Shielded Metal Arc Welding (SMAW) Techniques

Unit: Structural Systems

Problem Area: Metal Fabrication

Lesson: Shielded Metal Arc Welding (SMAW) Techniques

Student Learning Objectives.

Instruction in this lesson should result in students achieving the following objectives:

1. **Identify SMAW equipment and safety procedures.**
2. **Describe how to select shielded metal arc welding equipment and supplies.**
3. **Explain how to prepare metal for welding.**
4. **Identify and demonstrate the safety practices that should be observed when working with shielded metal arc welding.**
5. **Describe and demonstrate the procedures and techniques for shielded metal arc welding.**

Resources.

The following resources may be useful in teaching this lesson:

E-unit(s) corresponding to this lesson plan. CAERT, Inc. http://www.mycaert.com.

Herren, Ray V. *Agricultural Mechanics: Fundamentals & Applications*, 6th ed. Cengage Learning, 2010.

Jeffus, Larry. *Metal Fabrication Technology for Agriculture*, 2nd ed. Cengage Learning, 2012.

Equipment, Tools, Supplies, and Facilities

- ✓ Overhead or PowerPoint projector
- ✓ Visual(s) from accompanying master(s)
- ✓ Copies of sample test, lab sheet(s), and/or other items designed for duplication
- ✓ Materials listed on duplicated items
- ✓ Computers with printers and Internet access
- ✓ Classroom resource and reference materials

Key Terms.

The following terms are presented in this lesson (shown in bold italics):

- alternating current (AC)
- amperage
- arc length
- arc welding
- conductor
- crater
- direct current (DC)
- duty cycle
- electricity
- electrode
- electrons
- fillet weld
- groove weld
- padding
- polarity
- resistance
- shielded metal arc welding
- surface weld
- voltage
- weaving
- weld root
- welder
- welding
- weldor

Interest Approach.

Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

> *Show students a broken machinery part. Then ask how the broken piece might be repaired. Lead a class discussion concerning the repair of the part or*

replacement of it. If the part is to be repaired, have students list the skills needed to complete the job.

CONTENT SUMMARY AND TEACHING STRATEGIES

Objective 1: Identify SMAW equipment and safety procedures.

Anticipated Problem: What equipment and safety procedures are used in SMAW?

I. Basic fundamentals of welding must be understood.

A. ***Welding*** is the melting, flowing together, and freezing of metals under controlled conditions.

1. ***Arc welding*** is a process that uses electricity to heat and melt metal. The process operates in a closed electric circuit in which electrons flow from a source—the welder—and return to the source when the circuit is completed. When the electrode is brought in close contact with the base metal, an electric arc jumps the gap to complete the circuit. The arc reaches temperatures around 6,500°F. The high temperature melts the base metal and filler metal, thus joining them and creating the weld.
2. A ***weldor*** is a person doing the welding.
3. A ***welder*** is the machine doing the welding.
4. ***Shielded metal arc welding*** is welding in which fusion is produced by heating with an arc between a consumable stick electrode and the workpiece.
5. An ***electrode*** is a bare metal rod usually coated with chemical compounds called flux. The flux coatings burn in the intense heat and form a blanket of smoke and gas that shields the weld puddle from the air.
6. The electrode holder is a spring-loaded clamp mechanism used to hold the electrode and make it part of the circuit. The holder is attached to the welder by an insulated cable, and the handles of the holder are insulated to protect the weldor.
7. A ground clamp is a spring-loaded clamp attached to the table or project. The ground clamp is needed to complete the circuit by being attached to the welder. The ground clamp is not insulated because it does not pose a shock hazard.

B. A basic understanding of electrical terms is necessary to fully understand shielded metal arc welding. Because SMAW involves working with electricity and heat, numerous safety procedures must be followed.

1. ***Electricity*** is the flow of tiny particles called electrons through a conductor.
2. ***Electrons*** are negatively charged particles.

3. A ***conductor*** is an item that allows the flow of electrons.
4. ***Voltage*** is a measure of electrical pressure.
5. Most welders operate on a 220-volt source. A welder changes or transforms the 220-volt pressure to a much lower pressure at the electrode, usually between 15 and 25 volts.
6. ***Amperage*** is a measure of electrical current flowing through a circuit and is an indication of the heat being produced. The amount of current available is determined by the amperage setting on the welder.
7. ***Polarity*** is the direction in which the current is flowing.
8. ***Resistance*** is the opposition to the flow of current in a circuit. It is what causes the electric energy to be transformed into heat.
9. When electricity is conducted through a conductor, the movement of the electric energy heats the conductor due to the resistance of the conductor to the flow of electric current through it.
10. The greater the flow of current through a conductor, the greater the resistance to it, and the greater the heat generated (the higher the amperage setting, the greater the heat produced).
11. ***Alternating current (AC)*** is a situation in which electrical current alternates or reverses the direction of electron flow.
12. The arc is extinguished every half-cycle as the current passes through zero, usually at the rate of 120 times per second.
13. ***Direct current (DC)*** is a situation in which electrons flow in one direction. Direct current is straight polarity (DCSP) or reverse polarity (DCRP). It can be called direct current electrode negative (DCEN) and direct current electrode positive (DCEP).
    a. When the electrons flow from the electrode to the workpiece, it is straight polarity or electrode negative.
    b. When the electrons flow from the workpiece to the electrode, it is reverse polarity electrode positive.

