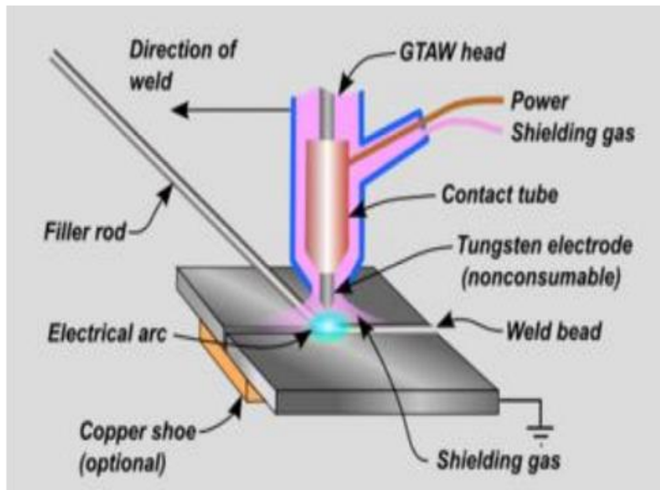
WELDING

Level-II

Based on March 2022, Curriculum Version 1



Module Title: - Performing Fillet Tungsten Inert Gas (TIG) Welding

Module code: IND WLD2 M04 0822

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Prepared By: Ministry Of Labour and Skill

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Addis Ababa, Ethiopia

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Ministry of Labor and Skills

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Acknowledgment

Ministry of Labor and Skills wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

Acronym

TIG	Tungsten Inert Gas
GTAW	Gas Tungsten Arc Welding
AC	Alternative Current
DC	Direct Current
DCEN	Direct current electrode negative
DCEP	Direct current electrode Positive
Ar	Argon Gas
He	Hilum Gas
N	Nitrogen Gas
AWS-	American Welding Society

INTRODUCTION TO THE MODULE

Gas tungsten arc welding (GTAW), also known as tungsten inert gas (TIG) welding, is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by a shielding gas (usually an inert gas such as argon), and a filler metal is normally used. The gas tungsten arc welding (GTAW) process is well established as a high quality fusion welding technique. Developments in the process have extended the potential application range and offer improved process control. The TIG welding process is in many cases the only practical solution to several necessary repair jobs on board. The most frequently used applications are welding of aluminum-brass (Yorcalbro), Conifers, and stainless, heat resistant or acid resistant steels, but the process may be used with good results on all wieldable materials. Among the unique advantages of using the argon gas protected TIG arc as heat source for welding are an easy-to-learn method which may be used in all positions. A stable, intense and well directed heat supply which ensures deep penetration and small heat affected zones. Clean, smooth welds of high quality, with little need for finishing (no slag)

This Module Covers The Units:

- Equipment and Materials
- Welding Machine and Accessories,
- Pre Heating Tools/ Equipment
- Tack Welding,
- Weld to job specification and
- Quality Weld Conformance
- Learning Objective of the Module
- Preparing equipment and materials
- Set-up welding machine and accessories
- Set-up pre heating tools/ equipment
- Perform tack welding
- Weld to job specification using TIG
- Assure quality weld conformance

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

- Read the information written in each unit
- Accomplish the Self-checks at the end of each unit
- Perform Operation Sheets which were provided at the end of units
- Do the "LAP test" giver at the end of each unit and
- Read the identified reference book for Examples and exercise

Unit One: Equipment And Materials

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- ✓ Weld work
- ✓ size, type and quantity of materials /components
- ✓ Prepare Materials
- ✓ Material assemble /alignment
- ✓ TIG Welding Machine Tools ,Equipment's and Accessories
- ✓ Work area and OHS Requirements

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- ✓ identify Weld work from order and /or drawings
- ✓ determine, obtain and inspect Correct size, type and quantity of materials / components
- ✓ prepare and assemble /align Materials
- ✓ identify TIG Welding Tools ,equipment and its accessories
- ✓ prepare appropriate Tools and equipment
- ✓ ensure Work area and OHS Requirements

1. Equipment And Materials

1.1.Weld Work requirement

1.1.1.Introduction

In the GTAW process, an arc is established between tungsten electrodes a base metal(s). GTAW is commonly known as TIG (tungsten inert gas) welding. Because fluxes are not used (like SMAW), the welds produced are sound, free of contaminants and slags, and as corrosion-resistant as the parent metal. Tungsten's extremely high melting temperature and good electrical conductivity makes it the best choice for a non-consumable electrode. The arc temperature is typically around 11,000° F. Typical shielding gasses are Ar, He, N, or a mixture of the two. As with GMAW, the filler material usually is the same composition as the base-metal.

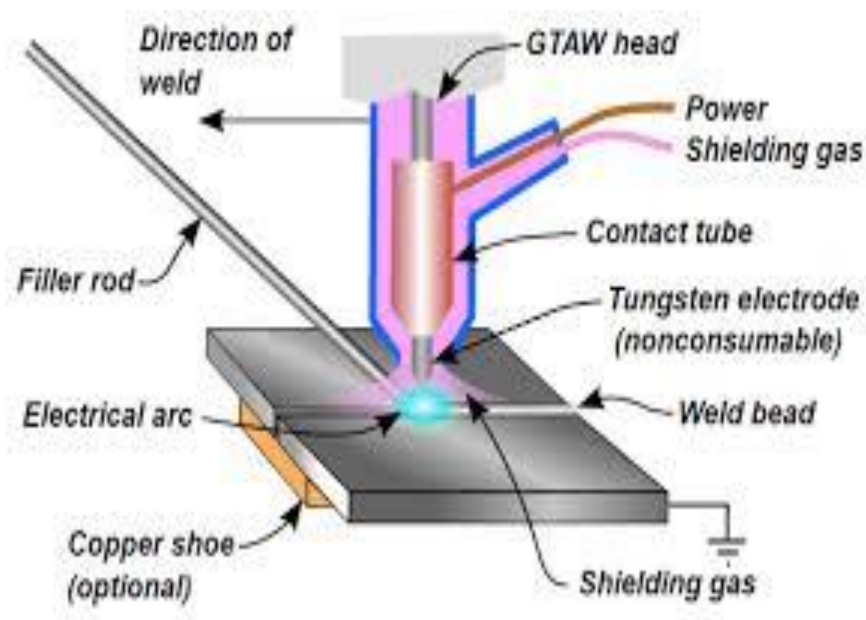


Fig.1.1. TIG welding process

1.1.2.The Principle of TIG Welding

TIG welding is an electric arc welding process in which the fusion energy is produced by an electric arc burning between the work piece and the tungsten electrode. During the welding process the electrode, the arc and the weld pool are protected against the damaging effects of the atmospheric air by an inert shielding gas. By means of a gas nozzle the shielding gas is lead to the welding zone where it replaces the atmospheric air. TIG welding differs from the other arc welding processes by the fact that the electrode is not consumed like the electrodes in other processes such as MIG/MAG and MMA. If it is necessary to use filler material, it is added either manually or automatically as a bare wire.

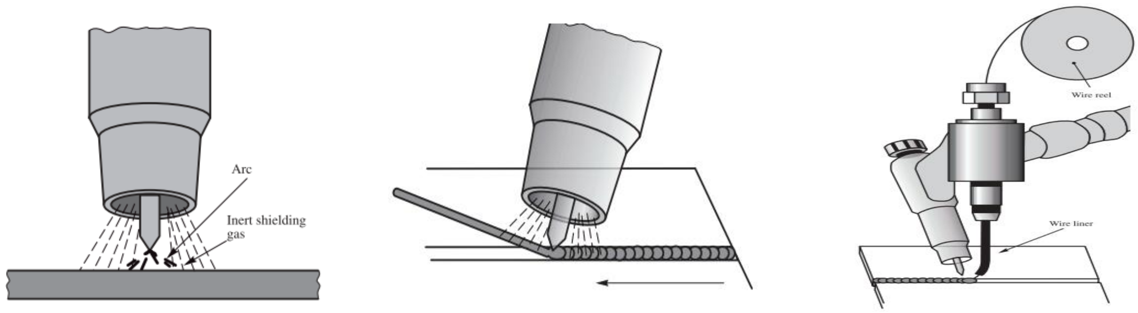


Fig. 1.2.TIG welding Principle, feeding of filler material and automatic feeding of filler material

1.1.3.Advantages and Limitations

Advantages of GTAW include:

- ✓ produces high-quality, low-distortion welds
- ✓ free of the spatter associated with other methods
- ✓ can be used with or without filler wire
- ✓ can be used with a range of power supplies
- ✓ welds almost all metals, including dissimilar ones
- ✓ gives precise control of welding heat

Limitations of GTAW include:

produces lower deposition rates than consumable electrode arc welding processes requires slightly more dexterity and welder coordination than gas metal arc welding (GMAW) or shielded metal arc welding (SMAW) for manual welding .Less economical than consumable electrode arc welding for thick sections greater than 9.5 mm (3 8in.) problematic in drafty environments because of difficulty in shielding the weld zone properly

1.1.4.AWS Welding Symbols

The welding symbols used today are considered shorthand for the welder. Develop a clear means of communication between the designing engineer and the welder building the project. The American Welding Society (AWS) has developed a standard set of symbols to be used for this purpose. Both the designing engineer and the welder use these symbols without need for further communication.

The welding symbol is made up of three parts.

- The Tail
- Reference Line
- The Arrow

The Tail

Inside the tail will be further information about the weld. Usually, the method of welding or type of welding rod to be used. Specification or other references will be placed here. The tail might not appear on the reference line if it is not being used

The Reference Line

The reference line is the main foundation for welding symbols used in blueprints. Anything written above the reference line itself indicates a weld on the other side of where the arrow points. Anything written below the reference line itself indicates a weld on the same side as the arrow points

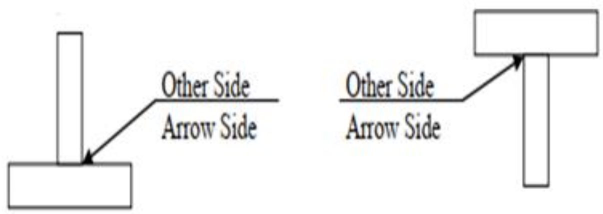


Fig.1.3. weld reference line

The Arrow

The arrow runs from the reference line and designates the joint that needs to be welded.

A straight arrow is used for weld locations. A broken-arrow line is used for joint preparation and breaks toward the piece that is to be beveled

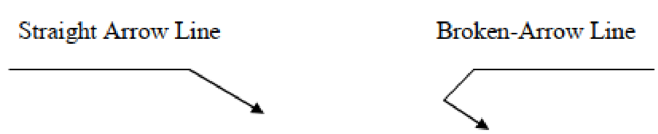


Fig. 1.4. weld arrow reference

The Weld Symbol

The most important feature of the welding symbol is the type of weld to be used on the joint.

- ✓ Fillet weld
- ✓ Plug or Slot weld
- ✓ Spot weld
- ✓ Seam weld
- ✓ Groove weld
- ✓ Size of Welds

The size of the weld will be indicated on the weld symbol. The size will be expressed in decimals, fractions, or metric unit (mm). The size will be located in front of the weld symbol on the reference line. The length of the weld will be placed after the weld symbol. If the lengths of the legs on a fillet weld are meant to be unequal they will be labeled with two dimensions. If a note gives the size of the welds, no dimensions will appear on the symbol

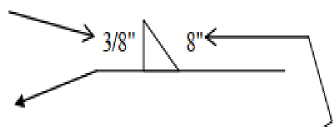


Fig. 1.5.weld size

Contour and Finish Symbols

- ✓ Flush –The flush symbol will be used when the finished surface needs to be flush.
- ✓ Convex –The convex symbol will be used when the finished surface needs to be convex.
- ✓ Concave –The concave symbol will be used when the finished surface needs to concave, this is very seldom used but it has its' purpose.

Finish Method

Most of time welding process will determine the finished surface. If a mechanical means of surfacing are needed it will be indicated by a letter, otherwise a letter will not appear.

- ✓ C – Chipping
- ✓ M – Machining G
- ✓ G – Grinding
- ✓ R – Rolling
- ✓ H – Hammering
- ✓ U – Unspecified

1.1.5.Back and Backing Welds

A Backing weld will be made on the opposite side of a groove before the groove weld is made and will also appear on the opposite side of the reference line. It will also be noted in the tail as to be a Back or Backing weld.

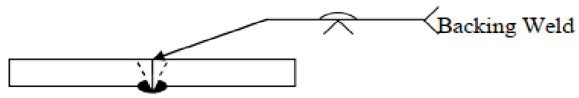


Fig. 1.6. Backing Welds before the groove weld

A Back weld will be made on the opposite side of a groove weld after the groove weld and will also appear on the opposite side of the reference line. It will also be noted in the tail as to be a Back or Backing weld.

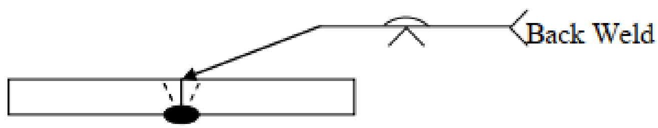


Fig. 1.7. Backing Welds after the groove weld

1.1.6.The TIG Arc

In TIG welding the arc burning is produced in between the tungsten electrode and the work piece. The wire feeding can be done manually or mechanically. In DC TIG welding the tungsten electrode is usually connected to negative polarity and the work piece to positive polarity. According to the theory of electrons the negatively charged electrons and positively charged ions will migrate when the arc is ignited. The electrons will migrate from the negative pole to the positive pole while the ions will travel in the opposite direction. In the arc there will therefore be a collision between the electron and the ions and this collision produces heat energy. The total produced heat energy is distributed by approx. 30% to the point of the electrode that is connected to the negative pole and approx. 70% to the work piece connected to the positive pole.

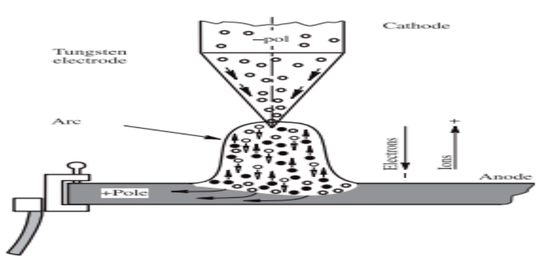


Fig.1.8. Migration of electrons and ions in TIG welding

1.1.7.Alternating Current

Alternating current is characterized by the fact that the voltage changes polarity a certain number of times, usually 100 times per second. The electrode has positive polarity in a semi period and in the same semi-period the work piece is negative. In the next semi-period the polarity is reversed, which means that the heat energy distributes with 50% on the electrode and 50% on the work piece

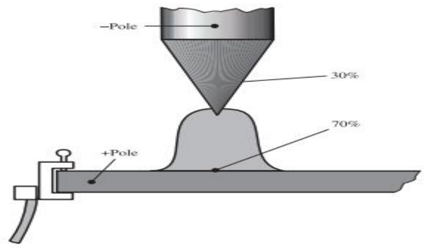


Fig.1.9. Heat distribution at TIG welding

1.1.8.Areas of application

TIG welding is often used for jobs that demand high quality welding such as for instance:

- ✓ The offshore industry
- ✓ Combined heat and power plants
- ✓ The petrochemical industry
- ✓ The food industry
- ✓ The chemical industry
- ✓ The nuclear industry

1.2.Correct Size, Type and Quantity of Materials and Components

1.2.1.TIG Welding Materials

- ➢ **C-Mn Steel**

TIG welding may be used for welding carbon steel but because deposition rates are low, it is usually only used for welding sheet and thin sections for high quality applications, small components, and root passes of multi-pass butt joints in plate and pipe. Standard DC TIG equipment is normally suitable and DCEN polarity is usually chosen to provide good work piece heating. Only inert or reducing gases should be used for TIG welding and pure argon is normally recommended as the shielding gas for steel. Filler rods are usually selected to match the chemical composition and the mechanical properties of the parent plate. The weld ability of the steel may impose restrictions on the choice of filler rod. Steels with carbon contents above about 0.3% are harden able, and fast cooling will produce a hard HAZ and this is liable to result in hydrogen cracking. This form of cracking can be prevented by use of preheat and suitable welding procedures.

Table.1.1.Carbon Steel Plate Joints at Different Parameters.

Plate Thickness (mm)	Joint Type	Number of Passes	Tungsten Electrode Size (mm)	Consumable Size (mm)	Current (A)	Welding Travel Speed (cm/min)	Gasflow (l/min)
0.8	Fillet	1	1.6	1.5	70	30	5
1.0	Fillet	1	1.6	1.5	90	30	5
1.5	Fillet	1	1.6	2.0	110	30	6
2.0	Fillet	1	2.4	2.5	130	25	6
1.0	Butt	1	1.6	1.5	80	20	6
1.5	Butt	1	1.6	2.0	120	20	7
2.0	Butt	1	2.4	2.5	140	20	7

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

- **Alloyed Steel**

TIG welding may be used for welding alloy steels but because deposition rates are low, it is usually only used for welding sheet and thin sections for high quality applications, small components, and root passes of multi-pass butt joints in plate and pipe. Standard DC TIG equipment is normally suitable and DCEN polarity is usually chosen to provide good work piece heating. Tungsten electrodes with additions of thorium oxide, cerium oxide, or lanthanum oxide are used for welding steel and they give good arc stability.

Table.1.2.Alloy Carbon Steel Plate Joints at Different Parameters.

Plate Thickness (mm)	Tungsten Electrode (mm)	Gas Flow (l/min)	Current (A)	Consumable Size (mm)
1.0	1.0	3 – 4	30 – 60	1.0
1.5	1.6	3 – 4	70 – 100	1.5
2.0	1.6	4	90 – 110	1.5 – 2.0
3.0	1.6 – 2.4	4 – 5	120 – 150	2.0 – 3.0
5.0	2.4 – 3.2	4 – 6	190 – 250	3.0 – 4.0
6.0	3.2 – 4.0	5 – 6	220 – 340	4.0 – 6.0
8.0	4.0	5 – 6	300 – 360	4.0 – 6.0
12.0	4.8 – 6.4	5 - 7	350 – 450	4.0 – 6.0

Polarity DC –

- **Stainless Steel**

Is a high quality process ideally suited for welding of stainless steels, particularly thin sheet up to about 5mm thick where weld integrity and good surface finish are critical. The process has a high degree of controllability resulting in clean, smooth, high quality welds with good penetration and strength with very low defect rates. When welding pipes an inert gas purge is required inside the pipe to prevent oxidation on the underside of the weld. Gas purging may also be used to protect the root side of butt welds in plate or sheet materials too.

- **Aluminum**

Is a high quality process widely used for welding aluminum, particularly in section size up to about 6mm.The process may be operated with or without filler. TIG welding of aluminum can be carried out using any of the three standard operating modes, alternating current (AC), direct current electrode negative (DCEN) and direct current electrode positive (DCEP). AC is the most frequently used since with AC cleaning of the oxide film occurs on the electrode positive cycle and heating occurs on the electrode negative cycle. With aluminum the surface oxide film must be removed to allow full fusion to take place and AC TIG does this efficiently, allowing high quality joints to be made. High purity argon and argon helium shielding gas mixtures can be used. The AC output may be conventional sine wave or square wave and many electronic power sources allow the AC waveform to be adjusted, and also provide facilities for pre- and post- gas flow and current slope-in and slope-out.

- **Balanced Square wave**

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

Table.1.3. Pure Aluminum Joint at Different Parameters.

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

Alternating current, Welding position: Downhand: Pure Aluminium

- **Copper and Copper Alloys**

Cleanliness is important when welding copper, and all dirt, grease, and other contaminants must be removed before welding. Copper alloys containing aluminum will form a surface oxide film and this must also be removed before welding. Preheat will be required for unalloyed copper but some copper alloys can be TIG welded without preheat except on thick sections. Aluminum bronze is normally TIG welded using AC current to break down the tenacious oxide film on the surface. Pure argon, helium, or argon-helium mixtures are standard shielding gases for DC TIG welding copper and copper alloys.Alushield Heavy is ideal for TIG welding copper and some copper alloys, particularly in thicker sections. Pure argon is the shielding gas used for AC TIG welding. TIG consumables are solid filler rods based on pure copper and several copper alloy compositions, including aluminum bronzes, silicon bronzes, and cupro-nickels. It is normal to try to use a filler material with a similar composition to that of the parent material but this is not always possible, and sometimes not desirable. Porosity is the main welding problem encountered when TIG welding unalloyed copper and some copper alloys are prone to solidification cracking and porosity. Certain alloys are difficult to weld (brass will lose zinc if welding is attempted), and those containing lead are virtually unweldable.

Table.1.4. Application Summary

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

2.1.1. Material and Joint Preparations

1.2.2.Materials Preparations

Material prepared for TIG weld may be the following

Table.1.5. TIG Materials

Material	Type of current	Electrode polarity
Unalloyed steels	=	-
Low-alloyed steels	=	-
Chromium/nickel steels	=	-
Chromium steels	=	-
Copper alloys	=	-
Nickel alloys	=	-
Titanium	=	-
Lead	=	-
Alluminium alloys	~	
Magnesium alloys	~	

Legend: = DC, ~ AC, - negative, + positive

Direct current with negative polarity on the electrode is used for TIG welding of most materials.

- **Edge preparation**

Factors which affect the choice of edge preparations

- Thickness
- Material
- Welding process
- Extent of penetrations
- Welding distortions
- Cost

- **Joint Preparations**

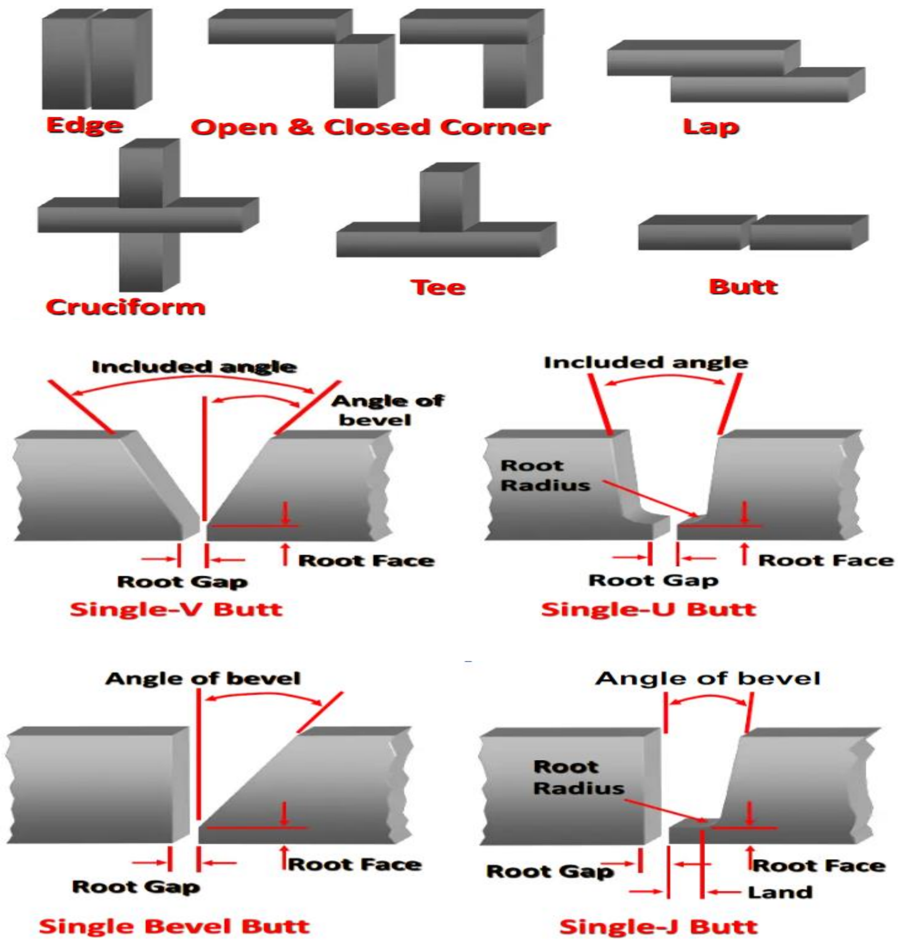


Fig.1.10. Different Edge Preparations

- **Single Sided Butt Preparations**

Single sided preparations are normally made on thinner materials, or when access from both sides is restricted

