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HYDROCARBON SECTOR
SKILL COUNCIL

Participant Handbook

Sector
Hydrocarbon

Sub-Sector
Midstream

Occupation
Construction & Services

Reference ID: **HYC/Q9101**
NSQF level: 4

Version No.: **8.0**

Industrial Welder (Oil & Gas)

This book is sponsored by

Hydrocarbon Sector Skill Council

OIDB Bhawan Tower C, 2nd Floor, Plot No. 2, Vikas Marg, Sector 73, Noida 201301 (UP)

Printed in India at

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If we have to move India towards development then Skill Development should be our mission."

Shri Narendra Modi
Prime Minister of India

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HYDROCARBON SECTOR SKILL COUNCIL

for

SKILLING CONTENT : PARTICIPANT HANDBOOK

Complying to National Occupational Standards of

Job Role / Qualification pack: **"Industrial Welder (Oil & Gas)"** QP No. "HYC/Q9101, **NSQF Level 4"**

Date of Issuance: March 31st 2017
Valid up to*: March 31st 2019

*Valid up to the next review date of the Qualification Pack or the 'Valid up to' date mentioned above (whichever is earlier)

Authorised Signatory
(Hydrocarbon Sector Skill Council)

Acknowledgements

HydroCarbon Sector Skill Council (HSSC) would like to express its gratitude to all the individuals and institutions who contributed in different ways towards the preparation of this "Participant Handbook". Without their contribution it could not have been completed. Special thanks are extended to those who collaborated in the preparation of its different modules. Sincere appreciation is also extended to all who provided peer review for these modules.

The preparation of this manual would not have been possible without the HydroCarbon Industry's support. Industry feedback has been extremely encouraging from inception to conclusion and it is with their input that we have tried to bridge the skill gaps existing today in the industry.

This participant manual is dedicated to the aspiring youth who desire to achieve special skills which will be a lifelong asset for their future endeavours.

About this Book

This Participant Handbook is designed for providing skill training and /or upgrading the knowledge level of the Trainees to take up the job of an "Industrial Welder" in the Hydrocarbon Sector.

This Participant Handbook is designed based on the Qualification Pack (QP) under the National Skill Qualification framework (NSQF) and it comprises of the following National Occupational Standards (NOS)/topics and additional topics.

- Introduction to Welding
- HYC/N9101 General Work Shop Practice Followed In The Shop Floor
- HYC/N9102 Welding Using Manual Metal Arc welding/Shielded Metal Arc Welding.
- HYC/N9103 Manually (semi-automatic) Welding Joints Using The MIG/MAG
- HYC/N9104 Perform Manually Welding Joints Using The TIG (GTAW) Process
- HYC/N6103 Work Effectively In A Team
- HYC/N6104 Follow Health, Safety And Security Procedures

Symbols Used

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It is recommended that all trainings include the appropriate Employability Skills Module Content for the same is available here:

https://www.skillindiadigital.gov.in/content/list

1. Introduction

Key Learning Outcomes

After attending the session, you will be able to:

1. Elaborate on the process of welding
2. Evaluate the different types Of Welding Processes
3. Analyze the Personal Traits and skills of an Industrial Welder
4. Analyze the range and uses of welding related equipment

Unit 1.1 Overview of Welding

Unit Objectives

At the end of this unit, you will be able to:

1. Elaborate on the process of welding
- Analyze the risks of welding
- Evaluate the concept of welding
- Evaluate the types of Welding Processes
- Analyze the personal traits needed in a welder
- Evaluate the skills needed for a welder

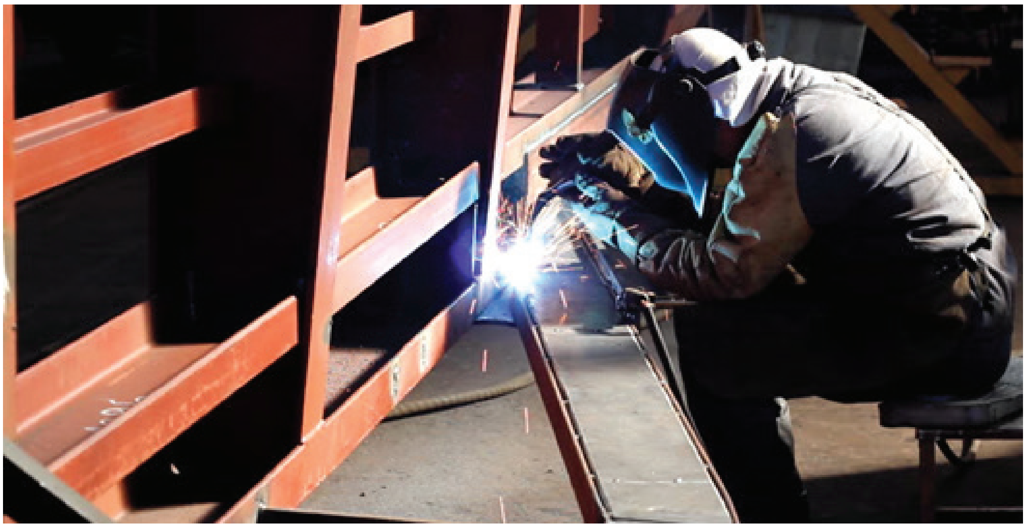

Fig.1.1: Wire highlighting Conductor and Insulator

- Welding processes involve temperatures up to 5500 degrees centigrade, which poses a high risk of fire, especially when combustible materials are around.
- Therefor it is vital to understand and recognize the risks and dangers involved when conducting welding operations, and to practice safe procedures to reduce these risks.
- Welding is frequently done by melting the work pieces and putting in a filler material to form a pool of molten material (the weld pool).
- The weld pool cools to become a strong joint and uses pressure sometimes in combination with heat, or by itself, to produce the weld.
- This is in contrast with soldering and brazing, which are done by melting a lower-melting-point material in the middle of the work pieces to create a bond between them, without needing to melt the workpieces.
- Several different energy sources can be employed for welding, including an electric arc, a gas flame, a laser, friction, an electron beam and ultrasound.
- The industrial process of welding can be performed in various different environments, including under water, open air and in outer space.
- As this is a hazardous undertaking, precautions must be taken to avoid electric shock, vision damage, burns, inhalation of poisonous gases and fumes, as well as exposure to intense ultraviolet radiation.

Unit 1.2 Different Types of Welding Processes

Unit Objectives

At the end of this unit, you will be able to:

- Practice the concept of welding
- Analyze the types of Welding Processes

What is Welding?

- When separate pieces of material are fused together using heat it is called a Weld
- The level of heat must be high enough to cause melting
- Pressure employed must be enough to force points together
- The material to be welded is the base metal
- Filler material from a rod or wire is added to the weld joint, and causes the weld joint to become stronger

The most common Welding Processes:

Welding has a host of applications, both industrially and domestically. Welded products could include automobiles, aircrafts, ships, electric and electronic parts, as well as parts in construction and building work. The most common processes are gas welding and arc welding. Below are a few types of welding:

- MIG Welding (Gas Metal Arc Welding or GMAW)
- TIG Welding (Gas Tungsten Arc Welding or GTAW)
- Flux-Cored Arc Welding (FCAW)
- Gas welding
- Atomic Hydrogen Welding (AHW)
- Resistance welding
- Energy Beam Welding (EBW)

The range and uses of trade related equipment includes:

- MIG Consumables
- MIG Guns
- MIG Welders
- MIG Pliers
- Wire Feeders
- Welding Torch
- TIG Welders
- TIG Welding Consumables
- Tungsten Electrodes
- Welding Magnets
- MIG Welding Wire
- Stick Electrodes
- Welding Flux
- Welding Framing Jig

- Submerged Arc Welding Wire
- Arc Welding Cable Reels
- MIG Welding Wire
- Welding Regulators
- Oxy-Fuel Cutting Machines
- Chop Saw
- Welding Cylinders
- Magnetic Welding Squares
- Speed Square
- Tin Snips
- Vice Grips
- Sheet Metal Gauge
- Auto-Darkening Welding Helmet
- Welding Gloves
- Metal Brush
- Angle Grinder
- Soapstone
- Cutting Fluids
- Welding Clamps
- Safety Glasses
- Fire Extinguishers
- Fire/Flame resistant clothing
- Ear muffs, ear plugs
- Rubber soled safety shoes
- C Clamps
- Chipping Hammer
- Thermo Chalks/Pen
- Thermocouple
- Shielding gas supply
- Flashlight
- Magnifying glass
- Protective lenses
- Weld gage
- Hammer and chisel
- Temperature Indicating Devices

Unit 1.3 Personal Traits and skills of an Industrial Welder

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the personal traits needed in a welder
- Evaluate the skills needed for a welder

Welders are have the job of joining metal parts together through various procedures to aid in manufacturing, construction and other areas where metals are involved. To gain success in the highly skilled field of welding, a competent welder must have:

1. **Awareness of Safety Standards:** A capable welder understands safety standards of the industry for protection of themselves, others, and the equipment and tools at hand.
2. **Knowledge of Metallurgy:** A knowledgeable welder must be very well- versed with various types of metals, their physical properties, and methods of working with them.
3. **Knowledge of Tools and Equipment:** A proficient welder is experienced with a variety of welding tools and equipment. They know how to most effectively use the tools to get the job done quickly in a safe manner.
4. **Manual Dexterity:** A skilful welder has excellent manual dexterity and good hand-eye coordination to perform the complicated physical manoeuvres required of a welding career.
5. **Good Eyesight:** A successful welder has sharp vision and is able to see intricate details of the project at hand.
6. **An Ability to Read Blueprints:** An experienced welder is able to read blueprints quickly and easily and understands how the information presented affects a project.
7. **Planning skills:** A skilled welder must possess the ability to plan and think in logical steps as well as three-dimensionally. Welders must realise the importance of working logically and in a well-organized manner in order to be successful and safe.
8. **Concentration:** A competent welder is able to give their attention fully to a project for long periods of time. They are able to remain committed to their work and ensure all aspects are completed correctly.
9. **Detail-Orientation:** A welder should be very detail-oriented when completing a welding task and does not overlook anything that could have large, unwanted effects.
10. **Thorough Knowledge of Various Welding Techniques:** A skilled welder has a thorough knowledge of various techniques, such as oxy-fuel, metal arc, gas tungsten arc and flux core arc welding.

Summary

- Welding processes involve temperatures up to 5500 degrees centigrade.
- Several different energy sources can be employed for welding, including an electric arc, a gas flame, a laser, friction, an electron beam and ultrasound.
- When separate pieces of material are fused together using heat it is called a Weld
- Welding has a host of applications, both industrially and domestically.
- A capable welder understands safety standards of the industry for protection of themselves, others, and the equipment and tools at hand.
- A skilful welder has excellent manual dexterity and good hand-eye coordination
- A competent welder is able to give their attention fully to a project for long periods of time.
- A skilled welder has a thorough knowledge of various techniques.

Notes

Notes

Notes

Scan the QR codes or click on the link to watch the related videos

https://www.youtube.com/watch?v=mL-8kH-QpufM

Scan the QR codes or click on the link to watch the related videos

https://www.youtube.com/watch?v=WCrQK-jXiCOk

Introduction to the Fundamentals of Welding

Scan the QR codes or click on the link to watch the related videos

https://www.youtube.com/watch?v=b0E-fJaYUfF8

Types of Welding Processes | Classification of Welding Processes

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2. General Work Shop Practice Followed on the Shop Floor

Unit 2.1 Interpretation of Drawing as per Standard

Unit 2.2 Basic Math knowledge

Unit 2.3 Isometric Drawings and Orthographic Projections

Unit 2.4 Selection of Datum Plane and its Importance

Unit 2.5 To Determine Limits, Fits and Tolerance

Unit 2.6 Know the Different Protective Coatings used in Pipes

Unit 2.7 Knowledge on different materials and the performance of this material in different applications

Unit 2.8 Basic Knowledge of the Property and Behaviour of Fluids, Liquids and Gases

Unit 2.9 Awareness on Basic Hydraulic and Pneumatic Elements and the Working

Unit 2.10 Application of Different Cutting Fluids s

Unit 2.11 Use of Different Fasteners for both Temporary and Permanent Fastening

HYC/N9101

Key Learning Outcomes

After attending the session, you will be able to:

1. Analyze the Interpretation of drawing
2. Evaluate the concept of GD&T
3. Analyze the different protective coatings used in pipes
4. Evaluate the property and behaviour of fluids, liquids and gases
5. Analyze the basic hydraulic and pneumatic elements
6. Evaluate the different types cutting fluids
7. Analyze temporary and permanent fastener

Unit 2.1 Interpretation of Drawing as per Standard

Unit Objectives

At the end of this unit, you will be able to:

- Practice how to interpret drawing
- Differentiate the standard symbols used in welding

In the field of welding there is a set of standard symbols, proper representation and layouts which are used to simplify the communication between designer and the welder. For example, check out the horizontal stick figures below:

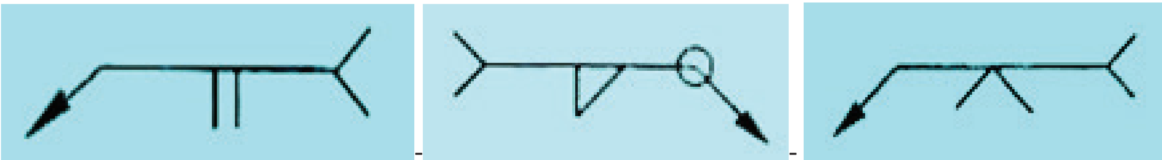


Figure 2.1_1: Core structures of all drafting specifications for a weld

- The figures above represent the core structure of all drafting specifications for a weld to be performed.
- The welding symbol has an arrow, this arrow points to the location on the drawing where a weld is required.
- The arrow is attached to a leader line that intersects with a horizontal reference line.
- Lastly, you have a tail at the opposite end of the reference line that forks off in two directions. This tail is optional and isrequired only for special instructions.
- Suspended from the middle of the reference line, you will see a geometric shape or two parallel lines indicating what type of weld should be performed on the metal.
- This is referred to as the weld symbol (but don't confusewith the overall welding symbol).
- In the drawings above the three weld symbols represent a square, fillet and V-groove weld, respectively.
- The placement of the weld symbol should be noted. If the weld symbol is shown hanging below the reference line, it indicates that the weld must be done on the "arrow side" of the joint.

You can see the actual weld in the second depiction.

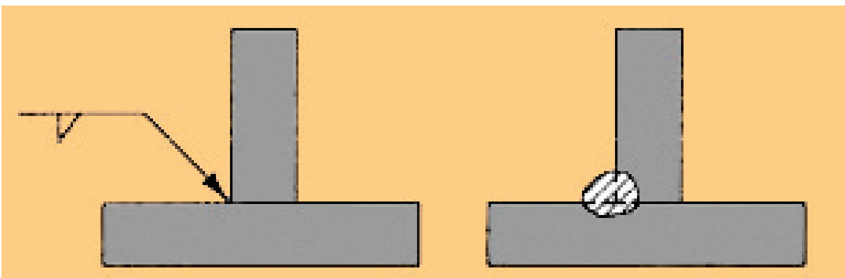


Figure 2.1_2: Welding symbols

Now, when the weld symbol is shown on top of the reference line, then the weld should be made on the opposite side of the joint where the arrow points. This is how it will look:

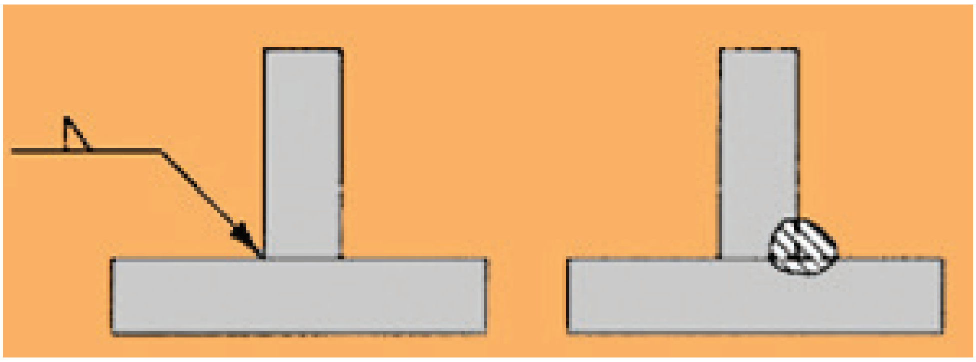


Figure 2.1_3: Welding symbols

When the weld symbol appears on both sides of the reference line, as seen below, it indicates that a weld must be performed on both sides of the joint.

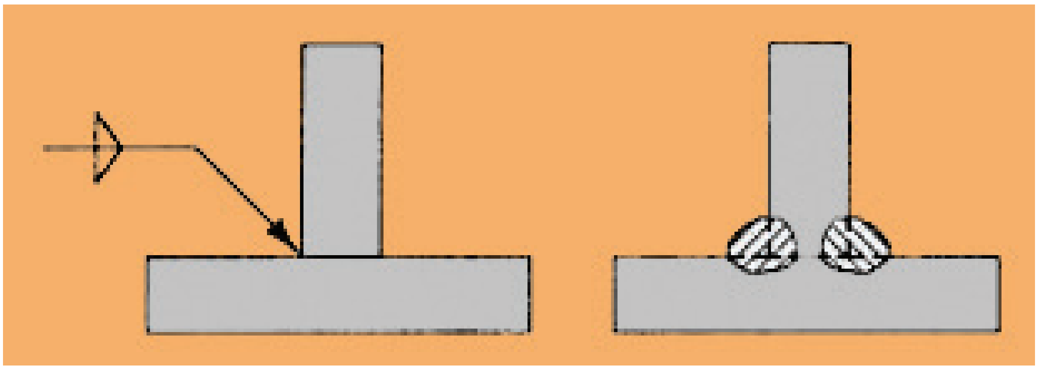


Figure 2.1_4: Welding symbols

Several weld symbols have been devised to represent all the different weld types used in the trade, as well as any joints that must be cut or beveled during fit-up. The following are the most common ones to learn:

Chart of symbols and drawings of the completed welds

Bead	Fillet	Plug or Slot	Groove or Butt						
			Square	V	Bevel	U	J	Flare V	Flare Bevel

Table 2.1_1: Different weld types

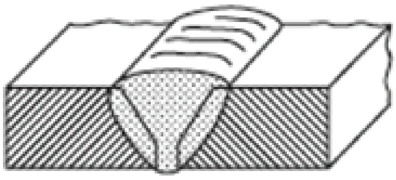
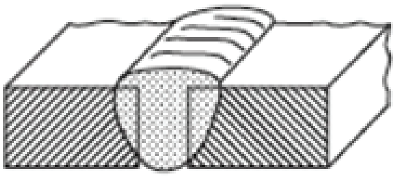
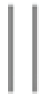
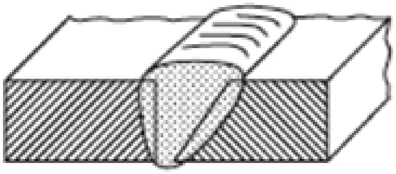
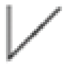
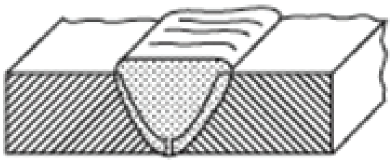
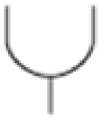
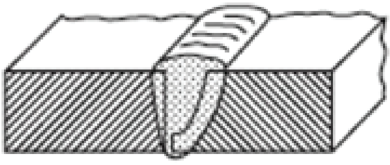
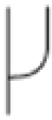
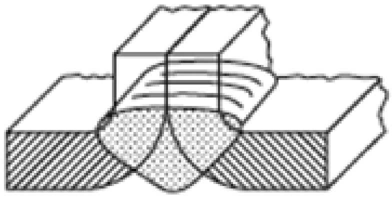
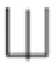
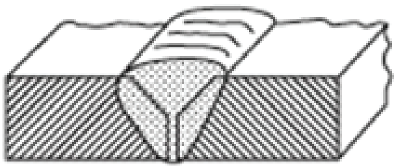
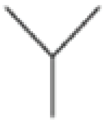
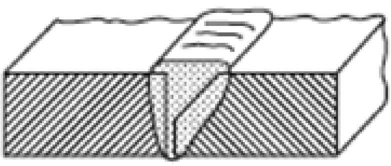
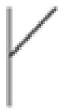
Designation	Illustration	Symbol
Single-V butt/groove weld		
Square butt/groove weld		
Single Bevel butt/groove weld		
Single-U butt/groove weld		
Single-J butt/groove weld		
Butt weld between plates with raised edges (ISO) Edge weld or flanged groo		 ISO  AWS
Single-V butt weld with broad root face		
Single bevel butt weld with broad root face		

Table 2.1_2 : Symbols and drawings of the completed welds

Dimensions and Angles

The depth, width and root opening and length of a weld, as well as the angle of any beveling required on the base metal before welding, can all be communicated to the welder clearly above or below the reference line.

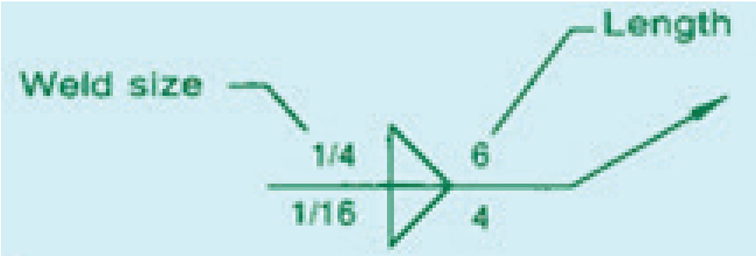
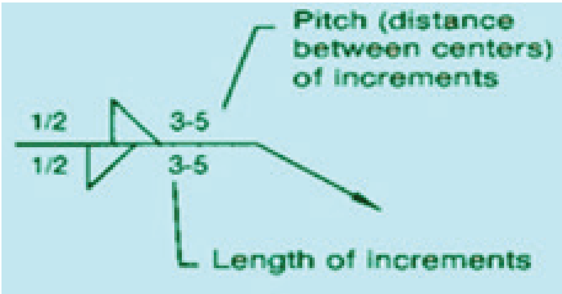


Figure 2.1_5: Welding symbols above and below reference line

At times, a series of separate welds is mentioned, instead than a single long weld. In the following drawing and symbol, 3-inch intermittent fillet welds are specified:



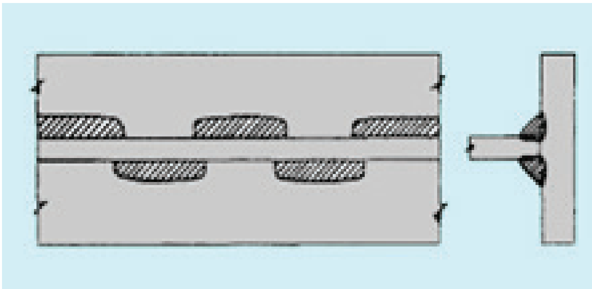
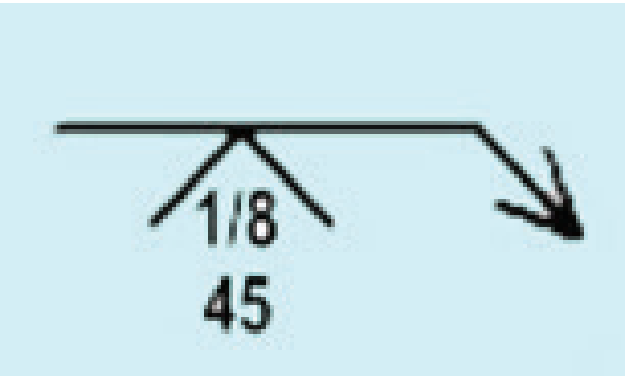


Figure 2.1_6: Welding symbols that indicate a series of separate welds

A weld symbol may also indicate an angle, root face dimension or root opening. This is frequently seen when the base metal to be welded on is thicker than 1/4 inch. The example below is a symbol and drawing indicating a V-groove joint:



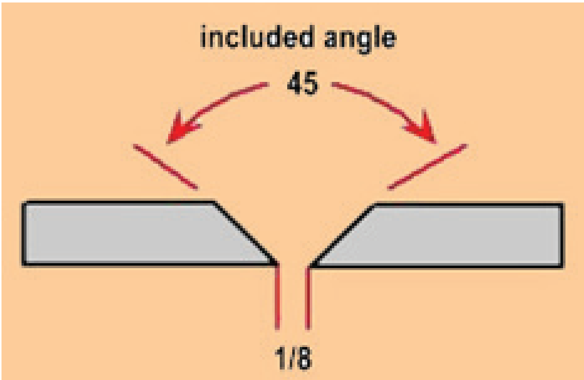


Figure 2.1_7: Welding symbols that indicate angles

Below are a few other types of instructions you might come across on a drawing:

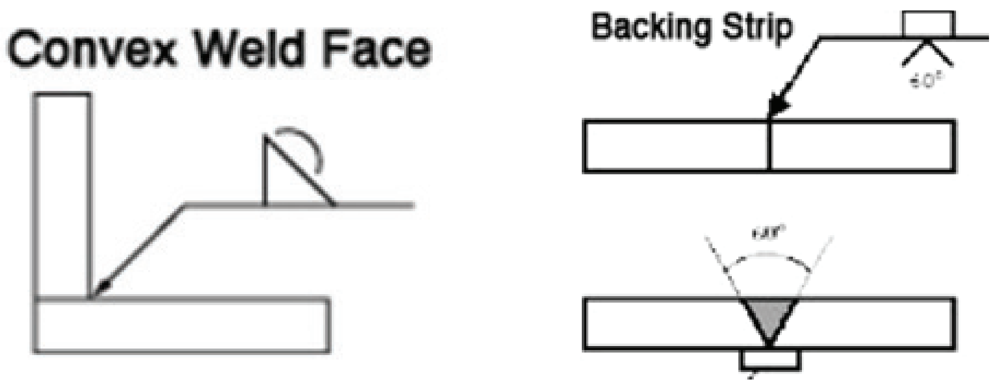


Figure 2.1_8: Symbols that indicate convex weld face and Backing strip

If a curve located is specified above the weld symbol's face it indicates that the finished weld should be convex, concave or flat. As you can see on the top right, a V-groove weld symbol with a box above it symbolises that a backing strip or bar is required for this joint. The strip or bar should be welded onto the back side of the joint before the groove weld is performed.

2.1.1 GD&T (Geometric Dimensioning and Tolerance)

Datums and Features

- Datum Reference Frame (DRF) can be considered one of the most important concepts in GD&T
- Datums and datum features are not the same.
- The illustrations below are provided to emphasize that Datums (left) are theoretical (perfect) and datum features (right) are real (imperfect).

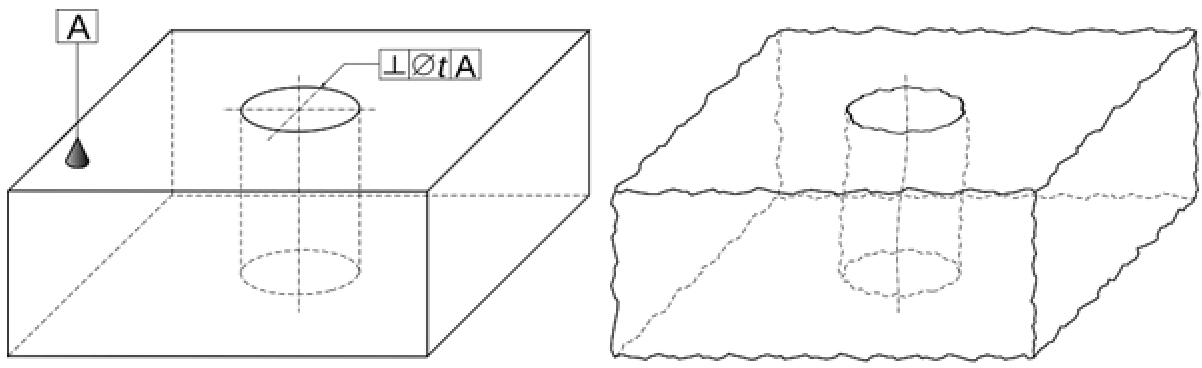


Figure 2.1_9: Datums (left) and Datum features (right)

- Geometric Dimensioning and Tolerance is a feature-based system, and parts are composed of features.
- Geometric tolerances are applied to features by feature control frames.
- The most commonly used tolerance categories are orientation, form and location.
- Form tolerances define the "shape" of features and are commonly used as a refinement of size.
- Orientation tolerances regulate the "tilt" of feature and are always linked with basic angle dimensions.
- Location tolerances regulate location and are always connected with basic linear dimensions.
- In total there are fourteen GD&T characteristics, and the symbols that represent them are shown in the symbol sheet below.

SYMBOL	GEOMETRIC CHARACTERISTIC	TOLERANCE TYPE	CONTROL SUMMARY
⏥	FLATNESS	FORM (NO RELATION BETWEEN FEATURES)	CONTROLS FORM (SHAPE) OF SURFACES AND CAN ALSO CONTROL FORM OF AN AXIS OR MEDIAN PLANE DATUM REFERENCE IS NOT ALLOWED
—	STRAIGHTNESS		
⌭	CYLINDRICITY		
○	CIRCULARITY (ROUNDNESS)		
⊥	PERPENDICULARITY	ORIENTATION (NO RELATION BETWEEN FEATURES)	CONTROLS ORIENTATION (TILT) OF SURFACES, AXES, OR MEDIAN PLANES FOR SIZE AND NON-SIZE FEATURES DATUM REFERENCE REQUIRED
//	PARALLELISM		
∠	ANGULARITY		
⌖	POSITION	LOCATION	LOCATES CENTER POINTS, AXES, AND MEDIAN PLANES FOR SIZE FEATURES ALSO CONTROLS ORIENTATION
⌓	PROFILE OF A SURFACE		LOCATES SURFACES ALSO CONTROLS SIZE, FORM, AND ORIENTATION OF SURFACES BASED ON DATUM REFERENCE
⌒	PROFILE OF A LINE		
⌰	TOTAL RUNOUT	RUNOUT	CONTROLS SURFACE COAXIALITY ALSO CONTROLS FORM AND ORIENTATION OF SURFACES
↗	CIRCULAR RUNOUT		
◎	CONCENTRICITY	LOCATION (DERIVED MEDIAN POINTS)	LOCATES DERIVED MEDIAN POINTS OF A FEATURE *NOT COMMON...CONSIDER USING POSITION, RUNOUT, OR PROFILE*
⌯	SYMMETRY		

Figure 2.1_3: GD&T characteristics and its corresponding symbols

Unit 2.2 Basic Math knowledge

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the unit conversions
- Analyze basic geometrical principles

Basic mathematical manipulation and unit conversion:

Metric	English	Metric-English
Length		
1 Km = 10 cubic m	1 ft = 12 in	1 in = 2.54 cm
1 cm = 10^-2 m	1 yd = 3 ft	1 m = 39.37 in
1 mm = 10^-3 m	1 mi = 5280 ft	1 mi = 1.609 Km
1 nm = 10^-9 m		
Volume		
1 cubic m = 10^3 L	1 Gal = 4 Qt.	1 cubic ft = 28.32 L
1 cubic cm(c.c) = 10^-3 L	1 Qt. = 57.75 cubic in	1L = 1.057 Qt.
Mass		
1 Kg = 10^3 gm	1 lb = 16 oz	1 lb = 453.6 gm
1 mg = 10^-3 gm	1 short ton = 2000 lb	1 gm = 0.03527 oz

Unit Conversion

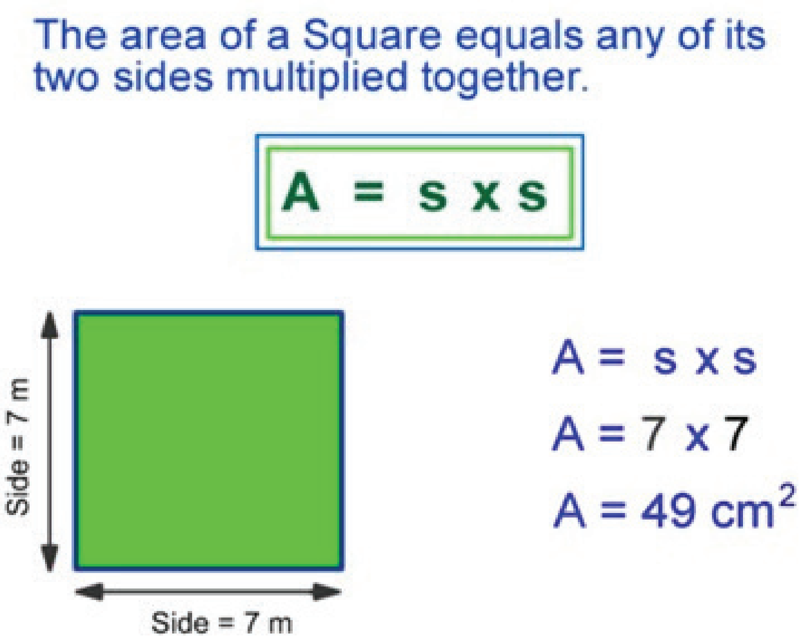


Figure 2.2_1: Area of a square

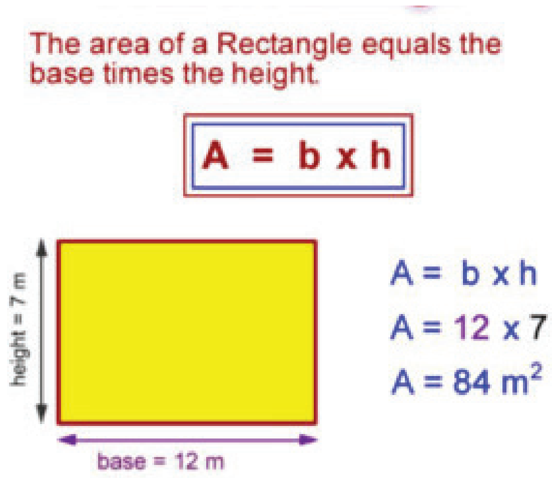
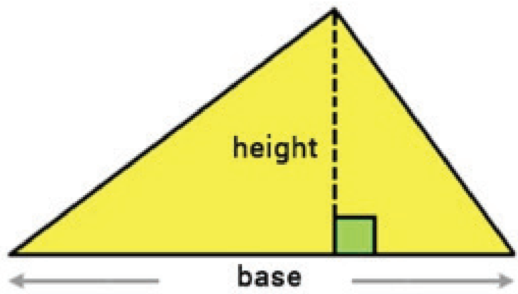


Figure 2.2_2: Area of a Rectangle



$$\text{Area} = \frac{1}{2} \times \text{base} \times \text{perpendicular height}$$

Figure 2.2_ 3: Area of a triangle

Figure 2.2_ 4: Area of a circle (Note: pi = 3.141592)

Introduction to sine, cosine and tan functions

As the name suggests, Trigonometry deals with right-angled triangles, where one of the internal angles measures 90°. This system of Trigonometry allows us to work out missing angles or sides in a triangle.

