TTE TRAINING LIMITED

Phase 1 Fabrication

Carousel 1

HEALTH, SAFETY AND WELFARE IN WELDING

HEALTH, SAFETY AND WELFARE IN WELDING

ARC WELDING – SAFETY PRECAUTIONS

The risk attached to electric arc welding processes must be recognised and suitable precautions taken.

These risks may be broadly classified under the following headings:

1. Electric shock
2. Radiation from the arc
3. Burns
4. Chipping from slag
5. Fumes

1. ELECTRIC SHOCK

Arc welding may be carried out with either direct or alternating current. The circuit or striking voltages employed are:

Direct Current (DC)	60 – 80 Volts
Alternating Current (AC)	80 – 100 Volts

The effect of an electric shock from an AC system is likely to be more sever than a DC system due to:

a) Higher open circuit voltages used.

b) The peak voltage, which will be 1.41 times the open circuit voltages (i.e. for 100 circuit the peak is 141 volts).

c) Difficulty in releasing the grasps when under the influence of shock from an AC system.

Certain working conditions will also increase the risk of electric shock, i.e. cramped spaces such as boilers and small tanks which may be warm and damp also where it is necessary to stand on the work, added the risk of a serious fall from a precarious position should a shock occur. Under these conditions DC should be used where possible.

Where the use of AC is unavoidable under such conditions, the lowest practicable open circuit voltage which will be effective should be chosen. For particular dangerous situations low voltage safety devises are available which automatically

reduce the open circuit voltage to approximately 10 volts but restore full voltage when the electrode contacts the work.

The Welding Circuit

These are three important connections in the welding circuit, these are:

The welding lead, or connection between the electrode holder and the set.

The welding return.

The welding earth.

The welding lead should be of flexible cable and ample size to carry the welding current without overheating and properly insulated to prevent short circuit losses and risk of shock. Wear of the insulation is particularly prone to occur near the electrode holder due to the constant flexing of the cable. This cable should be properly looked after, both in and out of use, and not allowed to trail anywhere it may be walked upon or damaged in any way.

The welding return should be of at least equal size to the welding lead, and should be clamped or bolted to some clean part of the work. The use of bare metal bars in place of insulated cable must never be used as alternative paths for the current may be formed by change contact with other metalwork, thereby increasing the risk of electric shock.

The welding earth connection is necessary on all circuits to keep the work, and any metal that may make contact with it, at earth potential.

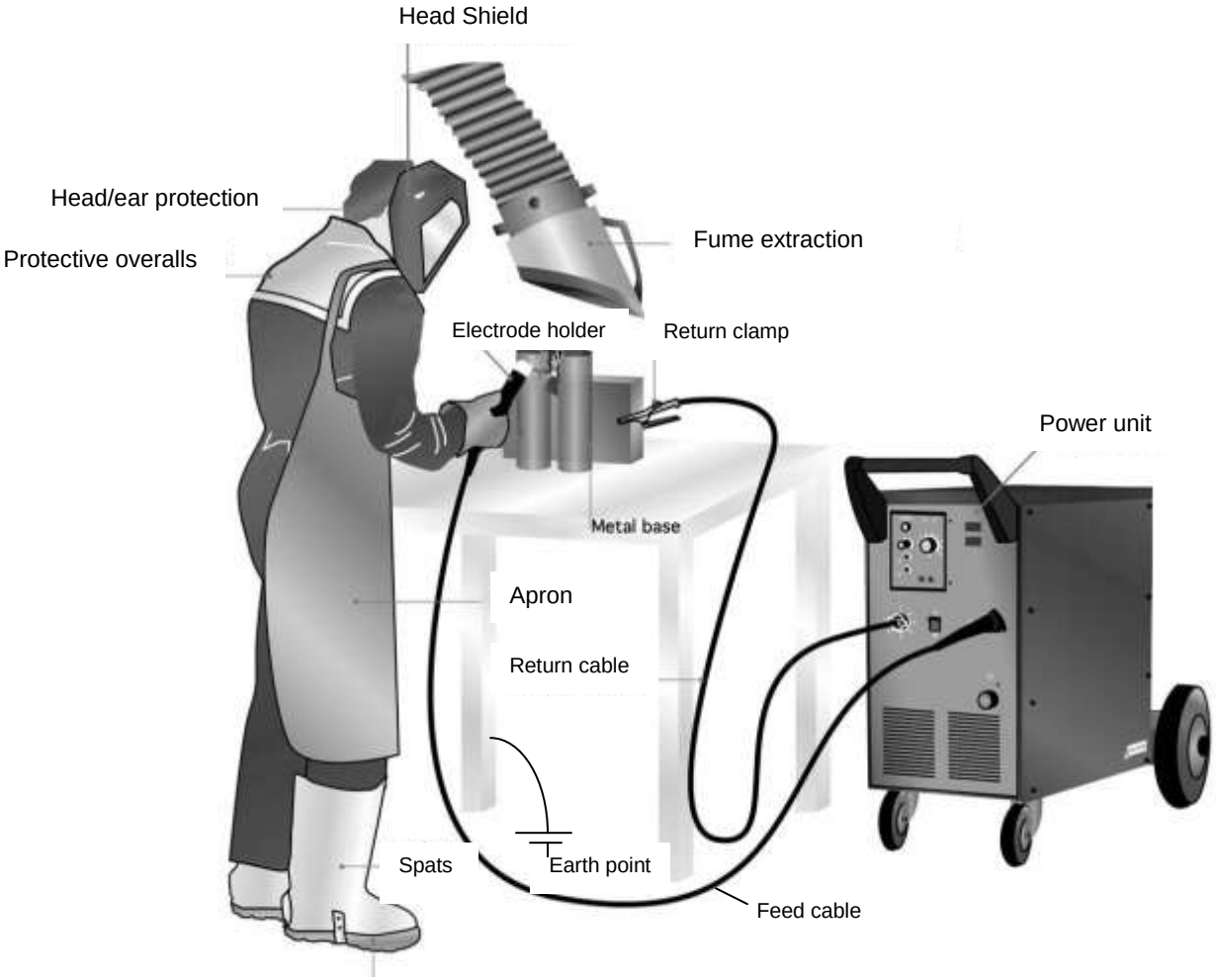
The inadequate provision of either welding earth or return leads may cause the current to be carried through the earthing core of multicore cables attached to portable tools with consequent damage to the cable and making the tool itself dangerous to use. Pipes conveying gas or flammable liquids should never be used as welding return or earth leads.