C. The art of welding is ancient, but the science of shielded metal arc welding is relatively new.
1. 1801—An English scientist discovered that an electric current would form an arc when forced across a gap.
2. 1881—A French inventor used the carbon arc.
3. 1887—A Russian inventor improved on the carbon arc and patented the process.
4. 1887—Another Russian discovered that a bare metal rod would melt off by the heat of the arc and act as filler metal in a weld.
5. 1889—A North American experimented with the metallic arc and received a patent. A bare electrode was difficult to use and resulted in a weld that was porous, brittle, and not as strong as the base metal.
6. 1910—A Swede found that welds were stronger and easier to make when a chemical coating was put on the metal electrode. The coating was called flux

because it cleaned the metal and aided in mixing the filler metal with the vase metal. However, it was difficult to apply.

7. 1927—A mass production method was developed to apply the flux to the bare metal rod.

Teaching Strategy: *Use VM–A through VM–C for lecture and discussion. An alternative approach is to transfer the information from the lesson to a multimedia presentation. Use text material to strengthen student understanding of concepts.*

Objective 2:

Describe how to select shielded metal arc welding equipment and supplies.

Anticipated Problem: How are equipment and supplies selected for use with shielded metal arc welding?

II. Several types of equipment and supplies exist.

A. Welding machines are classified in several ways, such as:

1. The type of output current produced by the welder, AC, DC, or AC/DC
2. The service
   a. A limited input welder provides satisfactory operation and is fairly inexpensive to operate. The cost is about a dollar per ampere of output.
   b. A limited service welder is used where lower cost is desired because the operation is quite intermittent.
   c. An industrial welder has a high-duty cycle, but the price is much higher.
3. Power source
   a. An electric motor-driven welder is self-contained and requires three-phase power. Electric power runs the motor, which turns a generator to produce DC welding current.
   b. An internal combustion engine drives a generator that produces the power for the welder to run.
   c. A line voltage welder runs on the power supplied by the power company.
4. ***Duty cycle*** is the percentage of a 10-minute period that a welder can operate at a given current setting and is another way to classify welders. A welder with a 60 percent duty cycle can be operated safely for 6 minutes of a 10-minute cycle repeated indefinitely.
5. When buying a new welder, a person should consider only one made by a well-known manufacturer and distributed by a reliable dealer.
   a. It is necessary to check the nameplate to see if the welder is National Electrical Manufacturers Association (NEMA) rated and approved and listed by Underwriters Laboratories (UL).
   b. It is important to compare prices of welders, equal capacity, and the kinds of accessories available.
   c. The guarantee should be read carefully, and questions should be asked.

B. Several other pieces of equipment and supplies are necessary to operate the shield metal arc welder.

1. Two cables, No. 2 gauge, are required.
2. The electrode holder grips the electrode during welding. It should be completely insulated and should have a spring-grip release. In addition, the jaws hold rods in 60-, 90-, 120-, and 180-degree positions in relation to the handle.
3. The ground clamp is fastened to the work or to the welding table.
4. The chipping hammer—with a straight peen and straight cone with a spiral wire-grip—is necessary to remove slag from the weld bead.
5. A wire brush is used to clean dirt, rust, and slag from metal.
6. Pliers are needed for handling hot metal. Welding gloves will be ruined by touching hot metal because moisture will be drawn out, so the leather will harden and shrink.
7. Safety glasses or goggles are required to protect the operator's eyes when chipping hot slag and grinding or cleaning metal for joint preparation.
8. Full gauntlet leather gloves should be worn.
9. Upper body protection is necessary to protect against rays, heat, spatter, and slag while welding.
10. A head shield is needed for protection from the rays of the electric arc as well as the heat and spatter of the molten metal.
11. It is important to use clearly labeled filter lenses with standard shade numbers and to be sure they meet the specifications of the welding being performed. For instance, a No. 10 lens meets applications up to 200 amps.
12. Electrodes convey electric current from the welding machine into a hot arc between its tip and the metal being welded.
13. Electrodes are covered with flux that provides four important functions:
    a. Flux protects the molten metal from the atmosphere.
    b. The flux covering burns in the intense heat of the arc, forming a blanket or shield of gas around the bead. Air contains oxygen and nitrogen that would combine with the metal to cause it to be brittle and weak.
    c. Flux mixes with the weld metal, floating the impurities to the top in the form of slag. Slag covers the bead to protect it from the air and to slow the rate of solidification and cooling.
    d. Flux stabilizes the arc. After the arc is started, current flows across the gap between the end of the electrode and the work.
14. Current does not jump the gap. It is conducted by a mass of ionized gas.
15. Gas is produced when chemical substances are vaporized by the heat of the arc.
16. Two classifications of electrodes are The American Welding Society (AWS) and the American Society for Testing Materials (ASTM). They have set up standard numerical classifications for most electrodes.

17. Every electrode has been assigned a specific symbol, such as E7014.
    a. The “E” indicates the electrode is used for electric welding.
    b. The first two digits of a four-digit number indicate tensile strength in thousands of pounds per square inch.
18. An E7014 electrode produces a weld with 70,000 psi of tensile strength.
19. An E6011 electrode produces a weld with 60,000 psi of tensile strength.
    a. If the number has five digits, the first three digits indicate tensile strength.
    b. The next-to-last digit indicates the welding position for which the electrode is recommended.
    c. The last digit indicates the operating characteristics of the electrode.
20. The National Electrical Manufacturers Association (NEMA) has adopted color marking for some classes.

