Automotive Body Repair And Paint Work

Level-III

Based on October 2023, Curriculum Version-II

Module Title: - Carrying-out Advanced Welding

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Table of Contents

Acknowledgment

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Introduction to the Module

In automotive body repair and paint field, carrying-out advanced welding module covers the compétence required to carry out advanced welding techniques including tungsten inert gas, metal inert gas welding, metal active gas welding and resistance spot welding on vehicle body repair work. The module also equips trainees the needed knowledge and skill for strong, durable, and permanent repair work.

This module covers the units:

- Fundamentals of vehicle body welding
- Performing Advanced Welding Procedures
- Maintaining Welding tools and Equipment

Learning Objective of the Module

- Understand Fundamentals of vehicle body welding
- Perform Advanced Welding Procedures
- Maintain Welding tools and Equipment

Module Instruction

For effective use, this module trainees are expected to follow the following module instructions:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for examples and exercise

Unit One: Fundamentals of Vehicle Body Welding

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

- Principles of welding for vehicle body parts
- Type of welding methods for vehicle body parts
- OHS Requirements

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

- Understand the principles of welding for vehicle body parts
- Identify type of welding methods for vehicle body parts
- Observe OHS requirements and personal protection needs

1.1 Principles of welding for vehicle body parts

Welding is a materials joining process in which two or more parts are coalesced at their contacting surfaces by a suitable application of heat and/or pressure. Many welding processes are accomplished by heat alone, with no pressure applied; others by a combination of heat and pressure; and still others by pressure alone, with no external heat supplied. In some welding processes, a filler material is added to facilitate coalescence. The assemblage of parts that are joined by welding is called a weldment. A weld can be defined as a coalescence of metals produced by heating to a suitable temperature with or without the application of pressure, and with or without the use of a filler material

Figure 1.1: Welding Vehicle body

Excellent welds are critical in the automotive field, adding to any vehicle's safety, reliability, and appearance. An auto body-welding technician could use different techniques and welding tools to complete individual jobs. There are numerous opportunities for using welding on cars to repair either collision or age-related damage.

The object of car body repair is to put damaged vehicles back into a pre-accident condition. Today’s chassis-less bodies hold engine, suspension and steering in the right places and are designed to absorb the impact of crashes by crumpling, thus shielding the passenger compartment (and its passengers) from shock and deformation. From the viewpoint of safety as well as mechanical efficiency, proper welding is vital in this kind of repair.

The average body shell is joined together by approximately 4500–6000 such spot welds. These remain ductile because the welding process does not alter the original specifications of the steel. Lighter body weight reduces the load on the car engine and therefore has a direct influence on petrol consumption.

Low-carbon steel bodies can be resistance spot-welded or gas (TIG) welded or arc (MIG) welded; but higher-strength steels should not undergo the last two processes, because they involve nearly three times the heat of resistance spot welding. The temperatures generated are over 3300°C for gas or arc welding but only 1350°C for resistance spot welds, for joints of similar strength.

A wide variety of automobile body components are joined using welding techniques. The necessity for development of new welding techniques for automotive applications is ever growing to meet the new material combinations for auto body parts.

The welding method chosen for the replacement of panels will be based in part on the type of weld joint, butt joint/open joint, butt joint with backing/insert, lap flange, plug on lap, RSW on lap and a flanged joint. In addition, the material to be welded must also be considered. The correct repair will require all these options to be considered and more.

The requirement for innovative welding processes is felt strongly in the recent days with automotive manufactures focusing on lighter yet strong and fuel efficient vehicles employing lightweight alternative materials. The most commonly used welding techniques in automotive applications are explained in the following sections.

There are many ways to use welding on cars to repair collision damage or damage due to age. Some welding applications for vehicles:

- Vehicle Frame or Fender Welding: Vehicle frames and fenders become bent or damages in collisions. A technician may need to cut out the warped piece of metal and replace it with a new piece. He or she can use automotive welding to adhere the new piece of metal and repair the car’s frame or fender safely.

- Welding Exhaust on a Car: Exhaust systems can rust and develop holes due to age, moisture and constant use. Some auto body technicians can cut the exhaust pipe, clamp the pieces, apply spot welding and complete the weld.
- Wheel Welding: This type of welding on cars is helpful to repair wheels damaged by potholes, which often crack metal wheel frames. Some auto body welders can repair the wheel frame using a TIG welder.

1.2 Types of welding for vehicle body work

Amongst the major areas of applications, welding is extensively used in automotive sector. The most commonly used welding methods for automotive applications include metal inert gas (MIG) welding, Metal Active Gas (MAG) welding, Tungsten inert gas (TIG) welding and resistance spot welding (RSW). The advanced welding processes for automotive applications have been developed envisaging reduction in vehicle weight and increase in fuel efficiency. In conventional welding methods, an additional material is always added to the weld joint that flows into the materials to be joined to produce an extremely strong bond. The added metal at each weld increases the vehicle weight, which in turn decreases fuel economy.

1.2.1 Metal inert/active gas (MIG/MAG) Welding

The process is a common, versatile welding process. It provides high deposition rates and is suited to a wide range of material thicknesses, thin too thick. Compared with Manual Arc welding the process provides a weld with minimal weld finishing as there is minimal spatter and no electrode slag.

Gas Metal Arc Welding (GMAW) is commonly referred to as MIG welding (Metal Inert Gas welding). It is also referred to as MAG welding (Manual Metal Arc Welding). The shielding gas used in MIG/MAG processes displaces the air in the arc area. The arc is struck within this blanket of shielding gas, producing a weld pool free from atmospheric contamination.

One of the important functions of the shielding gas is to protect the weld zone from the surrounding atmosphere and from the deleterious effects of oxygen, nitrogen and hydrogen upon the chemical composition and properties of the resulting weld.

MIG Welding: MIG welding is welding in an atmosphere of inert gas, which means welding with a shielding gas that does not react with other substances. Inert gases are for instance argon and helium of which argon is more used within the European region. Usually, the process is called MIG welding even when the inert gas is mixed with small quantities of O_2, CO_2, H_2 or similar substances.
MAG Welding: MAG welding is welding in an atmosphere of reacting gases, or as it is also called shielded by an active gas. This means that the gas is separated in the arc and to a smaller or larger extent reacts with the weld pool. CO_2 is mainly used as shielding gas, which is why the process is also known as CO_2 welding.