In a right-angled triangle, there is just one single right angle. It follows then that all sides of that triangle cannot be the same length. Following is a right-angled triangle:

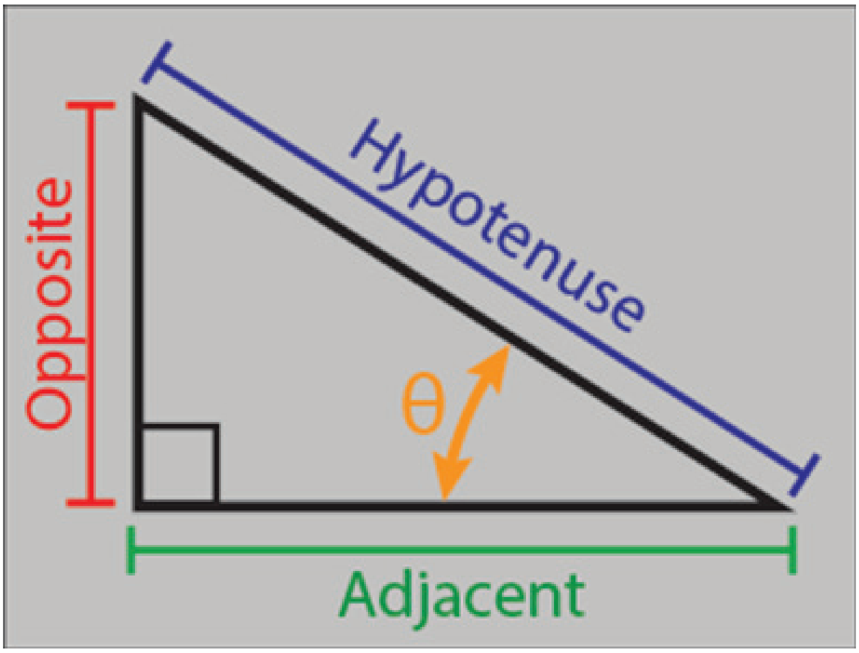


Figure 2.2_5: Right angled triangle

Sine, Cosine and Tangent

Three basic functions occur in the system of trigonometry, each of these functions is one side of a right-angled triangle divided by another.

Three functions of trigonometry are:

Name	Abbreviation	Relationship to sides of the triangle
Sine	Sin	Sin (θ) = Opposite/hypotenuse
Cosine	Cos	Cos (θ) = Adjacent/hypotenuse
Tangent	Tan	Tan (θ) = Opposite/adjacent

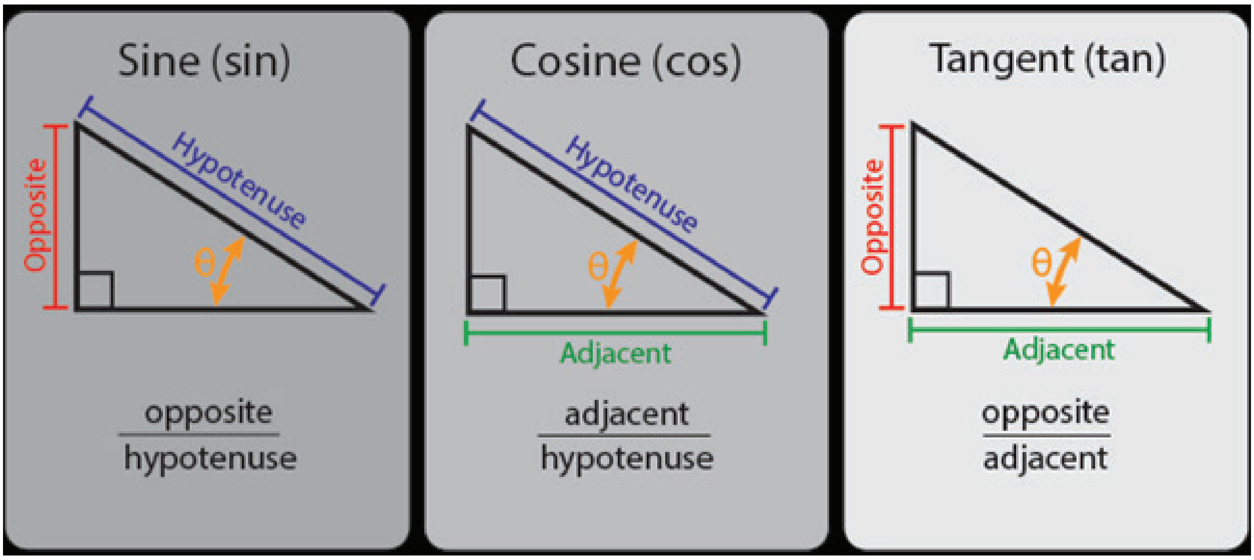


Figure 2.2_6: Right angled triangle

You can see the actual weld in the second depiction.

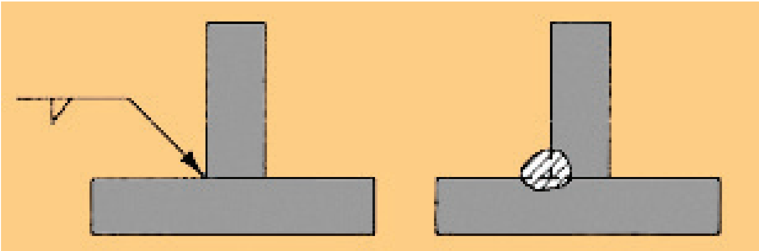


Figure 2.2_7: Right angled triangle

Unit 2.3 Isometric Drawings and Orthographic Projections

Unit Objectives

At the end of this unit, you will be able to:

- Analyze the concept of Isometric drawings
- Practice Isometric drawings

Isometric drawing is method of showing designs/drawings in three dimensions. In this case for a design to have a three dimensional appearance, a 30 degree angle is applied to its sides. The cube below, has been drawn in isometric projection.

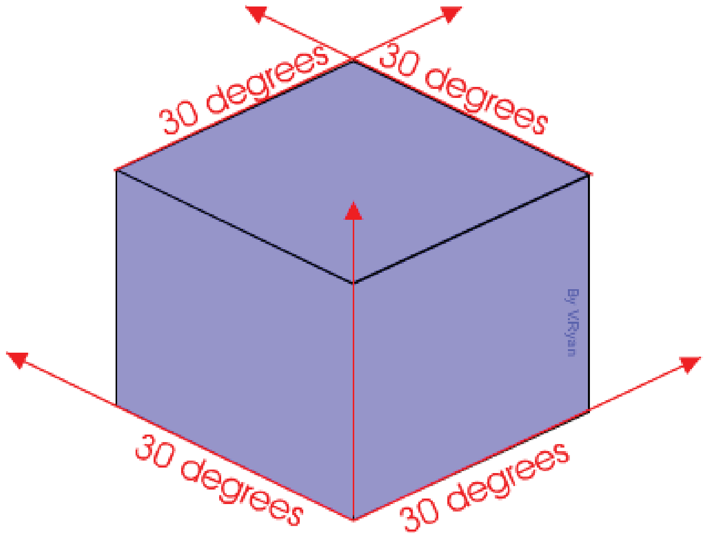


Figure 2.3_1: Making an Isometric Drawing

Making an Isometric Drawing

- It is a good idea to make a quick sketch of the object in isometric before you begin the isometric drawing.
- For an axonometric drawing the initial step is to draw the projection of the axes.
- Be sure that the position of the isometric axes is such that the view displayed best describes the object.
- Once you have finished drawing the axes, draw a box that will completely enclose the object you wish to draw.
- This is referred to as Box Construction.
- Width, breadth (length) and height for this box are obtained from the orthographic views, height = 50mm, width = 88mm, breath = 50mm.
- You need to draw the box lightly so that it can be easily removed when the drawing is finished.
- The key lies in good indexing techniques i.e. lettering points.
- Using good indexing practices reduce problems and lessen the time spent answering questions.
- Keep in mind that all measurements are marked off parallel to the isometric axes.
- When generating an isometric projection the same procedure is used, except an isometric scale is needed.

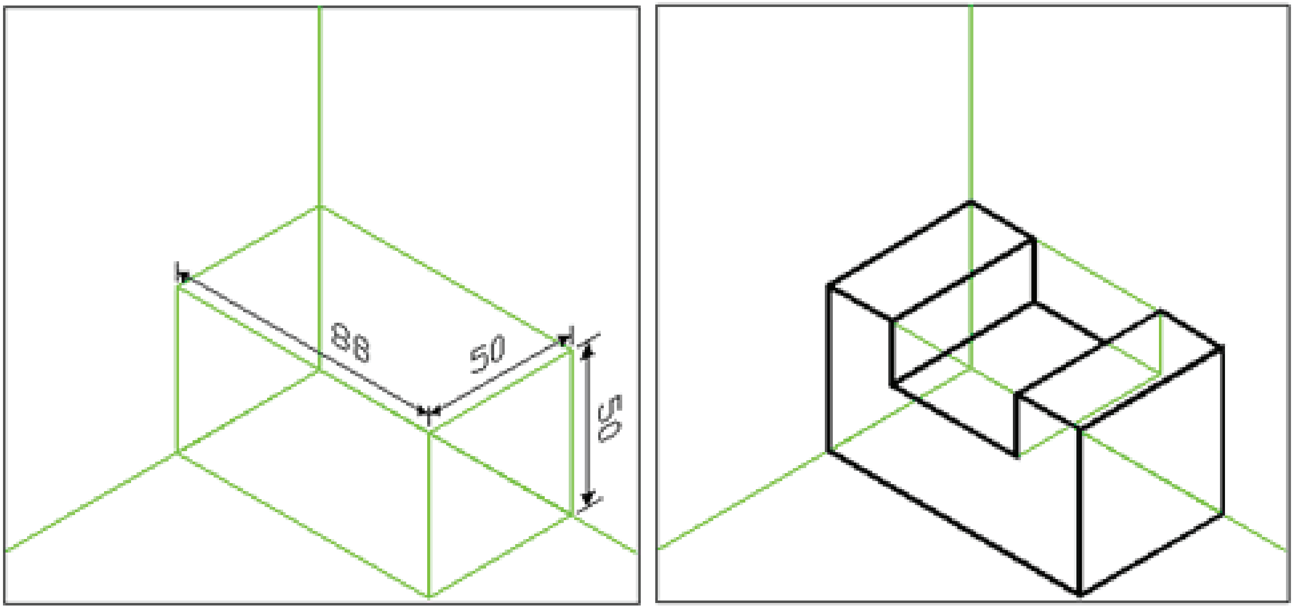


Figure 2.3_2: Isometric Drawing

Unit 2.4 Selection of Datum Plane and its Importance

Unit Objectives

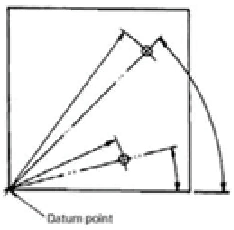
At the end of this unit, you will be able to:

- Evaluate the concept of datum planes
- Analyze the different types of datum planes

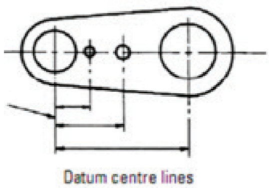
Datum can be defined as a point, line or edge, depending on the shape of the work piece, from which measurements are taken. Datum is employed to demonstrate a reference position from which all dimensions are taken and hence all measurements are made.

In order to have knowledge to establish a proper datum plane one must know the different types of datum planes.

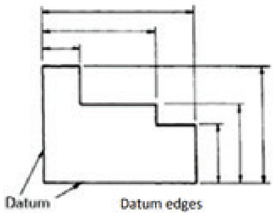
Point Datum



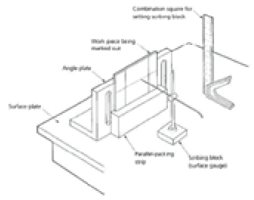
Line Datum



Edge Datum



Surface Datum



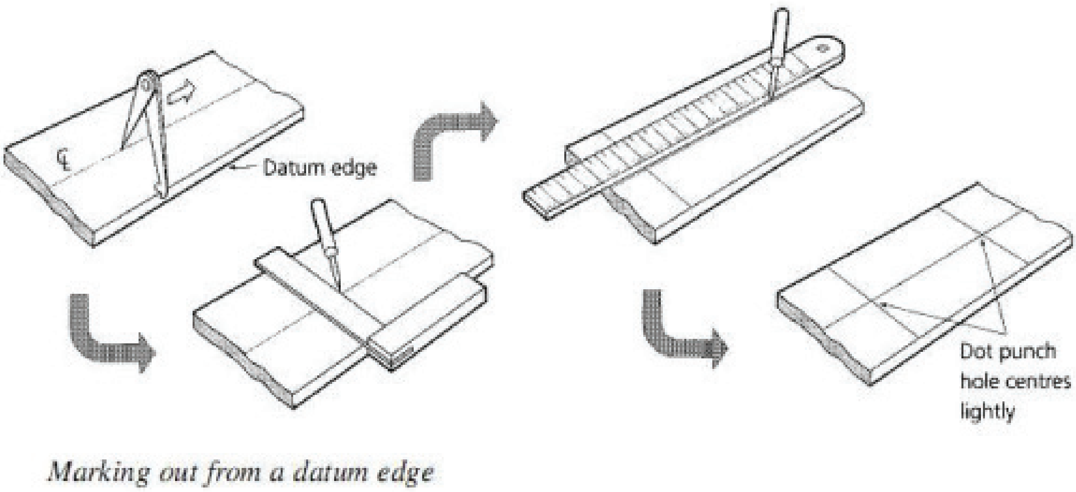


Figure 2.4_1: Making an Isometric Drawing

Unit 2.5 To Determine Limits, Fits and Tolerance

Unit Objectives

At the end of this unit, you will be able to:

- Practice the concept of Fits
- Analyze the concept of Limits
- Evaluate the concept of Tolerance

- **Fits**

In cases where two parts are to be assembled, the relation resulting from the difference between their sizes prior to assembly is referred to as a fit. Three classes of fit are shown in the figure below:

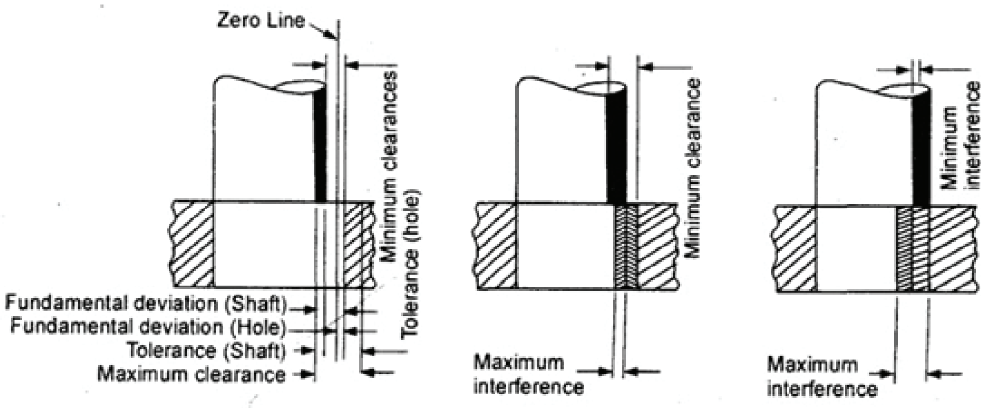


Figure 2.5_1: Three classes of fit

- **Limits of Size**

  The concept of limits of size refers to the two extreme permissible sizes for a dimension of a part, between which the actual size should lie. The upper or maximum limit is the largest permissible size for a dimension while the smallest size is called lower or minimum limit.

The limits of sizes are shown below:

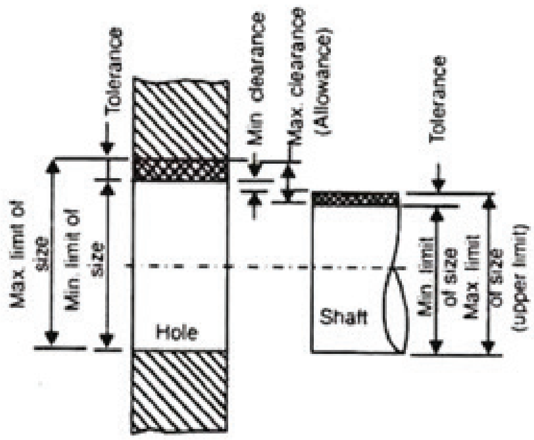


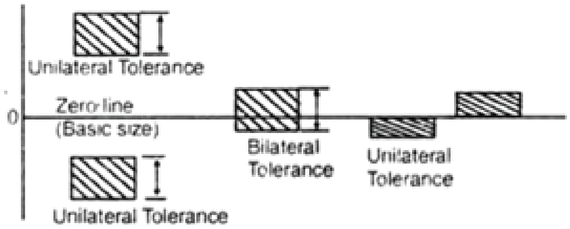
Figure 2.5_2: Limits of Size

- **Tolerance**

  The term tolerance in GD&T refers to the difference between the upper (maximum) limit and lower (minimum) limit of a dimension. The tolerance can be of two kinds i.e. unilateral or bilateral.

Example. *unilateral system* : $30.00^{+0.000}_{-0.006}$, $30.00^{-0.02}_{-0.05}$, $30.00^{+0.05}_{+0.02}$.

Bilateral system : $30.00^{+0.03}_{-0.02}$, $30.00^{+0.01}_{-0.05}$



Notes

Unit 2.6 Know the Different Protective Coatings used in Pipes

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the concept of protective coatings
- Differentiate the types of protective coatings used in pipes

There are several types of coating systems that are applied to hydrocarbon pipelines. The following are different types of external anti-corrosion coatings:

1. Three Layer Poly Ethylene/ Propylene (3LPE/ 3LPP) Coating
2. Fusion Bonded Epoxy (FBE) Coating
3. Coal Tar Enamel (CTE) Coating

1. Three Layer Poly Ethylene/ Propylene (3LPE/ 3LPP) Coating

This is a multi-layered coating that consists of of three functional components: a high performance fusion bonded epoxy (FBE), next is a copolymer adhesive and followed by an outer layer of Medium Density Polyethylene (MDPE) or High Density Polyethylene (HDPE), all of which offers protection against external corrosion.

2. Fusion Bonded Epoxy (FBE) Coating

This is an epoxy-based powder coating used widely in order to protect steel pipes which are used in pipeline construction from corrosion. These coatings are thermoset polymer coatings.

3. Coal Tar Enamel (CTE) Coating

This coating is a thermoplastic polymeric coating. The CTE coating system consists of four main components: coal tar enamel, primer, glass fibre outer-wrap and glass fibre inner-wrap.

Following are the essential properties of a coating system:

- Impact Resistance
- Stability at elevated temperature
- Penetration Resistance
- Resistance to cathodic disbondment
- Resistance to soil stress
- Resistance to water absorption
- Chemical resistance (Acids & alkali)
- Hardness (abrasion resistance)
- Volume resistivity
- Resistance to damages during handling
- Flexibility to bending
- Maintenance and refurbishment frequency
- HSE consideration

Unit 2.7 Knowledge on different materials and the performance of this material in different applications

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the different materials used in welding
- Analyze the application of different welding materials

Covered electrode

This type of electrode is coated in a metal mixture called 'flux' around the core steel rod.

Figure 2.7_1: Covered Electrode

Application:

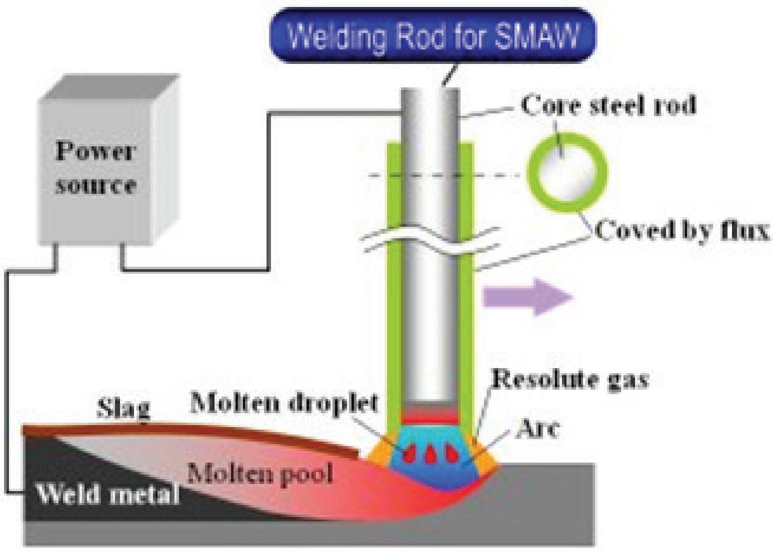


Figure 2.7_2: Covered Electrode used in application

TIG Welding Rod

In TIG welding, you have a filler rod that is fedby hand into the molten puddle. The selection of filler rod is very important as the rod must correctly match the alloy and material you will be welding.

Figure 2.7_3: TIG Welding Rod

Application:

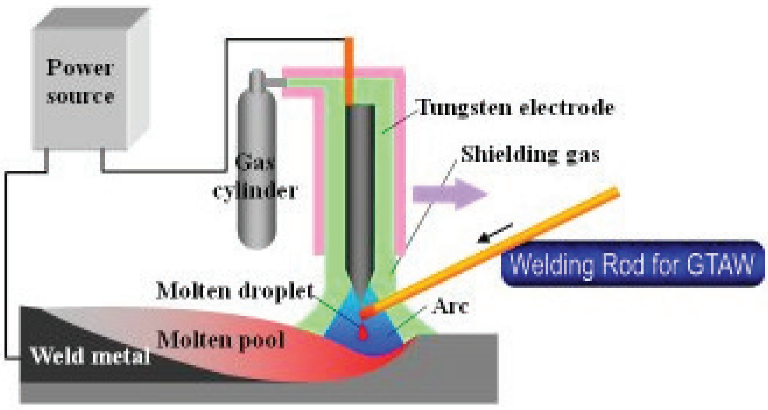


Figure 2.7_4: TIG Welding Rod used in application

GMAW Solid wire

Wires usually used are of mild steel and are typically copper-coloured as it is electroplated with a thin layer of copper to improve electrical conductivity, protect it from rusting, increase contact tip life, and improve arc performance.

Figure 2.7_5: GMAW Solid wire

GMAW Flux Cored Wire

There are two kinds of flux cored wires: self-shielded and gas shielded. Gas shielded flux cored wires need external shielding gas on the other hand self-shielding flux cored wire do not need external shielding gas.

Figure 2.7_6: GMAW Flux Cored Wire

Application:

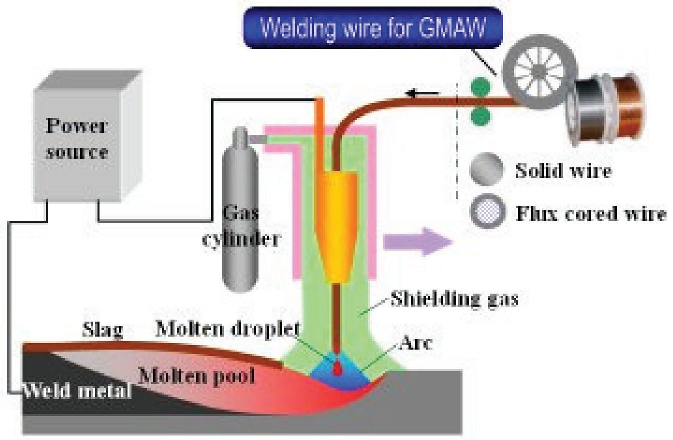


Figure 2.7_7: GMAW Solid wire and Flux Cored Wire used in application

SAW Wire

Usually these wires are mainly packed in non-spool coils. They are used in combination with flux.

Figure 2.7_8 : SAW Wire

SAW Flux

The granular flux in Submerged Arc Welding provides a blanket over the weld, which in turn protects it against sparks and spatter.

Figure 2.7_9 : SAW Flux

Application:

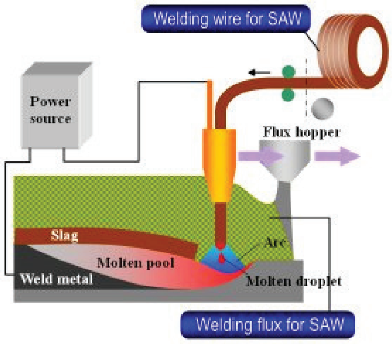


Figure 2.7_10 : SAW Wire and SAW Flux sued in application

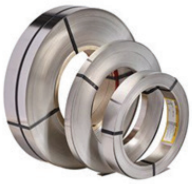


Figure 2.7_11 : Strip Electrodes

Strip Electrodes

These ribbon shaped electrodes are used as a weld overlay on another base metal surface. They are used in the electro-slag weldingor the submerged arc welding methods.

Application:

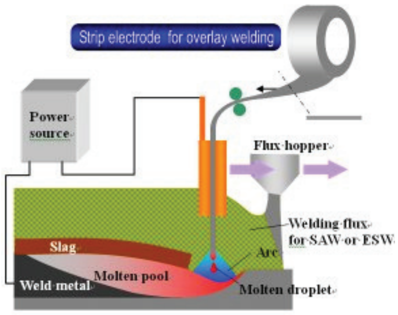


Figure 2.7_12 : Strip Electrodes used in application

Unit 2.8 Basic Knowledge of the Property and Behaviour of Fluids, Liquids and Gases

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the different States of Matter
- Recognize the changes in States of Matter

Different States of Matter

Solid: Matter can be considered a solid when it has a shape of its own. For example brick, metal, wood, etc.

Liquid: Matter can be considered a liquid when it takes the shape of the vessel in which it is poured. For example: water, kerosene, thinner, etc.

Gas: Matter can be considered a gas when it has no shape of its own and occupies the space available to it. For example: CNG, carbon dioxide, oxygen, etc.

- **Changes in States of Matter**

Matter can be changed from one state to another if the temperature or the pressure can be changed. If we raise or lower the pressure on it, the temperature will also change, and there will be a change in state.

Let us take the example of water:

Water has the capability to exist in three states. In solid state it is exists as ice, in liquid state as water and in gaseous state as water vapour. Change in the states of matter mainly depends on temperature and pressure.

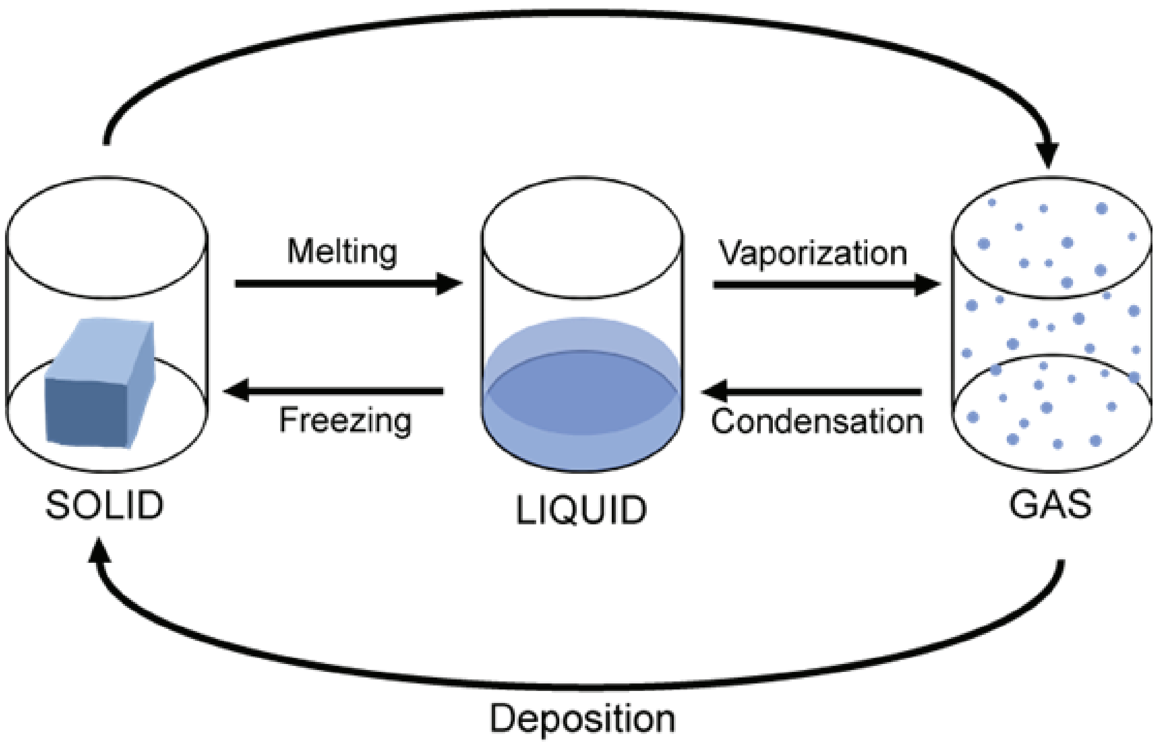


Figure 2.8_1 : Changes in the states of matter

Unit 2.9 Awareness on Basic Hydraulic and Pneumatic Elements and the Working

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate hydraulic elements and functions
- Evaluate pneumatic elements and functions

- **Pneumatic Equipment**

Pneumatics makes use of pressurized gas to facilitate motion. The air compressor is the source of compressed air that a pneumatic tool is powered by. The pipe or hose transmits this energy to the operating equipment. The tool manipulates the workpiece. Pneumatic tools have the advantage of being lighter than similar power tools as they have no motor.

The following are examples of Pneumatic Equipment

Pneumatic Cylinders: In a pneumatic system, cylinders are mechanical devices that produce force via compressed air.

Pneumatic Pumps: Employing an air exhausting mechanism, this pneumatic equipment draws in outside air, compresses it and harnesses the air for use.

Pneumatic Tubing: This component offers protection from leakage throughout the entire pneumatic device.

- **Hydraulic Equipment**

Hydraulic equipment works by using pressurized fluid to perform a host of machining operations. Here, pressurized fluid is pushed through hydraulic tubes to the machine's actuators, and the fluid's pressure is used to complete their assigned task.

The following are examples of hydraulic equipment:

Hydraulic Pump

A mechanical source of power that converts mechanical power into hydraulic energy is called a hydraulic pump.

Hydraulic Cylinders

Hydraulic pressure in this type of cylinder comes in the form of hydraulic fuels that are stored under pressure.

Hydraulic Jack

A hydraulic jack makes use of hydraulic power for lifting and moving heavy loads by the application of a much smaller force.

Notes

Unit 2.10 Application of Different Cutting Fluids

Unit Objectives

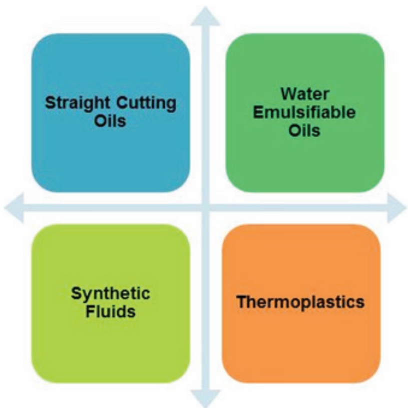
At the end of this unit, you will be able to:

- Evaluate the concept of cutting fluids
- Practice various cutting fluids

A Cutting Fluid is a type of coolant and lubricant designed for various metalwork operations.

The essential properties / qualities in a good Cutting Fluid are:

- Smooth lubrication to mitigate friction and minimize chances of wear and tear of the tool
- Effective Cooling for heat dissipation
- Low Viscosity to enable the fluid to seep through the components and lubricate / cool them better
- Anti-rusting and Anti-corrosion activities
- Natural resistance to Putrefaction
- Physically and chemically stable
- Non-vaporous to avoid mists and ensure a safe working environment
- Chemically non-toxic and biodegradable
- Non-combustible and non-smoking
- Easy storage conditions
- Cost-effective and easily available



- The range of materials, on which Cutting Fluids are applied, can be Ferrous and Non-ferrous.
- Among these, few materials do not require Cutting Fluids because they have inherent lubricating properties or because they have relatively low cutting fluids.
- Materials like Graphite, Aluminium and its Alloys, Bronze, Brass, Cast iron, etc. do not essentially require Cutting Fluids.
- However, Cutting Fluids may be applied on these materials, depending on the type of operation and cutting conditions.
- An increased concentration of Cutting Fluid may lead to toxicity, chemical hazards, dirt accumulation and grave safety concerns.

