Mechanics

Level-III

Learning Guide: 25

Unit of Competence: Performing Special Welding

Module Title: Performing Special Welding

Module Code: XXXXX

LG Code: XXXXX

TTLM Code: XXXXX

LO 1: Determine job requirement

Instruction Sheet	Learning Guide -25

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

- Drawing/plan/WPS interpretation
- Determining sequence of operation.
- Preparing work using tools and techniques.
- Selecting appropriate spray welding equipment and consumables.

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

- Draw/plan/WPS interpretation
- Determine sequence of operation.
- Prepare work using tools and techniques.
- Select appropriate spray welding equipment and consumables.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-check ”given
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
7. Submit your accomplished Self-check. This will form part of your training portfolio.

1. Fundamentals of the process

Submerged arc welding (SAW) produces coalescence of metals by heating them with an arc between a bare metal electrode and the work. The arc and molten metal are “submerged” in a blanket of granular fusible flux on the work. Pressure is not used, and filler metal is obtained from the electrode and sometimes from a supplemental source such as welding rod or metal granules.

In submerged arc welding, the arc is covered by a flux. This flux plays a main role in that:

- The stability of the arc is dependent on the flux,
- Mechanical and chemical properties of the final weld deposit can be controlled by flux, and
- The quality of the weld may be affected by the care and handling of the flux.

Submerged arc welding is a versatile production welding process capable of making welds with currents up to 2000 amperes, ac or dc, using single or multiple wires or strips of filler metal. Both ac and dc power sources may be used the same weld at the same time.

1.1. **Welding procedure specification for submerged arc welding**

1.1.1. Scope

This Welding Procedure Specification covers welding and related operations of steel structures which are fabricated in accordance with the terms outlined in CSA Standards W47.1 and W59, latest revisions. The attached Data Sheets form an essential part of this specification. A change in any of the essential variables contained in succeeding paragraphs or detailed on applicable

Welding Procedure Data Sheet(s) shall require a new Welding Procedure Specification and/or a new Welding Procedure Data Sheet(s).

1.1.2. Welding Procedure

The welding shall be done by the Submerged-Arc Process using either automatic or semi-automatic equipment, with single or multiple arcs as indicated on the Welding Data Sheets.

Joints shall be made following the procedural stipulations indicated in CSA Standard W59, and may consist of single or multiple passes in accordance with the accepted Welding Procedure Data Sheets to which this specification refers.

1.1.3. Base Metal

The base metal shall conform to the specifications of steel groups 1, 2, 3 of CSA Standard W59. Other groups may be welded providing Welding Procedure Data Sheets are accepted.

1.1.4. Base Metal Thickness

Base metal thicknesses from 3 mm (1/8") to UNLIMITED THICKNESS inclusive may be welded under this specification providing the respective Welding Procedure Data Sheets have been supplied and accepted for the appropriate weld size.

1.1.5. Filler Metal/Flux

The electrode and flux to be used in combination shall conform to the requirements of CSA Standard W48. Any combination of electrodes and fluxes not certified by the CWB shall be subject to procedure qualification.

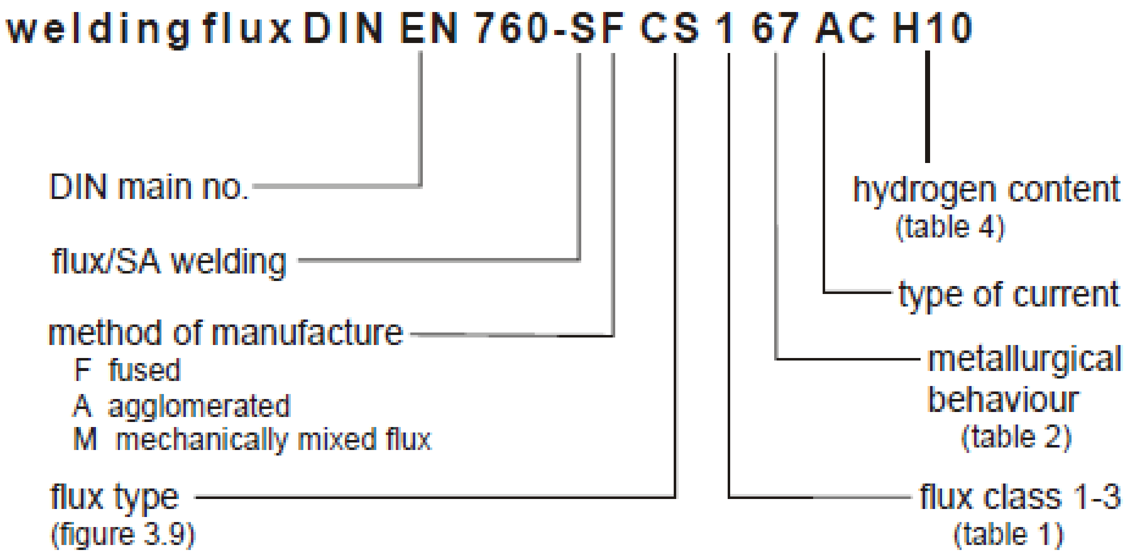

Figure 1. Identification of a welding flux according to DIN EN 760

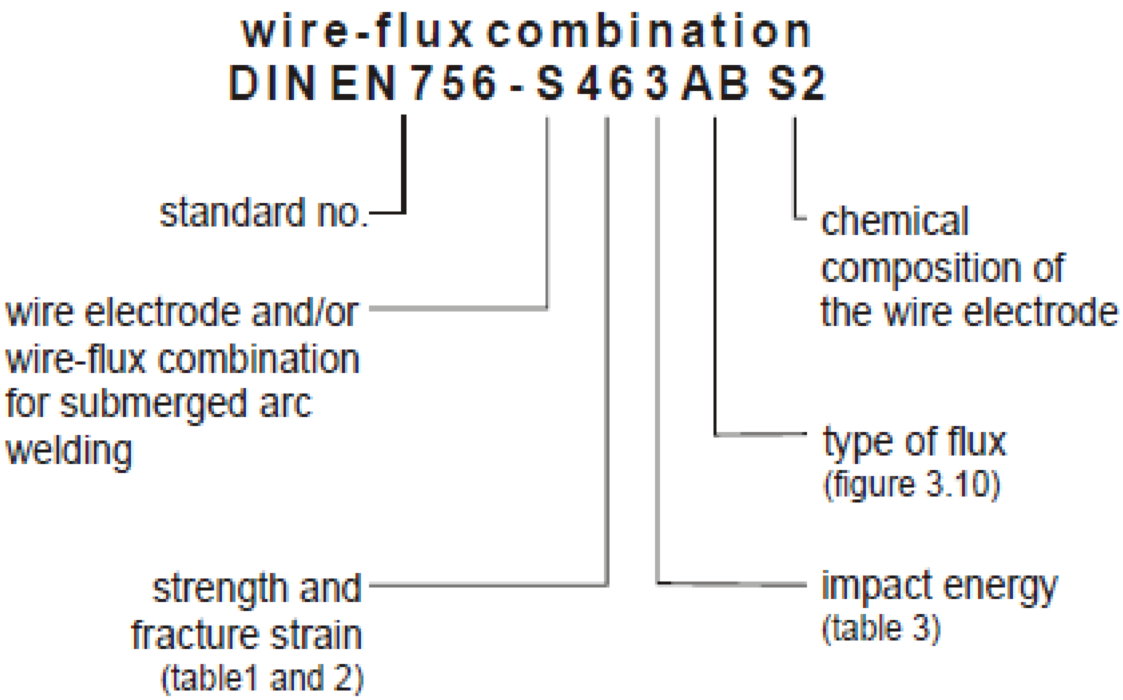

Figure 2. Identification of a wire-flux combination according to DIN EN 756

table 1 Identification for strength properties of multipass weld joints

identification	minimum yield point n/mm²	tensile strength N/mm²	minimum fracture strain %
35	355	440 up to 570	22
38	380	470 up to 600	20
42	420	500 up to 640	20
46	460	530 up to 680	20
50	500	560 up to 720	18

table 2 Identification for strength properties of welding by the pass/ capping pass method welded joints

identifi-cation	minimum base metal yield strength N/mm²	minimum tensile strength N/mm²
2T	275	370
3T	355	470
4T	420	520
5T	500	600

table 3 Identification for the impact energy of clean all-weld metal or of welding by the pass/ capping pass method welded joints

identification	Z	A	0	2	3	4	5	6	7	8
temp. for minimum impact energy 47J °C	no demands	+20	0	-20	-30	-40	-50	-60	-70	-80

Table1. Parameter for weld metal identification according to DIN EN 756

1.1.6. Storage and Conditioning of Electrodes/Fluxes

Electrodes shall be stored in suitable conditions that will keep them dry and free from surface rust and foreign material. Flux used for submerged arc welding shall be dry and free from contamination of dirt, mill scale or other foreign material. All flux shall be purchased in packages capable of being stored under normal conditions for at least 6 months without such storage affecting its welding characteristics or weld metal properties. Flux from damaged packages that have been exposed to free moisture shall be discarded or shall be dried before use in shallow layers (2 inches maximum) at minimum temperature of 500oF for at least 1 hour or at time and temperature conditions as recommended by the manufacturer. Flux fused in welding shall not be reused.

1.1.7. Position

The welding shall be done only in the position indicated on the Welding Data Sheet.

1.1.8. Preheat

The minimum preheat before welding will comply with Table 5.3 of CSA Standard W59. Minimum preheat to be maintained or exceeded during welding. If welding is interrupted for some time so that the temperature of the base metal falls below the minimum preheat temperature, and then arrangements will be made to preheat again prior to recommencing welding.

The weldment shall be allowed to cool to the ambient temperature, without external quench media being supplied. In other words, do not cool using water or by immediate placement in frigid conditions which will cause a quick temperature change.

1.1.9. Heat Treatment and Stress Relieving

This will not be applicable to structures welded under this specification, unless a specific Data Sheet showing all the parameters.

1.1.10. Electrical Characteristics

The current used shall be either direct current (DC) or alternating current (AC) as indicated on the Welding Data Sheets.

1.1.11. Welding Technique

The correct amperage and voltage, speed of travel, thickness of layers, and number of passes, position, material electrodes and any special instructions will be as per Data Sheet

1.1.12. Preparation of Base Material

The edges or surfaces of parts to be joined by welding shall be prepared by oxy-acetylene machine cutting. Where hand cutting is involved the edge will be ground to a smooth surface. All surfaces and edges shall be free from fins, tears, cracks or any other defects that will adversely affect the quality of the weld. All loose or thick scale, rust, moisture, grease or other foreign material that would prevent proper welding or produce objectionable fumes, shall be removed.

1.1.13. Quality

Cracks or blow holes that appear on the surface of any pass shall be removed before depositing the next covering pass. The procedure and technique shall be such that undercutting of base metal or adjacent passes is minimized.

1.1.14. Weld Metal Cleaning

Slag or flux remaining after a pass, shall be removed before applying the next covering pass. Prior to painting, etc., all slag shall be removed and the parts shall be free of loose scale, oil and dirt.

1.1.15. Treatment of Underside of Welding Groove

Prior to depositing weld metal on the underside of a welding groove, the root shall be gouged, or chipped to sound metal, unless otherwise specified on the applicable Data

ISO Specification

Further information can be given in the following order:

- process (e.g. in accordance with IS0 4063);
- acceptance level (e.g. in accordance with IS0 5817 and IS0 10042);
- working position (eg. in accordance with IS0 6947);
- Filler metal (e.g. in accordance with IS0 544, IS0 2560, IS0 3-58 1).

Welding classes

The welding classes are given in IS0 5817

If the designer has specified a welding class on a drawing, this has been done in order to ensure that the production unit is aware of the quality requirements applicable to the joint. IS0 5817 specifies three different quality levels: B, C and D, with Class B being the strictest. The standard includes tables that specify different types of defects, and how large they are permitted to be in the various quality levels.

Class D is usually used for non-load-carrying parts or in structures subjected to only low static loads. Parts subjected to high static loads are normally welded according to Class C. Parts subjected to fatigue loading are normally welded in Class C or Class B, with the additional requirement that the transition between the weld and the work piece materials must be smooth. In extreme cases of fatigue loading, there may be a requirement

Self check-1	Multiple choice

1. ISO specification for submerged arc welding can show:

   A. process B. engineering materials
   C. testing method D. none

2. Welding classes in submerged arc welding represented by letters:

   A. B, C, and D B.A, B, and C
   C. A, C, and B D. A, C, and D

3. One of the following alternatives show WPS in submerged arc welding
   A. scope B. flux C. base metal D. all

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ____________

Rating: _____________

Name: ____________________________ Date: ________________

Information sheet-2	Sequence of operation

2.1. General method

Submerged arc welding can be applied in three different Modes: semiautomatic, automatic, and machine. Each method requires that the work be positioned ***so*** that the **flux** and the molten weld pool will remain in place until they have solidified, Many types of fixtures and positioning equipment are available or can be built to satisfy this requirement

2.1.1. Semiautomatic

Semiautomatic welding is done with a hand-held welding gun, which delivers both flux and the electrode. The electrode is driven by a wire feeder. Flux may be supplied **by** a gravity hopper mounted on the gun or pressure fed through ***a*** hose. This method features manual guidance using relatively small diameter electrodes and moderate travel speeds. The travel may be manual or driven by **a** small gun-mounted driving motor.

2.1.2. Automatic

Automatic welding is done with equipment that performs the welding operation without requiring a welding operator to continually monitor and adjust the controls. Expensive self-regulating equipment can be justified in order to achieve high-production rates.