MIG/MAG Principles of operation

The basic principle of MIG Welding is, an arc is maintained between the end of the bare wire electrode and the work piece where the heat source required melting the parent metal is obtained. The arc melts the end of the electrode wire, which is transferred to the molten weld pool. For a given wire material and diameter, the arc current is determined by the wire feed rate. The arc and the weld pool is shielded from the atmospheric contamination by an externally supplied shield gas. Metal Inert Gas (MIG) welding is a 'flat' arc process (constant) voltage. The required voltage is selected by adjusting the voltage control knobs provided at the power source. The process itself can be manual, partly mechanized, fully mechanized or automatic.
Metal inert gas or active-gas shielded arc welding (consumable) is accomplished by means of a gas-shielded arc maintained between the work piece and a consumable (bare wire) electrode from which metal is transferred to the work piece. The transfer of metal through the protected arc column provides greater efficiency of heat input than that obtained in the TIG welding process. The resultant high intensity heat source permits very rapid welding. In this process, a continuously fed electrode passes through a gun, during which it passes through a contact area which impresses the preselected welding current upon the wire. The current causes the wire to melt at the set rate at which it is fed.

The shielding gas issuing from the nozzle protects the weld metal deposit and the electrode from contamination by atmospheric conditions, which might affect the welding process.

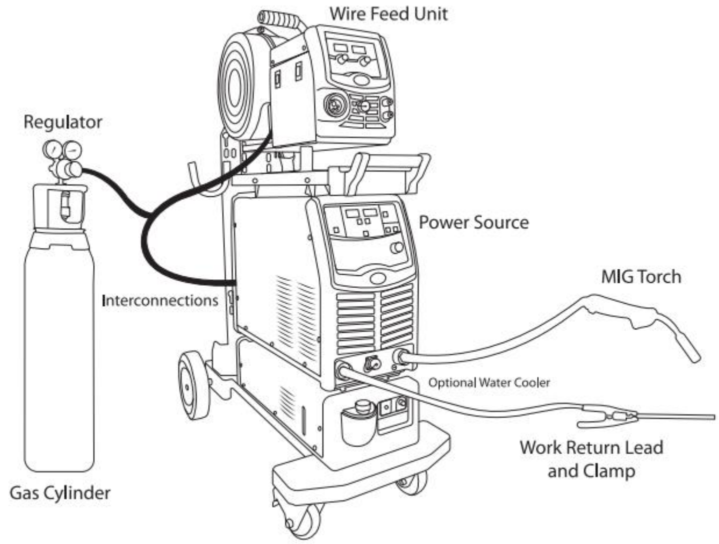


Figure 1-2: MIG/MAG welding machine parts

Advantages of MIG/MAG Welding

- The method is financially attractive due to a high welding speed
- Provides the opportunity for rational welding of materials, which are difficult to weld.
- Welding is possible in all positions.
- The arc and the weld pool is clearly visible.
- Usually only little after treatment of the weld is necessary.

Disadvantages of MIG/MAG Welding

- The method is very vulnerable to draughts from ventilation systems, open doors, windows, and the fans of air-cooled welding machines.
- There is a risk of serious welding errors such as lack of fusion, etc.
- The necessary, but costly, shielding of the welding place at outdoor jobs.
- Greater investments in welding equipment
- Greater expenses to maintenance to the welding equipment.

Application of resistance MIG/MAG welding for vehicle bodywork

The semi-automatic MIG/MAG welding process, which is used in the construction of vehicle bodies, is also used for the repair of these bodies. Equipment is now specially produced for thin-gauge welding in the repair of vehicle bodywork. Welding in the repair of car bodies was mainly carried out using oxy-acetylene and resistance spot welding techniques. Both of these techniques have certain disadvantages. In the oxy-acetylene method, the weld metal and surrounding panels are liable to distort owing to heat input. In spot welding if the repair is visible the joints, which in most cases are lapped, must be solder filled to achieve an acceptable finish.

The advantages of MIG/MAG welding equipment in repair are first that it is a dual machine being capable of welding in any position, and it can weld material from 0.5 mm to 4.4 mm in thickness. Second, it can be used for spot welding from one side of the panel only, which is an advantage when welding inaccessible panel assemblies.

Most equipment used in motor body repair usually has the following controls and functions: a weld timer, which can be set from 0.2 to (usually) 2.5 seconds; some form of wire speed control, which ranges from 2 to 12 m/min; and a voltage control usually ranging from 0 to 10, the 0 setting giving the lowest welding current.

1.2.2 Tungsten Inert Gas (TIG) welding

Arc welding in inert gas with infusible tungsten electrodes(or simply TIG-Tungsten Inert Gas welding) is a process in which heat is produced by an electric arc passing between anon-consumable electrode and the parts to be welded. The weld is achieved by fusing the edges of the parts to be welded, adding material if necessary in the form of rods.

Tungsten Inert Gas (TIG) welding is an electric arc welding process in which the fusion energy is produced by an electric arc burning between the work piece and the tungsten electrode. During the welding process the electrode, the arc and the weld pool are protected against the damaging effects of the atmospheric air by an inert shielding gas.

By means of a gas nozzle the shielding gas is lead to the welding zone where it replaces the atmospheric air. TIG welding differs from the other arc welding processes by the fact that the electrode is not consumed like the electrodes in other processes. The tungsten inert gas process can be used for welding aluminum, magnesium, stainless steel silicon bronze titanium, copper and copper alloy, and wide range of different metal thickness in mild steel. Top quality welds made in the above metal need little, if any, cleaning after welding period. TIG Welding is most often used for joining aluminum from 1/32 inch to 1/8 inch (0.79 to 3.2 mm) thick. Although heavier sections can be joined by TIG welding, other processes are usually more economical.

TIG welding is an easy method of joining metals that are considered hard−to−weld, and filler and base metals can be easily matched. With TIG welding, strip of scrap parent metal may be used for filler metal. Post−weld machining, grinding, or chipping can usually be eliminated due to the easily controlled weld reinforcement. The need for flux is eliminated, even on hard to weld metal such as aluminum.

TIG welding Principles of operation

The necessary heat for this process is produced by an electric arc maintained between a non-consumable electrode and the surface of the metal to be welded. The electrode used for carrying the current is usually a tungsten or tungsten alloy rod. The heated weld zone, the molten metal and the electrode are shielded from the atmosphere by a blanket of inert gas (argon or helium), fed through the electrode holder which is in the tip of the welding torch. A weld is made by applying the arc heat so that the edges of the metal are melted and joined together as the weld metal solidifies. In some cases a filler rod may be used to reinforce the weld metal.

TIG welding Modes of operation

The TIG process may be operated in one of the following ways:

- *In DC electrode negative* mode the electrode remains relatively cool whilst the workpiece is effectively heated. This is most common mode of operation for ferrous materials, copper, nickel and titanium alloys.

- *With DC electrode positive* there is a tendency for the electrode to overheat and fusion of the work piece is poor. The advantage of this mode of operation is the cathode cleaning effect which removes the tenacious oxide film from the surface of aluminum alloys
- AC alternating current offers a good compromise between plate heating and the cathode cleaning effect and is used with aluminum and with manganese alloys.