Teaching Strategy: *Use text material to strengthen student understanding of concepts. An alternative approach is to transfer the information from the lesson to a multimedia presentation.*

Objective 3: Explain how to prepare metal for welding.

Anticipated Problem: How is metal prepared for welding?

III. One of the most important and most often neglected parts of a welding job is metal preparation.

A. The metal must be free of dirt, grease, rust, paint, and other impurities that may combine with a molten weld bead and cause it to be weakened. Metal should be cleaned by grinding, brushing, filing, or cutting before welding.

B. Preparing the correct type of joint for each kind of metal is crucial to securing strong welded structures.

1. The basic types of joints are the butt, lap, tee, corner, and edge. These joints may be applied to the various weld types: fillet, groove, plug, slot, and surface.
    a. A tee weld is a type of fillet weld. The ***fillet weld*** is a weld that has two surfaces at right angles, and the bead is triangular in shape.
    b. The ***groove weld*** is a weld made in a space between the two pieces of metal to be joined.
    c. The plug and slot welds are used to join pieces that overlap. The welds are placed in plug or slot holes. These types of welds commonly take the place of rivets in welded structures.
    d. The ***surface weld*** is a bead deposited on a metal surface for the purpose of building up the base metal.
2. The square butt joint is used on metal sections no thicker than $^{3}/_{16}$ inch. This joint is strong in tension loads but is not good for repeated loads and impact forces.

3. The single V butt joint often is used on plate steel $^3/_8$ inch to $^3/_4$ inch in thickness. This joint is strong in loads with tension forces but is weak in loads that bend at the ***weld root***, which is the bottom of the weld groove opposite the weld face.
4. The single-bevel butt joint is used on metals from $^1/_8$ inch to $^1/_2$ inch in thickness, and the bevel is 45 degrees.
5. The double V butt joint is fine for all load conditions and is often used on metal sections over $^3/_4$ inch in thickness.
6. The lap joint is a type of fillet weld. Its strength depends on the size of the weld bead.
7. The single lap joint is one of the stronger weld joints. It is used on metal up to $^1/_2$ inch in thickness.
8. The double lap joint is almost as strong as the base metal.
9. The T-joint is a fillet weld and can be used on metals up to $^1/_2$ inch in thickness. It can withstand strong longitudinal shear forces. The T-joint can be square, beveled, or double beveled.
10. The corner joints can be flush, half-open, or full-open.
    a. The flush corner joint is primarily used on sheet metal.
    b. The half-open joint can be used on metals heavier than sheet metal and for joints that will not have large fatigue or impact loads. This joint can be welded from one side.
    c. The full-open corner joint is used for the metals that will carry heavy loads; can withstand large fatigue and impact loads; and can be welded on both sides.
11. Edge joints are used for metals less than $^1/_4$ inch in thickness and can only sustain light load applications.

Teaching Strategy: *Use VM–D through VM–H. An alternative approach is to transfer the information from the lesson to a multimedia presentation. Use text material to strengthen student understanding of concepts.*

Objective 4:

Identify and demonstrate the safety practices that should be observed when working with shielded metal arc welding.

Anticipated Problem: What are the safety practices that should be observed when performing shielded metal arc welding?

IV. The following are suggested practices and tips that will minimize or eliminate shop accidents when arc welding.

A. A welding helmet should be worn. In addition, leather or special fabric gloves should be worn at all times when arc welding to protect from hot electrodes, particles of spatter and slag, and the metal being welded.

B. High-top shoes should be worn to protect feet and ankles from burns caused by weld spatter. Clothing with turned up cuffs should not be worn. In addition, a collar and pockets should be kept buttoned. Also, ragged, oily, and/or greasy clothing should not be worn. Welding when skin is exposed (e.g., without a shirt or wearing a short-sleeve shirt or shorts) is dangerous because of the increased risk of burns. If leather clothing is not available, woolen clothing should be worn rather than cotton. Wool does not ignite as readily, so it and provides better protection.

C. Welding cables should be inspected for broken insulation and frayed conductors. The electrode holder and ground clamps should be checked for positive connections before beginning to weld. Loose connections and grounds may prove to be dangerous. A dry wooden platform should be provided to stand on, or rubber-soled shoes should be worn where damp floors may be present.

D. All combustible materials should be cleared away from the welding area before beginning to weld. Flying sparks from the spatter may ignite combustible material several feet from the welding operation. Therefore, the welding area should be cleared of rags, straw, paper, shavings, and other combustible items before starting.

E. Matches, lighters, papers, and cellophane wrappers should be kept out of pockets because these items ignite quickly and/or may explode.

F. An exhaust system should be turned on before beginning to weld. Welding fumes soon spread to all parts of the shop and may be injurious when inhaled. Special measures should be taken to avoid noxious fumes that occur when welding or cutting metals containing zinc. Inhaling zinc fumes will cause an ill feeling for several hours after welding.