2.1.3. Machine welding

Machine welding employs equipment that performs the complete welding operation. However, it must be monitored by a welding operator to position the work, start and stop

2.2. Principles of operation

In submerged arc welding, the end of a continuous bare wire electrode is inserted into a mound of flux that covers the area or joint to be welded. An arc is initiated using one of **six** arc- starting methods. **A** wire-feeding mechanism then begins to feed the electrode wire towards the joint at a controlled rate, and the feeder is moved manually or automatically along the weld seam. For machine or automatic welding, the work may be moved beneath a stationary wire feeder.

Additional flux is continually fed in front of and around the electrode, and continuously distributed over the joint. Heat evolved by the electric arc progressively melts some of the flux, the end of the wire, and the adjacent edges of the base metal, creating a pool of molten metal beneath a layer of liquid slag. The melted bath near the arc is in a highly turbulent state. Gas bubbles are quickly swept to the surface of the pool. The flux floats on the molten metal and completely shields the welding zone from the atmosphere.

The liquid flux may conduct some electric current between the wire and base metal, but an electric arc is the predominant heat source. The flux blanket on the top surface of the weld pool prevents atmospheric gases from contaminating the weld metal, and dissolves impurities in the base metal and electrode and floats them to the surface. The flux can also add or remove certain alloying elements to or from the weld metal.

As the welding zone progresses along the seam, the weld metal and then the liquid flux cool and solidify, forming a weld bead and a protective slag shield over it. It is important that the slag is completely removed before making another weld pass.

Factors that determine whether to use submerged arc welding include:

- The chemical composition and mechanical property
- Thickness of base metal to be welded
- Joint accessibility
- Position in which the weld is to be made
- Frequency or volume of welding to be performed

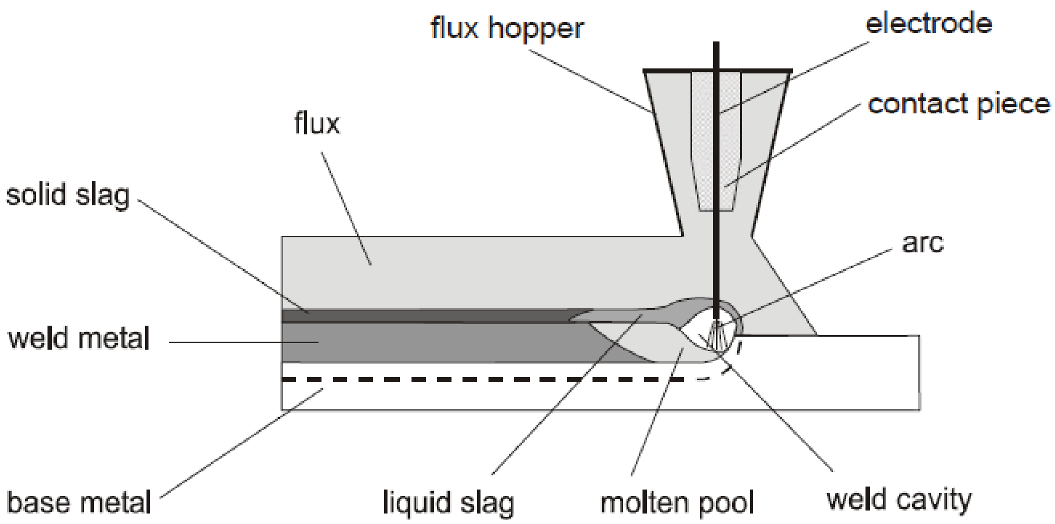

Figure 3. Process principle of submerged arc welding

Self-check-2	Multiple choice

Direction: Select one of the appropriate answer from the given alternatives

1. Modes of submerged arc welding that the welding operation without welding operator is:

A. semi-automatic welding B. automatic welding

C. machine welding D. none

2. Modes of submerged arc welding that employ equipment that performs the complete welding operation:

A. machine welding B. automatic welding C. semi-automatic welding

D. all

3. One of the following factors determine to use submerged arc welding

A. chemical composition B. position of weld C. thickness of metal

D. all

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ____________

Rating: ____________

Name: ___________________________ Date: ________________

1. Tools and techniques

SAW will apply the following tools and techniques:

1.1. Single electrode welding

Single electrode welding is the most common of all SAW process configurations, using only one electrode and one power source. It is normally used with direct current electrode positive (DCEP) polarity, but may also be used with direct current electrode negative (DCEN) polarity when less penetration into the base metal is required. The process may be used in the semiautomatic mode where the welder manipulates the electrode, or in the machine mode.

A single electrode is frequently used with special welding equipment for completing horizontal groove welds in large storage tanks and process vessels. The unit rides on the top of each ring as it is constructed and welds the circumferential joint below it. A special flux belt or other equipment is used to hold the flux in place against the shell ring. In addition, both sides of the joint (inside and outside) are usually welded simultaneously to reduce fabrication time.

1.2. Narrow groove welding

A narrow groove configuration is often adopted for welding material ***2*** in. (50 mm) thick and greater, with a root opening between 1/2 and 1 in. **(13** and ***25*** mm) wide at the bottom of the groove and a total included groove angle between 0 and **8** degrees. This process variation usually powers a single electrode with either DCEP or alternating current, depending on the type of electrode and **flux** being used. It is essential to use welding fluxes that have been developed for narrow groove welding because of the difficulty in removing slag. These fluxes have special characteristics for easier removal from the narrow groove.

1.3. **Multiple wires welding**

Multiple wire systems combine two or more welding wires feeding into the same puddle. The wires may be current- carrying electrodes or cold fillers. They may be supplied from single or multiple power sources. The power sources may be dc or ac or both. Multi wire welding systems not only increase weld metal deposition rates, but also improve operating flexibility and provide more efficient use of available weld metal. This increased control of metal deposition can also achieve higher welding speeds, up to five times those obtainable with a single wire.

1.4. Twin electrode saw process

This welding configuration uses two electrodes feeding into the same weld pool. The two electrodes are connected to a single power source and wire feeder, and are normally used with DCEP. Because two electrodes are melted, this mode offers increased deposition rates compared to single electrode submerged arc welding. The process is used in the machine or automatic welding mode and can be used for flat groove welds and horizontal fillet welding.

1.5. Tandem arc saw process

There are **two** variations of two-electrode tandem arc SAW**.** One configuration uses a DCEP lead electrode and an alternating current trail electrode. The electrodes are separated 0.75 in. (19 mm) but are active in the same weld puddle. This process offers higher deposition rates compared to the single electrode SAW process, up to 40 lbs per hour when using larger diameter electrodes. This configuration is used in the machine or automatic modes for welding thicker materials, 1 in. (25.4 mm) and greater, in the flat welding position (Figure ***6.26).*** It should be noted that additional ac trailing electrodes may be added to the configuration to increase deposition rates even more.

The second configuration uses two ac power sources electrically connected. This configuration is called a *Scott connection* and the interaction of the magnetic fields of the two arcs result in a forward deflection of the trail arc. The forward deflection allows for greater welding speeds without undercutting the base metal.

1.6. Triple-arc tandem arc saw

There are two popular variations of triple arc **SAW.** In the one variation all three electrodes are connected to ac transformers. The transformers are connected to the three phase primary. The first electrodes in this system are Scott connected the same.

Self check -3	Matching

Direction: match group-A within group-B

A	B
1. Multiple wire system	A. Using only one electrode
2. Single electrode system	B. Weld materials 50mm thick
3. Twin electrode system	C. Combines two or more wires
4. Narrow groove system	D. Use two electrodes feeding

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: _______________

1. Materials Used.

- Two materials are used in submerged arc welding: the welding flux and the consumable electrode wire.
- Submerged arc welding flux shields the arc and the molten weld metal from the harmful effects of atmospheric oxygen and nitrogen. The flux contains deoxidizers and scavengers which help to remove impurities from the molten weld metal. Flux also provides a means of introducing alloys into the weld metal. As this molten flux cools to a glassy slag, it forms a covering which protects the surface of the weld. The un melted portion of the flux does not change its form and its properties are not affected, so it can be recovered and reused. The flux that does melt and forms the slag covering must be removed from the weld bead. This is easily done after the weld has cooled. In many cases, the slag will actually peel without requiring special effort for removal. In groove welds, the solidified slag may have to be removed by a chipping hammer.
- Fluxes are designed for specific applications and for specific types of weld deposits. Submerged arc fluxes come in different particle sizes. Many fluxes are not marked for size of particles because the size is designed and produced for the intended application.
- There is no specification for submerged arc fluxes in use in North America. A method of classifying fluxes, however, is by means of the deposited weld metal produced by various combinations of electrodes and proprietary submerged arc fluxes. This is covered by the American Welding Society Standard. Bare carbon steel electrodes and fluxes for submerged arc welding. In this way, fluxes can be designated to be used with different electrodes to provide the deposited weld metal analysis that is desired.

2. Equipment

The equipment required for submerged arc welding consists of:

(1) A power supply,

(2) An electrode delivery system,

(3) A flux distribution system,

(4) A travel arrangement, and

(5) A process control system.

Optional equipment includes flux recovery systems and positioning or manipulating equipment.

Self check-4	**True/false**

Direction: write true /false for the given questions

1. Submerged arc welding flux is used to shield the arc
2. Submerged arc welding flux help to remove impurities from the molten weld metal
3. Power supply is one of equipment in submerged arc welding

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: _______________

List of reference materials

1. Fled, N. **A.** et al. "The role of filler metal wire and flux composition in submerged arc weld metal transformation kinetics: *Welding journal65 (5): 113s;* May *1986.*
2. Gowrisankar, I. et al. "Effect of the number of passes on the structure and properties of submerged arc welds of AIS1 type *316L* stainless steel: *Welding journal* 66(5):147s-151s; May 1987.
3. Hantsch, H. et al. "Submerged arc narrow-gap welding of thick walled components." *Welding Journal 61(7): 27- 34;* July *1982.*
4. Hinkel, J. E., and Forsthoefel, F. W. "High current density submerged arc welding with twin electrodes: *Welding journal* **55(3):** *175-180;* March *1976.*
5. Indacochea, J. E. et al. "Submerged arc welding: Evidence for electrochemical effects on the weld pool." *Welding journal 68(3): 77s-81s;* March *1989.*
6. Jackson, C. E. "Fluxes and slags in welding." Bulletin *190* New York: Welding Research Council, December *1973.*

Mechanics

Level-III

Learning Guide: 26

Unit of Competence: Perform Special Welding

Module Title: Performing Special Welding

Module Code: XXXXX

LG Code: XXXXX

TTLM Code: XXXXX

LO 2: Set up welding machine

Instruction Sheet	Learning Guide -26

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

- Determining requirements for welding.
- Setting up welding machine.
- Connecting welding machine polarity.
- Adjusting Current, voltage, and wire feed settings.
- Completing task without causing damage.
- Adjusting gas setting on spray welding equipment.
- Preparing and setting up replaceable moulds for exothermic weld.

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

- Determine requirements for welding.
- Set up welding machine.
- Connect welding machine polarity.
- Adjust current, voltage, and wire feed settings.
- Complete task without causing damage.
- Adjust gas setting on spray welding equipment.
- Prepare and set up replaceable moulds for exothermic weld.

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- Read the specific objectives of this Learning Guide.
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- Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
- Accomplish the “Self-check ”given

- Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).

- If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
- Submit your accomplished Self-check. This will form part of your training portfolio.

Information sheet-1	Determining requirements for welding from job requirements, welding procedures and specifications and/or technical drawings.

1. Weld Requirement

Submerged arc welding lends itself to a wide variety of wire and flux combinations, single and multiple electrode arrangements, and use of ac or dc welding power sources. The process has been adapted to a wide range of materials and thicknesses. Various multiple arc configurations may be used to control the weld profile and increase the deposition rates over single arc operation. Weld deposits may range from wide beads with shallow penetration for surfacing, to narrow beads with deep penetration for thick joints. Part of this versatility is derived from the use of ac

The principles which favor the use of ac to minimize arc blow in single arc welding are often applied in multiple arc welding to create a favorable arc deflection. The current flowing in adjacent electrodes sets up interacting magnetic fields that can either reinforce or diminish each other. In the space between the arcs, these magnetic fields are used to produce forces that will deflect the arcs (and thus distribute the heat) in directions beneficial to the intended welding application.

Various types of power sources and related equipment are designed and manufactured especially for multiple arcs welding. These relatively sophisticated machines are intended for high production on long runs of repetitive type applications.

Self check-1	True/false

Direction: write true/false for the given questions

1. SAW adapted to weld a wide range of materials and thicknesses

2. SAW favors the principle of single and multiple electrode arrangements

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: _______________

Information sheet-2	Setting up welding machine in accordance with job requirements, welding procedures and specifications, technical drawings and manufacturer's instructions.

1. Welding machine

Submerged arc welding is essential in high production rates and welds of good quality. Therefore it is important to set up welding machine in accordance with job requirements, welding procedures and specifications, technical drawings and manufacturer's instructions. To achieve the result the variables in order of their importance should be considered. The operator must know how the variables affect the welding action and what changes should be made to them. The variables are:

- Welding amperage
- Welding voltage
- Welding speed
- Size of electrode
- Electrode extension
- Width and depth of layer of flux
- Type of flux and particle distribution

1. **Welding amperage:** welding current is the most influential variable because it controls at which is melted and therefore the deposition rate, the depth of penetration, and the amount of base metal melted. If the current is too high at a given travel speed, the depth of fusion or penetration will be too great. If the current is too low, inadequate penetration or incomplete fusion may result.