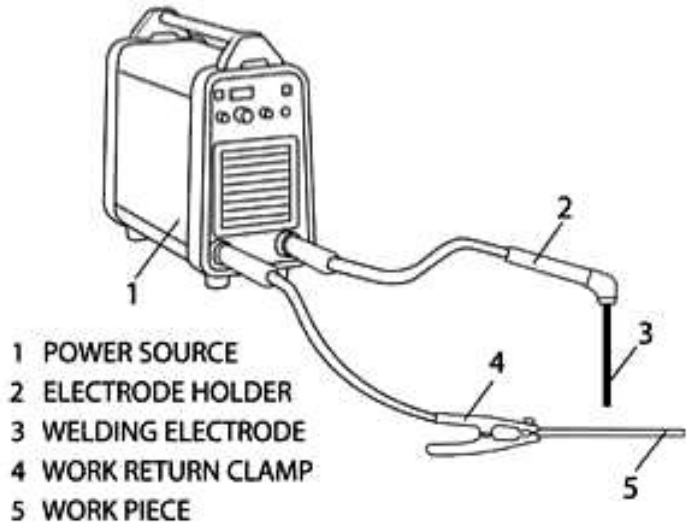
Electrode Holders

These must be capable of holding firmly electrodes of all sizes to be required. There should be no metal parts or exposed screws on the hand portion of the holder, which should be insulated by some tough, non-ignitable material.

Welding gauntlets should not be relied upon to provide protection from some electric shock as any insulating value of new dry gloves is completely lost when these become work or damp with perspiration.

THE WELDER AND EQUIPMENT





2. RADIATIONS FROM THE ARC

Ultra-violet and heat rays from the electric arc if not properly screened may produce the following conditions:-

Skin Effects

A condition similar to over-exposure to the sun which may be painful and severe cases result in blisters.

Precautions

Ensure that no part of the skin is exposed to the direct rays of the arc.

Eye effects

An extremely painful condition of the eye known as ‘arc eye’ or ‘arc flash’ may be caused by looking at an unscreened arc even from a distance of some yards and a few seconds only.

Symptoms

Watering of the eyes, sensitivity or intolerance to light, stinging ‘like sand in the eyes’, intense pain, headache and occasionally temporary loss of vision. The symptoms occur four to eight hours after exposure and recovery is generally complete 24 to 48 hours with no permanent ill effects.

Treatment

At the onset of symptoms protect the eyes from light. To obtain relief, cover the eyes with a cloth frequently, wrung out in cold water and continue the application for several hours.

Precautions

Protect the face and eyes with a suitable hand shield or adjustable head shield. This should be of a lightweight, tough, non-ignitable material which insulates against heat and electricity and is impervious to the rays of the arc, to comply with the recommendation of BS 1542. ‘Equipment for Eye, Face and Neck Protection against Radiation arising during welding and similar Operations’.

The filter glass for viewing the arc should be of the appropriate grade for the current employed as recommended in BS 679.
'Filters for use during welding and similar industrial operations'.

Filter recommended for Metal-Arc Welding in BS 679.

Welding Booth

Where several welding booths are situated in an enclosed workshop, fume concentration will arise which, although non-toxic, can produce a serious irritation to the nose and throat. Fixed systems are generally used with a down-coming duct from a common main entering each booth. Where the duct is adjustable, the welder should ensure that the hood is suitably positioned according to the work to be done.

Galvanised Metal

The fumes from galvanised metal, when welding, contain zinc oxide which, if inhaled, may cause a feeling of chill with shivering and sweating. These symptoms which are generally acute, come on a few hours after inhalation and pass of completely within 24 hours. Galvanised metals should, if possible, be welded out of doors, or a good extractor system employed. In particularly poor circumstances of where the foregoing precautions cannot be applied, it may be necessary for the welder to wear a respirator.

Inert Gas Shield Processes

Where heavier than air gases are used as the gas shielded processes, overhead ventilation or extraction systems may be ineffective and arrangements for extraction at a lower level has to be considered. Inert gases are not poisonous but if they displace the air, death from oxygen deficiency can occur.

For further information concerning oxygen deficiency, refer to Division Safety, Information note no. 3, 'The Hazards of Inert Gases and Oxygen Deficiency'.

Electrodes

The need for good ventilation increases when coating fluorides (e.g. low hydrogen rods), or when welding materials such as copper or stainless steels.

General Fume Safety

1. Unless welding outdoors or in a good general ventilation, use a fume extractor.

2. Reposition fume extractor frequently to ensure fume capture.

3. In confined spaces, consider the use of air fed breathing equipment.

In addition to individual safeguards for the welder, adequate screening should always be provided around the welding position for the protection of other persons in the vicinity.

3. **Burns**

Burns may be caused as a result of sparks or hot particles thrown off from the arc whilst welding, these either contacting the unprotected flesh or becoming trapped in the clothing and cause it to ignite.

The need for protective clothing depends upon the position of the arc relative to the welder's body. A hand shield or helmet and leather gauntlets may be sufficient for bench work, but for positional work, although the welder quickly learns to place himself, where possible, to avoid the main shower of sparks, further protective clothing, i.e. leather apron, jacket, leggings and skull cap may be required according to the particular circumstances.

Facial precautions must be taken against fire risks if welding is being carried out where any flammable substances or gases are present.

4. **CHIPPING OF SLAG**

Effective screens or suitable goggles with clear lenses should be provided to protect the eyes from flying particles when chipping slags from a weld. Serious injury may result if the eyes are not protected during this operation especially if the slag is hot.

5. **FUMES**

Fumes produced by the welding of mild steel are not generally injurious to health and where work is undertaken out of doors, no special measures are required.

Adequate ventilation must always be provided in enclosed buildings. Mechanical fume extraction may be necessary especially when considering the following:

Confined spaces, i.e. working in boilers or tanks

Welding booths

Galvanised metals

Electrode coatings containing fluorides and filler metals other than mild inert gas shielded processes.

Confined spaces

When working in enclosed vessels the welder may be rapidly deprived of oxygen by the build up of fumes. The extractor used is generally of the portable type with flexible trunking. It is essential that the suction hood be placed near the stem being welded to ensure that fumes are extracted at source and not allowed to concentrate before being removed.