G. It is critical not to strike an arc before covering the face and eyes with a protective shield or helmet. The ultraviolet light rays given off by the arc are the same as those transmitted by sunlight, except they are more intense and concentrated. Exposure to these rays will cause a severe burn. Eye irritation and burns will result if eyes are not shielded.

H. Other workers should be protected by using a welding screen to enclose the area. People standing nearby should be warned. For instance, a weldor may say “cover,” so people cover their eyes before someone strikes an arc.

I. People should avoid looking directly at the arc without protecting their eyes. The rays can penetrate through closed eyelids if welding is performed at a close range. Contact lenses should not be worn while welding or around a welder.

J. It is important not to weld barrels, tanks, or other containers that may have held combustible material. These operations are best performed by professional weldors.

K. It is critical not to chip slag from a weld unless the eyes of the weldor and those of others nearby are protected by safety glasses.

L. It is important to be alert for fires at all times. Because the operator’s helmet is lowered and vision is obscured, clothing may catch on fire without being noticed. Human senses of touch, smell, and hearing may indicate that something is wrong.

In case of a clothing fire, a weldor should remove the clothing, if possible. Running fans the flames, so it should be avoided. A person may wrap himself or herself in a fire blanket or improvise with a coat or a piece of canvas. If there is nothing at hand to wrap in, the person should drop to the floor and roll slowly.

M. All hot metal should be handled with tongs or pliers to prevent burning hands or gloves. All hot metal should be placed where no one will come in contact with it. People should develop the habit of feeling all metal cautiously before picking it up. Hot metals should not be left where anyone may touch or step on them.

N. It is necessary to guard against clothing saturation by perspiration or moisture because this increases the shock hazard.

O. The welder should be disconnected when being repaired or adjusted.

P. The welder should always be unplugged, and all equipment should be put away when finished for the day.

Q. In case of eye or skin burns, first-aid treatment should be sought. All burns and injuries should be reported immediately to the instructor.

R. Fuel tanks and fuel lines should be protected with wet sheet asbestos when welding near motors or power units. Accumulations of dry trash, husks, lint, and chaff should be cleaned off of farm machinery before welding. Also, the paint on machinery may start to burn from the heat of welding.

Teaching Strategy: *Look online for relevant videos, such as https://www.youtube.com/watch?v=nGlsqp5kKUk, to share with your class.*

Objective 5:

Describe and demonstrate the procedures and techniques for shielded metal arc welding.

Anticipated Problem: What are the procedures and techniques for shielded metal arc welding?

V. Good welds can be attributed to correct selection and manipulation of the electrode and welding current.

A. The following skills must be performed in unison to achieve a weld of acceptable quality.

1. The proper amperage setting for any welding job is necessary to achieve good penetration with minimum spatter. Correct amperage can be identified somewhat by sound.

a. When the amperage is correct, a sharp crackling sound can be heard.

b. A humming sound will indicate too low of an amperage setting. As a result, the deposited electrode will pile up, leaving a narrow high bead that has poor penetration and little strength.

c. A popping sound will indicate too high of an amperage setting. As a result, the bead will be flat with excessive spatter. The electrode will become red hot, and the metal along the edge of the bead will be undercut.

2. The correct amp setting depends on the thickness of the base metal and the diameter of the electrode.
3. Learning to maintain the correct arc length for the electrode being used is necessary to be successful.
    a. ***Arc length*** is the distance from the tip of the bare end of the electrode to the base metal.
    b. Arc length is equal to the diameter of the bare end of the electrode.
4. The correct angle of the electrode will depend on the type of weld to be completed. It is important to hold the electrode at a 90-degree angle to the work, called work angle, as viewed from the end of the two plates being joined, and 5 to 15 degrees in the direction of travel called travel angle.
5. The correct speed of travel affects the amount of electrode deposited and the uniformity of the bead. It should produce a bead 1.5 to 2 times the diameter of the bare end of the electrode.

B. Following proper procedures when preparing to weld and striking the arc will develop confidence.
1. It is essential to prepare the work area so everything is ready and convenient before starting.
2. A final check should be made to ensure flammable materials are out of the way and unnecessary tools are not lying around.
3. The machine must be turned off.
4. The machine must be set to the desired amperage.
5. The bare end of the electrode should be inserted in the electrode holder and held about 1 inch above the metal at the point where the weld is to be started.
6. Then the welder should be turned on.
7. The helmet should be lowered over the eyes of the weldor. Next, the electrode should make contact with the work and then be withdrawn slightly.
    a. Current jumps the small gap, thereby creating the electric arc.
    b. The moment the arc is struck, the concentration of intense heat—estimated between 6,000° and 9,000°F—melts the base metal and the end of the electrode to form a molten metal pool called a ***crater***.
8. The following methods are used in starting the arc:
    a. A striking movement is similar to striking a match.
    b. A tapping movement is an act in which the electrode is quickly tapped on the surface of the metal to prevent it from sticking to the base metal.
    c. If the electrode is not instantly pulled away, it will fuse with the base metal and stick.
    d. If the electrode is pulled too far away, the arc will be extinguished.
9. It is important to raise the tip of the electrode to about $^{3}/_{16}$ inch above the base metal. This forms a long arc that is held for a three count to preheat the base metal.
10. It is necessary to lower the electrode to the correct arc length.