MATERIAL	DRILLING	REAMING	TAPPING	TURNING	THREADING	MILLING
Aluminum	Soluble Oil Kerosene Kerosene & Lard Oil	Soluble OilKerosene Mineral Oil	Soluble Oil Mineral Oil	Soluble Oil	Soluble Oil Kerosene & Lard Oil	Soluble Oil Lard Oil Lard Or Mineral Oil
Brass	Dry Soluble Oil Kerosene & Lard Oil	Soluble Oil Dry	Soluble Oil Lard Oil Dry	Soluble Oil	Soluble Oil Lard Oil	Soluble Oil Dry
Bronze	Dry Soluble Oil Lard Oil Mineral Oil	Soluble Oil Lard Oil Dry	Soluble Oil Lard Oil Dry	Soluble Oil	Soluble Oil Lard Oil	Soluble Oil Lard Oil Dry
Cast Iron	Dry Soluble Oil Air Jet	Soluble Oil Mineral Lard Oil	Mineral Lard Oil	Soluble Oil Mineral Lard Oil Dry	Dry Sulfurized Oil	DrySoluble Oil
Copper	DrySoluble Or Lard OilKerosene Mineral Lard Oil	Soluble Oil Lard Oil Dry	Soluble Oil Mineral Lard Oil	Soluble Oil	Soluble Oil Lard Oil	Soluble Oil Dry
Malleable Iron	Dry Soda Water	Dry Soda water	Soluble Oil	Soluble Oil	Lard Oil Soda Water	Dry Soda Water
Monel Metal	Soluble Oil Lard Oil	Soluble Oil Lard Oil	Mineral Lard OilSulfurized Oil	Soluble Oil	Lard Oil	Soluble Oil
Steel Alloys	Soluble Oil Sulfurized Oil Mineral Lard Oil	Soluble Oil Mineral Lard Oil	Sulfurized Oil Mineral Oil	Soluble Oil	Lard Oil Sulfurized Oil	Soluble Oil Mineral Lard Oil
Steel Forgings Low Carbon	Soluble Oil Sulfurized Lard Oil Lard Oil Mineral Lard Oil	Soluble Oil Mineral Lard Oil	Soluble Oil Lard Oil	Soluble Oil	Soluble Oil Mineral Lard Oil	Soluble Oil Mineral Lard Oil
Tool Steel	Soluble Oil Sulfurized Oil Mineral Lard Oil	Soluble Oil Sulfurized Oil Lard Oil	Mineral Lard OilSulfurized Oil	Soluble Oil	Lard Oil Sulfurized Oil	Soluble Oil,Lard Oil

Table: Different Materials and their Cutting Oil Requirements during various operations

Unit 2.11 Use of Different Fasteners for both Temporary and Permanent Fastening

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the concept of fasteners
- Differentiate between temporary and permanent fasteners

Fasteners play a vital role in our day to day life. From joining together the chairs and tables we use to the automobiles we use to travel; almost everything we use is held in place by means of a 'fastener'. A fastener can be defined as a piece of hardware that joins or fixes two items together for a non-permanent joint.

Temporary fastening

If a joint can be removed or dismantled without destroying or damaging the adjoining components it can be termed as a non-permanent joint.

Permanent fastening

If a welding joint or a riveted joint tends to damage or destroy both the joining components as well as the joint itself, it can be termed as a permanent fastening.

Features of a fastener:

- The basis of a fastener is basically a screw thread.
- The male part is basically the screw with an external thread
- The female part is a hole with an internal thread.
- The female part can also be a nut.

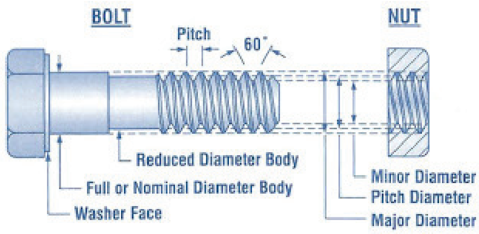


Figure 2.11_1: Features of a fastener

The head portion of the fastener is available in various shapes and sizes as shown below:

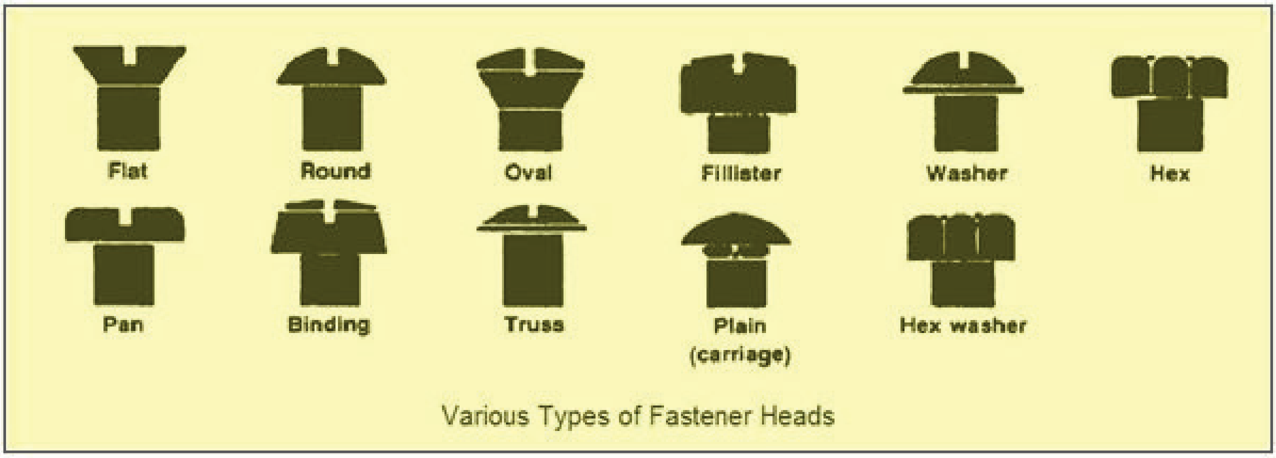


Figure 2.11_2 : Various types of fastener heads

Summary

- In the field of welding there is a set of standard symbols, proper representation and layouts which are used to simplify the communication between designer and the welder.
- Orientation tolerances regulate the “tilt” of feature and are always linked with basic angle dimensions.
- Form tolerances define the “shape” of features and are commonly used as a refinement of size.
- Isometric drawing is method of showing designs/drawings in three dimensions.
- For an axonometric drawing the initial step is to draw the projection of the axes.
- Datum can be defined as a point, line or edge, depending on the shape of the work piece, from which measurements are taken.
- In cases where two parts are to be assembled, the relation resulting from the difference between their sizes prior to assembly is referred to as a fit.
- There are several types of coating systems that are applied to hydrocarbon pipelines.
- A covered electrode is coated in a metal mixture called ‘flux’ around the core steel rod.
- There are two kinds of flux cored wires: self-shielded and gas shielded.
- Solid: A matter is solid when it has a shape of its own. For example brick, metal, wood, etc.
- Pneumatics makes use of pressurized gas to facilitate motion.
- A Cutting Fluid is a type of coolant and lubricant designed for various metalwork operations.
- If a joint can be removed or dismantled without destroying or damaging the adjoining components it can be termed as a non-permanent joint.

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Skill India
कौशल भारत - कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

3. Welding using Manual Metal Arc welding/Shielded Metal Arc welding

HYDROCARBON SECTOR
SKILL COUNCIL

Unit 3.1 Types of Welding

Unit 3.2 Ability to keep up to date with Changing Technology

Unit 3.3 Range of Destructive and Non-destructive Weld Testing

Unit 3.4 Types of Fire Extinguishers and Their Suitable Uses

Unit 3.5 Methods of Managing Welding Fume Hazards

Unit 3.6 Awareness and Importance of Cable Size and Length

Unit 3.7 Understanding Polarity

Unit 3.8 Various Types of Base Metals used in Welding and Their Implications

Unit 3.9 Magnetic arc blow or arc deflection

Unit 3.10 Significance of Diffusible Hydrogen for Welds

Unit 3.11 Welding Process Specification Sheet

Unit 3.12 Travel Speed and Heat Inputst

Unit 3.13 Amperage Requirements for Different Classification of Electrodes and Positions

Unit 3.14 Pre-heating and Post-heating in Welding

Unit 3.15 Types of visual inspection indicators and methods

HYC/N9102

Key Learning Outcomes

After attending the session, you will be able to:

1. Identify the Types of Welding
2. Evaluate and maintain changing technology
3. Analyze the destructive and non-destructive weld testing
4. Evaluate the different types of fire extinguishers
5. Practice how to manage welding fume hazards
6. Analyze the importance of cable size and length
7. Evaluate the various types of base metals used in welding
8. Analyze Magnetic arc blow
9. Analyze diffusible hydrogen
10. Analyze the storage requirements for consumable electrodes
11. Differentiate Welding process specification sheet
12. Evaluate the concept of Travel Speed and Heat Inputs
13. Evaluate the classification of electrodes
14. Analyze pre-heating and post-heating in welding

Unit 3.1 Types of Welding

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the types of welding
- Analyze welding specifications used in different types of welding

- **Aerospace Precision Welding**
  - Aerospace welders carry out operations on technology and equipment found in space shuttles, airplanes and similar structures.
  - This type of welding calls for metals like carbon steel, stainless steel and aluminium.
  - These precision welders carry out operations on manufacturing parts and products from airplanes to space shuttles.

- **Manufacturing welding**
  - Manufacturing welding is frequently used invarious manufacturing and construction industries.
  - In manufacturing productivity is the central focus of all operations.
  - High productivity can be accomplished in manufacturing operations by using MIG welding for its clean welds.

- **Pipeline Construction Welding**
  - Pipelines can be considered as the veins of our infrastructure, distributing the water, natural gas, and oil.
  - Pipe welders have the task of joining and repairing tubular products and metallic pipe components and assemblies as part of the construction of structures, vessels, and stand-alone pipelines.

Unit 3.2 Ability to keep up to date with Changing Technology

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the importance of staying up-to-date with the latest welding technology
- Differentiate the latest technology in welding

Figure 3.2_1 : A welder at work

Welding is a fundamental technology without which the manufacturing, construction and other industries would be unable to operate. Like most other technologies, welding is steadily evolving. Some of the latest technology is used in the following welding processes.

- **Surface tension transfer process**

This process is has the aim of boosting productivity by substituting such older welding methods as gas tungsten arc welding and gas metal arc welding.

- **Friction stir welding**

This new method is capable of generating a more stable, secure bond between two materials by means of moving a rotating tool on the top of aluminium, which is then bonded to steel.

- **Laser welding**

Laser welding is being used more and more for connecting thin steel sheets. As laser welding utilizes power sources of higher capacity, lasers are also used to join heavy plates together.

- **Resistance spot welding**

This welding process has to do with direct application of opposing forces by using the pointed-tip electrodes. Using this technology aluminium pieces can directly be welded together with the help of a multi-ringed dome electrode.

Unit 3.3 Range of Destructive and Non-destructive Weld Testing

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the destructive weld testing
- Evaluate the non-destructive weld testing

Weld analysis and testing are required to assure the correctness and quality of the weld once it has been completed. This term usually refers to analysis and testing that gauges the strength and quality of the weld. These tests are conducted to ensure the manufacture of quality welds by collecting quantitative and qualitative data.

- **Types of Weld Testing**

Non Destructive Weld Testing

- o Without physical damage to the workpiece and joint
- o Qualitative data is gained

Destructive Weld Testing

- o Involves physical damage to workpiece and welded joint.
- o Quantitative data gained

Types of Destructive Weld Testing

Tensile Test, Bend Test — Workshop

Hardness Test, Toughness Testing, Fatigue Behaviour — Laboratory

Types of Non Destructive Weld Testing

Detection of internal flaws:

- o Radiography
- o Ultrasonic Testing
- o Eddy current Testing

Detection of surface flaws:

- o Visual
- o Magnetic Particle Inspection
- o Fluorescent Dye Penetrant Inspection

Unit 3.4 Types of Fire Extinguishers and Their Suitable Uses

Unit Objectives

At the end of this unit, you will be able to:

- Differentiate various fire extinguishers
- Analyze the uses of different types of fire extinguishers

There is no one extinguisher type which works on all classes of fire. The fire risk from the different classes of fire in your business premises will determine which fire extinguisher types you need. Different materials used for extinguishing fire include sand, water, foam, CO2, dry powder.

- **Water Extinguishers**

Water extinguishers are the most common fire extinguisher type for Class A fire risk.

Use for:

Organic materials such as:

  - Paper and cardboard
  - Fabrics and textiles
  - Wood and coal

Figure 3.4_1 : Water Extinguisher

- **Foam Extinguishers**

Foam extinguishers are most common type of fire extinguisher for Class B fires, but also work on Class A fires.

Use for:

Organic materials such as:

  - Paper and cardboard
  - Fabrics and textiles
  - Wood and coal

Plus:

Flammable liquids, like paint and petrol

Figure 3.4_2: Foam Extinguisher

- **Dry Powder Extinguishers**

These extinguishers tackle class A, B and C fires, however they are not recommended for use in enclosed spaces.

Use for:

Organic materials such as:

  - Paper and cardboard
  - Fabrics and textiles
  - Wood and coal

Figure 3.4_3: Dry Powder Extinguisher

Plus:
- Flammable liquids, like paint and petrol

Plus:
- Flammable gases, like liquid petroleum gas (LPG) and acetylene

Plus:
- Fires involving electrical equipment up to 1000v

- **Carbon Dioxide (CO2) Extinguishers**

CO2 extinguishers are predominantly used for electrical fire risks as well as Class B fires.

Use for:
- Flammable liquids, like paint and petrol
- Electrical fires

Figure 3.4_4 : Carbon Dioxide (CO2) Extinguisher

- **Wet Chemical Extinguishers**

Wet chemical extinguishers are designed for use on Class F fires, involving cooking oils and fats.

Use for:
  - Cooking oil/fat fires
  - Organic materials such as:
    - Paper and cardboard
    - Fabrics and textiles
    - Wood and coal

Weld analysis and testing are required to assure the correctness and quality of the weld once it has been completed. This term usually refers to analysis and testing that gauges the strength and quality of the weld. These tests are conducted to ensure the manufacture of quality welds by collecting quantitative and qualitative data.

Figure 3.4_5 : Wet Chemical Extinguisher

Notes

Unit 3.5 Methods of Managing Welding Fume Hazards

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the hazards of welding fumes
- Practice the methods of managing welding fume hazards

- **Effects of exposure to welding fume**
  - Acute exposure to welding gases and fume can result in nose, eye and throat irritation, nausea and dizziness.
  - Workers in the field who experience these symptoms must exit the area immediately, seek fresh air and get medical attention.
  - Constant exposure to welding fume has the potential to cause various types of cancer, including lung, larynx and urinary tract as well as lung damage.
  - Health disorders from certain toxic fumes may include stomach ulcers, metal fume fever, nervous system damage and kidney damage.
  - Gases such as carbon dioxide, argon, helium and displace oxygen in the air and can lead to suffocation, particularly when welding in confined or enclosed spaces.
  - Carbon monoxide gas poses a serious asphyxiation hazard.

- **Methods of managing welding fume hazards**
  - Welders should understand the hazards of the materials they are working with.
  - Employers must provide welders with Material Data Safety Sheets (MSDSs)
  - You should use the safest welding method and materials for the job.
  - Welding surfaces must be cleaned of any coating that have the potential of creating toxic exposure
  - While welding in outdoor environments operators should position themselves upwind to avoid breathing welding gases and fumes.
  - General ventilation, which means the natural or forced movement of fresh air, can reduce gas and fume levels.
  - Local exhaust ventilation systems should be utilized to remove gases and fumes from the welding area.
  - Flexible or portable exhaust systems should be positioned in such a way that gases and fumes are drawn away from the welder.
  - You must never weld in confined spaces without proper ventilation.
  - You must use personal protective equipment while performing the welding tasks.

Unit 3.6 Awareness and Importance of Cable Size and Length

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the measurements of different welding cables
- Analyze the importance of cable size and length

Figure 3.6_1 Welding cable

- Welding cables are developed for use in electric arc-welding machines to power an electrode, a metal rod specially designed to conduct a charge.
- Welding cable is made to be significantly flexible and durable.
- Durable cables are vital in the industrial field where burns, from sparks, oil and water exposure as well as cuts, abrasions can quickly wear out a weaker cable.
- The cable used should be long enough to reach every corner of the space you will be welding within.
- Keep in mind that:
    - One cable connects from the welder to the electrode
    - A second cable will connect from the welder to the piece that is being welded
- Longer and thinner welding cables indicate lower ampere capacity.
- If the cable has a higher strand count that indicates that it is more flexible

Unit 3.7 Understanding Polarity

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the concept of AC and DC
- Analyze the types of polarity

What is AC and DC?

Welders need to possess knowledge of the practical application of electricity in order to conduct welding operations.

In alternating current or AC the movement or flow of electricity reverses its direction at regular intervals. This means that an electric charge would move forward, then backward, then forward, then backward, over and over again.

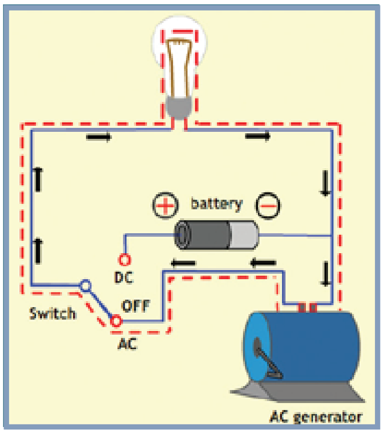


Figure 3.7_1 : Alternating current or AC

In direct current or DC, the flow of electricity is only in one direction. This means that the current steadily moves in just one direction. Its strength remains constant.

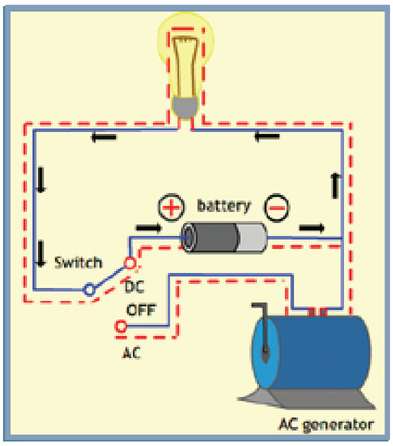


Figure 3.7_2 : Direct current or DC

3.7.1 Types of Polarity

- As with any electrical current moving through a circuit, a welding arc too has polarity, with a negative and positive pole.
- Polarity is referred to as the direction of the current flow within a circuit.
- Polarity has a substantial influence on the strength of a weld.
- Electrode-positive (reverse) polarity leads to a deeper penetration of the weld then electrode-negative (straight) polarity.
- If it is a straight polarity, the electrode is negative and the workpiece positive.
- If it is a reverse polarity, the electrode is positive and the work-piece negative.
- Generally DC welding is the preferred type of welding. As it tends to produce a smoother weld than AC.
- Being significantly inferior to DC welding, AC welding is only used in rare circumstances.

The following are similarities and differences between A.C. and D.C. motors:

	DC Motor	AC Motor
Similarities	1. To convert electrical energy to rotational mechanical energy.	1. To convert electrical power to rotational mechanical energy.
Differences	1. Commutator present. 2. Cheap. 3. Fixed speed. 4. Requires direct current.	1. Absence of commutator (use slip rings). 2. Expensive. 3. Variable speed. 4. Requires alternating current.

Table: 3.7_1 : Differentiate AC/DC Machines

Comparison of D.C. and A.C. arc welding

	Alternating Current (from Transformer)	Direct Current (from Generator)
1	More efficiency	Less efficiency
2	Power consumption less	Power consumption more
3	Cost of equipment is less	Cost of equipment is more
4	Higher voltage – hence not safe	Low voltage – safer operation
5	Not suitable for welding non-ferrous metals	Suitable for both ferrous non-ferrous metals
6	Not preferred for welding thin sections	Preferred for welding thin sections
7	Any terminal can be connected to the work or electrode	Positive terminal connected to the work Negative terminal connected to the electrode

Table: 3.7_2 : Table: A.C. and D.C.

Unit 3.8 Various Types of Base Metals used in Welding and Their Implications

Unit Objectives

At the end of this unit, you will be able to:

- Distinguish the base metals used in welding
- Evaluate the implications of base metals used in welding

A welding operator should have the ability to apply knowledge of metals and non-metals. Find below a table that shows the differences between metals and non-metals.

Metals	Non-metals
State: Metals are generally solids at room temperature. Exception: Mercury and gallium are liquid at room temperature.	State: Non-metals are generally solids or gases. Exception: Bromine is the only non-metal in liquid state.
Hardness: Metals are generally hard.	Hardness: Non-metals are generally soft.
Lustre: Metals in their pure state have a brilliant shine called as metallic lustre.	Lustre: Non-metals generally do not have lustre.
Density: Metals generally have high density.	Density: Non-metals generally have low density
Malleability: Metals are generally malleable (can be beaten into sheets).	Malleability: Non-metals are non-malleable; if they are hammered they form powdery mass.
Ductility: Metals are ductile (Drawn or stretched into thin wires).	Ductility: Non-metals are non-ductile.
Metals are good conductors of heat and electricity.	Non-metals are in general bad conductors of electricity.
Metals are strong and tough, they have high tensile strength.	Non-metals are not strong, they have low tensile strength.
Metals are sonorous, they produce a ringing sound when struck.	Non-metals are not sonorous.

Table: 3.8_1 : Metals and Non-metals

Understanding welding metals is one of the pillars of knowledge needed to be a successful welder. Each metal and metal alloy responds differently to heat and in the way they can be manipulated. Metals expand and soften when heated, resulting in different uses and applications. They also respond in different ways to the various types of welding methods used.

The following are different types of metals used in welding operations.

Steel

It is an alloy that contains iron and 2% of other elements. As it is versatile, steel can be used in many welding processes.

Figure 3.8_1: Steel

Stainless Steel

Figure 3.8_2 : Stainless Steel

Unlike plain steel, stainless has the properties to resist corrosion and is hygienic. Stainless steel can be welded using arc welding processes like TIG, MIG and Stick welding.

Aluminium

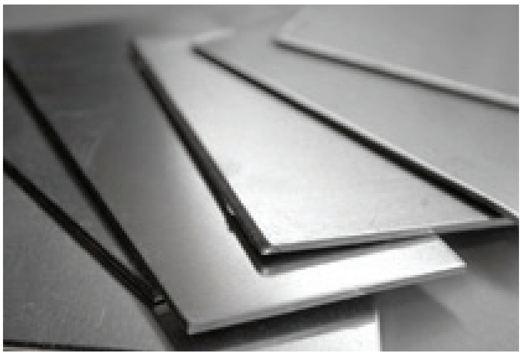


Figure 3.8_3 :Aluminium

Like stainless steel, aluminium too is not as susceptible to corrosion as other metals. It is lighter than stainless steel. GTAW is the process of choice for aluminium welding.

Copper

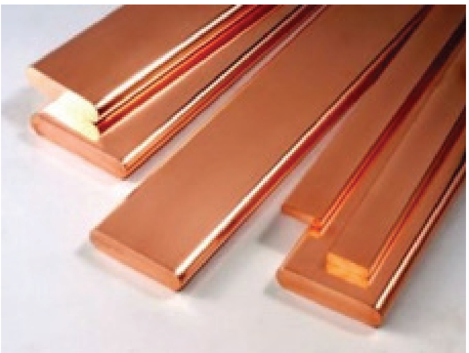


Figure 3.8_4 : Copper

Among all the welding metals, copper is popular, thanks to its corrosion resistance, heat conductivity, electrical conductivity, wear resistance and appearance. Copper is welded using Gas Metal Arc Welding and Gas Tungsten Arc Welding.

Cast Iron

Figure 3.8_5: Cast Iron

Cast iron properties include higher carbon and silicon content. This metal is not very ductile. While welding with cast iron the surface needs to be thoroughly cleaned to get rid of any ingrained grease and oil. Oxyacetylene welding is used for cast iron metal.

Magnesium

Figure 3.8_6 :Magnesium

As magnesium alloys are light weight (2/3 of aluminium), they have the property of absorbing vibration and are easy to cast. This metal is welded using TIG welding.

Notes

Unit 3.9 Magnetic arc blow or arc deflection

Unit Objectives

At the end of this unit, you will be able to:

- Analyze the concept of Arc Blow
- Practice the methods to avoid or compensate for magnetic problems

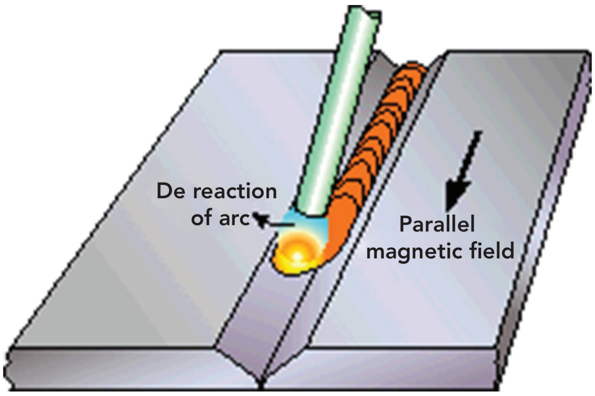


Figure 3.9_1 : Magnetic arc blow

- All welding processes that use either an arc or a beam of electrons by their nature are subject to disruption in a magnetic field.
- This results from the electrons being forced to move along a curved path when they pass through the magnetic field.
- This causes the arc to deflect and behave erratically.
- Arc blow effects can be reduced by welding at higher currents which result in a stiffer arc.
- Welding that is performed in hyperbaric conditions is more prone to arc blow.
- TIG welding has the tendency of being more sensitive to arc blow than MMA or MIG welding, as lower arc voltages are used.

Methods to avoid or compensate for magnetic problems:

- In the first case it is essential to know the strength of the magnetic field the weld preparation.
- If there are fields of 4mT (40 gauss), it will exert a perceptible pull on a welding rod (not for an austenitic rod).
- A gauss meter or a magnetic field meter gives a quantitative reading and indicates whether the magnetic field is uniform or along the joint.
- In cases where the field is relatively low it is possible to reduce the problem to controllable levels by adjusting the welding parameters.
- When dealing with small components, these can be passed through a demagnetising coil powered from the mains.
- When dealing with large components, such as a tubular structure or a pipeline, there is an excess of stored magnetic energy, which makes demagnetisation virtually impossible to achieve.
- Nonetheless, you can remove magnetism in a joint preparation, thus enabling welding to take place

Unit 3.10 Significance of Diffusible Hydrogen for Welds

Unit Objectives

At the end of this unit, you will be able to:

- Define diffusible hydrogen in welds
- Analyze how to diminish diffusible hydrogen in welds

The welding process produces hydrogen which is generated from the dissociation of water vapour in the welding arc. When certain metals like aluminium and steel are at or near their melting temperatures, they diffuse hydrogen at a very high rate.

- o When the hydrogen atoms are in the weld metal, they diffuse swiftly into the heat-affected zone (HAZ) of the base metal, as diffusible hydrogen ([H]D), as they have a diameter that is much smaller than the lattice size of the metals.
- o [H]D content of weld metal can be measured by several different methods.
- o The method commonly used for measuring the [H]D content of the weld metals produced by the SMAW,SAW and FCAW processes is gas chromatography.
- o [H]D can result in hydrogen cracking. The possibility for hydrogen cracking in th

In order to decrease the content of [H]D and diminish its negative effects when welding, the following points are recommended:

(1) Make use of low hydrogen welding consumables and, in fact extra-low and ultra-low hydrogen welding consumables.

(2) Storage and re-drying of the welding consumables should be carried out according to the manufacturers' recommendations.

(3) See that the welding groove and the area around it are cleaned carefully to get rid of such hydrogen sources a soil, rust, rainwater, paint, and dew.

Unit 3.11 Welding Process Specification Sheet

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the concept of Welding process specification sheet
- Analyze the details of Welding process specification sheet

The following is an example of a WPS that is used by welding operators. This document acts as a formal written document giving the details of welding procedures, welding directions and other information that a welder requires to perform the project at hand. The aim of this document is to guide welding operators so that they conduct accepted procedures. This ensures trusted and repeatable welding techniques and finished products. A WPS is developed for each welding type and for each material alloy used.

Code: AWS D1.1

Company Name: www.WPSAmerica.com

Address: info@WPSAmerica.com, 1 (877) WPS-WELD

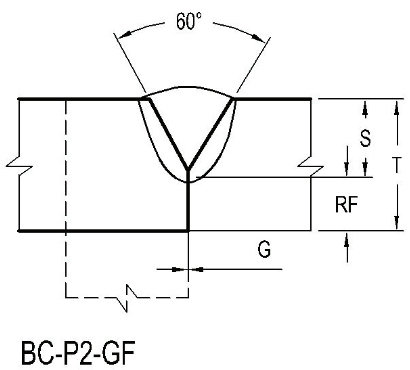
Identification #:	GMAW-DEMO
WPS Prequalified:	Yes

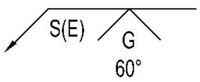
Welding Process:	**Process Type:**	**Position(s):**	**Supporting PQR No.(s):**
GMAW	Semi-Automatic	Flat	N/A

Base Metal Part I (Material Spec., type or grade):	**Base Metal Part II (Material Spec., type or grade):**
Steels in Group I and II of Table 3.1-AWS D1.1	Steels in Group I and II of Table 3.1-AWS D1.1

Qualified Thickness and Diameter Range:	**Filler Metals: AWS Classification/AWS Specification:**
Groove (Fillet): mm (in) T > = 6 mm (1/4 in)	E70C-6M H4 A5.18

Joint Details/Sketch:





RF≥3mm ($\frac{1}{8}$ in)
G=0
E=S
T ≥ 6 mm ($\frac{1}{4}$ in)

Table 3.4 of AWS D1.1		
T	S	E min
in	in	in
T = $\frac{1}{4}$	As specified in the drawing	$\frac{1}{8}$
T ≤ $\frac{1}{2}$		$\frac{3}{16}$
T ≤ $\frac{3}{4}$		$\frac{1}{4}$
T ≤ 1-$\frac{1}{2}$		$\frac{5}{16}$
T ≤ 2-$\frac{1}{4}$		$\frac{3}{8}$

Joint Design Used: mm (in)

Root Opening G: *0* Root Face RF: > = *3 mm (1/8 in.)* Groove Angle: *60 °* Radius (J-U): *N/A*

Weld Type:	**Joint Type:**
Partial Joint Penetration Groove Weld	Butt Joint Corner Joint

Backing Option:	**Backing Material:**	**Back Gouging Method:**
Welded without backing	N/A	N/A

Identification #: GMAW-DEMO

Sheet 2 of 3

Electrical Characteristics:

Current Type/Polarity: DCEP

Transfer Mode (GMAW): Spray

Tungsten Electrode (GTAW):

Type: N/A

Size: mm (in) N/A

Shielding:

Gas Composition (Flux for SAW): Ar + 5 to 15% CO_2

Gas Flow Rate: lt/min. (CFH) 40 to 50 CFH

Gas Cup Size: 5/8 in.

Welding Procedure

Weld Layers	Pass No.	Process	Filler Metal Classification	Filler Metal Diameter mm (in)	Current Amps	Current Type & Polarity	Wire Feed Speed (in/min)	Volts	Travel Speed (in/min)	Remarks [Heat Input] J/mm (J/in)
1	1	GMAW	E491C-6M-H4	1.4 mm (0.052)	200-250	DCEP	200-250	25-27	10-14	Root Pass
1 to 2	2 to 3	GMAW	E491C-6M-H4	1.4 mm (0.052)	200-250	DCEP	200-250	25-27	10-14	Fill Pass
2 to n	3 to n	GMAW	E491C-6M-H4	1.4 mm (0.052)	270-300	DCEP	270-320	26-28	12-18	Weld Size > = 10 mm (3/8 in.)

Technique:

Stringer or Weave Bead: *Stringer Bead*

Contact Tube to Work Distance: *1 to1-1/8 in.*

Initial/Interpass Cleaning: *Wire Brush, Grind*

Peening: *N/A*

Number of Electrodes: *Single*

Electrodes Spacing: *Longitudinal: N/A* *Lateral: N/A* *Angle: N/A*

Heat Treatment:

Preheat Temp. Min °C (°F): *0 to 10 °C-Table 3.2 AWS D1.1*

Interpass Temp. Min/Max °C (°F): *0 to 10 °C-Table 3.2 AWS D1.1*

Postweld Heat Treatment: Temp. °C (°F): *N/A*

Time: *N/A*

Additional Notes:

The end of contact tube recommended to be recessed in the cup nozzle at least 6 mm (1/4 in.)