Electric Arc Welding

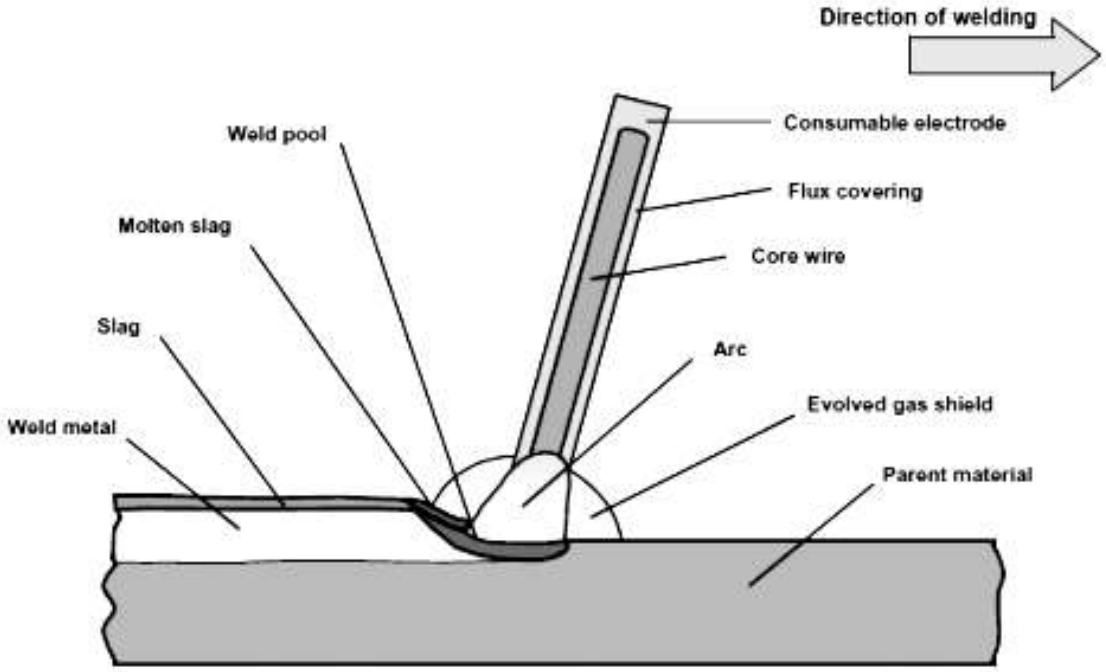
In electric arc welding, the process involves the heating of special electrodes bypassing an electric current through the electrode which heats up the end causing it to become molten, together with a small area of metal being welded. The molten metal from the electrode detaches itself in the form of a globule and falls onto the molten weld pool which is formed on the metal being welded. On cooling, the molten metal solidifies to form a 'weld'.

An important aspect of all welding processes where the metal is heated into a molten state is that the molten metal must always be protected from the atmosphere gasses which surround it. In the case of electric arc welding, this is done by using flux coated electrodes which give off a gas shield completely surrounds the area being welded. On cooling, some of the gas solidifies to form a slag which covers the weld and serves in many ways to produce a sound weld.

The coating generally melts at a slightly higher temperature than the core wire, and therefore extends a little beyond the core wire. This had the effect of directing the arc.

The gas formed by the coating usually emits electrons sufficient to re-ignite and maintain the AC arc when it is extinguished due to the zero point of amperage. It also helps to reduce heat loss and rapid cooling. On cooling the gas solidifies on the weld as slag which protects the welded seam against contamination.

When laying down multi-run welds, it cannot be over-emphasised the importance of completely removing all slag before starting the next layer.



Points to look for when inspecting electrodes are swelling of the coating during welding, white deposit on coating, rusting of core metal, breaking of the coating during welding excessive spatter.

When welding low alloy, high tensile steel or work subjected to high stresses, low hydrogen electrodes are used to ensure that the moisture level is kept to a minimum; the electrodes are baked in a special designed drying cabinet for a period of time before being used.

The effect of moisture in the electrode coating would result in a weld having holes (porosity) of cracking in the parent metal close to the weld.

All electrodes are coded BS 639.

The size of electrode to use on a particular job may be determined by a number of factors:

a) The thickness of metal being welded.

b) The type of metal.

c) The position in which the joint is made (i.e. downhand, vertical, overhead).

d) The type and size of weld required.

e) Accessibility of electrode into weld preparation.

As a general rule, the largest gauge of electrode should be used where the above points allow.

Some coatings may contain elements of alloys which are added to the welded stem during the welding process to improve the mechanical properties of the weld metal.

Welding Electrodes

The electrode provides filler metal for the weld and conducts electric current to the job. The passage of current between the electrode and the workplace in an arc, hot enough to melt to electrode and the surface of the workpiece.

Functions of the Flux coating

To act as flux and remove impurities from the surface being welded.

To form a slag over the weld, which protects the molten metal from atmospheric contamination.

Forms a gas shield around the arc which protects the molten metal from oxygen and nitrogen in the surrounding atmosphere.

Slows down the cooling rate of the weld helping to prevent brittleness.

Provides a smoother surface to the finish of the weld.

Helps to stabilise the arc, which allows an AC current to be used.

It can be used to add certain constituents to the weld which are lost in the welding process and ensure that the deposit has good chemical, physical and mechanical strength.

It provides good welding characteristics.

SIZES OF ELECTRODES (DIAMETER OF CORE WIRE)

1.5 mm	60 amps (approx)
2.0 mm	75 amps (approx)
2.5 mm	90 amps (approx)
3.25 mm	120 amps (approx)
4.0 mm	170 amps (approx)

Storage of electrodes

To avoid damage to electrodes, they should be stored in a well ventilated room in dry conditions to prevent moisture absorption.
Care must always be taken when handling electrodes to prevent damage to the flux coating as this would result in an unsound weld.

Power source

The electrical energy can be produced for welding in two forms:

1) As a Direct Current 2) As an Alternating Current

DIRECT CURRENT (DC)

With this system the current is produced by an independent generator which has its own drive unit. The drive unit may be a petrol or a diesel engine, thus making the welding unit completely portable, or the drive may be an electric motor which will require a mains supply.