C. To make a wider bead or when doing out-of-position welding, weaving or oscillating movements should be used. These movements usually require more time, and the beads are shorter per inch of electrode used.
    1. ***Weaving*** is running a bead with a sideways or oscillating motion. It is used when covering a wide area with weld metal or to maintain a large molten weld crater.
    2. ***Padding*** is the process of building up several layers of weld deposit by running overlapping passes. Padding is used to rebuild worn pieces by building up the piece to an oversized condition and grinding or machining it to the correct size.

D. Four positions are used when welding: flat, horizontal, vertical, and overhead. The flat position produces stronger welds than any other position.

E. Distortion, warping, and cracking are major concerns when welding because of forces that cause their shape or position to change.
    1. During the welding process, the arc heats the area being welded, causing it to become larger or to expand. As heat is removed, the surrounding metal and air cause a cooling effect upon the heated area. This results in the metal becoming smaller or contracting. There is no way to avoid the laws of expansion and contraction.
    2. Several methods can be used to control distortion.
        a. A tack weld can be used. In this case, a short bead is placed at the edge of the end being welded to. The length of the tack weld should be twice the thickness of the base metal. It is important to avoid over-welding by using as little weld metal as possible for the necessary strength.
        b. Intermittent welding should be practiced. In this case, short beads are run, and spaces are skipped between them. It is necessary to run short passes and to allow them to cool before running the next pass.
        c. The back step method should be used. In this method, each short pass is started ahead and run back into the previous weld.
        d. The contraction of one bead can be balanced by the contraction of another.
        e. A weldor should carefully hammer or peen a weld deposit to stretch the weld and make up for contraction due to cooling.
        f. It is necessary to clamp material in a jig or to another rigid support during welding and cooling.
        g. The materials being welded should be preheated. Preheating makes welding easier and decreases the possibility of cracks.

Teaching Strategy: *Use VM–I through VM–K. Assign LS–A.*

Review/Summary. Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. If a textbook is being used, questions at the ends of chapters may be included in the Review/Summary.

Application. Use the included visual master(s) and lab sheet(s) to apply the information presented in the lesson. Before attempting the lab activities, proper safety precautions in the agriculture mechanics shop must be covered thoroughly.

Evaluation. Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance, on the application activities. A sample written test is attached.

Answers to Sample Test:

Part One: Matching

1. i
2. e
3. j
4. g
5. b
6. h
7. d
8. f
9. c
10. a

Part Two: Completion

1. direct current (DC)
2. padding
3. Arc length
4. 1.5, 2
5. thickness, diameter
6. alternating current (AC)
7. Resistance
8. weaving

Part Three: Short Answer

1. Amp setting, arc length, angle of electrode, and speed travel
2. It protects molten metal from the atmosphere, mixes with weld metal and floats impurities to the top, and stabilizes the arc.
3. The two cables are the electrode holder and ground clamp. The electrode holder holds the electrode and is insulated to protect the weldor. The ground clamp is clamped to the work table or workpiece and completes the circuit when welding.

Sample Test

Name _____

Shielded Metal Arc Welding (SMAW) Techniques

Part One: Matching

Instructions: **Match the term with the correct definition.**

a. arc length
b. arc welding
c. duty cycle
d. electricity
e. electrode
f. polarity
g. resistance
h. welder
i. welding
j. weldor

_____1. The melting, flowing together, and freezing of metals under controlled conditions

_____2. A bare metal rod usually coated with chemical compounds called flux

_____3. A person doing the welding

_____4. The opposition to the flow of current in a circuit

_____5. A process that uses electricity to heat and melt metal

_____6. The machine doing the welding

_____7. The flow of tiny particles called electrons through a conductor

_____8. The direction in which the current is flowing

_____9. The percentage of a 10-minute period that a welder can operate at a given current setting and is another way to classify welders

____10. The distance from the tip of the bare end of the electrode to the base metal

Part Two: Completion

Instructions: **Provide the word or words to complete the following statements.**

1. Electron flow in one direction is called _____.
2. The process of building up several layers of weld deposit by running overlapping passes is known as _____.
3. _____ is equal to the diameter of the bare end of the electrode.
4. Correct speed of travel should produce a bead that is _____ to _____ times the diameter of the bare end of the electrode.
5. Correct amp setting depends on the _____ of the base metal and the _____ of the electrode.
6. When electrical current alternates or reverses, the direction of electron flow is called _____.
7. _____ is what causes the electric energy to be transformed into heat.
8. Running a bead with a sidewise or oscillating motion is called _____.

