



**INTERNATIONAL WELDING SPECIALIST (IWS)
INCORPORATING WTIA WELDING SUPERVISOR
AS 1796 CERTIFICATE 10 AND AS 2214
WELDING SUPERVISOR**

AND

**INTERNATIONAL WELDING INSPECTION
PERSONNEL STANDARD (IWI S)
INCORPORATING
WTIA WELDING INSPECTOR**

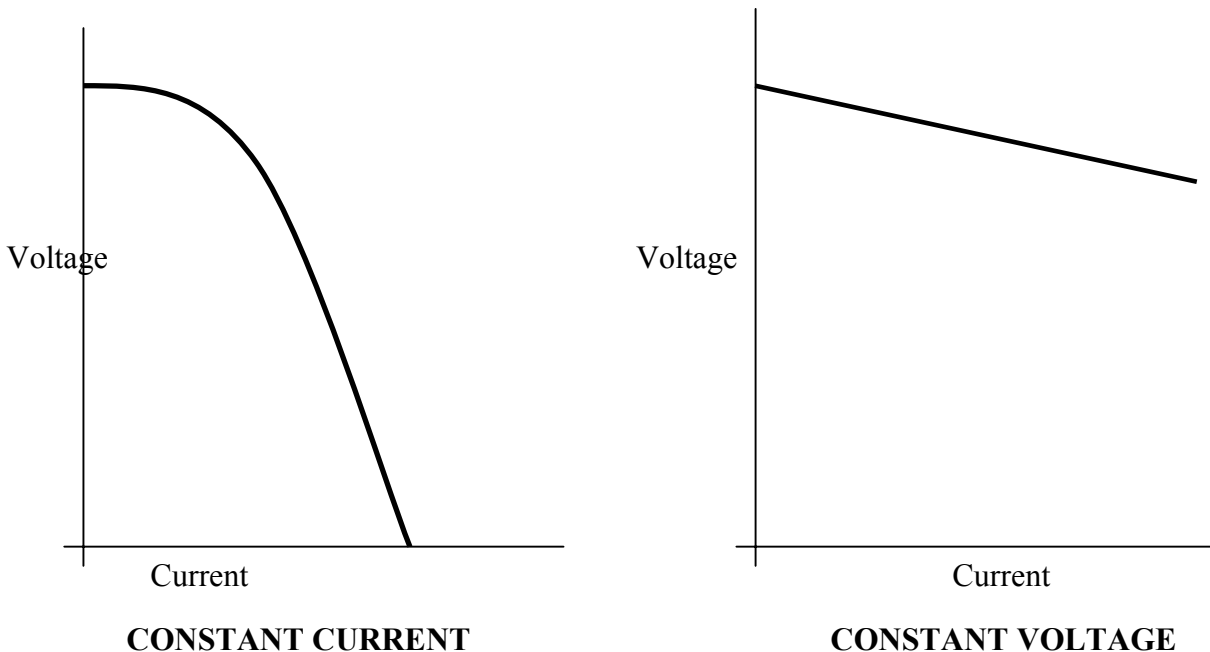
**SAMPLE
QUESTIONS AND ANSWERS
BANK**

QUESTION 1

1.1 State five functions of the flux in the flux cored arc welding process. **5 marks (Ref: 1.8)**

- Stabilise the arc
- Shield molten metal from atmosphere
- Scavenge impurities
- Controls shape and appearance of weld
- Adjusts chemical composition of weld

1.2 With the aid of diagrams, briefly explain the difference between Constant Current and Constant Voltage welding power sources. **10 marks (Ref: 1.5, 1.8, 1.9)**



Welding machines are usually classified as constant current (CC) or constant voltage (CV). A constant current machine will vary its output voltage to maintain a steady current while a constant voltage machine will fluctuate its output current to maintain a set voltage. Shielded metal arc welding use a constant current source and gas metal arc welding and flux-cored arc welding typically use constant voltage sources

1.3 List the four main modes of metal transfer in Gas Metal Arc Welding (GMAW) process. **5 marks (Ref: 1.8)**

- Short circuiting transfer
- Globular transfer
- Spray Transfer
- Pulsed spray transfer

QUESTION 2

2.1 List three reasons why SAW solid wires are copper coated. **5 marks (Ref: 1.10)**

- It improves the current pickup between contact tip and the electrode.
- It aids in the drawing process
- Helps prevent rusting of the wire when it is exposed to the atmosphere.

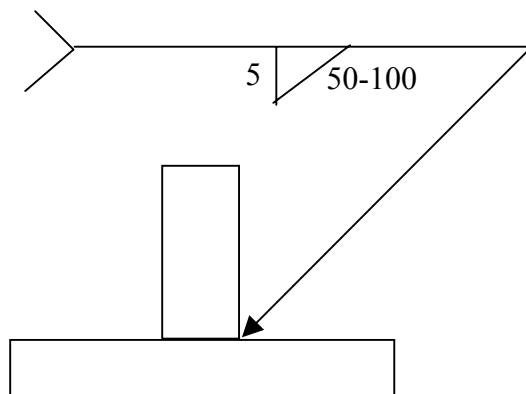
2.2 What is “twin wire” (tandem wire) GMAW? What are the two variations in the welding process? **8 marks (Ref: 1.8)**

Automated GMAW process with two wires under one shielding gas nozzle. The tips are insulated from one another and connected to their own wire feeder and power source and regulated by electronic control system. Welding current may be pulsed or non-pulsed. The lead wire generates the required penetration while the trail wire provides additional joint filling as well as an excellent weld profile.