Manufacturer/ Contractor Welding Engineer:

Name: *Jim Clark*

Title: *Welding Engineer*

Date: *12/12/2005*

Authorized by:

Name: *John Smith*

Title: *QA Manager*

Date: *12/12/2005*

Identification #: GMAW-DEMO Sheet 3 of 3

Heat Treatment (AWS Code's Guideline):

PREHEAT TABLE:

Preheat and interpass temperature shall be sufficient to prevent cold cracking.
The need for and the temperature of preheat are dependent upon a number of factors such as chemical analysis, degree of restraint of the parts being joined, elevated temperature mechanical properties, and material thicknesses.
AWS D1.1, Table 3.2 Prequalified Minimum Preheat and Interpass Temperature °F (°C):
Preheat and Interpass temperature is provided for each material and thickness and process type on this material group.
Guideline on Alternative Methods for Determining Preheat/Interpass: See Annex XI of AWS D1.1
Preheat requirements shall be based on Welding Procedure Specification (WPS).

POSTWELD HEAT TREATMENT:

PWHT requirements shall be based on Welding Procedure Specification (WPS).
AWS D1.1, 5.8 Stress-Relief Heat Treatment: Where required by the contract drawings or specifications, welded assemblies shall be stress relieved by heat treating.
(See AWS D1.1, 5.8.1, Requirements for stress-relief treatment;
Table 5.2, Minimum Holding Time; Table 5.3, Alternate Stress-Relief Heat Treatment)
See AWS D1.1, 5.8.3, Steels Not Recommended for PWHT

WPS Qualified Range (AWS Code's Guideline):

Qualified Position (s): For Prequalified WPS, only Position (s) allowed for prequalified joint details shown in WPS based on Figures 3.3 or 3.4 of AWS D1.1

Qualified Thicknesses: For Prequalified WPS, only thickness ranges allowed for prequalified joint details shown in WPS based on Figures 3.3 or 3.4 of AWS D1.1

Qualified Diameters: For Prequalified WPS, pipe diameters [over or less than 24 in. (600 mm OD)] allowed for prequalified joint details shown in WPS based on Figures 3.3 or 3.4 of AWS D1.1

Prequalified WPS Base Metal Group Allowed: Only Base Metal Group-Filler Metal Combinations for Matching Strength as shown in Table 3.1 of AWS D1.1

Filler Metal Allowed in Prequalified WPS: Only Filler Metal-Base Metal Group Combinations for Matching Strength as shown in Table 3.1 of AWS D1.1 (Size and other limit on electrode for prequalification of each process, as per Table 3.7 of AWS D1.1)

Unit 3.12 Travel Speed and Heat Inputst

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the concept of Travel Speed
- Evaluate the concept of Heat Input

What is Heat Input?

- Heat input can be defined as "the electrical energy supplied by the welding arc to the workpiece."
- In practice, heat input is characterized as the ratio of the arc power supplied to the electrode to the arc travel speed, as shown in the following equation below:

$$HI = \frac{A \times V \times 60}{S}$$

Where "A" is welding current (ampere: the quantity of electricity conveyed in one second).

"V" is welding arc-voltage (volt);

"S" is the arc travel speed or welding speed (mm/min or cm/min)

"60" standardizes the units for "A" and "S," since 1 minute is 60 seconds).

- The primary characteristic of heat input is that it governs the cooling rates in welds.
- This in turn affects the heat-affected zone and microstructure of the weld metal.
- A variation in microstructure directly affects the mechanical properties of welds.
- Thus, the control of heat input is extremely important in arc welding in terms of quality control.

What is Travel Speed?

- Travel speed is considered a function of time and distance travelled.
- Distance travelled indicates the actual length for which weld metal is deposited from the initiation of the arc to the termination of the arc.
- To calculate for a given welding process is quite simple.
- You need to determine the actual location on the workpiece at which you will begin depositing filler metal along with a starting time.
- You can make use of a stopwatch or a timepiece with a second hand for this.
- Start timing the welding process when you initiate the arc and stop when the weld pass is terminated.
- After that determine how much time elapsed along with the total length of filler metal deposited.

For example, if the welder travelled 4.5 inches in 50 seconds. Divide 4.5 by 50 and you get 0.09 inches per second. Multiply 0.09 by 60 (seconds per minute) and the resultant answer is 5.4 inches per minute (in./min). This particular welder's travel speed is 5.4 in./min at his/her current welding parameters.

Unit 3.13 Amperage Requirements for Different Classification of Electrodes and Positions

Unit Objectives

At the end of this unit, you will be able to:

- Define Classification of electrodes
- Evaluate the implications of various diameters of electrodes
- Analyze electrode size and amperage requirements

Operators must able to identify and use the correct welding electrodes. The American Welding Society (AWS) numbering system enables a welder to learn quite a lot about various stick electrodes including what application they works best in and how they should be used to maximize performance.

See chart below:

Digit	Type of Coating	Welding Current
0	High cellulose sodium	DC+
1	High cellulose potassium	AC, DC+ or DC-
2	High titania sodium	AC, DC-
3	High titania potassium	AC, DC+
4	Iron powder, titania	AC, DC+ or DC-
5	Low hydrogen sodium	DC+
6	Low hydrogen potassium	AC, DC+
7	High iron oxide, iron powder	AC, DC+ or DC-
8	Low hydrogen potassium, iron pow-der	AC, DC+ or DC-

3.13.1 Importance and implications of various diameters of electrodes

There are several different types of electrodes used in the shielded metal arc welding, (SMAW) process. Arc welding electrodes are made in sizes from 1/16 to 5/16. An example would be a welding rod identified as an 1/8" E6011 electrode.

- The electrode is 1/8" in diameter
- The "E" stands for arc welding electrode.
- Next will be either a 4 or 5 digit number stamped on the electrode. The first two numbers of a 4 digit number and the first 3 digits of a 5 digit number indicate the minimum tensile strength (in thousands of pounds per square inch) of the weld that the rod will produce, stress relieved. Examples would be as follows:
- E60xx would have a tensile strength of 60,000 psi E110XX would be 110,000 psi
- The next to last digit indicates the position the electrode can be used in.
- EXX1X is for use in all positions

- EXX2X is for use in flat and horizontal positions
- EXX3X is for flat welding
- The last two digits together, indicate the type of coating on the electrode and the welding current the electrode can be used with. Such as DC straight, (DC -) DC reverse (DC+) or A.C.

3.13.2 Electrode Size and Amperage requirements

Below you will find a basic guide of the amp range that can be used for different size electrodes. Note that these ratings can be different between various electrode manufactures for the same size rod. The type coating used on the electrode has the potential of affecting the amperage range.

ELECTRODE DIAMETER (THICKNESS)	AMP RANGE	PLATE
1/16"	20 - 40	UP TO 3/16"
3/32"	40 - 125	UP TO 1/4"
1/8	75 - 185	OVER 1/8"
5/32"	105 - 250	OVER 1/4"
3/16"	140 - 305	OVER 3/8"
1/4"	210 - 430	OVER 3/8"
5/16"	275 - 450	OVER 1/2"

Note: The thicker the material to be welded, the higher the current needed and the larger the electrode needed.

3.13.3 Storage Requirements for Consumable Electrodes

Covered electrodes are by their nature sensitive to moisture pick up. Hazards like high moisture contents in the coating could lead to hydrogen cracking or porosity. This is why they must be stored under the appropriate climatic conditions.

Low hydrogen electrodes

- Low hydrogen electrodes may be re-dried if they exceed exposure limits.
- It is critical to avoid drying electrodes at temperatures above those recommended.

Non-Low Hydrogen Electrodes

- If exposed to humid air for long periods of time the welding characteristics may be affected.
- If moisture appears to be causing problems it is recommended to store open containers in cabinets heated to 100F – 120F.

Notes

Unit 3.14 Pre-heating and Post-heating in Welding

Unit Objectives

At the end of this unit, you will be able to:

- Define the purpose of pre-heating base metals
- Define the types of post-weld heating operations
- Analyze the tools to measure temperature for pre-heat and post-heat requirements

3.14.1 Purpose and Importance of Pre-heating Requirements for Base Metals

- Pre heating is normally required in order to ensure appropriate weld integrity and will typically remove or prevent undesirable characteristics in the completed weld.
- Preheating may be performed by the use of oxy-gas flames, gas burners, electric blankets, heating in a furnace or by induction heating.
- To gain good results, it is crucial for the heating to be uniform around the joint area.
- You would need to obtain a uniform temperature through the material thickness, so it is necessary to apply the heating sources to one side of the material surface and to measure the material temperature on the opposite side.
- It is vital to ensure that the entire material thickness has been heated uniformly.

Reasons for preheating are:

To keep moisture away from the weld area:

- This is conducted by heating the surface of the material to a low temperature, just above the boiling point of water.
- This serves to dry the plate surface and get rid of the undesirable contaminants.

To lower the thermal gradient:

- A sharp temperature differential tends to occur between the localized heat source and the cool base of the material being welded.
- This stark temperature difference results in differential thermal contraction and expansion as well as high stresses around the welded area.
- Lowering this temperature differential by means of preheating the base material will minimize problems associated with excessive residual stress and distortion.

3.14.2 Purpose and Importance of Post-heating in Welding

Post-heating can be termed as the application of heat to an assembly after welding. Post-heating includes immediate postweld heating (IPWH), postweld heat treatment (PWHT), normalizing, tempering (aging) and quenching. The main reasons of these operations in welding fabrication are as follows:

- IPWH: relieves diffusible hydrogen
- PWHT: relieves residual stresses
- Normalizing: refines microstructures deformed by hot forming (e.g., applied on the end plate of vessels)
- Tempering (Aging): stabilizes microstructures after quenching or welding
- Quenching: hardens welds by rapid cooling, using water, air, or mist (e.g., applied on surfaced shafts)

3.14.3 Tools and Methods to Measure Temperature for Pre-heat and Post-heat Requirements

Thermo Chalks/Pen

Thermo Chalks, commonly known as Hot Marking Chalks, are used for temporary marking of metals, alloys before the preheating, cutting and welding operations commence. These are heat resistant in nature and can comfortably be used on hot and rough surfaces.

Figure 3.14.3_1 : Thermo chalks/pens

Thermocouple

- This is a device used extensively for measuring temperature.
- Thermocouples comprise two wire legs made from different metals.
- These wires legs are welded or joined together at one end, creating a junction. The temperature is measured at this junction.
- Once the junction experiences a change in temperature, a voltage is created.
- The voltage recorded can then be interpreted using thermocouple reference tables to calculate the temperature.

Figure 3.14.3_2 : Thermocouple

Unit 3.15 Types of visual inspection indicators and methods

Unit Objectives

At the end of this unit, you will be able to:

- Define different types of visual inspection
- Evaluate the need for visual inspection of welds

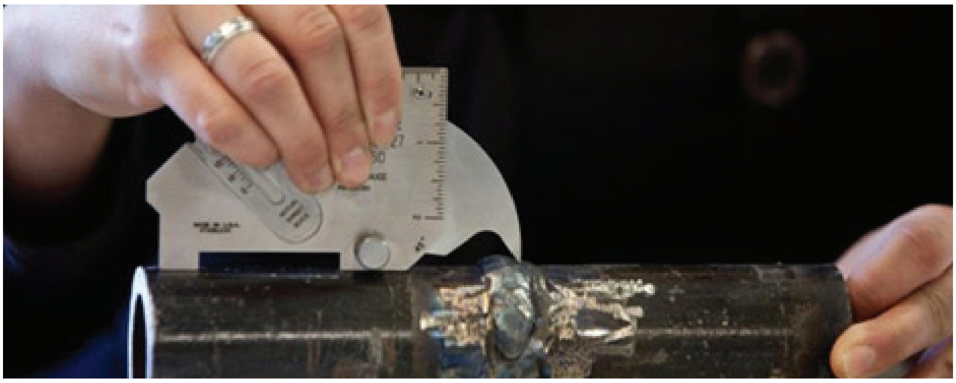


Figure 3.15_1 : Visual Inspection

Often visual inspection can be utilized to maintain acceptable welding quality as well as prevent welding problems from happening in the first place.

The welding inspection function is often divided into three areas.

1. Pre-Weld Inspection

- This inspection is conducted prior to the start of the welding operation.
- At this stage the welder can introduce controls that may prevent defective welding.
- Joint preparation inspection/pre-weld setup are some areas of pre-weld inspection.
- Inspection would include temperature and heating method, preheat verification, type and efficacy of gas purging, documentation verification, material certification etc.

2. Inspection During Welding

- This inspection is carried out during the welding operation.
- It is concerned mainly with the requirements of the welding procedure specification (WPS).
- Items such as welding current settings, interpass temperature control, interpass cleaning methods, welding travel speed, gas flow rate, shielding gas type are inspected.
- Environmental conditions such as rain, wind, and extreme temperatures that could affect the quality of the weld are also inspected.

3. Post-Weld Inspection

- At this stage the integrity of the completed weld is typically in focus.
- Several non-destructive testing (NDT) methods are employed during post-weld inspection.
- Common welding discontinuities seen during visual inspection include surface porosity, undercut, overlap, undersized welds, surface cracking etc.

Summary

- Aerospace welders carry out operations on technology and equipment found in space shuttles, airplanes and similar structures.
- Surface tension transfer process has the aim of boosting productivity by substituting such older welding methods
- Destructive Weld Testing involves physical damage to workpiece and welded joint.
- There is no one extinguisher type which works on all classes of fire.
- Acute exposure to welding gases and fume can result in nose, eyeand throat irritation, nausea and dizziness.
- Welding cables are developed for use in electric arc-welding machines to power an electrode, a metal rod specially designed to conduct a charge.
- In alternating current or AC the movement or flow of electricity reverses its direction at regular intervals.
- Steel is an alloy that contains iron and 2% of other elements.
- All welding processes that use either an arc or a beam of electrons by their nature are subject to disruption in a magnetic field.
- Make use of low hydrogen welding consumables and, in fact extra-low and ultra-low hydrogen welding consumables.
- Covered electrodes are by their nature sensitive to moisture pick up.
- In practice, heat input is characterized as the ratio of the arc power supplied to the electrode to the arc travel speed.
- Travel speed is considered a function of time and distance travelled.
- Arc welding electrodes are made in sizes from 1/16 to 5/16.
- Pre heating is normally required in order to ensure appropriate weld integrity.
- Thermo Chalks, commonly known as Hot Marking Chalks, are used for temporary marking of metals and alloys.
- Often visual inspection can be utilized to maintain acceptable welding quality as well as prevent welding problems from happening in the first place.

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Scan the QR codes or click on the link to watch the related videos

https://www.youtube.com/watch?v=Tf0T-cu-UURk

Shielded Metal Arc Welding

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https://www.youtube.com/watch?v=Y3L-tOhDOMek

Difference Between Shielded Metal Arc Welding (SMAW) and Gas Metal Arc Welding (GMAW)

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https://www.youtube.com/watch?v=n_Du-zHRZ4JI

Welding, Types of Welding and Types of weld joints

Scan the QR codes or click on the link to watch the related videos

https://www.youtube.com/watch?v=kOiadm-NORu8&t=414s

Weld Testing Methods

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Intro to Welding Polarity

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4. Manually (semi-automatic) Welding Joints using the MIG/MAG

HYDROCARBON SECTOR
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Key Learning Outcomes

After attending the session, you will be able to:

1. Define welding equipment available for GMAW
2. Evaluate the principles and techniques of MIG/MAG welding
3. Define the hazards associated with MIG welding
4. Analyze the functions of Shielding Gases
5. Analyze gas pressures and flow rates
6. Define modes of metal transfer
7. Analyze the types of welded joints
8. Evaluate the checks to be made prior to welding
9. Define the factors that determine weld bead shape
10. Evaluate the electrical characteristics of the MIG/MAG welding arc
11. Analyze the problems during welding activities
12. Practice the visual examination of the welds

Unit 4.1 Range of Welding Equipment available for GMAW Welding

Unit Objectives

At the end of this unit, you will be able to:

- Define the GMAW welding equipment
- Evaluate the importance of GMAW welding equipment

To perform gas metal arc welding, the basic necessary equipment include:

- A welding gun
- A wire feed unit
- A welding power supply
- A welding electrode wire
- A shielding gas supply

Welding Gun

The primary function of a welding gun, also known as a torch, is to deliver the welding current, welding wire and shielding gas to the welding arc.

Wire feed unit

The wire feed unit ensures a steady supply the electrode to the workpiece, driving it through the conduit and on to the contact tip.

Welding power supply

Two types of power sources are used for MIG welding:

a. Constant current power supply
b. Constant voltage power supply

Welding electrode wire

The mechanical properties of the weld are greatly influenced byelectrode selection and play a key factor in weld quality.

Shielding gas supply

Shielding gases are essential for GMAW welding in order to protect the welding area from atmospheric gases such as oxygen and nitrogen, which have the potential of causing weld metal embrittlement, fusion defects and porosity if they come in contact with the electrode, the arc, or the welding metal.

Unit 4.2 Functions of Welding Equipment

Unit Objectives

At the end of this unit, you will be able to:

- Define the functions of Welding equipment
- Analyze the uses of Welding equipment

MIG welder

Figure 4.2_1 : MIG welder

In a MIG welder, the tank is filled with a mixture named Metal Inert Gas. A MIG welder is also a wire-feed type welder. A MIG welder has a number of different heat settings.

TIG welder

Figure 4.2_2 : TIG Welder

A TIG welder makes use of a non-consumable electrode and a shielding gas to create and protect the joint throughout the welding process. TIG employs long rods that have to be held separately and fed into the weld puddle.

Shielding Gas

Figure 4.2_3 : Shielding Gas

Shielding gases are gasses that are semi-inert or inert. They are frequently used in various welding processes. They serve the purpose of protecting the weld area from water vapour and oxygen.

Welding Regulator

Figure 4.2_4 :Welding Regulator

A welding regulator carries out the function of monitoring the flow of shielding gas to the welding puddle. Gas needs to flow out to the welding arc in an easy and controlled manner.

Welding Rods and Electrodes

Figure 4.2_5:Welding Rods and Electrodes

In some arc welding methods the welding rod is sometimes used as an electrode, and it is usually made of the same material as the base material that is being welded.

The welding rod is connected to the welding machine and becomes a transmitter to supply electric current which is needed to weld two pieces of metal together.

Welding Pliers

Figure 4.2_5 :Welding Pliers

These pliers have a specially designed nose for easily removing welding spatter. They are also used for cutting welding wire and tightening contact tips etc.

Tin Snips

Figure 4.2_6 :Tin Snips

Aviation tin snips are designed is a way that allows right and left hand cuts and yet they do not deform the metal.

Vice Grips

Figure 4.2_7: Vice Grips

This equipment is used for holding and securing panels that are being welded.

Chipping Hammers

Figure 4.2_8 : Chipping Hammers

The welder uses a chipping hammer that's 8-10 inches long to gently dislodge the slag from the weld surface.

Spanners

Figure 4.2_9: Spanners

A Double ended Spanner is a tool used by welders for fitting gas regulators.

Earth Clamps

Figure 4.2_10 : Earth Clamp

The welding current passes through the earth clamp. This tool allows the electrical circuit to reach the ground safely and securely.

Electrode Holders

Figure 4.2_11 : Electrode Holder

Also known as a stinger, an electrode holder, is a clamping device that serves the purpose of holding the electrode securely in any position.

Tools to measure and mark materials as per the drawing

Steel rule and tape

Figure 4.2_12 : Steel rule and tape

When measuring for most welded items, you do not require accuracies more than what can be gained with a steel tape or a steel rule.

Inside and Outside Calipers

Figure 4.2_13 : Inside and Outside Caliper

Usually these come in two types- inside and outside caliper. Calipers are used to measure external and internal size of an object. It needs an external scale to compare the measured value.

Weld Fillet Gauges

Figure 4.2_14 : Fillet Gaugee

The fillet gauge is a tool that is simple to use for weld joint preparation functions as well as for examination of the weld joint. The tool combines a depth gauge, angle gauge, bore gauge & weld height gauge.

Unit 4.3 Principles and Techniques of MIG/MAG Welding

Unit Objectives

At the end of this unit, you will be able to:

- Define the principles of MIG welding
- Analyze the equipment used in MIG welding
- Evaluate Current and Polarity required for GMAW

MIG stands for metal inert gas welding or sometimes it is known as Gas Metal Arc welding (GMAW). It is arguably the most popular and easiest to welding process to learn. This arc welding process can be automatic or semi-automatic. In the MIG process inert gases are used as shielding gas and a consumable wire electrode is used.

Principles of MIG welding

This type of welding works on basic principle of heat generation due to electric arc. The heat produced further melts the consumable electrode and base metal which then solidify together and create a strong joint.

Equipment used in MIG welding

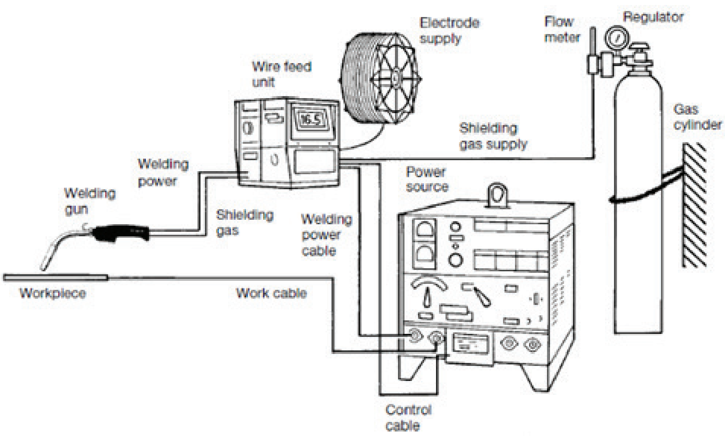


Figure 4.3_1: Equipment used in MIG welding

Current and Polarity required for GMAW:

The current required for MIG or GMAW welding is DC electrode positive or reverse polarity. The polarity connections are normally located on the inside of the machine.

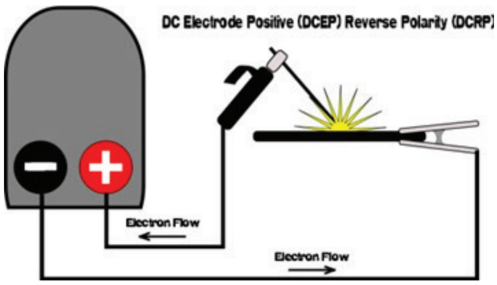


Figure 4.3_2: Current and Polarity required for GMAW

Wire Feeder System:

MIG welding needs continuous consumable electrode supply for welding two plates. This consumable electrode used in form of wire, which is continuously supplied by a wire feed mechanism.

Welding Torch:

The welding torch used for MIG welding has a mechanism which holds the wire and supplies it continuously with the help of a wire feed.

Shielding Gases:

The primary function of shielding gases is to protect weld area from other reactive gases like oxygen etc.

Regulators:

As the name implies, they are used to regulate the flow of inert gases from the cylinder.

Process of MIG welding:

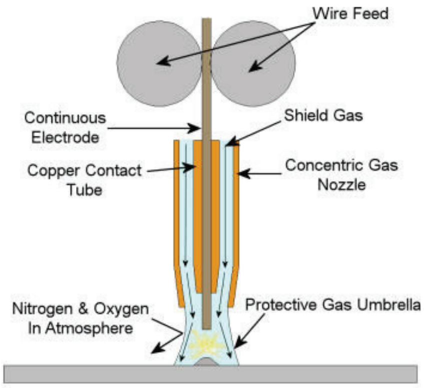


Figure 4.3_3: Process of MIG welding

- First, a high voltage current is change into DC current supply with high current at low voltage. This current passes though welding electrode.
- A consumable wire is used as an electrode. The electrode is connected to the negative terminal and the work piece from a positive terminal.
- A fine intense arc will be generated between the electrode and work piece because of power supply.
- This arc is used to produce heat which melts the electrode and the base metal. Frequently the electrode is of the same metal as the base metal in order to create a uniform joint.
- This arc is well shielded by shielding gases. These gases protect the weld form other reactive gases which can damage the strength of welding joint.
- This electrode travels continuously on the welding area in order to make a proper weld joint. The angle of the direction of travel should be kept between 10-15 degrees. For fillet joints the angle should be 45 degree.

Care and maintenance of machines while welding

Regular care and maintenance for welding equipment is highly required. This is to ensure effective performance as well as protection for the user

- It's crucial to follow and read carefully the safety information provided in the operator's manual.
- The very basic step to maintain the effectiveness of welding equipment is by following its specifications.

- Be aware of the rated duty cycle of the machine. Do not use your welding equipment beyond its limit as this would serve to harm it.
- The dust can accumulate and cover the mechanical parts of the welding machine, and this can be easily removed by taking off the cover and blow it with a compressed air.
- See that the welding equipment is checked by a qualified technician to remove the dirt buildup, grime and dust in various parts of the machine.
- Parts like tips or nozzles on welding torches as well as other worn out parts will need to be replaced frequently.

Notes

Unit 4.4 Safe Working Practices and Procedures to be Followed when preparing and Using MIG/MAG Welding Equipment

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the need for Safe working practices
- Practice safe working procedures during MIG welding

Any and all practices related to MIG welding safety are required to protect the welder against the forces of gas, heat, electricity and light. The following are Standard Operating Procedure to be used during MIG welding:

- Adequate lighting
- Check for gas leaks
- Ventilation per OSHA standards
- Safe storage of flammable gases and liquids
- Check integrity of electrical cords
- Keep a first aid kit on hand
- Keep a fire extinguisher on hand

Use proper welding gear:

- Approved safety glasses must be worn at all times in addition to a welding helmet.
- Appropriate footwear with substantial uppers and rubber soles must be worn.
- Protective welding helmet with the correct grade of UV lens for MIG must be worn.
- Protective leather welding gloves must be worn when using this equipment.
- Close fitting protective clothing or overalls, a leather apron & spats must be worn.
- Rings & jewellery should NOT be worn when using any welding equipment.

Pre-operational safety checks:

- Ensure that you have a suitable safe work area for welding.
- Keep the area clean & free of grease, oils & flammables.
- Ensure that fellow workers and supervisors are protected from any UV flash.
- Ensure the area is well ventilated (follow fume extraction safety procedures).

Operational safety checks:

- See that the machine is correctly set up for current, voltage, wire feed and shielding gas flow rate.
- Make sure that other workers in this locality are protected from any UV & IR radiation flash. Always close the UV curtain to the welding bay or erecting a UV screen.
- Check the condition of, welding leads, earthling arrangements and electrode holder
- Check to see if the welding return cable (earth) makes firm contact to provide a good electrical contact.
- Confirm whether the workpiece has been prepared to be free of any paint, oxides or other surface finishes ensuring a good electrical contact.
- Take particular care to avoid accidental UV welding flash to the skin or eyes.

- Never leave the MIG welder running unattended.
- Frequently inspect the welding tip and shield for damage.
- Report any faults or potential hazards to appropriate authority.
- If welding is finished or interrupted, be sure to turn off the shielding gas at the regulator, turn off the machine as well as secure the handpiece safely.

Housekeeping:

- Make sure that the shielding gas bottle valve and regulator are closed.
- Ensure the welder and fume extraction are switched off.
- Keep the welding gun and hoses securely hung up.
- Exit the work area after leaving welding bench in a safe, clean, & tidy condition.
- It is important that welders adhere to procedures or systems in place for health and safety both at the site and the workshop.

Unit 4.5 Hazards Associated with MIG Welding

Unit Objectives

At the end of this unit, you will be able to:

- Define MIG welding hazards
- Practice precautions against MIG welding hazards
- Evaluate the importance of correct storage of gas cylinders
- Practice proper storage methods for gas cylinders

Hazard: Electric shock

While welding operations are being carried out the potential of electric shock is one of the most serious risks that can be encountered. Secondary voltage shock from an arc welding circuit is the most common type of electric shock among welders.

Precautions:

- To prevent secondary voltage shock, operators should don dry gloves and never touch either the electrode or the metal portions of the electrode holder with their bare skin or wet clothing.
- Welders should be sure to insulate themselves from both the ground as well as the workpiece, maintaining dry insulation between their body and the metal being welded.
- When a welder accidently touches the electrically "hot" parts inside the electric distribution system he/she could receive a primary voltage shock.
- Only repair technicians who are qualified may attempt to repair or service welding equipment.

Hazard: Fumes and gases

It is known that welding fume consists of potentially harmful complex metal oxide compounds that rise from base metal and the base-metal coatings as well as the consumables.

Precautions:

It's vital to keep your head away from the fumes and use enough ventilation and/or exhaust.

Welding operators should wear an approved respirator (when specified).

Hazard: Fire and explosions

The welding arc gives rise to extremely high temperatures and thus can be considered a significant fire and explosions hazard. The arc itself is not so hazardous but from the heat, sparks and spatter created by the arc are.

Precautions:

- To avoid fires, before welding operations begin inspect the area for any flammable materials and take them out of the area.
- Be aware of where the fire alarms and extinguishers and the nearest exits are located.

Hazard: Injuries from insufficient PPE

With the help of personal protective equipment (PPE) welding operators are kept free from injury, such as exposure to arc rays and burns.

Precautions:

- Even if you are wearing a helmet you also need to wear goggles or safety glasses with side shields to prevent sparks or debris from coming in contact with your eyes.
- Wearing leather boots that have 6-to-8-inch ankle coverage provide the best foot protection.
- Appropriate flame-resistant gloves must always be worn to protect from burns, cuts and scratches.
- To keep your ears protected from factory noises as well as metal and other debris, wear ear plugs or ear muffs.

4.5.1 Correct Handling and Storage of Gas Cylinders

Handling Gas cylinders

- Use the correct procedures, right equipment, and adequate number of persons to carry and move cylinders to prevent cylinder damage and personal injury.
- Don appropriate footwear, safety goggles, and heavy gloves.
- Place cylinders upright on a suitable hand truck or cylinder cart
- Do not roll or drag the cylinders
- Be careful not to bang or drop the cylinders
- Before you can connect the cylinder to a regulator, remain on one side, and briefly open the valve and then shut it immediately. This process is known as "cracking" the valve.
- When open valves do so gently by hand to avoid gauge damage.
- When not in use the gas cylinder valves must be kept closed

Figure 4.5.1_1: Handling Gas cylinders

Storage of gas cylinders

- Storage areas for cylinders should be clearly identified, well-ventilated and dry
- Make sure the area is not exposed to heat or the direct rays of the sun, and is positioned away from elevators, aisles, doorways and stairs.
- Both empty and full cylinders must be stored in the upright position
- Secure the cylinders using non-conductive belt or an insulated chain.
- Once in storage, see that the cylinder valves are closed with their protective caps.
- Cylinders need to be stored away from combustible and flammable liquids
- The storage area should have the required precautionary signs.
- Empty cylinders must be stored separate from full ones.
- Oxygen cylinders must be stored at least 20 feet away from fuel-gas cylinders

Figure 4.5.1_2: Danger Sign

Unit 4.6 Type and Thickness of Base Metals for Welding Purposes

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the types of base metals used for welding
- Analyze the properties of base metals used for welding

The different types of metals that are commonly used for welding can be categorized into two broad categories. They are ferrous and non-ferrous metals. A welder needs to be able to identify Ferrous and non-ferrous metals in order to perform the welding tasks. Let us see the two broad categories of metals in detail.

Ferrous Metals: These are the metals that contain iron. Ferrous metals are magnetic meaning you can pick it up with a magnet. Examples of ferrous metals are: Steel, stainless steel, and all types of iron like wrought iron, cast iron etc.

Non-ferrous Metals: Metals that do not contain iron are called non - ferrous metals. They are non-magnetic. Examples of non - ferrous metals are aluminium, tin, copper etc.

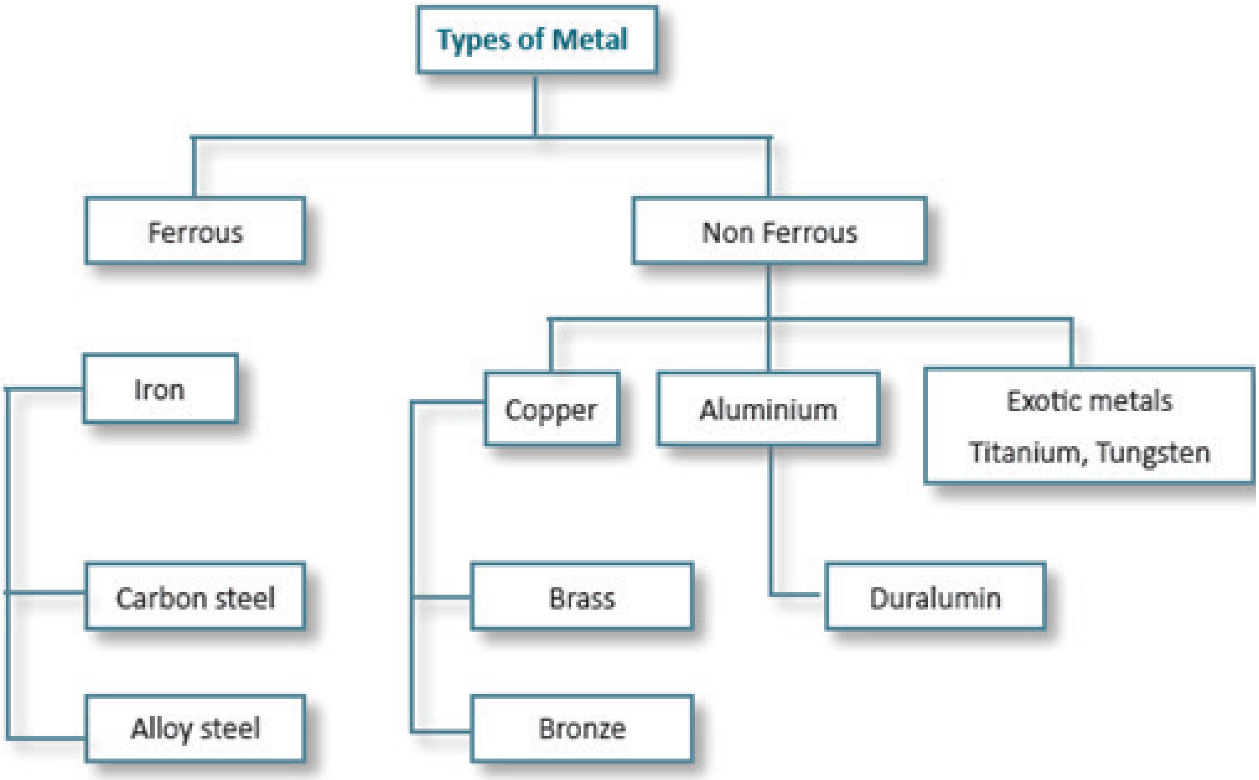


Figure 4.6_1: Classification of Metals

4.6.1 Types of Ferrous Metals

The ferrous group of metals include all the types of iron, steel and their alloys.