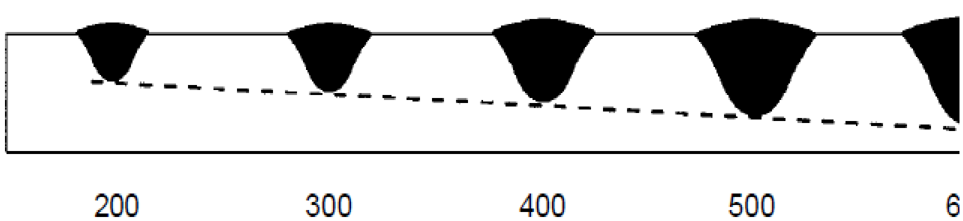

Figure 4. The effect of welding current on weld appearance.

2. Welding voltage: Welding voltage adjustment varies the length of the arc between the electrode and the molten weld metal. If the overall voltage is increased, the arc length increases; if the voltage decreased, the arc length decreases. Voltage has little effect on the electrode deposition rate, which is determined by welding current. The voltage principally determines the shape of the weld bead cross section and its external appearance. Increasing the welding voltage with constant current and travel speed will:

- Produce a flatter and wider bead.
- Increase flux consumption.
- Tend to reduce porosity caused by rust or scale on
- Help to bridge an excessive root opening when fit-up is Poor
- Increase pickup of alloying elements from an alloy flux.

Excessively high-arc voltage will:

- Produce a wide bead shape that is subject to
- Make slag removal difficult in groove welds.
- Produce a concave shaped weld that may be subject
- Increase undercut along the edge(s) of fillet welds,

Lowering the voltage produces a “stiffer” arc, which improves penetration in a deep weld groove and resists arc blow. An excessively low voltage produces a high, narrow bead and causes difficult slag removal along the bead edges to cracking

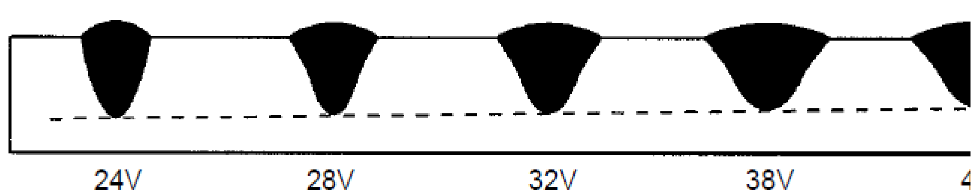

Figure 5. the effect of arc voltage on the appearance of the weld

3. Travel speed: With any combination of welding current and voltage, the effects of changing the travel speed conform to **a** general pattern. If the travel speed is increased:

- Less filler metal is applied per unit length of weld, resulting in less weld reinforcement. Thus, the weld bead becomes smaller.

Weld penetration is affected more by travel speed than by any variable other than current. This is true except for excessively slow speeds when the molten weld pool is beneath the welding electrode. Then the penetrating force of the arc is cushioned by the molten pool. Excessive speed may cause undercutting. Within limits, travel speed can be adjusted to control weld size and penetration. In these respects, it is related to current and the type of flux. Excessively high travel speed promotes undercut, arc blow, porosity, and uneven bead shape. Relatively slow travel speeds provide time for gases to escape from the molten metal thus reducing porosity.

Excessively slow speeds produce

- A convex bead shape that is subject to cracking,
- Excessive arc exposure, which is uncomfortable for the operator, and
- a large molten pool that flows around the arc, resulting in a rough bead and slag inclusions.

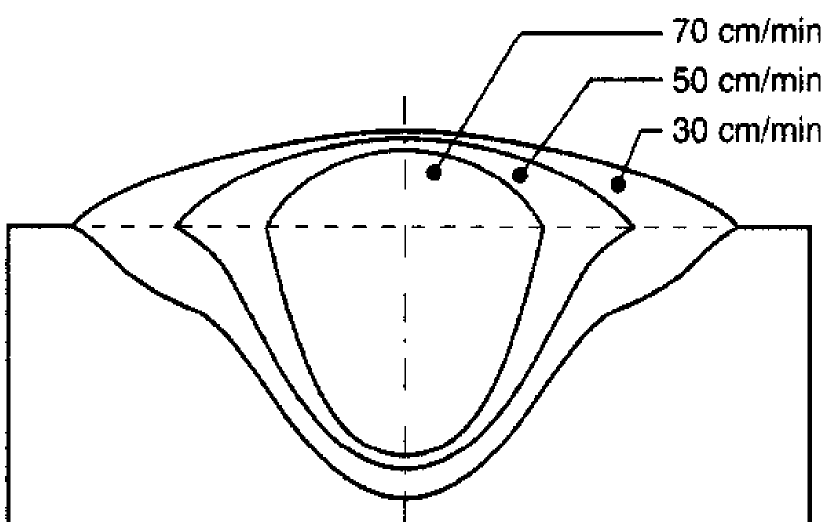

Figure 6. effect of welding speed on weld appearance with constant values of current and voltage.

4. Electrode size: Electrode size affects the weld bead shape and the depth of penetration at a fixed current. Small diameter electrodes are used with semiautomatic equipment to provide flexibility of movement. They are also used for multiple electrode parallel power equipment. Where poor fit-up is encountered, a larger diameter electrode is better than small ones for bridging large root openings.

Electrode size also influences the deposition rate. At any given current, a small diameter electrode will have a higher current density and a higher deposition rate than a larger electrode. However, a larger diameter electrode can carry more current than a smaller electrode, and produce a higher deposition rate at higher amperage. If a desired electrode feed rate is higher (or lower) than the feed motor can maintain, changing to a larger (or smaller) size electrode will permit the desired deposition rate

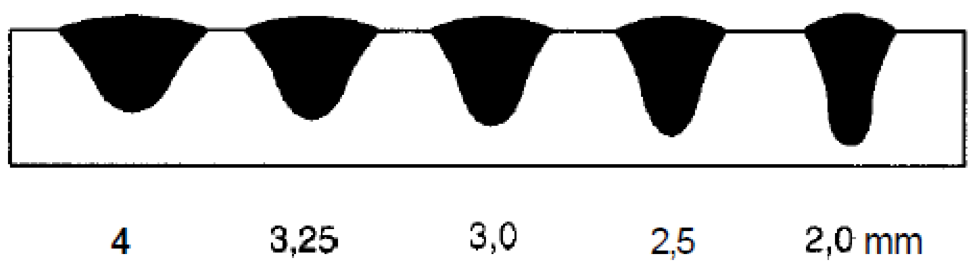

Figure 7: effect of wire diameter on weld appearance

5. Electrode extension: At current density above 80 *000* A/in2 (125 A/mm2), electrode extension becomes an important variable. At high-current densities, resistance heating of the electrode between the contact tube and the arc increases the electrode melting rate. The longer the extension, the greater is the amount of heating and the higher the melting rate. This resistance heating is commonly referred to as 12R heating. In developing a procedure, an electrode extension of approximately eight times the electrode diameter is a good starting point. As the procedure is developed, the length is modified to achieve the optimum electrode melting rate with fixed amperage.

Self check-2	Multiple choice

Direction: Select one of the appropriate answer from the given alternatives

1. One of the following variables affects the welding action of SAW

   A. welding current   B. welding speed   C. size of electrode   D. all

2. Increasing welding voltage with constant current and travel speed will:

   A. increase porosity of weld   B. increase flux consumption

   C. decrease flux consumption   D. produce narrow bead

3. Identify the correct statement about travel speed in SAW

   A. excessively slow speed   B. excessively slow speed produce convex bead shape

   C. excessively slow speed produce comfortable arc for weld

   D. none

4. Electrode size may influence:

   A. deposition rate   B. weld bead shape   C. amount of current carried   D. all

Note: Satisfactory rating - 3 points   Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________   Date: _______________

Information sheet-3	Connecting welding machine polarity

1. Power sources

The power source chosen for a submerged arc welding system plays a major operating role.

Several types of power supply are suitable for submerged arc welding. A dc power supply may be a transformer-rectifier or a motor or engine generator, which will provide a constant voltage (CV), constant current (CC), or a selectable CV/CC output. AC power supplies are generally transformer types, and may provide either a CC output or a CV square wave output. Because SAW is generally a high-current process with high-duty cycle, a power supply capable of providing high amperage at 100 percent duty cycle is recommended.

1.1. Dc constant-voltage power

Dc constant-voltage power supplies are available in both transformer-rectifier and motor-generator models. These power sources are used for semiautomatic **SAW** at currents ranging from about 300 to 600 A with 1/16, 5/64, and 3/32 in. (1.6, 2.0, and 2.4 mm) diameter electrodes.

Automatic welding is done at currents ranging from 300 to over 1000 A, with wire diameters generally ranging from **3/32** to 1/4 in. (2.4 to **6.4** mm). However, applications for dc welding at over 1000 A are limited because severe arc blow may occur at such high current.
With some older CV supplies, the minimum useful current density is about 40 000 A/in2 (62 A/mm2), based on electrode diameter. Below this current density, the arc becomes unstable. However, this problem has been overcome by more recent power supplies and a stable arc can be maintained at current densities as low as 15 000 A/in2 (23 A/mm2).

A constant-voltage power supply is self-regulating, so it can be used with a constant-speed wire feeder. No voltage or current sensing is required to maintain a stable arc, so very simple wire feed speed controls may be used. The wire feed speed and wire diameter control the arc current, and the power supply controls the arc voltage.

Constant-voltage dc power supplies are the most commonly used supplies for submerged arc welding. They work well for most applications where the arc current does not exceed 1000 A, and may work without a problem at higher currents. The CV dc power supply is the best choice for high-speed welding of thin steel.

1.2. Constant-current DC power sources

Constant-current dc power sources are available in both transformer-rectifier and motor-generator models, with rated outputs up to 1500 A. Some CC dc power sources may also be used for GTAW, SMAW, and air carbon arc cutting. With the exception of high-speed welding of thin steel, CC dc sources can be used for the same range of applications as CV dc supplies.

Constant-current sources are not self-regulating, so they must be used with a voltage-sensing variable wire feed speed control. This type of control adjusts the wire feed speed in response to changes in arc voltage. The voltage is monitored to maintain a constant arc length.

There are a large number of variations to the process that give submerged arc welding additional capabilities. Some of the more popular variations are:

- Two-wire systems--same power source.
- Two-wire systems--separate power source.
- Three-wire systems--separate power source.
- Strip electrode for surfacing.
- Iron powder additions to the flux.
- Long stick out welding.
- Electrically "cold" filler wire

Polarity: also affects the penetration. If the filler wire is positive, penetration is deeper than if the filler wire is negative. This means that it is better to use negative polarity when performing cladding, in order to avoid mixing the cladding material into the base material. Melting rate is increased by about 30 % percent when negative polarity is used.

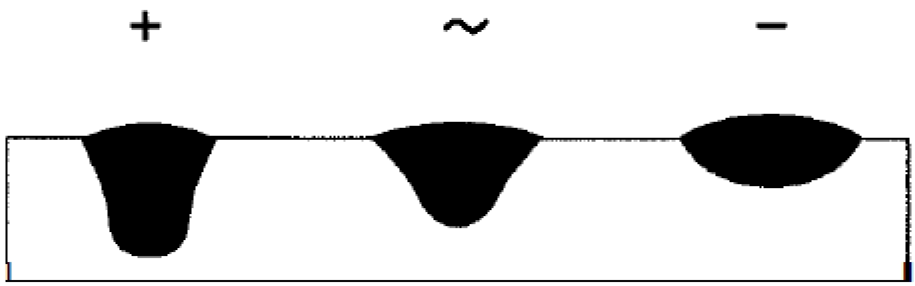

Figure 8: The **effect of wire polarity on penetration.**

Self check-1	Multiple choice

Direction: Select one of the appropriate answer from the given alternatives

1. Which one of the following power sources will provide a constant voltage and current for SAW?
   A. DC power supply B. AC power supply AC/DC D. none
2. Which one of the following power sources is a self regulating?
   A. constant-current DC power supply
   B. constant-voltage DC power supply
   C. Three wire system
   D. all
3. Polarity in SAW may affect:
   A. penetration of weld B. metal melting rate D. wire melting rate D. all

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ____________

Rating: ____________

Name: ____________________________ Date: ________________

Information sheet-4	Adjusting current, voltage, and wire feed settings consistent with job requirements to produce acceptable weld.

1. CONTROLS

The control systems used for semiautomatic submerged arc welding are simple wire feed speed controls. Controls used with constant-voltage power supplies maintain a constant wire feed speed. Controls used with constant-current back loops interfaced with the power supply and wire feed motor, to maintain the welding voltage and wire speed at preset values. The great advantage of digital controls is their precise control of the welding process. The disadvantages are that the controls are not compatible with some power supplies, and they are slightly less rugged than most analog controls.

Digital controls are currently available only for use with constant voltage power supplies. These controls provide for wire feed speed adjustment (current control), power supply adjustment (voltage control), weld start-stop, automatic and manual travel on-off, cold wire feed up-down, run-in and crater fill control, burn back, and flux feed on off.

Digital current, voltage, and wire feed speed meters are standard on digital controls. Analog controls are available for use with both constant- voltage and constant-current power supplies. Basic controls consist of a wire feed speed control (adjusts current in CV systems; controls voltage in CC systems), a power supply control (adjusts voltage in CV systems; adjusts current in CC systems), a weld start-stop switch, automatic or manual travel on-off, and cold wire feed up down, These controls have the same advantages as analog controls for semiautomatic SAW, but they are prone to drift and do not allow precise process control.