A. **AC TIG-welding:** Usually uses argon as a shielding gas. The process is amulti purposeprocess, which offers the user great flexibility. By changing the diameter of the tungstenelectrode, welding may be performed with a wide range of heat input at different thicknesses.AC TIG-welding is possible with thicknesses down to about 0.5 mm. For larger thicknesses,> 5 mm, AC TIG-welding is less economical compared to MIG-welding due to lowerwelding speed.
B. DC TIG-welding: With electrode negative is used for welding thicknesses above 4 mm. Thenegative electrode gives a poor oxide cleaning compared to AC-TIG and MIG, and specialcleaning of joint surfaces is necessary. The process usually uses helium shielding gas. Thisgives a better penetration in thicker sections. DC TIG-welding is applicable for weldingthicknesses in the range 0.3to12 mm. More and more popular is also pulsed DC TIG-welding, which makes it possible to weld uniform welds with deeper penetration at the sameheat input. Pulse frequency is usually in the range 1 to10 Hz.

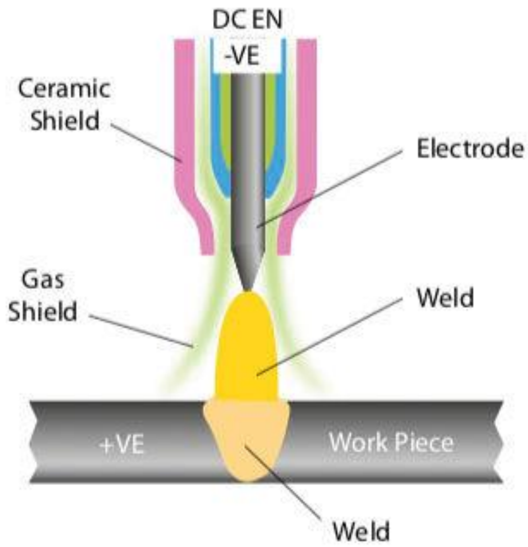


Figure 1-3: DC TIG-welding

Advantages of TIG welding

- It provides a concentrated heating of the work piece.
- It provides an effective protection of the weld pool by an inert shielding gas.
- It can be independent of filler material.
- The filler materials do not need to be finely prepared if only the alloying is all right.
- There is no need for after treatment of the weld as no slag or spatters are produced.
- Places of difficult access can be welded

Dis advantages of TIG welding

- Equipment is relatively expensive and a high degree of skill is required
- Not suitable for use on dirty material and does not like a windy environment.
- Not suitable for thicker sections or high productivity work
- Has more intense arc radiation and fume safety hazards

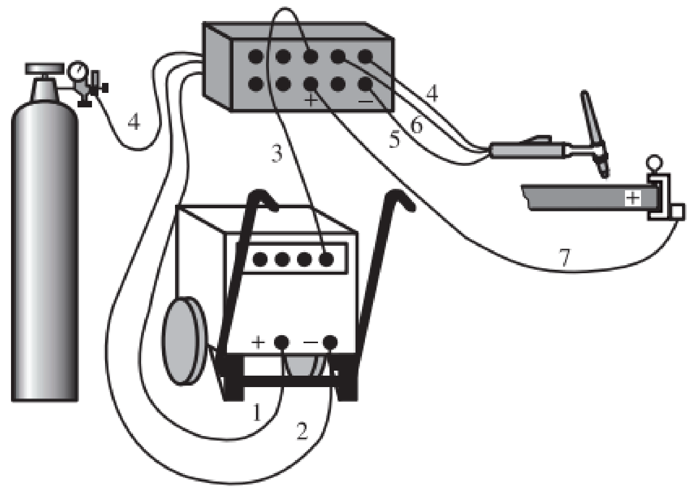
In order to handle the TIG welding process and make it work to its full capability you need equipment consisting of different parts with their own separate function. The TIG welding equipment chiefly consists of:

• A TIG torch that is the tool the welder uses to control the arc.

• A power source, which is capable of providing the necessary welding current.

• A TIG unit with incorporated control systems that make it possible to adjust the welding current, arc initiation etc.

• A shielding gas cylinder with pressure reducing valve and flowmeter.



1	Cable for welding current
2	Cable for welding current
3	Control cable for TIG unit
4	Shielding gas
5	Cable for welding cable for TIG torch
6	Control cable for TIG torch
7	Welding cable with +polarity

Figure 1-4: Tungsten inert gas welding components.

Application of TIG welding for vehicle bodyworks

Today, MIG welding is the mainstay of most auto body welding. It is relatively easy to learn this technique. It is being used here to fill weak spots in a sheet metal floor.

Figure 1-5: Application of TIG welding for vehicle bodyworks

1.2.3 Resistance Spot welding

There are many resistance-welding processes, but the most common is Resistance Spot Welding. All resistance-welding processes use three primary process variables; current, time, and pressure (or force). The automotive industry makes extensive use of resistance welding,

Resistance welding (RW). Resistance welding achieves coalescence using heat from electrical resistance to the flow of a current passing between the faying surfaces of two parts held together under pressure. included spot welding and seam welding, two joining methods widely used today in sheet metal working.

Resistance spot welding is the joining of overlapping pieces of metal by applying pressure and electrical current. These joints created by resistance spot welding form a “button” or “fused nugget.” Resistance spot welding is the principle joining method used in automotive industries and has been for many years. They are found typically on flanges, staggered in a single row of consecutive welds. The conventional steel body of a car, on an average, contains 4500 spot weld joints.

In this method, the joint is produced by the heat generated due to the resistance of work pieces to the flow of current and application of pressure. Spot welds are formed when a large amount of current is passed through the panels for the correct amount of time and with the correct amount of pressure. In a typical spot welding application there are two electrodes, opposite each other, which squeeze the metal pieces together. This squeezing pressure is controlled.

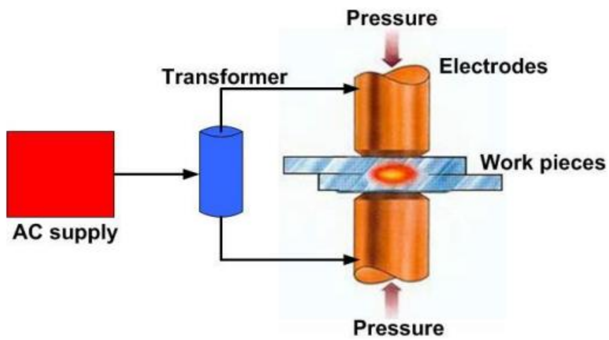


Figure 1-6: Resistance Spot welding

Principle of Resistance Spot welding

The operation of spot welding involves a coordinated application of current of the proper magnitude for the correct length of time. This current must pass through a closed circuit. Its continuity is assured by forces applied to the electrodes, which are shaped to provide the necessary density of current and pressure. The entire sequence of operations is required to develop sufficient heat to raise a confined volume of metal, under pressure, to temperature must be such that fusion or incipient fusion is obtained, but not so high that molten metal will be forced from the weld zone. The rates of the rise and fall of temperature must be sufficiently rapid to obtain commercial welding speeds, but neither rate may be permitted to be so rapid that either inconsistent or brittle welds will be produced. The rates of rise and fall of temperature and the time of maintenance at temperature are determined by the characteristics of the metals being welded and by the capacity of available equipment.