- **Pig iron**

Pig iron is an intermediate product obtained during the process of smelting iron ore. Owing to the high carbon content and the other impurities pig iron is a very brittle metal.

- **Cast iron**

The properties of cast iron include good compressive strength but comparatively poor tensile strength. The casting process allows the construction of complex shapes.

- **Wrought iron**

Compared to cast iron, wrought iron has better tensile strength and ductility. Wrought iron is malleable and can easily be heated and re heated.

- **Stainless Steel**

Stainless steel is a metal that is strong and hard but it is not a good conductor of electricity and heat. It is magnetic, ductile, maintains its strength and cutting edge irrespective of temperature.

- **Mild steel**

Mild steel is the type of metal that does not possess good structural strength. As it tends to get corroded easily mild steel needs to be sealed or painted to keep it from rusting. Being a soft metal makes mild steel is easy to weld.

- **High Carbon Steel**

High Carbon steel possesses high strength and hardness. This metal is very rich in carbon and has the properties of resisting rust.

4.6.2 Describe the basics of Heat treatment principles

Heat treatment is a series of operations involving the heating and cooling of a metal or alloy in the solid state for the purpose of obtaining certain desirable characteristics.

There are two general objectives of heat treatment:

Hardening: Hardening is a process of increasing the metal hardness, strength, toughness, fatigue resistance.

Annealing: Annealing is a heat treatment procedure involving heating the alloy and holding it at a certain temperature, followed by controlled cooling.

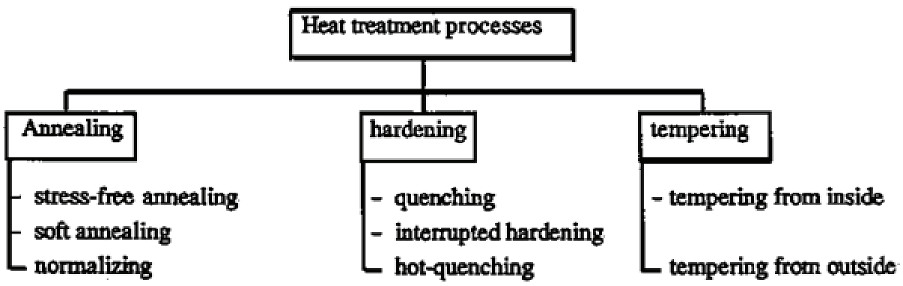


Figure 4.6.2_1: Heat Treatment Processes

Unit 4.7 Shielding Gases

Unit Objectives

At the end of this unit, you will be able to:

- Define the concept of shielding gases
- Analyze the reasons for using shielding gases
- Evaluate the use, impact and importance of gas pressures and flow rates

- Shielding gases can be divided into two categories: semi-inert or inert.
- The noble gases argon and helium are used in both GTAW and GMAW welding.
- Active shield gases or semi-inert shielding gases include nitrogen, oxygen, hydrogen, and carbon dioxide.
- In GMAW welding these gases are used on ferrous metals.

4.7.1 Reasons for Using Shielding Gases

- The main function of shielding gas is to stop the molten weld pool from exposure to hydrogen, nitrogen and oxygen contained in the air atmosphere.
- If these elements come in contact with the weld pool it can cause a variety of problems, like excessive spatter and porosity.
- Different shielding gases also serve to determine mechanical properties of the finished weld, arc stability, weld penetration profiles and more.
- Argon, Helium, Carbon Dioxide and Oxygen are the four most frequently used shielding gases in MIG welding.

4.7.2 Use, Impact and Importance of Gas Pressures and Flow Rates in MIG Welding

- Shielding gas flow rate in MIG welding is measured in cubic feet of gas per hour (CFH), as opposed to pressure i.e. psi.
- MIG gas flow rates are very low unlike oxyfuel cutting and welding.
- When welding flow restrictions in the cable gas passages and small size MIG guns vary.
- As spatter builds in the gun nozzle and gas diffuser the pressure changes.
- In MIG welding the measurement of how fast gas flows over the weld puddle is called the gas flow rate.

Unit 4.8 Modes of Metal Transfer

Unit Objectives

At the end of this unit, you will be able to:

- Define the various modes of metal transfer
- Evaluate the significance of the modes of metal transfer

In gas metal arc welding (GMAW) process there are four basic modes to transfer metal from the electrode to the workpiece.

- **Short-circuit Transfer**
  - In this mode, the electrode touches the work and short circuits.
  - The short circuit causes the metal to transfer.
  - The rate at which this occurs is 20 to more than 200 times per second.
  - In short-circuit transfer maintaining a constant contact tip-to-work distance is important in order to maintain a smooth transfer.

- **Globular Transfer**
  - In this transfer mode the weld metal transfers across the arc in big droplets.
  - Generally this mode of transfer is employed only on carbon steel and makes use of a 100 per cent CO2 shielding gas.
  - The electrodes of choice are typically carbon steel ER70S-3 and ER70S-6.

- **Pulse-Spray Transfer**
  - In this mode the power supply rotates between a low background current and a high spray transfer current.
  - Thus during the background cycle the weld pool goes through supercooling.
  - This transfer mode can be utilized to weld out of position on thick sections with higher energy than the short-circuit transfer, and in this way producing a higher average current and improved side-wall fusion.

- **Spray Transfer Mode**
  - This mode gets its name from the spray of minute molten droplets across the arc.
  - Spray transfer is typically smaller than the diameter of the wire and makes use of relatively high voltage and amperage or wire feed speeds.
  - This mode does not give rise to a lot of spatter and is most often used on thick metals in the flat and horizontal positions.
  - Spray transfer is produced with the help of a high percentages of argon in the shielding gas

Unit 4.9 Understanding the Type of Welded Joints to be Produced

Unit Objectives

At the end of this unit, you will be able to:

- Define the types of welds
- Define the various types of joints

Types of welds

Welds can be broadly classified into 2 types.

1) Fillet Weld

2) Groove Weld

Fillet Weld: A fillet weld is one in which the weld beads are deposited on the edge of the two surfaces to be joined. Fillet weld is also called T joint. These surfaces do not have any groove. The weld bead is laid on the surface.

Groove Weld: Groove welds are welds made in the groove between two pieces to be joined.

Types of Joints

There are five basic types of joints.

1. **Butt Joint:** A joint between two members lying almost in the same plane.
2. **Corner Joint:** A joint between two members located almost at right angles to each other in the form of an angle.
3. **Edge Joint:** A joint between two edges of two or more parallel or almost parallel members.
4. **Lap Joint:** A joint between two overlapping members.
5. **Tee Joint:** A joint between two members located almost at right angles to each other in the form of a T.

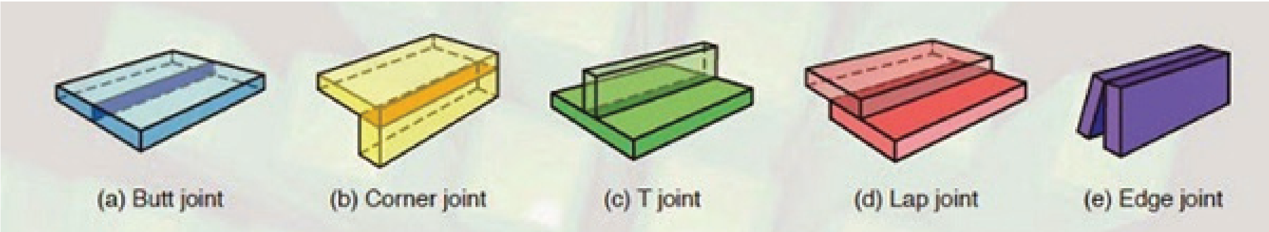


Figure 4.9_1 Types of joints

Unit 4.10 Type, Components and Features of a Manual Gas Shielded Arc Welding Torch

Unit Objectives

At the end of this unit, you will be able to:

- Analyze the components of manual gas shielded arc welding torch
- Evaluate the features of different types of manual gas shielded arc welding torches
- Analyze which materials are needed for the welding activity
- Define the importance of preparing materials in readiness for the welding
- Practice the correct use of anti-spatter compound
- Define the importance of cleaning torch tip and liner

- A welding torch used in various types of welding is a mechanical tool.
- This tool infuses an open flame with oxygen and gas fuel in order to melt two pieces of metal together, thus creating a tight seam.
- A welding torch comprises a long metallic stem that is normally bent at an angle at the end. This allows the welder to aim it appropriately.
- At the end of all welding torches you have a small, controlled flame.
- The metal stem of a welding torch consists of two pipes carrying oxygen and gas fuel.
- This tool is connected to a fuel source by hoses.
- Depending on his/her requirement the welder can adjust the mix of oxygen and fuel.
- When the oxygen and fuel are ignited, they generate a small blue flame.
- This flame heats up to a temperature hot enough to melt metals as varied as aluminium, steel and tin.

Components of a welding torch

The components of a basic welding torch include:

- Gas Nozzle
- Copper contact tube
- Gas hose
- Welding cable
- Water hose (if water cooled)
- Trigger switch
- Wire conduit

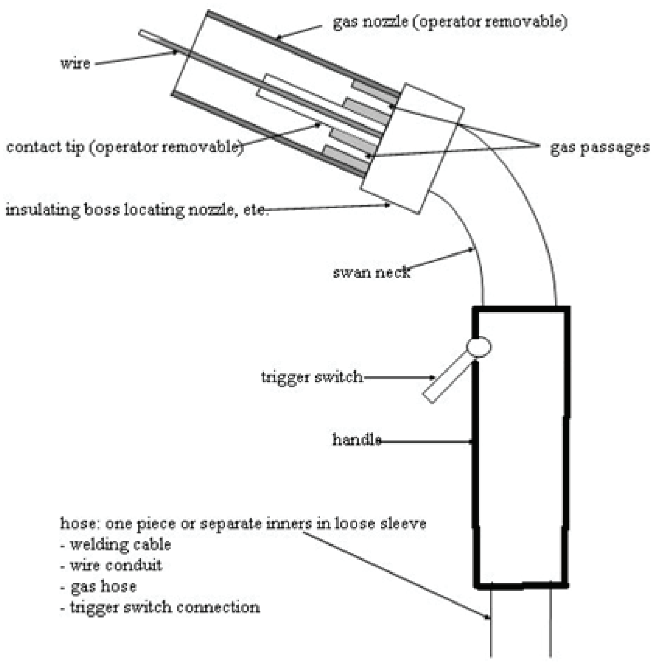


Figure 4.10_1 MIG Welding Torch

4.10.1 How to Prepare the Materials in Readiness For The Welding Activity

Before setting up your welder and striking an arc, you must first get your metal prepared for welding. The following are some ways you can prepare metal for welding.

Wire Brush

A wire brush is good tool which is employed for removing thick layers of slag, mill scale, or any other thick contaminants that adhere to a metal work piece. Keep in mind that particular metals will call for particular brushes.

Sand Paper

Another way to remove imperfections and impurities from metal before welding is using sand paper. Nonetheless, be sure you use the right type of sandpaper for the welding application and specific metal.

Cloth and Solvent

Selecting the wrong cleaner can also lead to problems. Try using lacquer thinners or acetone in order to purify the metal without leaving a residue.

Angle Grinder

One of the most versatile tools you can own in a welding shop is an angle grinder. With this tool you can change the wheels in order to clean metal or even cut thin or small pieces of metal.

Chop Saw

A chop saw is usually utilized in order to make the kind of cuts that an angle grinder is unable to handle or perform neatly. When using a chop saw the most important rule is to shift to a thin blade when cutting thicker metal.

Oxy-Fuel Cutting

When you need to cut thick metal in bulk, an oxy-fuel set up is quick, effective and highly versatile. Oxy-fuel has the ability to make cleaner cuts as compared to a chop saw.

Plasma Cutter

If a welder needs to frequently cut thick metal, a plasma cutter is the most suitable way to cut metal before welding activities. These cutters have the advantage of making fast, clean cuts with a small kerf.

4.10.2 Purpose and Correct Use Of Anti-Spatter Compound

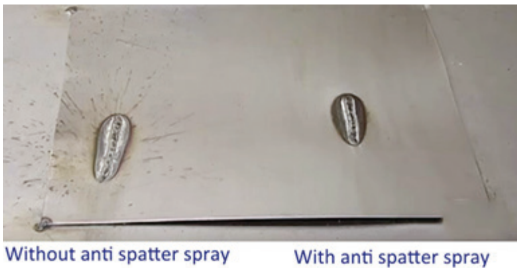


Figure 4.10.2_1 :Use of spatter

4.10.1 How to Prepare the Materials in Readiness For The Welding Activity

- Welding is a high intensity operation which causes spatter to occur naturally.
- The purpose of anti-spatter sprays is to help avoid impediments within your welding equipment.
- Over time spatter can accumulate and electrically connect the contact tube to the insulated nozzle.
- This is why you must use an anti-spatter compounds on your gun, contact tube end and nozzle.
- Anti-spatter compound (if applied properly and in the correct volume), does not drip like water.
- The compound simply creates a barrier between any spatter generated during the welding process and the nozzle.
- Once you perform the reaming cycle the spatter easily falls off the nozzle.
- Thus the nozzle and other front-end consumables remain clean and spatter-free.
- The compound should be reapplied regularly to continuously maintain that barrier.

4.10.3 Remove slag in an appropriate manner

- Welding slag is a by-product of certain welding processes.
- Before the painting stage or final finish, this by-product must be completely removed from the part in order to make sure there is proper paint adhesion.
- Cleaning fillet welds is not a simple task. It is the solidified remaining flux after the weld area cools.
- As slag is waste material it needs to be removed. This is required for the reasons below:
    - Visual appearance
    - In order to inspect the quality of the weld area
    - In order to prepare the surface for coatings such as paint or oil
    - In cases where a second layer or pass of welding needs to be made above the first
- It can be removed using either manual or power tools.
- Manual tools may include a chipping or a welding hammer.
- This type of hammer has a pointed tip on one end to break up large pieces of slag efficiently. Wire brushes can also be used.
- Power tools used to remove slag include angle grinders with grinder disks or wire brush wheels.

4.10.4 Importance and Procedure To Clean Torch Tip And Liner

Figure 4.10.4_1: MIG gun's consumables

- Cleaning gun liner
  - Improperly maintained contact tips lead to process failures like arc failure, such as arc instability, burnback or bad starts.
  - Using compressed air blows out the inside of the feeder part of the machine.
  - This should be done at least once every week in order tomaintain drive rolls and to keep them in the best shape for feeding out the welding wire.
  - As the wire runs through the drive rolls and into the gun liner, dirt and dust buildup can be found in the liner.
  - For this again you need to use compressed air to blow out the liner from the contact tip end of the gun around once a week to remove built-up dirt and dust.

- **Cleaning gun contact tips**
  - If you want trouble-free welding performance you need to regularly maintain the gun cone, contact tips and diffuser.
  - During the welding process, the gun nozzle frequently fills up with spatter. By using the nozzle dip you can make sure to keep the nozzle spatter free.
  - For spatter accumulated in the diffuser you can make use of a rag or wire brush to wipe it clean.
  - To make sure that your gun contact tips remain in the best shape, see that you do not touch the tip to the work piece.
  - The contact tip should ideally sit tightly in the diffuser and the inside bore should not be too worn.

Notes

Unit 4.11 Appropriate Tack Welding Size and Spacing

Unit Objectives

At the end of this unit, you will be able to:

- Define correct tack welding sizes
- Define the correct spacing of tack welds
- Practice checks prior to welding

- Once parts to be welded have been positioned as needed, usually by clamping them on appropriate fixtures, you can then use tack welds.
- Tack welds act as a short-term means to keep the parts in the proper alignment, location and distance apart, till the time final welding is completed.
- When carrying out tack welding in order to hold the part in place, be sure that the welding tack size is sufficient to hold it in place and that it does not go beyond the final welding size.
- Tack weld the joint at appropriate intervals, and check the joint for accuracy before final welding
- Number of tacks and spacing will vary depending on your requirement.

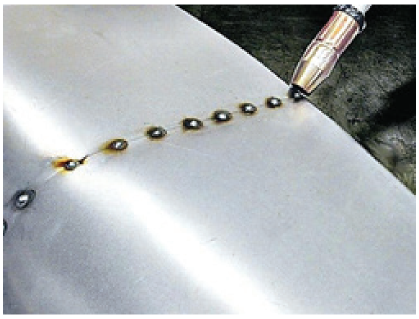


Figure 4.11_1: Tack Welding

- See that the tacks are of minimum size and are closely spaced.
- The tack size and spacing distance should increase proportionately to the wall thickness of the metal

4.11.1 Checks to be Made Prior To Welding

Weld inspection is vital to the overall operations and should not just take place at the end of the welding activity. Inspection before and during welding is crucial too.

The following are checks to be made before welding:

- Review standards and drawings to check if any special considerations are necessary.
- Check whether purchased material (consumables and base materials) are as per those specified.
- Review chemical compositions and material test reports against requirements.
- Check storage and condition of welding consumables.
- Verify whether material fit-up is adequate
- Confirm correct setup of the joint.
- Ensure that the joint is fit up and is in accordance to the WPS (Welding Process Specification Sheet).
- Verify the cleanliness of the joint.
- Ensure that proper welder qualifications and welding procedures specification are in place.
- In case preheat is required, ensure it is done and measured suitably.
- Check that earthing arrangements and welding return cables are made.
- Always ground both the frame of the welding equipment itself, as well as the metal that you are welding.

Unit 4.12 Factors that Determine Weld Bead Shape

Unit Objectives

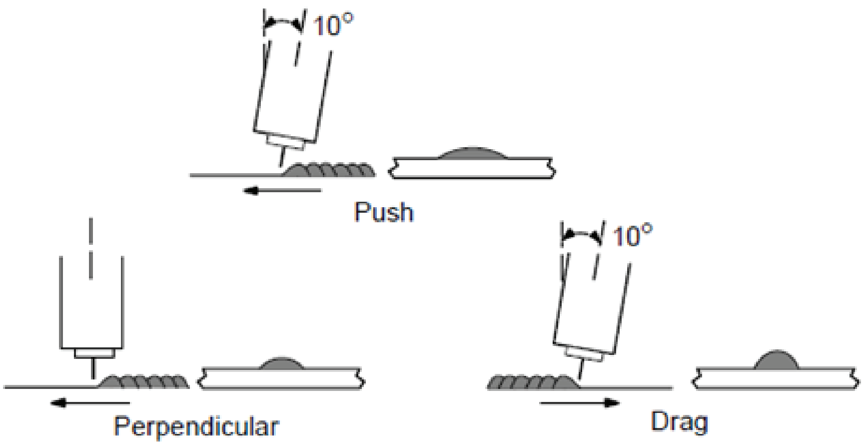
At the end of this unit, you will be able to:

- Define the Types of weld beads
- Evaluate the Weld Bead Quality Characteristics

The following points show us the factors that determine the weld bead shape:

- Gun Angles And Weld Bead Profiles
  1. Push
  2. Perpendicular
  3. Drag
- Electrode Extensions (Stickout)
  1. Short
  2. Normal
  3. Long
- Fillet Weld Electrode Extension(Stickout)
  1. Short
  2. Normal
  3. Long
- Gun Travel Speed
  1. Slow
  2. Normal
  3. Fast

The diagram below gives a detailed understanding of various factors that determine weld bead shape.



GUN ANGLES AND WELD BEAD PROFILES

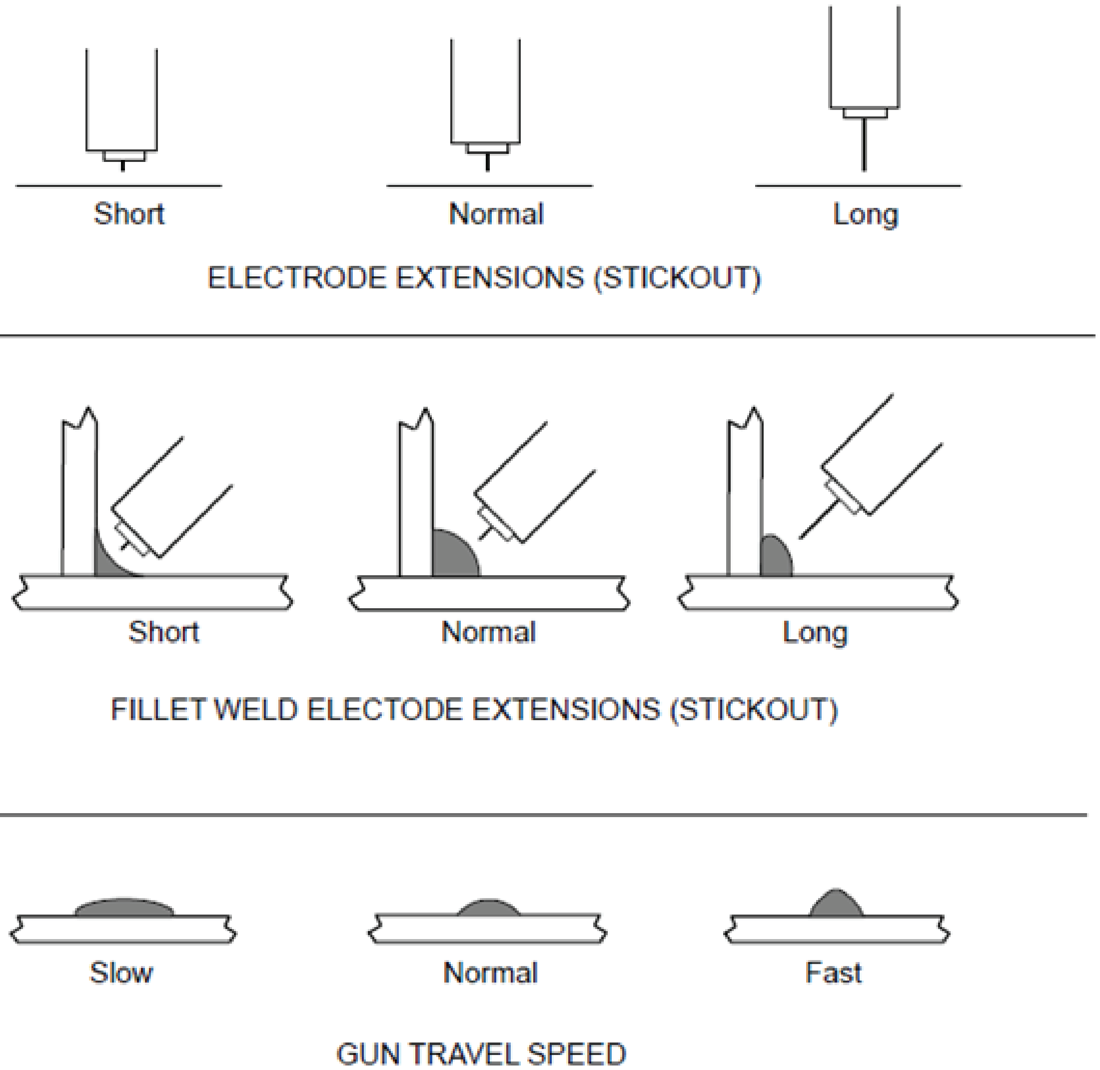


Figure 4.12_1 : Factors that determine weld bead shape

4.12.1 Types of Weld Beads

The deposited filler metal on and in the work surface when the wire or electrode is melted and fused into the steel is called a weld bead.

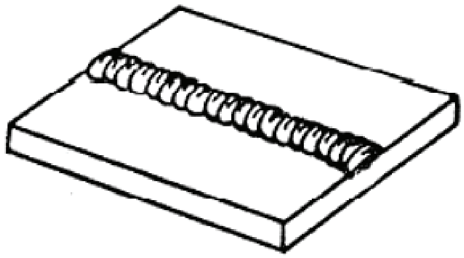


Figure 4.12.1_1 :Types of weld beads

The different types of weld beads include:

Stringer Beads

In this type of bead you can either push or "drag" (pull) the torch across the joint with slight (if any) side-to-side movement. In dragging the electrode is positioned back towards the puddle, leading it. This allows for thorough penetration and a robust-looking weld.

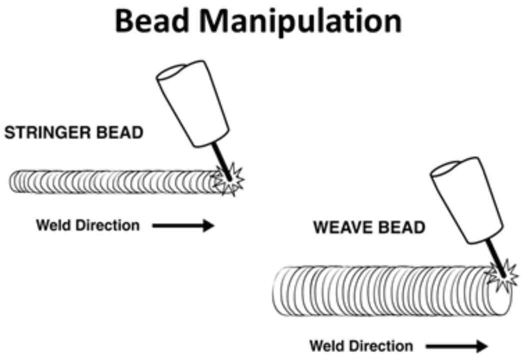


Figure 4.12.1_2 :Bead Manipulation

Weave Beads

You can weave from side to side along a joint to get wider welds. For a thick joint, weaving is the quickest way to complete a welding assignment. Weave beads are commonly used on fillet welds.

4.12.2 Weld Bead Quality Characteristics

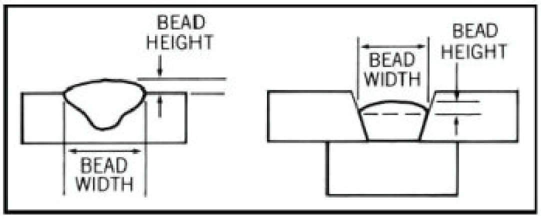


Figure 4.12.2_1 : Weld Bead Quality Characteristics

- The weld bead's two main characteristics are its width and height.
- These characteristics are vital to assure that the weld joint is accurately filled, with the least amount defects.
- A bead height that is too great makes it highly difficult to make subsequent weld passes that will have good fusion.
- The more narrow and peaked the weld bead, the higher the chance that poor fusion may occur.
- Travel speed and welding current are the welding factors primarily used to control weld bead size.
- Weld bead size can also be influenced by varying the arc travel speed.
- Arc voltage also influences the shape of the weld bead.
- A technique called backhand welding also produces a narrow, high weld bead.
- When you decrease the lagging torch angle it will cause the bead height to be decreased and increase the width.
- On the other hand the technique called forehand welding produces the widest, flattest weld beads.

Unit 4.13 Effect of the Electrical Characteristics of the MIG/MAG Welding Arc

Unit Objectives

At the end of this unit, you will be able to:

- Define the electrical characteristics of the MIG welding arc
- Evaluate the effect produced the electrical characteristics of the MIG welding arc

- Direct current, constant potential (voltage) power sources are employed for most MIG welding.
- MIG power source offers the arc a relatively constant voltage during welding.
- This voltage defines the arc length.
- When there is a momentary change in arc length or a sudden change in wire-feed speed the power source suddenly decreases or increases the current.
- To restore the original arc length the burnoff rate of wire changes automatically.
- This results in permanent changes in arc length which are made by regulating the output voltage of the power source.
- The wire-feed speed, that the welder chooses prior to welding, determines the arc current.

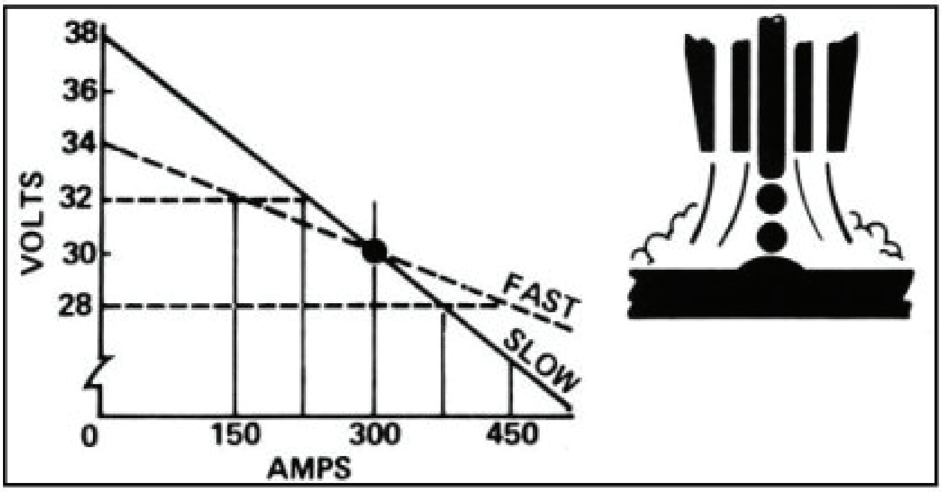


Figure 4.13_1 : Effect of Wire Feed Speed

Unit 4.14 Problems that can occur with the Welding Activities

Unit Objectives

At the end of this unit, you will be able to:

- Define the problems during welding
- Analyze the solutions to those problems during welding

Most common welding problems fall into four categories:

1. Weld porosity
2. Improper weld bead profile
3. Lack of fusion
4. Faulty wire delivery related to equipment set-up and maintenance.

- Weld Metal Porosity

Problem #1: Weld porosity is frequently caused by improper surface condition of the metal.

Remedy: In order to keep this porosity under control you need to use a deoxidizer within the wire such as manganese, silicon or trace amounts of aluminium, titanium or zirconium.

Problem #2: Problems with the shielding gas coverage is the second leading cause of porosity in welds.

Remedy: You need to use a flow meter to ensure that the shielding gas flow is set properly.

Problem#3: The chemistry of the base metal is another problem during welding.

Remedy: The easiest remedy is to switch to a slag-generating welding process or use a different grade of steel.

- **Improper Weld Bead Profile**

Problem #1: When heat in the weld is insufficient and is unable to penetrate into the base metal.

Remedy: You must review relevant charts and figure out if the amperage is proper for the thickness of the material.

Problem #2: A convex or concave-shaped bead may also be caused because of improper welding techniques.

Remedy: To get best bead shapes, you should use a push angle of 5-10 degrees.

Problem #3: Work cable problems can lead to inadequate voltage available at the arc.

Remedy: Select a suitable cable once you have consulted a chart to figure out size based on length and current being used.

- **Lack of Fusion**

Problem #1: A lack of fusion may occur in case the consumable has adhered to the base metal improperly.

Remedy: To ensure correct fusion, see that amperage and voltage are set correctly.

- **Faulty Wire Delivery**

Problem #1: When operators use oversized tips, which can lead to inconsistencies in the arc, contact problems, poor bead shape and porosity.

Remedy: Ensure that you keep the contact tip of the gun in good working condition and that it is sized correctly to the wire being used.

Problem #2: When the wire is not being fed smoothly as the gun liner has not been cleaned or replaced.

Remedy: To clean the liner, use low-pressure compressed air to blow it out with from the contact tip end, or if needed replace the liner.

Problem #3: Worn out of broken welding gun

Remedy: If you notice the gun becoming very hot in one particular area during the welding activity, this could indicate that there is internal damage. You will need to replace it.

Problem #4: Drive rolls on the wire feeder periodically wear out.

Remedy: Ensure that the drive roll tension is set correctly. The guide tube and the drive rolls should be as close together as possible.

4.14.1 Own Responsibility to Assist In Preparation of Welds And Weld Pieces For Examination

- Check weld against code and standards
- Confirm size with gauges and prints
- Review contour and finish
- Inspect for cracks against standards
- Check for overlap
- Look for undercut
- Check if spatter is at acceptable levels

Notes

Unit 4.15 Various Procedures for Visual Examination of the Welds for Cracks

Unit Objectives

At the end of this unit, you will be able to:
- Define the visual examination of the welds for cracks
- Evaluate the responsibility during preparation and inspection of welds
- Identify non-destructive weld tests

Equipment required:
- Flashlight
- Magnifying glass
- Protective lenses
- Weld gage
- Hammer and chisel
- Temperature Indicating Devices
- Magnet

Visual Inspection (VT)
- To assure weld quality, all welds should be inspected. In some cases, the inspection involves nothing more than a visual examination by the welder.
- During fabrication, visual examination of a weld bead and the end crater may reveal problems such as inadequate penetration, cracks and slag or gas inclusions.
- Visual inspection conducted after welding can detect a variety of surface flaws, including unfilled craters, porosity and cracks irrespective of subsequent inspection procedures.
- Warpage, appearance flaws and dimensional variances as well as weld size characteristics, should be evaluated.
- Welds must be cleaned of slag before checking for surface flaws
- Welder should be keep in mind that visual inspection can only detect defects in the weld surface.