Weld heads and torches: A submerged arc welding head comprises the wire feed motor and feed roll assembly, the torch assembly and contact tip, and accessories for mounting and positioning the head. A flux nozzle is usually mounted on the weld head, to deposit the flux either slightly ahead of or concentric with the welding wire. Wire feed motors are typically heavy duty, permanent magnet-type motors with an integral reducing gearbox, feeding wire at speeds in the range of 20 to 550 in./min. **(8** to 235 mm/sec). The feed roll assembly may have one drive and one idler roll, two drive rolls, or four drive rolls. Four-roll drive assemblies are reported to provide positive feeding with the least wire slippage.

Feed rolls may be knurled-V or smooth-V type; hurled-V rolls are the most common. In some cases, where the wire is being pushed through a conduit, smoother feeding will result if smooth V- groove rolls are used. Torch assembly designs are numerous, but their purpose is always the same. The torch assembly guides the wire through the contact tip to the weld zone, and also delivers welding power to the wire at the contact tip.

Special equipment is needed for standard submerged arc welding, narrow groove (SAW-NG), and strip electrode SAM. Parallel wire SAW uses special feed roll and torch assemblies that provide positive feeding of two wires through one torch body. Strip electrode SAW also requires a special feed roll and torch assembly. Torches that feed strip are generally adjustable to accommodate several sizes of strip, typically 1.2,1.8,2.4,3.5 in. wide, and up to 0.04 in. thick (30,45,60,90 mm wide; up to 1 mm thick). The assemblies for parallel wire and strip electrode SAW are generally designed for mounting on standard welding heads with little or no modification.

The special SAW-NG equipment has long narrow torch assemblies and long narrow flux nozzles to deliver the flux and wire to the bottom of deep narrow grooves. These systems may also have some means to bend the wire to assure good side wall fusion in the narrow groove. Simple SAW-NG adaptors can be mounted directly on standard weld heads; more complex systems are available as complete weld head assemblies.

For semiautomatic SAW the weld head may be a GMAW-type wire feeder that pushes the electrode through a conduit to the torch assembly. Such wire feeders accept any of the drive roll systems discussed above and are generally capable of feeding wire up to 3/32 in. (2.4 mm) in diameter at wire feed speeds over *550* in,/min. (235 mm/s). The torch-conduit assembly allows for welding at up to 15 ft (4.6 m) from the wire feeder. Flux feed is provided either by a small 4 lb (1.8 kg) gravity feed flux hopper mounted on the torch, or from a remote flux tank that uses compressed air to push the flux to the weld zone. In both cases, the flux is delivered through the torch surrounding the welding wire.

Self check-4	**True/false**

Direction: write true /false for the given questions

1. A SAW head comprises the wire feed motors and feed roll assembly

2. The great advantage of digital controls is their precise control of the welding

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ____________

Rating: ____________

Name: ___________________________ Date: ________________

Information sheet -5	Completing task without causing damage to the tools, equipment and materials and injury to self and others

Operators should always wear eye protection to guard against weld spatter, arc glare exposure, and flying slag particles. Power supplies and accessory equipment such as wire feeders should be properly grounded. Welding cables should be kept in good condition. Certain elements, when vaporized, can be potentially dangerous. Alloy steels, stainless steels, and nickel alloys contain such elements as chromium, cobalt, manganese, nickel, and vanadium. Material safety data sheets should be obtained from the manufacturers to determine the content of the potentially dangerous elements and their threshold limit values. For many of these elements the limit is *1.0* milligram per cubic meter or less.

The submerged arc process greatly limits exposure of operators to air contaminants because few welding fumes escape from the flux overburden. Adequate ventilation will generally keep the welding area clear of hazards. The type of fan, exhaust, or other air movement system will be dependent on the work area to be cleared. The various manufacturers of such equipment should be consulted for a particular application.

Self check-5	True/false

Direction: Write true/false for the given questions

1. Material safety data sheet can show dangerous elements

2. SAW power supplies and accessory equipment may cause danger

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: _______________

Information sheet -6	Adjusting gas setting on spray welding equipment to task requirements

1. **General description**

The spray process is an umbrella name for multiple processes. All involve use of a coating material in the form of wire rod or powder which is melted by one of sources of energy. The molten powder, wire or rod is accelerated and propelled towards the substrate by gas or an atomization jet. The coating can be applied at different thickness. It is used to repair worn components and machine parts or to improve performance and promote longer component life.

The arc spray process uses DC power to energize negative and positive wire which is fed through a gun head. The wires arc against each other in the head, creating the heat necessary for the creation of molten metal. Air that is compressed is introduced in to the arc, atomizing the molten metal and then moving the droplets to the material being worked on. The droplets interlock on top of each other to create the weld or bond. In spray arc mode the wire forms a point (funnel) at the electrode wire end.

Wires are fed through a spray welding system. Both wires meet at the gun head and create an arc. Dry compressed air atomizes the material and propels it otherwise porosity increase.

Self check-6	True/false

Direction: write true /false for the given questions

1. The arc spray process uses DC power to energize negative and positive wire

2. Dry compressed air atomizes the material

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: _______________

Information sheet-7	Preparing replaceable moulds for exothermic weld according to task requirements

Exothermic molds used in the **Ultras hot** process have been proven to last several times longer than ones being used in the conventional process. **Exothermic connections** are the preferred connection method especially for below grade applications.

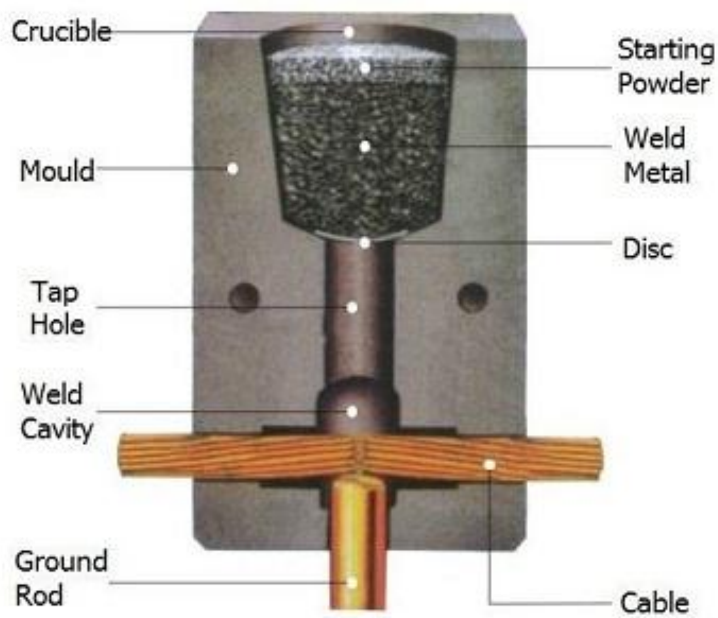

Figure 9: exothermic mould

Self check-7	True/False

Direction: write true/false

1. Ground rod is one of the parts of exothermic weld

2. Exothermic weld moulds used in the ultra shot

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ____________

Rating: ____________

Name: ___________________________ Date: ________________

List of reference materials

1. Fled, N. **A.** et al. “The role of filler metal wire and flux composition in submerged arc weld metal transformation kinetics: *Welding journal65 (5): 113s;* May *1986.*
2. Gowrisankar, I. et al. “Effect of the number of passes on the structure and properties of submerged arc welds of AIS1 type *316L* stainless steel: *Welding journal 66(5):147s-151s;* May *1987.*
3. Hantsch, H. et al. “Submerged arc narrow-gap welding of thick walled components.” *Welding Journal 61(7): 27- 34;* July *1982.*
4. Hinkel, J. E., and Forsthoefel, F. W. “High current density submerged arc welding with twin electrodes: *Welding journal* **55(3):** *175-180;* March *1976.*
5. Indacochea, J. E. et al. “Submerged arc welding: Evidence for electrochemical effects on the weld pool.” *Welding journal 68(3): 77s-81s;* March *1989.*
6. Jackson, C. E. “Fluxes and slags in welding.” Bulletin *190* New York: Welding Research Council, December *197*

Mechanics

Level-III

Learning Guide: 27

Unit of Competence: Perform Special Welding

Module Title: Performing Special Welding

Module Code: XXXXX

LG Code: XXXXX

TTLM Code: XXXXX

LO 3: Set up welding accessories

Instruction Sheet	Learning Guide -27

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

- Identifying welding machine accessories and consumables.
- Setting up welding machine accessories and consumables.
- Locking and adjusting spools firmly to holder, rollers to correct tension.
- Installing flux recovery equipment and flux oven /heaters.
- Obtaining aluminum powder and metal oxide compositions.

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

- Identify welding machine accessories and consumables.
- Set up welding machine accessories and consumables.
- Lock and adjust spools firmly to holder, rollers to correct tension.
- Install flux recovery equipment and flux oven /heaters.
- Obtain aluminum powder and metal oxide compositions

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
- Accomplish the “Self-check ”given
- Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
- If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1 and submit your accomplished Self-check.

Information sheet-1	Identifying welding machine accessories and consumables

1. Accessory equipment

The welding equipment consists of a wire feed unit, in the form of a drive motor, reduction gear and feed rollers, which feeds the wire from the wire spool to a contact device, preferably with spring-loaded contact pads. The flux is supplied to the weld from a flux container, and is often recovered after the weld by a suction unit which sucks up the surplus flux and returns it to the flux container. Travel is normally mechanized, although there are welding torches intended for semi automatic submerged arc welding. The power source, wire feed speed and linear travel speed are all automatically controlled.

Accessory equipment commonly used with SAW include:

- travel equipment
- **flux** recovery units
- fixturing equipment, and
- Positioning equipment.

2. Consumable

The proper choices of filler wire and flux composition are important for the finished weld. The aim is generally to achieve a composition and strength of the weld metal similar to that of the base material. The weld metal analysis depends on the materials used in the filler wire, with allowance for such factors as possible loss of alloying elements by bum-off in the arc, melting of the base metal and alloying from the flux. When using a strongly alloying flux in a joint with many passes, there is a risk of build-up of alloying material through uptake of material from previous passes

Common consumables SAW are:

- Filler wires and Flux

Self check-1	Multiple choice

Direction: Select the appropriate answer from the given alternatives

1. One of the following is categorized under accessory equipment

   A. flux recovery unit B. flux C. wire D. none

2. Filler wires classified under:

   A. accessories B. consumables C. power source D. tools

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: _______________

1. Filler wires

The wire grade and its content of alloying metals primarily affect the mechanical properties and chemical analysis of the weld metal. When deciding on an appropriate choice of wire, it is very important to allow for the following factors:

The strength of the weld metal can be increased by alloying with manganese and silicon.

The use of molybdenum and nickel as alloying elements improves the toughness of the weld metal at low temperatures.

The filler wire may be copper-plated in order to improve electrical contact and to protect against corrosion. Common wire diameters are 1.6, 2.0, 2.5, 3, 4, 5 and 6mm. Filler material in the form of strip (e.g. 0.5 x 100 mm) is often used when applying stainless steel cladding, e.g. to pressure vessel steel. As a result of the rectangular cross section, penetration is exceptionally low, producing a smooth and wide weld. The favorable low dilution from parent metal does not affect the corrosion resistance of the surface layer. The method is also used for repair of worn parts.

2. FLUXES

Fluxes shield the molten weld pool from the atmosphere by covering the metal with molten slag (fused flux). Fluxes clean the molten weld pool, modify the chemical composition of the weld metal, and influence the shape of the weld bead and its mechanical properties. Fluxes are granular mineral compounds mixed according to various formulations. Based on the choice of several manufacturing methods, the different types of fluxes are fused, bonded (also known as agglomerated), and mechanically mixed.

2.1. Fused Fluxes

To manufacture a fused flux, the raw materials are dry mixed and melted in an electric furnace. After melting and any final additions, the furnace charge is poured and cooled. Cooling may be accomplished by shooting the melt through a stream of water or by pouring it onto large chill blocks. The result is a product with a glassy appearance which is then crushed, screened for size, and packaged.

Fused fluxes have the following advantages:

- Good chemical homogeneity
- Easy removal **of** the fines without affecting composition
- Not hygroscopic normally, which simplifies handling storage, and welding problems
- Readily recycled through feeding and recovery systems without significant change in particle size or composition
- Their main disadvantage is the difficulty of adding deoxidizers and Ferro-alloys to them during manufacture without segregation or extremely high losses. The high temperatures needed to melt the raw ingredients limit the range of flux compositions.

2.2. Bonded Fluxes

To manufacture a bonded flux, the raw materials are powdered, dry mixed, and bonded with either potassium silicate, sodium silicate, or a mixture of the two. After bonding, the wet mix is pelletized and baked at a temperature lower than that used for fused fluxes. The pellets are then broken up, screened to size, and packaged.

The advantages of bonded fluxes include the following:

- Easy addition of deoxidizers and alloying elements; alloying elements are added as Ferro-alloys or as elemental metals to produce alloys not readily available as electrodes, or to adjust weld metal compositions.
- Usable with thicker layer of flux when welding
- Color identification

The disadvantages are the following:

- Tendency for some fluxes to absorb moisture in a manner similar to coatings on some shielded metal arc electrodes
- Possible gas evolution from the molten slag
- Possible change in flux composition due to segregation or removal of fine mesh particles

2.3. Mechanically Mixed Fluxes

To produce a mechanically mixed flux, two or more fused or bonded fluxes are mixed in any ratio necessary to yield the desired results. The advantage of mechanically mixed fluxes is that several commercial fluxes may be mixed for highly critical or proprietary welding operations.