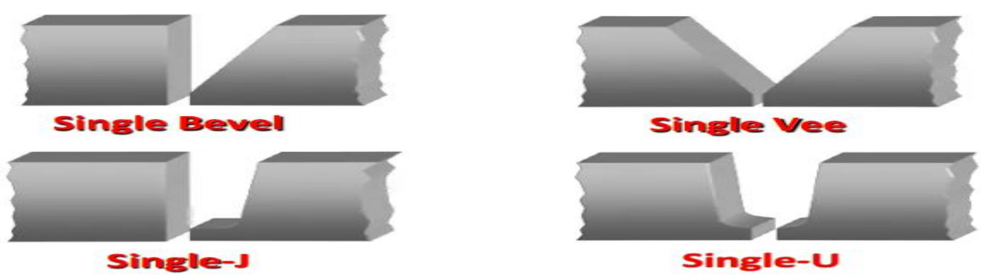


Fig.1.11. Single side butt preparation

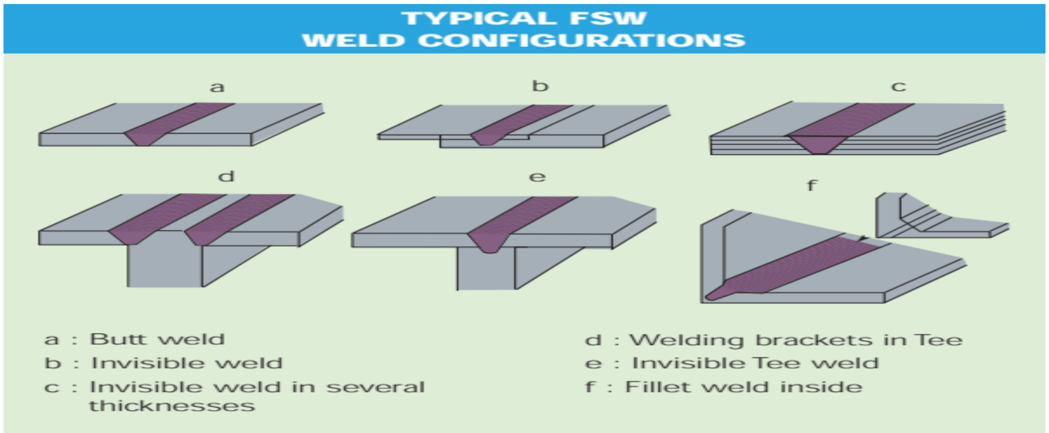
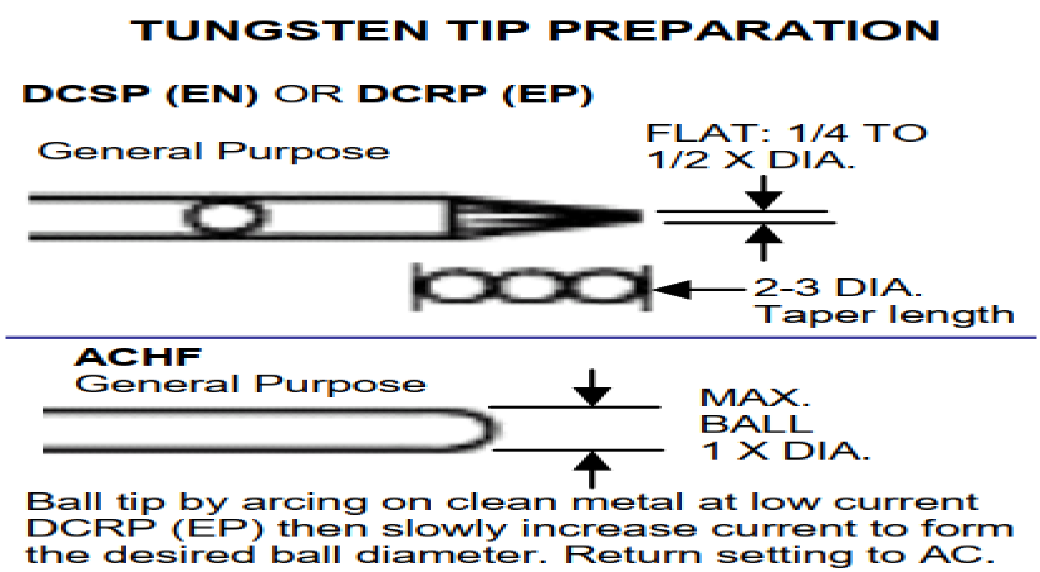
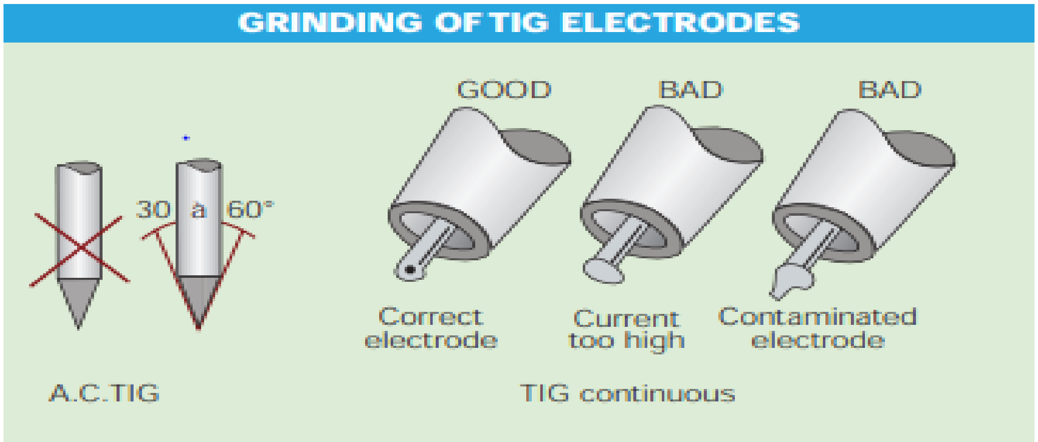


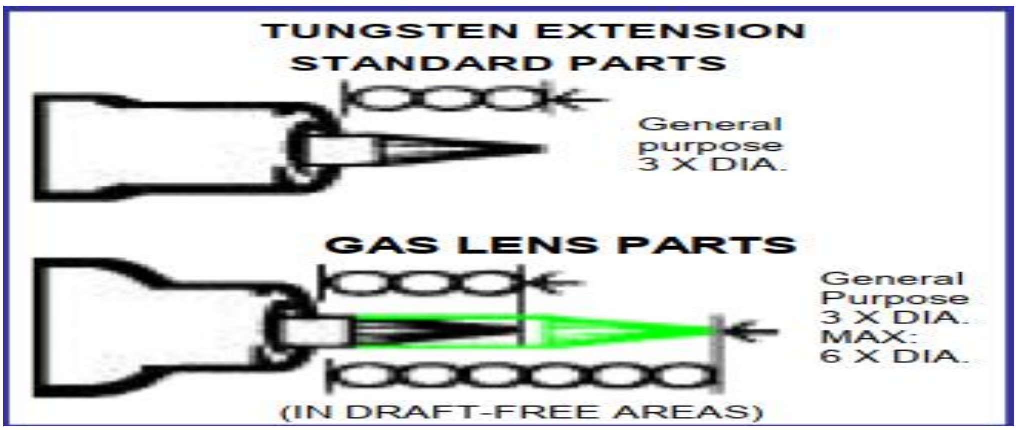
Fig.1.12.Diffirent joint preparation with their welding positions

- **Tungsten Electrode Tip Shapes Preparations**

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







1.3.Aligning Weld Material Components

1.3.1.Introduction

Before making a weld, the joint must be fit up and checked to ensure it conforms to the WPS. Follow the following steps.

- ✓ Check all electrical circuit connections to make sure they are tight.
- ✓ Check for the proper diameter electrode and cup size.
- ✓ Adjust the electrode stick out so it extends about 1/8" to 3/16" beyond the end of the gas cup for butt-welding and approximately 1/4″ to 3/8″ for fillet welding. See Figure.
- ✓ Check the electrode to be certain that it is firmly held in the collet.
- ✓ If the electrode moves in the nozzle, tighten the collet holder or gas cup.
- ✓ Be careful not to over tighten the gas cup because this will strip the threads very easily.
- ✓ Set the machine for the correct welding amperage.
- ✓ (See Tables. If a water-cooled torch is to be used, turn on the water.

Turn on the inert gas and set to the correct flow. Set the after flow (post purge) timer.

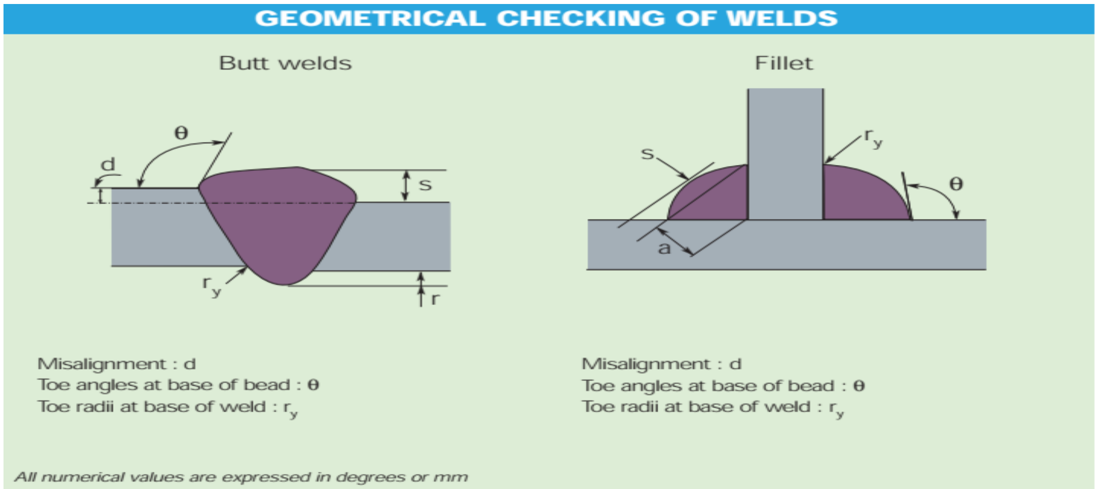


Fig.1.13. Materials alignment

Alignment of components

The most common tools used to layout and check joint fit-ups are straightedges, squares, levels and Hi-lo gauges.

Straightedges

- ✓ It is used to mark straight lines and check joint alignment.
- ✓ Many have calibrations along their length for measuring.
- ✓ Straightedges, particularly longer ones, are typically fabricated on the job from small channel or angle iron.

Squares

- ✓ Two types of squares are used for layout: pipefitter’s square and a combination square.
- ✓ Pipefitter’s square is used to measure angles and check squarenes.
- ✓ Combination squares are smaller with blades typically 12” or 18” long.
- ✓ They have replaceable attachments that slide along the blade.

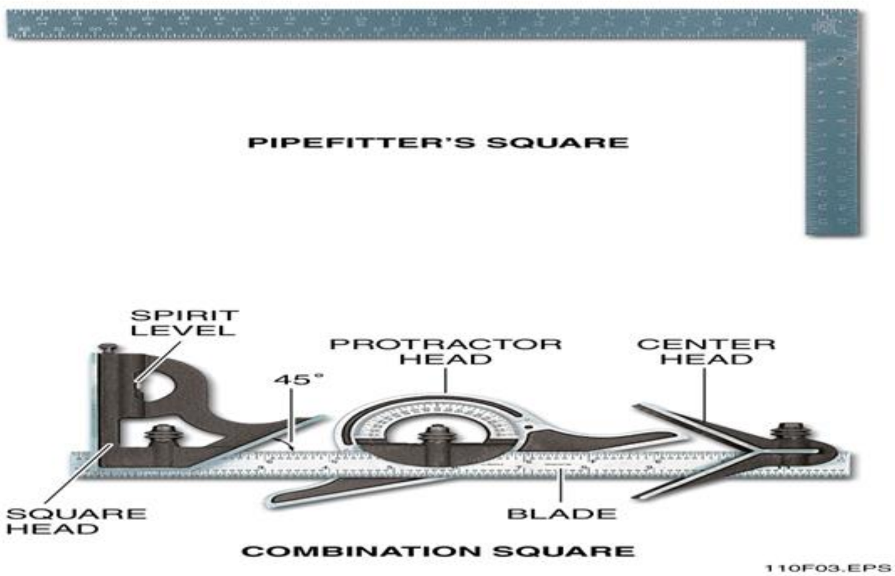


Fig.1.14. Squares

Levels

Levels come in a variety of sizes and shapes.

- ✓ Some have magnetized bases.
- ✓ Levels are used to check that layouts are level (horizontal) and plumb (vertical).
- ✓ Levels use a bubble in a glass vial to check level and plumb.
- ✓ Centering the bubble between the lines marked on the vial indicates level or plumb.
- ✓ Some levels have a 45 degree.

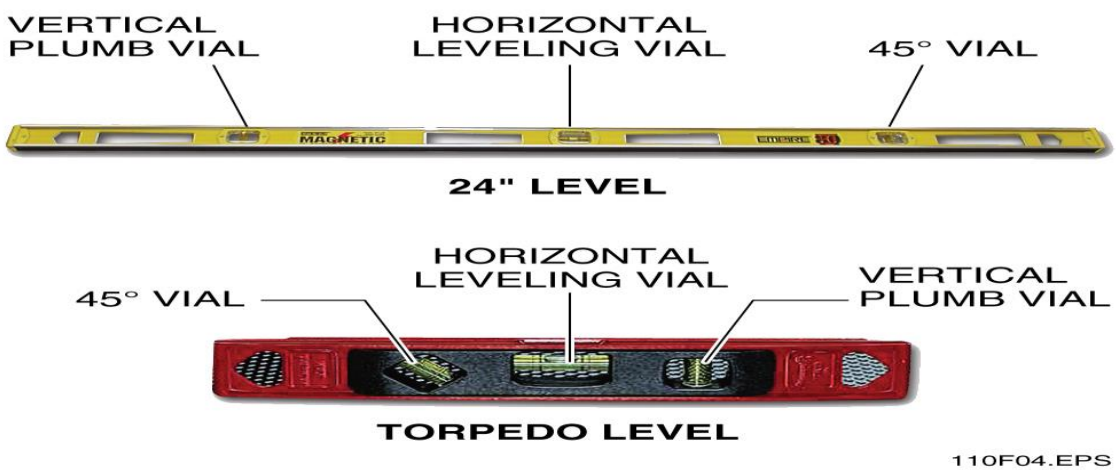


Fig.1.15. Leveling

Hi-Lo Gauges

- ✓ The primary purpose of a Hi-Lo gauge is to check for pipe joint misalignment.
- ✓ The name of the gauge comes from the relationship between the alignments of one pipe to the other pipe, which is called high-low.

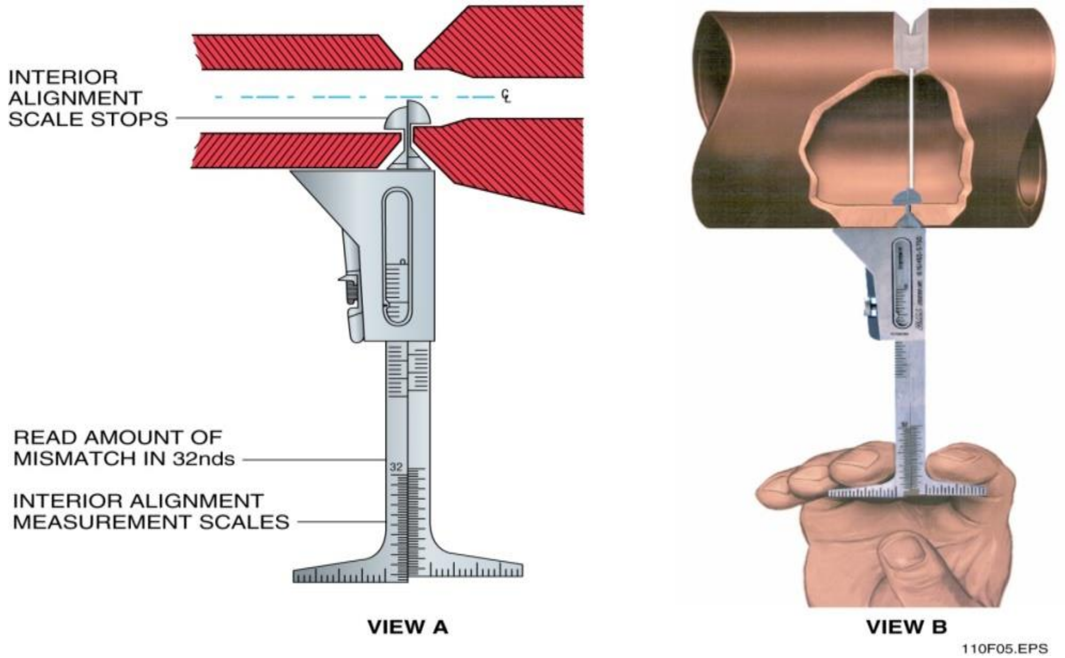


Fig.1.16.Hi-Lo Gauges

1.4.Welding Machine Tools ,Equipment's and Accessories

1.4.1.TIG Welding Machines

TIG machine is a power source that provides either basic or advanced TIG welding functionalities. A basic TIG welder has a CC power source, as previously noted, most often outputs DC current, and it has support for the TIG torch connection. A more advanced specialized TIG machine outputs AC and DC, has a High-Frequency arc start, and advanced features like pulse modification, and AC balance adjustments.

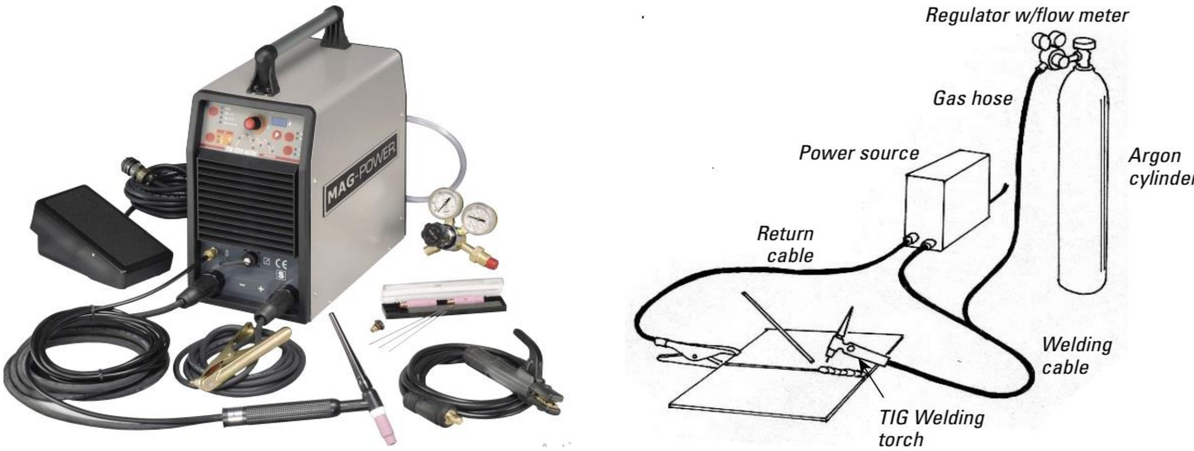


Fig.1.17. TIG Welding Machine with Its Accessories

1.4.2.TIG Torch

There are many different TIG torch sizes and types of consumables, but to keep this simple, we'll analyze a standard 17-style torch. Most TIG torches are composed of a ceramic cup, collet body, collet, tungsten, and back catp. But if they use a more advanced "gas lens" style of consumables, the list is slightly different. The collet houses the tungsten electrode and has two slits to tighten around the electrode firmly. The collet and tungsten are inserted into the collet body, which threads to the TIG torch head.

Fig.1.18.TIG torch part list

TIG torch parts in summary:

- ✓ Electrical leads- Connection with a TIG welder/power source
- ✓ Torch head- Removable end of the electrical lead that houses the rest of the torch components
- ✓ Collet- Grips the tungsten electrode in place
- ✓ Collet body- Accepts the collet and threads to the torch head

- ✓ Tungsten electrode- Electrically hot element central for the arc ignition and welding
- ✓ Shielding gas nozzle- A cup is usually made of ceramics, but some use cases require plastic, metal,
- ✓ Gas hose- Supplies the shielding gas
- ✓ Water coolant hose- Only used with water-cooled
- ✓ TIG torches, not smaller air cooled typically used for light welding.

A water cooled torch requires three hoses.

- ✓ 1st uses to Carry the shielding gas,
- ✓ 2nd uses to Supply a combination of coolant and the electrode lead, and
- ✓ 3rd uses to return the coolant to the storage reservoir.

1.4.3.Tungsten TIG Welding Electrodes

A crucial part of TIG equipment is tungsten electrodes. The non-consumable tungsten electrode focuses the TIG welding arc into a tiny spot and is responsible for most of the characteristics of the TIG welding process. While the tungsten is not consumable, it must be shaped, ground, and broken to achieve the desired TIG weld results. So, these electrodes don't last indefinitely. The tungsten electrodes vary by finish and principle oxide composition. Here is a short rundown of tungsten types:

Fig.1.19. Tungsten TIG Welding Electrodes

Selecting the Best Tungsten Composition:

To correctly prepare your tungsten electrode for welding you must first select the composition and diameter best suited for your application. Below listed are the 5 most commonly produced tungsten welding electrodes for TIG DC, TIG-AC, and Plasma welding

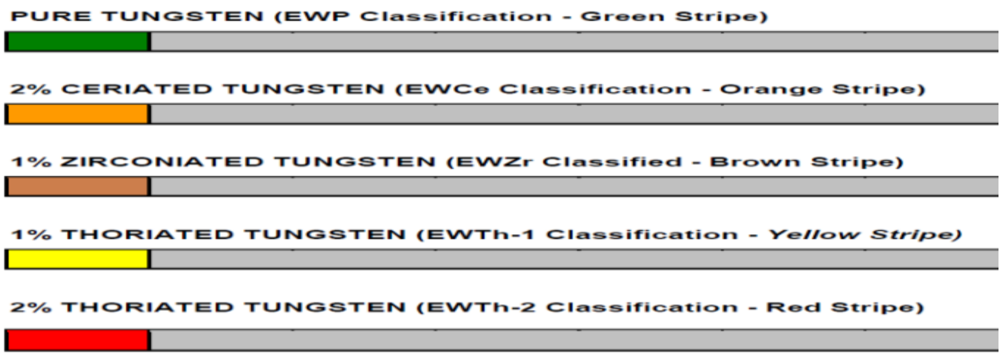


Fig.1.18. Tungsten Electrode Composition:

Table.1.5. Different types of composition tungsten electrodes

COLOR CODE FOR TUNGSTEN ELECTRODES

Designation		Chemical Composition Impurities ≤0.1%		
ISO 6848	AWS A5.12	OXIDE ADDITIVE	TUNGSTEN	TIP COLOR
WT20	EWTh-2	ThO_2: 1.70–2.20%	2% THORIATED	Red
WP	EWP	~~~~~~	PURE	Green
WL15	EWLa-1.5	LaO_2: 1.30–1.70%	1.5% LANTHANATED	Gold
WC20	EWCe-2	CeO_2: 1.80–2.20%	2% CERIATED	Gray
WL20	EWLa-2	La_2O_3: 1.80–2.20%	2% LANTHANATED	Blue
WZ8	EWZr-8	ZrO_2: 0.70–0.90%	0.8% ZIRCONIATED	White
LaYZr™	EWG	La_2O_3: 1.3–1.7%; Y_2O_3: 0.06–0.10%; ZrO_2: 0.6–1.0%	1.5% LANTHANATED 0.8% YTTRIATED 0.8% ZIRCONIATED	Chartreuse

1.4.4.TIG Welding Shielding Gases (Ar & He)

The most commonly used shielding gas for TIG welding is argon (Ar), and the second place takes helium (He). Sometimes hydrogen (H) and nitrogen (N) are added used as well or as a mixture.

100% Argon Shielding Gas

Most manual TIG welding applications are made using a 100% Ar shielding gas. In fact, you are unlikely ever to use other mixtures unless you have a good reason to do so. Additionally, argon is the only commercially available gas that allows the cleaning part of AC to clean the aluminum oxide. This gas ionizes well, making it exceptional for conducting current and arc starts. It handles arc length changes very well because it works great with long arcs and low voltages. It's much denser than air. This lets argon shield welds in deep groves very effectively as well.

- ✓ Provides more control and operates at lower heat levels,
- ✓ Making it better for thinner metal welding.
- ✓ Cheaper than helium
- ✓ Lower arc voltage (when compared to helium).
- ✓ Good arc stability
- ✓ arc cone is focused
- ✓ Good cleaning action
- ✓ Lower arc voltages
- ✓ 10-30 CFH flow rates
- ✓ Good arc starting

Cheap Helium Shielding Gas

Helium is an inert gas like argon. Using helium provides deeper penetration and higher welding speed. However, the arc is more difficult to control, it's lighter than air, difficult to ionize, and the cleaning action necessary for aluminum doesn't occur. To combat these negative characteristics and still benefit from the deeper penetration, helium is often used as a mixture with argon of 75% He and 25% Ar. Used when thicker metal is being welded that requires higher arc voltages.