Part Three: Short Answer

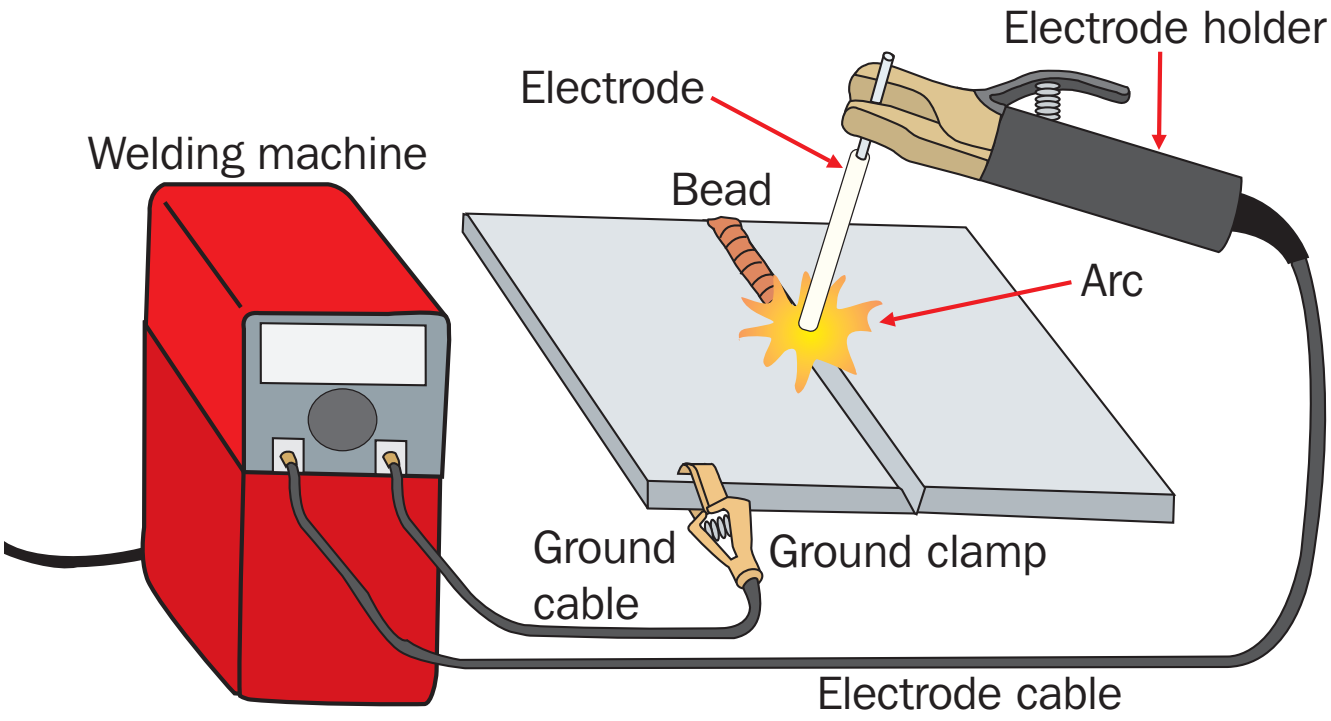
Instructions: **Answer the following.**

1. What are the requirements of a good weld?

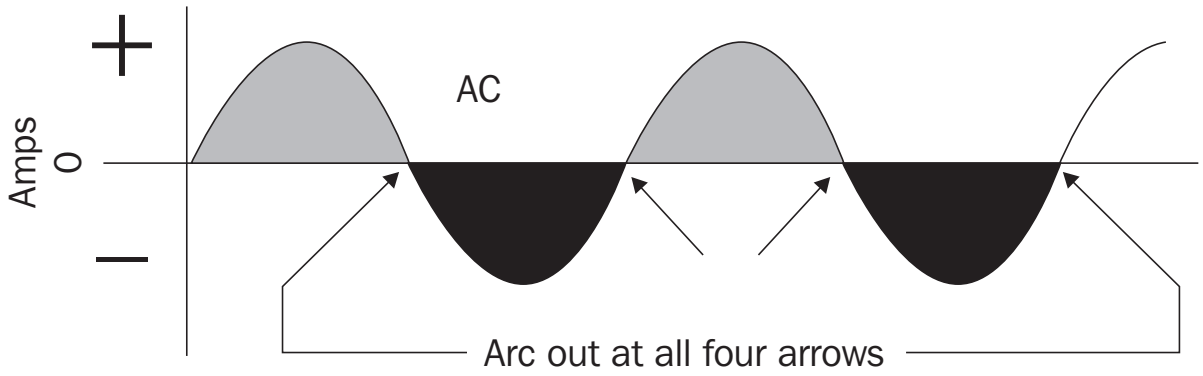
2. What are the three functions of flux?