Resistance Spot Welding is the most common of the resistance welding processes. Its combination of extremely fast welding speeds and “self-clamping” electrodes make it an ideal process for automation (Figure 3.8) and high production environments. The pieces to be welded are heated by passing welding current through them. Several thousand amperes of welding current are applied for a specified period. As the temperature is elevated, the metal is heated to a plastic state. The force of the welding tip will deform the metal and form a small dent as the metal gets hot.

As the heat builds in the metal, a small liquid pool of metal is formed at the interface. This pool is typically the same size as the face of the welding tip. When welding temperature is reached, the timer should expire. The weld zone cools very quickly because the copper welding tips pull heat out of the weld zone. Heat also escapes as it flows into the surrounding metal.

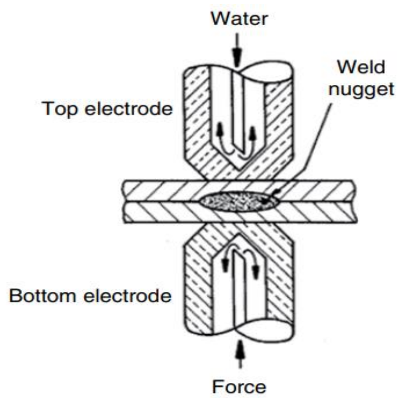


Figure 1-7: Resistance spot welding

Resistance spot welding is faster, more cost-efficient and more straightforward to learn than traditional welding methods, but you cannot use it in every situation. Spot welding may be done on material as low as 0,0001” in thickness. The bulk of resistance welding is confined to metals that are less than ¼ “ in thickness.

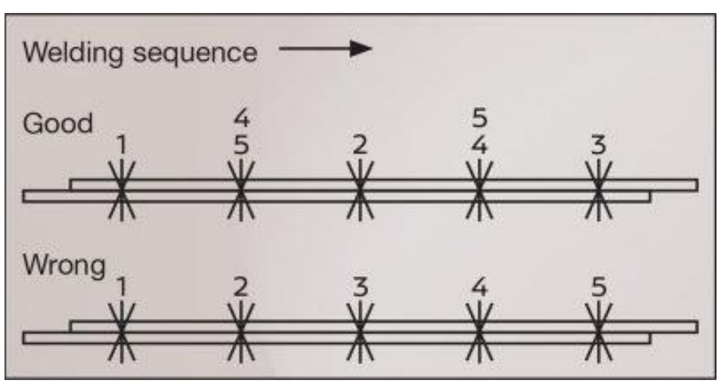


Figure 1-8: Several spot welds on the same work piece

1.3 OHS Requirements

As in any welding process, Gas Tungsten Arc Welding (GTAW) safety precautions are very important. All information relating to the safe operation of the welding equipment and the welding process must be fully understood before attempting to begin work. A careless welder who does not observe some simple rules can cause a dangerous situation for everyone in the area. The process of arc welding creates several hazards, which must be guarded against. Useful safety information can be found in the Owner's Manual that comes with each item of welding equipment.

1.3.1 Personal Safety Equipment

Personal protective equipment (PPE) is perhaps the most important factor for enhancing the productivity and safety of welders in the workplace, since, without it, they could be exposed to extreme heat conditions that can cause serious discomfort or injury. Safely protected by welding PPE, welders are free to concentrate on the task at hand without worrying about their eyesight, their skin, their hair, or their clothing. Here are just some of the essential pieces of PPE welders value most:

- *Welding Goggles:* Welding goggles protect your eyes from ultraviolet and infrared light waves, plus provide added physical protection against sparks or flying debris. Additionally, welding goggles help to reduce the impact of radiating heat on your sensitive eyes, also covering the eyebrows to prevent them from becoming singed. While welding goggles provide a certain amount of protection for small projects (specifically gas welding projects), larger more intensive projects (like arc welding projects) may require more extensive face, eye, and head protection.
- *Welding Face Shields:* If you feel most comfortable welding in goggles, but need extra protection from heat, debris, and flying sparks, a welding face shield can be worn over your goggles to protect the entirety of your face and neck. Wearing a welding shield can allow you to get closer to projects for better visibility, and protect the parts of your face not protected by welding goggles

- *Welding Gloves:* The working gloves protect the hands and wrists against heat and light. The gloves are usually made of leather and the top should be at least 120 mm long. The gloves should be kept dry due to the electrical safety (electrical leak resistance is greatest at dry gloves)
- *Ear Protection:* Welding can be loud, and while short bursts may not impact hearing, extended exposure can cause significant hearing loss and even cell damage at certain frequencies. Additionally, many facilities where welders work pose other noise hazards, so wearing hearing protection is necessary for safe operation.
- *Welding Aprons:* Welding aprons cover the front of the torso and the legs, providing protection from oncoming sparks. Though less protective than a jacket, welding aprons used in conjunction with gloves can provide ample protection for smaller projects.

Figure 1-9: Welding Personal Safety Equipment

Electrical Shock: Welders must be concerned about the possibility of electrical shock. If there is a proper secondary circuit, the current will follow that path. However, if there are poor connections, bare spots on cables, or wet conditions, the possibility of electrical shock does exist. A welder should never weld while standing in water. If wet working conditions exist, certain measures should be taken. Such measures include standing on a dry board or a dry rubber mat when welding. Likewise, the welding equipment should not be placed in water. In addition, gloves and shoes must be kept dry. Even a person's perspiration can lower the body's resistance to electrical shock. Hence:

- Do not touch live electrical parts
- Wear dry, hole−free insulating gloves and body protection
- Insulate yourself from work and ground using dry insulating mats or covers
- Disconnect input power or stop engine before installing or servicing this equipment
- Properly install and ground the equipment including the welding table
- When making input connections, attach proper grounding conductor first
- Turn off all equipment when not in use
- Do not use worn, damaged, undersized, or poorly spliced cables
- Do not touch electrode if in contact with the work or ground
- Use only well maintained equipment. Repair or replace damaged parts at once
- Keep all panels and covers securely in place

Arc Rays: Several possible hazards exist due to the electric arc, infrared and ultraviolet rays. The light and rays can produce a burn similar to sunburn, The arc rays, however, are more stronger than sunburn since the welder is so close to the source. These rays can quickly burn any exposed skin. Hence:

- Keep your head out of the fumes. Do not breathe the fumes.
- If inside, ventilate the area and/or use exhaust at the arc to remove welding fumes and gases

Fumes and Gases: Fumes and gases can be hazardous to health. Hence:

- Wear a welding helmet fitted with a proper shade of filter to protect your face and eyes

Welding or watching: Use protective screens or barriers to protect others from flash and glare; warn others not to watch the arc.