With DC the polarities remain constant, one side being positive and the other negative. The positive pole will carry 2/3 of the total heat, therefore considerations must be as to where the most heat is required, at the electrode or the work, and then the welding lead and return lead can be connected to the generator accordingly. This effect can be advantageous for certain welding operations.

The constant polarity of DC provides a stable arc.
A disadvantage of DC is that a magnetic force field is set up during welding, a characteristic known as ‘Arc blow’. This can have a slight effect on the weld and if required there are certain remedies that can relieve this problem.

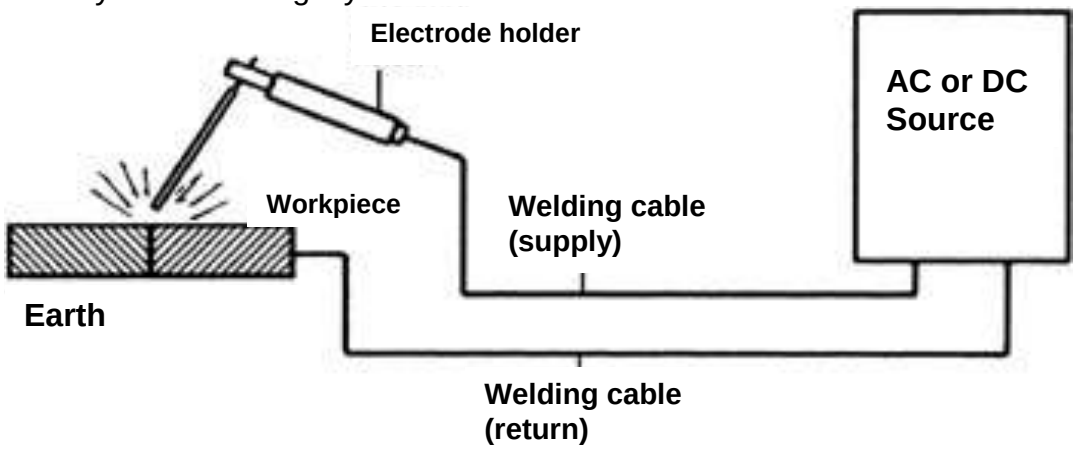
1. Reverse direction of travel to welding.
2. Remove return lead to another location (opposite end).
3. Coil the return lead around the work to counteract the magnetic force field.

DC generators involve more equipment than AC arrangements and as such are more costly. Also due to the number of moving parts involved, regular maintenance will be required.

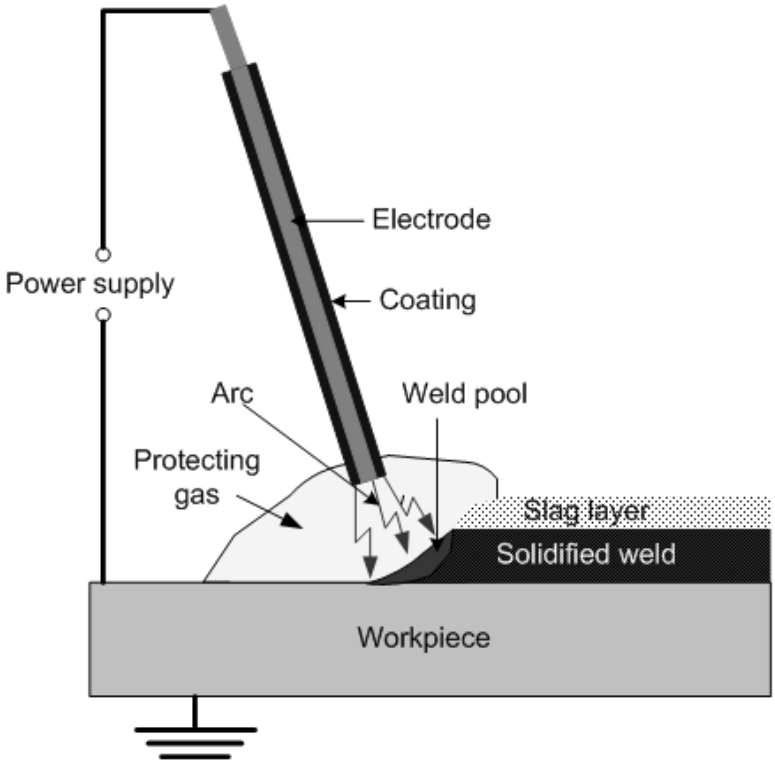
ALTERNATING CURRENT (AC)

For this system current is fed from a mains supply to a welding Transformer. A welding lead and a return lead are taken from the transformer to the work.

The alternating nature of the current means that the polarity of each lead is constantly changing, several times each second, and as such the effect of the positive pole carrying twice as much heat as the negative is totally lost and both the electrode and the work are heated evenly. The alternating nature can affect the stability of the arc slightly.



The MMA welding process diagram



SAFETY CHECKLIST

Electric arc welding calls for extreme measures of safety. The light rays given off from the arc are very harmful to eyes and skin. Hot slag can burn deeply. Loose clothing can catch sparks or hot slag leading to burns or fires. Faulty equipment can lead to electric shock.

The following safety precautions must be closely adhered to:-

1. Safety glasses must always be work when in an area where welding operations are being carried out.

2. Full welding shields must be used when welding.

3. All welding must be safely screened off and welding bays must be non-reflective colours inside, i.e. matt black.

4. All skin must be covered and the correct clothing worn, i.e. leather gauntlets, aprons, spats, hats, overalls to be completely fastened and sleeves rolled down.