3. What are the two cables attached to the welder, and what do they do?

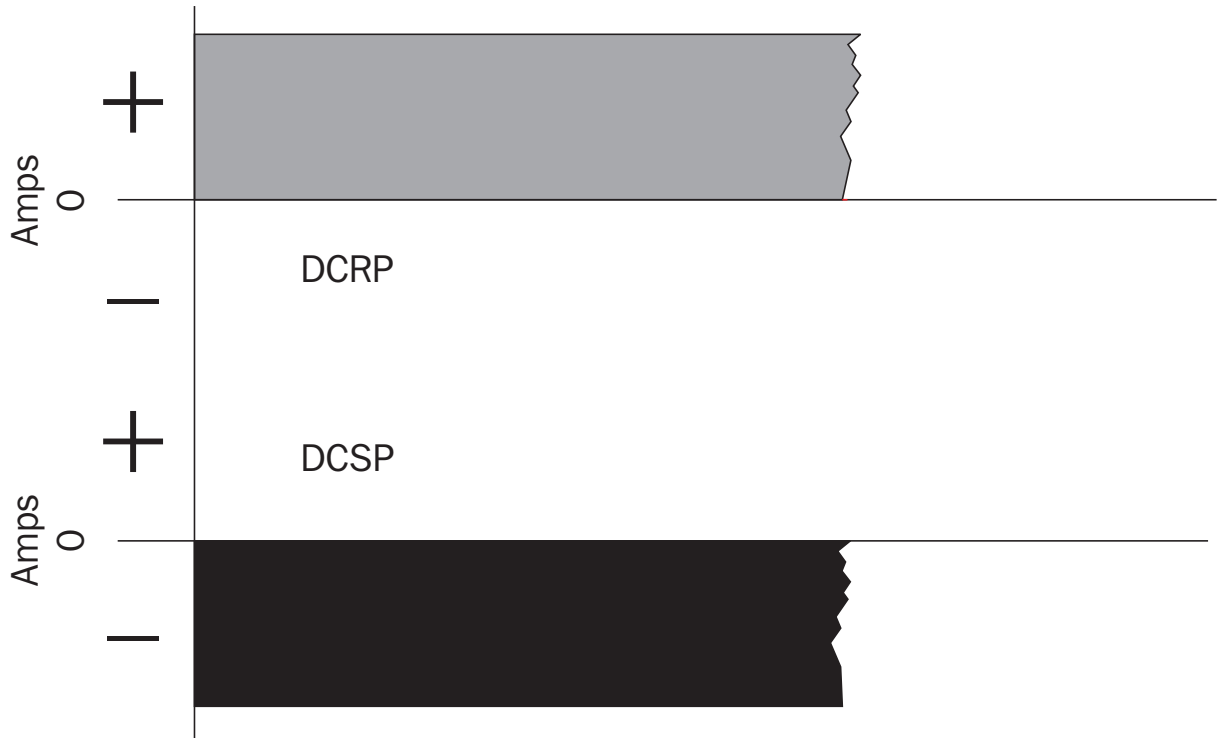
COMPONENTS OF AN ARC WELDING SYSTEM



AC AND DC CURRENT

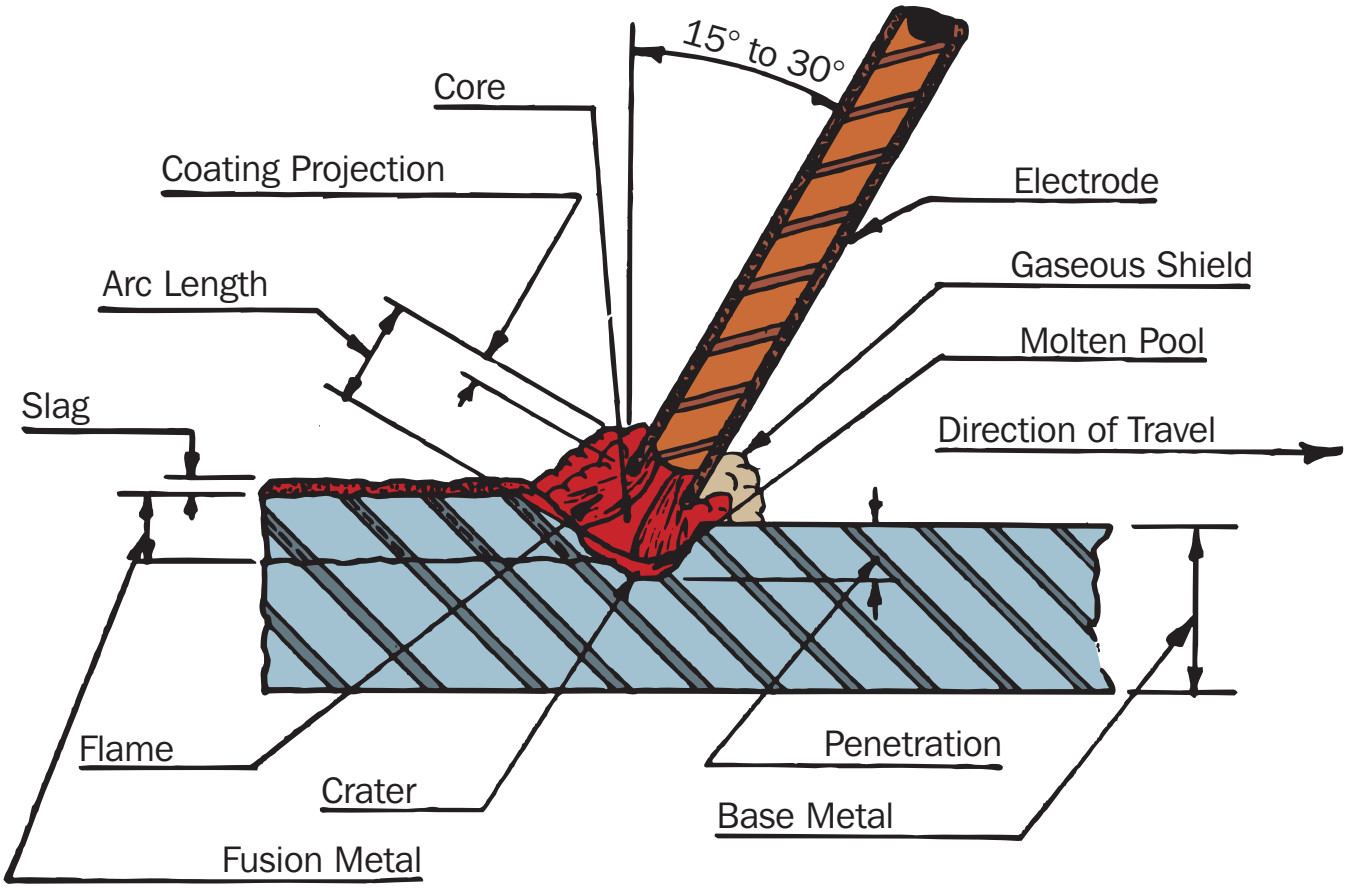


The arc is extinguished every half-cycle in AC welding.