4.15.1 Types of Non-Destructive And Destructive Tests For Assessing Weld Quality

Destructive Tests (DT)

These tests fall under two categories:
- Workshop based tests
- Laboratory test

- Nick Break Test

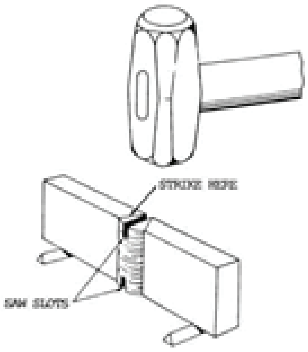


Figure 4.15.1_1 : Nick Break Test

  - The Nick break test evaluates whether the weld metal of a welded butt joint reveals any internal defects.
  - For this test the specimen can be obtained from a welded butt joint either by cutting with an oxyacetylene torch or by machining.

- Tensile Strength Test
  - This test is used to gauge tensile properties of the weld joints which include ultimate strength, ductility and yield.
  - The weld joint's Tensile properties are gauged in two ways

    a) transverse section of weld joints and b) all weld specimen

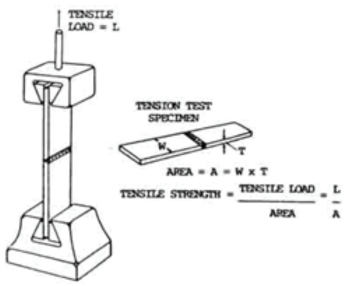


Figure 4.15.1_2 : Tensile Strength Test

- **Bend test**
  - This is a frequently used destructive test to gauge the soundness and ductility of the weld joint.
  - For this test, bending the weld joint can be carried out from root or face side depending upon the requirement i.e. whichever side of the weld needs to be assessed.

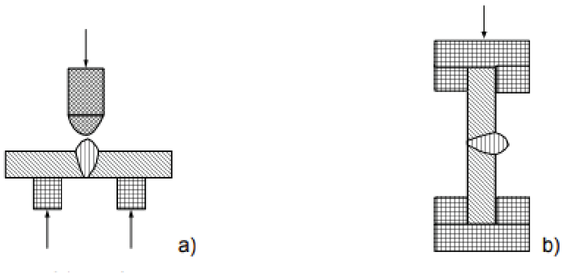


Figure 4.15.1_3 : Schematics of Free Bend test

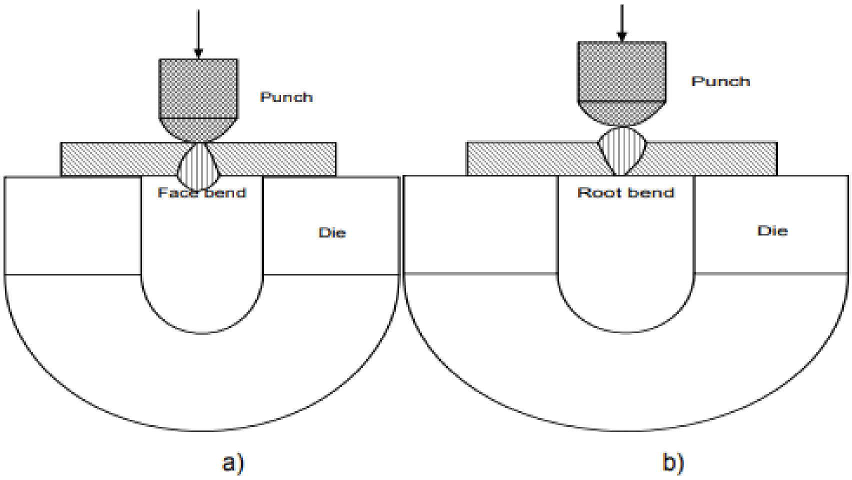


Figure 4.15.1_4 : Schematics of guided bend tests a) face bend and b) root bend

Non-destructive Tests (NDT)

Non-destructive testing ensures that the weld is neither damaged nor broken and is thus a cheaper method of testing.

Visual Inspection

The finished weld needs to be examined for defects such as surface irregularities, overlap, undercut, porosity and cracks during visual inspection. This inspection must not be ignored as it gives us a lot of information about the weld.

- **Dye Penetrant Test**

In dye penetrant test the weld is inspected for cracks, porosity or any other surface defect. This test detects surface-breaking discontinuities, or discontinuities that are open to the surface where the penetrant has been applied.

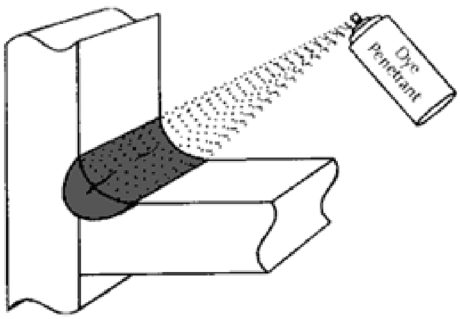


Figure 4.15.1_5 : Dye Penetrant Test

- **Ultrasonic Test**

Ultrasonic inspection is used to detect and locate internal defects such as cracks, porosity, inclusions, lack of fusion and incomplete penetration. Wall thickness can be measured in close vessels or in cases where such measurement cannot otherwise be made.

Figure 4.15.1_6: Ultrasonic Test

- **Magnetic particle testing**

Magnetic particle testing method involves creating a magnetic field in the part to be tested and putting magnetic probes on its surface. This tends to attract any particles that are present to the poles or magnet ends. Discontinuities can be detected by the accumulations of these particles.

Figure 4.15.1_7 Magnetic particle testing

Summary

- Gas metal arc welding (GMAW), at times is called by its types, metal active gas (MAG) welding or metal inert gas (MIG) welding.
- The primary function of a welding gun, also known as a torch, isto deliver the welding current, welding wire and shielding gas to the welding arc.
- Shielding gases are gasses that are semi-inert or inert.
- MIG type of welding works on basic principle of heat generation due to electric arc.
- The current required for MIG or GMAW welding is DC electrode positive or reverse polarity.
- Keep a fire extinguisher on hand while welding.
- Only repair technicians who are qualified may attempt to repair or service welding equipment.
- Ferrous Metals: These are the metals that contain iron. Ferrous metals are magnetic meaning you can pick it up with a magnet.
- Active shield gases or semi-inert shielding gases include nitrogen, oxygen, hydrogen, and carbon dioxide.
- In MIG welding the measurement of how fast gas flows over the weld puddle is called the gas flow rate.
- A fillet weld is one in which the weld beads are deposited on the edge of the two surfaces to be joined.
- A wire brush is good tool which is employed for removing thick layers ofslag, mill scale, or any other thick contaminants that adhere to a metal work piece.
- Welding is a high intensity operation which causes spatter to occur naturally.
- Using compressed air blows out the inside of the feeder part of the machine.
- Once parts to be welded have been positioned as needed, usually by clamping them on appropriate fixtures, you can then use tack welds.
- Always ground both the frame of the welding equipment itself, as well as the metal that you are welding.
- Weld porosity is frequently caused by improper surface condition of the metal.
- You must review relevant charts and figure out if the amperage is proper for the thickness of the material.
- To assure weld quality, all welds should be inspected.
- The Nick break test evaluates whether the weld metal of a welded butt joint reveals any internal defects.
- Ultrasonic inspection is used to detect and locate internal defects such as cracks, porosity, inclusions, lack of fusion and incomplete penetration.

Notes

Notes

Notes

Scan the QR codes or click on the link to watch the related videos

https://www.youtube.com/watch?v=jXm_UyKuhLQ

Semi-automatic MIG welding

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https://www.youtube.com/watch?v=sR8m-LOMey7U

GMAW (MIG/MAG) EQUIPMENTS AND ACCESSORIES

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SHIELDIND GASES FOR GMAW WELDING

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MIG Welding Safety Tips

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5. Perform Manually Welding Joints Using The TIG (GTAW) Process

HSSC
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Key Learning Outcomes

After attending the session, you will be able to:

1. Analyze the range of equipment available for GTAW welding
2. Evaluate the Basic principles of TIG welding
3. Practice Safe working principles
4. Defne the variants of the TIG welding
5. Practice the Manual TIG welding process
6. Define the Types of Tungsten
7. Define the Pre and Post-Flow purge
8. Evaluate the Welding Positions
9. Evaluate the Types of torches
10. Develope an understanding of the range of joints
11. Define the Electrical Characteristics of the TIG welding arc
12. Define the Gouging and back gouging
13. Evaluate how to control distortion in welding
14. Practice the Dye Penetrant Test procedure
15. Practice how to handle weld specimens for tests

Unit 5.1 Range of Equipment Available for GTAW Welding

Unit Objectives

At the end of this unit, you will be able to:

- Define the different GMAW welding equipment
- Evaluate the uses of different GMAW welding equipment
- Analyze the Basic principles of TIG welding
- Analyze the functions of welding equipment

- tungsten electrodes
- AC or DC welding machine
- torch or electrode holder
- shielding gas cylinder or facilities to handle liquid gases
- shielding gas regulator
- gas flowmeter
- shielded gas hoses and fittings
- filler metal rod
- water cooling system with hoses
- Foot rheostat (switch)
- personal safety equipment

5.1.1 Basic Principles Of TIG Welding And The Functions Of Welding Equipment

- GTAW (TIG) Welding can be done in any welding position and in manual, semiautomatic and automatic modes.
- The melting temperature necessary to weld materials in the Gas Tungsten Arc Welding (GTAW) process is obtained by maintaining an arc between a tungsten alloy electrode and the workpiece.
- Weld pool temperatures can approach 2500 °C (4530 °F).
- An inert gas sustains the arc and protects the molten metal from atmospheric contamination.
- The inert gas is normally argon, helium, or a mixture of helium and argon.

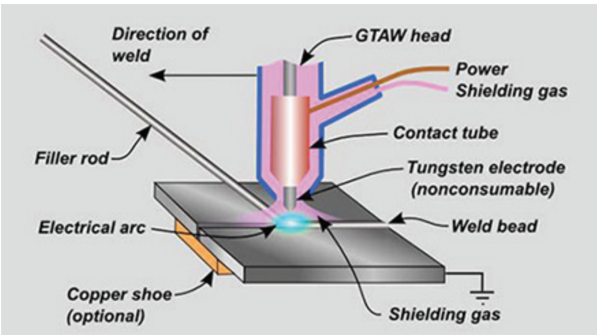


Figure 5.1.1_1: GTWA principle

Functions of TIG welding equipment

Shielding gas

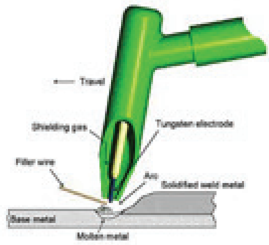
Shielding gases are vital in Gas Tungsten Arc Welding (GTAW) as they serve to protect the welding area from atmospheric gases such as oxygen and nitrogen which lead to various defects.

Power Source

For TIG welding the power source can be either AC or DC. The arc voltage/welding current dynamic offers a constant current for a given power source setting.

Welding Torch

To strike the arc the torch draws the power from the power source. This is a delivery tool and makes power available for generating heat to strike an arc. The torch is of two types – heavy duty and light duty depending on the current it draws.

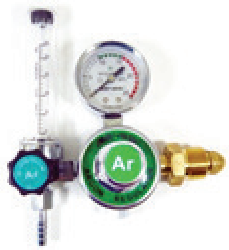


Electrode

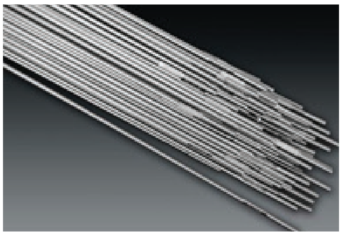
During manual welding, regardless of the electrode diameter the electrode tip is generally ground to an angle of 60 to 90 degrees. During AC welding, the electrode commonly used is pure tungsten.

Gas flowmeter

Gas flowmeters have the function of sending a constant flow of gas between a gas cylinder, regulator and the welder.



Filler metal rod



Filler rods for GTAW are fed by a second hand because the first hand holds the tungsten torch. The composition of the filler rod is the same as MIG.

Unit 5.2 Different types of Power Sources in TIG Welding

Unit Objectives

At the end of this unit, you will be able to:

- Define the types of power sources in TIG welding
- Evaluate the function of power sources in TIG welding

Power-Sources or supplies generate and maintain the electric arc. Arc welding processes use specific equipment and consumables. TIG welding uses CC (Constant Current) power sources.

With TIG welding there are three choices of welding current:

- Direct Current Straight Polarity
- Direct Current Reverse Polarity
- Alternating Current

Direct Current Straight Polarity (DCSP)

DCSP type of connection is the most commonly used in the DC type welding current connections. Here the tungsten is connected to the negative terminal and that is why it only receives 30% of the welding energy (heat).

Current Type	DCSP
Electrode Polarity	Electrode Negative
Oxide Cleaning Action	No
Heat Balance in the Arc	70% at work end 30% at electrode end
Penetration Profile	Deep, narrow
Electrode Capacity	Excellent

Table 5.2_1: Direct Current Straight Polarity (DCSP)

Direct Current Reverse Polarity (DCRP)

Very rarely is DCRP type of connection is used. As most of the heat is focused on the tungsten it could lead to the tungsten overheating and burning away. DCRP produces a wide, shallow profile and is chiefly used on extremely light material at low amps.

Current Type	DCRP
Electrode Polarity	Electrode Positive
Oxide Cleaning Action	Yes
Heat Balance in the Arc	30% at work end 70% at electrode end
Penetration Profile	Shallow, wide
Electrode Capacity	Poor

Table 5.2_2: Direct Current Reverse Polarity (DCRP)

Alternating Current (AC)

For most white metals like magnesium and aluminium AC welding is the most preferred type of current. The heat input received by the tungsten gets averaged out when the AC wave passes from one side of the wave to the other.

Current Type	AC
Electrode Polarity	Electrode Positive
Oxide Cleaning Action	Yes
Heat Balance in the Arc	30% at work end 70% at electrode end
Penetration Profile	Shallow, wide
Electrode Capacity	Poor

Table 5.2_3: Alternating Current (AC)

Notes

Unit 5.3 Safe Working Practices, Precautions and Procedures to be Followed while Using TIG Equipment

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the need for safe practices and procedures
- Practice precaution and proper procedures while welding

There are several different types of safety hazards that stem from TIG welding. The main risks are from welding fume, electric shock and radiation.

Figure 5.3: List of PPEs used for TIG Welding

Pre-operational safety checks:

- Ensure that you are knowledgeable about all machine controls and operations.
- Inspect walkways, workspaces and routing of welding cables to see that no slip/trip hazards are present.
- Confirm that the work zone is clean and clear of oil, grease and other combustible or flammable materials.
- The welding equipment, work zone, as well as your gloves and other PPE should be dry to avoid electric shocks.
- See that your gloves, jacket, the welding cables and TIG torch are in good condition.
- Make sure that other fellow workers are protected from flashes by welding curtains or screens.
- Make sure the fume extraction unit is in proper working condition before welding.
- If using an auto-darkening hood verify the lens function.
- Read the SDSs for the gas and rod to be used.

Safe operating practices:

- Be sure that the machine is appropriately set up (e.g. polarity, tungsten size, amperage and gas flow).
- Confirm that there is good connection of ground cable to workpiece.
- Before initiating arc say “EYES” or “COVER”.
- See that the upper end of rod is bent to avoid poking hazard.
- Before placing the tip of the filler rod into the weld pool initiate the arc and create a weld puddle.
- Before changing electrode or servicing torch check to see that the torch is not energized and your body is not completing the welding circuit.
- To avoid inadvertent arc flash lay the torch with care, and position foot pedal away from traffic.

Ending operations and cleaning up:

- When work is completed shut off the machine and fume extraction unit.
- Shut the gas cylinder valve.
- Keep the TIG torch and leads hung up.
- Label all hot items and inspect the work zone for fire risk.
- Exit the work area once you make sure that the work area is maintained and left in a safe and tidy condition

Don’ts:

- Don’t drape cables over body.
- Don’t roll damaging items across torch cable.
- Don’t weld on painted or plated materials, tanks, drums etc. without permission.
- Don’t use faulty equipment; report the items to your supervisor.
- Don’t leave the welder running unattended.

Unit 5.4 Different Variants of the TIG Welding

Unit Objectives

At the end of this unit, you will be able to:

- Define the variants of TIG Welding
- Define the functions of the variants of TIG Welding

Orbital welding

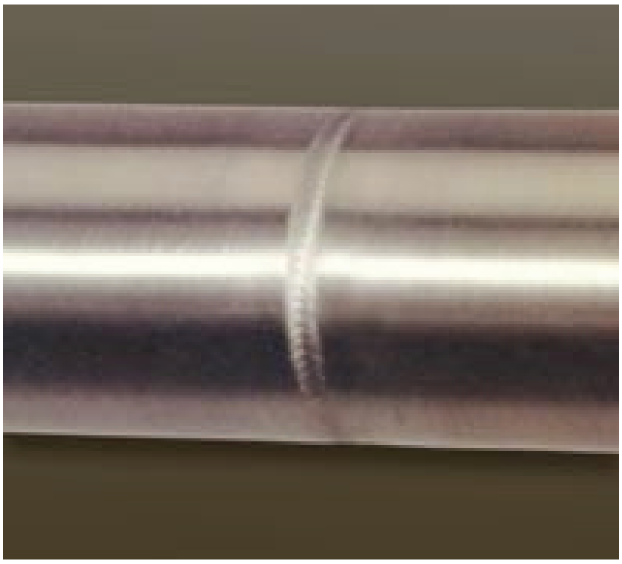


Figure 5.4_1: Orbital tube weld

Figure 5.4_2: Orbital Welding Equipment

- When the welding arc is mechanically rotated around a static work piece continuously it is known as Orbital welding.
- This technique of welding is carried out on items that are highly difficult to weld manually, like pipes.
- In this process tubes/pipes are clamped in place while an orbital weld head proceeds to rotate an electrode and electric arc around the weld joint in order to create the required weld.
- This technique employs non-consumable electrodes.
- Thanks to this process of orbital welding many different types of metals can be welded.
- As it is performed in an inert atmosphere, the regulated process results in welds that have a low particle count, are very clean and are free from spatter.

Internal Bore Welding

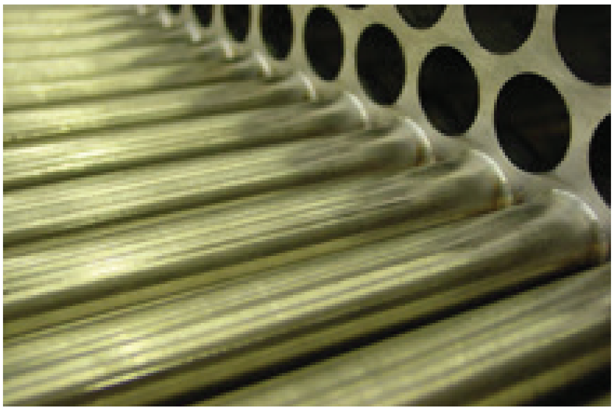


Figure 5.4_3: Internal Bore Welding

- In cases where tube failure must not occur, the welder may need to weld the tube to the inner face of the tube sheet using the internal bore welding technique.
- We see this procedure used mainly for high pressure water heaters in power stations.
- In this procedure the tube sheet is machined so as to provide a socket and spigot joint through which the end of the tube fits.
- The weld is made by the GTAW process from the inside.
- Gas is supplied both via the tube as well as on the outside, through a channel that clamps around the joint.
- Welding is carried out with the tube sheet vertical, employing pulsed current to make the positional weld possible.

Unit 5.5 Manual TIG welding process

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the need for Manual TIG welding
- Practice the process of Manual TIG welding

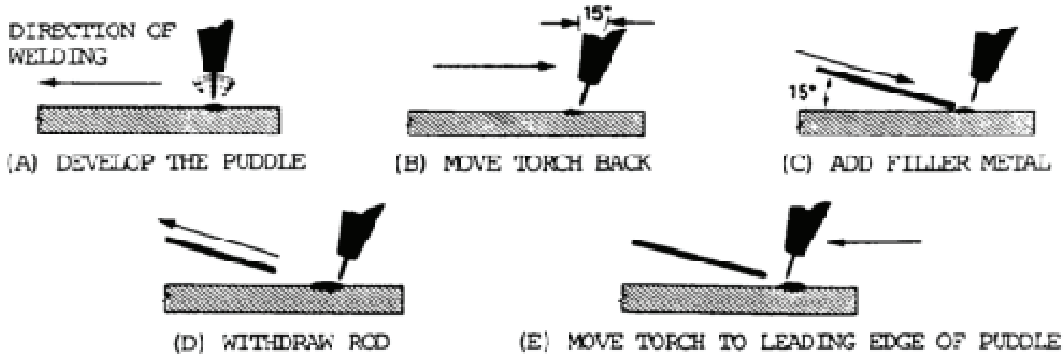


Figure 5.5: Manual TIG welding process

TIG welding is a process where thin metals are welded for metal and pipeline welding. Before the TIG welding begins, all paint, grease, dirt, oil, rust and other impurities from the welded areas. This may be carried out by the use of vapour, liquid cleaners or by mechanical means.

- The torch should be held at a travel angle of about 15 degrees once the arc is started, when welding manually
- Ensure that the recommended gas flow is being followed based on the metal size and the nozzle selected.
- Now, calibrate the gas welding machine to the suggested type of amperage and current for the TIG process being performed.
- Switch the welder on. Position the control in an area which is most comfortable for you.
- Press down on the foot control and strike the arc.
- Once a puddle is created, add the filler rod to the leading edge.
- To avoid contaminating the tungsten, when the filler rod is added you should move the TIG welding torch to the back of the puddle.
- The substantial shielding gas cover will serve to prevent exposure to air. Shielding gas is that is normally used is argon.

5.5.1 Types of Torches Such As Air Cooled And Liquid Cooled

The GTAW process makes use of an electric torch. Here the welder hand feeds a filler rod into the molten puddle. There are a variety of torches that you can use like:

Air-Cooled TIG Torch

Figure 5.5.1_1: Air-Cooled TIG Torch

- One of the benefits of welding with an air-cooled TIG torch is that you don't have to have a water supply nearby.
- Also installation will likely be a quicker process than for a water-cooled torch.
- They are light and easy to handle.
- Tight connections eliminate shielding gas loss and ensure a steady flow of shielding gas at the torch, leading to good weld quality.

Liquid- Cooled TIG Torch

Figure 5.5.1_2: Liquid- Cooled TIG Torch

- With the water-cooled torches you will need a convenient water supply at hand.
- First check that the required water cooler has enough coolant, usually about 3 gallons.
- Use only distilled water or an approved welding coolant.
- When connecting the water-cooled GTAW torch to the water-cooling system, it is important that you set up the water flow properly.

Unit 5.6 Types of Tungsten

Unit Objectives

At the end of this unit, you will be able to:

- Define the types of tungsten electrodes used in welding
- Evaluate the properties of the different types of tungsten electrodes used in welding

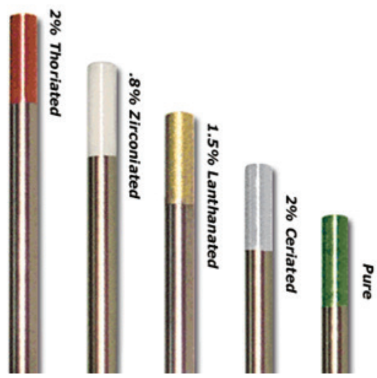


Figure 5.6: Types of Tungsten

The Tungsten rod you select will hinge on a few factors. This will include the thickness of the metal you are welding, your particular machine and the settings you have available.

The following electrodes can be used for TIG welding aluminium:

- **Pure, Green:** Firstly, pure tungsten is apt for use with AC but not DC welding. Pure tungsten electrodes are 99.5% tungsten. Pure tungsten is appropriate for application of low to medium amperages with magnesium and aluminium alloys.

- **Lanthanated, Gold:** These electrodes are suitable for use with direct current. Lanthanated electrodes contain 97.8% tungsten and between 1.3 and 1.7% lanthanum. The electrodes have great arc starting and stability, impressive re-ignition properties and low burn-off rate.

- **Ceriated, Orange:** These electrodes have a 1.8 to 2.2%, presence of cerium oxide whereas the pure tungsten composition is at a minimum of 97.3%. These are mostly suitable for low-current AC usage. Properties include longevity, excellent arc stability, low erosion rate, good ignition and re-ignition.

- **Thoriated, Red:** This type of tungsten electrode contains 97.3% pure tungsten and 1.7-2.2% thorium oxide. They are suitable for both AC and DC applications. They are easy to use and last for a long time.

- **Zirconiated, Brown:** Zirconiated tungsten electrodes contain0.15-0.4 Zirconium and 99.1% pure tungsten. They are suitable for AC welding. They don't contaminate easily and are highly resistant to splitting.

Unit 5.7 Impact of Shielding Gas Composition and Purity on Quality Welds

Unit Objectives

At the end of this unit, you will be able to:

- Define the shielding gas
- Evaluate the impact of shielding gases to create quality welds

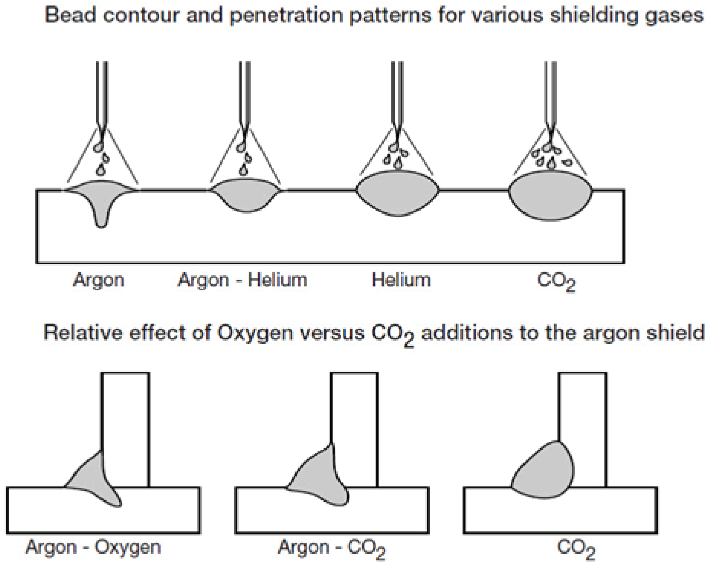


Figure 5.7: Impact of shielding gas weld quality

The main gases used in the GTAW process are hydrogen, helium, argon and at times nitrogen is also used. The purity and composition of the gas or gas mixture should be custom-made to meet the process, application and material requirements you are working on. Shielding gases are used in either in blends of varying components or in pure form.

- **Bead Profile and Overwelding:** A CO2 shielded weld bead often gives rise to convex shape and causes overwelding. On the other hand Argon-based blends provide good bead shape control that reduces overwelding.

- **Spatter Control and Postweld Cleaning:** As Argon has a low ionization potential it leads to improved arc stability, which in turn helps eliminate spatter. To ensure the best colour match, select a blend of helium or argon with low levels of CO2 or oxygen to lessen weld surface oxidation.

- **Filler Metal Deposition Rate and Efficiency:** If a shielding gas blend possesses high argon content this tends to result in high productivity. If a helium-enhanced argon blend is used it could increase weld metal deposition rates by up to 15 per cent.

- **Bead Penetration, Potential for Burn-through:** One of the properties of pure CO2 is that it leads to increased weld pool energy as compared to an argon/ CO2 blend. If you control the blend's CO2 content you can also reduce the burn-through.

- **Weld Metal Mechanical Properties:** As high-argon blends are normally less reactive than other blends, more alloying elements in the filler wire get transferred to the weld pool resulting in increased weld strength.

Notes

Unit 5.8 Pre and Post-Flow purge

Unit Objectives

At the end of this unit, you will be able to:

- Define pre-flow purging
- Define post-flow purging

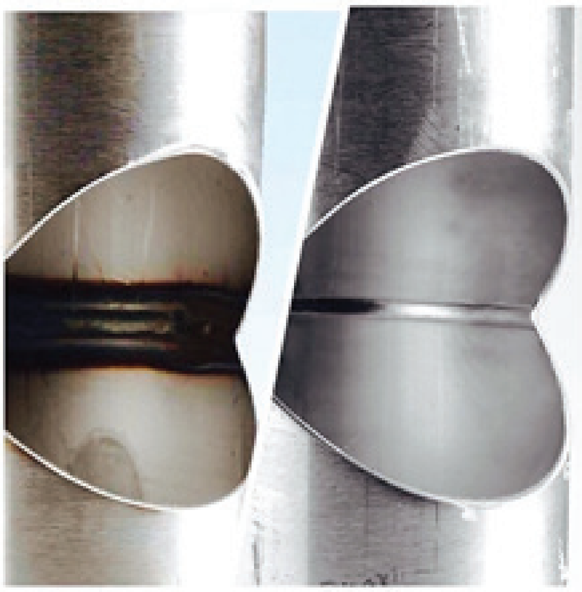


Figure 5.8: A bad weld on the left and a purged weld on the right

The term purging is used when a gas is supplied on the backside of a weld. In this process an inert gas is used to prevent the materials from reacting. The common inert gases include Helium and Argon as well as Xenon, Krypton and Neon.

Pre Purge

- The condition in which the flow of the shielding gas through a ceramic nozzle on the torch commences before the arc is struck.
- The pre-flow period is mostly fairly short but serves to ensure only aminimum of free oxygen remains in the arc area when wielding commences.
- For certain critical and certified welds extra-long pre-purge periods are often specified.

Post Purge

- Here the shielding gas continues to flow through a ceramic nozzle on the torch for a period after the arc is extinguished.
- The welder should follow a specified post purge time.
- As the post flow period blankets the weld area while it is cooling it serves to prevent undue oxidation and leads to a better cosmetic appearance of the finished weld.

5.8.1 Importance and Application of Back Purging

- It is essential to shield the root side of the weld joint against oxidation while welding with an inert shielding gas.
- Back purging is the shielding technique, which protects the inside of the pipe.
- Back-purging is accomplished in two steps:
  - The dams must be installed and the weld zone volume purged using acceptable levels of argon.
  - Purging must go on and continue during the actual welding operations.

Unit 5.9 Terminology Used for the Appropriate Welding Positions

Unit Objectives

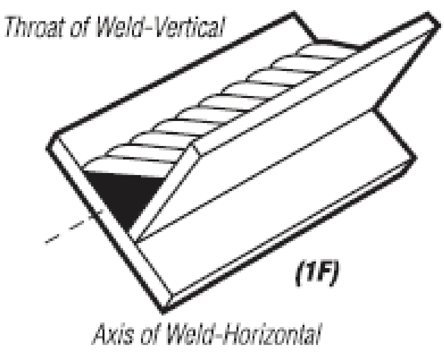
At the end of this unit, you will be able to:

- Evaluate the importance of welding positions
- Define the terminology that indicates various welding positions

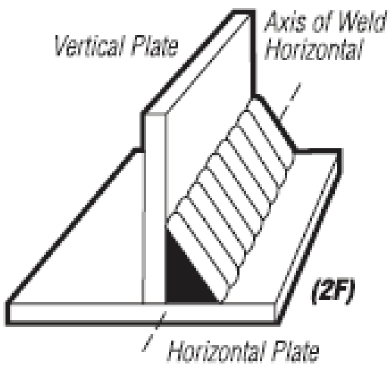
Welding operations very often cannot be carried out in the most desirable position. They must be done keeping in mind the position in which the part will be used. Frequently that could be on the floor, on the ceiling or in the corner. A welder needs to have a proper description and definition of these positions in order to produce the welding positions as per the WPS specified to him/her.

The American Welding Society has defined the four basic welding positions as shown below.

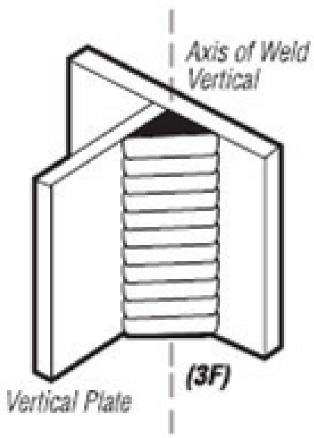
Fillet Weld



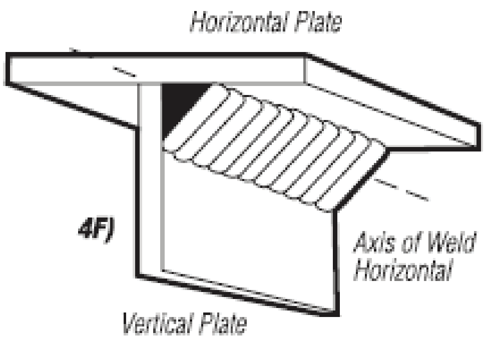
Flat Position



Horizontal Position

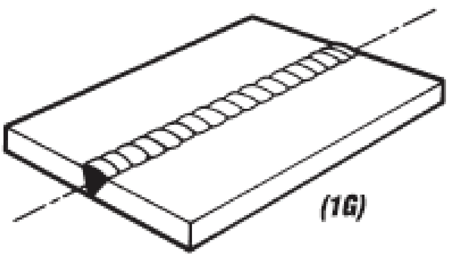


Vertical Position

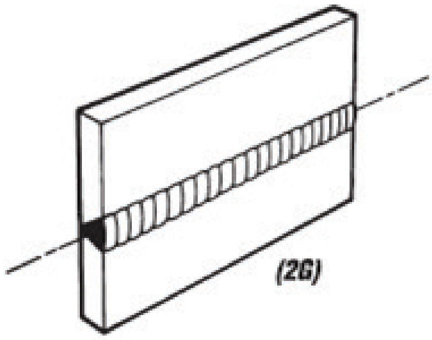


Overhead Position

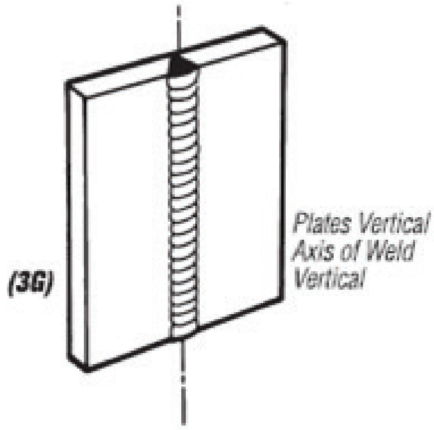
Groove Weld



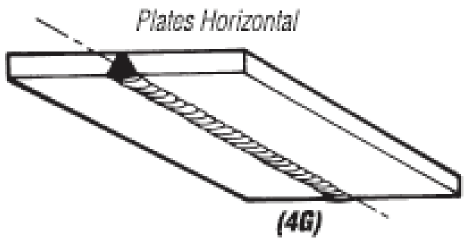
Flat Position



Horizontal Position



Vertical Position



Overhead Position

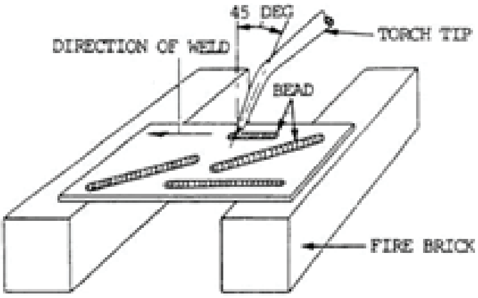
Basic Welding Positions

A number is used to define the position and an F for Fillet or G for groove refers to the type of weld.