5. All welding arrangements must be fully earthed.

6. Always keep equipment in good condition.

7. Keep all cables safe. Avoid causing tripping hazards or leaving them where they can be run over by traffic.

8. Use adequate ventilation and fume extraction systems.

9. Keep all flammable material clear.

10. Always consider fellow worker when welding. Make sure that they have the correct safety equipment.

11. Warn others when welding is to commence

12. Isolate welding sets when not in use.

13. Ensure electrodes are removed from holders when not in use.

14. Keep all equipment tidily in its proper place.

15. Report faulty equipment and prevent usage whilst faulty.

The fundamentals for good welding which must be achieved by the newcomer are:

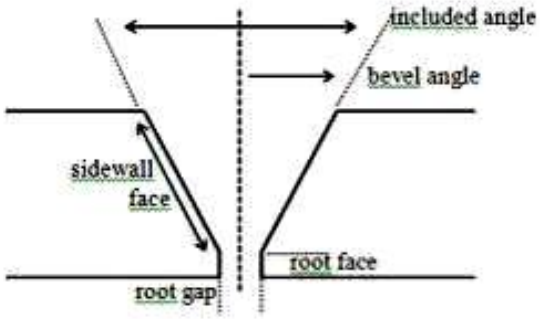
1. To be comfortable while welding.
2. To strike the arc as and when required.
3. To maintain the arc at its correct length.
4. To readily distinguish between molten metal and slag.
5. To ensure work is clean and correctly prepared.
6. To ensure that the equipment is in good condition.
7. To avoid rushing or cutting corners
8. To ask if in doubt
9. To maintain a safe and tidy work environment

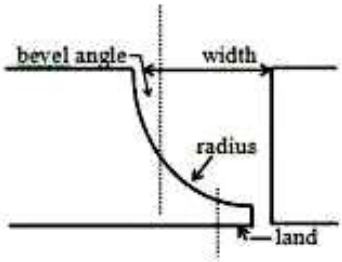
Welding Terminology

The following are the meanings of some of the terms used in welding:

Angle of Bevel

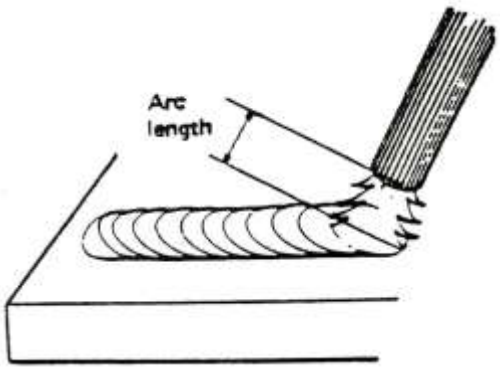
The angle of an edge or end which is cut or chamfered.





Arc length

The distance between the end of an electrode and the surface of the weld pool.



Fusion Face

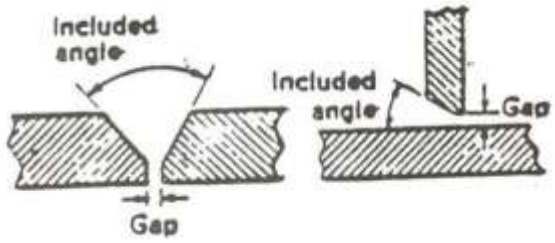
The surfaces or edges of the parent metal
to be fused by welding.

Fusion Zone

The place where the deposited metal Fuses with the work-pieces.

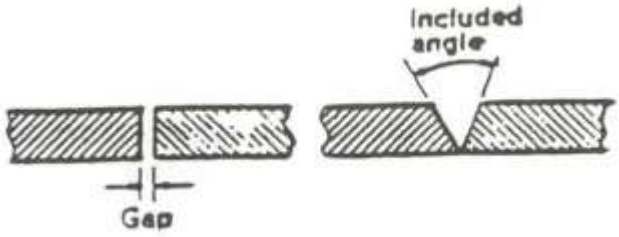
Gap

The distance between the parts to be joined.



Included Angle

The total angle between the Fusion faces of the parts in Position ready for welding.

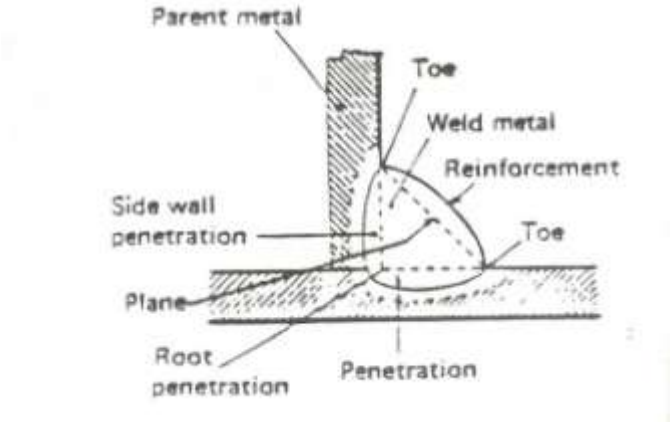


Parent Metal (or workpieces)

The materials and or the parts to be welded.

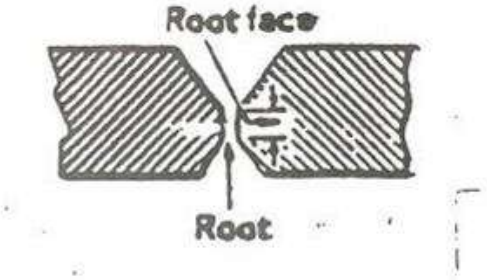
Penetration

The depth the molten metal from the electrode penetrates the parent metal.



Reinforcement (excess weld metal)

Weld metal lying outside the plane joining the toes.

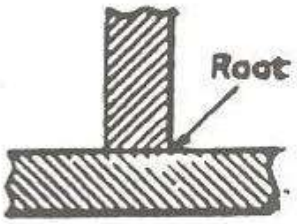


Root

The position in a prepared butt Joint where the parts to be Joined are nearest together.

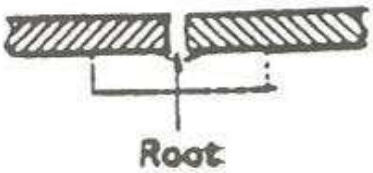
Or

The corner of the angle formed by the two fusion faces of a fillet joint.



Toe of Weld

The top and bottom position where the weld face joins the parent metal.

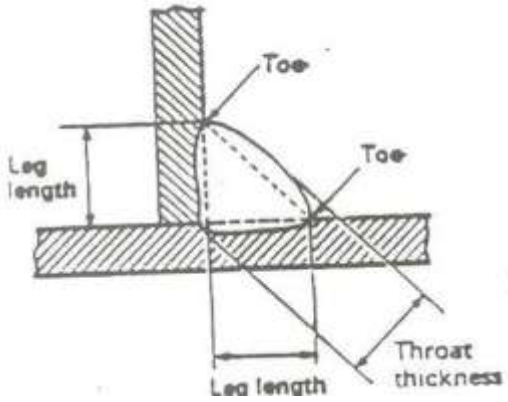


Leg Length

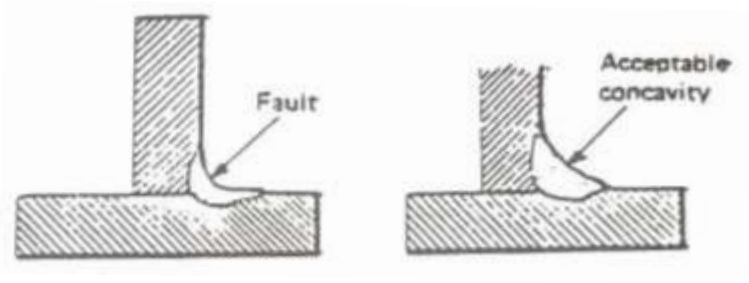
The distance from the root to the toe of the weld.