- ✓ Less low amp stability
- ✓ Increased penetration
- ✓ Less cleaning action
- ✓ Flared arc cone
- ✓ Higher arc voltages
- ✓ Higher flow rates (2x)
- ✓ Difficult arc starting
- ✓ Higher cost than argon
- ✓ Faster travel speeds

Argon and Helium Gas Mixture

- ✓ Advantages over Pure Argon
- ✓ Higher costs than using 100% argon
- ✓ Improved travel speeds
- ✓ Improved penetration
- ✓ Cleaning properties closer to pure argon
- ✓ Higher flow rates than pure argon

Advantages over Pure Helium

- ✓ Improved arc starting
- ✓ Improved arc stability
- ✓ Arc cone shape more focused
- ✓ Produces Arc voltages between pure argon and pure helium

1.4.5.Filler Metal Rod

This filler material is a metal alloy specifically designed to withstand the high heat of welds and to fuse the two pieces of stock together as a composite. TIG filler rods typically come in 3-foot lengths, packed in 10 or 50-pound boxes (or tubes). The diameter usually ranges from 1/16 to 1/4 inch. The filler rods are also made with several alloys to handle different metals. Since the TIG filler rod composition needed is often the same as that used for MIG filler material, some of the MIG wires are also sold for TIG welding. These are identified as "TIG cut lengths."

Steel

- For most types of mild steel
- Highly durable
- Highly fluid
- Highly resistant to corrosion
- 1/16-inch TIG filler

Fig.1.20. TIG filler rods

1.4.6.Foot Pedal

It is generally used in an area where the welder can sit down. The welder raises or lowers the pedal for more or less welding current. However, for out-of-position welds, hand controls are used to allow the welder more freedom to move.

Fig.1.21. foot pedal controls welding current

1.4.7.Personal Protective Equipment

Safety glasses must be worn at all times in addition to welding mask.

A welding mask with correct grade lens for GMAW must be worn.

Oil free leather gloves and spats must be worn.

Sturdy footwear with rubber soles must be worn.

Long and loose hair must be contained.

Rings and jewellery must not be worn.

Respiratory protection devices may be required.

Close fitting/protective clothing to cover arms and legs must be worn.

1.5.Work Area and OHS Requirements

1.5.1.Pre-Operational Safety Checks

- ✓ Locate and ensure you are familiar with all machine operations and controls.
- ✓ Check workspaces and walkways to ensure no slip/trip hazards are present.
- ✓ Ensure the work area is clean and clear of grease, oil and any flammable materials.
- ✓ Keep the welding equipment, work area and your gloves dry to avoid electric shocks.
- ✓ Ensure your gloves, welding torch and work leads are in good condition.
- ✓ Ensure other people are protected from flashes by closing the curtain to the welding bay or erecting screens.
- ✓ Start the fume extraction unit is on before beginning to weld.
- ✓ Ensure work leads do not create a tripping hazard.

1.5.2.Operational Safety Checks

- ✓ Ensure machine is correctly set up for current, voltage, and gas flow.
- ✓ Ensure work return earth cables make firm contact to provide a good electrical connection.
- ✓ Strike the arc before placing the tip of the filler wire in the weld zone.
- ✓ Turn off the power while changing tungsten electrodes.

- ✓ Take care to avoid flashes.
- ✓ Ending Operations And Cleaning Up
- ✓ Switch off the machine and fume extraction unit when work completed.
- ✓ Close the gas cylinder valve.
- ✓ Hang up welding gun and leads.
- ✓ Leave the work area in a safe, clean and tidy state.

1.5.3.Potential Hazards

- ✓ Electric shock.
- ✓ Fumes.
- ✓ Radiation burns to eyes or body.
- ✓ Body burns due to hot or molten materials.
- ✓ Flying sparks.
- ✓ Fire.

1.5.4.DON'T

- ➢ Do not use faulty equipment. Immediately report suspect equipment
- ➢ Never leave the welder running unattended.

Note: This SWP does not necessarily cover all possible hazards associated with this equipment and should be used in conjunction with other references. It is designed as a guide to be used to compliment training and as a reminder to users prior to equipment use.

1.5.5.General instructions for safe use of TIG welding machine:

Proper installation, grounding, and operating of the TIG welding machine should be provided according to local codes

- ✓ Check the welding machine and other equipment.
- ✓ Make sure that right gas cylinder mounted to the system.
- ✓ Turn on the main switch.
- ✓ Open the gas cylinder valve.
- ✓ Set the gas pressure and current according to welding type.
- ✓ Connect work piece to the apparatus.
- ✓ Press the start button and start welding process.

Self-check-1

<u>PART ONE</u>: Say true or false

1. Levels come in a variety of sizes and shapes.
2. The most important feature of the welding symbol is the type of weld to be used on the joint
3. The welding symbol is made up of five parts.
4. The factors that influencing the edge preparations the material it be prepared.

<u>PART TWO</u>: - Choose the Correct Answer for the Following Questions (2 Point Each)

1. One of the following is GTAW equipment.

A. Gas cylinder C. Ground clamp
B. Gas regulator D. All

2. Its GTAW equipment used to control the flow of gas.

A. Gas regulator C. Foot pedal
B. welding torch D. Gas cylinder

3. One of the following is not the part of GTAW torch.

A. nozzle C. Collet
B. torch body D. foot pedal

4. The current recommended for plate thickness of 1.5mm and Tungsten Electrode of 1.6mm is_

A. 90-110 C. 30-60
B. 70-110 D. 50-60

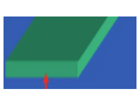
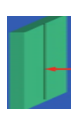
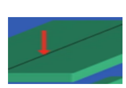
5. Which one of the following is the indication color of pure Tungsten Electrodes?

A.  C. 
B.  D. 

6. One of the following is not the advantages of TIG.

A. produces high-quality, low-distortion welds
B. free of the spatter associated with other methods
C. can be used only filler wire
D. can be used with a range of power supplies

7. Which one a 3G welding positions?

A.  C.  B.  D. 

<u>PART THREE</u>: - Write Short Answer

1. Write at List five advantage of TIG welding points.(5 points)
2. Write the limitations of the GTAW

Unit Two: Welding Machine And Accessories,

This unit to provide you the necessary information regarding the following content coverage and topics:

- ✓ Machine Settings, Accessories, Fixtures And Consumables
- ✓ Power Supply And Set To The Polarity
- ✓ Current And Voltage
- ✓ Braces, Stiffeners, Rails And Other Jigs
- ✓ Distortion Prevention Measures

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- ✓ Identify and select machine settings, accessories, fixtures and consumables
- ✓ Connect machine to an independent power supply and wired up or set to the polarity
- ✓ Fine-Tuned or adjusted Current and voltage
- ✓ Provide Braces, stiffeners, rails and other jigs
- ✓ Select Appropriate distortion prevention measures

2.2.Machine Settings, Accessories, Fixtures and Consumables

2.2.1.Setting up a TIG Welding

Prior to beginning any welding operation it will be necessary to set up the welding machine for "optimum" operation. In order to make these "optimum settings" you need to know the following:

- ✓ What type of metal is to be welded?
- ✓ How thick is the metal?
- ✓ What type of joint is being welded?
- ✓ What welding position will be used?

From the "type of metal" you will select the "type of current' namely, DCEN, DCEP or AC with HF. From the thickness of metal you will set the "amperage" for welding. From the type of joint you will select the torch nozzle and the gas flow. From the welding position you will "adjust" all parameters. Note that in this basic course we are concerned only with "flat" or "down-hand" welding positions. In more advanced modules we shall deal with "out of position welding" such as you will experience when welding pipe joints etc.

For purposes of this module we need set the following parameters at the welding machine (power source):

- ✓ Current type and Polarity.
- ✓ Welding Current (Amperage).
- ✓ Shielding Gas flow-rate.

Please consult Tables 1.6, 1 and 2 for "nominal settings" of common materials.

MILD STEEL - DCEN					
THICKNESS MM	JOINT	WELDING (AMPS)	ELECTRODE SIZE mm	FILLER WIRE SIZE mm	GAS FLOW (Lpm)
1.6	Butt Lap Corner Fillet	60 - 70 70 - 90 60 - 70 70 - 90	1.59	1.59	5 5 5 5
3.18	Butt Lap Corner Fillet	80 - 100 90 - 115 80 - 100 90 - 115	1.59 – 2.38	2.38	7 7 7 7
4.76	Butt Lap Corner Fillet	115 - 135 140 - 165 115 - 135 140 – 170	2.38	3.18	9 9 9 9
6.35	Butt Lap Corner Fillet	160 - 175 170 - 200 160 - 175 175 - 200	3.18	4.0	9 14 9 14

Tables 1.7 Stainless Steel -DCEN.

STAINLESS STEEL - DCEN					
THICKNESS MM	JOINT	WELDING (AMPS)	ELECTRODE SIZE mm	FILLER WIRE SIZE mm	GAS FLOW (Lpm)
1.6	Butt Lap Corner Fillet	40 - 60 50 - 70 40 - 60 50 – 70	1.59	1.59	3 – 4 5 3 – 4 5
3.18	Butt Lap Corner Fillet	65 - 85 90 - 110 65 - 85 90 – 110	2.38	2.38	5 7 5 7
4.76	Butt Lap Corner Fillet	100 - 125 125 - 150 100 - 125 125 – 150	2.38	3.18	7 9 7 9
6.35	Butt Lap Corner Fillet	135 - 160 160 - 180 135 - 160 160 - 180	3.18	4.0	9 9 9 9 - 14

Tables 1.8 Aluminium-AC/HF -DCEN

ALUMINIUM – AC/HF					
THICKNESS MM	JOINT	WELDING (AMPS)	ELECTRODE SIZE mm	FILLER WIRE SIZE mm	GAS FLOW (Lpm)
1.6	Butt Lap Corner Fillet	60 - 85 70 - 90 60 - 85 75 - 100	1.59	1.59	5 5 5 7
3.18	Butt Lap Corner Fillet	125 – 150 130 - 160 120 - 140 130 - 160	2.38 3.18 2.38 3.18	2.38	9 9 12 12
4.76	Butt Lap Corner Fillet	180 - 225 190 - 240 180 - 225 190 - 240	2.38 4.0 3.18 4.0	3.18	14 14 14 14
6.35	Butt Lap Corner Fillet	240 - 280 250 - 320 240 - 280 250 - 320	4.0 4.76 4.0 4.76	4	14 14 14 14

TIG welding setup with a water-cooled torch

This prevents the water and gas hoses from accidentally being reversed when they are attached to the welder. The return water hose also contains the welding power cable. This permits a much smaller-size cable to be used because the water keeps it cool. The water must be supplied to the torch head and return around the cable. This allows the head to receive the maximum cooling from the water before the power cable warms it. Running the water through the torch first has another advantage. That is, when the water solenoid is closed, there is no water pressure in the hoses, which is particularly important. This feature also prevents condensation in the torch. If a water leak should occur during welding, the welding power is stopped, closing the water solenoid and thus stopping the leak.

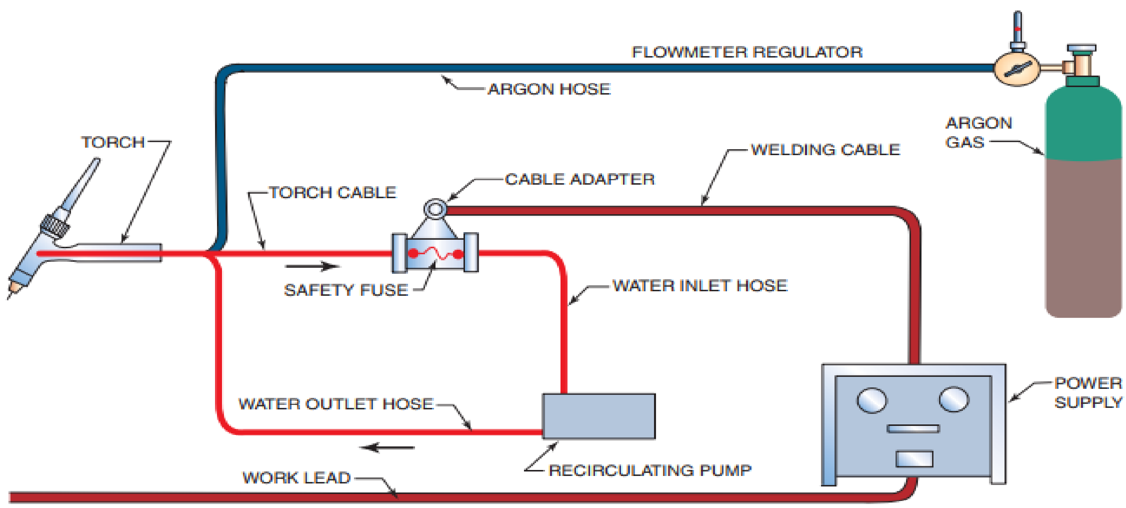


Fig.2.1. Schematic of a GTA welding setup with a water-cooled torch

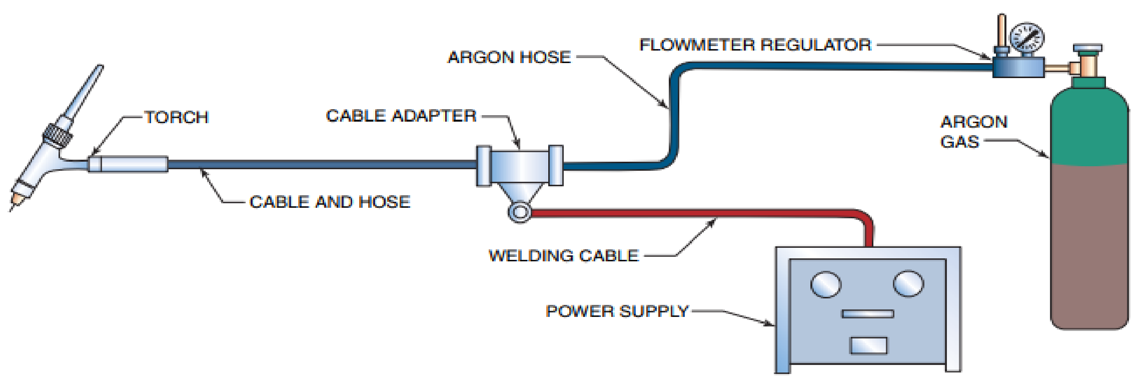


Fig.2.2. Schematic of a GTA welding setup with an air-cooled torch

Gas Set Up

TIG welding requires a shielding gas to protect the weld from outside contaminants. The good news is it doesn't matter what kind of metal you're welding; pure argon gas alone will cover almost every TIG application, so you won't need to swap between bottles. (You can still get gas mixtures for specific applications, however.) TIG welding requires a flow meter so you can adjust the gas flow rate. Every UNIMIG TIG welding machine comes with the needed flow meter, which you insert into the top of your gas tank. The flow meter has two parts: a pressure gauge and a flow tube. The pressure gauge tells you how much gas is left in the tank and the tube (which is adjusted by a valve on the side) show you how much gas is pumping into your torch per minute. Turn the valve so that it's fully closed before you open your gas bottle. An 8-10L per minute gas flow is a standard amount that will cover all metal types and keep your weld safe.

Torch Set Up

There are two different types of TIG torch that you can use. One comes with a button and one doesn't. The type of torch that you have will determine the ways you can ignite your arc.

To set up your torch you should have:

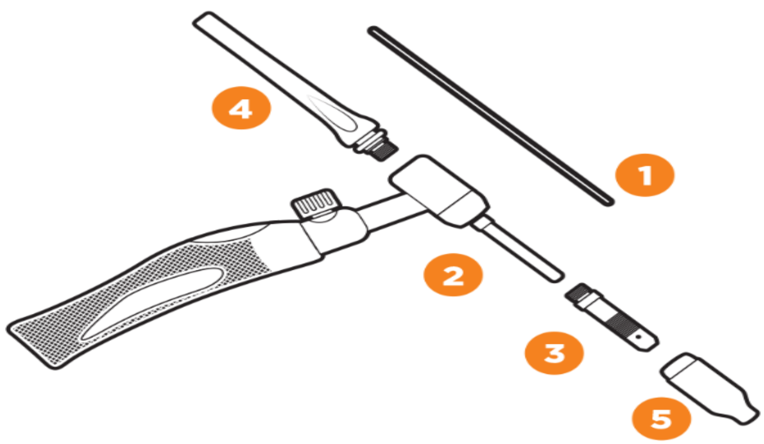


Fig.2.3. TIG Torch Consumables

Torch Assembly

- ✓ Fit the collet into the collet body.
- ✓ Fit the tungsten through the collet and collet body.
- ✓ Screw the collet body into the torch head.
- ✓ Screw the back cap onto the torch head. Don't fully tighten just yet.
- ✓ Screw in the ceramic cup onto the front of the torch.
- ✓ Finally, adjust the tungsten to your desired length, and then fully tighten the back cap.

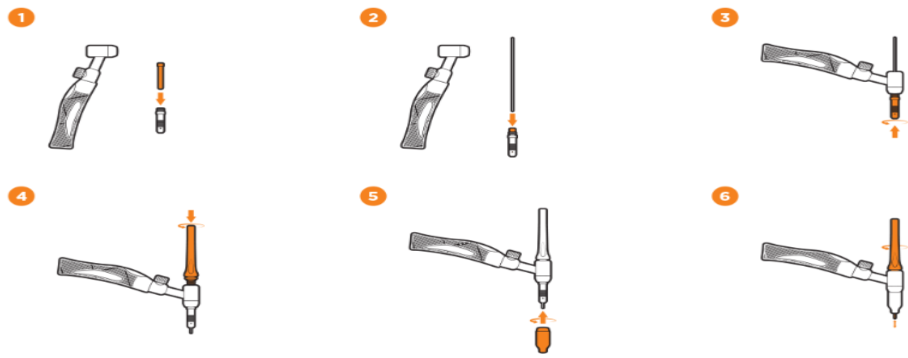


Fig.2.4. TIG Torch Setup Instructions

Standard lens vs. Gas lens

Standard nozzles release a broad plume of shielding gas over your weld. In comparison, a **gas lens** improves shielding gas coverage by distributing gas around the tungsten more efficiently with less turbulence. You can also have the tungsten stick out further with a gas lens, giving you better manoeuvrability and visibility of the weld pool. This is great for when you need to weld in tight spaces. If you are using a gas lens, you'll need a gas lens ceramic cup, as a standard one won't fit. The below steps don't change much if you're using a gas lens.

Fig.2.5. Lens vs. Gas lens

2.1.2 TIG accessories and consumables

AK-2 Kit

- ✓ SR17 – Back Cap - Short
- ✓ 0.40" – Collet / Collet Body / Tungsten Electrode / Alumina Cup #4
- ✓ 1/16" – Collet / Collet Body / Tungsten Electrode / Alumina Cup #5
- ✓ 3/32" – Collet / Collet Body / Tungsten Electrode / Alumina Cup #6

AK-3 Kit

- ✓ SR26 – Back Cap - Short
- ✓ 1/16” – Collet / Collet Body / Tungsten Electrode / Alumina Cup #5
- ✓ 3/32” – Collet / Collet Body / Tungsten Electrode / Alumina Cup #6
- ✓ 1/8” – Collet / Collet Body / Tungsten Electrode / Alumina Cup #8

TIG Foot Pedal Control

- ✓ Specifically designed for MAG-TG221 Inverter Machine
- ✓ All steel construction with Sure-Grip face
- ✓ Totally hands-free operation of welding process
- ✓ Heavy-duty, all steel contraction with non-slip feet
- ✓ On/Off arc control in both HF and strike-arc modes
- ✓ Full-range output amperage adjustability
- ✓ Direct connect 25’ shielded control cable

Auto-Silver Welding Helmet

- ✓ Wide View Area: 3.75” X 1.75” (6.56 sq./in.)
- ✓ Full Time UV/IR Protection: 16 DIN
- ✓ High Speed Sensitivity: 1/25,000th sec.
- ✓ Light Shade Set-Up: 3.5 DIN
- ✓ Dark Shade External Adjustment: 9-13 DIN
- ✓ Solar Powered / Auto On-Off: No battery

- ✓ Replaceable Lens Covers: interior & exterior
- ✓ Comfort Headband: padded w/locking ratchet
- ✓ Meets Standards: EN, DIN, ISO & ANSI Z87.1

2.2.2.Jigs and Fixtures

Holding the metal in a fixed position will prevent excessive movement from its tendency to expand and contract, so using jigs and fixtures can help prevent distortion. A jig or fixture is simply a device used to hold the metal rigidly in position during the welding operation (Figure XXXX). Jigs can be temporarily developed for a unique part, or they can be an adjustable worktable that allows for various preparation positions

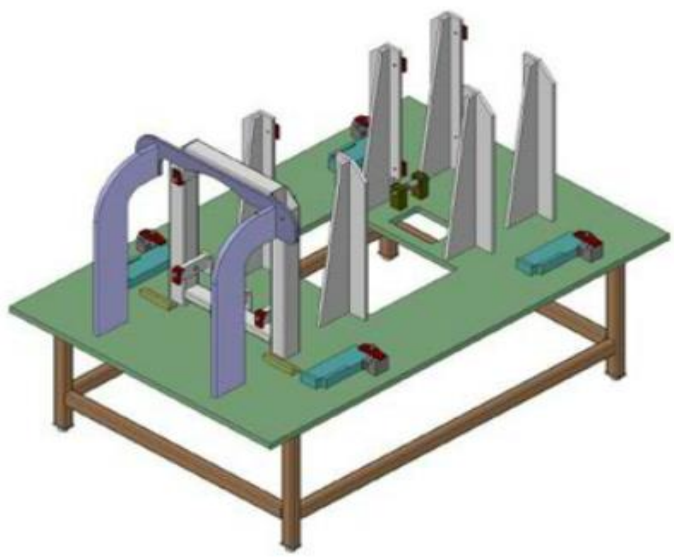


Fig.2.6. Example of a welding jig

2.2.3.Preparation of the Work Station

Welding operations may be done "on site" or at your "welding bay" but either way you must make this area safe for welding. Apart from erecting flash screens you should also make every effort to keep the area clean, dry and clear of obstacles. Set out your welding leads in such a way that they are "free" to extend to your work. You don't want the leads to "snag" as you are attempting to make a weld. Work on a clean and dry surface. Take the time to wipe down the welding bench (where applicable) and remove unnecessary "clutter" from the area. Make sure that you are equipped with all necessary PPE and, where applicable, run the extractor fan.

The Full Set-Up (In Summary)

So far we have covered individual items and described various procedures necessary to "prepare" that item for a welding operation. Let us now look at the actual "set-up procedure" that you would normally take when preparing to start a welding operation.

Procedure in steps:

1. Prepare the power source for the work-piece to be welded.
2. Prepare your torch with the correct electrode and nozzle
3. Prepare and connect the welding leads.
4. Set the shielding gas flow rate.
5. Obtain the necessary "filler wire" (If applicable).
6. Make sure you are wearing the necessary PPE.
7. Prepare your work area (make it safe).
8. Get started!

2.3.Connect Welding Machine to Power Supply

2.3.1.Input Connection

Before connecting the machine you should ensure that the correct supply is available. Details of the machine requirements can be found on the data plate of the machine or in the technical parameters shown in the manual. The equipment should be connected by a suitably qualified competent person. Always ensure the equipment has a proper grounding. Never connect the machine to the mains supply with the panels removed.

2.3.2.Output Connections

Electrode polarity

In general when using manual arc welding electrodes the electrode holder is connected the positive terminal and the work return to the negative terminal. Always consult the electrode manufacturer’s data sheet if you have any doubts. When using the machine for TIG welding the TIG torch should be connected to the negative terminal and the work return to the positive terminal.

2.3.3.Shielding Gas Connection

When working the machine in the TIG mode of welding the process requires a shielding gas. The shielding gas can be supplied via a pressure regulator to the machine from either a fixed installation or single cylinder of gas. If a cylinder of gas is used, please ensure that the cylinder is securely fastened (refer to the section on cylinder handling and safety), before starting any welding operation. Refer to the application section for the selection of the correct shielding gas.

2.3.4.TIG Torch Connection

The W26F/FX AC/DC TIG torch is fitted to the machine by means of the dinse back end. For DC (-) TIG operation fit the torch back end to the negative dinse connection (similarly for DC (+) fit the torch backend to the positive dinse connection). The gas hose is fitted to the gas fitting (GAS) located on the front bottom panel of the machine.

2.4.Set up welding Machine To The Polarity

The R-Tech AC/DC range can be used as a MMA welding machine by fitting a electrode holder and a work return lead to the respective dinse connectors (dependant on the type of electrodes being used. Please consult the packaging supplied by the manufacturer for the correct polarities).

