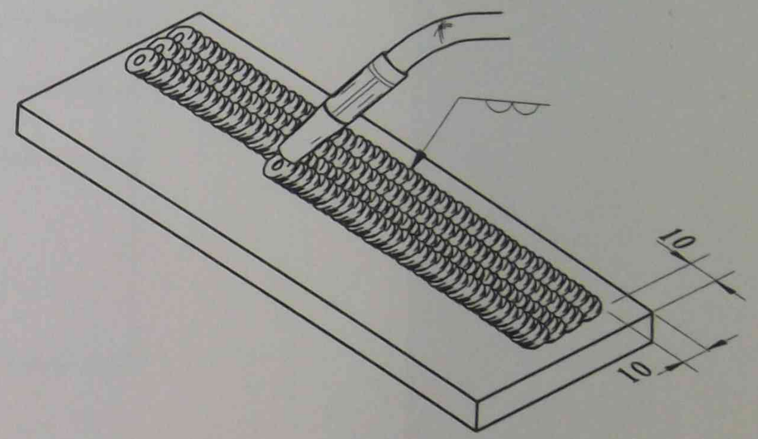
Objective To deposit a pad weld on low carbon steel plate using the gas metal arc welding process to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

Method

1. Trial welding conditions on scrap material, to establish the weld procedure.
2. Mark a rectangular outline of the required bead weld on the plate.
3. Deposit the pad shape as shown.
4. Clean the weld and submit your work for inspection.
5. Turn the plate and repeat the exercise.
6. Evaluate the weld exercise and complete the procedure sheet.
7. Submit your work for evaluation.



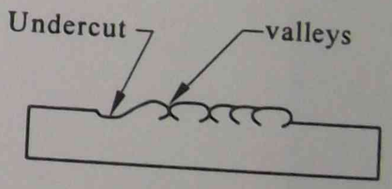
Requirements

- Smooth regular weld profile free from splatter
- Pad height of 3 +2 -1 mm
- A maximum of four significant surface defects per unit area of 40 x 150 mm with an accumulative defect area not exceeding the square of the plate thickness

Material unit 1 piece 100 x 12 x 225 mm low carbon steel

Unit required 1

Economy Use scrap material for setting equipment, and opposite side of plate for further practice.



Common faults

Notes

4. Is more versatile

Section 21: Gas metal arc welding - fillet weld

SUGGESTED DURATION	PREAMBLE
1 hour 45 minutes	This section enables you to safely deposit fillet welds in the flat position.

Objectives

At the end of this section you will be able to:

- ☐ deposit fillet welds in the flat position on 10 mm thick low carbon steel plate to the following requirements
  - correct alignment and assembly with angular distortion 0°-5°mm
  - smooth regular weld profile with the weld size 6 +2 -1 mm
  - a maximum of two significant weld defects per 250 mm weld length with an accumulative area not exceeding the square of the plate thickness
- ☐ record the weld procedure
- ☐ follow Occupational Health & Safety workshop procedures.

Safety

- Follow Occupational Health & Safety workshop procedures.
- Wear the proper eye protection.
- Never watch the arc except through a filter glass of the correct shade. The usual range of filters are shades 10, 11 and 13.
- Work on a well-insulated floor. Where possible, use wooden duckboards or insulated mats.
- Wear suitable protective clothing.

Sketch		
Electric output data Amps Volts open circuit Volts arc		**Consumables data** Wire type Wire diameter Gas type Flow rate
Electrode data Electrical stick out Wire feed rate Torch angles Lead Lateral		**Material data** Type Thickness **Weld time** Start Finish Units completed
Assessment	**Complies**	**Does not comply**
Bead height		
Surface finish		
Spatter		
Name	**Exercise Number**	

Skill practice 15
Assessment event 9 (practical)
Gas metal arc welding - fillet weld

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 1 hour 45 minutes
Assessment: 15 minutes

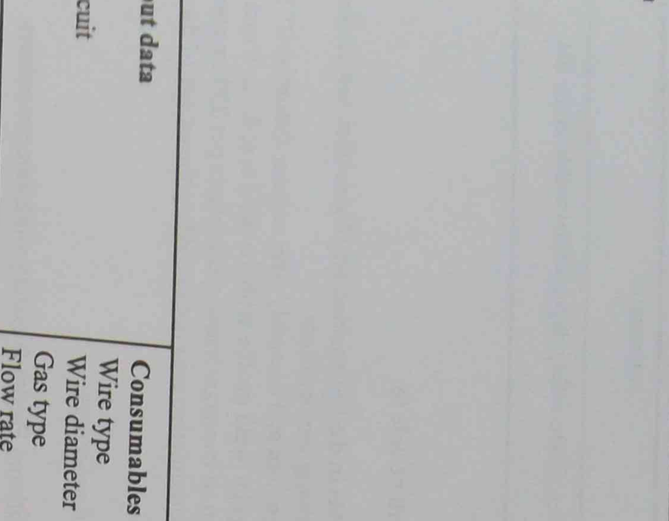
Objective To deposit a fillet weld to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