Throat Thickness

The shortest distance from the Root of the weld to the weld Face in a fillet weld.

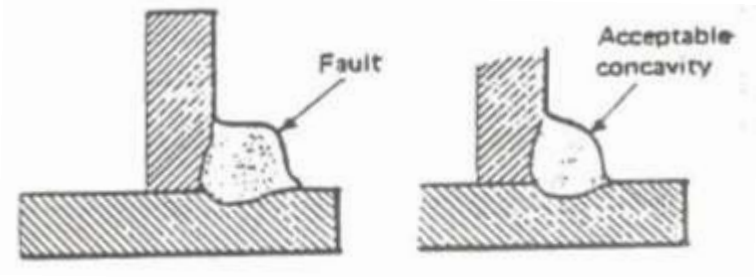


Concave Weld – the weld run has a too shallow throat.



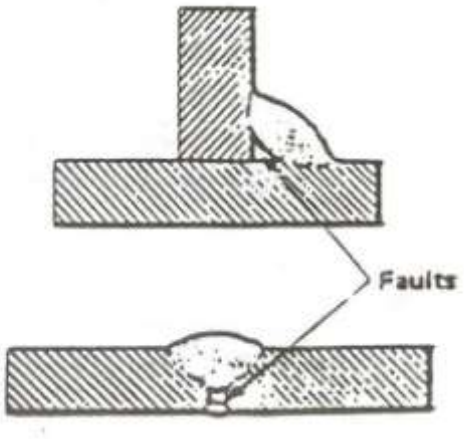
Cause	Remedy
Speed of travel too fast.	Reduce speed of travel to achieve acceptable weld shape.

Convex Weld – the weld run is excessively thick at the throat of the weld.



Cause	Remedy
Wrong size of electrode.	Ensure that the specified electrode is used.
Welding current too low.	Set welding current higher, within limit specified in the weld procedure.

Lack of Penetration – a gap is formed at the root of the weld (not always visible but apparent on test).

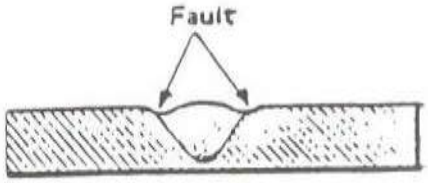


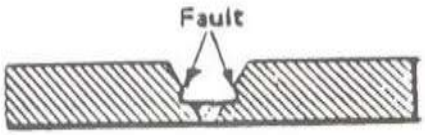
Cause	Remedy
Welding current is too low.	Set the welding current as specified in the weld procedure.
Wrong electrode angle and manipulation.	Ensure that the angle and manipulation of electrode is correct for the type of joint and welding position.
Speed of travel too fast.	Reduce speed of travel to achieve correct penetration.
Inadequate back-chipping or gouging of initial run before depositing sealing run.	Ensure that clean metal is exposed after back-chipping or gouging.

Excess Penetration – the weld Metal protrudes through the Root of a joint.

Cause	Remedy
Welding current too high causing excessive heat build up.	Set the welding current as specified in the weld procedure.
Wrong electrode angle and manipulation.	Ensure that the angle and manipulation of electrode is correct for the type of joint and welding position.
Speed of travel too fast.	Reduce speed of travel to achieve correct penetration.
Inadequate back-chipping or gouging of initial run before depositing sealing run.	Ensure that clean metal is exposed after back-chipping or gouging.

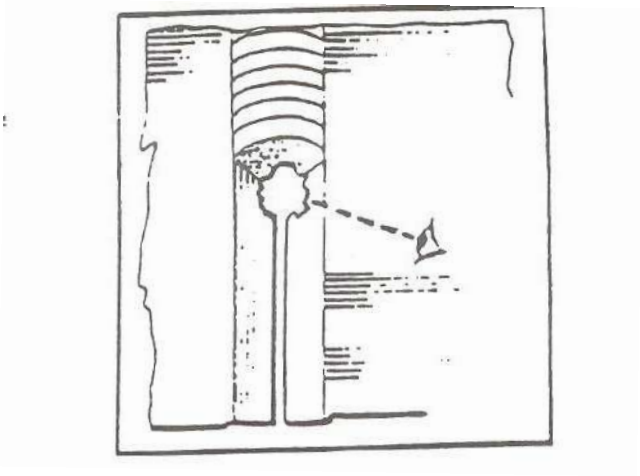
Undercut or 'groove-out' in the surface fusion face of the parent metal at the toe of the run.





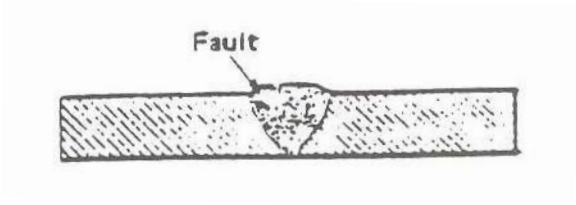
Cause	Remedy
Mill scale on or near the fusion face.	Ensure that the parent metal is clean.
Welding current too high.	Set the welding current as specified in the weld procedure.
Wrong electrode angle and manipulation.	Ensure that angle and manipulation of electrode are correct for the type of joint and welding position.

Burn through in a butt joint
- part of the weld pool on parent metal preparation has collapsed and an excessive hole is formed.



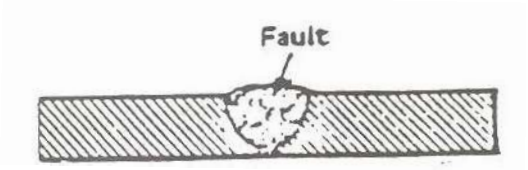
Cause	Remedy
Welding current too high	Set the welding current as specified in the weld procedure.
Slow speed of travel causing excessive heat build up	Increase speed of travel to reduce heat build up.
Unsuitable edge preparation	Inform the supervisor.