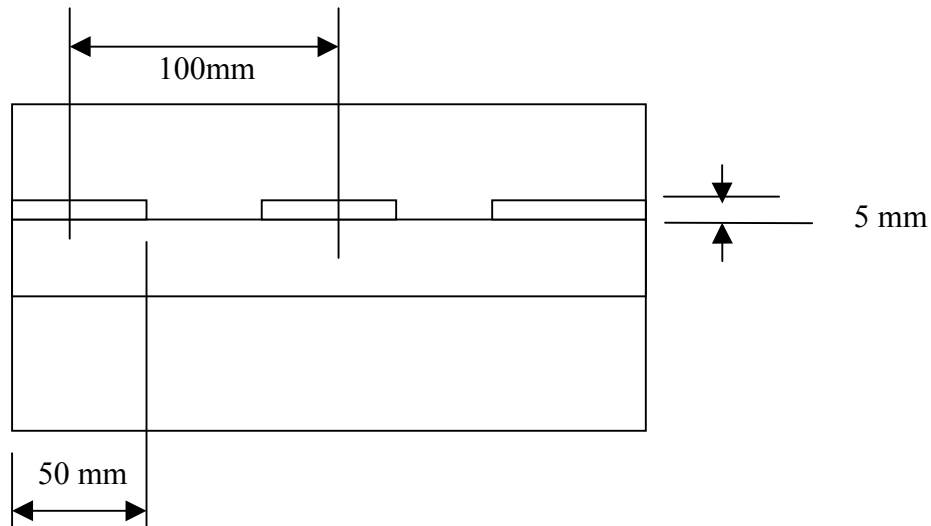
Variation 1: The lead wire uses non-pulsed current, while the trailing wire uses pulsed current

Variation 2: Pulsed current is applied to both wires, alternatively

2.3 Given the welding symbol as shown below, explain in full with the aid of a diagram, the information conveyed through it. **7 marks (Ref: 1.1)**



- Fillet weld on one side of the joint
- Stitch welding
- Fillet leg length : 5 mm
- Length of fillet weld: 50 mm
- Pitch between welds : 100 mm



QUESTION 3

3.1 Define the following welding terms: **(Ref: 1.1)**

a) Open circuit voltage of a welding power source **4 marks**

A welding machine that is turned on but not being used for welding at the moment will have a voltage applied to the cables attached to the output terminals of the welding machine. No current flows in the circuit because the circuit is open. The voltage is impressed upon the circuit, however, so that when the circuit is completed, the current will flow immediately.

b) Operator duty cycle **4 marks**

Operator duty cycle is the actual time an operator is actually welding versus time spent on related activities such as set up, clean up or some other non-welding activities.

c) Deposition efficiency (for continuous electrodes) **4 marks**

Deposition efficiency in arc welding is the ratio of the weight of the weld metal deposited to the nett weight of the filler material used.

d) Welding symbol **4 marks**

Welding symbols are a simple way of communicating design office details to a number of different industrial shop floor personnel such as welders, supervisors, and inspectors. Information provided by a welding symbol include weld type, edge preparation, finish, testing requirement, dimensions etc

e) Polarity **4 marks**

Polarity refers to the manner in which the electrode holder and workpiece connections are connected to the electrical supply. In DCEN polarity, for example, current is DC with electrode negative.

QUESTION 4

- 4.1 Explain the difference between soldering and welding. **5 marks (Ref: 1.1)**

Soldering is a group of joining processes that produce coalescence of materials by heating them to the soldering temperature and by using a filler metal (solder) having a liquidus not exceeding 450°C, and below the solidus of the base metals.

In welding, fusion takes place with melting of both the base metal and usually a filler metal.

- 4.2 Explain the phenomenon of “flashback”. How does a flashback arrestor assist in preventing flashbacks? **7 marks (Ref: 1.2)**

Unequal gas pressure can lead to a backflow i.e. mixing of gases in torch, hoses etc that can result in a flashback. A flashback is the flame burning back into the torch, hoses, regulator or even the cylinders.

A flashback arrestor is designed to prevent the backflow of gas, quench the flame produced by a flashback and may provide additional protection by shutting off the gas flow if certain temperatures and/or pressures are exceeded.

- 4.3 What are Voltage Reducing Devices (VRDs)? List the three types of VRDs commonly used in the industry. **8 marks (Ref: 1.8)**

A device that assists in the reduction of electrical shock to personnel involved in welding activities is known as VRD. It is a device that reduces open-circuit voltage to a safe value until welding commences. Upon arc strike, full selected current and voltage becomes available. Upon completion of welding, the Open Circuit Voltage is returned to a safe value until the next welding cycle.

The three types of VRDs are:

Type 1: Externally fitted to secondary circuit

Type 2: Internally fitted to secondary circuit

Type 3: Fitted to primary circuit

QUESTION 5

- 5.1 What is magnetic arc blow? State three methods of reducing it. **5 marks (Ref: 1.8, 1.9)**

Magnetic arc blow, also called arc wandering, occurs in DC arc welding when the arc does not follow the shortest path between the electrode and the workpiece and deflects forward or backward from the direction of travel or less frequently, to one side.