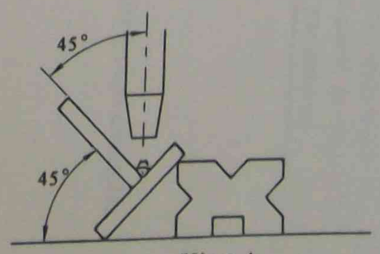
Method

1. Wire brush fusion faces to remove surface rust and mill scale.
2. Tack both ends of the plates, ensuring a close fit.
3. Complete approximately 50 mm of the weld and examine weld and profile.
4. Complete the weld and present to the teacher for inspection.
5. Break the weld and reposition for further practice.
6. Evaluate the weld exercise and compete the procedure sheet.
7. For assessment, repeat the fillet weld to the requirements given below.



Requirements

- Correct alignment and assembly with angular distortion limited to 0°-5°
- Smooth regular weld profile with weld size equal 6 +2 -1 mm
- A maximum of two significant surface defects per weld length with an accumulative defect area not exceeding the square of the plate thickness



View A

Material unit 2 pieces low carbon steel 50 x 10 x 225 mm

Unit required 2

Economy Consumables are expensive, use shielding gas and electrode wire economically.

Skill practice 15
Assessment event 9 (practical)
Gas metal arc welding - fillet weld

IF IN DOUBT ASK YOUR TEACHER

Suggested time Skill practice: 1 hour 45 minutes
Assessment: 15 minutes

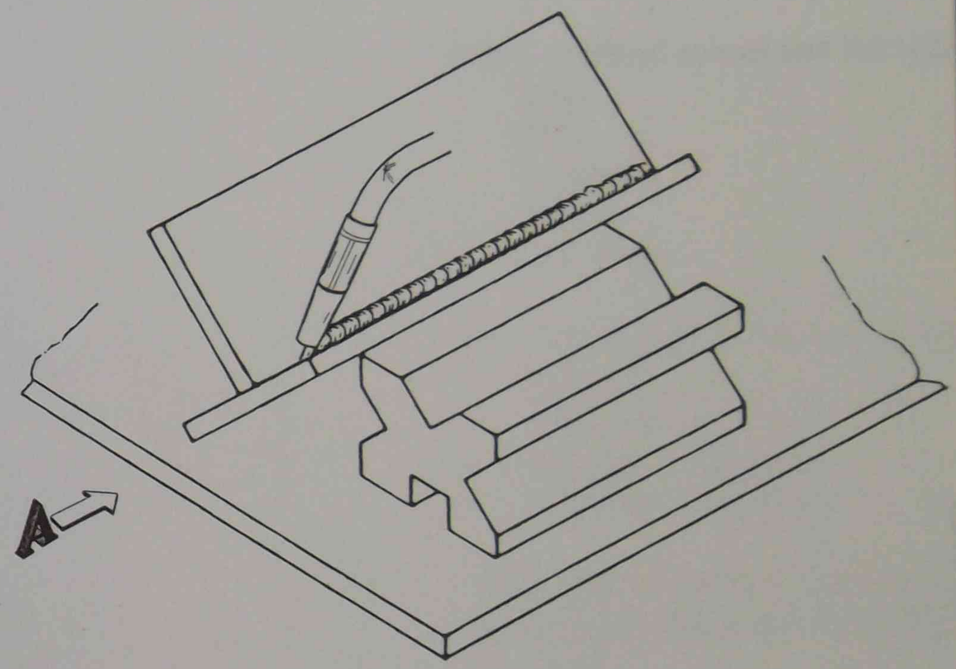
Objective To deposit a fillet weld to the requirements given below.

Position Flat.

Procedure Demonstrated by the teacher.

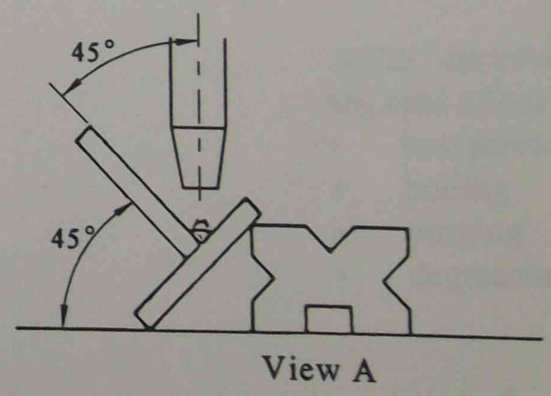
Method

1. Wire brush fusion faces to remove surface rust and mill scale.
2. Tack both ends of the plates, ensuring a close fit.
3. Complete approximately 50 mm of the weld and examine weld and profile.
4. Complete the weld and present to the teacher for inspection.
5. Break the weld and reposition for further practice.
6. Evaluate the weld exercise and compete the procedure sheet.
7. For assessment, repeat the fillet weld to the requirements given below.