- Wear approved safety glasses. Side shields recommended.

Fires or Explosion: Welding can cause fire or explosion. Hence: Welding, chipping, wire brushing, and grinding can cause spark and flying metal. As weld cool down they can throw slag. Wear approved safety face shield with side protection

Gas Cylinders: Regardless of the content, pressurized cylinders must at all times be handled with great care. Shielding gases such as carbon dioxide, argon and helium are nonflammable and nonexplosive. But for instant a broken off valve, however, will release extremely high pressures, which could cause the cylinder to be hurled about at dangerously high speeds. Another way of thinking about this pressure is to compare a cylinder to a balloon.

Chains are usually used to secure a cylinder to a wall or cylinder cart. When moving or storing a cylinder, a threaded protector cap must be fastened to the top of the cylinder. This protects the valve system should it be bumped or the cylinder dropped. It is accepted procedure to roll a cylinder in the upright position when moving the cylinder. It is also very important to keep excess heat of any kind away from cylinders. When a cylinder is exposed to too much heat, the pressure inside the cylinder will increase. Hence:

- Keep cylinders away from any welding or other electrical circuits
- Don’t allow a welding electrode to touch any other cylinder
- Install and secure cylinders in an upright position by haining those to a stationary support or equipment cylinder rack to prevent falling or tipping

Self-Check 1.1

Part-I: Choose the correct answer

1. The object of car body repair is to put damaged vehicles back into a pre-accident condition.

   A. True B. False

2. The average body shell is joined together by approximately 4500–6000 such spot welds.

   A. 4500–6000 B. 5000-6000 C. 3500-5000 D. 4000-6000

3. One of the following is not the welding applications for vehicles.

   A. Vehicle fender welding
   B. Welding Exhaust on a car
   C. Wheel welding
   D. Welding power transmission lines

Part-II: Matching

A	B
1. welding in an atmosphere of reacting gases	a. MIG welding
2. welding in an atmosphere of inert gas	b. MAG Welding
3. Independent of filler material	c. TIG welding
4. Overlapping metal by applying pressure and electrical current.	d. Spot welding

Part-II: Explain the following questions accordingly

1. ____________ is a materials joining process in which two or more parts are coalesced at their contacting surfaces by a suitable application of heat and/or pressure.
2. Write down the applications of welding for welding vehicle body
3. GTAW stands for_______________________________
4. List down some of the essential pieces of PPE welders value most

Unit Two: Performing Advanced Welding Procedures

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

- Performing MIG/MAG welding
- Performing TIG welding
- Performing Resistance spot welding

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

- Perform MIG/MAG welding
- Perform TIG welding
- Perform Resistance spot welding

2.1 Performing MIG/MAG welding

A welding procedure specification (WPS) is a written document providing direction to the welder (or welding operator). It contains all the necessary parameters viz. joints, base metals, filler metals, positions, preheat , gas etc. (including ranges, if any) under which the welding process must be performed. A welding procedure identifies all the welding variables pertinent to a particular job or project.

In MIG/MAG welding, an arc is created with the power source through the welding gun between the welding wire being fed and the work piece. The arc fuses the material being welded and the welding wire, thus creating the weld. The wire feeder continuously feeds welding wire through the welding gun throughout the welding process. The welding gun also provides shielding gas to the weld.

The MIG and MAG welding methods differ from each other in that MIG (metal inert gas) welding uses an inert shielding gas, which does not participate in the welding process, while MAG (metal active gas) welding employs an active shielding gas that participates in the welding process.

Usually, the shielding gas contains active carbon dioxide or oxygen, and therefore MAG welding is by far more common than MIG welding. In fact, the term MIG welding is often accidentally used in connection with MAG welding.

In MIG/MAG welding, the welder’s tool is a welding gun. It is used to introduce the filler material wire, shielding gas, and the required welding current to the work piece. The most important issues related to MIG/MAG welding are the welding position, welding gun angle, wire stick-out length, welding speed, and the shape of the molten weld pool.

2.2 Performing TIG welding

Tungsten Inert Gas (TIG) welding, also known as Gas Tungsten Arc Welding (GTAW) is an arc welding process that produces the weld with a non-consumable tungsten electrode. Tungsten inert gas (TIG) welding became an overnight success in the 1940s for joining magnesium and aluminum.

Best practices to perform an efficient and successful TIG welding procedure!

1. Ensure the cleaning of the material and place to be welded: Before starting any welding procedure, make sure that everything is free of impurities. Contamination damages the result. Therefore, make sure that the tops to be welded have no oils or fats. Also, check that the protective gloves and the material to be used are also clean.

2. Use the appropriate tungsten electrode: Each material and procedure has its characteristics. Therefore, you should always analyze the type and diameter of the most suitable tungsten electrode. When making this selection, consider the current intensity and the constitution of the protection gas that will be used.

3. Correct the electrode: Always prepare the tip of the electrode before starting work. Correct it in the direction of the shaft, leaving it pointed, if it is to be used direct current, or more rounded, if you apply alternating current.

4. Check the sensitivity of materials to the gas: If welding sensitive materials, use appropriate protective gases. By doing so, you will be preventing their embrittlement by oxidation.

5. Use the appropriate amount of shielding gas: The shielding gas used in the welding process should have its flow adjusted to the torch size. It is this gas that prevents oxidation. Therefore, even after the completion of the welding, it should continue to flow for some time to protect the fusion bath and the electrode.

6. Position the rod correctly: For a perfect result, use the rods correctly. Avoid oxidation by ensuring that the tip of the rod stays under the protective gas jet throughout the procedure. It must always be at an angle to the material to be welded.

7. Ensure procedural safety: For all welding processes, there are safety standards that must be followed. Check the rules of the materials and machines you will use and follow the instructions exactly. If you find any defects in the equipment, do not proceed.

The first step in the TIG welding process is to adjust the machine to the right settings, such as the current and voltage, through the rotating knobs on the machine. Next, the correct pressure for the inert gas in the supply tank must be set through a flowmeter regulator.

The TIG torch should also be modified according to the project requirements by choosing an electrode with the correct diameter, TIG collet, and other parts. Above everything else, prioritize having clean protective gear to have clear vision while doing welds.

TIG welding is an important technique in the restoration of old cars because it allows for precise welding of thin, intricate metal components without causing damage to the surrounding areas. Restoring old cars involves repairing or replacing various metal parts such as body panels, frame components, and engine parts.