Some of the methods to reduce it are:

- If DC is being used with MMAW process change to AC
- Hold as short an arc as possible to help arc force counteract arc blow

- Reduce the welding current
- Angle the electrode with the work opposite to the direction of arc blow
- Use a backstep welding method
- Wrap the work cable around the workpiece so that the current returning to the power supply passes through it in such a direction that the magnetic field set up neutralises the magnetic field causing the arc blow

5.2 Give five advantages of waterjet cutting over LASER cutting. **5 marks (Ref: 1.12)**

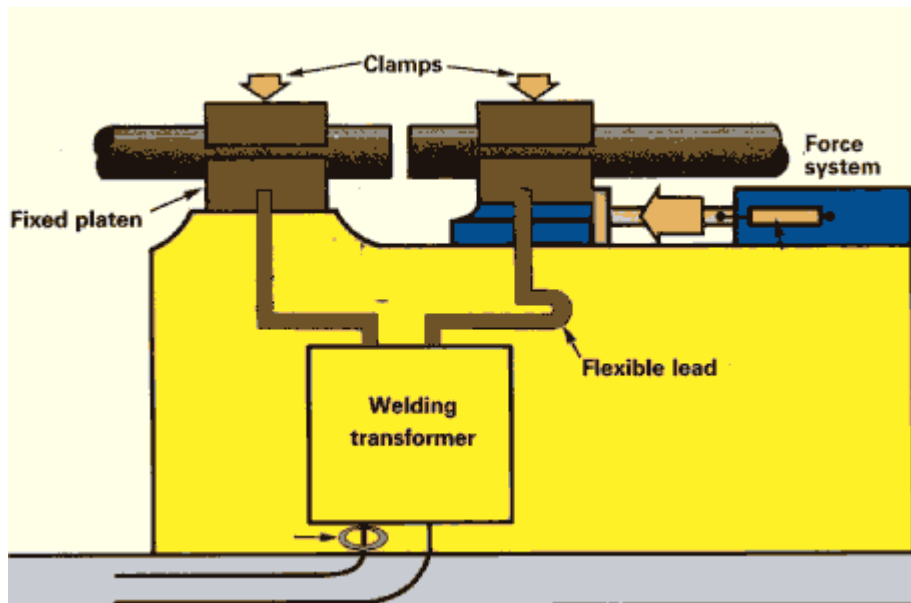
- Abrasive waterjets can machine many materials that lasers cannot. (Reflective materials in particular, such as Aluminum and Copper.)
- Uniformity of material is not very important to an Abrasive jet.
- Abrasive jets do not heat the part. Thus there is no thermal distortion or hardening of the material.
- Precision abrasive jet machines can obtain about the same or higher tolerances than lasers (especially as thickness increases).
- Capital equipment costs for water jet are generally much lower than that for a laser.
- Abrasive jets can machine thicker materials.
- Abrasive jets are safer. No burnt fingers, no noxious fumes and no fires.
- Abrasive jets are more environmentally friendly.
- Maintenance on the abrasive jet nozzle is simpler than that of a laser, though probably just as frequent.
- Modern Abrasive jets are typically much easier to operate and maintain than lasers
- Abrasive jets don't create "scaley" edges, which makes it easier to make a high quality weld

5.3 Explain the principles of Flash Butt Welding with neat sketches. **5 marks (Ref: 1.12)**

Flash butt welding is done by placing two work parts in the jaws of the flash butt machine. As the parts are brought together into very light contact, a voltage is applied which produces a flashing action between work parts. Flashing continues as the parts advance until the parts reach a forging temperature. The weld is then completed by application of sufficient forging pressure and the interruption of current.

The overall flashing time is important. This is the total time during which the flashing takes place. If the time is too short, sufficient heat is generated in the parts and it is impossible to obtain the proper upset. If it is too long, the weld area is overheated. It is therefore difficult to expel the excessive molten metal and maintain an adequate forging force.

Schematic representation of flash butt welding



- 5.4 List two problems with welding coated steels and give one solution for each problem.

5 marks (Ref: 1.8, 1.9)

For metal arc welding and other high temperature welding methods, precautions must be taken to avoid porosity and cracking of the weld that can be caused by penetration of zinc into the weld pool. High levels of spatter and welding fume and poor bead shape are common. The right wire size and type, matched with the most appropriate shielding gas, can substantially improve gas metal arc welding (GMAW) performance on galvanized and coated steels.

For all galvanized products, extremely high welding current is to be avoided, because excessive heating tends to cause expulsion of the zinc coating under the electrodes. The optimum setting of the welding parameters must be determined by trial and are dependent on the specific application and sheet characteristics such as thickness or coating weight. The thicker the zinc coating, the more fumes are generated. In general, resistance welding is preferred for joining galvanized sheet products because it results in less fuming than other types of welding.

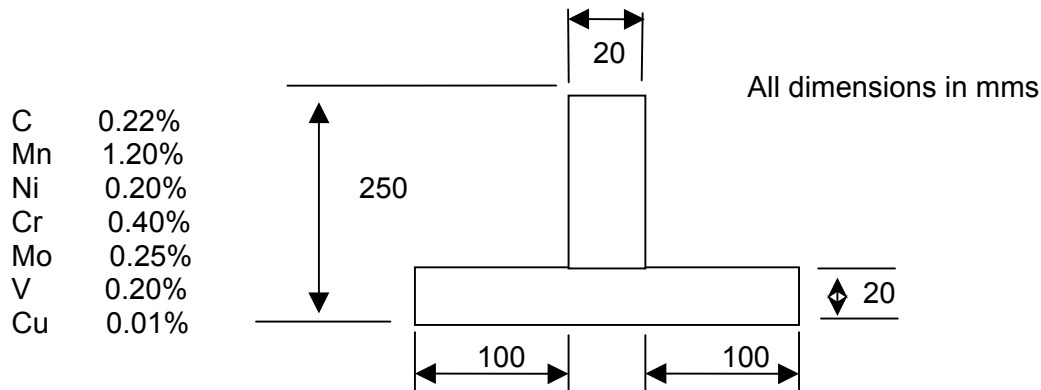
Pulsed metal transfer GMAW can help improve galvanized steel weld quality even more. By reducing spatter, it increases process efficiency and minimizes cleanup

PAPER SA2

MATERIALS AND THEIR BEHAVIOUR DURING WELDING

QUESTION 1

- 2.1 A steel, with the chemical composition as shown below, and of known heat analysis, is to be used in structural fabrication. (Ref: 2.7, 2.8, 2.9)