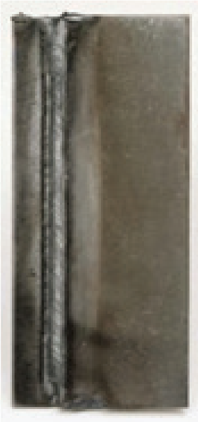
- 1 refers to a flat position, either 1F or 1G
- 2 refers to a horizontal position, either 2F or 2G
- 3 is a vertical position, either 3F or 3G
- 4 is an overhead position, either 4F or 4G

- **Horizontal Position Welding:** Here, the weld axis is approximately horizontal, but the weld type dictates the complete definition.

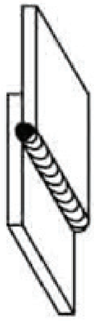
- **Flat Position Welding:** In Flat Position Welding the welding is performed from the upper side of the joint.



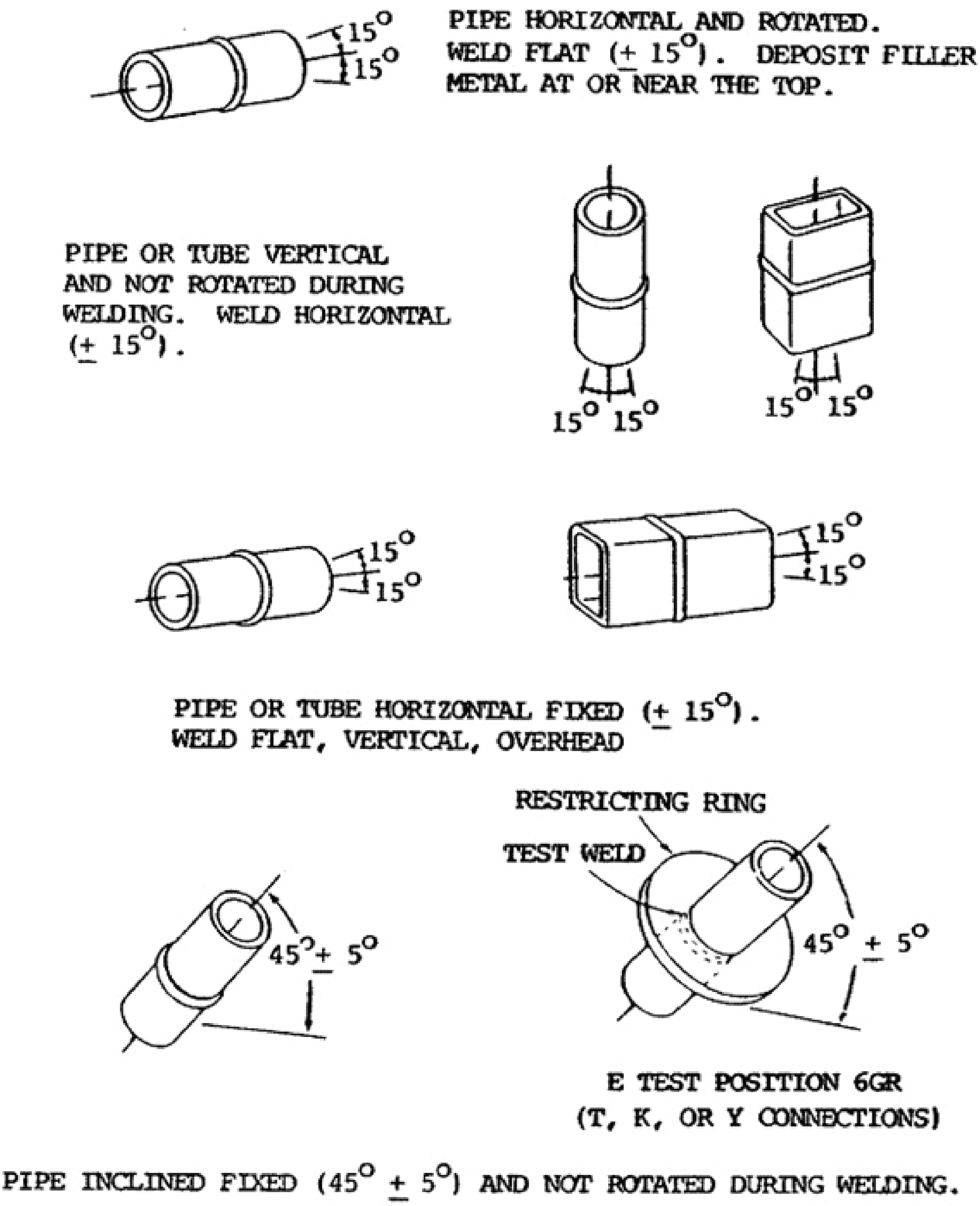
- **Vertical Position Welding:** When Vertical Position Welding is done, the molten metal has a tendency to run downward and pile up.



- **Overhead Position Welding:** Overhead welding is conducted from the underside of a joint.



- **Pipe welding positions:** Pipe welds are constructed keeping in mind a variety of different requirements and in different welding situations. Positions and procedures for welding pipe are outlined below.



Figute 5.9: Positions and procedures for welding pipe

Unit 5.10 Operating the Welding Equipment to Produce a Range of Joints

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the range of joints
- Practice to operate equipment to produce a range of joints

A welding joint can be described as an edge or point where two or multiple pieces of metal are joined together. As we have seen in a previous chapter, there are five types of welding joints. These include, butt, corner, edge, lap, and tee. The following are the methods to make a few common joints.

Equipment:

- The welding torch/gun
- The workpiece or base metal
- The electrical power supply
- The feed unit
- The electrode (filler metal) source
- The inert shielding gas source
- Personal protective equipment

Step 1: Turn on the Gas

The first step is to turn on the compressed inert gas.

Step 2: Turn on the Machine and Adjust Settings

After that you will need to turn on the power to the machine and calibrate any necessary settings.

Step 3: Square Joint (set Up)

A square joint is made by of welding together two pieces of metal end to end, as shown above. The two pieces must be parallel and the top surfaces flat.

Step 4: Square Joint (tack Welds)

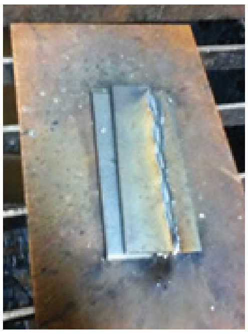
The use of tack welds is to ensure that the two workpieces stay a consistent distance apart while welding. Once the tack welds are done, the seam weld is laid down.

Step 5: Square Joint (weld)

Step 6: Lap Joint (Set Up)

A lap joint is constructed when one piece of metal overlaps the other, and the seam between the two is welded. While welding a lap joint, you need to use tack welds to get a better fixture. A lap joint is typically employed to weld two perpendicular faces (fillet weld).

Step 7: Lap Joint (weld)



Step 8: Tee Joint (set Up)

As they both involve welding two perpendicular faces, a tee joint is similar to a lap joint. But while a lap joint is made of two workpieces oriented in the same plane, the tee joint on the other hand has one piece perpendicular to the other. Fixturing is vital in tee joints because of the thermal contraction and expansion of the metal.

Step 9: Tee Joint (weld)

Unit 5.11 Effects of the Electrical Characteristics of the TIG welding arc

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the electrical characteristics of the TIG welding arc
- Analyze the effect produced the electrical characteristics of the TIG welding arc

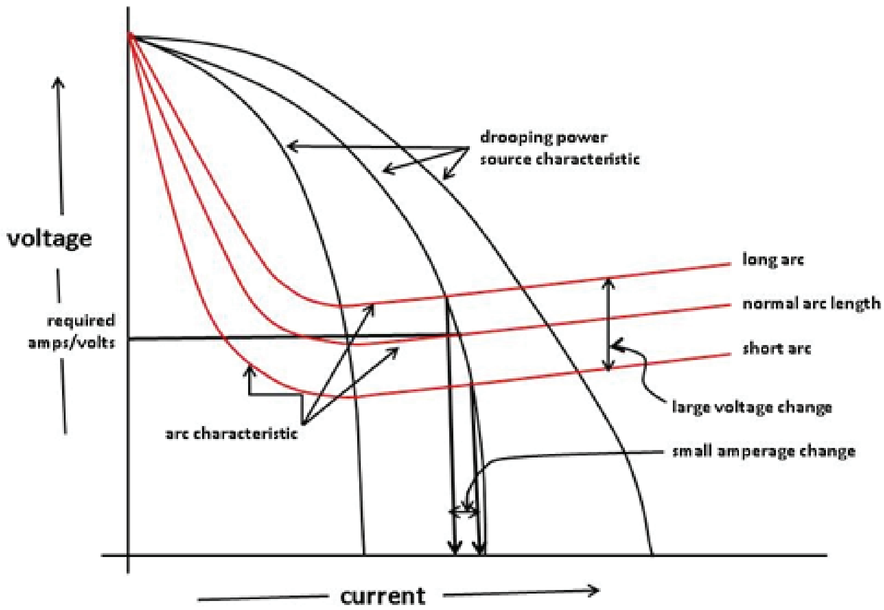


Figure: Electrical Characteristics of the TIG welding arc

- In TIG welding a drooping output or constant current static characteristic is used.
- During manual welding the arc length constantly changes because the welder is unable to maintain a constant arc length.
- With a constant current power source, as the arc length changes due to the welder's manipulation of the welding torch there is only a small change in the welding current.
- This means that the steeper the curve the smaller the change in current so there will be no current surges and a stable welding condition is achieved.
- The welding current chiefly determines such features as the electrode consumption and penetration.
- Thus we realise that the arc length is less critical, and the welder's task in achieving proper, defect free welds is much easier.

Notes

Unit 5.12 Gouging and Back Gouging Principles, Methods and Procedures

Unit Objectives

At the end of this unit, you will be able to:

- Define the concepts of gouging and back gouging
- Evaluate the procedures for gouging and back gouging

- The method of gouging is used for removal of defective welds and during joint preparation.
- The Gouging method has similarities to gas cutting.
- In this process the oxy-fuel gas flame heats up the workpiece to the level of ignition temperature
- The cutting oxygen jet combusts and leads the molten metal away.
- Except for the nozzle, the equipment is the same as in gas cutting
- In gouging the position of the oxygen beam should be almost parallel to the surface of the workpiece.
- Welders use a range of techniques to achieve different gouge sizes and profiles.
- Typically, the torch is positioned at a 40- to 60-degree angle to the piece being worked on, while the pilot arc is formed and the arc transfers to the plate.
- The welder then feeds the arc into the gouge, moving the torch along the plate in a forward motion.
- Slower speeds and steeper angles lead the arc to penetrate more deeply into the workpiece.
- Faster speeds and smaller angles remove less material and produce a shallower gouge.

The table below shows some of the gouge profiles that are possible.

Gouge Profile			
Speed (IPM)	24	48	24
Torch Angle (degrees)	45	45	60
Torch-to-Work Distance (in.)	0.125	0.125	0.125
Gas Pressure (PSI)	50	50	50
Gouge Width (in.)	0.300	0.260	0.210
Gouge Depth (in.)	0.248	0.131	0.216
Gouge Area (in.2)	0.040	0.015	0.022
Volume Removed/Min. (in.3/min.)	0.96	0.72	0.53
Volume Removed/Hr. (in.3/hr.)	57.6	43.2	31.8
Pounds Removed/Hr (lb./ hr.)	16.7	12.5	9.2

Table 5.12: Gouge profiles

Several gouge profiles can be obtained by varying the process parameters of speed, torch angle, and standoff.

Three different techniques are:

- Straight gouge
- Side gouge
- Weaving gouge

Back gouging

- The technique of back gouging can be described as the removal of base metal and weld metal from the weld root side of a welded joint.
- This is done to enable thorough fusion and thorough joint penetration when subsequent welding is done from that side.
- Methods include grinding to sound metal (GTSM), air carbon arc and plasma.

Unit 5.13 Distortion and how to Control Distortion in Welding

Unit Objectives

At the end of this unit, you will be able to:

- Define the concept of weld distortion
- Practice how to control distortion in welding

In construction of metallic structures, the fundamental dimensional changes that occur during welding are called weld distortions. The following are types of distortions that an operator would encounter.

Types of Welding Distortions

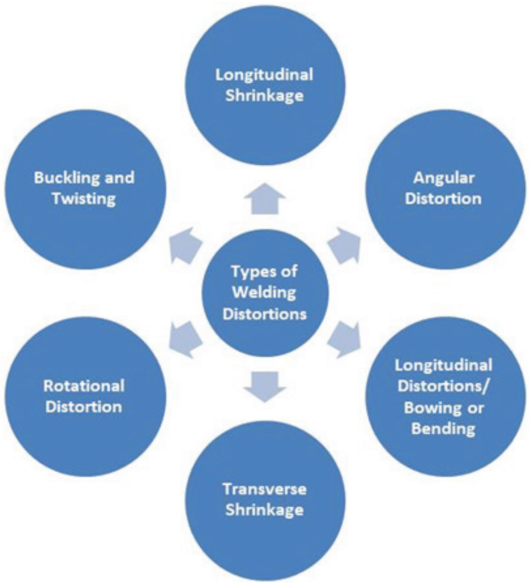


Figure 5.13_1: Types of Welding Distortions

Various techniques can often be crucial in minimising distortion while performing welding operations. The different areas include assembly techniques, welding procedure, and welding sequence.

1. Longitudinal stiffeners prevent bowing in butt welded thin plate joints.

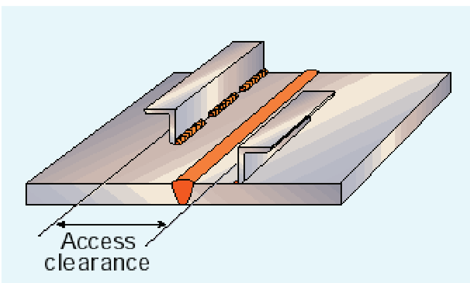


Figure 5.13_2: Technique to prevent distortion

2. Back-to-back assembly to control distortion when welding two identical components.
    a. assemblies tacked together before welding
    b. use of wedges for components that distort on separation after welding

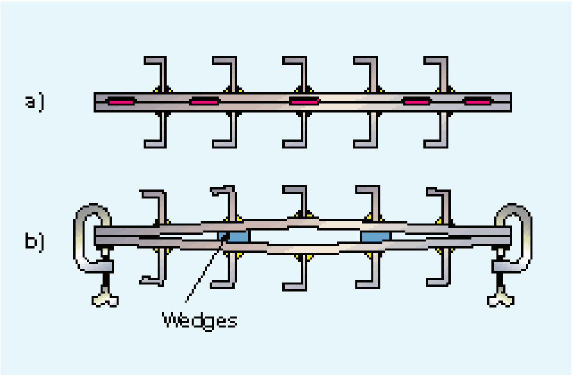


Figure 5.13_3: Technique to prevent distortion

3. Alternative procedures used for tack welding to prevent transverse shrinkage.
    a. tack weld straight through to end of joint
    b. tack weld one end, then use back-step technique for tacking the rest of the joint
    c. tack weld the centre, then complete the tack welding by the back-step technique

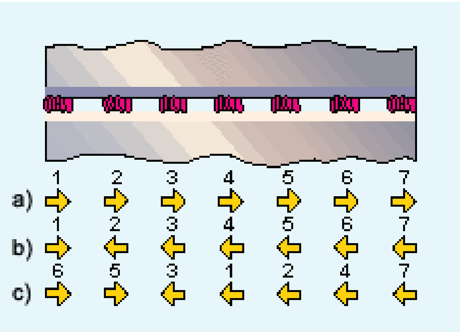


Figure 5.13_4: Technique to prevent distortion

4. Use of welding direction to control distortion.
    a. Back-step welding
    b. Skip welding

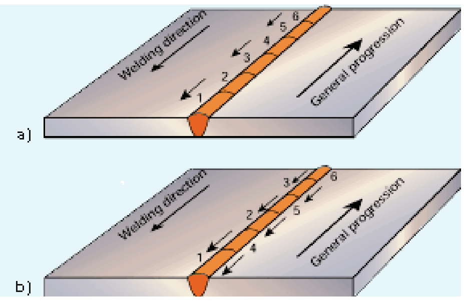


Figure 5.13_5: Technique to prevent distortion

5. Angular distortion of the joint as determined by the number of runs in the fillet weld.

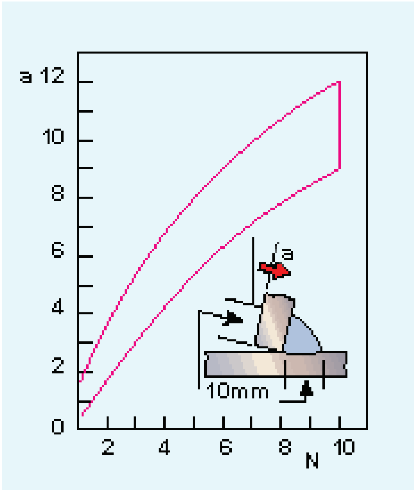


Figure 5.13_6: Technique to prevent distortion

Unit 5.14 Correct Procedure for Carrying Out the Dye Penetrant Test

Unit Objectives

At the end of this unit, you will be able to:

- Practice Dye Penetrant Test
- Practice the procedure for the Dye Penetrant Test

This is a non-destructive testing technique which serves the purpose of locating surface breaking flaws such as seams, laps, porosity, cracks and all other surface discontinuities. This test can be applied to both ferrous and non-ferrous materials.

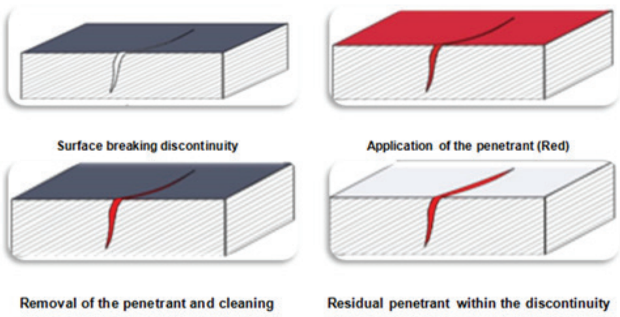


Figure 5.14: Dye Penetrant Test Procedure

Dye Penetrant Test Procedure:

- Prior to the test, the area to be inspected and at least one inch on either side shall be free from all contaminants.
- A liquid penetrant which may be a visible or a fluorescent material is applied evenly over the surface being examined.
- Immersion (dipping), flow-on, spray, or brushing technique is used to apply the penetrant to the pre-cleaned dry specimen.
- Penetrant dwell times are critical and should be adjusted depending on temperature and other conditions.
- Care shall be taken to prevent drying out of the applied penetrant and additional penetrant must be applied to re-wet the surface.
- After the dwell time has passed the excess penetrant is removed by water spray.
- Water at 60°F to 110°F and a pressure not exceeding 30 psi (210 KPa) is applied with a droplet type sprayer. Avoid over-washing.
- The test surface must be dry prior to the application of non-aqueous or dry developers.
- When the drying process is complete, the specimen is ready for the application of either dry or non-aqueous wet developer.
- Dry developer is applied to the specimen by brushing with soft brush, by use of a powder gun.
- Applied developer shall not be removed from test surface.
- The area under inspection shall be observed during application of developer.
- The recommended development time is between 7 and 30 minutes.

Unit 5.15 Handling of Weld Specimens for Tests

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the weld specimens for testing
- Practice handling weld specimens correctly

Destructive weld testing, as the name suggests, involves the physical destruction of the completed weld in order to assess its characteristics. It is employed to gauge mechanical properties, such as strength, toughness and hardness and so on. The samples are put under different loads and stress. This helps to analyse at which point the material eventually gives up and cracks. The results gained are then compared to regulations and/or quality guidelines.

Macro Etch Testing:

- Usually involves the removal of small samples of the welded joint.
- These samples are polished across their cross-section and then etched using some type of mild acid mixture.

Fillet Weld Break Test

- This test involves breaking a sample fillet weld that is welded on one side only.
- The sample has load applied to its unwelded side.
- The load is increased until the weld has failed.

Transverse Tensile Test

- Transverse tensile test is performed on the test specimen, which is extracted in the transverse direction or across the sample of item such as plate or pipe.
- It measures transverse tensile strength, yield strength, proof stress, elongation and reduction of area.

Guided Bend Test

- This is a test method in which a specimen is bent to a specified bend radius.
- The specimen is bent in a U-shaped die.
- The types of specimens are usually rectangular ones machined from plates and pipes.

Summary

- GTAW or TIG Welding is a process that employs a non-consumable tungsten electrode to create a weld with or without the use filler material.
- Weld pool temperatures in TIG welding can approach 2500 °C (4530 °F).
- Most welding falls into two categories: arc welding and torch welding.
- DCSP type of connection is the most commonly used in the DC type welding current connections.
- Inspect walkways, workspaces and routing of welding cables to see that no slip/trip hazards are present.
- When the welding arc is mechanically rotated around a static work piece continuously it is known as Orbital welding.
- In TIG welding ensure that the recommended gas flow is being followed based on the metal size and the nozzle selected.
- Thoriated tungsten electrodes are easy to use and last a long time.
- A CO_2 shielded weld bead often gives rise to convex shape and causes overwelding.
- The term purging is used when a gas is supplied on the backside of a weld.
- In Flat Position Welding the welding is performed from the upper side of the joint.
- One of the benefits of welding with an air-cooled TIG torch is that you don't have to have a water supply nearby.
- The use of tack welds is to ensure that the two workpieces stay a consistent distance apart while welding.
- The method of gouging is used for removal of defective welds and during joint preparation.
- Various techniques can often be crucial in minimising distortion while performing welding operations.
- Immersion (dipping), flow-on, spray, or brushing technique is used to apply the penetrant to the pre-cleaned dry specimen.
- Destructive weld testing, as the name suggests, involves the physical destruction of the completed weld in order to assess its characteristics.
- Transverse tensile test measures transverse tensile strength, yield strength, proof stress, elongation and reduction of area.

Notes

Notes

Scan the QR codes or click on the link to watch the related videos

https://www.youtube.com/watch?v=uO5pV-LOAmD4

What is TIG Welding

Scan the QR codes or click on the link to watch the related videos

https://www.youtube.com/watch?v=t-QKxa-JU2hI&t=46s

How to choose the correct Tungsten for TIG Welding

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6. Work Effectively in a Team

Unit 6.1 Effective Communication between Co-workers

Unit 6.2 Importance of Helping Colleagues with Problems

HYC/N6103

Learning Outcomes

After attending the session, you will be able to:

1. Practice Effective Communication among co-workers
2. Evaluate the importance of helping colleagues with problems

Unit 6.1 Effective Communication between Co-workers

Unit Objectives

At the end of this unit, you will be able to:

- Define the importance of Effective Communication
- Practice Effective Communication between Co-workers

Effective peer-to-peer communication helps in establishing mutually respectful relationships that can not only promote employee satisfaction, but can improve productivity as well.

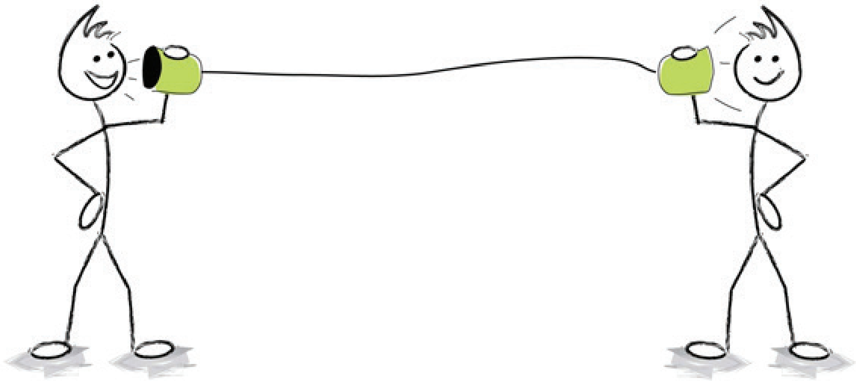

Figure 6.1: Effective Communication

The various elements of effective communication between co-workers are given below:

- Building professional relationships
- Seeking first to understand each other at work
- Avoiding defensive attitude
- Embracing diverse perspectives with an open mind
- Being honest, polite and direct
- Taking care of the tone of communication
- Handling peer feedback positively
- Taking care of one's body language so that it does not contradict with the tone and purpose of communication
- Coordinating with the fellow Industrial Welders to promote effective teamwork

6.1.1 Oral Communication

It is vital for an operator to maintain clear communication with colleagues especially while communicating orally. Following are the reasons for good oral communication:

- Give instructions and directions to truck drivers who would be picking up and dropping off the finished material
- Converse with tool room staff regarding supplies, tools and PPE
- Request co-workers for assistance with operational tasks like lifting, moving or to provide information
- Coordinate with fellow welders about the fit and size of the pieces, and compare calculations and measurements when building a structure
- Discuss work assignments with your supervisor to comprehend expectations
- Describe welding designs and methods to customers
- Inform manager/ supervisor about a issues such as broken equipment

Unit 6.2 Importance of Helping Colleagues with Problems

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the areas where operators must help colleagues
- Analyze the importance of helping colleagues with problems

Figure 6.2: Helping colleagues with problems

Any task or errand in the Construction site or Workshop, is impossible without proper teamwork. Lack of teamwork can be destructive and can foil the entire assignment or project. This would, in turn, lead to delayed delivery of project and loss of client relationships.

- Effective teamwork for an Industrial Welder includes, but is not limited to the following:
- Understanding, in close coordination with the team members and fellow Industrial Welders, the purpose of the Welding operations and what needs to be achieved through the welding operations
- Identifying the different activities within his work area where a coordination and close interaction with other workers is required
- Consulting the team members and fellow Industrial Welders on the following:
  - applicable techniques of work
  - properties of materials to be used
  - tools and equipment to be used
  - safety standards required for each tool, equipment and process under use
- Supporting and gaining support from fellow Industrial Welders while facing challenges in smoothly carrying out the operations
- Cooperating with team members and trusting them in their areas of work
- Identifying risks and hazards associated with an assignment before starting a project and allocating responsibilities among the fellow team members
- Assessing and prioritizing the risks, based on the likelihood and consequence of their occurrence and subsequently developing a plan for mitigating each one.

Summary

- Effective peer-to-peer communication helps in establishing mutually respectful relationships that can not only promote employee satisfaction, but can improve productivity as well.
- Seeking first to understand each other at work
- Converse with tool room staff regarding supplies, tools and PPE
- Coordinate with fellow welders about the fit and size of the pieces, and compare calculations and measurements when building a structure
- Take care of your body language so that it does not contradict with the tone and purpose of communication.
- A welder needs to support and gain support from fellow Industrial Welders while facing challenges in smoothly carrying out the operations.
- A welder needs to identify the risks and hazards associated with an assignment before starting a project and allocating responsibilities among the fellow team members
- Coordinating with the fellow Industrial Welders promotes effective teamwork

Notes

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7. Follow Health, Safety and Security procedures

Unit 7.1 Meaning of 'hazards' and 'risks'

Unit 7.2 Possible Causes Of Risks And Accident

Unit 7.3 Safe Work Practices When Working At Various Hazardous Sites

Unit 7.4 General Health and Safety Equipment in the Workplace

Unit 7.5 Importance of Using Protective Clothing/Equipment while Working

Unit 7.6 Electrical dangers and toxic exposures while welding

Unit 7.7 Fire safety

Unit 7.8 Various Types of Safety Signs

Unit 7.9 Appropriate Basic First Aid Treatment

Unit 7.10 Safe Lifting and Carrying Practices

Unit 7.11 Personal Safety and Health and Dignity Issues Relating to the Movement of a Person by Others

HYC/N6104

Key Learning Outcomes

After attending the session, you will be able to:

1. Define the different Health and safety hazards
2. Practice safe working practices with tools/machines
3. Evaluate Health and Safety equipment
4. Evaluate the Importance of using PPE
5. Analyze the electrical equipment dangers
6. Analyze awareness on Fire safety
7. Evaluate the different types of safety signs
8. Evaluate preventative actions during exposure to toxic material
9. Define basic first aid treatment
10. Define the need for Accident Report writing
11. Evaluate safe lifting and carrying practices
12. Analyze the correct way of moving an accident victim

Unit 7.1 Meaning of 'hazards' and 'risks'

Unit Objectives

At the end of this unit, you will be able to:

- Define the concept of hazards
- Define the concept of risk
- Evaluate the hazards commonly present in the welding environment

Hazard is anything that can cause harm, for example: chemicals, electricity, dangerous equipment at the workplace etc. On the other hand, risk is the chance that can be low or high for any hazard to actually cause somebody harm.

Accidents and emergencies may occur due to the following:

- Faulty Equipment
- Fire and explosion
- Lack of oxygen in confined spaces
- Electrical hazards
- Slips and trips

Operators must consistently apply and promote health and safety legislation and best practices in order to prevent harmful effects of various welding hazards.

7.1.1 Health and Safety Hazards Commonly Present In The Work Environment

There are different types of hazards that a welder has to face at the work place. If welders follow the health and safety legislation as well as the best practices in welding, it will serve to keep them well-protected against welding hazards.

These hazards are:

- Fumes and gases: As they contain various poisonous chemicals fumes and gases can be hazardous to your health.
- Arc rays: As they are powerful, arc rays can injure eyes and burn skin just like the sun's rays.
- Hot objects: Hot objects can cause severe burns.
- Electric shock: An electric shock can kill or cause serious injury.
- Fire and explosion: Fires and explosions can occur due to welding sparks. Welding sparks rise to the height of as much as 35 feet and cause serious damage to the operators and the workplace.
- Noise: Loud noises can damage your hearing.

Precautions to be taken to avoid workplace hazards:

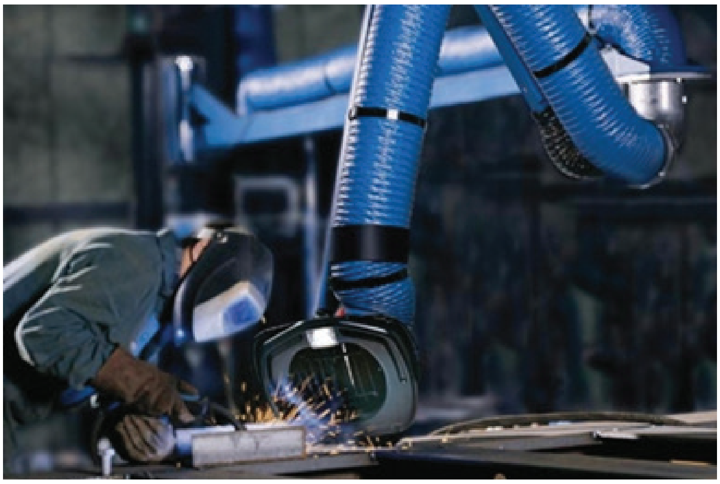


Figure7.1: Local Exhaust Ventilation

You have to be careful while handling and working with the welding equipment. Below given are the ways to avoid hazards:

Fumes and gases:

- To protect yourself from fumes and gases keep your head out of the fumes.
- Make sure there is proper ventilation so that the fumes can escape.

Electric shock:

- Do not touch any live electrical parts.
- Insulate yourself from the open wires and electrical equipment and follow all the warnings given on the welding equipment.

Arc rays:

- Arc rays contain UV rays so you must protect your eyes and skin.
- You should wear the correct type of eye and body protection.

Fire and explosion:

- To avoid fire and explosion, either remove all materials that burn easily from welding area or shield them from sparks and spatter.
- Fire extinguishers should be kept ready at designated places.
- Check the welding area 30 minutes after welding to see if there is a fire.

Noise:

- Welding factories or sites are known to have an excess amount of sound.
- Protect your ears by using proper hearing protection such as ear plugs and ear muffs as and when required.