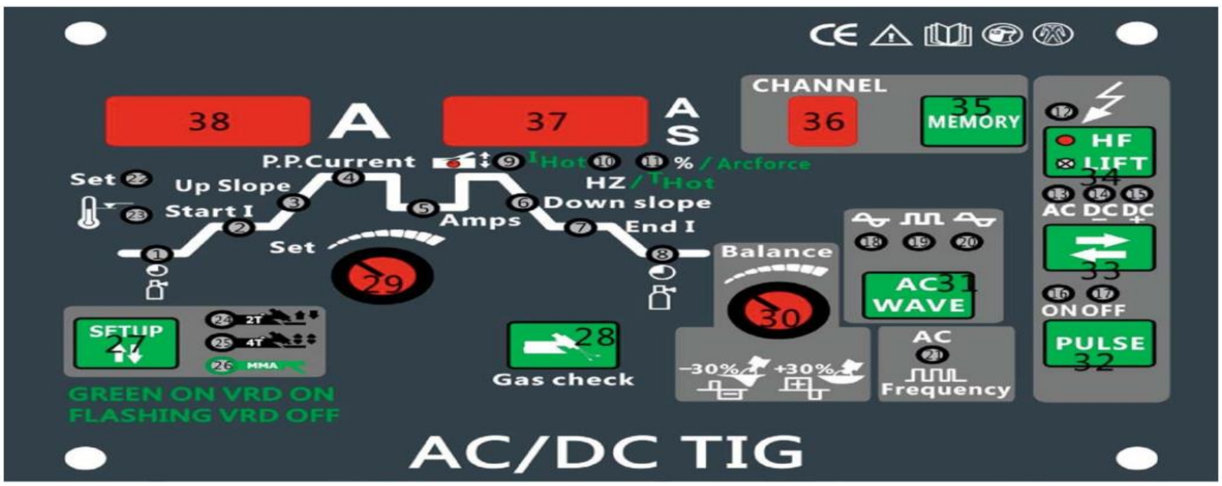


Table 2.1. Description of control penal

Description of the control panels		
No.	**Function**	**Description**
1	Argon In Indicator	
2	Starting Current Indicator	For tig welding
3	Upslope Time Indicator	period in TIG welding during which the starting current IS is increased to the specified main current
4	P.P.Current Indicator	Pulse Peak Current (1-100%)
5	Welding Current(Amps) Indicator	Main current
6	Downslope Time Indicator	period in TIG welding during which the specified main current I1 is lowered to the final current I
7	Ending Current I Indicator	For tig welding
8	Argon In Stopping Indicator	For tig welding
9	Foot Switch Indicator	Lights up if foot switch connected
10	Hot Start	For MMA welding
11	Arc Force	For MMA welding
12	HF Contact Indicator	ON/OFF
13	TIG AC Indicator	
14	TIG DC+ Welding Indicator	
15	TIG DC- Welding Indicator	
16	Pulse On Indicator	
17	Pulse Off Indicator	
18	Sin Indicator	Sinusoidal waveform indicator

19	OFF Indicator	100% rectangular waveform
20	rEc Indicator	Rectangular waveform
21	AC Frequency Indicator	
22	Setup Indicator	Lights up if under setting status
23	Over- heat Indicator Save the data	Lights up if the power source overheats (e.g. because the duty cycle has been exceeded). For more information on this, see the "Troubleshooting" section.
24	2-step Mode Indicator	
25	4-step Mode Indicator	
26	MMA Mode Indicator	
27	Mode Button	Used to select 2-step mode or 4-step mode or MMA Welding
28	Gas Test Button	Used to set the required amount of shielding gas at the pressure regulator. After you press this button, gas will flow out for 30s. Press the button again to stop the test gas flow before the 30 seconds are up.
29	Parameter Adjusting Knob	Used to adjust welding parameter
30	Balance	(- 30%/+30%) Used to set the fusing power/cleaning action for TIG AC welding
31	Wave Pattern	Used to select wave form (Sin, OFF or rEC)
32	Pulse Selection Button	ON/OFF
33	Process Button	used to select the process depending on the mode that has been chosen
34	HF Contact Button	ON/OFF
35	Store Button	used to store 9 jobs
36	Memory Display	Memory display,1 or 2 or 3…………..9
37	Actual Output Current Display	
38	Current Presetting	
39	LocalNet connection	standardised connection socket for system add - ons (e .g remote control TIG torch .)etc
40	Output Nozzle	
41	"- " output	
42	"+" output	
43	power switch	switching the power source on and off
44	power input	
45	shielding gas connection	

DC or AC Selection

GTAW uses three types of current: direct current electrode negative (DCEN), direct current electrode positive (DCEP), or alternating current (AC). The type of current used depends on the metal to be welded.

Direct current electrode negative (DCEN):- for welding most metals. In DCEN, electricity flows from the tungsten electrode to the work piece. In turn, DCEN generates the greatest amount of heat in the work piece. This produces deeper weld penetration. However, one disadvantage is that DCEN does not provide a cleaning action on the surface of the metal. This is generally acceptable except for when welding aluminum. Aluminum has an oxide film on its surface, which must be removed before welding.

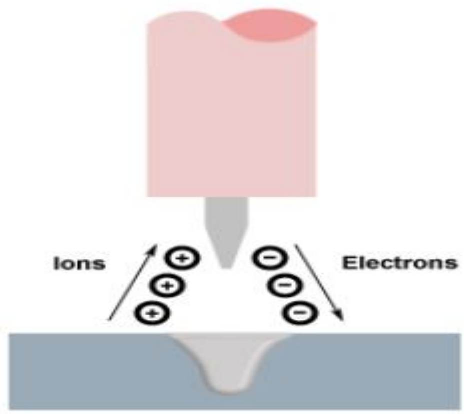


Fig.2.7. DCEN generates the greatest amount of heat in the work piece

Direct current electrode positive (DCEP):- electricity flows from the work piece to the tungsten electrode. In turn, the tungsten electrode receives most of the heat. This produces shallow weld penetration. DCEP has limited use in GTAW because it directs most of the heat toward the tungsten, taking away the heat required in the work piece. However, one advantage of DCEP is that it provides a cleaning action to remove the oxide film from the metal's surface.

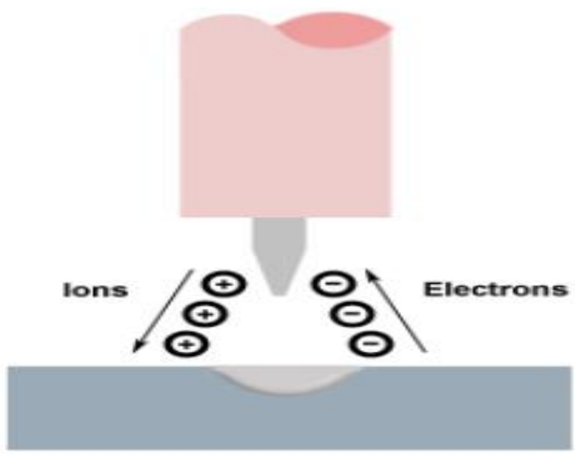


Fig.2.8. DCEP generates heat in the tungsten electrode.

Alternating current (AC):- combines the deep penetration characteristic of DCEN with the cleaning action of DCEP. Aluminum and magnesium are generally welded using AC because, during the DCEP part of the cycle, weld penetration is reduced and more heat is directed at the tungsten electrode. As a result, the arc removes the oxides from the surface of the material, making welding easier. During the DCEN part of the cycle, most of the heat accumulates in the work piece.

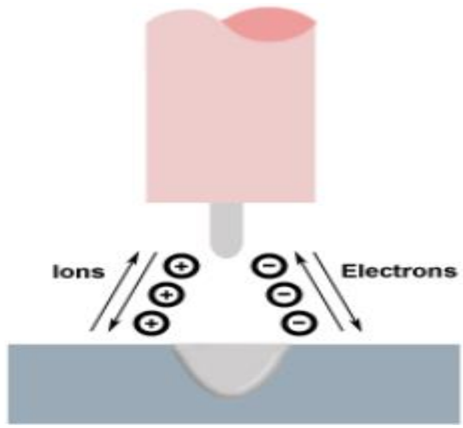


Fig.2.9. AC combines characteristics of DCEN and DCEP.

2.5.Current and Voltage Settings

2.5.1.Amperage

The amount of amperage determines the amount of heat in the arc. GTAW uses a constant current welder. This means that amperage is pre-set before welding begins, and the welder calculates voltage automatically. In GTAW, the constant current welder must provide enough amperage for melting the metal at a low voltage.

Fig.2.10. GTAW uses a constant current welder.

However, GTAW typically uses constant current with a drooping characteristic. With a drooping characteristic, the welder may vary the current level slightly by changing the arc length. Welders can change the current level with the use of hand or foot controls. These controls allow the welder to apply additional current for deeper penetration, or reduce current levels for bridging gaps. Welders can also apply current slowly to prevent burn through on thin material.

Fig.2.11. use of torch with a hand to control current levels.

GTAW has a wide range of amperage capabilities. It can use 2-3 amps to weld 0-005 in. metal sheet, or use 1000 amps to weld 1 in. metal plate. In other words, each 0.001 in. of the weld poof metal generally requires about 1 amp of welding power

2.5.2.Voltage

In GTAW, the amperage is pre-set on the welder, and the welder calculates the voltage automatically. Voltage is a dependent variable and is affected by other variables such as current, tip shape, arc length, and type of shielding gas. Voltage varies in proportion to the amperage. For this reason, keep a fixed arc length, if the amperage changes, it is also necessary to change the voltage settings. Arc length is important because it affects the width of the weld pool. A shorter arc length yields a narrower weld pool. A narrow weld is essential in GTAW.

Fig.2.12.Narrow welds in GTAW.

High voltage is generally used to start the arc. However, using excessive voltage, shown in Figure 2, can cause porosity, spatter, and undercut. In addition, the welder may lose control of the weld pool.

Fig.2.13. cause of Excessive voltage on a Control of the weld pool.

On the other hand, using insufficient voltage, shown in Figure 3, can cause an erratic, popping arc that will not melt the base metals. This may also cause the tungsten to stick to the workpiece.

Fig. 2.14. Cause of insufficient voltage on the electrode to stick.

2.5.3.Technical Specifications

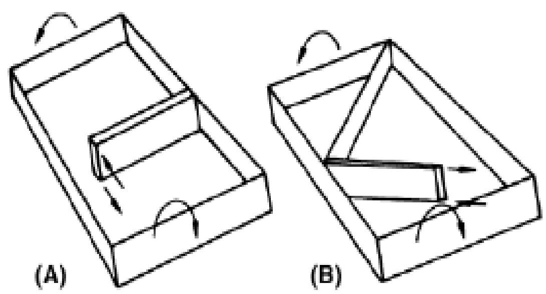
Table. 2.2. Technical Specifications of current voltage

Model No.	AC/DC TIG210	AC/DC TIG320	AC/DC TIG500
Part No.	AC/DC TIG210	AC/DC TIG320	AC/DC TIG500
Power voltage (V)	1 phase AC 240v	3 phase AC 415v	3 phase AC415v
Frequency (HZ)	50/60	50/60	50/60
Fuse rating (A)	16	32	32
Output Current (A)	Stick 10-160 DC TIG 5-210 AC TIG 10-210	Stick 10-320 DC TIG 5-210 AC TIG 10-320	Stick 10-400 DC TIG 5-210 AC TIG 10-500
No-load voltage (V)	62	62	62
Duty Cycle 35% @	210a	320a	500a
Power Factor	0.95	0.95	0.95
Protection Grading	1P23	1P23	1P23
Weight (kg)	17	27	29
Dimensions (mm)	430 x 208 x 410	490 x 255 x 480	490 x 255 x 480
Warranty	3 Years	3 Years	3 Years

2.6.Braces, Stiffeners, Rails and Other Jigs

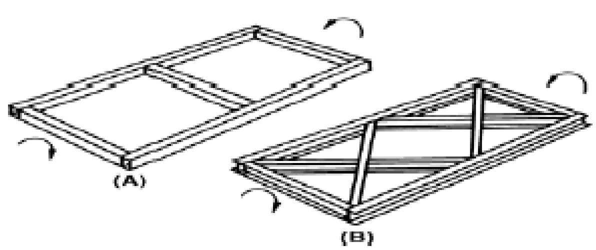
2.6.1.Braces

Diagonal Bracing. Diagonal bracing is very effective in preventing the twisting of frames. A simple explanation of the effectiveness of diagonal bracing involves an understanding of the directions of the forces involved. A flat bar of steel has little resistance to twisting, but has exceptional resistance of bending (stiffness) about its major axis. Transverse bars or open sections at 90° to the main members are not effective for increasing the torsional resistance of a frame because, as shown in Figure 2.10(A), they contribute only relatively low torsional resistance. However, if the bars are oriented diagonally at 45° across the frame, as in Figure 2.10 (B), the twisting of the frame is resisted by the stiffness of the bars. To be effective, the diagonal braces must have good bending stiffness perpendicular to the plane of the frame.



Source: Adapted from the Lincoln Electric Company, 1995, Procedure Handbook of Arc Welding, 13th ed., Cleveland: The Lincoln Electric Company,

Figure.2.15 Frames Subjected to Torsion with (A) Transverse Rib Bracing and (B) Diagonal Bracing



Source: Adapted from the Lincoln Electric Company, 1995, *Procedure Handbook of Arc Welding*, 13th ed., Cleveland: The Lincoln Electric Company, Figure xx.

Fig.2.16.Application of (A) Closed Tubular Sections or (B) Open Structures with Diagonal racing to Resist Torsion.

2.6.2.Stiffeners

Stiffeners are typically plate welded to the web. These plate cabs be applied to either just one side of the web or both side. By addition of these extra plates we increase the moment of inertia of plate girder which enhances the rigidity in turns it prevents buckling.

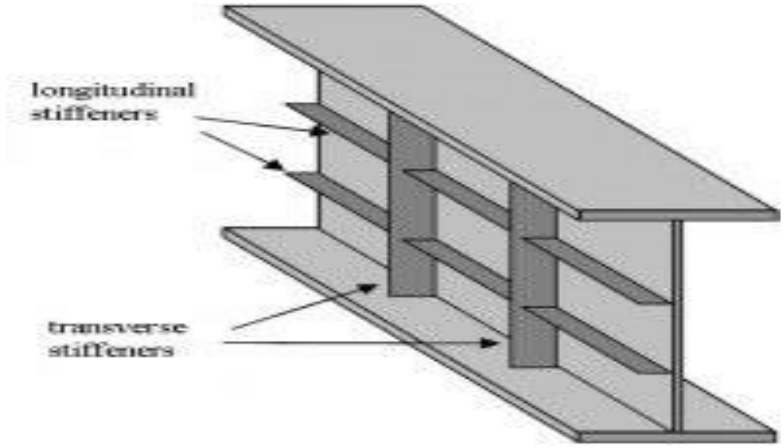


Fig.2.17. **Stiffener**

The **longitudinal stiffener** can increase shear and bending strengths of plate girder. Generally, they are not essential as transverse stiffeners. **Transverse stiffeners** are provided under the outward projection of the flange. But, however there is also a chance that when the transverse stiffeners take load from the flange, they may exposed to *buckling*, as in case of a **c**olumn. So to avoid the buckling of the stiffeners

2.6.3.Jigs and Fixtures

Fixtures and jigs are devices used to hold the parts to be welded in proper relation to each other. This alignment is called fit-up. Good fit-up is required for obtaining high quality welds. Poor fit-up increases welding time and causes many poor quality welds. The size of the root opening has an effect on the speed at which the welding of the root pass can be accomplished. Root openings are used so that full penetration welds can be made. Root passes in joints with a proper root opening can be welded much faster than joints that have excessive root opening. Fixtures and jigs are used for three major purposes:

1. To minimize distortion caused by welding heat
2. To minimize fit-up problems
3. To increase the welding efficiency of the welder.

When a welder employs a welding fixture or jig, the components of a weldment can be assembled and securely held in place while the weldment is positioned and welded. The use of those devices is dependent on the specific application. These devices are more often used when a large number of similar parts are produced. Using fixtures and jigs, when possible can greatly reduce the production time for the weldment.

Welding Jig

A jig is a large brace that keeps a welding project stable in the face of pressure, heat, motion, and force. A quality jig will streamline welding work by keeping parts together in a vice grip. Whether the welding is entirely manual, partially automatic, or fully robotic, a jig moves the work piece while the tool remains stationary.

2.7.Distortion Prevention Measures

2.7.1.Introduction

Undesirable change in dimension of a fabricated structure Caused due to unequal expansion of the parent metal during heating followed by its solidification shrinkage during cooling Under normal conditions, stress developed after welding remains as residual stress which may be removed by subsequent heat treatment If stress is high enough, contraction may take place, which pulls base metal out of alignment and cause distortion. Structures in I R susceptible to welding distortion Bogie frame of loco, coach, frame of wagon, bridge girder etc.

2.7.2.Undesirable Effects of Welding Distortion

- ✓ Mismatching problem.
- ✓ Aesthetics of the component is lost.
- ✓ Functional requirement of the component is affected.
- ✓ Additional expenditure to correct its dimensions.
- ✓ Component may have to be rejected due to fitment

2.7.3.Common Types Of Welding Distortion

- ✓ Longitudinal distortion
- ✓ Transverse distortion
- ✓ Angular distortion

Longitudinal Distortion

When a weld is deposited lengthwise on a light, narrow and perfectly flat strip of material that is neither clamped nor held in any way, the strip will tend to bow upwards in direction of the welding bead due to longitudinal contraction of the weld metal as it cools after welding. Longitudinal contraction maximum along the weld center line and decreases towards the edge. This phenomenon is called longitudinal distortion.

Longitudinal distortion depends upon:

- ✓ Contraction forces
- ✓ Stiffness of the section being welded.
- ✓ Distance between the centroids of weld & section.

Longitudinal Distortion

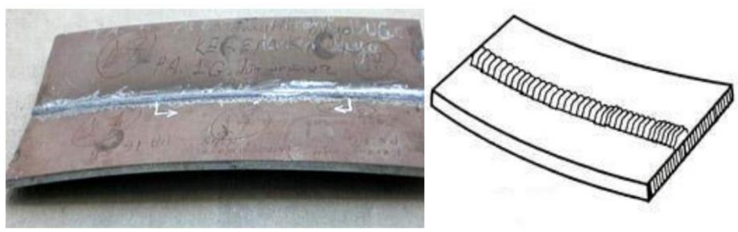


Fig.2.18. Longitudinal distortion

Transverse Distortion

When two plates butt welded together are neither too heavy nor held together and are thus free to move, they will be drawn closer together by the uneven contraction of weld metal. This phenomenon is called Transverse distortion. Transverse distortion depends upon the extent of permanent contraction of the weld Zone.

Fig.2.19.Transverse Distortion

Angular Distortion

When two beveled plates are welded, it is found that the plates are pulled out of line with each other. Since the opening at the top of the single V groove is greater than at the bottom. A greater portion of the weld portion is deposited there and thus the drawing or pulling is greater at that side of the joint.

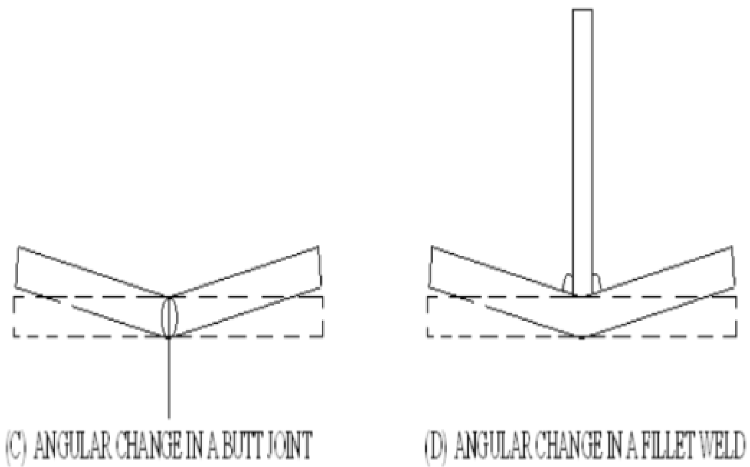


Fig.2.19.Angular Distortion

2.7.4.Control of Welding Distortion

- ✓ Joint Design
- ✓ Assembly weld Preheating
- ✓ Elastic pre-straining
- ✓ Pre-setting
- ✓ Back step welding
- ✓ Welding Sequence

Joint Design

Economic Design

- ✓ Fewest number of parts
- ✓ Minimum welding.
- ✓ For minimum weld metal use.
- ✓ Use double ‘V’ preparation instead of single ‘V’.
- ✓ Use J or U preparation.

- ✓ Root gap should be minimum.
- ✓ For fillet weld, weld size shall be smallest that meets the design requirement.
- ✓ Avoid over welding.

Assembly Weld

Large weldment can be broken into small sub-assemblies which can be welded without restraint. In this manner, distortion error can be rectified and finally, sub-assemblies are welded together using fixtures to form the main integrated structure. In this case, only the final welding is carried out under condition of restraint. Hence distortion is minimized.

Pre-Heating:

Preheating helps in reducing distortion by reducing temperature gradient.

- ✓ Elastic Pre-straining:
- ✓ Here the plates are bent elastically.
- ✓ Angular change can be reduced significantly after removal of the restraint.
- ✓ Shrinkage force is balanced with opposing force.

Back Step Weld

Weld bead increments are deposited in the direction opposite to the progress of the weld Due to small weld length degree of residual stress formed is much less.

Welding Sequence

An incorrect sequence causes distortion & sometimes cracks in the weldment due to stress concentration at some points. By using proper welding sequence the distortion can be reduced significantly. Proper welding sequence depend on the component being fabricated and therefore should be treated on its own merit & established by experiment. It is the order of making welds in a complex job involving a number of welds.

Correction of Distortion

- ✓ Mechanical methods are mostly used.
- ✓ In this process the member can be straightened with a press or a jack.
- ✓ Application of heat may be required in the localized area by using oxy-acetylene flame.

Self-check-2

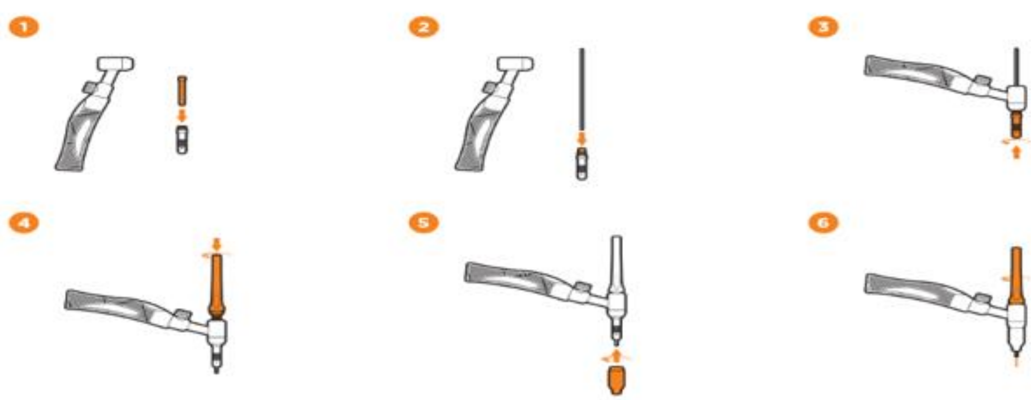
PART ONE:-Say True/False

1. The machine may appear to operate with an incorrectly connected ground wire operate properly
2. Warning indicator shows the approximate welding amps controlled by base current.
3. The gas outlet connects to the torch through the trigger controlled solenoid.
4. The amount of amperage determines the amount of heat in the arc.
5. GTAW uses two types of current.

PART TWO:-Choose the Correct Answers

1. Which one is not the types of TIG accessories and consumables?
   A. Auto-Silver Welding Helmet C. Tungsten Electrode
   B. Troches D. TIG Foot Pedal Control
2. One of the following is GTAW equipment.
   A. Gas cylinder C. Ground clamp
   B. Gas regulator D. All
3. Its GTAW equipment used to control the flow of gas.
   A. Gas regulator C. Foot pedal
   B. Welding torch D. Gas cylinder
4. One of the following is not the part of GTAW torch.
   A. nozzle C. Collet
   B. torch body D. foot pedal

PART THREE:-Write the name of Following Numbers.



Operation Sheet.2.1.

Tittle -Identifying and selecting welding machine settings, accessories and consumables

Instructions. Follow the following steps to identify the given task

Step1. Wear PPE

Step2. Prepare tools and equipment

Step3. Identifying welding machine accessories and consumable

Step4. Cleaning the work area.

Operation Sheet. 2.2.

Tittle- Adjusting current and voltage consistent with work requirements

Instructions: - Follow the following steps to identify the given task

Step1. Wear PPE

Step2. Prepare tools and equipment

Step3. Connect welding machine to in independent power supply

Step4. Select welding polarity (DCEN, DCEP&AC)

Step5. Connect to the welding machine

Step6. Connect the welding machine to the power sources

Step7. Adjust current and voltage

Step8. Cleaning the work area.

Task1. Identifying welding machine accessories and consumable

Task2. Connect welding machine to in independent power supply

Task3. Set welding polarity

Task4. Adjust current and voltage

Operation Sheet. 2.3.