Requirements

- Correct alignment and assembly with angular distortion limited to 0°-5°
- Smooth regular weld profile with weld size equal 6 +2 -1 mm
- A maximum of two significant surface defects per weld length with an accumulative defect area not exceeding the square of the plate thickness



View A

Material unit 2 pieces low carbon steel 50 x 10 x 225 mm

Unit required 2

Economy Consumables are expensive, use shielding gas and electrode wire economically.

Notes

Section 22: Hazardous locations and situations

SUGGESTED DURATION	PREAMBLE
2 hours 30 minutes	This section enables you to identify hazardous locations, confined spaces and containers that could cause an explosion or fire, if heat was applied, and the required safety procedures.

Objectives

At the end of this section you will be able to:

- ☐ define hazardous locations and list typical examples
  - chemical plants
  - refineries
  - textile mills
  - woodchip mills
  - and others
- ☐ list the procedure for welding or cutting in hazardous locations
  - work permit
  - fire prevention
- ☐ define confined spaces and list typical examples
  - tanks
  - ships
  - hoppers
  - vessels
  - and others
- ☐ list the safety precautions necessary when working in a confined space
  - assistant
  - ventilation
  - use of welding plant
  - electrical equipment
- ☐ list typical substances that make a container potentially dangerous if subjected to flame cutting, welding or heating
  - acid
  - petrochemicals
- ☐ outline the treatments and testing required to make a small container that has held a flammable substance, safe to heat, flame cut or weld
  - low pressure steam
  - boiling
  - purging
  - degreasing.

Hazardous locations and situations

Hazardous locations are areas where flammable or explosive substances are present or have been present. No welding or cutting is permitted in this area without written approval from the safety officer responsible for the location. When there's any doubt about the safety of a location, see your supervisor before starting work.

Areas classed as hazardous locations include the following.

- Alcohol distilleries
- Oil refineries
- Paint factories
- Explosives manufacturers
- Coal crushers
- Flour mills
- Plastics manufacturers
- Saw mills
- Wheat silos
- Clothing factories
- Paper mills

This list is only a guide and by no means complete.

Work processes which generate heat and can be dangerous in these locations include:

- flame heating
- oxy cutting
- gouging
- arc welding
- grinding.

Normal procedures for welding or cutting in hazardous locations

Before work can begin in any of these areas, the safety officer responsible must be informed of what you plan to do. The officer is then required to inspect the site thoroughly and make any special safety recommendations. The safety officer must issue a work permit before any work can begin. A typical work permit lists all the specific safety requirements and must be signed by the Responsible Officer.

Sample cutting and welding work permit

WORK PERMIT
FOR ARC OR FLAME CUTTING, FLAME HEATING AND ARC OR GAS WELDING OPERATIONS

Reference ..... *Date* .....

Period of Issue: From ..... *am/pm To* ..... *am/pm*

Premises/Ship .....

Department ..... *Floor* ..... *Location* .....

Nature of hazard .....

Precautions to be taken .....

.....

.....

Welder .....

All necessary precautions have been taken to avoid any possible fire or explosion hazard and permission is given for arc/or flame cutting, flame heating and arc or gas welding operations to be carried out in conformity with the above instructions.

Signed ..... *Welder* ..... *Responsible Officer*

Note: The work permit is valid only for the location and period indicated and is to be returned to the Responsible Officer on completion of the work.

Fire prevention

The Responsible Officer will tell those who are cutting, heating or welding to watch out for fire and where to contact the nearest fire brigade. The correct type and number of fire extinguishers must always be available for immediate use in your work area. After cutting, heating and welding the Responsible Officer must arrange for a watch to be kept for at least 1 hour.

Confined working areas

A confined working area is a location with restricted ventilation and/or access. Some examples are given below.

- Tanks and containers (road and rail tankers)
- Bins and silos (quarries, grain handlers, mines)
- Ship hull compartments
- Ducts and chutes
- Pipelines (large diameters)

Before you begin any work in these areas, check with your supervisor.

Working in confined areas

Working in confined areas requires a number of safety precautions.

- Ventilation by forced draught, using fans and/or air ducts.
- An assistant outside the location to observe the welders at all times - the assistant will operate the controls of the gas cylinders or welding machines and help in the event of an emergency.
- Rescue apparatus harness available so the attendant can assist without getting into danger.
- Gas cylinders and welding machines outside the location in a well ventilated position.
- Blowpipes lit outside, whenever practicable and be removed from the location when not in use.
- Electrical hand tools and lighting (32 volt maximum).