Blow Hole or large cavity in the weld (not always visible but apparent on test).



Cause	Remedy
Moisture or contamination on parent metal or electrode	Check that the parent metal is clean and dry.
	Ensure electrodes are dry and coating is not damaged.

Porosity or small holes in the Weld (apparent only on test).

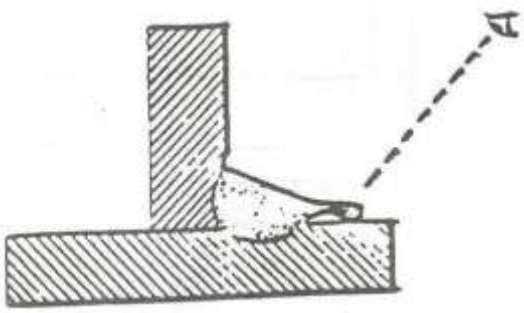


Cause	Remedy
Damp parent metal.	Ensure that the parent metal is clean and dry.
Damp or damaged electrode.	Ensure electrodes are dry and coating is not broken.
Wrong starting technique.	Use correct technique. Care to be taken when starting and re-starting weld runs.
Arc length too long.	Shorten arc length to establish even metal transfer.

TRAINING NOTES

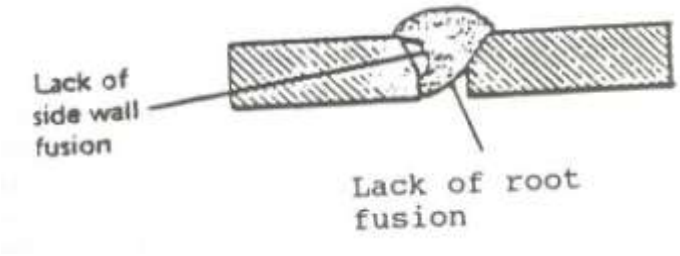
Faults in welds

Overlap – metal has flowed on to the surface of the parent metal without fusing it.



Cause	Remedy
Unclean parent metal.	Ensure that the parent metal is clean and dry.
Inadequate heat at toes of the weld.	Set the welding current as specified in the weld procedure.
Wrong electrode angle and manipulation.	Ensure that the angle and manipulation of electrode is correct for the type of joint and welding position.
Wrong welding techniques.	Ensure that the welding methods specified in the weld procedure are adhered to.

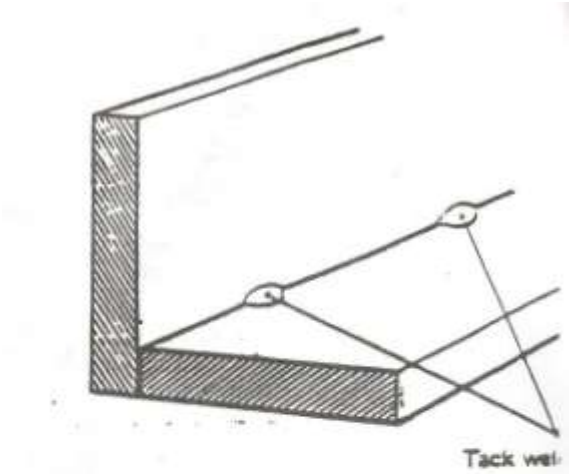
Lack of Fusion – the edges of the work have not melted (not always visible but apparent on test).



Name	Cause	Remedy
Lack of Root Fusion	Wrong size of electrode.	Use the specified size of electrode.
	Welding current too low.	Set welding current higher, within limits given in the weld procedure.
	Wrong electrode angle and manipulation.	Ensure that the angle and manipulation of electrode is correct for the type of joint and welding positions.
Lack of Side Fusion	Incorrect placing of runs in multi-run welds	Follow the correct arrangement of successive runs in multi-run welds to achieve smooth fusion.
	Wrong preparation and set up joint.	Inform the Supervisor.

Tack Weld

A short weld used to help assembly by holding workpieces in position during welding.

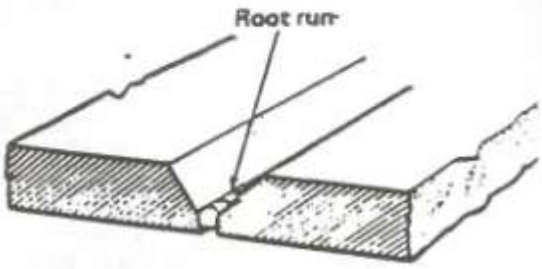


Run or Pass

The molten metal deposited during the passage of the electrode.

Root Run

The first run deposited in the root of a joint where there is to be more than one run.

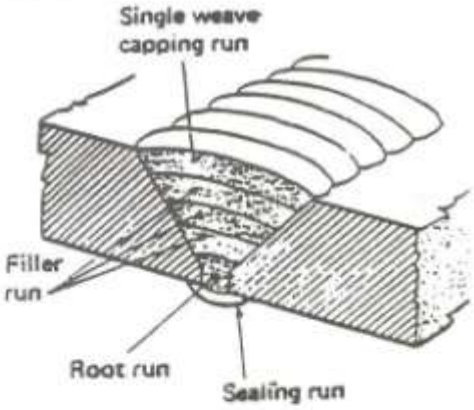


Filler Runs or Passes

The build up run(s) between root and capping run (s).

Capping or Final Runs

The weld runs which make up the top layer of the joint.

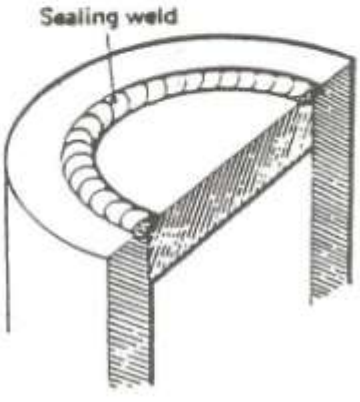


Sealing Run

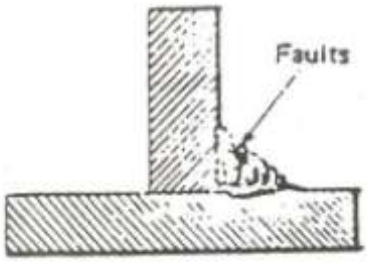
A weld deposited on the root side of a butt or corner joint, after completion of the main weld.