The following are disadvantages of mechanically mixed fluxes:

- Segregation of the combined fluxes during ship
- Segregation occurring in the feeding and recovery
- Inconsistency in the combined flux from mix to mix

Wire Diameter		Current Range (Amperes)
in.	mm	
5/64	2.3	200 - 500
3/32	2.4	300 - 600
1/8	3.2	300 - 800
5/32	4.0	400 - 900
3/16	4.8	500 - 1200
1/32	5.6	600 - 1300
1/4	6.4	600 - 1600

Table 2. Submerged arc wires diameter vs. current range

2.4. GENERAL DESCRIPTION

A ***positioner*** **is** a mechanical device that supports and moves a weldment to the desired position for welding and other operations. In some cases, a positioner may move **a** weldment **as** welding progresses along a joint. A welding fixture may be mounted on a positioner to place the fixture and weldment in the most advantage**ous** positions for loading, welding, and unloading.

Some assemblies may be fixture on the floor and the joints tack welded to hold the assembly together. Then, the weldment **k** removed from the fixture and mounted on a positioned for welding the joints in the best positions for economical production.

A weldment on a positioner may be repositioned during welding or upon completion for cleaning, machining a specified weld contour, nondestructive inspection, and weld repairs.

2.5. Travel Equipment

Weld head travel in SAW is generally provided by a tractor-type carriage, a side beam carriage, or a manipulator. A tractor-type carriage provides travel along straight or gently curved weld joints by riding on tracks set up along the joint, or by riding on the work.

Side beam carriages provide linear travel only, and are capable of travel speeds in excess of 200 in./min. (85 mm/s). Because side beam systems are generally fixed and the work piece must be brought to the weld station, their greatest use is for shop welding. The weld head, wire, flux hopper, and sometimes the control are mounted on the carriage. Figure 6.10 shows two weld heads mounted on a single carriage for a cladding operation.

Manipulators are similar to side beams, in that they are fixed and the work piece must be brought to the welder. Manipulators are more versatile than side beams in that they are capable of linear motion in three axes. The weld head, wire, flux hopper, and often the control and operator ride on the manipulator.

Following are three rules concerning welding current:

- Increasing current increases penetration and melting
- Excessively high current produces a digging arc and
- Too low welding current produces an unstable

Self check-2	Multiple choice

Direction: Write true/false for the given questions

1. The wire grade and its content of alloying affect the mechanical properties

2. SAW flux shields the molten weld pool from the atmosphere

3. Fluxes have tendency to absorb moisture that affect the weld

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: _______________

.

Information sheet-3	Locking spools to holder, rollers and adjusting to correct tension

1. Mechanization aids

Equipment used for the longitudinal travel motion includes:

- Welding tractor that run directly on the sheet to be welded
- **A** welding head that can be mounted on a column and boom unit
- Powered rollers for rotating cylindrical work pieces

It may also be necessary to have some kind of equipment to guide travel along the joint. One simple method is to project a spot of light in front of the welding point, and for the operator to keep this centered on the line of the joint. Another method involves purely mechanical control, using support rollers etc. In the case of larger work pieces, it may be appropriate to have some type of automatic joint tracking control. A common principle is to have a sensor finger that rides in the joint ahead of the arc, to provide servo control of a crosshead that carries the welding head.

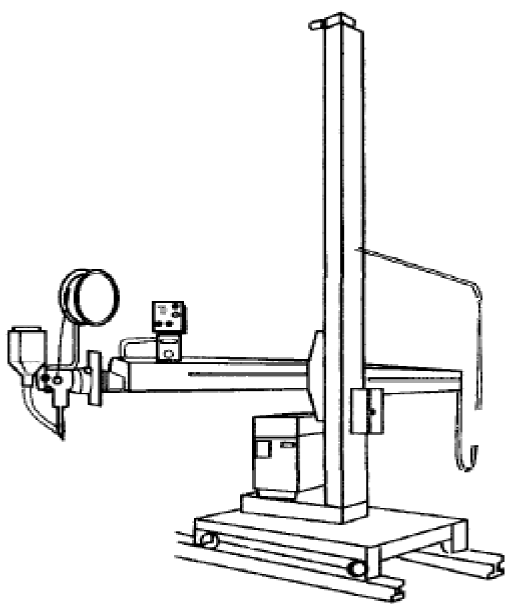

Figure 10: welding head fitted to a column and boom unit

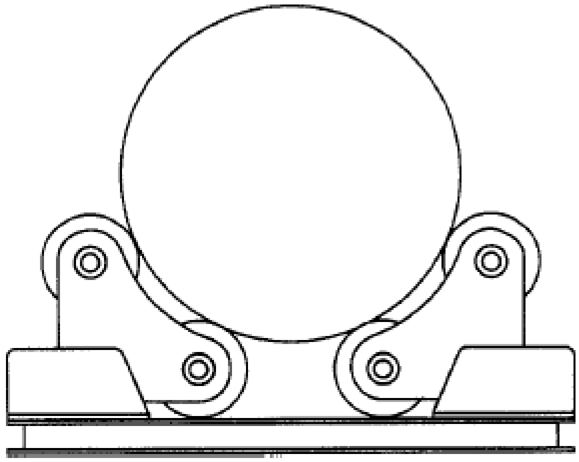

Figure 11: Roller beds that automatically adapt to the work piece diameter.

They are often used together with a column and boom unit. The rotational speed is controlled by the built-in motor.

Self check-3	True/false

Direction: write true/false for the given questions

1. Power rollers used to rotate cylindrical work pieces

2. Rollers are used together with a column and boom unit

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: ________

Information sheet -4	Installing flux recovery equipment and flux oven /heaters

1. Flux Recovery Units

Flux recovery units are frequently used to maximize flux utilization and minimize manual clean-up. Flux recovery units may do any combination of the following:

- Remove unused **flux** and fused slag behind the weld
- Screen out fused slag and other oversized material.
- Remove magnetic particles.
- Remove fines.
- Reticulate flux back to a hopper for reuse.
- Heat flux in a hopper to keep it dry.

2. Flux oven /heaters

The submerged arc welding heating over/heater is a particular sub-type of electric arc oven used to produce phosphorus and other products. Submerged arc oven mainly used for production of Ferro-alloys. The nomenclature submerged means that the heater electrodes are buried deep in the oven burden. A reduction action takes place near the tip of the electrodes to facilitate the heater process

Self check-4	Multiple choice

Direction: Select one of the appropriate answer from the given alternatives

1. Pick one of the use of flux recovery units

   A. to maximize electric consumption B. to maximize flux utilization

   C. to maximize oxidation of weld D. to maximize flux discharge

2. SAW flux oven/heater mainly used:

   A. for production of steel B. for production of cast iron

   C. for production of Ferro-alloys D. for production of HSS

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

1. Metal powder addition

Metal powder additions may increase deposition rates up to 70 percent. The technique gives smooth fusion, improved bead appearance, and reduced penetration and dilution. Metal powders can also modify the chemical composition of the final weld deposit. These powders can be added ahead of the weld pool or directly into the pool, either by gravity feed or using the magnetic field surrounding the wire to transport the powder. Testing of metal powder additions has confirmed that the increase in deposition rate does not require additional arc energy, does not deteriorate weld metal toughness nor increase risks of cracking. These tests also indicate that weld properties may be enhanced by control of resulting grain structures due to the lower heat input and restoration of diluted weld metal chemistries.

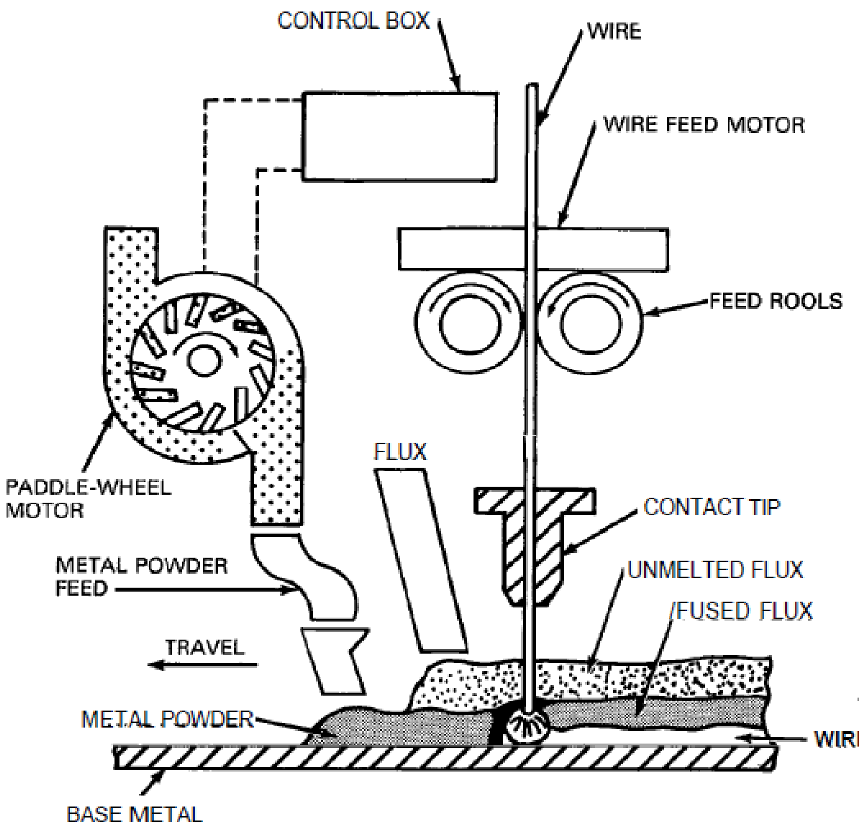

Figure12: Typical Metal Powder Addition Diagram

In submerged arc welding with iron powder addition can the deposition rate be substantially increased at constant electrical parameters? The increased deposition rate is realized by either the addition of a current less wire **(**cold wire**)** or of a preheated filler wire **(**hot wire). The use of a rectangular strip instead of a wire electrode allows a higher current carrying capacity and opens the SA method also for the wide application range of surfacing.

However, the mentioned process variations can be combined over wide ranges, where the electrode distances and positions have to be appropriately optimized. Current type, polarity, geometrical coordination of the individual weld heads and the selected weld parameters also have substantial influence on the weld result.

Self check-5	True/false

Direction: write true/false for the given questions

1. Metal powder addition in SAW may increase deposition rate
2. Addition of metal powder to weld pool causes weld cracking

Note: Satisfactory rating - 3 points   Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________   Date: _______________

List of reference materials

1. Fled, N. **A.** et al. "The role of filler metal wire and flux composition in submerged arc weld metal transformation kinetics: *Welding journal65 (5): 113s;* May *1986.*
2. Gowrisankar, I. et al. "Effect of the number of passes on the structure and properties of submerged arc welds of AIS1 type *316L* stainless steel: *Welding journal 66(5):147s-151s;* May *1987.*
3. Hantsch, H. et al. "Submerged arc narrow-gap welding of thick walled components." *Welding Journal 61(7): 27- 34;* July *1982.*
4. Hinkel, J. E., and Forsthoefel, F. W. "High current density submerged arc welding with twin electrodes: *Welding journal* **55(3):** *175-180;* March *1976.*
5. Indacochea, J. E. et al. "Submerged arc welding: Evidence for electrochemical effects on the weld pool." Welding journal 68(3): 77s-81s; March 1989.
6. Jackson, C. E. "Fluxes and slags in welding." Bulletin *190* New York: Welding Research Council, December *1973.*

Mechanics

Level-III

Learning Guide: 28

Unit of Competence: Perform Special Welding

Module Title: Performing Special Welding

Module Code: XXXXX

LG Code: XXXXX

TTLM Code: XXXXX

LO 4: Perform tack welding

Instruction Sheet	Learning Guide -28

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

- Fitting up Joints free foreign materials.
- Performing root gap.
- Performing tack welding.
- Performing tack welding visually and dimensionally.
- Installing backing plate, stiffener, running plate.

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

- Fit up Joints free foreign materials.
- Perform root gap.
- Perform tack welding.
- Perform tack welding visually and dimensionally.
- Install backing plate, stiffener, running plate.

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
- Accomplish the "Self-check "given
- Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1)

- If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
- Submit your accomplished Self-check. This will form part of your training portfolio

Information sheet-1	Joints are free from rust, paints, grease and other foreign materials prior to fit up or tacking.

1. Joint preparation

Submerged arc welding is suitable for welding sheet metal from about 1.5 mm thick and upwards, although it is mostly used for somewhat thicker materials. As the process is a mechanized method, the quality of joint preparation prior to welding is important. Insufficient attention to tolerances or cleaning will result in a defective weld. A clean, properly prepared joint also allows higher welding speeds to be used, with reduced cost of making good, which more than compensates for the more expensive preparation. Single-sided welding is often convenient, which usually involves some form of root support:

- A backing tongue of steel, which is allowed to remain after welding.
- A backing support in the form of a water-cooled copper bar.
- A flux bed in a grooved copper bar.
- A special ceramic backing support.

Double-sided welding means that there is no need to provide root support. The good penetration of submerged arc welding means that butt welds can be made in plate up to 15 mm thick without requiring a gap or joint preparation. Thicker materials require joint preparation in the form of V-shaped or X-shaped joint faces, perhaps also in conjunction with multiple weld passes.