Continuous fillet welds have to be made simultaneously on a Tee Joint whose thickness is 20 mm. MMAW is to be used throughout using 5 mm diameter E 4818 electrodes. (Note: Use WTIA Technote 1: The Weldability of Steels for solving this problem)

- i) Calculate the carbon equivalent for this steel 5 marks

Using the IIW formula below and substituting the values:

$$C_{eq} = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15 = 0.604 + 0.01 = 0.614$$

- ii) For the welding conditions given below, calculate the arc energy
 Arc Voltage = 23 V, Amperage = 230 A, Travel Speed = 200 mm/min 5 marks

$$\text{Arc Energy} = (\text{Voltage} \times \text{Current}) / \text{Travel Speed} = (230 \times 23) / 200 = 1.587 \text{ kJ}$$

- iii) Using the above information and results, determine from the welding data sheets provided

- a) The group number of this steel 5 marks

Using the graph in Fig 1 in WTIA Tech Note 1, Group No is **8**

- b) The preheat necessary for control of HAZ properties of this steel to avoid cold cracking with the given joint configuration, welding conditions and electrode size 5 marks

Using the graph in Fig 3 in WTIA Tech Note 1, preheat = **150° C**

QUESTION 2

- 2.1 What is re-heat cracking? Explain the reasons why re-heat cracking occurs in low alloy steels **10 marks (Ref: 2.11)**

Reheat cracking may occur in low alloy steels containing alloying additions of chromium, vanadium and molybdenum when the welded component is being subjected to post weld heat treatment, such as stress relief heat treatment, or has been subjected to high temperature service (typically 350 to 550°C).

Cracking is almost exclusively found in the coarse grained regions of the heat affected zone (HAZ) beneath the weld, or cladding, and in the coarse grained regions within the weld metal. The cracks can often be seen visually, usually associated with areas of stress concentration such as the weld toe.

The principal cause is that when heat treating susceptible steels, the grain interior becomes strengthened by carbide precipitation, forcing the relaxation of residual stresses by creep deformation at the grain boundaries.

The presence of impurities which segregate to the grain boundaries and promote temper embrittlement, e.g. sulphur, arsenic, tin and phosphorus, will increase the susceptibility to reheat cracking.

The joint design can increase the risk of cracking. For example, joints likely to contain stress concentration, such as partial penetration welds, are more liable to initiate cracks.

The welding procedure also has an influence. Large weld beads are undesirable, as they produce a coarse grained HAZ which is less likely to be refined by the subsequent pass, and therefore will be more susceptible to reheat cracking.

- 2.2 Give four precautions that can assist in re-heat cracking being avoided in low alloy steels.

10 marks (Ref: 2.11)

The risk of reheat cracking can be reduced through the choice of steel, specifying the maximum impurity level and by adopting a more tolerant welding procedure / technique.

Steel choice: If possible, avoid welding steels known to be susceptible to reheat cracking.

Welding procedure and technique:

The welding procedure can be used to minimise the risk of reheat cracking by

- * Producing the maximum refinement of the coarse grain HAZ
- * Limiting the degree of austenite grain growth
- * Eliminating stress concentrations

QUESTION 3

- 3.1 The risk of porosity during the welding of aluminium and aluminium alloys can be minimised by rigorous cleaning of material surface and filler wires used. Explain the three cleaning techniques that are available for achieving this. **10 marks (Ref: 2.23)**

To minimise the risk, rigorous cleaning of material surface and filler wire should be carried out. Three cleaning techniques are suitable; mechanical cleaning, solvent degreasing and chemical etch cleaning.

Mechanical cleaning: Wire brushing (stainless steel bristles), scraping or filing can be used to remove surface oxide and contaminants. Degreasing should be carried out before mechanical cleaning.

Solvents: Dipping, spraying or wiping with organic solvents can be used to remove grease, oil, dirt and loose particles.

Chemical etching: A solution of 5% sodium hydroxide can be used for batch cleaning but this should be followed by rinsing in HNO_3 and water to remove reaction products on the surface.

- 3.2 How is dilution of filler material defined and expressed? What are the factors that effect the final chemical composition and mechanical/physical properties of the welded joint?

10 marks (Ref: 2.25)

Dilution of filler material by the infusion of parent metal during liquidus state in welding is a fundamental process of welding and can be defined as the reduction in alloy content of a weld deposit by virtue of melting and incorporating melted base metal of lower alloy content

Dilution is commonly expressed as the percentage of base metal that has entered into the weld metal.

The factors that affect the final composition are:

- The type of process being used
- The parameters being used by the process
- The nature of the base and filler materials

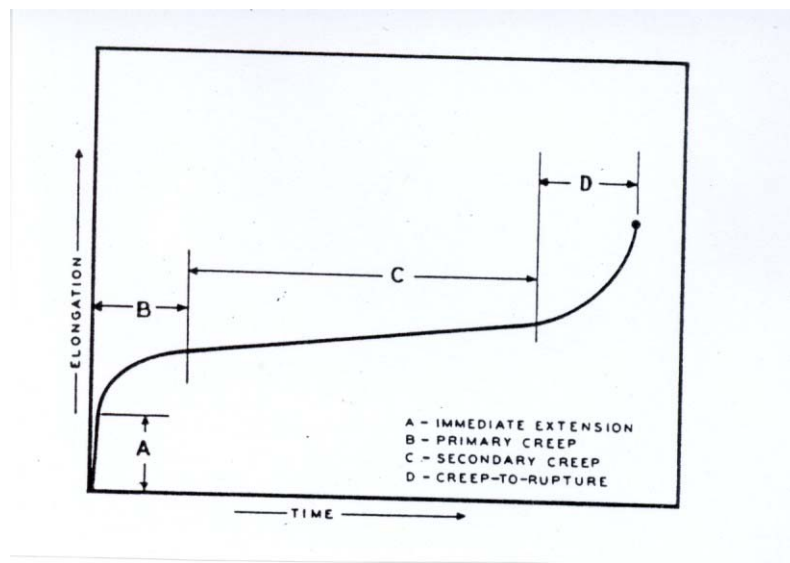
QUESTION 4

- 4.1 What is a phase diagram (also called equilibrium diagram or constitution diagram)? Give two uses of the iron-carbon equilibrium diagram. **8 marks (Ref: 2.4)**

It is a two-dimensional graph which indicates the phases present at a given temperature and composition.