Tittle: TIG equipment preparations

INSTRUCTIONS

Complete the following exercise without reference to your notes or the video. When you have completed the exercise check your answers / responses by:

- ✓ Referring to the notes.
- ✓ Reviewing the video material.
- ✓ Asking your Facilitator / Mentor

QUESTIONS	YES	NO
1. What do the letters "TIG" mean? ANS: ______________________________	○	○
2. What other letters also describe the TIG process? ANS: ______________________________	○	○
3. For which metal type is TIG particularly useful? ANS: ______________________________	○	○
4. Which component in the TIG system contains the metal "Tungsten"? ANS: ______________________________	○	○
5. What does the "Inert Gas" do in the process? ANS: ______________________________ ______________________________	○	○
6. What type of gas is most commonly used in the TIG process? ANS: ______________________________	○	○
7. List those units required to make up a full TIG welding system: i) ______________________________ ii) ______________________________ iii) ______________________________ iv) ______________________________	○	○

8. The electrons in an arc move in which direction? (tick applicable answer) a) From negative to positive pole. ☐ b) From positive to negative pole. ☐ c) In both directions. ☐	○	○
9. Approximately how much of the "arc-heat" is deposited by electrons onto the pole? (Tick applicable answer) a) 30%. ☐ b) 70%. ☐ c) 100%. ☐	○	○
10. Straight Polarity (DCSP) means what? (Tick applicable answer) a) Electrode positive. ☐ b) Electrode negative. ☐ c) Alternating current. ☐	○	○
11. Reverse Polarity (DCRP) means what? (Tick applicable answer) a) Electrode negative. ☐ b) Electrode positive. ☐ c) Alternating current. ☐	○	○
12. Which DC polarity would you use for maximum cleaning action? ANS: ____	○	○
13. What factor in the TIG arc is responsible for the "cleaning action"? ANS: ____	○	○
14. What "desirable features" does AC welding current provide? ANS: ____	○	○
15. What are considered "essential" items of PPE when using TIG? i) ____ ii) ____ iii) ____	○	○
16. What makes the TIG process “hazardous" in a confined space? ANS: ____	○	○

Operation sheet 2.4.

Tittle: TIG equipment

NSTRUCTIONS: complete the following exercise without reference to your notes or the video. When you have completed the exercise check your answers / responses by:

- ✓ Referring to the notes.
- ✓ Reviewing the video material.
- ✓ Asking your Facilitator / Mentor.

QUESTIONS	YES	NO
1. What two features must a welding machine have if you want to use it with TIG? i) ______________________________ ii) ______________________________	○	○
2. When connecting the welding leads to a DC machine to which "output connection" would you "normally" connect the "electrode lead"? ANS: ______________________________	○	○
3. When you have connected the electrode lead as answered in question 2 then you have set the welding current to what? (Tick the answers that relate) a) DCRP. ☐ b) DCSP. ☐ c) DCEN. ☐ d) DCEP. ☐	○	○
4. Which type of welding current is normally used when welding Aluminium? ANS: ______________________________	○	○
5. What are the 4 main functions of a TIG welding-torch? i. ______________________________ ii. ______________________________ iii. ______________________________ iv. ______________________________	○	○

6. Name the main parts of a typical TIG torch. 1) ____ 2) ____ 3) ____ 4) ____ 5) ____ 6) ____ 7) ____	○	○
7. In this country (South Africa) you will usually obtain electrodes colour coded red or white. What do these colours indicate? a) White electrodes are used with ________________ . b) Red electrodes are used with __________________ .	○	○
8. What is the purpose of a "regulator/flow-meter"? ANS: ____	○	○
9. Filler rods (or wires) suitable for TIG welding can be identified how? (give 2 answers) 1) ____ 2) ____	○	○

Unit Three: Pre Heating Tools/Equipment

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- ✓ Pre-heating equipment Setting up
- ✓ Equipment operation
- ✓ Tools and equipment

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- ✓ Pre-heating equipment set-up
- ✓ Equipment operation
- ✓ regular checkup of Tools and equipment

3. Pre Heating Tools/Equipment

3.1.Pre-Heating Equipment

3.1.1. Preheating

Preheating the aluminum work piece can help avoid weld cracking. The preheating temperature should not exceed 110°C (230°F). To prevent overheating, close control of temperature monitoring is advised. Use of a laser temperature indicator is very useful and recommended. In addition, tack welding the ends of the plate to be welded helps keep the heat within the work piece and makes the preheating more effective.

Why is preheat sometimes required before welding?

Preheating the steel to be welded slows the cooling rate in the weld area. This may be necessary to avoid cracking of the weld metal or heat affected zone. The need for preheat increases with steel thickness, weld restraint, the carbon/alloy content of the steel, and the diffusible hydrogen of the weld metal. Preheat is commonly applied with fuel gas torches or electrical resistance heaters.

The purpose of preheat:

- ✓ Reduce the risk of hydrogen cracking
- ✓ Reduce the hardness of the weld heat affected zone
- ✓ Reduce shrinkage stresses during cooling and improve the distribution of residual stresses.
- ✓ If preheat is locally applied it must extend to at least 75mm from the weld location and be preferably measured on the opposite face to the one being welded.

3.2.Equipment Operation

3.2.1.Introduction

Configuration In order to handle the TIG welding process and make it work to its full capability you need equipment consisting of different parts with their own separate function.

As we have seen the above lesson TIG welding equipment chiefly consists of:

- ✓ A TIG torch that is the tool the welder uses to control the arc.
- ✓ A power source which is capable of providing the necessary welding current.
- ✓ A TIG unit with incorporated control systems that make it possible to adjust the welding current, arc initiation etc.
- ✓ A shielding gas cylinder with pressure reducing valve and flow meter.

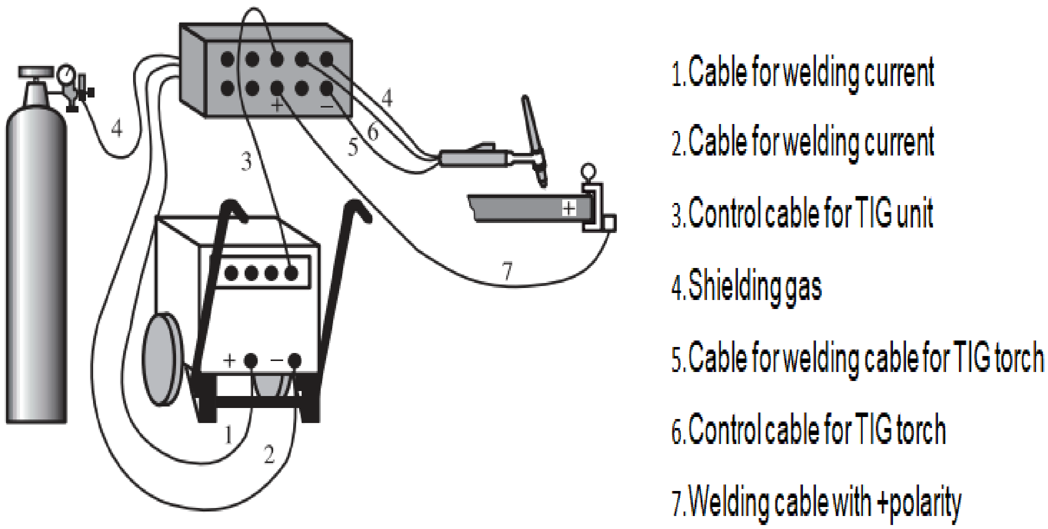


Fig.3.1. Example for configuration of welding equipment

Many TIG welding machines are constructed in such a way that the power source and the TIG unit are one unit.

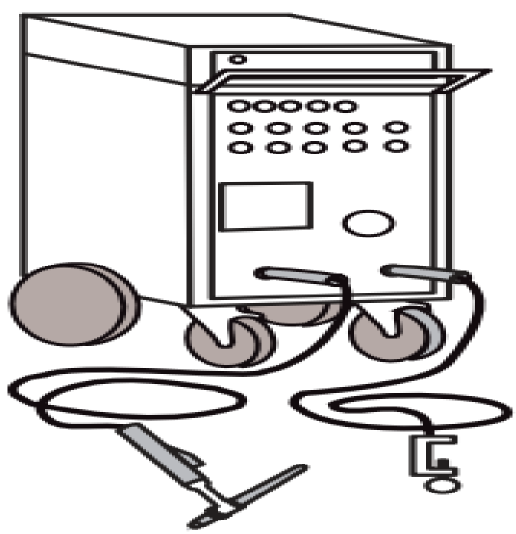
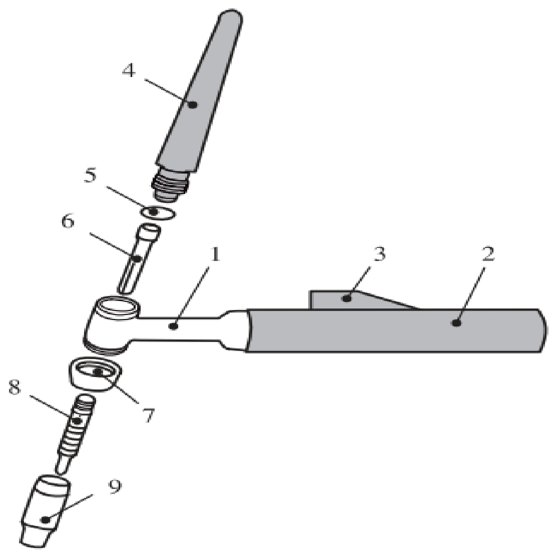


Fig.3.2. Power source and TIG unit in one unit

3.2.2.Drawing of TIG welding torch

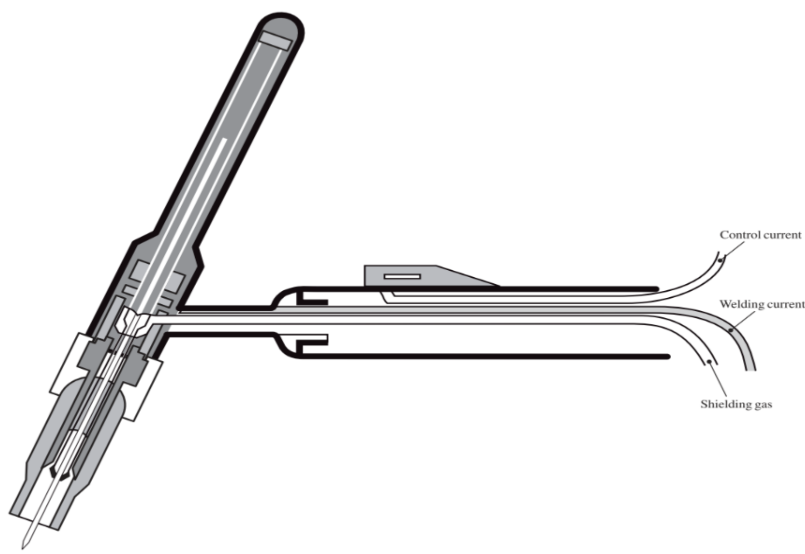
The main purpose of the TIG torch is to carry the welding current and shielding gas to the weld. The TIG torch is constructed on the basis of the welding handle and a torch head that is coated with an electrically insulated material. The torch handle is usually fitted with a switch to turn the welding current and the shielding gas on and off.



1. Torch head
2. Handle
3. Control switch
4. Electrode cap
5. Sealing ring
6. Electrode collet
7. Heat shield
8. Collet body
9. Gas nozzle

Fig.3.3. the correct draw of TIG welding torch.

TIG torches are available in many different sizes and designs according to the maximum required current loads and the circumstances under which the torch is to be used. The size of the torch will also depend on its cooling capacity during welding.



Cooling of the TIG Torch

Some torches are constructed in such a way that it is the flowing shielding gas that cools the torch. However, the torch also gives off heat to the surrounding air. Other torches are constructed with cooling tubes. Water-cooled torches are mainly used for welding with larger current intensities and AC-welding. Usually a water-cooled TIG torch is smaller than an air-cooled torch designed to the same maximum current intensities. Some of the new TIG torches also have a trigger on the torch handle for control of the welding current during welding

The Gas Nozzle

The function of the gas nozzle is to lead the shielding gas down around the welding zone and thereby replace the atmospheric air. The gas nozzle is screwed onto the TIG torch so it can be exchanged if required. It is usually made of a ceramic material able to stand the massive heat. The size of the gas nozzle is often indicated by a number that refers to the interior diameter of the orifice in 1/16”.

Example: A gas nozzle no. 4 has an interior diameter of 4/16” corresponding to 6.4 mm.

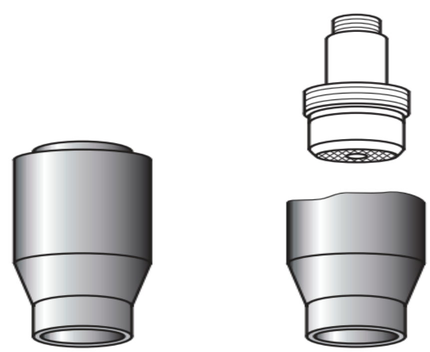


Fig.3.4. Common gas nozzle and gas nozzle with gas lens

Gas Lens

Another type of gas nozzle is the gas lens which is constructed in a way that the shielding gas passes through a wire grid in order to make the flow of gas more stable at a longer distance.

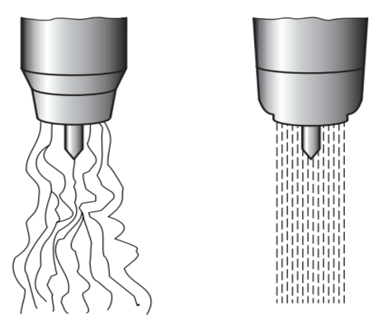


Fig.3.5. Flow of shielding gas

The advantage of the long gas flow is the fact that the electrode can have a longer stick-out thus allowing the welder to have a better view of the weld pool. By means of a gas diffuser it is also possible to reduce the consumption of shielding gas.

The Power Source

The power sources for TIG welding generally have an open circuit voltage of about 70 to 80 V. For welding with direct current a power source is used that rectify the alternating current of the mains supply of 400 V to the suitable output for the TIG process and at the same time changes the current intensity to the level set by the welder on the welding machine. Modern welding machines are capable of welding of welding either in a DC mode or some units provide both AC and DC modes.

3.3.Regular Check Up of Tools and Equipment's of TIG

- ✓ Remove contamination; clean surfaces
- ✓ Use of specific wire/gas mix for specific types of impurities
- ✓ Use proper wire
- ✓ Install wire-cleaning system
- ✓ Prevent industrial dust/dirt/grit from contaminating wire during storage or use
- ✓ Prevent build-up of aluminum oxide on exposed aluminum
- ✓ Protect weld from drafts (curtains/screens)
- ✓ Use tapered or bottleneck gas nozzles when drafts cannot be avoided
- ✓ Tighten all hose connection points
- ✓ Repair or replace equipment's
- ✓ Adjust mixer
- ✓ Repair leaks
- ✓ Overhaul system; fit filters and/or dryers
- ✓ Regulate pressure into flow meter for consistent cfh delivery of gas
- ✓ Clean nozzle and tip regularly; spray with anti-spatter fluid
- ✓ Replace nozzle
- ✓ Clean or replace
- ✓ Check duty cycle rating of torch
- ✓ Adjust speed

Self-Check-3

<u>PART ONE</u>:-Say True or False

1.Which one of the following shows the purpose of pre heating?

A. Reduce the risk of hydrogen cracking

B. Reduce the hardness of the weld heat affected zone

C. Reduce shrinkage stresses during cooling and improve the distribution stresses.

D. All

2.___ is an electric arc welding process in which the fusion energy is produced by an electric arc burning between the work piece and the tungsten electrode.

A. <u>TIG welding</u> C. Plasma welding

B. MIG welding D. SMAW welding

<u>PART TWO</u>: Matching

A.	B.
____1. Reduce the risk of hydrogen cracking	A. Gas Lens
____2. To make the flow of gas more stable at a longer distance	B. Gas Nozzle
____3. It help avoid weld cracking	C. Preheating
____4. Used to lead the shielding gas down around the welding zone	D. Regular Check Up

<u>PART TWO</u>:-Write the Short Answer

1. Write at List five advantage of TIG welding points. (5 points)
2. Write the limitations of the GTAW. (5 points)

Operation sheet. 3.1.

Tittle: - **Equipment Preparation**

Instructions

complete the following exercise without reference to your notes or the video. When you have completed the exercise check your answers / responses by:

- ✓ Referring to the notes.
- ✓ Reviewing the video material.
- ✓ Asking your Facilitator / Mentor

QUESTIONS	YES	NO
1. If you discover any fault with your welding equipment during the "pre-inspection", what must you do? ANS: ______________________________	◯	◯
2. Before you fit or swap the welding-cables what must you be sure to do? ANS: ______________________________	◯	◯
3. Why must "pin type connectors" be fully turned or twisted into their sockets? ANS: ______________________________	◯	◯
4. What is important when connecting the work-lead clamp to the work or a welding-bench? ANS: ______________________________	◯	◯
5. When "reading" a floating-ball type flow-meter the reading must be taken where? ANS: ______________________________	◯	◯
6. What "rule of thumb" is used when setting the "post-flow"? ANS: ______________________________	◯	◯
7. What type of electrode must you fit when you are using DC welding current? ANS: ______________________________	◯	◯

8. What type of electrode must you fit when you are using AC welding current? ANS: ______________________________	◯	◯
9. How do you determine the nozzle-size for a weld? ANS: ______________________________ ______________________________	◯	◯
10. Why must you not fit or use a nozzle that is cracked or has slag" inside it? ANS: ______________________________	◯	◯
11. How much protrusion, normally, must you allow the electrode beyond the nozzle? ANS: ______________________________	◯	◯

Unit Four: Tack Welding

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- ✓ Joints
- ✓ Root gap
- ✓ Alignment
- ✓ Backing plate, stiffener and running plate.
- ✓ Tack weld

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

make Joints free from rust, paints, grease and other foreign materials

- ✓ Make joints
- ✓ perform Root gap
- ✓ check Alignment
- ✓ Install Backing plate, stiffener and running plate are as required.
- ✓ perform Tack welding

3.3.1.

3.3.2.

3.3.3.

4.1.Make Joints

4.1.1. Butt Joint

It is a Joint between two members lying 65approximately in the same plane. A butt joint may be closed. (No root gap) or open (root gap present)

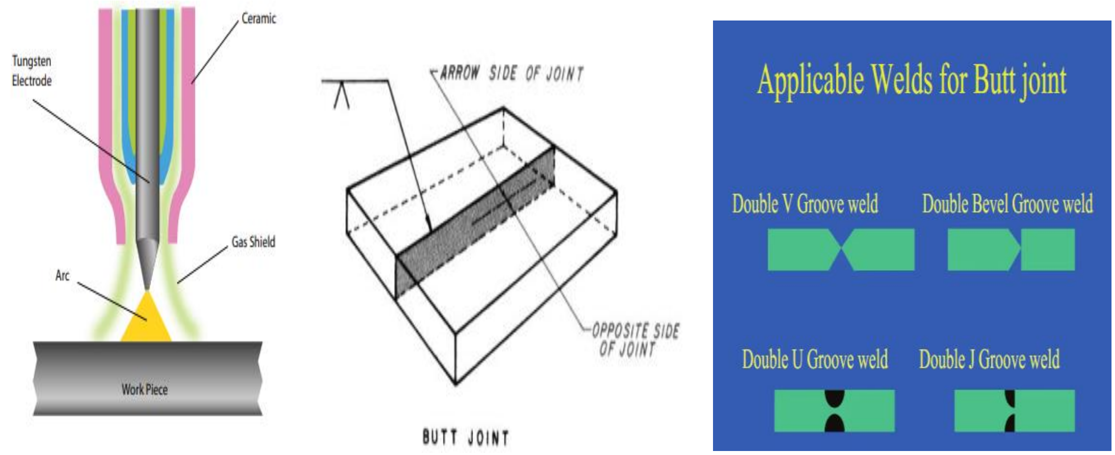


Fig.4.1. Butt Joint

4.1.2.Corner Joint

A joint between two members located approximately at right angles to each other in the form of a corner.

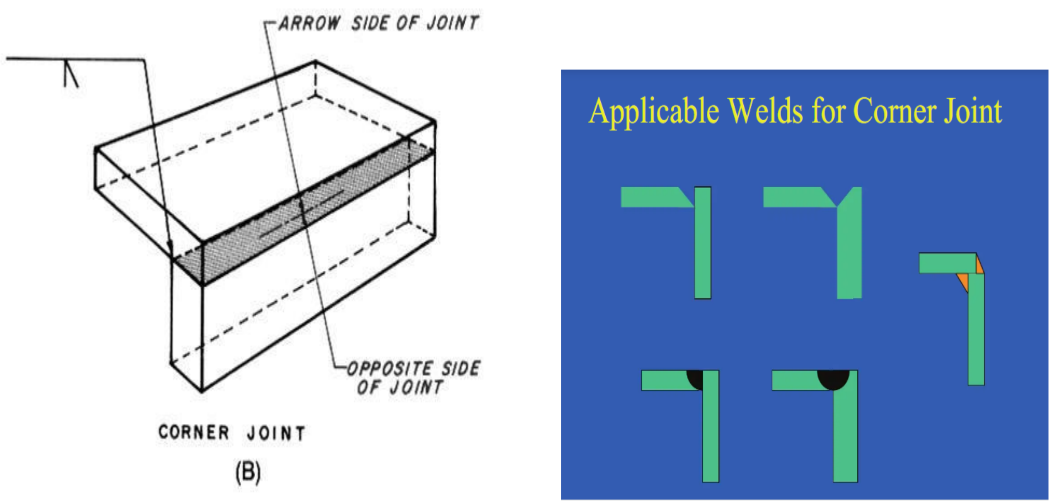
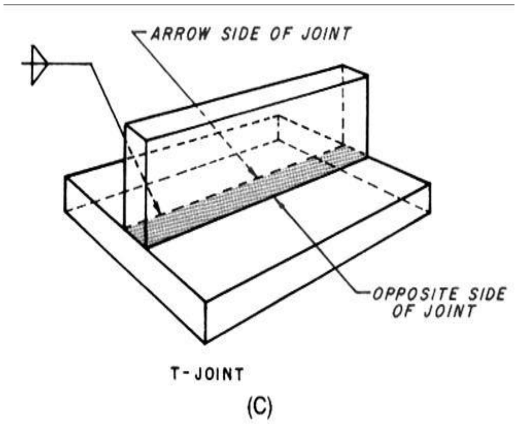


Fig.4.2. Corner Joint

4.1.3.Tee Joint

A joint between two members located approximately at right angles to each other in the form of a T.



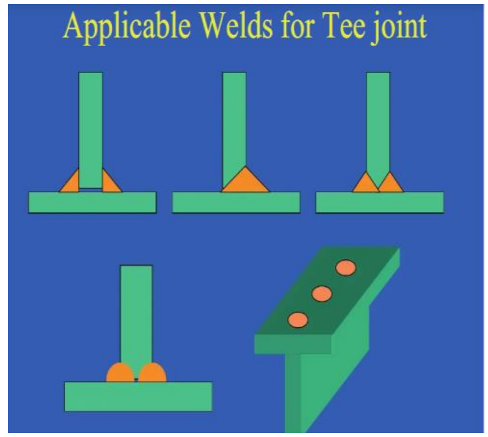
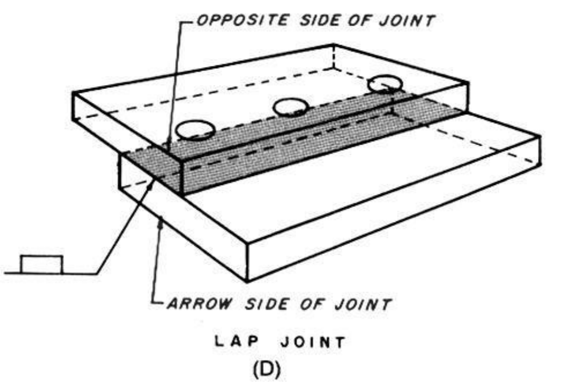


Fig.4.3. T-Joint

4.1.4.Lap Joint

It is a joint between two overlapping members.



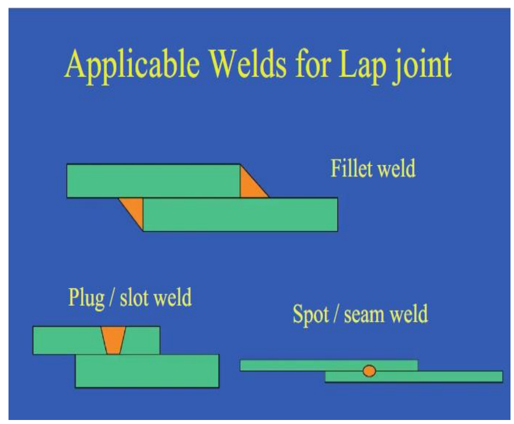


Fig.4.4. Lap Joint

4.1.5.Edge Joint

It is a joint between the edges of two or more parallel or mainly parallel members.