Asymmetrical X-joint faces are used in order to even out distortion. The first pass is made in the smaller of the two gaps. As the weld metal cools and contracts, it pulls the plate slightly upwards along the line of the joint. Other types of joint include fillet joints, which are very common. Narrow gap welding is preferable for welding very thick materials.

The objective of edge preparation is to ensure the degree of penetration and ease of welding necessary to obtain sound welds. Type of preparation depends upon:

(*a*) type and thickness of material

(*b*) welding process

(*c*) degree of penetration required for the situation

(*d*) economy of edge preparation and weld metal

(*e*) accessibility and welding position

(*f*) distortion control

(*g*) type of joint.

Selfcheck-1	True/false

Direction: write true/false for the given questions

1. SAW is suitable for welding thicker materials

2. Cleaned and properly prepared joint cause defects on the weld

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: _______________

Information sheet-2	Performing root gap

1. Root gap

The plate edges must be tightly butted 91/32in max.gap) as with square butt joint. When the welding composition is retained by a support below the joint, slightly greater root pass are permissible. If the root gap exceeds 1/16in submerged arc welding flux should be tamped into a head of the weld. Square edges simplify assembly. Excellent penetration and reinforcement can be obtained and normal practical variation in voltage, current, welding speed, and edge preparation cause minimum damage to the backing

Joint designs especially for plate welding often call for a root opening of 1/32 to 1/16 in. (0.8 to 1.6 mm) to prevent angular distortion or cracking due to shrinkage stresses. However, a root opening that is larger than that required for proper welding will increase welding time and costs. This is true for both groove and fillet welding. Edge preparation may be done by any of the thermal cutting methods or by machining.

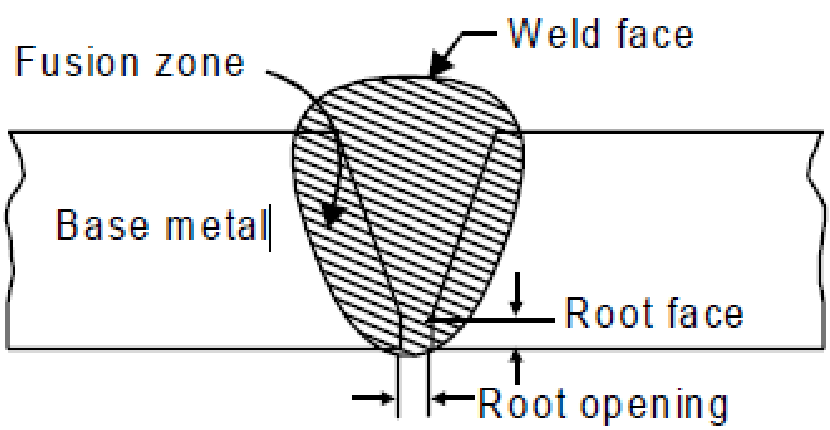

Figure 13: butt root gap

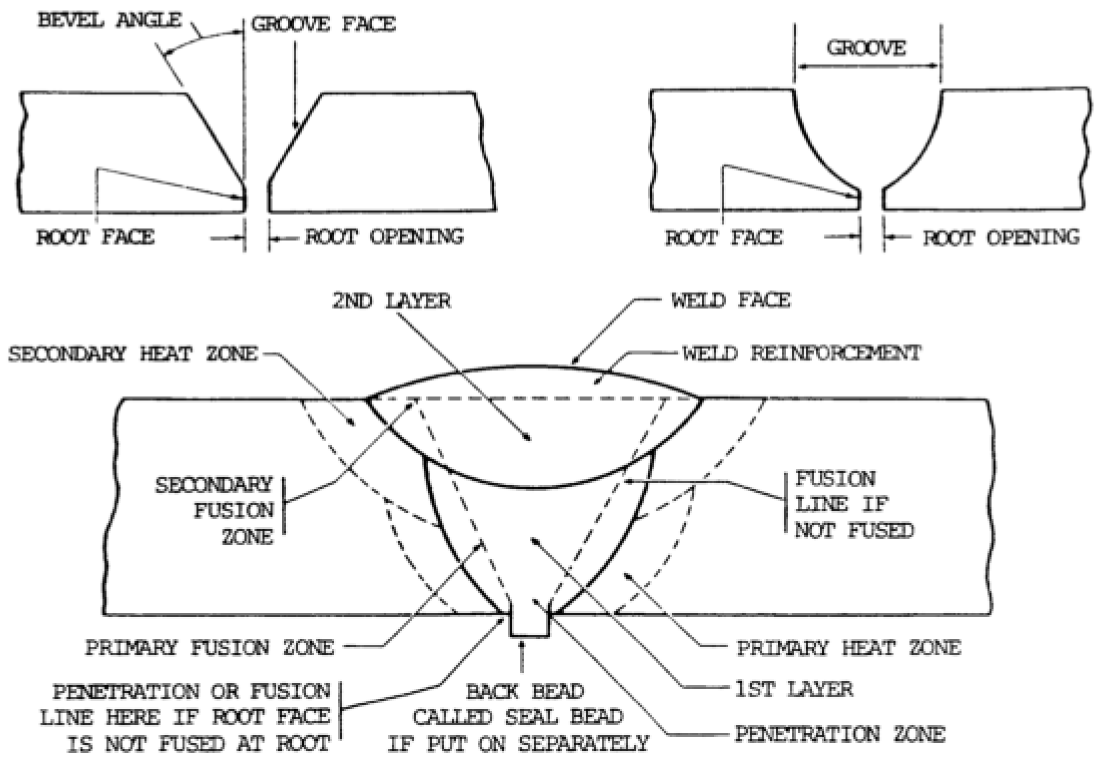

Figure 14: heat zone and root opening

Self check-2	True/false

Direction: Select one of the appropriate answers from the given alternatives

1. Identify one of the correct statements

   A. root gap can not affect weld quality
   B. root gap depends on edge preparation
   C. large root opening will provide good weld
   D. none

2. Root gap will be related to the welding variable:

   A. speed   B. current   C. voltage   D. all

Note: Satisfactory rating - 3 points   Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________   Date: _______________

1. Tack welding

Once fit-up is complete, it is time for placement of tack welds. A tack weld is a permanent weld used to fit up and hold the weld joint in place for welding. Tack welds are an integral part of the weld assembly. They must have complete joint penetration, and be large enough to hold the pipe rigidly in place to withstand expansion and contraction forces introduced during placement of the root pass. Otherwise, the weld joint will not stay properly aligned, or the root opening may close preventing fusion through the root of the joint.

Positioning of tack welds, both in number and location, is imperative to success in achieving complete joint penetration, meeting strength, and code requirements. Tack welds spaced equal distance and centered at the four quadrants of the pipe circumference for most small diameter pipe applications. For larger diameter pipe, more tack welds may be placed at intervals frequent enough to eliminate closing of the root opening. When welding pipe for procedure qualification or welder qualification, tack welds maybe placed at positions other than were test pieces are taken.

The final steps for finishing of tack welds are to clean by chipping and brushing, followed by grinding. Grind the weld to feather it out to a uniform, smooth contour. It is important to smooth out cold weld starts, where build-up is convex and likely too thick to accept fusion through the root of the subsequent root pass.

Self check-2	True/false

Direction: write true /false for the given questions

1. A tack weld is a permanent weld used to fit-up and hold the weld joint

2. Without making a tack weld joints can stay properly aligned

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: _______________

Information sheet-4	Performing tack welding visually and dimensionally acceptable

1. Joint fit-up

Joint fit-up is an important part of the assembly or subassembly operations, and it can materially affect the quality, strength, and appearance of the finished weld. Uniformity of joint alignment and of the root opening must be maintained. The accuracy of edge preparation is important, especially for machine or automatic welding. For example, if a joint designed with a 1/4 in. (6.4 mm) root face were actually produced with a root face that tapered from 5/16 to 1/8 in. (7.9 to 3.2 mm) along the length of the joint, the weld might be unacceptable because of lack of penetration at the start and excessive melt-through at the end. In such a case, the capability of the cutting equipment, as well as the skill of the operator,

Self check-4	True/false

Direction: write true/false for the given questions

1. Appearance of weld can be checked visually

2. Appropriate weld tacking may increase weld acceptance

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ____________

Rating: ____________

Name: ___________________________ Date: ________________

Information sheet-5	Installing backing plate, stiffener, running plate

1. Backing weld

Shops using SAW are advised to make edge preparations with automatic thermal cutting equipment (oxy-acetylene or plasma-arc), or by machining. In the absence of such facilities, SAW becomes a slow and unproductive operation with frequent interruptions and increased proportion of weld rectification

In SAW, the weld puddle is of large size and remains in a molten condition for a long time. The welding procedure must ensure that this molten puddle is supported and contained until it has solidified at the root of the weld. This precaution is a must when full joint penetration has to be achieved in a butt joint.

The various commonly used techniques involve use of the following:

- Base metal backing
- Structural backing
- Weld backing
- Backing strip
- Copper backing
- Flux backing
- Backing tapes

1. Base metal backing: The root face is kept sufficiently thick to support the weld pool without burn-through. This technique is used for square or partially beveled butt joints, for fillet welds and for plug or slot welds. Care has to be taken that the root faces of grove welds are in close contact. The first pass, deposited sometimes with lower current, acts as a backing for the second pass deposited with higher current to get through penetration

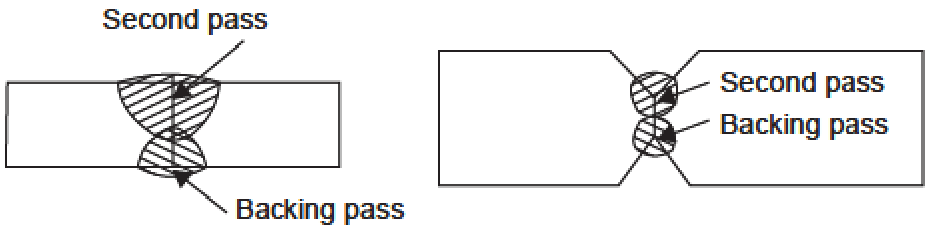

Figure 15: backing metals

2. Structure backing: In certain cases where design permits, another structural member can serve as a backing for the weld. It is very important that the contact surfaces of the joint are clean and the contact is intimate in order to avoid porosity and slag inclusions. The weld must also provide sufficient depth of fission in the backing member.

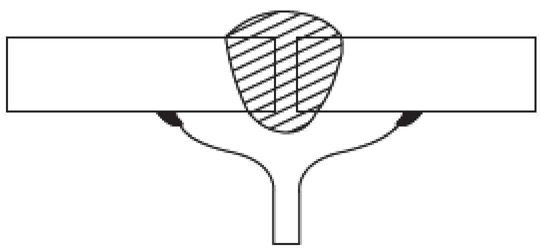

Figure 16: Structure backing for SAW

3. Weld backing: The backing weld is deposited at lower current and with a moderately penetrating arc using the manual arc, CO2 shielded are or flux-cored arc process. It may be in one or more passes to obtain sufficient depth to support the submerged-arc weld. The backing weld may be retained in the joint if it is of suitable quality. If otherwise, it may be removed by oxygen on arc gouging, by chipping or by machining after the submerged-arc welds have been deposited. The resulting groove is filled up with a submerged-arc weld.

4. Backing strip: The backing strip is of metal that is compatible with the one being welded. The weld metal fuses into the backing strip, so that it becomes an integral part of the joint. In this case, it is termed a permanent backing. In case it is intended to be a temporary backing, it may be removed finally by machining. Suitable root opening must be kept to ensure full penetration.

It varies between 1.6 and 4.8 mm, depending on joint thickness. It is important that the contact surfaces between the plates and the strip are clean and the contact is intimate; otherwise porosity and leakage of molten weld metal may occur.

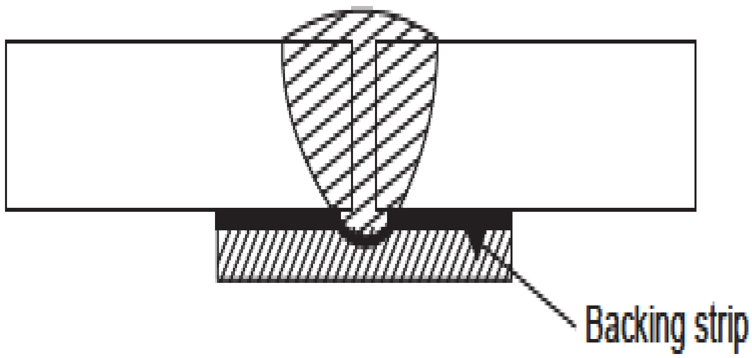

Figure 17: backing strip for SAW

5. Copper backing:

It has several advantages. Its high thermal conductivity enables it to extract the heat rapidly from the molten weld pool. Also the molten steel weld metal does not fuse with the copper material. Hence it only serves as a temporary backing. The copper backing bar is either as long as the joint; or it is of short length and designed to slide underneath the travelling arc. In still other applications, it may be in the form of a rotating wheel.