Sealing Weld

A weld used to make a fluid-tight joint.

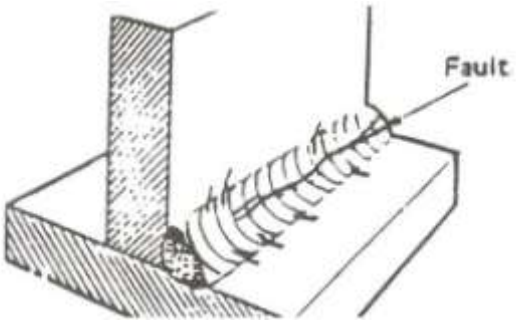


Contamination by slag or other matter trapped in the weld (not always visible but apparent on test).

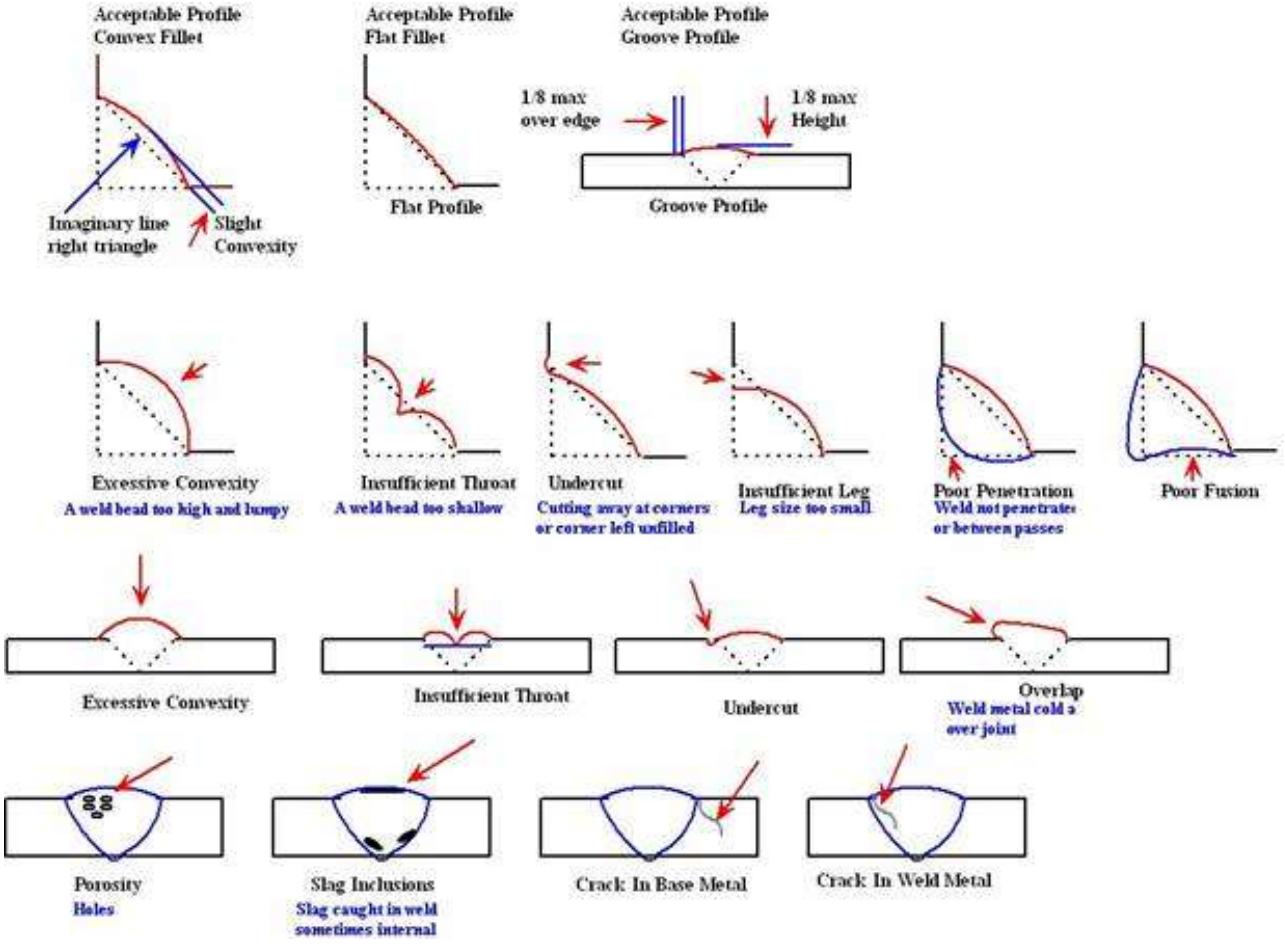


Cause	Remedy
Unclean parent metal.	Ensure that the parent metal is clean and dry.
Slag not cleaned from preceding runs.	Clean preceding runs thoroughly.
Welding current too low.	Set the welding current as specified in the weld procedure.
Wrong electrode angle and/or manipulation.	Ensure that the angle and manipulation of electrode is correct for the type of joint and welding position.
Incorrect placing of runs in multi-run welds.	Ensure correct arrangement of successive runs in multi-run welds to achieve smooth fusion.

Cracking at the toe or through weld (not always visible but apparent on test).



Cause	Remedy
Wrong electrode.	Ensure that the specified electrode is used.
Wrong welding technique.	Ensure that the correct welding technique and procedures specified in the weld procedure are adhered to.
Wrong preparation and set up of joint.	Inform the supervisor.


Acceptable Profile
Convex Fillet
Imaginary line
right triangle
Slight
Convexity
Acceptable Profile
Flat Fillet
Flat Profile
Acceptable Profile
Groove Profile
1/8 max
over edge
1/8 max
Height
Groove Profile
Excessive Convexity
A weld head too high and lumpy
Insufficient Throat
A weld head too shallow
Undercut
Cutting away at corners
or corner left unfilled
Insufficient Leg
Leg size too small
Poor Penetration
Weld not penetrate
or between passes
Poor Fusion
Excessive Convexity
Insufficient Throat
Undercut
Overlap
Weld metal cold o
over joint
Porosity
Holes
Slag Inclusions
Slag caught in weld
sometimes internal
Crack In Base Metal
Crack In Weld Metal