- To get some idea of the conditions of temperature and pressure that are most likely to produce a gas, a liquid, or a solid.
- To find the combinations of temperature and pressure at which two states are in equilibrium.

4.2 With the aid of a diagram, describe the phenomenon of creep. State three elements that contribute to the rate of creep damage. **12 marks (Ref: 2.14)**



Creep is the term given to the material deformation that occurs as a result of long term exposure to levels of stress that are below the yield or ultimate strength. Rather than failing suddenly with a fracture, the material permanently strains over a longer period of time until it finally fails. Creep does not happen upon sudden loading but the accumulation of creep strain in longer times causes failure of the material. This makes creep deformation a "time-dependent" deformation of the material.

The rate of this damage is a function of the material properties and the exposure time, exposure temperature and the applied load (stress). Depending on the magnitude of the applied stress and its duration, the deformation may become so large that a component can no longer perform its function

QUESTION 5

5.1 What is the effect of corrosion on the fatigue strength of welded structures?

6 marks (Ref: 2.15)

The presence of a corrosive environment may accelerate fatigue crack propagation in structural steels. If pitting conditions exist, development of corrosion pits will introduce additional points of stress concentration at which cracking may develop. Both these mechanisms are likely to reduce fatigue strength below that in an inert environment.

- 5.2 Give two reasons why preheat is used when welding a high carbon equivalent steel? List two methods of applying preheat. **6 marks (Ref: 2.8, 2.9)**

Preheating is the process applied to raise the temperature of the parent steel before welding. It is used for the following main reasons:

- To slow the cooling rate of the weld and the base material, resulting in softer weld metal and heat affected zone microstructures with a greater resistance to fabrication hydrogen cracking.
- The slower cooling rate encourages hydrogen diffusion from the weld area by extending the time period over which it is at elevated temperature (particularly the time at temperatures above approximately 100°C) at which temperatures hydrogen diffusion rates are significantly higher than at ambient temperature. The reduction in hydrogen reduces the risk of cracking.

Preheat can be applied through various means. The choice of method of applying preheat will depend on the material thickness, weldment size and the heating equipment available at the time of welding. The methods can include furnace heating for small production assemblies or, for large structural components, arrays of torches, electrical strip heaters, induction heaters or radiation heaters.

- 5.3 List two specific imperfections that can result in the welding of each of the following:

- a) Austenitic stainless steel **4 marks (Ref: 2.16)**

Common imperfections found on welding are:

Although austenitic stainless steel is readily welded, weld metal and HAZ cracking can occur. Weld metal solidification cracking is more likely in fully austenitic structures which are more crack sensitive than those containing a small amount of ferrite.

- b) Copper and copper alloys **4 marks (Ref: 2.21)**

In fusion welding tough pitch copper, high oxygen content leads to embrittlement in the heat affected zone (HAZ) and weld metal porosity. Phosphorus deoxidised copper is more weldable but residual oxygen can result in porosity in autogenous welds especially in the presence of hydrogen. Porosity is best avoided by using appropriate filler wire containing deoxidants (Al, Mn, Si, P and Ti).

PAPER SA3

CONSTRUCTION AND DESIGN

QUESTION 1 5 marks (Ref: 3.1, 3.2, 3.3, 3.4)

1.1 What is meant by “joint efficiency”

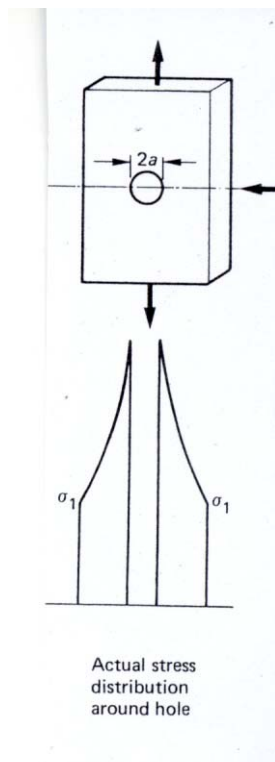
Joint efficiency is the ratio between the tensile strength of the joint and the tensile strength of the parent material expressed as a percentage

1.2 Define the “design throat thickness” and “load carrying area” for a fillet weld
8 marks

Design throat thickness is the shortest distance from the root of the fillet weld to the line drawn between the toes of the weld.

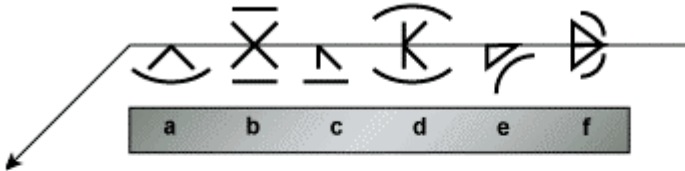
The load carrying area is the design throat thickness multiplied by the length of the weld.