In addition, TIG welding can also be used to repair cracks, holes, and other damages in metal components. The precise nature welding speed of the welding technique allows small, intricate repairs to be made, which can save otherwise damaged components from being discarded and replaced.

2.3 Performing Resistance spot welding

Spot welding is a resistance welding process that is used primarily for welding two or more metal sheets together by applying pressure and heat to the weld areas. It works by contacting copper alloy electrodes to the sheet surfaces, whereby pressure.

Spot welding is a resistance welding procedure and is a method that does not require shielding gas. The work pieces to be joined are placed on top of each other precisely in the first step. Two electrodes press the two work pieces together mechanically and fix the parts to be welded. Three welding conditions of resistance welding: Welding current, weld time, and welding force are called three welding conditions. These conditions are closely related to each other. So, it is important to combine the conditions properly. In addition, there is a tip diameter of the electrode. Spot welding uses the heat from an electrical current to join 2 pieces of metal quickly, and is typically used for joining sheet metal. It's also easy to do with a spot welding machine, which has 2 electrode tongs about 6 inches (15 cm) long that pass an electrical current through the metal to fuse them together.

Operation sheet 2.1

Operation Title: Performing TIG welding

Purpose: To carryout TIG welding process on different thickness materials.

Conditions or situations for the operations:

- Safe working area
- Properly operated tools and equipment
- Appropriate working cloths fit with the body

Precautions:

- Wearing proper clothes, eye glass, glove
- Make working area hazard free
- Read and interpret manual, which guide you how to use tools and equipment.

Equipment Tools and Materials:

- TIG torch
- Tungsten electrode
- Grinding wheel
- Shielding gases
- Trainee's tool kit
- Body panel
- Wire brush

Steps in doing the task

1. Turn ON the power supply
2. Activate the switch at the machine
3. Set the Argon gas pressure to 30L/min by turning the gas regulator and nozzle.
4. Choose types of Current. Power supply for steel, mild steel and copper is Direct Current (DC) or Power supply for alloy is Alternate Current (AC).
5. Set the current to 70A (for mild steel).
6. Clamp the earth cable to work piece.
7. Touch the electrode (Tungsten) at 450tothework piece.

8. Press and release the Argon gas trigger until spark appears.
9. Weld the work piece with feeder by moving outwards.
10. Make sure both gas regulator and nozzle is fully close dafter working.
11. Ensure that the gas pressure is set to ZERO.
12. Press the gas trigger to release all the gas in the pipe.
13. Switch OFF the TIG machine and the main socket switch.

Quality Criteria: Assured performing of all the activities according to the procedures

Operation sheet 2.2

Operation Title: Carry out resistance spot welding

Purpose: To carryout resistance spot welding process on different thickness materials.

Conditions or situations for the operations:

- Safe working area
- Properly operated tools and equipment
- Appropriate working cloths fit with the body

Precautions:

- Wearing proper clothes, eye glass, glove
- Make working area hazard free
- Read and interpret manual, which guide you how to use tools and equipment.

Equipment, Tools and Materials:

- Resistance spot welding machine
- Vehicle body panel
- Welding wire
- Cotton waste
- Soap oil
- Wire brush

Steps in doing the task

1. Check metal sheet thickness.
2. Prepare the resistance spot welding machine.
3. Check the current flows from the tips through the base metal causing the metal to melt and fuse together.
4. Measure the current flow through electrodes and through the two pieces of metal and set the correct current flow.
5. Clean the metal sheet to be spot-welded.
6. Refer the operator’s manual for setting a resistance spot welding.
7. Select the arm according to the area to be welded

8. Keep the gun arm as short as possible to obtain the maximum pressures for welding
9. Securely tighten the gun arm and tip.
10. Align the upper and lower electrode tips on the same axis.
11. Decrease the diameter of spot weld when the diameter of the electrode tip increases.
12. Electrical current flow has a relationship to formation a spot-weld, when the electrical current flow time increases the generated increases the spot weld diameter and penetrates.
13. Adjust the arm length or welding time according to the thickness of the panels to get best welding result (Fig 1). Follow the spot welding positions as table below.

Table 1 - Spot welding positions

Panel thickness	Pitch S	Edge distance P
1/64 in.	7/16 in or more	13/64 in or more
1/32 in.	9/16 in or more	13/64 in or more
Less than 3/64 in.	11/16 in or more	1/4 in or more
3/64 in.	7/8 in or more	9/32 in or more
1/16 in.	1-9/16 in or more	5/16 in or more

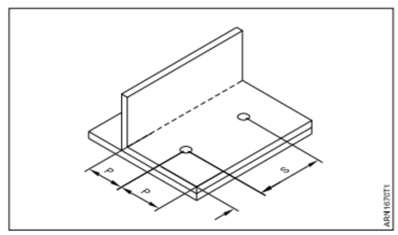
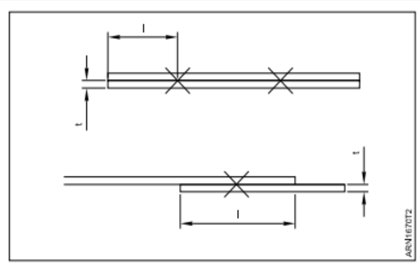


Table 2 - Positions welding spot from end of panel

Thickness (t)	Minimum Pitch (l)
1/64 in.	7/16 in. or over
1/32 in.	7/16 in. or over
Less than 3/64 in.	15/32 in. or over
3/64 in.	9/16 in. or over
1/16 in.	5/8 in. or over
1/64 in.	11/16 in. or over