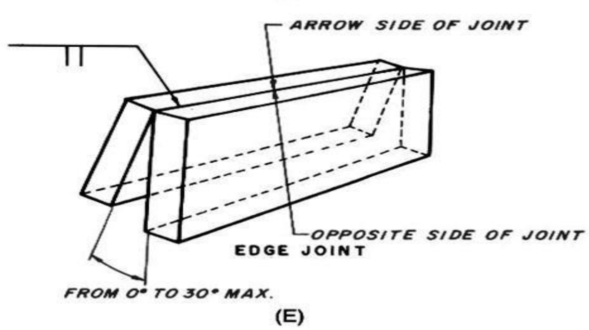
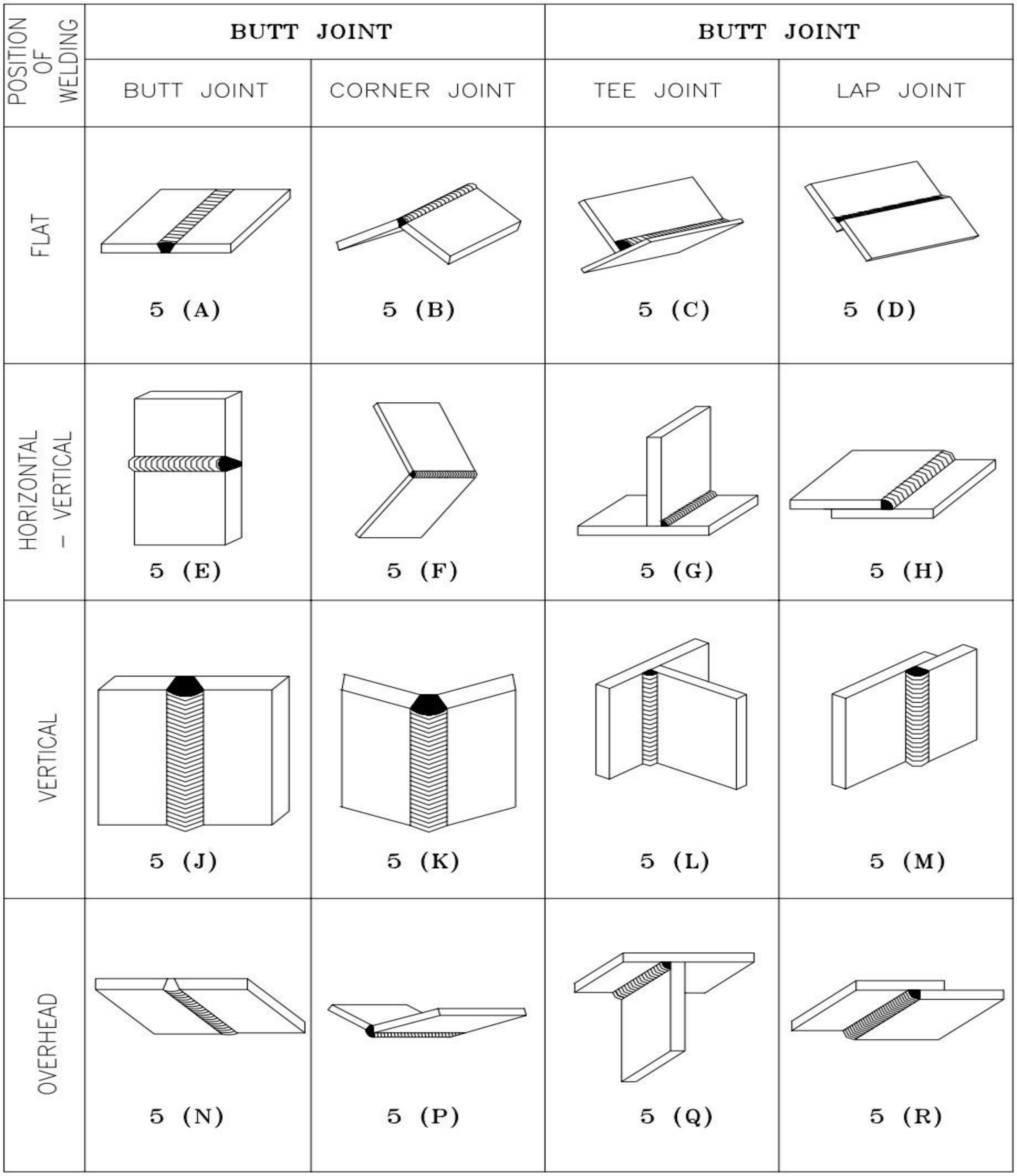


Fig.4.5. Edge Joint



POSITION OF WELDING

Fig.4.6. position of welding

3.3.4.

4.2.Root Gap

A root gap is provided to facilitate the escape of gases generating during the process to avoid defects of blow holes in welding. Also, the narrow opening at the bottom of the mating plates ensures the full penetration of the arc and profiled root bead penetration, which indicates a sound welding joint.

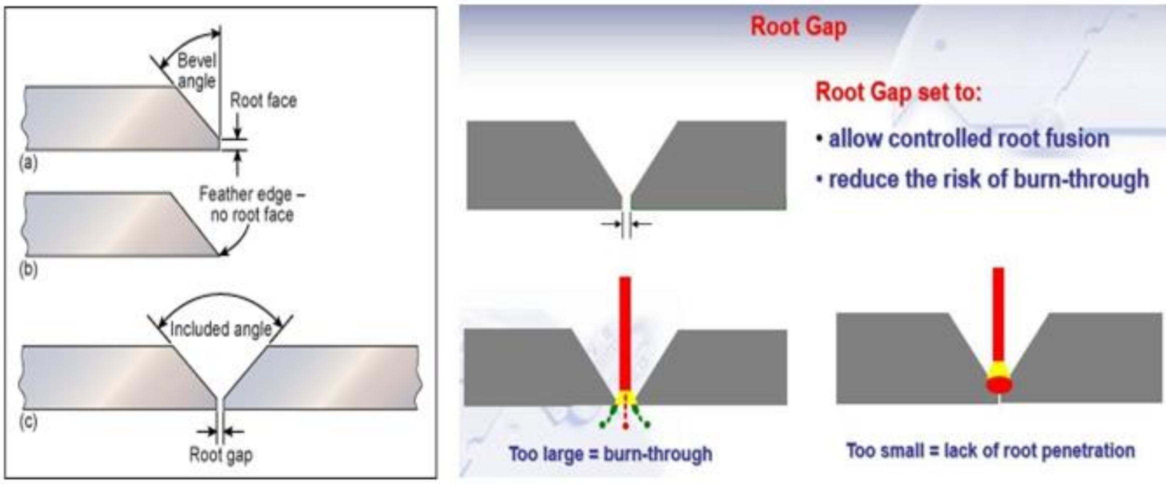


Fig.4.7. Root gap

4.2.1.Butt weld practice

The butt weld, typical forms of which are illustrated in below fig.4.8. is a simple and easily designed joint which uses the minimum amount of material. Figure also includes definitions of some of the features of a weld preparation such as 'root face', 'angle of bevel' and 'included angle'. Butt welds, as illustrated in Fig. , may also be classified as full penetration or partial penetration. With the conventional fusion welding processes of TIG and MIG penetration of weld metal into the surface of a flat plate from a bead-on-plate run is typically 3 mm and 6 mm respectively. To achieve a full penetration butt weld at thicknesses over these it is necessary for the two close square - butted edges to be beveled, although leaving a small gap between the edges will increase penetration. Typical weld preparations for the various processes will be found in the relevant process chapter. Butt joints may be single or double sided - if double sided it is often necessary to back-gouge or back-grind the first side to be welded to achieve a joint that is free of any lack of penetration.

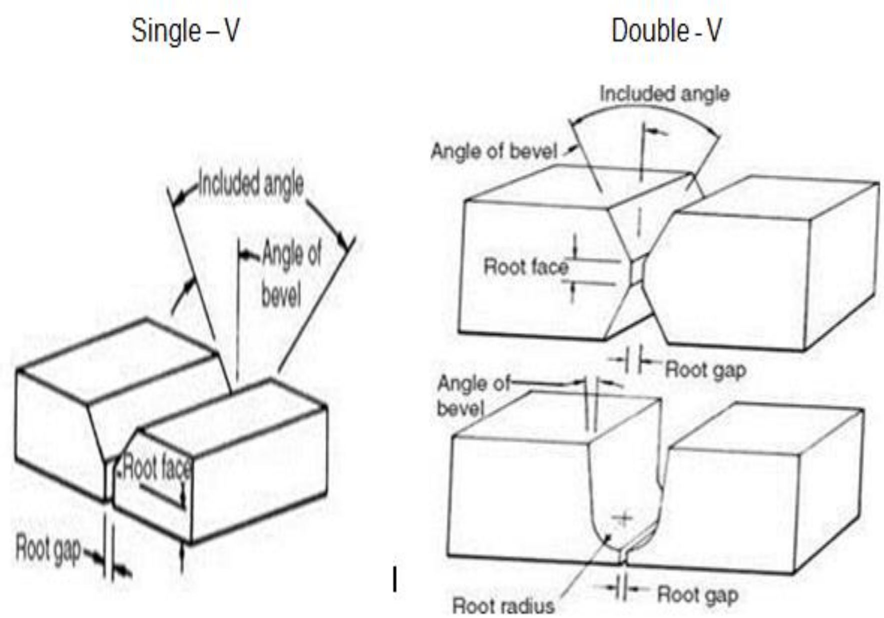


Fig.4.8. Butt Weld

Butt weld (joint)

A joint between two members aligned approximately in the same plane. Butt weld or groove weld is a weld made in the groove between two members to be joined as butt joint. Groove welds are also done on T fillet joints if the plate thickness is more than 12mm.

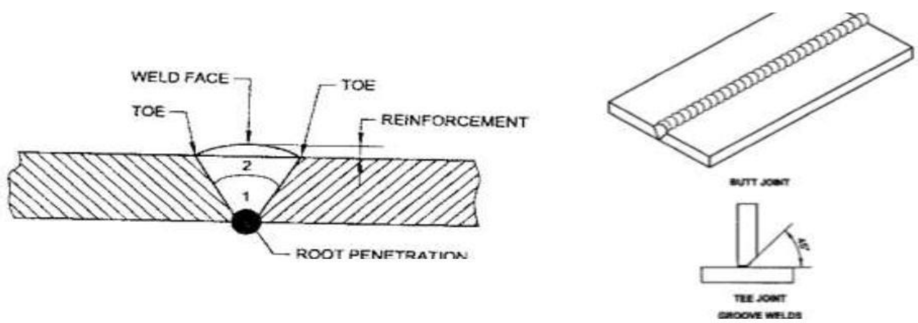


Fig.4.9. Butt weld joint preparations

PA	1G / 1F	Flat / Downhand
PB	2F	Horizontal-Vertical
PC	2G	Horizontal
PD	4F	Horizontal-Vertical (Overhead)
PE	4G	Overhead
PF	3G / 5G	Vertical-Up
PG	3G / 5G	Vertical-Down
H-L045	6G	Inclined Pipe (Upwards)
J-L045	6G	Inclined Pipe (Downwards)

Fig. 4.10. Butt Joint in Plate

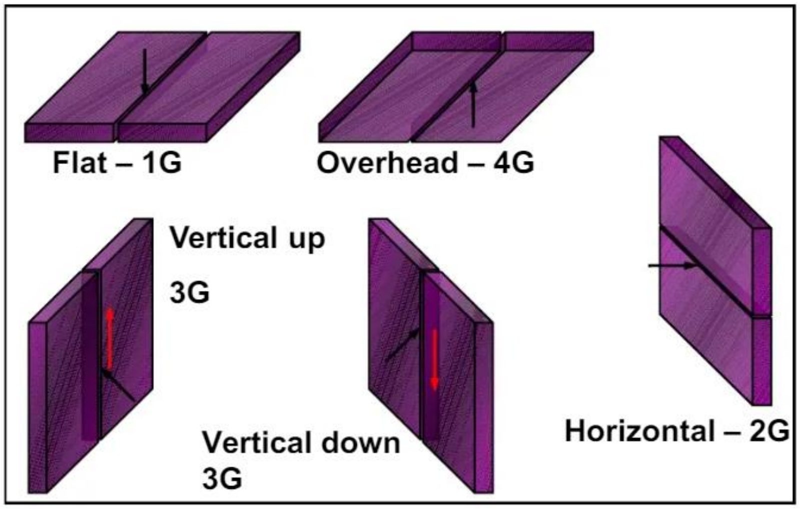
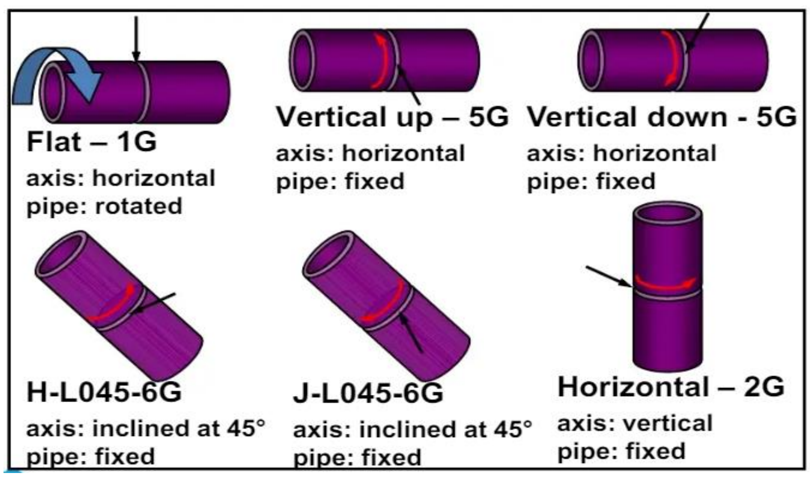


Fig. 4.11. Butt Joint in Pipe



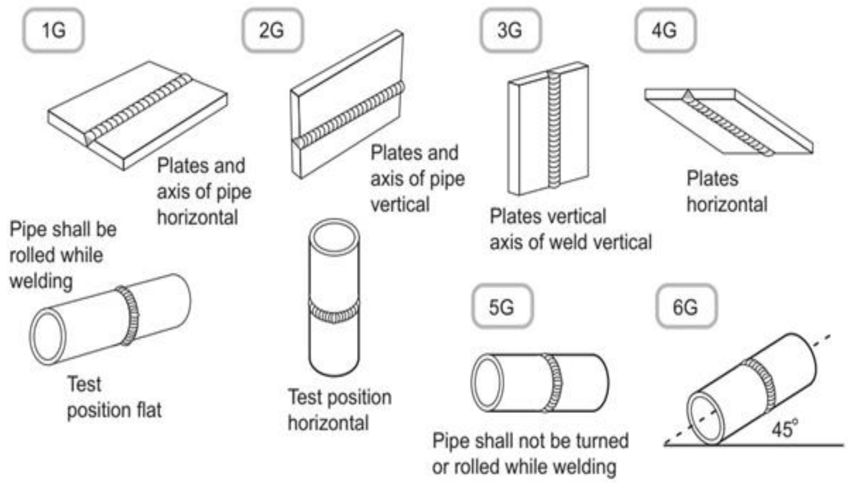


Fig.4.12. Butt weld terms

4.2.2.Fillet weld

A weld of approximately triangular cross section joining two surfaces at approximately right angles to each other.

Fillet weld is a weld, having a triangular cross-section, joining two surfaces at right angle to each other such as:

- ✓ Lap joint
- ✓ Tee joint
- ✓ Corner joint

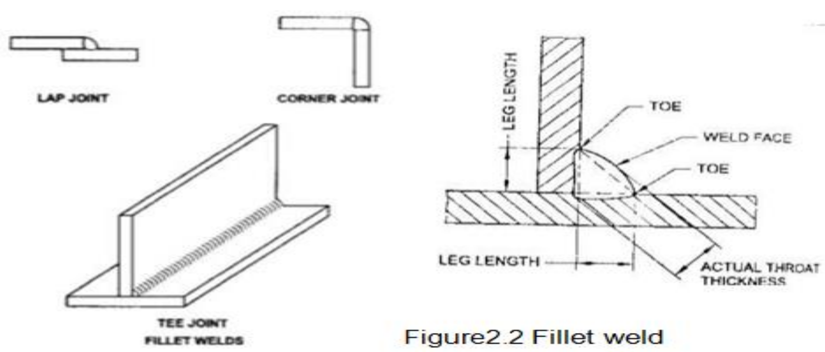


Fig.4.13. Fillet Weld on Plate

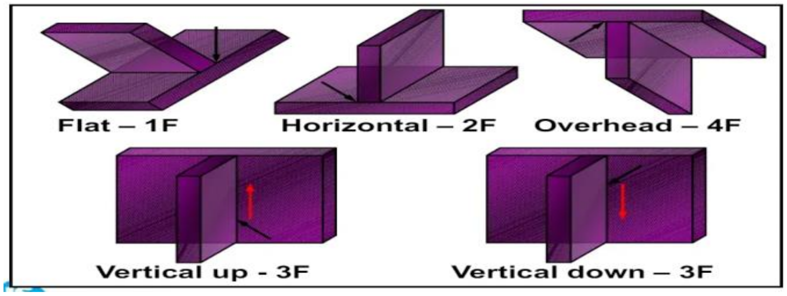
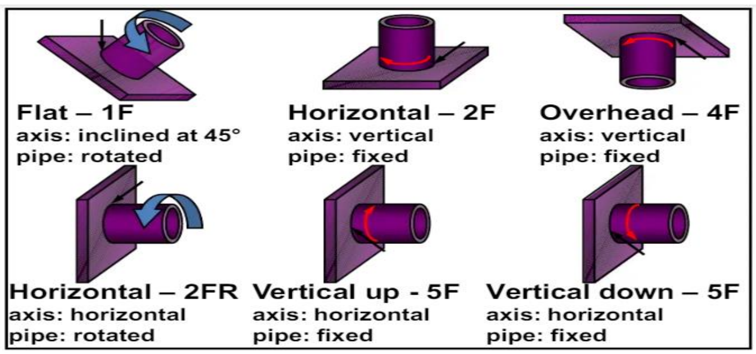


Fig.4.14. Fillet Weld on Pipe



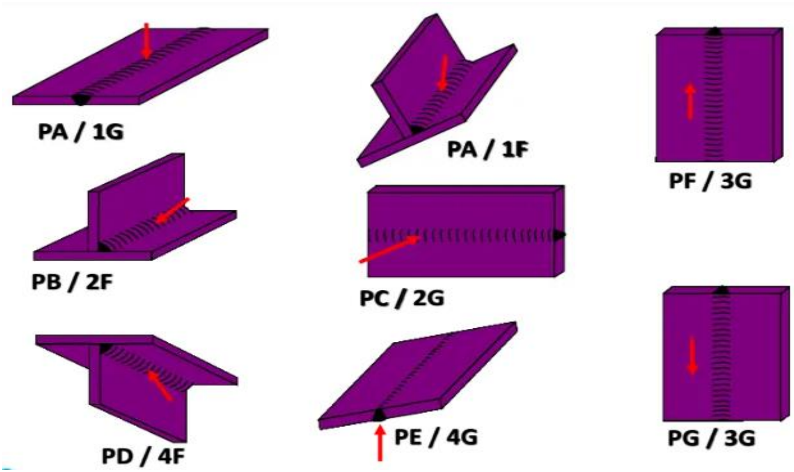


Fig.4.15 welding preparations of fillet joint

PA	1G / 1F	Flat / Downhand
PB	2F	Horizontal-Vertical
PC	2G	Horizontal
PD	4F	Horizontal-Vertical (Overhead)
PE	4G	Overhead
PF	3G / 5G	Vertical-Up
PG	3G / 5G	Vertical-Down
H-L045	6G	Inclined Pipe (Upwards)
J-L045	6G	Inclined Pipe (Downwards)

PA	1G / 1F	Flat / Downhand
PB	2F	Horizontal-Vertical
PC	2G	Horizontal
PD	4F	Horizontal-Vertical (Overhead)

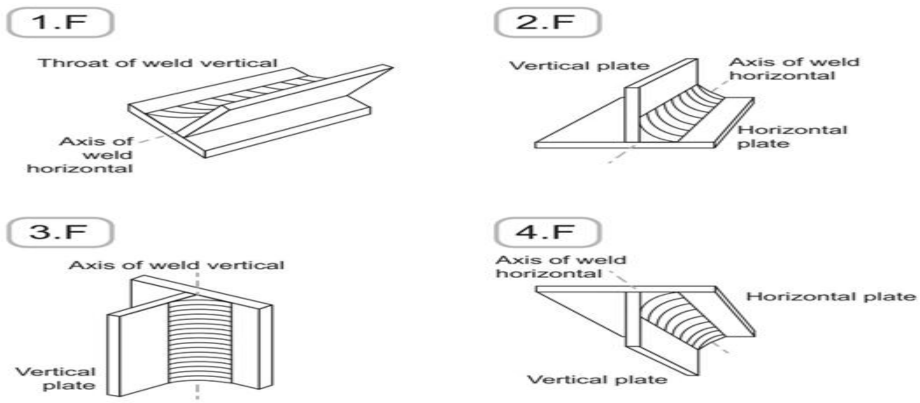


Fig.4.16. Fillet weld terms

4.3.Alignment

4.3.1.Alignment checks along the way (TIG)

I would like some input into alignment checks that occur along the way. What kind of things do you check and in what order to you join the tubes and make the checks? For my current build, the first step is the seat tube to BB joint. For this joint my tacking was short welds in the front and back. This is my third build and I am still trying to refine my process as I grow to understand the impact of weld sequence. After short tacking welds fore/aft I was 6mm out of alignment when measured at the end of the seat tube. The lean was towards the drive side. My weld along the non-drive side "pulled" the tube to be about 1mm off (it was off in the same direction). I did a second pass on the non-drive side to bring the seat tube to be 1mm off this time leaning away from the drive side. When welding the drive side I tried to go fast and after this was complete, the lean was 0.3mm towards the drive side. Is a 0.3mm alignment at this point in the process typical? I figure some things will change when I put the seat stays and chain stays in place, hopefully keeping an eye on this along the way will allow this bike to be built true. For my next step, is it better to attach the seat stays first or should I attach the chain stays prior to putting the seat stays on? The other option is to do the down tube/BB joint as the next step, so many options

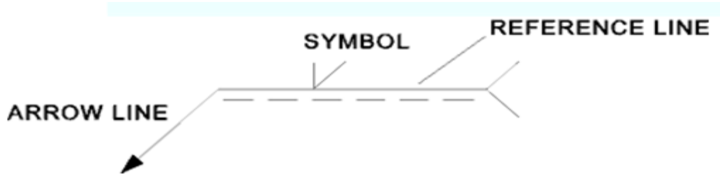
4.3.2.Drawing Standards and Weld Symbols

Standards

The British Standard for weld symbols is BS EN 22553.When identification of the weld process is required as part of the weld symbol the relevant weld process code is listed in BS EN ISO 4063.

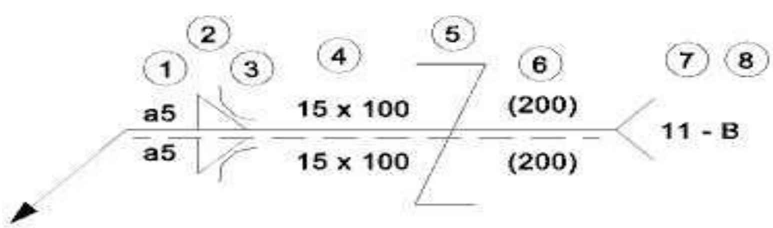
Basic Weld Symbol

- ✓ The weld symbol always includes
- ✓ An arrow line
- ✓ A reference line
- ✓ A symbol



Note: Weld symbols on the full reference line relates to welds on the near side of the plate being welded. Weld symbols on the dashed line relates to weld on the far side of the plate. If the welds are symmetrical on both sides of the plate the dashed line is omitted. If the dashed line is above the full line then the symbol for the nearside weld is drawn below the reference line and the symbol for the far side weld is above the dashed line

More Detailed Symbolic Representation of Weld

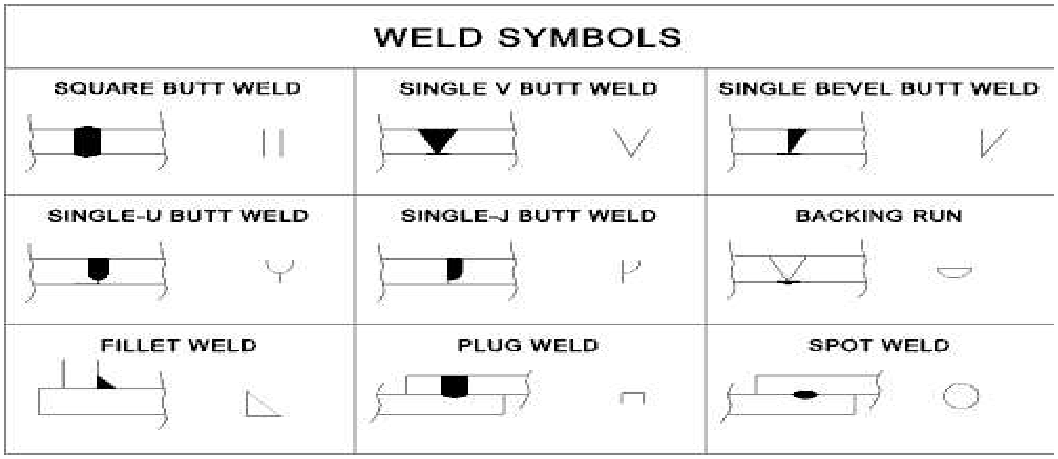


Information above reference line identifies weld on same side as symbolic representation
Information below reference line identifies weld on opposite side to symbolic representation.