1.3 Graphically represent the actual stress distribution around the hole in the plate shown, which is under tension. **7 marks**



QUESTION 2

2.1 Given below are a few welding symbols. Describe what each symbol represents **12 marks**
(Ref: 3.4)



- a) single vee butt weld with convex profile
- b) double vee butt weld flushed off both sides on weld face
- c) single bevel butt weld flushed
- d) double bevel butt convex (as welded)
- e) concave fillet weld
- f) double sided convex fillet weld

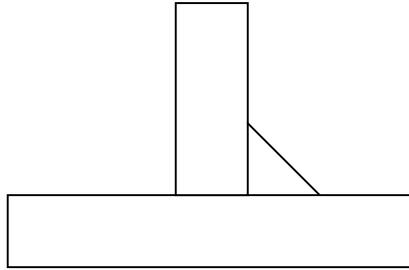
2.2 What is the “Poisson's ratio” and what does it indicate? **8 marks (Ref: 3.1)**

When a sample of material is stretched in one direction, it tends to get thinner in the other two directions. **Poisson's ratio** (ν) is a measure of this tendency. It is defined as the ratio of the strain in the direction of the applied load to the strain normal to the load.

QUESTION 3

3.1 Find the weld throat size and the weld throat shear stress of the given fillet weld, as shown below, for the given information: **12 marks (Ref: 3.4)**

Leg length	= 10 mm (equal legs)
Longitudinal shear load	= 1500 N
Weld length	= 100 mm



$$\text{Throat size} = \sin 45^\circ \times 10 \text{ mm} = 0.707 \times 10 = \mathbf{7.07 \text{ mm}}$$

$$\text{Weld throat shear stress} = \text{Load} / \text{area} = 1500 / 100 \times 7.07 = \mathbf{2.12 \text{ N/mm}^2}$$

3.2 What factors (give at least five) are taken into account when selecting/designing a joint for an application **8 marks (Ref: 3.4)**

- Load requirements
- Least amount of weld material
- Reduce residual internal stresses
- Reduce distortion
- Reduce cost
- Decrease welding time

QUESTION 4

4.1 How are residual stresses caused? **5 marks (Ref: 3.7)**

Because of the high localised heat input of the welding process, the grain sizes are changed in the weld zone. Because the surrounding parent metal restricts free expansion and contraction during heating and cooling cycle, stresses are locked into the local weld areas. This stress build up is called residual stress. Residual stress can also be caused by cold working material such as bending or rolling plates.

4.2 State at least five factors that affect fatigue life. How does shot peening improve fatigue life? **10 marks (Ref: 3.9)**

- Magnitude of stress including stress concentrations caused by part geometry.

- Quality of the surface; surface roughness, scratches, etc. cause stress concentrations or provide crack nucleation sites which can lower fatigue life depending on how the stress is applied.
- Surface defect geometry and location. The size, shape, and location of surface defects such as scratches, gouges, and dents can have a significant impact on fatigue life.
- Significantly uneven cooling, leading to a heterogeneous distribution of material properties such as hardness and ductility and, in the case of alloys, structural composition.
- Size, frequency, and location of internal defects. Casting defects such as gas porosity and shrinkage voids, for example, can significantly impact fatigue life.
- In metals where strain-rate sensitivity is observed (ferrous metals, copper, titanium, etc.) strain rate also affects fatigue life in low-cycle fatigue situations.
- For non-isotropic materials, the direction of the applied stress can affect fatigue life.
- Grain size; for most metals, fine-grained parts exhibit a longer fatigue life than coarse-grained parts. Environmental conditions and exposure time can cause erosion, corrosion, or gas-phase embrittlement, which all affect fatigue life.

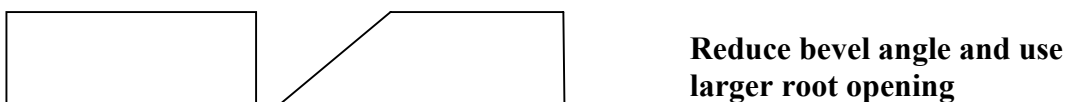
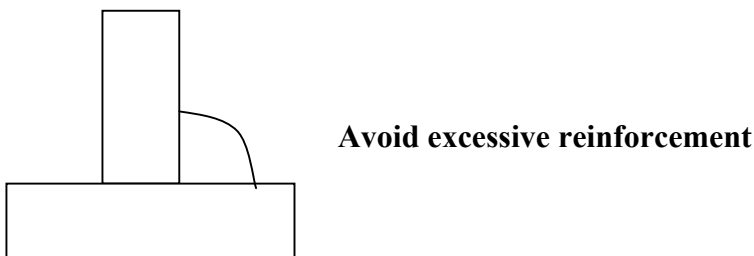
Shot peening puts the surface in a state of compressive stress which inhibits crack formation thus improving fatigue life

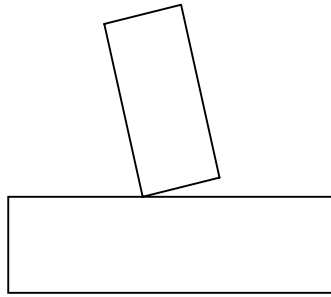
- 4.3 What significant properties does “9% Ni steel” have and what applications is it used for ? **5 marks (Ref: 3.6, 3.10)**

The only alloy steel recommended for cryogenic service is 9% nickel steel. It is satisfactory for service down to -195°C and is used for transport and storage of cryogenics because of its low cost and ease of fabrication. Other alloy steels are suitable for service in the low-temperature range. The steels A201 and T-1 can suffice to -45°C , nickel steels with 2.25% Ni can suffice to -59°C , and nickel steels with 3.5% Ni to -101°C .