For high production applications, the copper bar is provided with internal water circulation to maintain it relatively cool. The bar is usually grooved as shown in the figure to obtain weld reinforcement on the underside of the joint. It is important to ensure that the copper bar has sufficient mass to prevent melting of the copper material, which can result in contamination of the weld with copper. It must be borne in mind that mechanical

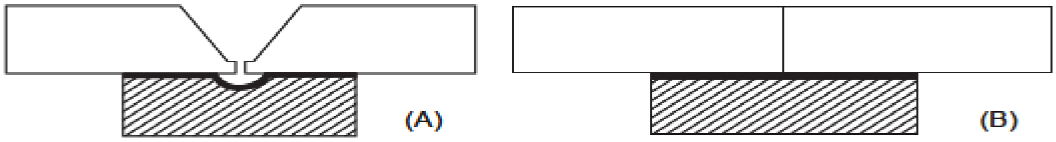

Figure 18: copper backing for SAW (A) V-groove butt (B) square butt

6. Flux backing: dry granular SA flux is placed in a trough of flexible sheet material. This sheet material rests on a rubberized canvas hose, which can be inflated to hold the flux tightly against the back of the joint.

7. Backing tapes: Ceramic back-up tapes consisting of a ceramic material on an aluminum foil backing are available in the USA. The exposed aluminum foil edges are covered with pressures sensitive adhesive covered with a removable liner. Lengths of strips are 0.5 to 1.0 meter. These can be easily applied to joints or seams to provide shielding or back-up for one side welding and root pass back-up for two-side welds to be deposited by TIG, MIG and other are processes. By using these tapes, are gouging and further backside joint operations such as grinding are eliminated or minimized. They avoid the use of expensive and clumsy fixtures, back-up bars and gas purging of weld.

8. Stiffening

Longitudinal shrinkage in butt welded seams often results in bowing, especially when fabricating thin plate structures. Longitudinal stiffeners in the form of flats or angles, welded along each side of the seam (Fig. 1) are effective in preventing longitudinal bowing. Stiffener location is important: they must be placed at a sufficient distance from the joint so they do not interfere with welding, unless located on the reverse side of a joint welded from one side

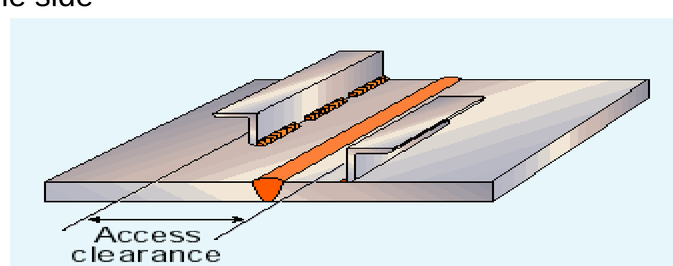

Figure 19: stiffener

Self check-5	True/false and multiple choice

Direction: write true/false for the given questions

1. Stiffeners support molten puddle to solidify at the root

2. Method of using running plate and stiffener increase productivity

1. Which one of the following indicates weld backing techniques in submerged arc welding

   A. base metal backing   B. structural backing

   C. copper backing   D. all

2. One of weld backing of metal that is compatible with the one being welded

   A. flux backing   B. backing strip   C. copper backing

   D. structural backing

B. Write true /false for the given questions

1. All weld backing can be used for all joints

2. Weld backing help to retain molten metal

Note: Satisfactory rating - 3 points   Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________   Date: _______________

List of reference materials

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2. Gowrisankar, I. et al. “Effect of the number of passes on the structure and properties of submerged arc welds of AIS1 type *316L* stainless steel: *Welding journal 66(5):147s-151s;* May *1987.*
3. Hantsch, H. et al. “Submerged arc narrow-gap welding of thick walled components.” *Welding Journal 61(7): 27- 34;* July *1982.*
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5. Indacochea, J. E. et al. “Submerged arc welding: Evidence for electrochemical effects on the weld pool.” *Welding journal 68(3): 77s-81s;* March *1989.*
6. Jackson, C. E. “Fluxes and slags in welding.” Bulletin *190* New York: Welding Research Council, December *1973.*

Mechanics

Level-III

Learning Guide: 29

Unit of Competence: Perform Special Welding

Module Title: Performing Special Welding

Module Code: XXXXX

LG Code: XXXXX

TTLM Code: XXXXX

LO 5: Perform special welds

Instruction Sheet	Learning Guide -29

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

- Performing root pass with WPS.
- Performing subsequent/filling passes.
- Performing capping with WPS.
- Performing exothermic welding with WPS.
- Performing task with approved WPS.

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

- Perform root pass with WPS.
- Perform subsequent/filling passes.
- Perform capping with WPS.
- Perform exothermic welding with WPS.
- Perform task with approved WPS.

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
- Accomplish the "Self-check "given
- Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
- If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
- Submit your accomplished Self-check.

1. Root pass

The root pass is the initial pass deposited after the parts are fit-up and tack-welded together. Where final visual inspection is concerned, the root pass and the cover or cap-pass is the decisive factors for determining whether or not welding was successful. If the pipe has been prepared with the correct groove design and fit-up and the tack welding has been done correctly, welding the root pass can proceed. It is important to start the initial weld of the root pass by starting the arc at least ¼ inches back (overlapping) on the tack weld and progress forward from there. This will allow the weld pool to develop, creating enough heat to cause proper melt through and fusion with the tack weld and tie into the keyhole. This same method must be repeated with each tie-in (restart) to complete the root pass.

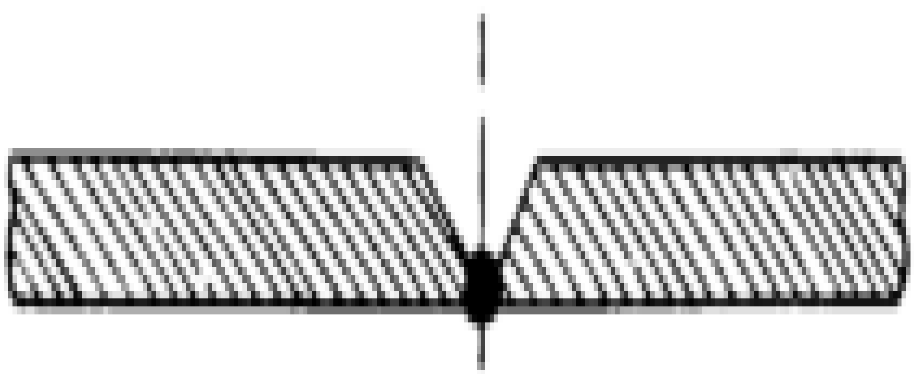


Figure 20: root pass

Self check-1	True/false

Direction: write true/false for the given questions

1. The root pass is the initial deposited after the parts are fit-up.

2. Root pass can be performed without tacking

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

1. Fill pass

Once the root pass is completed, it must be cleaned thoroughly to ensure that any slag, cold starts, or any other irregularity, which may reduce fusion in the next passes, are removed. Inter pass cleaning–chipping, wire brushing, and grinding are necessary steps in producing sound welds. When using EXX10 and EXX11 class electrodes with SMAW, a hot pass may be used after brushing and grinding. Due to the turbulent nature of the arc, electrode manipulation, and narrow groove faces of the joint root, these electrodes tend to leave a weld face that can be more difficult to clean than those of welds made with low-hydrogen-type electrodes. A hot pass is a second pass, at higher welding currents, used to help eliminate and float out any difficult to remove slag particles.

After the root pass and hot pass (if needed) are completed, the groove is filled by layering with overlapping weld beads. Fill passes are used to complete the interior portion of multi pass groove welds. Fill passes are used to nearly fill the groove, leaving only enough space for the cap passes, the final weld layer. It is necessary to maintain an even layer-by-layer approach at this stage.

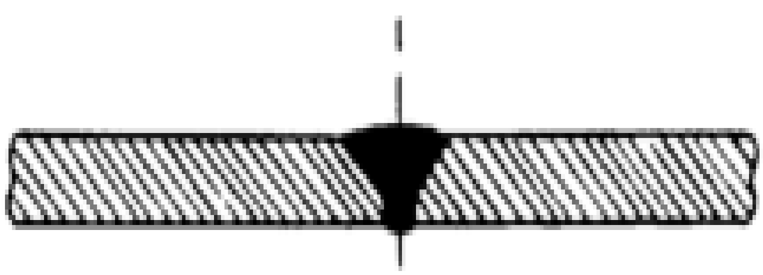


Figure 21: fill pass

Self check-2	True/false

Direction: write true/false for the following questions

1. Fill passes used to complete the interior portion of multi pass groove welds
2. Fill passes are used to nearly fill the groove

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: _______________

Information sheet-3	Performing capping in accordance with WPS and/or client specifications

1. Capping

The cap pass is the final visible weld layer on a multi pass groove weld. Several factors must be met for the final weld and weld layer to be acceptable. First of all, the weld penetration including reinforcement has a minimum thickness equal to the base metal thickness. Second, the reinforcement height cannot exceed code requirements, and in most cases, this is 1/8” maximum. The cap pass width should be as narrow as possible while filling the groove completely. Finally, the weld must have a smooth transition to the base metal at the weld toes.

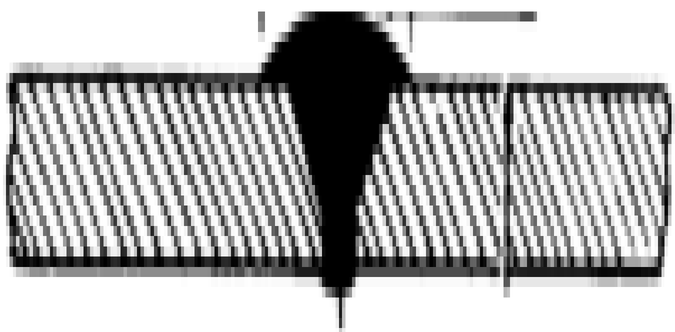


Fig.1. capping

Self check-3	True/false

Direction: write true/false

1. The cap pass is the final pass weld layer
2. The cap pass width should be as narrow as possible

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: _______________

Information sheet-4	Performing exothermic welding in accordance with WPS and/or client specifications

1. Exothermic welding

Exothermic welding, also known as exothermic bonding, termite welding (TW)and termite **welding** is a welding process that employs molten metal to permanently join the conductors. The process employs an exothermic reaction of a termite composition to heat the metal, and requires no external source of heat or current. The chemical reaction that produces the heat is an alumina thermal reaction between aluminum powder and a metal oxide.

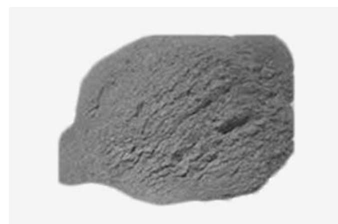
Exothermic weld has higher mechanical strength than other forms of weld, and excellent corrosion resistance. It is also highly stable when subject to repeated short-circuit pulses, and does not suffer from increased electrical resistance over the lifetime of the installation. However, the process is costly relative to other welding processes, requires a supply of replaceable moulds, suffers from a lack of repeatability, and can be impeded by wet conditions or bad weather (when performed outdoors)Properties

In other words exothermic weld is a joining technique used to create a permanent connection between two metallic components. It involves a chemical reaction that generates heat, known as an exothermic reaction. This process is particularly noted for the durability of the bond produced and for preserving good electrical conductivity between the joined components. Creating a bond by exothermic weld typically involves heat created by a chemical reaction between some type of heavy metal oxide and a reducing agent. For example, iron oxide is a commonly used metal oxide and aluminum is a common reducing agent. These reactants produce heat extremely rapidly when ignited, thereby achieving the high temperatures needed for welding. Such heating is generally initiated once the parts to be joined are fitted together in a mold which contains the materials and the reaction as it takes place. Filler metal in liquid form is produced by this reaction and mixes with melted metal from the parts being joined to form a bond shaped by the mold. Molds used in exothermic weld may be made of graphite, ceramic, or other appropriate materials.

Exothermic Weld Camp Handler

Exothermic Welding Flit Gun

Exothermic Welding Slug Removal Tool



Exothermic Welding Powder

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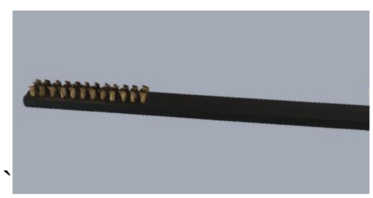

Exothermic Welding File Brush

Exothermic Welding Flame

	True/false

 Self check-4	

Direction: write true/false

1. Exothermic weld has lower mechanical strength than other forms of weld

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ___________

Rating: ___________

Name: _________________________ Date: _______________

Information sheet-5	Performing task in accordance with approved WPS

1. Performing task to the standard

The welder must take care not to over grind and remove too much of the tacks weld. This may result in melting the tack weld completely out and the root faces pulling together, reducing root fusion. In the case of welding aluminum, GTAW tack welds are preferred over GMAW tack welds. Cold starts can be a problem with GMAW and this may obstruct fusion in the root pass. Use of a welding power source with a "hot start" function can help to reduce this problem.

The method of attachment and the location of the work lead connection are important considerations in submerged arc welding since they can affect the arc action, the quality of the weld, and the speed of welding. **A** poor work lead location can cause or increase arc blow, resulting in porosity, lack of penetration, and poor bead shape. Testing may be necessary since it is often difficult to predict the effect of the work lead location. Generally, the best direction of welding is away from the work connection.

There may be a tendency for the welding current to change slowly in welding long seams. This can happen because the path and electrical characteristics of the circuit change as the weld progresses. **A** more uniform weld can frequently be obtained by attaching work leads to both ends of the object being welded. When the longitudinal seam of a light gage cylinder is welded in a clamping fixture with copper backing, it is usually best to connect the work lead on the bottom of the cylinder at the start end. If this is not possible, then the work lead should be attached to the fixture at the start end.
It is undesirable to connect the work lead to a copper backing bar, because the welding current will enter or leave the work at the point of best electrical contact, not necessarily beneath the arc. If the current sets up a magnetic field around some length of the backing bar, that may cause arc blow. When current return is through a sliding shoe, two or more shoes should always be used. This will prevent interruptions of current.