1) Dimension referring to cross section of weld
2) Weld Symbol
3) Supplementary symbol
4) Number of weld elements x length of weld element
5) Symbol for staggered intermittent weld
6) Distance between weld elements
7) Welding process reference
8) Welding class

Welding.....Weld process numbers.

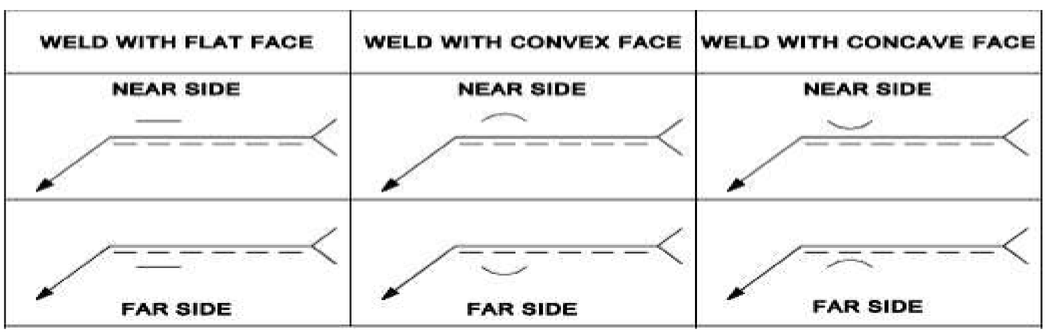
Table 4.1.Weld Symbols



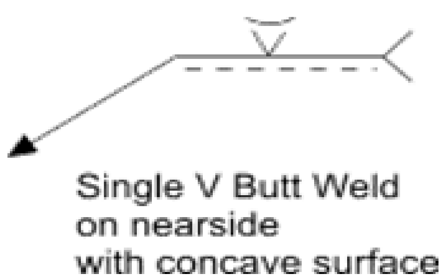
Supplementary Symbols

The weld symbols below are used in addition to the primary weld symbols as shown above. They are not used on their own.

Supplementary Symbols

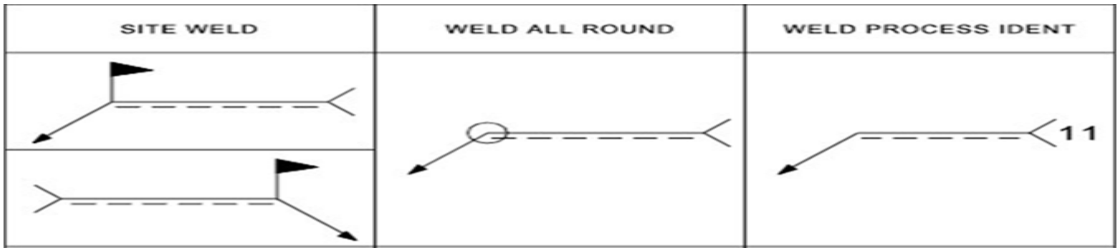


Below is an example of the application of this symbol.

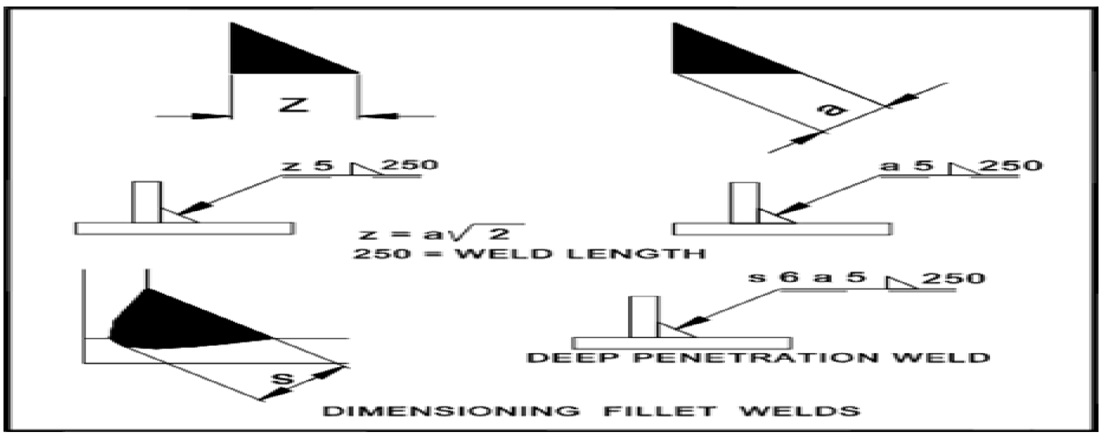


Complementary Indication

Complementary Symbols



Dimensioning Welds



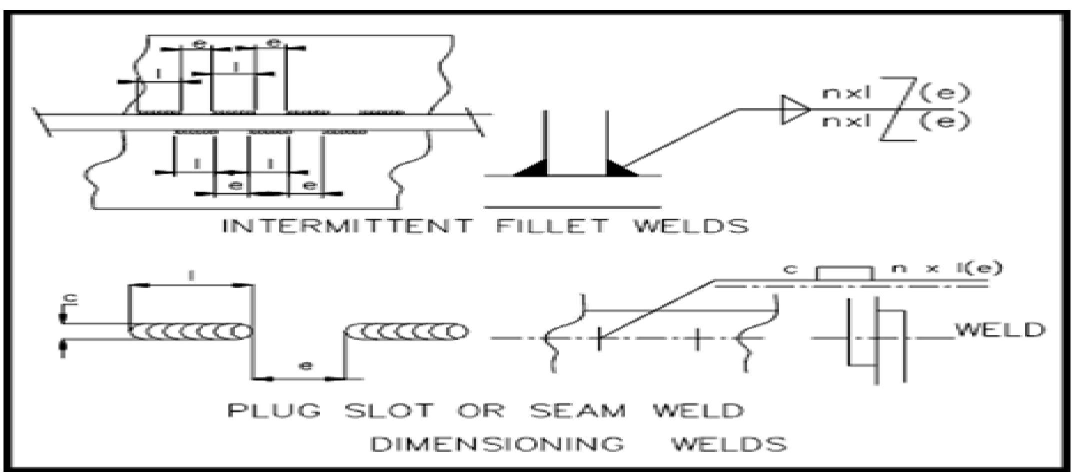
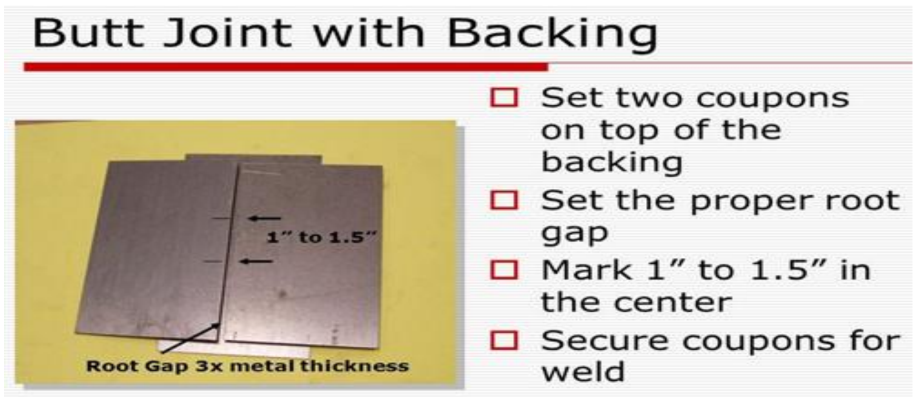


Fig.4.17. weld symbol

4.4.Installing Backing Plate, Stiffener and Running Plate

4.4.1.Backing plate

A permanent backing plate is a convenient way to ensure that the joint will have a complete weld through the section when you cannot access the other side or you would be forced to weld overhead.



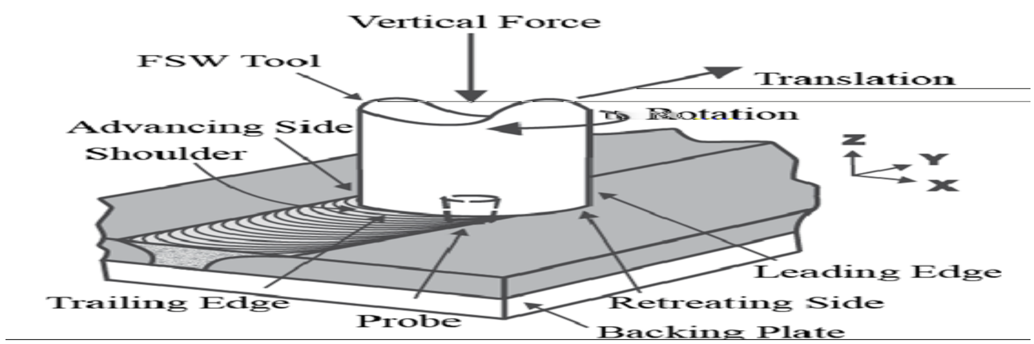


Fig.4.18. Backing plate

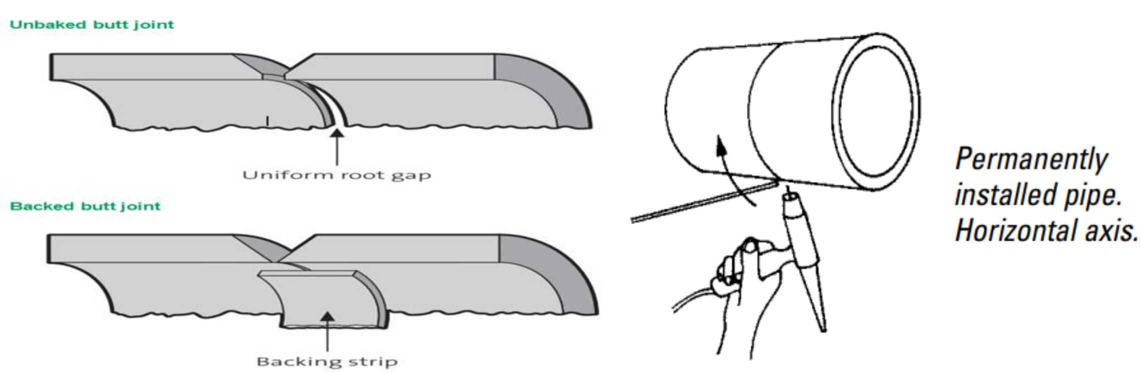


Fig.4.19. Backing strip and uniform

4.4.2.Stiffener and running plate

Longitudinal shrinkage in butt welded seams often results in bowing, especially when fabricating thin plate structures. Longitudinal stiffeners in the form of flats or angles, welded along each side of the seam are effective in preventing longitudinal bowing. Stiffener location is important: they must be placed at a sufficient distance from the joint so they do not interfere with welding, unless located on the reverse side of a joint welded from one side.

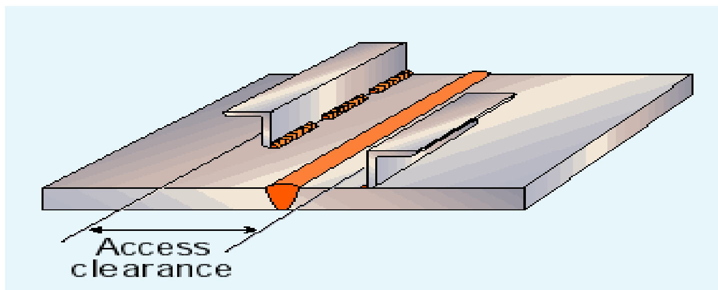


Fig.4.20. stiffener

4.4.3.Backing runs

Backing material is used to support the root run of a butt weld, or to provide a sound weld through the full plate thickness, when access is possible from one side only. To help reduce weld deposition rates complete penetration butt welds are often welded from both sides. The back of the first root run should be gouged and/or ground to clean metal to ensure complete penetration of the other side run.

4.4.4.Backing material

Permanent backing material is known as a backing strip. Temporary backing material is known as a backing bar. Backing strips are fused into the weld and should: Be no less than 3 mm thick and be of sufficient size to ensure they do not burn through. Have weld ability not less than that of the parent metal Fit as close as possible with a maximum gap between the parent metal and the backing strip of 1.5 mm.

4.5.Performing Tack Welding

4.5.1.Tack Welding

After items to be welded together have been positioned as required, generally by clamping them on suitable fixtures, tack welds are used as a *temporary* means to hold the components in the proper location, alignment, and distance apart, until final welding can be completed. In short-production-run manual welding operations, tack welding can be used to set up the work pieces without using fixtures. Typically, tack welds are short welds. In any construction, several tack welds are made at some distance from each other to hold edges together. An advantage of this *provisional* assembly procedure is that if the alignment for final welding is found to be incorrect, the parts can be disassembled easily, realigned, and tack welded again. In general, tack welding is performed by the same process that is used for the final weld. For example, aluminum-alloy assemblies to be joined by friction stir welding are tack-welded by the same process using a small tool developed for this purpose. Or electron beam tack welds, created with reduced power, are used to supplement or replace fixture and to maintain the correct shape and dimensions during final electron beam welding.

If the final welding is performed while the elements are still clamped in a fixture, tack welding must keep the elements in place and resist considerable stresses, not sufficiently contrasted by clamping devices that tend to separate the components.

- ✓ Temporary but very important
- ✓ Small enough to be welded over
- ✓ Strong enough to hold metal in position
- ✓ Position every 3-4 inches
- ✓ Tack all sides if possible.

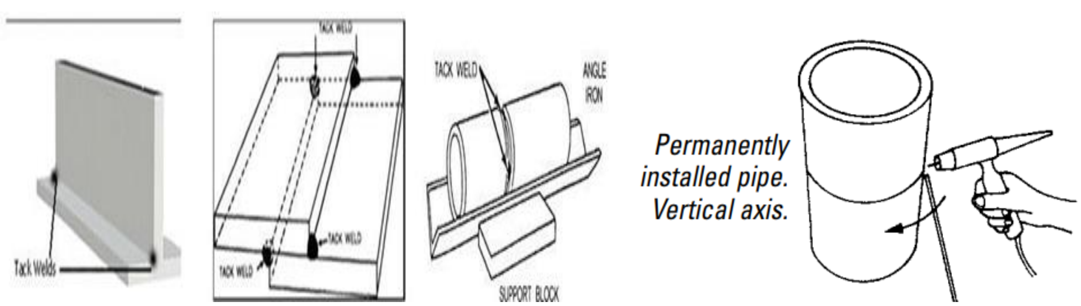


Fig.4.21.Tack Welding

4.5.2.Tack Welds Important

The temporary nature of tack welds may give the false impression that the quality of these auxiliary joining aids is not as important as that of final weld and that this operation doesn't have to be properly programmed, performed, and inspected. This is not true. Tack welding is real welding, even if the welds are deposited in separate short beads. It performs the following functions: Holds the assembled components in place and establishes their mutual location

- ✓ Ensures their alignment
- ✓ Complements the function of a fixture, or permits its removal, if necessary
- ✓ Controls and contrasts movement and distortion during welding
- ✓ Sets and maintains the joint gap
- ✓ Temporarily ensures the assembly's mechanical strength against its own weight if hoisted, moved, manipulated, or overturned

Self-check-4

PART ONE: - Say True/False

1. But joint is a temporary means to hold the components in the proper location.
2. Backing material is used to support the root run of a butt weld.
3. Backing plate is a convenient way to ensure that the joint will have a complete weld through the section.

PART TWO:-Choose the Best Answer

1. A joint between two members aligned approximately in the same plane. (2 points)

A. Butt weld (joint) C. A and B

B. Fillet weld D. All

2. A weld of approximately triangular cross section joining two surfaces at approximately right angles to each other. (2 points)

A. Butt weld (joint) C. A and B

B. Fillet weld D. All

Operation sheet-4.1.

Tittle: - "Fusion Run/weld

Instructions

when you have made a "successful" fusion run (bead) on 3 mm mild steel plate use the checklist below in order to assess the quality of your work.

CRITERIA	YES	NO
1. The run(s) follows the marked lines.	○	○
2. Runs are "clean" in appearance – no inclusions of oxide.	○	○
3. Uniform width (approximately 6 mm wide).	○	○
4. "Ripples" are uniformly spaced along the run.	○	○
5. Beads follow the scribed lines.	○	○

Operation sheet-4.2.

Tittle: - Stringer Bead

Instructions:-when you have made a "successful" stringer-bead on 3 mm mild steel plate, use the checklist below in order to assess the quality of your work.

CRITERIA	YES	NO
1. The bead is of uniform width @ approximately 6mm wide.	○	○
2. The bead is of uniform height.	○	○
3. The 'ripples' are consistent (evenly spaced).	○	○
4. The beads are on the line (straight).	○	○
5. Beads are free of contamination (oxide).	○	○

Unit Five: Weld Using TIG

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- ✓ Root pass
- ✓ filling passes
- ✓ Capping
- ✓ Weld Materials and deposit.
- ✓ Routine maintenance

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- ✓ performed Root pass and clean
- ✓ performed Subsequent filling passes
- ✓ performed Capping
- ✓ ensure Weld Materials and deposit using TIG process
- ✓ Routine maintenance on welding machine and work area

3.3.5.

5. Weld Using TIG

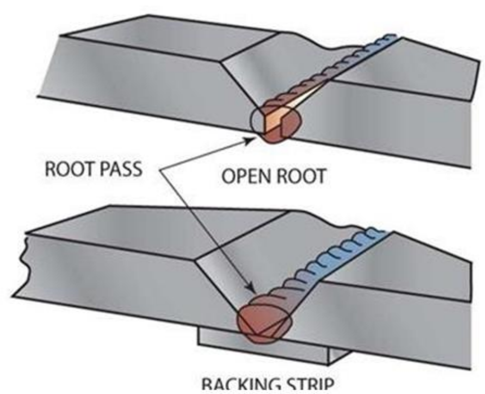
3.3.6.

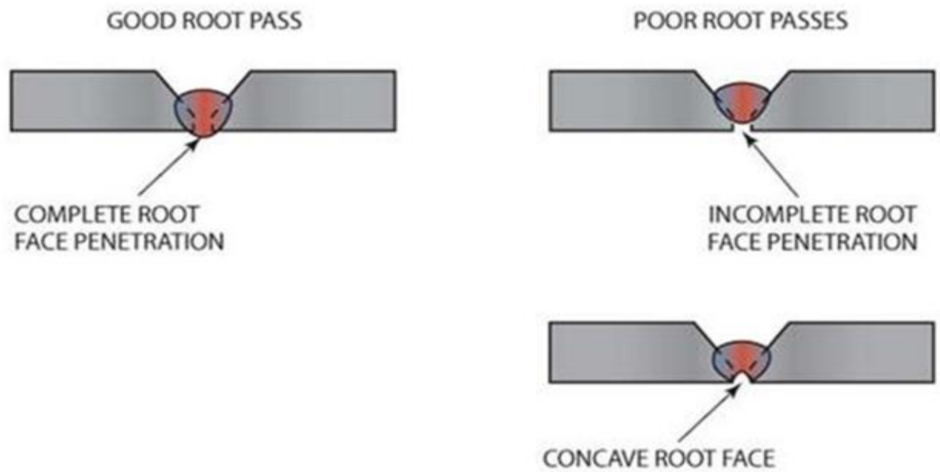
5.1.Root Pass

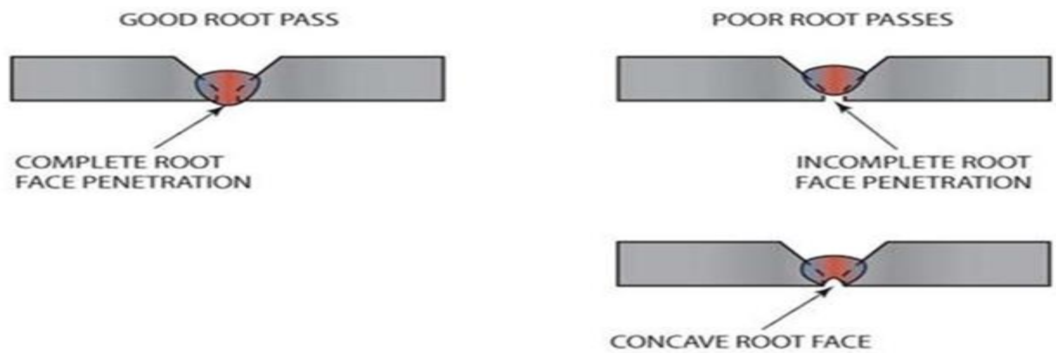
Root pass is a first pass welded to start weld. After that all passes are subsequent passes. You need to take smaller diameter electrodes for root pass while welding a bevel edged butt joint to prevent root face melt out. In some cases root pass requires some kind of Nondestructive testing.

5.1.1.Perform Root Pass

- ✓ 45 degree angle
- ✓ Adjust height of jig
- ✓ Ground clamp
- ✓ Hand tools needed
- ✓ Materials needed
- ✓ Notify the welding assessor that you are ready to start your root pass







Tips: - in perfuming root pass

- ✓ Make sure you can see the weld puddle
- ✓ Maintain a short arc and concentrate on the root gap
- ✓ Ensure root pass penetrations
- ✓ Point your rod to the center of the pipe to melt both edges
- ✓ Push the rod inside the pipe so the arc is in the inside when welding

Clean Root Pass

- ✓ Using the angle grinder clean root pass free from slag.
- ✓ Clean all trapped slag and porosity
- ✓ Redefine the groove face to serve as outline your filling pass
- ✓ Repair porosity or pinholes holes with electrode
- ✓ Clean root pass until shines

5.2.Filling Passes

5.2.1.Introduction

The first layer after the root run should be welded with the wire from the front of the electrode. For the other filling passes, the wire can be fed alternately from the front and back. The direction should be changed for each pass. This procedure can be pre-programmed. When the wire is fed behind the electrode, it is important that the wire in the exact position, otherwise it can touch the molten pool and stick. This can be avoided by making manual adjustments during the actual welding procedure. It is also possible to take this into account when programming the welding process. The arc voltage should normally be increased by 0.4 volts. The final filling pass is normally welded with weaving to obtain a low. Smooth transition between the pipes.

Fill – Also referred to as a fill pass, it is the amount of weld bead necessary to fill the weld joint. This pass comes after the root passes and before the cap pass.

5.2.2.Welding sequence

The sequence, or direction, of welding is important and should be towards the free end of the joint. For long welds, the whole of the weld is not completed in one direction. Short runs, for example using the back-step or skip welding technique, are very effective in distortion control (Fig. 1.1).

Back-step welding involves depositing short adjacent weld lengths in the opposite direction to the general progression.

Skip welding is laying short weld lengths in a predetermined, evenly spaced, sequence along the seam. Weld lengths and the spaces between them are generally equal to the natural run-out length of one electrode. The direction of deposit for each electrode is the same, but it is not necessary for the welding direction to be opposite to the direction of general progression.

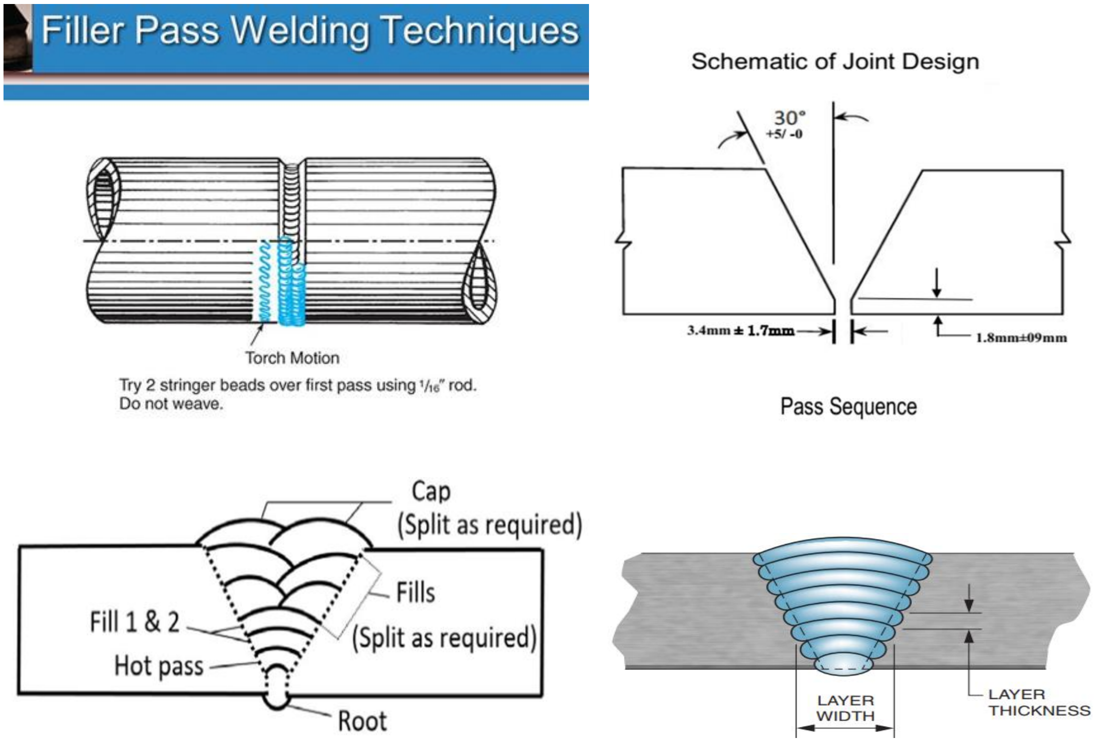


Fig.5.2. Fill **passes welding**

5.3. Capping

5.3.1.Capping with WPS

Cap welding is the common term used for the projection spot welding of the caps (or lids) on electronic packages. The process seems to be fairly straightforward: place components in a metal package and seal. Cap - the last bead of a groove weld, it can be made with a weave motion back and forth, or with stringer beads tied into each other. Also what you need to wear on your head when welding TIG. Vertical, or any process overhead, to keep hot sparks off of your head.