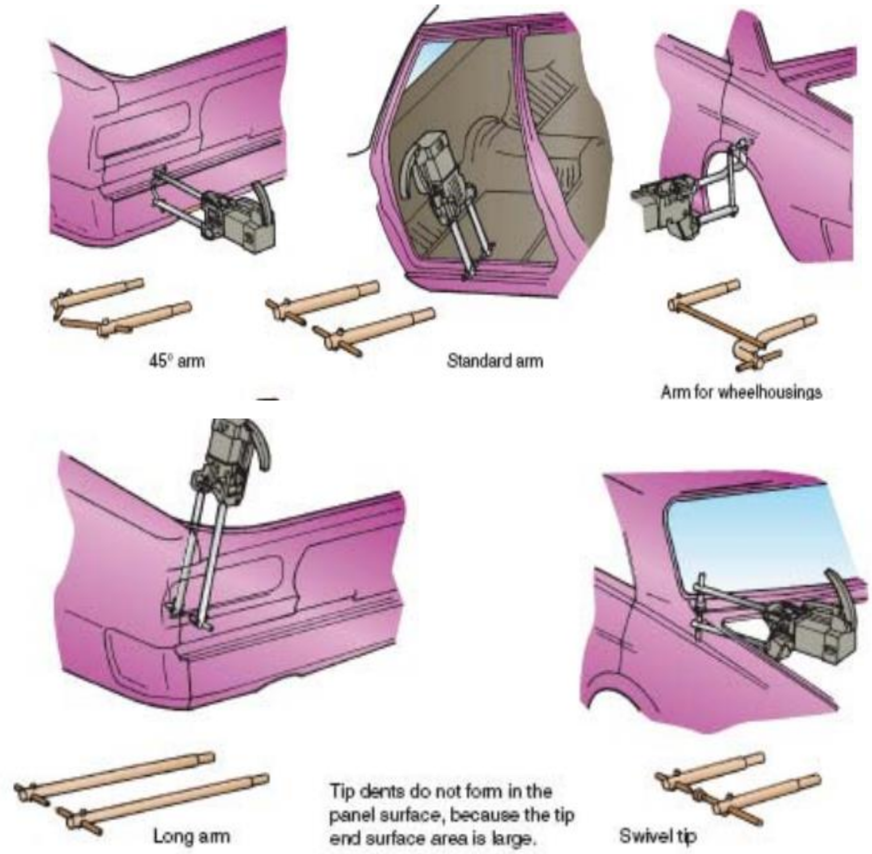


Figure 1

Quality Criteria: Assured performing of all the activities according to the procedures

Operation sheet 2.3

Operation Title: Perform MIG/MAG welding

Purpose: To use clamping and welding panel and performing MIG/MAG welding

Conditions or situations for the operations:

- Safe working area
- Properly operated tools and equipment
- Appropriate working cloths fit with the body

Equipment Tools and Materials:

- Clamping tools
- Resistance spot welding machine
- Power source
- Vehicle body panel
- Wire feeder
- Grounding cable
- Welding gun
- Shielding gas tank

Precautions:

- Wearing proper clothes, eye glass, glove
- Make working area hazard free
- Read and interpret manual which guide you how to use tools and equipment

Task 1: Surface preparation and setting of welding parameters

Steps in doing the task

1. Clean the weld area to be welded are completely both front and back use wax, access point remover and a clean rag, clean the metal until shining with steel wire brush.
2. Identify which metal sheet used at damaged panel.
3. Measure the thickness of sheet.
4. Select the type of weld required to panel repair work.

5. Match the suitable weld wire to the damaged panel.
6. Set the wire speed as suitable for the panel metal.
7. Set the voltage for the arc
8. Set the shielding gas flow rate.
9. Set work cable and clamp assembly work piece.
10. Position the two pieces together and lay a bead along the entire joint. The distance between contact tip and weld should be 8-14 mm.
11. Set the power supply to control welding current.
12. Adjust the line pressure regulator.
13. Adjust and control the gas pressure adjustment valve
14. Refer the table 1 for welding parameters and techniques.

	Desired changes							
Welding variables to change	Penetration		Deposition rate		Bead size		Bead with	
	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
Current & wire feed speed	Increase	Decrease	Increase	Decrease	Increase	Decrease	No effect	No effect
Voltage	Little effect	Little effect	No effect	No effect	No effect	No effect	Increase	Decrease
Travel Speed	Little effect	Little effect	No effect	No effect	Increase	Decrease	Increase	Decrease
Stickout	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
Wire diameter	Increase	Decrease	Increase	Decrease	No effect	No effect	No effect	No effect
Shield gas percent CO_2	Increase	Decrease	No effect	No effect	No effect	No effect	Increase	Decrease
Torch angle	Backhand to 25°	Forehand	No effect	No effect	No effect	No effect	Backhand	Forehand

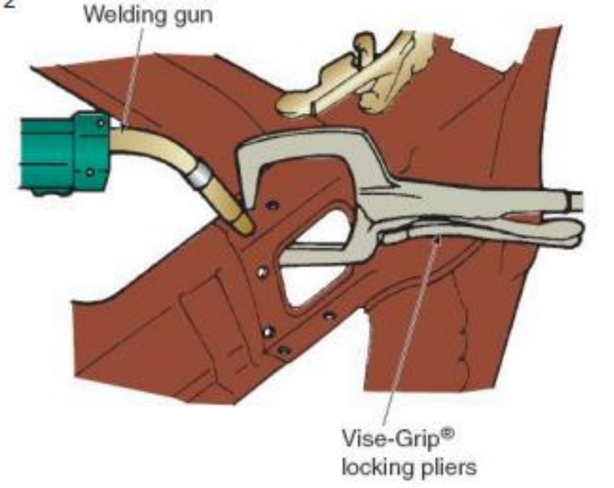
Task 2: Use of clamping tools for welding (Fig-2)

Steps in doing the task

1. Identify the clamping tool required to hold the panel like locking jaw, pliers, c-clamps, and sheet metal screws tack weld or special clamps.
2. Clamping tools are used to clamp panels together
3. Take care and close attention during clamp panels together for welding practice.
4. Where both side of panel not possible to use clamp, use the sheet metal screws or pop rivets.
5. Always use the proper clamping tool during welding operation.

6. To clamp panels together with sheet metal screws punch or drill holes through the panel.

Fig 2



Task 3: Plug weld hole for body panel replacement

Steps in doing the task

1. Every holes on the panel is filled with a sheet metal screw.
2. The empty holes are plug welded by using proper plug welding techniques.
3. After plug weld the holes remove the metal screws
4. After removing the metal screws welded the holes plug welding.
5. Fixture can also be used in case additional clamping required to hold the panels to be welded proper alignments.

Quality Criteria: Assured performing of all the activities according to the procedures

Unit Three: Maintaining Welding tools and Equipment
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Inspecting welding tools and equipment • Maintaining welding tools and equipment. This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Clean welding tools and equipment • Maintain welding tools and equipment.

3.1 Inspecting welding tools and equipment

In addition to safety checks, it is important to keep equipment as clean as possible. It is common for the welder's gun nozzle to become filled with spatter, which can result in poor weld quality. Keep this area clean by using a nozzle dip to clear any spatter. Welding helmet will also require regular cleanings in order to preserve its lifespan.

The purpose of inspection is to identify whether the work equipment can be operating, adjusted and maintained safely with any deterioration before it results in a health and safety risk. Not all work equipment needs formal inspection to ensure safety and, in many cases, a quick visual check before use will be sufficient.

However, inspection is necessary for any equipment where significant risks to health and safety may arise from incorrect installation, reinstallation, deterioration or any other circumstances. The need for inspection and inspection frequencies should be determined through risk assessment. For the best result, the gas and contact nozzle of the welding torch must be clean from the welding spatter at regular interval.