Self check-5	True/false

Direction: write true/false

1. Work lead connection can affect the arc action

2. A poor work lead connection decrease arc blow

3. A more uniform weld can frequently be obtained by proper attachment

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Score = ____________

Rating: ____________

Name: ___________________________ Date: ________________

List of reference

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Mechanics
Level-III

Learning Guide: 30

Unit of Competence: Perform Special Welding

Module Title: Performing Special Welding

Module Code: XXXXX

LG Code: XXXXX

TTLM Code: XXXXX

LO 6: Assure weld quality and clean up

Instruction Sheet	Learning Guide -30

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

- Checking and repairing weld defects.
- Making visually acceptable weld.
- Observing OHS procedures.

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

- Check and repairing weld defects.
- Make visually acceptable weld.
- Observe OHS procedures.

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
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- If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
- Submit your accomplished Self-check. This will form part of your training portfolio.

1. Risks of weld defects

Hydrogen embrittlement: This is also referred to as hydrogen cracking, hardening cracking or cold cracking. The cracks occur in the **HAZ,** close to the melt boundary as the material cools, sometimes several hours after welding. The effect is caused by a combination of shrinkage stresses, hydrogen diffusing in from the weld metal and the formation of the hard martensite phase structure in the metal.

A drawback of all welding processes involving protection by flux is the risk of moisture absorption and the resulting increased risk of cold cracking. The flux should be properly stored in order to keep it *dry.* Materials having high carbon equivalents and thicknesses must be welded at elevated temperatures, in accordance with the relevant rules.

Hydrogen is introduced from the molten pool through moisture or hydrogen containing elements on the surface of the parent metal. The hydrogen diffuses from the weld bead to the adjacent regions of the heat affected zone. Fast cooling in combination with steels with higher strength can give hardening effect. If hydrogen is present there is a great risk for hydrogen cracking. Thick plates and low heat input gives high cooling rate and this increases the risk for hydrogen cracking. **An** increased operating temperature of the work piece and carefully dried consumables is an important way to assure the quality.

Pores can be caused by several factors, such **as:**

- Moisture in the flux
- Dirt on the work piece, such as rust or paint.

Problems with pores have a tendency to increase if the molten metal cools rapidly.

Pinholes are due to the release of gas (mainly hydrogen) during solidification of the metal, i.e. during primary crystallization. The gas is unable to escape sufficiently easily from the weld metal, but is retained in the metal and acts as nuclei around which the metal solidifies. Pinholes form in the middle of the weld, running along it like a string of beads.

Pinhole formation can be reduced by reducing the speed of welding, carefully cleaning the surface of the weld joint prior to welding.

Poor impact strength due to grain growth occurs in connection with slow cooling.

The high performance and good penetration of submerged arc welding it is best to weld even so thicker materials with as few passes as possible. However, this results in high yield energy, so it may be better to make several passes when welding difficult materials.

Solidification cracks, also called hot cracks arise **as** the material cools, if certain combinations of unfavorable conditions occur

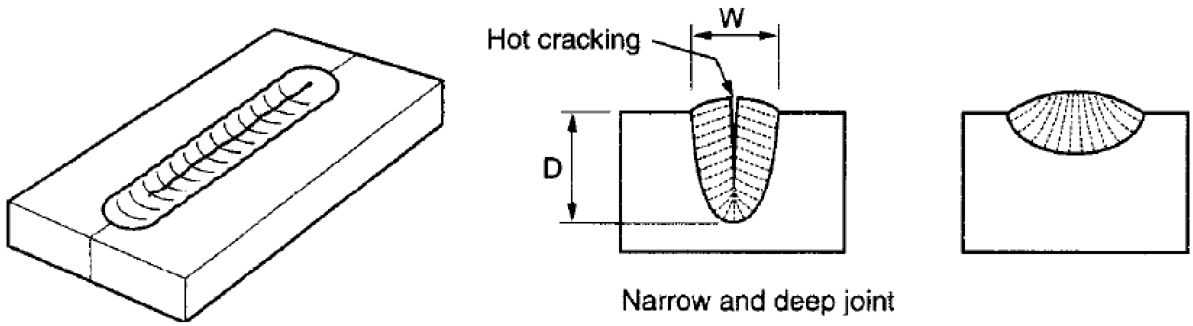


Figure 22: Solidification cracks may appear when the weld is deep and narrow

Undercutting is a defect that indicates that the appropriate voltage range for the process has been exceeded. Too low voltage results in a narrow high weld convexity. Increasing the voltage makes the weld wider, but too high a voltage can easily cause undercutting at the edge of the convexity. Too high a linear speed along the weld can cause both a high convexity and undercutting together. The undercut will appear when the weld metal doesn't fill up the cavity that is cut by the arc. It is most often troublesome in connection with welding of upright fillet joints, where it occurs in the web.

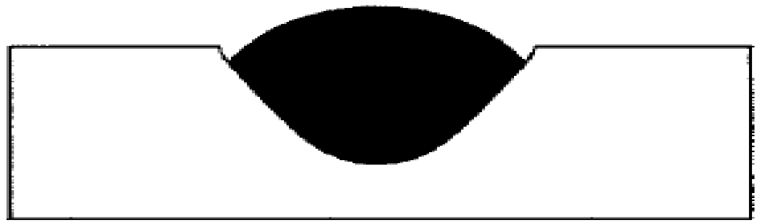


Figure 23. Too high voltage or welding speed may result in undercuts

Slag inclusions are uncommon in automatic welds. If they do occur, it is usually between the passes in multi-pass welds. When making such welds in thick plate, care must be taken to remove all traces of slag.

Uneven weld bead will be the result if welding current is high in comparison to the wire diameter - about **1100 A** or more. This is caused by the high arc pressure on the weld pool. The result of this effect is that the penetration is excessive for the wire size in use, causing the molten metal to be ejected over the edge of the joint and sometimes also causing lack of fusion.

If the current for a wire is in excess of the recommended value, it is necessary to change up to the next wire size

1.1. POROSITY PROBLEMS

Submerged arc deposited weld metal is usually clean and free of injurious porosity because of the excellent protection afforded by the blanket of molten slag. When porosity does occur, it may be found on the weld bead surface or beneath a sound surface. Various factors that may cause porosity are the following:

- Contaminants in the joint
- Electrode contamination
- Insufficient flux coverage
- Contaminants in the flux
- Entrapped flux at the bottom of the joint

- Segregation of constituents in the weld metal
- Excessive travel speed
- Slag residue from tack welds made with covered Electrodes

As with other welding processes, the base metal and electrode must be clean and dry. High travel speeds and associated fast weld metal solidification do not provide time for gas to escape from the molten weld metal. The travel speed can be reduced, but other solutions should Le investigated first to avoid higher welding costs. Porosity from covered electrode tack welds can be avoided by using electrodes that will not leave a porosity-causing residue.

Recommended tack weld electrodes are E6010, E6011, E7016, and E7018.

1.2. CRACKING PROBLEMS

Cracking of **welds** in steel is usually associated with liquid metal cracking (center bead cracking). Cause may be traced to the joint geometry, welding variables, or stresses at the point where the weld metal is solidifying. This problem can occur in both butt welds and in fillet welds, including grooves and fillet welds simultaneously welded from two sides. One solution to this problem is to keep the depth of the weld bead less than or equal to the width of the face of the weld. Weld bead dimensions may best be measured by sectioning and etching a sample weld. To correct the problem the welding variables or the joint geometry must be changed. To decrease the depth of penetration compared to the width of the face of the joint, the welding travel speed as well as the welding current can be reduced.

Cracking in the weld metal or the heat-affected zone may be caused by diffusible hydrogen in the weld metal, The hydrogen may enter the molten weld pool from the following sources: flux, grease or dirt on the electrode or base metal, and hydrogen in the electrode or base metal.

Cracking due to diffusible hydrogen in the weld metal is usually associated with low alloy steels and with increasing tensile and yield strengths. It sometimes can occur in carbon steels. There is always some hydrogen present in deposited weld metal, but it must be limited to relatively small amounts. **As** tensile strength increases, the amount of diffusible hydrogen that can be tolerated in the deposited weld decreases.

Cracking due to excessive hydrogen in the weld is called *delayed cracking,* it usually occurs several hours, up to approximately 72 hours, after the weld has cooled to ambient temperature. Hydrogen will diffuse out of the base metal at elevated temperatures [above approximately
200°F (93"C)I without resulting in cracking. It is at ambient temperatures that hydrogen accumulated at small defects in the weld metal or base metal results in cracking.
To keep the hydrogen content of the weld metal low:

- Remove moisture from the flux by baking in an oven (follow the manufacturer's recommendations).
- Remove oil, grease, or dirt from the electrode and base material.
- Increase the work temperature to allow more hydrogen to escape during the welding operation. This may be done by continuing the "preheat" until the seam is completely welded, or by post heating the weld joint for several hours before letting it cool to ambient temperature.

Self check-1	Multiple choice

Direction: Select one of the correct answers.

1. Pores can be caused by:

A. moisture B. dirty on the work
C. rapidly cooling D. all

2. Pin holes are due to:

A. release of gases B. base metal code
C. diameter of electrode D. all

Information sheet-2	Making weld acceptable in accordance with applicable codes and standards

1. Weld Quality

As the welded joints are finding applications in critical components where the failure results into a catastrophe, the inspection methods and acceptance standards are increasing. Acceptance standards represent the minimum weld quality and are based upon test of welded specimens containing some discontinuities; usually a safety factor is added to yield the final acceptance standard. A good research effort is being directed to correlate the discontinuities with the performance.

It is important to deal with the weld discontinuities commonly observed in the welds, their causes, remedies and their significance. Small imperfections, which cause some variation in the normal average properties of the weld-metal are called discontinuities.

When the discontinuity is large enough to affect the function of the joint it is termed a defect. Standard codes do permit limited level of defects based on fracture mechanics principles, taking consideration the service conditions of the fabrication.

Self check-2	True/false

Direction: write true/false

1. Inspection increase the acceptance of weld quality

2. Standards help to deal with weld quality

Information sheet-3	*Observing OHS procedures*

1. Safety recommendations

Operators should always wear eye protection to guard against weld spatter, arc glare exposure, and flying slag particles. Power supplies and accessory equipment such as wire feeders should be properly grounded. Welding cables should be kept in good condition. Certain elements, when vaporized, can be potential dangerous. Alloy steels, stainless steels, and nickel alloys contain such elements as chromium, cobalt, manganese, nickel, and vanadium. Material safety data sheets should be obtained from the manufacturers to determine the content of the potentially dangerous elements and their threshold limit values. For many of these elements the limit is *1.0* milligram per cubic meter or less.

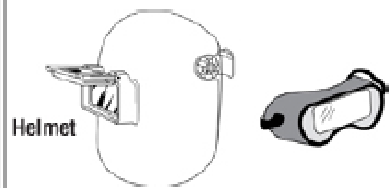
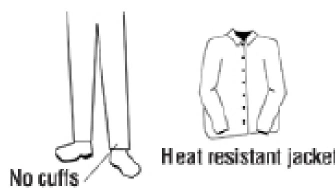
The submerged arc process greatly limits exposure of operators to air contaminants because few welding fumes escape from the flux overburden. Adequate ventilation will generally keep the welding area clear of hazards. The type of fan, exhaust, or other air movement system will be dependent on the work area to be cleared. The various manufacturers of such equipment should be consulted for a particular application.

1.1. Safety tips for using protective clothing

Wear clothing made from heavyweight, tightly woven, 100% wool or cotton to protect from UV radiation, hot metal, sparks and open flames. Flame retardant treatments become less effective with repeated laundering.

- Keep clothing clean and free of oils, greases and combustible contaminants.
- Wear long-sleeved shirts with buttoned cuffs and a collar to protect the neck. Dark colors prevent light reflection.
- Tape shirt pockets closed to avoid collecting sparks or hot metal or keep them covered with flaps.

- Pant legs must not have cuffs and must cover the tops of the boots. Cuffs can collect sparks.
- Repair all frayed edges, tears or holes in clothing.
- Wear high top boots fully laced to prevent sparks from entering into the boots.
- Use fire-resistant boot protectors or spats strapped around the pant legs and boot tops, to prevent sparks from bouncing in the top of the boots.
- Remove all ignition sources such as matches and butane lighters from pockets. Hot welding sparks may light the matches or ignite leaking lighter fuel.

Welding - Personal Protective Equipment			
Body Part	**Equipment**	**Illustration**	**Reason**
Eyes and face	Welding helmet, hand shield, or goggles		Protects from: • radiation • 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 Notes: 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 plugs where sparks or splatter may enter the ear.

1.3. Prevention of exposure to Welding Gases

It is important to follow manufacturer's instructions, MSDSs, and safety protocols to minimize the hazards of welding gases.

- Use substitute materials such as water based cleaners or high flash point solvents.
- Cover the degreaser baths or containers
- Do not weld on surfaces that are still wet with a degreasing solvent.
- Do not weld near degreasing baths

Self check-3	Multiple choice

Direction: Select one of the appropriate answer from the given alternatives

1. One of the following PPE used to protect eyes and face

   A. ear muffs B. hand shield C. fume D. apron

2. PPE used to protect:

   A. eyes B. hands C. face D. all

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