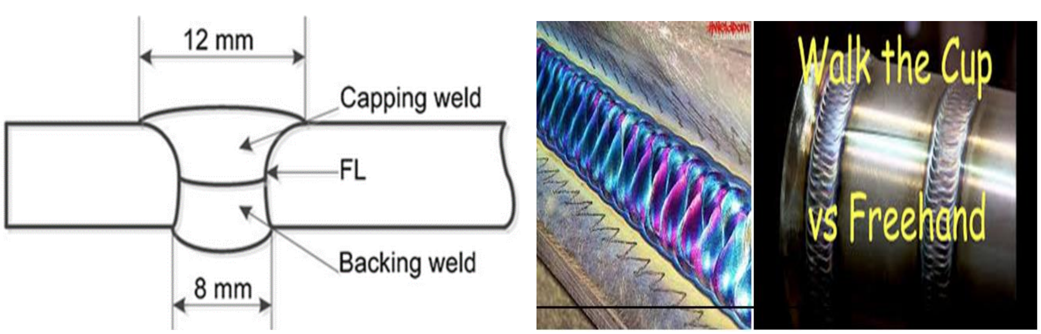
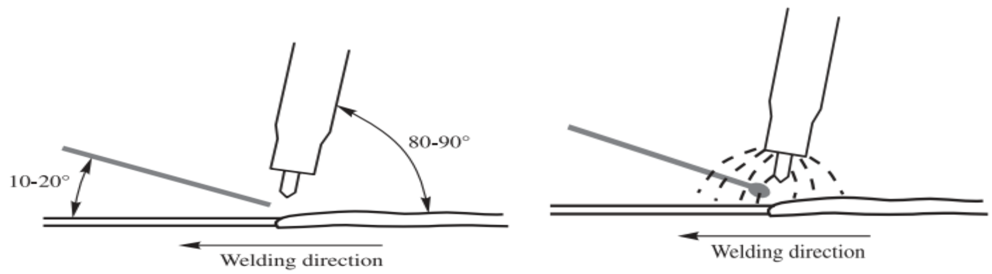


Fig.5.3. Capping

5.4.Weld Materials and deposit.

5.4.1.Welding Techniques

During welding the torch are guided forward at a lateral perpendicular angle of 80 to 90o in the welding direction. The filler wire are fed in step with the progressing welding in an angle of about 10 to 20o to the base material. The welding method is much like that of MIG/MAG welding, leftward welding with small dipping movements. During welding it is important that the filler wire is kept strictly within the gas flow from the gas nozzle. This will prevent the melting and still hot wire from oxidizing in connection with the atmospheric air.



Every form of oxidation and pollution of the filler wire will cause a contamination of the weld pool. It is therefore very important that the welder only uses clean filler materials that are not dirty, greasy or moist. Mostly grease and dirt will come from using dirty gloves. It is therefore a good idea to clean the filler wire with for instance acetone immediately before the welding starts. Grease and moisture both on the filler wire and on the base material may cause serious welding errors such as porosities, hydrogen cracks, etc.

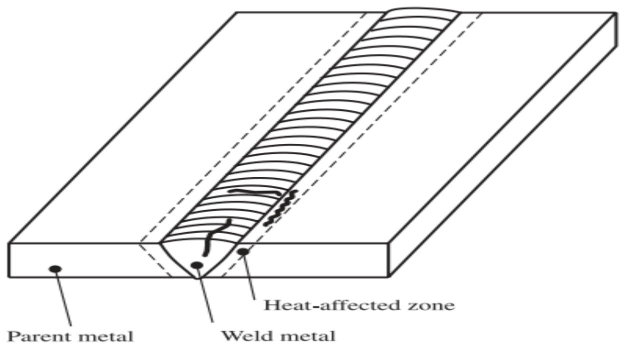
5.4.2.Errors in TIG Welding of Butt Welds

The types of errors are divided into the following six main groups:

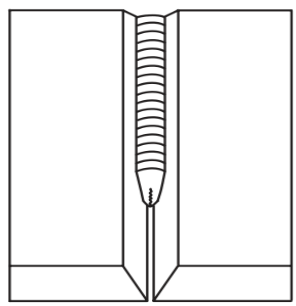
- ✓ Cracks
- ✓ Porosities
- ✓ Inclusions
- ✓ Lack of fusion and lack of penetration
- ✓ Imperfect shape
- ✓ Various errors that do not belong to any of the above groups.

Cracks

Cracks in connection with TIG welding are rarely seen, but may occur both as vertical or horizontal cracks. The cracks can occur in the weld metal, the heat affected zone or in the parent metal.



The most frequent type of cracks in TIG welding are cracks in the ending crater, the so-called crater cracks.

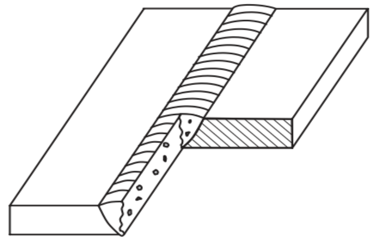


The reason for the formation of cracks can be:

- ✓ Wrong or no use of the slope-down facility
- ✓ Too small or too few stitches
- ✓ Wrong welding order
- ✓ Too rapid cooling of the weld zone
- ✓ Wrong or no pre-heating and post heating treatment

Cavities

According to DS/ISO 6520 cavities are defined as cavities in the weld due to entrapped gases. Cavities are often found in TIG welds due to the many possibilities for this error to occur.

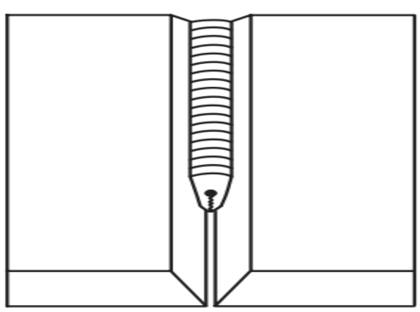


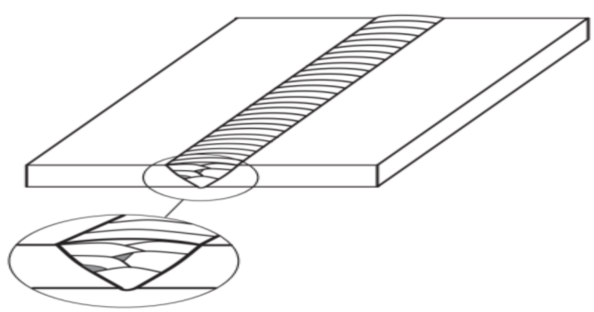
The reason for the formation of porosities can be:

- ✓ Lacking or impure shielding gas
- ✓ Inadequate cleaning of the groove edges and filler material
- ✓ Incorrect adjustment of the flow of shielding gas
- ✓ Wrong inclination of the torch
- ✓ Wrong size of gas nozzle
- ✓ Too quickly an interruption of the shielding gas by the end of a weld
- ✓ Draught caused by a wrongly placed exhaust unit
- ✓ Leaking hose connections
- ✓ Inadequate airing of the TIG torch before welding

Shrinkage Cavity

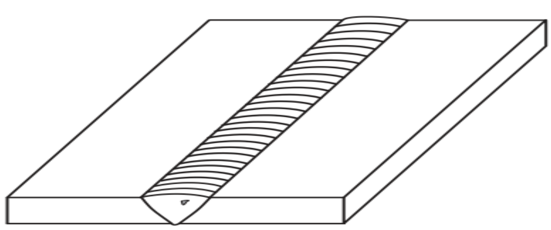
A shrinkage cavity is a cavity that occurs by the end of a weld





Metallic Inclusion

Inclusions of tungsten are a particular problem for TIG welding.



Lacks of fusion and penetration may be caused by:

- ✓ Too small current intensity
- ✓ Wrong inclination angle of the TIG torch
- ✓ Too much feeding of filler wire
- ✓ Too large dimension of filler wire

5.5.Routine maintenance

Welding machines must be blown out regularly to maintain reliable performance.

- ✓ Power sources.-Approximately every six months use clean, dry air to blow out.
- ✓ Load bank testing.
- ✓ Cable connections, cables and electrode holders.
- ✓ Guns.
- ✓ Cables and liners.
- ✓ Drive rolls.
- ✓ Water coolers.
- ✓ Gas hoses.

5.6.Welding Equipment Maintenance

Whether you're talking about an arc, gas, MIG or TIG welder, a little preventive maintenance will go a long way toward getting a long and productive life out of your welding equipment. With so many shops today having one or more welders, and most industrial plants employing welding equipment for maintenance and production, the need to maintain that equipment is greater than ever.

Welders can often costs thousands of dollars or more, and replacement parts can be scarce and quite expensive. So the maintenance of welding equipment is essential to keeping costs down and production going at optimum levels.

The maintenance of welding equipment will differ depending on the type of welder in question. Arc welder maintenance, for example, will depend on whether it's an AC or DC unit. And an ox fuel welder will require an entirely different maintenance program to keep it in good working order.

It's a good idea to set up a regular welder maintenance schedule and stick to all year round. This will ensure that your machine is kept in good operating condition at all times, and the equipment should last longer and need fewer costly repairs.

A good place to start is by thoroughly inspecting your equipment at least every 3 months. Clean all dust and dirt from the welding and other accessories, clean and lubricate the bearings with the proper grease, and check brushes to make sure they're making contact with the commutator. Also clean switches, connectors and relays on a regular basis.

5.6.1.A.C. Arc Equipment Maintenance

Here the type and level of maintenance of welding equipment depends on whether the motor generator is a transformer. With a transformer unit, the transformer will need to be cleaned at least twice per year by blowing it out with low pressure air hose. Then you'll want to tighten any loose electrical connections, and oil the bearings on the ventilating fans if never force the contact arms apart.

Fig.5.5. TIG welding machine

5.6.2.D.C. Arc Equipment Maintenance

With DC motor generator arc welders, a more extensive maintenance program is needed due to the fact that these units have more moving parts that are subject to additional wear.

At least once per week you'll want to inspect the brushes on the unit for wear. Replace any brushes that are short, cracked or brittle or worn. Always make sure the replacement brushes are of the same grade as recommended by the manufacturer. Also check the brush springs for to make sure they're not cracked or worn out. Another item to check is the color of the commutator a reddish or bluish tint indicates overheating. A deep brown color indicates a commutator in good operating condition. If the commutator is too badly worn, it may be necessary to turn the component on a lathe to bring it back into good operating condition.

Next you'll want to blow out the machine with a low-pressure air hose. Blow out the field coils, motor coils and the armature. Try to remove all dust, debris and metal filings from the machine. Lubricate any bearings or any other moving parts that require grease or oil. Replace any frayed or defective wiring, connections or insulation. Also check all the controls on the welder, making sure they're well-adjusted and functioning correctly.

Self-check-5

PART ONE: Multiple Choose

1. __approximately every six months use clean, dry air to blow out the inside of the Machine. (3 points)Guns. C. Cables and liners.

   B. Drive rolls D. Power sources

2. Welding equipment depends on whether the motor generator is a ____________. 3 points)

   A. Guns. C. Cables and liners.

   B. Drive rolls D. transformer

Unit Six: Quality Weld Conformance

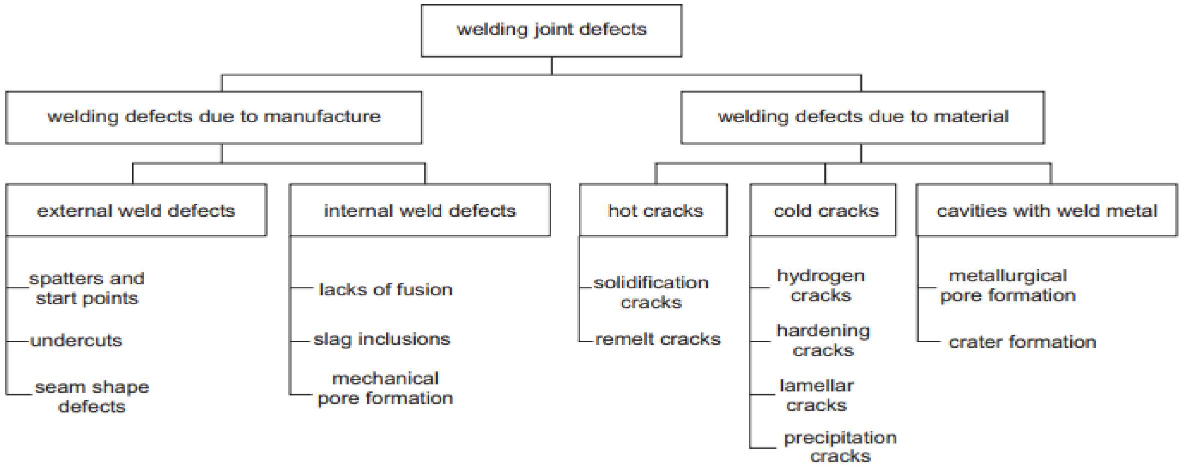
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- ✓ Weld Defects, Levels of Acceptance, and Inspection
- ✓ Weld records and completion details
- ✓ General OHS procedures

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- ✓ make Welded parts free from weld defects and inspect Weld joints
- ✓ complete and maintain Weld records and completion details
- ✓ observe OHS procedures are throughout this unit

3.3.7. 6.1. Welding Defects, Levels of Acceptance, and Inspection



3.3.8. 6.2. Weld Records and Completion Details

FORM QW-484A SUGGESTED FORMAT A FOR WELDER PERFORMANCE QUALIFICATIONS (WPQ)
(See QW-301, Section IX, ASME Boiler and Pressure Vessel Code)

Welder's name ______________ Identification no. ______________

Test Description

Identification of WPS followed ______________ ☐ Test coupon ☐ Production weld Date welded ______________

Specification and type/grade or UNS Number of base metal(s) ______________ Thickness ______________

Testing Variables and Qualification Limits

Welding Variables (QW-350)	Actual Values	Range Qualified
Welding process(es)		
Type (i.e.; manual, semi-automatic) used		
Backing (with/without)		
☐ Plate ☐ Pipe (enter diameter if pipe or tube)		
Base metal P-Number to P-Number		
Filler metal or electrode specification(s) (SFA) (info. only)		
Filler metal or electrode classification(s) (info. only)		
Filler metal F-Number(s)		
Consumable insert (GTAW or PAW)		
Filler Metal Product Form (QW-404.23) (GTAW or PAW)		
Deposit thickness for each process		
Process 1 ______ 3 layers minimum ☐Yes ☐No		
Process 2 ______ 3 layers minimum ☐Yes ☐No		
Position(s)		
Vertical progression (uphill or downhill)		
Type of fuel gas (OFW)		
Use of backing gas (GTAW, PAW, GMAW)		
Transfer mode (spray, globular, or pulse to short circuit-GMAW)		
GTAW current type and polarity (AC, DCEP, DCEN)		

RESULTS

Visual examination of completed weld (QW-302.4) ______________

☐ Transverse face and root bends [QW-462.3(a)] ☐ Longitudinal bends [QW-462.3(b)] ☐ Side bends (QW-462.2)

☐ Pipe bend specimen, corrosion-resistant weld metal overlay [QW-462.5(c)]

☐ Plate bend specimen, corrosion-resistant weld metal overlay [QW-462.5(d)]

☐ Pipe specimen, macro test for fusion [QW-462.5(b)] ☐ Plate specimen, macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result

Alternative Volumetric Examination Results (QW-191): ______________ RT ☐ or UT ☐ (check one)

Fillet weld — fracture test (QW-181.2) ______________ Length and percent of defects ______________

☐ Fillet welds in plate [QW-462.4(b)] ☐ Fillet welds in pipe [QW-462.4(c)]

Macro examination (QW-184) ______ Fillet size (in.) ______ × ______ Concavity or convexity (in.) ______

Other tests ______________

Film or specimens evaluated by ______________ Company ______________

Mechanical tests conducted by ______________ Laboratory test no. ______________

Welding supervised by ______________

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME BOILER AND PRESSURE VESSEL CODE.

Organization ______________

Date ______________ Certified by ______________

3.3.9. 6.3. General OHS Procedures

6.3.1. Safe Work Practices

A risk assessment is to be undertaken prior to a welding activity being carried out on site so as to identify the specific category of the welding area / environment, and to determine the necessary control measures to be implemented.

Note: Specialist welding and engineering workers may need to be sourced to assist in the determination of required welding and expected welding outcomes, (i.e. specific welds, welding techniques, inspections, etc.) as part of welding planning processes.

6.3.2. General Controls

During work tasks or when stored, welding leads, hoses, blowpipes, tips and nozzles are not to be left lying across workshop floors where they may be subject to damage and/or where they may create a trip hazard.

Specific manufacturer requirements for each welding apparatus or item of equipment are to be followed at all times. Where specific requirements or safety precautions are not known, workers are to seek advice from a competent person prior to undertaking the work.

Welding equipment and machines are to be manufactured in accordance with AS 60974.1:2006 Arc welding equipment Part 1: Welding Power Sources.

Welding machines are required to have a clearly visible and permanent name plate that provides legible information relevant to the operating conditions of the machine.

Welding machines must be within the current testing period. Attached to the machine will be a colored electrical test tag indicating the category it has been tested for and current and next test date.

All bottles, hoses and connections are to be checked to ensure that they are connected properly and ready for safe use prior to undertaking welding tasks.

Gas cylinders are to be restrained and secured against movement at all times during storage, transport and use, and are not to be positioned in an access way or traffic area. Gas cylinders are to be transported in accordance with the Australian Dangerous Goods Code 2011, and are not to be transported within closed vehicles.

Areas in which welding is undertaken are to be isolated through the use of translucent screens to reduce the impact of welding flash on persons working adjacent to the welding operations.

Prior to undertaking welding tasks outside workshops and designated areas on site, specific planning and controls as per OHS-PROC-128 Hot Work and the Safe Work System are to be implemented.

If during any welding task, a faulty or unsafe item of welding plant is identified, the piece being worked on becomes unsafe, or the environment becomes unsafe, the task is to cease until the equipment or situation is corrected and it is safe to re-start work.

6.3.3. Fire and Explosion Controls

During welding tasks, controls are to be implemented to prevent fire and explosion as a result from: sparks and hot metallic particles and slag being generated that can cause combustion and shouldering of adjacent materials; electrode stubs that remain at high temperatures; gas leakages, improper use of oxygen and unsafe equipment; pierced or cut pressure hosing by sharp objects; burning of hosing by sparks, flame or hot slag; heating of gas cylinders; welding and cutting containers and piping that contain unknown gases / substances capable of causing ignition or explosion; burning or cutting through walls and partitions; poor electrical connections; and

Igniting metallic and non-metallic dusts capable of causing fire or explosions. Note: The draining or opening of lines containing flammable substances and materials may also need to be supplemented by specific cleaning, rinsing and purging actions prior to work. Flash back arrestors, suitable for the types of equipment used are to be fitted into both oxygen and fuel gas lines: between the blowpipe and hose; and at the regulator outlet. Welding tasks that are required to be undertaken in, or adjacent to, a hazardous area on site must have the appropriate controls in place.

6.3.4. Fume Inhalation Controls

The type of welding and the work pieces being used dictate the various types of fumes that may be produced. During welding a range of metal oxide fumes and gases such as carbon dioxide, carbon monoxide, nitrogen oxide, ozone, argon and helium, are the principle constituents that may be produced. Specific precautions need to be taken during aluminum welding and tasks that may produce high levels of ozone, nitrogen, and oxides of aluminum, zinc and copper, including the use of suitable respiratory protective equipment.

Adequate ventilation and fume controls (natural ventilation, local exhaust ventilation or mechanical dilution ventilation) are to be ensured whenever welding tasks are being undertaken.

Where a welding product is also a hazardous chemical, the Safety Data Sheet (SDS) for the product is to be provided. Refer to Hazardous Chemicals OHS-PROC-108, for further information regarding hazardous chemical use.

Extraction systems and fans, both fixed within workshops and mobile units, are to be used wherever practicable to reduce the likelihood of workers breathing in fumes and other particulates. Air-supplied welding hoods are also to be used to supplement the above mentioned ventilation and extraction methods where fumes cannot be adequately drawn away from the breathing zones of workers.

Where the following types of welding tasks are performed, additional information and verification is to be sought, as deemed necessary, from competent persons, the Health and Safety team, suppliers and / or welding documentation to ensure appropriate controls are implemented: during the grinding of tungsten rods where dust may be inhaled; during the MIG welding of high grades of stainless where chrome VI may be inhaled; during welding tasks involving ‘exotic metals’ where quantities of such constituents improve the performance of high-pressure systems or those that require a high level of chemical resistance;

during the welding of items covered or surrounded in coatings, paints, teflon, etc. where toxic compounds in a gas form may be inhaled that are not able to be blocked by particulate respirators.

6.3.5. Electrical Safety

General Control’s

Electrodes and work pieces are to be considered electrically ‘live’ at all times.

During manual metal arc welding and arc-air gouging, the welder often frequently changes electrodes while the electrode holder is live. Fuses or earth leakage contact breakers do not protect the welder from such a hazard. Therefore, workers are to take every precaution to ensure they do not simultaneously touch the electrode and the work piece or steel work in the welder return path.

Note: Hazard reduction devices (HRD) must be fitted on Category B and Category C welders which can be either a voltage reduction device (VRD) or a hand piece trigger switch. Remote isolation devices (RID) should also be fitted to the arc welding units and used wherever practicable by SCL workers and contractors to minimize the electrical hazards during arc welding tasks.

Faulty lead insulation and faulty insulation on the electrode holder or torch is also a common way in which electrocution may occur, therefore workers are to inspect their equipment to ensure that it is safe to work with prior to commencing welding tasks.

Where practicable, measures are to be taken to ensure that live welding leads are not dragged on the ground during work and / or that they are protected against damage.

The work area and piece(s) being welded are to be made dry and electrically safe as best as possible by using dry, fire-resisting insulation. Wooden duckboards, leather covered cushions, leather aprons and / or heat resistant blankets etc. may be used to achieve this.

Areas where welding tasks are to be undertaken are to be made and / or kept as dry and cool as possible.

In hot conditions or where high levels of perspiration may occur, suitable ventilation, regular rest breaks and glove / clothing changes are to be implemented as required and as practicable during the work.

Other electrical requirements include, but are not limited to: equipment is to be connected through a residual current device or safety switch; equipment, welding devices, leads and connections are to be checked and inspected prior to work to ensure that they are safe; when not in use, electrode holders and torches are to be placed in a location where they cannot make electrical contact with persons or the work piece / conductive objects; all equipment is to be turned off or disconnected, and manual metal arc welding (MMAW) electrodes and stubs removed from electrode holders, when not in use;

manufacturer's instructions regarding electrical precautions for all equipment is to be implemented at all times; electrical and welding equipment is not to be used in a wet environment; unauthorized repairs or modifications (other than those by the manufacturer or SCL authorized electrician for electrical work tasks) on electrical and welding equipment is not to be undertaken; and

Extension cords and return leads are not to be left across access ways.

6.3.6. Personal Protective Equipment (PPE)

The level of PPE required is to be determined through the risk assessment process, however the following minimum PPE is to be worn at all times by workers when undertaking welding tasks on site:

- ✓ welding gloves - dry and hole free;
- ✓ fireproof / protective clothing;
- ✓ welding helmet or face shield;
- ✓ goggles or safety glasses with side shields;
- ✓ suitable respirator (where relevant); and
- ✓ Rubber soled boots (without bare steel toe caps).

Note: Refer also to Personal Protective Equipment (PPE) OHS-PROC-30, for further information regarding PPE requirements.

6.3.7. Training and Competency

All workers involved with welding and welding tasks including those assessing and inspecting finished welding and welding standards are to be deemed competent. This may be evident through the verification of completed trade / welding certificates and training courses.

Self-check-6

PART ONE: - Say True/False

1. Electrodes and work pieces are to be considered electrically ‘live’ at all times.
2. Areas where welding tasks are to be undertaken are to be made and / or kept as dry and cool as possible
3. Adequate ventilation and fume controls (natural ventilation, local exhaust ventilation are to be ensured whenever welding tasks are being undertaken.

Reference

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