When cleaning, the gun of spatter and deposits the condition of the gas distributer should also be checked, and if it appears to be burnt and worn by spatter then it should be replaced. It is also recommended the machine should be cleaned with a compressed air once a year or more frequently if it is used in dusty conditions. The feed mechanism and rollers require more frequent cleaning.

Electrical Welding Components

Because electricity plays such a critical part in most types of welding, listed below are the parts to be monitor, fix and replace if issues develop.

- Cables: Inspect monthly for breaks, cracks and other wear, such as compromised insulation. Replace any cables with extreme wear or damage.
- Circuit breakers and interlocks on safety equipment: Check monthly to ensure all are working.
- Wire feeder and drive rolls: Check and clean with a wire brush (if dirty) every few months.

- Inlet and outlet guides: Check and clean with a wire brush (if dirty) every few months.
- All power units: Disconnect every six months and vacuum or blow out a welding machine's interior.

Gas Welding Components

- If welding method requires shielding gas, this part is important.
- Shielding gas cylinders: Store all cylinders upright in a cool, dry place
- Valves and regulators: Check these a couple times a year. If you find leaks or other issues.
- Hoses: Coil up hoses prior to storage to avoid stepping on them and creating kinks.

3.2 Maintaining Welding tools and equipment

Welding carries inherent risks that can cause serious injury or even death. For that reason, to minimize the risk of equipment failure with conscientious maintenance in addition to wearing appropriate personal protective equipment. Welders can often costs thousands of dollars or more, and replacement parts can be scarce and quite expensive. Therefore, the maintenance of welding equipment is essential to keeping costs down and production going at optimum levels.

Properly maintenance of welding tools and equipment will secure safety and ensure equipment delivers quality results for as long as possible. Performing regular safety checks on welder to evaluate emissions, leakage, grounding, voltage, and wiring. In general, more advanced welders like TIG and MIG welders will require more maintenance. Appropriate and thorough maintenance of welding equipment is easy and keeps it running safely and reliably for a long time.

Following a regiment of appropriate and thorough maintenance procedures allows a welding machine to run safely and dependably for a long time. Improper, incomplete or totally neglected maintenance can not only result in equipment failure, but it can also lead to serious hazards including severe injury or even death.

Welding machine maintenance includes:

- Electrical Systems: The dangers of electricity are huge, and the consequences of accidents resulting from problems with electricity include debilitating injury or death. These risks necessitate regular inspection of all electrical components incorporated in the welding machine. This includes the following routine practices:

✓ Disconnect all of the power units and blow out or vacuum the machines interior at least once every six months.

✓ Check and clean (with a wire brush) the wire feeder and drive rolls (replacing if necessary) at least once every three to four months. In addition, inspect and cleaning (or replacing if necessary) the inlet and outlet guides.

✓ Arrange for a technician to service the welding gun and liner assembly at least once a year.

✓ Inspect all of the electrical cables at least once a month for signs of wear, including cracks and breaks, immediately replacing any cables with excessively worn or damaged insulation.

✓ Inspect electrical safety equipment on a monthly basis to ensure circuit breaks and interlocks are functioning properly.

- Shielding Gas Cylinder Maintenance: Always store shielding gas cylinders in a cool and dry environment. Also, make sure to keep them in an upright position. Inspect and test regulators and valves at least once every six months to make sure there are no leaks or breaches that are causing incorrect pressure readings. The hoses need to be coiled up for storage. This will prevent damage from prolonged kinks that occurs when hoses are improperly stored or stepped on when left on the ground. Any creaked or damaged hoses require replacement immediately.

  To ensure that your welding equipment runs smoothly:

  1. *Dry out the air inside the machine*

  Before any maintenance procedure, make sure to unplug all power units from wire feeders. Don't forget to look at the operator's manual before servicing the equipment. The ideal cleaning schedule is every six months, but for heavy-service machines, it must be done weekly. Failure to dry the air out of the machine can result in premature wearing and overheating. All equipment should be dried to avoid electric shock during the welding process.

2. *Inspect electrical cables for potential tears and cracks*

Poor circuit connections can lead to erratic arcs and drifting weld parameters. To prevent any loose wirings, immediately tighten the weld terminals and check the electrode holders or ground leads for any cracks. It's best to replace cracked cables with new ones than hold them together using adhesive tapes. Undersized cables may not be compatible with the machine, preventing it from carrying enough current and voltage. Always get proper cable measurements based on the manufacturer's specifications to avoid arc wandering and overheating.

3. *Remove all traces of oil and fuel spills*

Gas leaks are common in poorly secured welding machines. These spills might be due to worn O-rings or severed connections at the back of your welding gun. While it can be costly to repair severe perforations, following a good maintenance schedule can prevent it from happening. Welders must perform manual equipment assessment at the start of each process.

4. *Clean the wire feeder and drive rolls*

Welding machines normally suck air to cool down properly. However, the fans can also absorb dust, metal shavings, and other air contaminants that can ruin the electrical components inside the machine. If the drive rolls are dirty, get rid of any residues using a wire brush. Without regular cleaning and inspection, the liner will clog the wires and cables.

5. Check regulators and valves for leaks

Porosity in welding happens when there is a lack of shielding gas coverage. If you notice rising pressure even with the downstream valve closed, this may indicate a faulty regulator. Contaminants can mix with the weld puddle, which can cause impure welds. When repairing a worn hose, close the cylinder valve and splice the affected area.

6. *Monitor the air quality of filtration units*

Safety must be your top priority in the weld zone. Welders are at risk of inhaling welding dust and fume which can eventually lead to fatal respiratory illnesses such as severe pneumonia, asthma, and lung cancer. Maintenance procedures must include regular checkups and cleaning of filtration units to safeguard against the harmful effects of welding. Local ventilation systems should be in place to get rid of excess pollutants on the welding site

Self-check-3.1

Part-I: Choose the correct answer

1. Inspection is not necessary for any equipment where significant risks to health and safety may arise
   A. True B. False
2. One of the following is not included while inspecting electrical welding components
   A. Cables B. Circuit breakers C. Wire feeder D. All
3. While inspecting gas-welding components, one of the following is not important task to be accomplished.
   A. Coil up hoses prior to storage to avoid stepping on them and creating kinks.
   B. Check these a couple times a year. If you find leaks or other issues.
   C. Store all cylinders upright in a cool, dry place.
   D. None of the above

Part-I: Give short answer

1. Explain the need to keep equipment as clean?
2. Write down the precautions to ensure that your welding equipment runs smoothly?

LAP Tests

Practical Demonstration

Name: ____________________ Date: _____________________

Time started: _____________ Time finished: _______________

Given necessary tools, materials and equipments perform the following tasks accordingly.

Task 1: Perform MIG/MAG welding

Task 2: Carry out resistance spot welding

Task 3: Performing TIG welding

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