Dangerous containers

Containers are dangerous to work on especially if they contain flammable substances. They can be just as dangerous when empty, if gas or other residues remain. Even very small amounts of some residues are dangerous and they may collect in seams which makes them difficult to remove. Some examples of dangerous containers are given below.

- Vessels used for petroleum products or other types of explosive liquids that release a flammable gas.
- Vessels used for acid - hydrogen may be present.
- Vessels used for gum, resin, varnish, bitumen or similar products - these will release explosive gases when heated.
- Containers holding, or having held, a flammable or explosive solid - these may have particles of dust still in them which could cause an explosion.

Preparation of dangerous containers for welding or cutting operations

You should not rely on sight or smell to decide whether a container is safe or not. A work permit must be obtained before work begins on the container. If you are in doubt about any aspect, you should ask for help from a qualified chemist.

Cleaning and purging procedures for small containers

Steaming

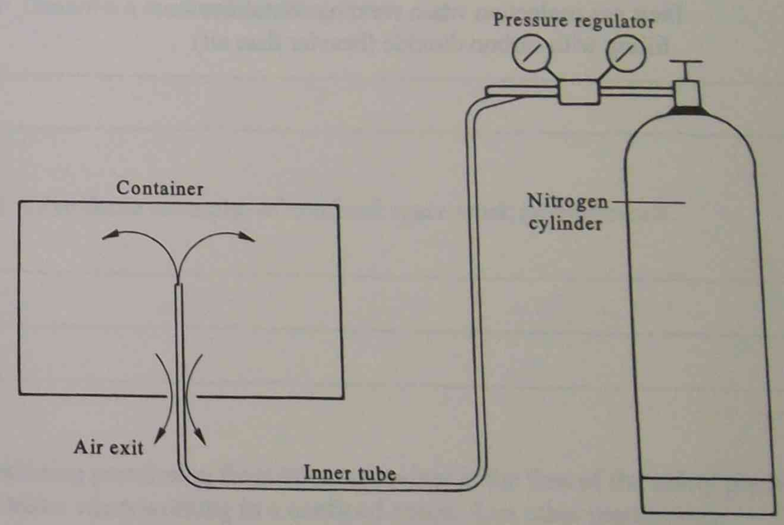
Fill the container with steam under low pressure and drain out the steam and condensed water at the lowest point. Steam for a least half an hour after the container is hot, and be sure the flammable substance is completely removed.

Boiling

Remove the caps from the container and immerse it in boiling water. You may use degreasing agents but take care not to use an agent that will cause the container to corrode. The container should be boiled for at least half an hour. Be sure the flammable substance has been completely removed.

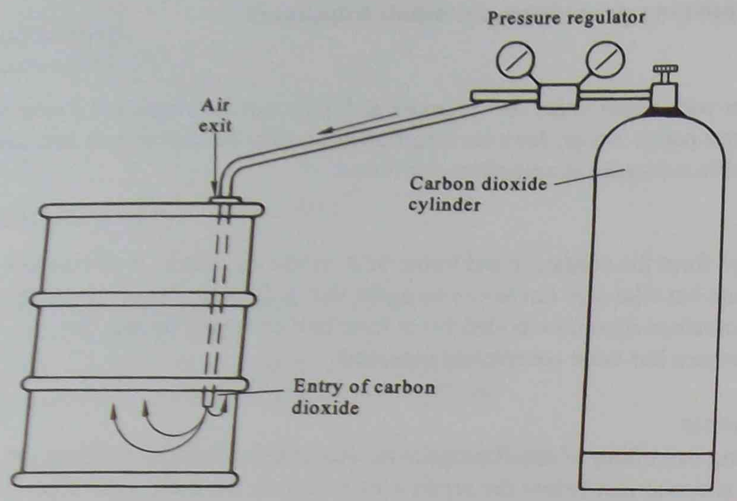
Other treatments

Besides steaming or boiling of small containers, other methods include filling the container with water to just below the repair area to reduce the incidence of gas build up or ignition.



Before welding or cutting, partially fill the container with water, vent to the atmosphere and ask the welding supervisor to inspect it and confirm that it is safe to work on.

You can also supplement the process by filling the container with inert gas such as argon, carbon dioxide or nitrogen which will act in the same way as water.



Inert gas protection when welding containers - filling with carbon dioxide (heavier than air)

Review questions

These questions will help you revise what you've learnt in Section 22.

1. List **three** of the locations that are classed as hazardous.

   - _____
   - _____
   - _____

2. What must you do first before beginning work in a hazardous location?

   _____

3. (a) Describe a confined working space.

   _____

   _____

   (b) Give **three** examples of confined space work environments.

   - _____
   - _____
   - _____

4. Obtaining permission from your supervisor is the first of the safety precautions to be taken when working in a confined space. List other precautions.

   _____

   _____

   _____

   _____