Hot objects:

- Do not touch the electrode or other "electrically hot" parts of the welding machine without proper insulation.
- Any metal object at a welding area can be very hot, so take care before touching.

Unit 7.2 Possible Causes of Risks and Accident

Unit Objectives

At the end of this unit, you will be able to:

- Define risks and accidents in the welding industry
- Analyze the causes of welding accidents and risks
- Practice proper protocol while using welding tools

Figure 7.2: Hazards while welding

- Welding produces vapours and sparks that pose physical hazards to operators and others.
- Electric shock occurs when welders touch two metal objects that have a voltage between them, thereby inserting themselves into the electrical circuit.
- Be aware that even a shock of 50 volts or less is enough to injure or kill an operator.
- When idle but still turned on, most welding equipment contains a voltage that ranges from 20 to 100 volts, which pose a big risk for electric shock.
- Welding fumes are made up of potentially harmful complex metal oxide compounds from parts like consumables, base metal and the base-metal coatings.
- Not having satisfactory ventilation and local exhaust to keep fumes and gases from the breathing zone can be hazardous to your health.
- Spatter created by the arc can reach up to 35 feet away from the welding space and can cause fires
- Flammable materials that remain in the welding area can get ignited.

7.2.1 Safe Working Practices When Working With Tools And Machines

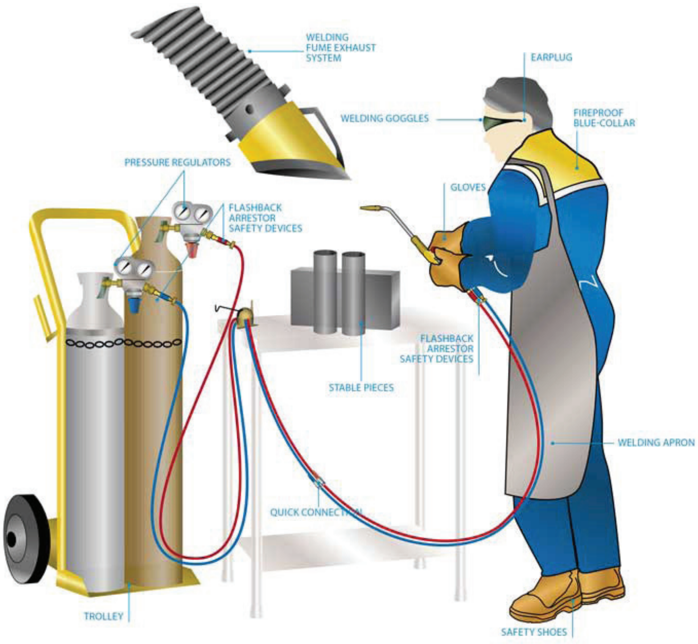


Figure 7.2.1: Safe working practices during welding

How to use and operate tools safely:

Welding equipment installation must only be carried out by well qualified staff. These individuals must operate trade machinery effectively, safely and in accordance with manufacturers' instructions.

- The operator is responsible for checking the equipment (electrode holder, coupling devices and cable) regularly to inspect for damage and then reporting all defects.
- To prevent shock the electrode holder must be insulated while changing the electrode.
- During outdoor welding, the equipment should have the appropriate level of waterproofing.
- In cases where two or more welders using separate power sources are welding the same work piece, it is essential that they remain at a safe distance from each other.
- The operator must regularly check that all external connections are tight and clean.
- High Frequency welders must come equipped with built-in safety devices to safe guard welders and maintenance personnel.
- The operator must use a hand or head shield and protective clothing in order to remain protected from light radiation emitted from the arc.

7.2.2 Specific safety issues relating to work involving cutting tools

Several sizes and types of cutters are used for cutting a variety of metal products. Cutters are designed in ma manner that allows them to cut materials of different kinds of products such as metal slabs, wires, metal girders, etc.

While performing cutting operations you must follow the following safety procedures:

- Don goggles and safety glasses, or even a faceshield as well as welding gloves when using cutters.
- Select the appropriate cutter for the job.
- Different cutters are designed for a specific size, hardness and type of material.
- Cut materials straight across – make sure that the material is kept at right angles in relation to the cutting edges of jaws.
- Avoid injury from flying metal by placing a cloth or rag around the cutting jaws.
- See that the cutting tools are always kept in good repair.
- Adjust and lubricate cutter, sharpen jaws according to manufacturers' instructions.

Notes

Unit 7.3 Safe Work Practices when Working at Various Hazardous Sites

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the various sites where welding is carried out
- Practice safe methods while welding in different sites

Welding operations are not always confined to the work shop or factory but might take place in a wide variety of locations under many different conditions. Welding operations are carried out in factories, building construction sites, pits, vats, mines, tanks, ship compartments and just about everywhere that metals are joined or cut.

Welding activities create a large amount of light, heat and sometimes smoke. This poses health hazards to the welder. A welding operator must focus on the measures they need to take to protect themselves and their fellow workers from various workplace hazards.

- Making sure that the surface to weld is free of grease, paint and powder coating which can burn can create toxic smoke.
- Wear the proper safety gear, including helmet, gloves and clothing and footwear.
- Make sure that your work area is not cluttered by keeping all tools and equipment in their appropriate place.
- Use fixturing whenever possible as it increases safety by eliminating the use of a chain and hoist to flip the component.
- Welding on construction sites can impact the safety of the welder as well as adjacent workers
- Staff within 20 feet of a welding arc should be wearing safety glasses or shielded by an opaque barrier to guard them from flash burn.
- Operators need to wear a hood with a dark lens to guard themselves from retinal burns.
- If the welding equipment is wet you need to dry it out once you have disconnected the power source.
- Inspect the lead for any exposed wiring that could cause a shock or fire.
- Examine the gas hose for leaks when inert gas welding is used.
- Electrode holders must be stored in places where they do not make contact with personnel or fuel.
- Supervisors have the responsibility of making a critical assessment of work to be carried out in confined spaces to prevent injury and loss of life.

Unit 7.4 General Health and Safety Equipment in the Workplace

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate health and safety while using equipment
- Analyze the PPE needed during welding activities

Protective equipment is at the heart of any welding safety plan. As the operator is exposed to flash burns, falling and heavy objects, chemical hazards etc. they must make use of the safety equipment available to keep them protected.

Welding screen/curtain:

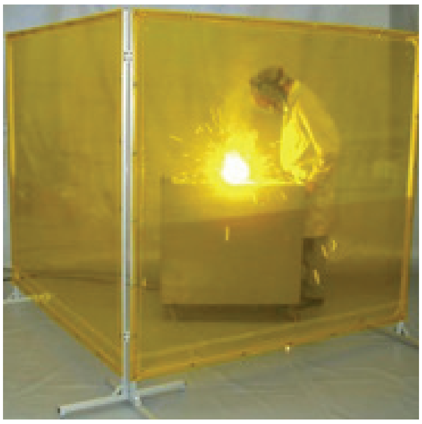


Figure 7.4_1: Welding screen/curtain

- Welding screens are generally used by welders who need to perform welding activities in the vicinity of other workers.
- Using a welding screen serves to reduce flash burns and the amount of dangerous UV light that your fellow workers are exposed to.

Welding Blankets:

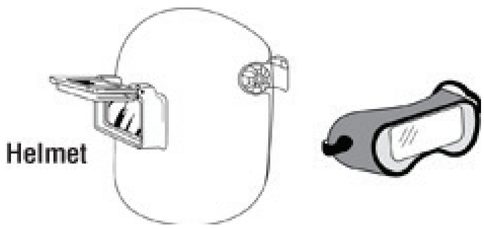
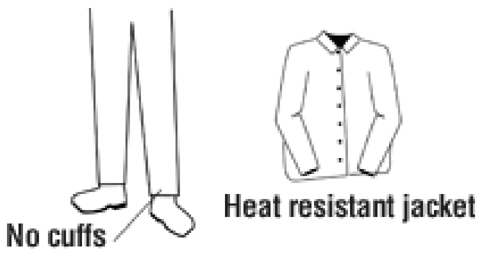
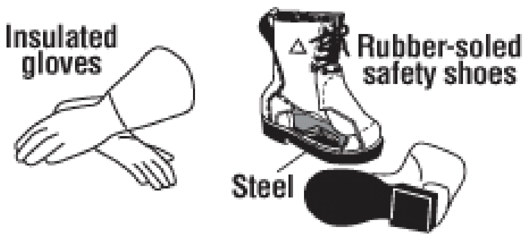
Figure 7.4_2: Welding Blankets

- Blankets protect against weld spatter, stray sparks, welding fire, extreme temperatures, and liquid metal.
- These blankets usually consist of a layer of flexible protective and heat resistant material.

Personal protective equipment (PPE) for welders:

Figure 7.4_3: Welder wearing PPE

Find below a chart that sums up the various types of personal protective equipment that a welder needs to use.

Welding - Personal Protective Equipment			
Body Part	**Equipment**	**Illustration**	**Reason**
Eyes and face	Welding helmet, hand shield, or goggles		Protects from: • radiation • flying particles, debris • hot slag, sparks • intense light • irritation and chemical burns Wear fire resistant head coverings under the helmet where appropriate
Lungs (breathing)	Respirators		Protects against: • fumes and oxides
Exposed skin (other than feet, hands, and head)	Fire/Flame resistant clothing and aprons		Protects against: • heat, fires • burns • radiation Note: pants should not have cuffs, shirts should have flaps over pockets or be taped closed
Ears - hearing	Ear muffs, ear plugs		Protects against: • noise Use fire resistant ear muffs where sparks or splatter may enter the ear, rather than plugs.
Feet and hands	Boots, gloves		Protects against: • electric shock • heat • burns • fires

Unit 7.5 Importance of Using Protective Clothing/Equipment while Working

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the importance of using PPE while welding
- Define the descriptions of various PPE used by welders

Welding operators everywhere are exposed to a host of chemical and physical hazards in the workplace and other sites. Thus it is mandatory that they should wear all the PPE necessary to prevent any problems.

- **Welding Cap**

As a head protection from hot metal and slag splatter a welder's cap should be worn. Additionally, long hair should be tied back and tucked inside the welding jacket.

- **Eye protection**

During all electric welding processes, operators must don safety goggles to guard their eyes from weld spatter which occasionally tends to get inside the operator's helmet.

- **Hearing Protection**

There are many noise-generating devices in the welding zone that can damage your hearing as well as debris that can enter your ear canal. Ear muffs or ear plugs can be worn to provide ear protection while welding.

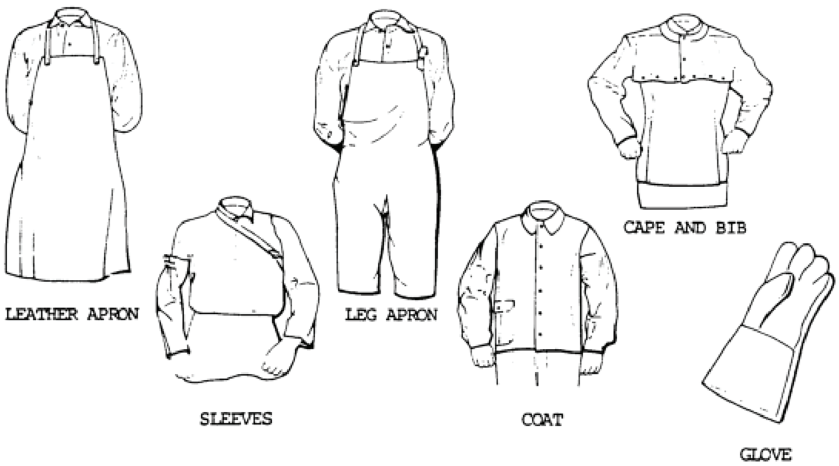
- **Welding Gloves**

Leather welding gloves are your best option to protect your hands during welding operations. The gloves serve to protect the hands and arms from rays of the arc, molten metal spatter, sparks, and hot metal.

- **Breathing Protection**

The high quantity of fumes and gases produced from welding and associated processes can adversely affect your health. To protect against particulates and fumes it is important to wear mask respirator.

- **Clothing**



Protective clothing.

Proper clothing while conducting welding activities can provide a great amount of protection. Long sleeved shirts and long pants are also required. Flameproof aprons or jackets made of leather are also recommended.

- **Footwear**

Proper footwear will protect your feet from hot sparks or falling objects. Impact and compression resistant footwear is constructed with a toe-cap to protect your foot from falling objects.

- **Welding Helmet**

Typically welding helmets are made from pressed fibre insulating material. It serves to lessen glare and reflection produced by the intense light. The lenses are designed to prevent eye damage and flash burns.

- **Face shields**

For welding processes that tend to produce high velocity particles, a full-face shield is required.

Unit 7.6 Electrical dangers and toxic exposures while welding

Unit Objectives

At the end of this unit, you will be able to:

- Define the electrical equipment used in welding
- Evaluate the various dangers while using electrical equipment
- Practice preventative actions against exposure to toxic material

7.6.1 Various Dangers Associated With The Use of Electrical Equipment

Figure 7.6.1: Dangers related to electrical equipment

A live electrical circuit is used in the arc welding process. This means that all arc welders using hand held equipment are at a high risk of electrical burns and electric shock.

- Do not discount low currents as they also have the potential of causing severe health effects like muscle paralysis, burns, spasms, or even death.
- If a person touches a live conductor, current may flow through the body to the ground and cause a shock.
- Increased electrical contact with the ground increases the risk of shock.
- While welding, standing in water and other wet surfaces, working with wet hands or wearing sweaty garments must strictly be avoided.
- Small shocks mightcatch you off-guard and cause you to fall or slip.
- Welders may sustain radiation from exposure to an electric welding arc.
- Welders are also prone to electrical burns when electricity of sufficient current and voltage passes through their body.

7.6.2 Preventative and Remedial Actions To Be Taken In The Case Of Exposure To Toxic Material

Figure 7.6.2: Exposure to toxic material

Breathing welding fumes is extremely harmful for welders and exposes their lungs to multiple hazards. The welding fumes consist of a combination of gases, water molecules and dust which due to their small sizes get into the respiratory system.

Generally, welding fumes and gases come from:

- the base material being welded or the filler material that is used;
- coatings and paints on the metal being welded, or coatings covering the electrode;
- shielding gases supplied from cylinders;
- chemical reactions which result by the action of ultraviolet light from the arc and heat;
- process and consumables used; and
- contaminants in the air, for example vapours from cleaners and degreasers

Remedies and methods to prevent illnesses caused by toxic material

- A welder must keep his/her head away of the fume plume
- Keep fumes and gases from your breathing zone and general area using various ventilation methods
- Wear the appropriate respirator if adequate ventilation cannot be provided.
- Read the product label to review the warnings, safety precautions.
- Read the MSDS for the base metal being welded
- Substitute less hazardous materials for hazardous materials.
- Sample the welding area fumes for both short-term and long-term evaluations using a filter-cassette

Handling spills in the workshop

- A welder should know how to handle spills and respond to the spills.
- Oil and gas spills present a serious problem when not managed properly
- A Mobile Spill Kit enables you respond to a variety of spills like water, petroleum and chemical-based spills.
- Fuel spill kits are equipped with the following: protective gear, containers, absorbents, disposable bags, and instruction books.
- It also features wheels that render the clean-up process extremely convenient.
- These kits quickly carry all required supplies, including containers and absorbents, to the scene.
- This will ensure that you and the environment in the work shop remain safe

Unit 7.7 Fire safety

Unit Objectives

At the end of this unit, you will be able to:

- Practice the steps to extinguish a fire
- Practice rescue techniques applied during a fire hazard

Figure 7.7: Various causes of fire

Welding fires can be caused by various sources like:

- Heating of metal
- Spontaneous ignition
- Sparking
- Electrical heating
- Loose fires
- Chemical fires

The welding arc has an extremely high temperature range but the heat does not cause fires. It is the spatter, arc rays and sparks produced during welding that can cause fire if they fall on combustible materials or electrical fittings or lines. The following are some causes of fires during welding operations.

- **Heating of metal:** Drips of molten metal and hot metal parts can easily start a fire. These drips of metal and slag can travel a significant distance and can start fires in nearbyareas.

- **Spontaneous Ignition:** Oils and greases may spontaneously ignite in the presence of pure oxygen. Do not let equipment or parts to be contaminated with grease or oil under any circumstances.

- **Sparks:** Welding fires can also be caused by torch flames and sparks. The opertor must clear away wood, fabric, cardboard and other flammable material before starting the job.

- **Electrical heating:** Metal fabrication or welding can also cause electrical fire, especially when the sparks fall on papers or cloth or any flammable material. Check equipment for loose and worn-out wiring and faulty connections.

7.7.1 Techniques of Using The Different Types of Fire Extinguishers

Fire extinguishers come in a wide variety of types — each one designed to put out a different kind of fire.

Body Part	Equipment
	Class A – Ordinary solid combustibles like wood, cloth, and paper products.
	Class B – Flammable liquids and gases.
	Class C – Electrical fires. (Do not use water to put out this kind of fire – you could get electrocuted!)
	Class D – Flammable metals.
	Class K – Oils and grease fires. (Never use water on a grease fire – it will cause the flames to explode and spread.)

Table 7.7.1: Types of Fire Extinguishers

7.7.2 Steps to extinguish a fire

Operators need to demonstrate the correct use of a fire extinguisher. To employ the extinguisher with proper technique, just remember the acronym "PASS" which stands for Pull, Aim, Squeeze, and Sweep.

Pull the pin.
This will allow you to discharge the extinguisher.

Aim at the base of the fire.
If you aim at the flames (which is frequently the temptation), the extinguishing agent will fly right through and do no good. You want to hit the fuel.

Squeeze the top handle or lever.
This depresses a button that releases the pressurized extinguishing agent in the extinguisher.

Sweep from side to side
until the fire is completely out. Start using the extinguisher from a safe distance away, then move forward. Once the fire is out, keep an eye on the area in case it re-ignites.

Figure 7.7.2: Steps to extinguish a fire

7.7.3 Rescue techniques applied during a fire hazard

- The work shop, factory or any other site where the welding operations are taking place should have fire detection and alarm systems installed.
- Employees should be trained on procedures using those systems as well as manually activating the fire alarms.
- The welder should be able to respond to various possible types of fire: electrical fires, chemical fires, general fires
- They should also know the appropriate class of fire extinguishers to be used.

Methods of rescue:

There are basically various methods with the help of which people can be rescued from an area engulfed in a blazing fire. 2 of the important steps that we will discuss now also come under the best safe lifting and carrying practices.

Conventional technique

- This is a good method if there is an open area close by.
- The first rescuers will make the victim sit reach under armpits, and finally grab their wrist.
- The other rescuer will cross the ankle (victim), pull up that person's legs on his shoulder.
- Finally, on the count of 3, both will lift the person up and move out.

Fast strap

- In case the victim is completely incapable of moving out of the fire zone, the rescuers should follow this method.
- One of the rescuers will place their knee between victim's shoulder and head.
- Pin the loop of webbing to the ground with the help of the knee. This acts as an anchor.
- With the non-dominant hand hold the other end of the webbing and make a loop.
- With steady hands pull in victim's hand from the loop, tie it securely and finally clip the webbing loops

Notes

Unit 7.8 Various Types of Safety Signs

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the various Types of safety signs
- Analyze the significance of various Types of safety signs

Welders should be able to identify common hazard signs displayed in various areas around the work shop or site. Some commonly found safety signs at a welding site include:

- **Danger- Eye Safety Sign:** This sign informs fellow workers and visitors that the welding arc is in use which is hazardous

- **Danger- Welding Overhead- Sign** to inform everyone of Welding Overhead and keep them away from harm's way.

- **Welding Area Sign-** Cylinders Only: Mark welding areas like cylinder storage areas in your facility with this sign.

- **Caution Sign-Welding Fumes May Be Present:** Public service signs to indicate that fumes may be present in an area.

- **Caution Hot/Burn:** This sign makes your Process Hazards message clear to employees, visitors and inspectors.

- **Danger High Voltage Keep Away:** This sign is a helpful tool to help protect the health and safety of personnel

Unit 7.9 Appropriate Basic First Aid Treatment

Unit Objectives

At the end of this unit, you will be able to:

- Define different first aid items
- Evaluate the uses of different first aid items
- Analyze what goes into writing an Accident Report

First Aid treatment at workplace

First aid is defined as “treatment given before regular medical services can be provided.” To protect both visitors and operators who fall ill and are hurt, it is important to have at least one person per shift trained in first aid and in CPR.

First Aid Kit Contents

- An assortment of adhesive bandages
- Gauze pads
- Safety pins
- Adhesive tape
- Antibiotic
- Antiseptic and hydrocortisone creams
- Insect sting relief pads
- Cotton balls
- Cotton swabs
- Vaseline
- Pain relievers
- Digital thermometer
- Tweezers
- Scissors
- A needle
- Hand sanitizer
- Saline solution

Adhesive bandages

Adhesive tape

Insect sting relief

Vaseline

Gauze pads

Antibiotic

Cotton balls

Pain relievers

Safety pins

Antiseptic

Cotton swabs

Digital thermometer

Common Accidents that require First Aid

Burns

- For minor burns:
  - o Hold the injured part under cold running water for five minutes. It needs no further treatment. It should simply be left exposed to air.
  - o Don't apply any oil or ointment.
  - o Don't prick or remove blisters.
- **For large and deep burns:**
  - o Needs medical attention
  - o Relieve pain by immersing the area in cold water or applying cold wet cloths.
  - o Wrap or cover injury with clean cloth and light bandage.
  - o Treat the victim for shock while waiting for medical help

Cuts Or Abrasions

- These may be caused in many ways and if not treated properly may sometimes get infected.
- The wound should be cleaned with warm water and antiseptic solution and then covered with a clean dressing.
- In case of bleeding pressure should be applied on the wound once it is free of foreign particles.
- For deep cuts and excessive bleeding the person should be taken immediately to a hospital.

For Controlling Bleeding:

- Apply direct pressure to the wound, using fingers or hand.
- If the wound is large, press the edges together, gently, firmly maintaining pressure.
- Consider what you can use as a pad to control the bleeding more effectively, a clean folded handkerchief is ideal.
- If bleeding is from limb, elevate it.
- If direct pressure seems to control bleeding, put a sterile or clean dressing on the wound.
- Bandage should be firm enough to prevent bleeding but not so tight to cut off circulation.

Nose Bleeding

- Make the victim sit down with his or her head over a sink or bowl.
- Pinch the sides of nose together, apply a cold pad to bridge of nose and wait.
- Instruct the victim to breathe through the mouth and not to sniff.
- If bleeding doesn't stop within 20 mins, take the person to the hospital immediately.

Fractures General Principles:

- Avoid unnecessary movements at the fracture site.
- With leg fractures, only move the victim if he or she is in dangerous situation.
- A person with arm, hand or collar fracture may be made comfortable by applying padding and support sling.
- Always pad the fracture site and avoid undue pressure.
- Use of excellent splints is important.

7.9.1 Content of Written Accident Report

Employers in the welding field are legally obliged to look out for the welfare of their operators when they are at work. Factories and work-shops have special provision of maintaining an incident report form in which one can easily write an accident report. In case you or your fellow worker comes across an accident at work you should make sure the accident is reported in the accident book. One should remember to include this information in the report.

- In the 1st section, you need to record the basic things related to the accident like:
  - Date of accident
  - Time
  - Specific location
  - Accounts of witnesses
  - Their names
  - Event that caused that accident
  - What other welders were doing at that moment
  - Circumstances like PPE, materials, equipment, tool
  - Environmental conditions
  - Specific injuries
  - Person(s) who gave first aid

Figure 7.9.1: Accident Report

- In the 2nd section, it is mandatory to give a complete description of the accident, including necessary details and relevant facts. The use of language should be formal.
- In the 3rd section, the person writing the report requires to sign it with the current date.
- It is essential that a photocopy of the written accident report be made before submission.

Notes

Unit 7.10 Safe Lifting and Carrying Practices

Unit Objectives

At the end of this unit, you will be able to:

- Define the importance of safe Lifting and carrying practices
- Practice safe lifting and carrying practices

Figure 7.10: Safe lifting techniques

- Welding operators need to manually lift, carry, push, pull or move items like cylinders, tools, materials, equipment and consumables, etc.
- One of the most common injuries experienced by workers is back injury during manual handling.
- These hazards can be controlled and significantly reduced if proper safety training is given to the operators.
- The risks can also be minimized if f safe working practices and emergency procedures are in place.
- Equipment and tools should be maintained in good condition.
- The welder or operator must maintain concentration and awareness in order to reduce the risk of these accidents.

7.10.1 Potential Injuries and Ill Health Associated With Incorrect Manual Handling

- **Long-term injuries**

  Major damages in this scenario are related to the body's musculoskeletal system. This causes due to wear and tear in areas like:

  - blood vessels
  - nerves
  - ligaments
  - joints
  - bones
  - tendons
  - muscles

The disorder is commonly called musculoskeletal disorders. This can also occur due to abrupt bending, turning and twisting the torso, neck and back.

- **Superficial injuries or Short-term injuries**

  This may occur when lifting or loading heavy objects at awkward angle. This can cause cuts, fractures, bruises, strain in the muscles, etc.

Unit 7.11 Personal Safety and Health and Dignity Issues Relating to the Movement of a Person by Others

Unit Objectives

At the end of this unit, you will be able to:

- Evaluate the need for correct lifting of an accident victim
- Practice the correct procedure of lifting of an accident victim
- Demonstrate how to free a person from electrocution

- While it is correct for an operator to help fellow operator or welder during injuries and situations of medical emergencies, it is also important that the individual should also maintain their own personal safety.
- In an industrial work site, there can be accidents due to various reasons.
- Fires and electric shocks are the common cases that are frequent in most cases.
- However, accidents due to toxic chemicals or chemical burns are also the other reasons that can cause accidents.
- In this case, the blistered area of the victim contains traces of chemicals.
- There is a higher possibility of that toxic material to transfer in the rescuer's skin.
- So, it is important that the rescuers should maintain certain precautionary measures and a detailed check-up after transferring the victim to the hospital or even to the ambulance.

7.11.1 Potential Impact to a Person Who is Moved Incorrectly

When transferring an injured operator to the hospital, it is important that the movement of the injured party should be appropriate. Here is a simple explanation.

- **Broken bone**

  A person with a broken bone or a sprained limb will be in excruciating pain, and it is necessary that to transfer that person to the ambulance, correct method is applied.

  The person with a broken bone should be laid on a flat surface and an ice pack should be applied to the injury. Take a long cylindrical item like a stick and wrap it with the help of a bandage or cloth around the broken area. An incorrect movement in that situation can cause permanent distortion of that area.

- **Severe cut**

  In this case, it is important to wash the area carefully using antiseptics. A tourniquet should be applied on that area to stem the bleeding. An incorrect movement in this case can cause not only excessive blood loss but also may increase the chances of infection, leading to gangrene.

- **Electric shock**

  In this case, if the victim is moved inappropriately, there are chances that breathing of the person may cease, leading to instant death.

7.11.2 Demonstrate how to free a person from electrocution

Figure 7.11.1: Saving a victim from electrocution

- Your first priority is to cut off the power, to prevent the victim receiving further injury
- It is safe to touch the victim once the power source is turned off.
- But be cautious, use an object that doesn't conduct electricity (e.g. a piece of wood or a rope) to move the accident victim away from the source of electrocution.
- Call the emergency services. These professionals have the training and expertise to help the victim.
- As you are awaiting emergency services you should carry out first aid on the victim.
- If the victim's heart has stopped carry out Cardiopulmonary Resuscitation (CPR)

Summary

- Hazard is anything that can cause harm, for example: chemicals, electricity, dangerous equipment at the workplace etc.
- Hot objects can cause severe burns.
- Be aware that even a shock of 50 volts or less is enough to injure or kill an operator.
- Welding fumes are made up of potentially harmful complex metal oxide compounds
- The operator is responsible for checking the equipment (electrode holder, coupling devices and cable) regularly to inspect for damage and then reporting all defects.
- High Frequency welders must come equipped with built-in safety devices to safeguard welders and maintenance personnel.
- Use fixturing whenever possible as it increases safety by eliminating the use of a chain and hoist to flip the component.
- Electrode holders must be stored in places where they do not make contact with personnel or fuel.
- Welding screens are generally used by welders who need to perform welding activities in the vicinity of other workers.0
- Ear muffs or ear plugs can be worn to provide ear protection while welding.
- Proper clothing while conducting welding activities can provide a great amount of protection.
- Welding helmets serves to lessen glare and reflection produced by the intense light.
- A live electrical circuit is used in the arc welding process.
- A welder must keep his/her head away of the fume plume.
- Oils and greases may spontaneously ignite in the presence of pure oxygen.
- To employ the extinguisher with proper technique, just remember the acronym "PASS" which stands for Pull, Aim, Squeeze, and Sweep.
- Danger- Eye Safety Sign: This sign informs fellow workers and visitors that the welding arc is in use which is hazardous.
- Welding Area Sign- Cylinders Only: Mark welding areas like cylinder storage areas in your facility with this sign.
- For deep cuts and excessive bleeding the person should be taken immediately to a hospital.
- For large and deep burns: Relieve pain by immersing the area in cold water or applying cold wet cloths.
- Employers in the welding field are legally obliged to look out for the welfare of their operators when they are at work.
- Drips of molten metal and hot metal parts can easily start a fire.
- It is essential that a photocopy of the written accident report be made before submission.
- Welding operators need to manually lift, carry, push, pull or move items like cylinders, tools, materials, equipment and consumables, etc.
- In an industrial work site, there can be accidents due to various reasons.
- A person with a broken bone or a sprained limb will be in excruciating pain, and it is necessary that to transfer that person to the ambulance, correct method is applied.

Notes

8. Annexure

S No.	Module No.	Unit No. and Name	Topic Name	Page No.	URL	QR Code (s)
1	Module 1	Introduction	Introduction	1	https://www.youtube.com/watch?v=mL-8kHQpufM	
2	Module 1	Introduction	Overview of Welding	3	https://www.youtube.com/watch?v=WCrQKjXiCOk	**Introduction to the Fundamentals of Welding**
3	Module 1	Introduction	Different Types of Welding Processes	4	https://www.youtube.com/watch?v=b0EfJaYUfF8	**Types of Welding Processes | Classification of Welding Processes**
4	Module 3	Welding using Manual Metal Arc welding/ Shielded Metal Arc welding	Welding using Manual Metal Arc welding/ Shielded Metal Arc welding	43	https://www.youtube.com/watch?v=Tf0T-cuUURk	**Shielded Metal Arc Welding**
5	Module 3	Welding using Manual Metal Arc welding/ Shielded Metal Arc welding	Welding using Manual Metal Arc welding/ Shielded Metal Arc welding	43	https://www.youtube.com/ watch?v=Y3LtOhDOMek	**Difference Between Shielded Metal Arc Welding (SMAW) and Gas Metal Arc Welding (GMAW)**
6	Module 3	Welding using Manual Metal Arc welding/ Shielded Metal Arc welding	Types of Welding	45	https://www.youtube.com/watch?v=n_Du-zHRZ4JI	**Welding, Types of Welding and Types of weld joints**

S No.	Module No.	Unit No. and Name	Topic Name	Page No.	URL	QR Code (s)
7	Module 3	Welding using Manual Metal Arc welding/ Shielded Metal Arc welding	Range of Destructive and Non-destructive Weld Testing	47	https://www.youtube.com/ watch?v=kOiadmNORu8&t=414s	**Weld Testing Methods**
8	Module 3	Welding using Manual Metal Arc welding/ Shielded Metal Arc welding	Understanding Polarity	53	https://www.youtube.com/watch?v=OzXx8w5vNgc	**Intro to Welding Polarity**
9	Module 4	Manually (semi-automatic) Welding Joints using the MIG/MAG	Manually (semi-automatic) Welding Joints using the MIG/MAG	75	https://www.youtube.com/watch?v=jXm_UyKuhLQ	**Semi-automatic MIG welding**
10	Module 4	Manually (semi-automatic) Welding Joints using the MIG/MAG	Range of Welding Equipment available for GMAW Welding	77	https://www.youtube.com/watch?v=sR8mLOMey7U	**GMAW (MIG/MAG) EQUIPMENTS AND ACCESSORIES**
11	Module 4	Manually (semi-automatic) Welding Joints using the MIG/MAG	Principles and Techniques of MIG/MAG Welding	83	https://www.youtube.com/watch?v=UQc3-KDByjg	
12	Module 4	Manually (semi-automatic) Welding Joints using the MIG/MAG	Safe Working Practices and procedures to be followed when preparing and using MIG/ MAG welding equipments	86	https://www.youtube.com/watch?v=ubB-fyX2efI	**MIG Welding Safety Tips**

S No.	Module No.	Unit No. and Name	Topic Name	Page No.	URL	QR Code (s)
13	Module 4	Manually (semi-automatic) Welding Joints using the MIG/ MAG	Shielding Gases	92	https://www.youtube.com/watch?v=4Jc8kR3LDbs	SHIELDIND GASES FOR GMAW WELDING
14	Module 5	Perform Manually Welding Joints Using The TIG (GTAW) Process	Different Variants of the TIG Welding	121	https://www.youtube.com/watch?v=uO5pVLOAmD4	What is TIG Welding
15	Module 5	Perform Manually Welding Joints Using The TIG (GTAW) Process	Types of Tungsten	130	https://www.youtube.com/watch?v=t-QKxaJU2hI&t=46s	How to choose the correct Tungsten for TIG Welding

Notes

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