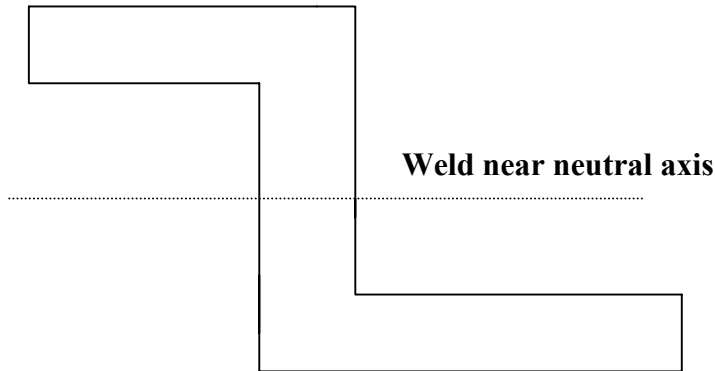
QUESTION 5

- 5.1 Give five examples, with sketches, of how the designer can reduce distortion at the design stage. **10 marks (Ref: 3.4)**

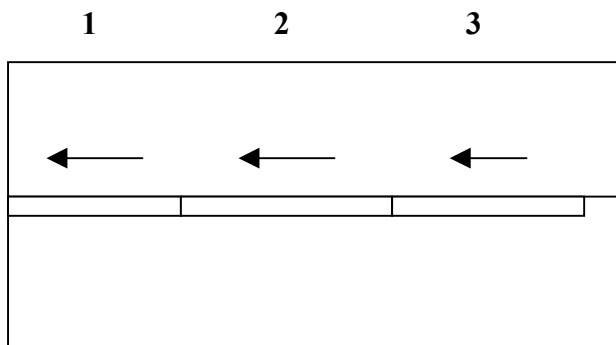




Preset parts



Weld near neutral axis



Specify backstep welding procedure

5.2 Consider the following data for a thin-walled air receiver:

Diameter (d) = 800 mm
 Internal pressure (p) = 10 bars
 Hoop stress = 100 N/mm²

Find the wall thickness of the air receiver and the longitudinal stress. **10 marks (Ref: 3.10)**

Longitudinal stress is half of hoop stress = $100/2 = 50 \text{ N/mm}^2$

Hoop Stress = $pd/2t$

Substituting the values in the above,

$$100 = (1 \times 800) / 2t \quad \quad \quad \mathbf{t = 4 \text{ mm}}$$

PAPER SA4

FABRICATION AND APPLICATIONS

ENGINEERING

QUESTION 1

(Ref: 4.1, 4.2)

- 1.1 List the three stages in the development of welding procedures. **5 marks**
- The proposed welding procedure
 - The procedure qualification record-PQR
 - The welding procedure specification- WPS
- 1.2 List five common essential variables for the MMAW process with reference to AS/NZS 1554 Part 1. **5 marks**
- A change in specified mean arc voltage
 - A change in specified mean welding current
 - A change in position in which the welding is done or change in welding direction
 - A change from single pass to multipass
 - A change in minimum specified preheat or inter-run temperature
- 1.3 List the five methods of qualifying welding procedures available in AS/NZS 1554 Part1. **10 marks**
- A pre-qualified procedure
 - Production of documentary evidence of relevant prior experience by the fabricator
 - Production of a suitable length of test piece of the same joint type, material type, material thickness and edge preparation, material type and direction of rolling
 - Preparation of a special test piece
 - Destructive testing of a prototype joint
 - A welding procedure qualified by another fabricator

QUESTION 2

(Ref: 4.1, 4.2)

- 2.1 List three reasons for having an “Inspection and Test Plan (ITP)”. **5 marks**

For smooth production and effective quality control it is necessary to plan for inspection and testing. The ITP integrates inspection activity and customer’s involvement with the production phases. All actions should have a procedure or instruction which will be referenced or indicated on the plan. In general, work should not proceed to the next stage until it has been inspected. Route cards are used to assist further the planning and recording of work. The plan can also specify the extent of NDT of weld and who is to perform the inspection

2.2 List ten components or elements of a typical ITP. **5 marks**

Material (at source of supply)	Material testing
Material (receipt)	Material cutting
Component – mark out	Component – flame cutting
Fitup components	Weld procedures
Welder qualification	Welding
Pressure testing	Prior to painting
Grit blasting	Painting
Assembly	Packing & Dispatch
Documentation	

2.3 What is the intended action for the manufacturer's inspector when the following test points are specified in the ITP?

a) H **5 marks**

Fabrication is not to proceed until manufacturer's inspector has verified the performance and results of the inspection and test.

b) W **5 marks**

Fabrication is not to proceed until the manufacturer's inspector has verified the performance and results of the inspection and test. The inspector may delegate this authority to a suitable trained person whose training has been approved and recorded by the manufacturer.

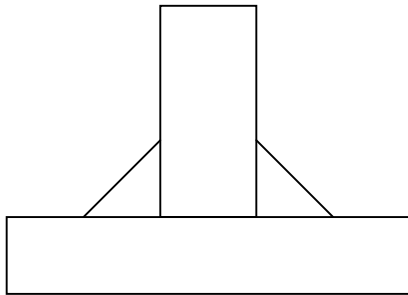
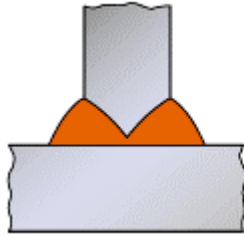
QUESTION 3 (REF: 4.1, 4.2)

3.1 Give three reasons for lamellar tearing to occur. **6 marks**

1. Transverse strain - the shrinkage strains on welding must act in the short direction of the plate i.e. through the plate thickness
2. Weld orientation - the fusion boundary will be roughly parallel to the plane of the inclusions
3. Material susceptibility - the plate must have poor ductility in the through-thickness direction

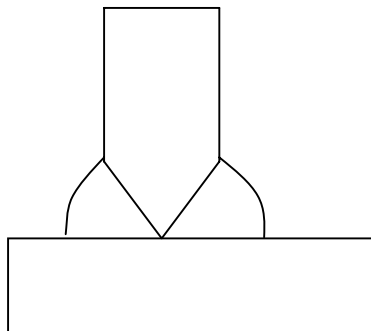
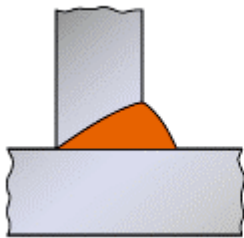
3.2 For the welded joints given below, recommend an alternative joint configuration to reduce the risk of lamellar tearing **6 marks**

a)



As tearing is more likely to occur in full penetration T butt joints, if possible, use two fillet welds

b)



Double-sided welds are less susceptible than large single-sided welds and balanced welding to reduce the stresses will further reduce the risk of tearing especially in the root

3.3 Give two possible causes for each of the welding imperfections and one method of preventing each cause.

i) Excessive weld metal

4 marks

Excessive weld metal which is usually a result of poor welder technique for manual processes but may be due to poor parameter selection when the process is mechanised. That is, too much filler metal for the travel speed used.

If the imperfection is a result of welder technique then welder retraining is required. For mechanised techniques an increase in travel speed or voltage will help to reduce cap height.

ii) Undercut

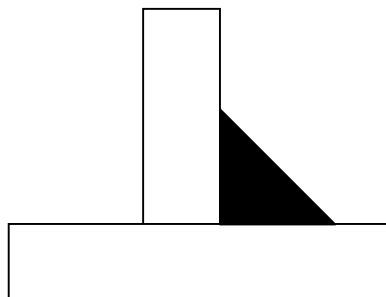
4 marks

A wide spreading arc (high arc voltage) with insufficient fill (low current or high travel speed) is the usual cause. However, welder technique, especially when weaving, and the way the welding torch is angled can both cause and be used to overcome undercutting (ie angled to push the weld metal to fill the melted groove). High welding current will also cause undercut - this is generally associated with the need for a high travel speed to avoid overfilling of the joint.

This imperfection may be avoided by reducing travel speed and/or the welding current and by maintaining the correct arc length.

QUESTION 4 (REF: 4.8)

3.1 Calculate the **labour cost** and the **filler material cost** for a welding job given the following data, as below. **20 marks**



DATA

- Weld Joint type: T joint
- Single pass
- Type of weld: Fillet (mitre)
- Weld leg length: 6 mm

- Total weld length: 1000 mm
- Material: Carbon steel
- Welding Process: GMAW
- Wire diameter = 0.9 mm
- Deposition Efficiency = 95%
- Deposition Rate = 3.6 kg/hr
- Density of steel = $7.85 \times 10^3 \text{ kg/m}^3$
- Cost of filler material = \$5/kg
- Hourly labour rate (including overhead) = \$25
- Operator Factor = 60%

Area of cross section of electrode = $\frac{1}{2} \times \text{base} \times \text{height} = \frac{1}{2} \times 0.6 \times 0.6 = \mathbf{0.18 \text{ cm}^2}$

Volume of weld metal = area of cross section x length = $0.18 \times 100 = \mathbf{18 \text{ cm}^3}$

Weight of weld metal = Density x volume = $7.85 \times 18 / 1000 = \mathbf{0.1413 \text{ kg}}$

Actual weld metal used = weight/ deposition efficiency = $0.1413/0.95 = \mathbf{0.1487 \text{ kg}}$

Filler metal cost = Actual weld metal used x cost of filler material
 $= 0.1487 \times 5 = \mathbf{\$ 0.7435}$

Arc on time = Weld metal deposited/ Deposition rate = $0.1487/3.6 \times 60 = \mathbf{2.47 \text{ mins}}$

Labour hours = Arc on time / Operator factor = $2.47/0.6 = \mathbf{4.13 \text{ mins}}$

Labour cost = Labour hours x Labour rate = $4.13/60 \times 25 = \mathbf{\$1.72}$

QUESTION 5 (REF: 4.7, 4.9)

5.1 State two limitations of the ultrasonic inspection method **4 marks**

- Permanent record is difficult to obtain
- Requires high level of skill in interpreting indications

5.2 How is the penetrameter used to determine the sensitivity of the radiograph? **4 marks**

In order to determine the sensitivity of a radiograph, a penetrameter or image quality indicator is used. IQI are used as a means of assessing the image quality of the radiograph.

For a wire laid across a weld, the diameter of the smallest wire that is visible to the eye under the correct lighting conditions is established. To then calculate the IQI sensitivity of the radiograph, tables can be used as given in the National Standard or the diameter of the wire is divided by the weld thickness and then multiplied by 100 to give the sensitivity percentage

5.3 List the general steps involved in the repairs of cast iron components for large areas **12 marks**

- For larger areas, MMAW or powder technique can be used for buttering the edges of the joint followed by MMAW or GMAW/FCAW welding to fill the groove.

- Remove defective area preferably by grinding or tungsten carbide burr. If air arc or MMA gouging is used, the component must be preheated locally to typically 300 degrees C.
- After gouging, the prepared area should be lightly ground to remove any hardened material.
- Preheat the casting to the required temperature
- Butter the surface of the groove with MMAW using a small diameter (2.4mm or 3mm) electrode; use a nickel or Monel rod to produce a soft, ductile 'battered' layer; alternatively use oxy-acetylene with a powder consumable.
- Remove slag and peen each weld bead whilst still hot.
- Fill the groove using nickel (3 or 4mm diameter) or nickel-iron electrodes for greater strength.
- Finally, to avoid cracking through residual stresses, the weld area should be covered to ensure the casting will cool slowly to room temperature