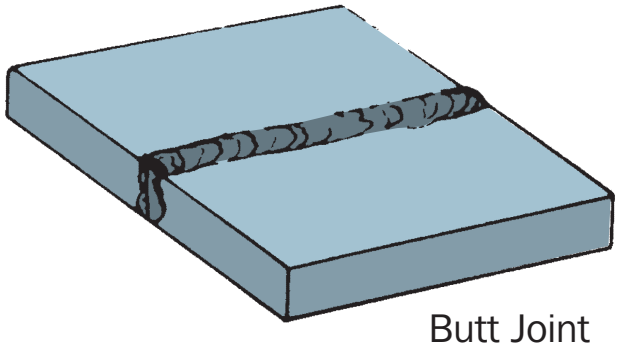


Current flow for reverse and straight polarity

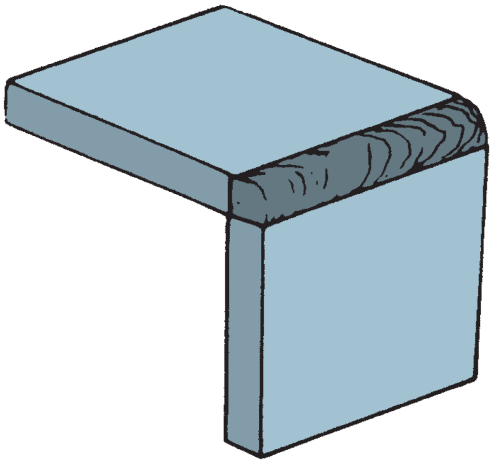
SHIELDED METAL ARC WELDING



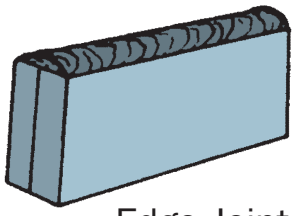
COMMON WELDS



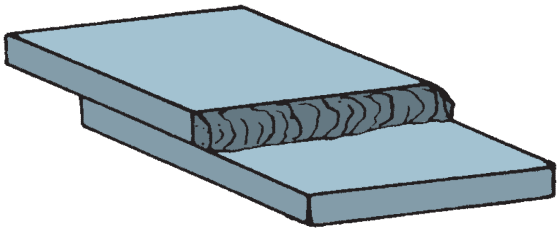
Butt Joint



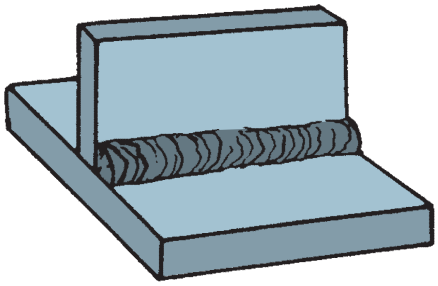
Corner Joint



Edge Joint

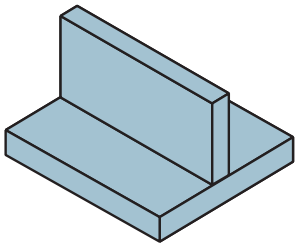
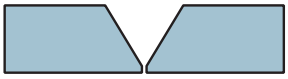
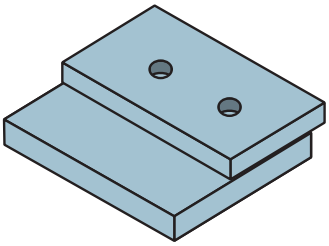
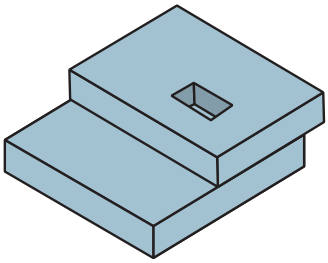
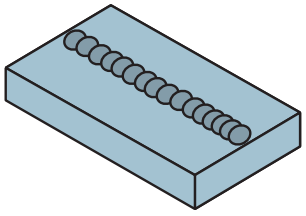


Lap Joint

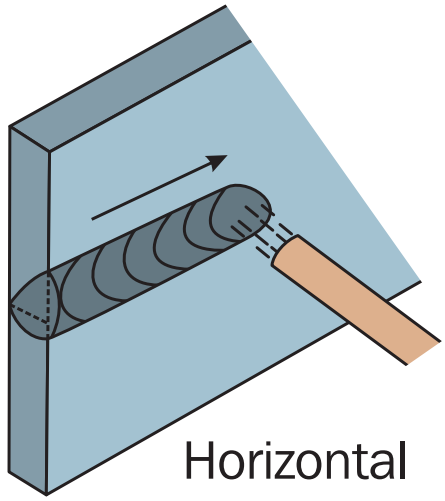


Tee (Fillet) Joint

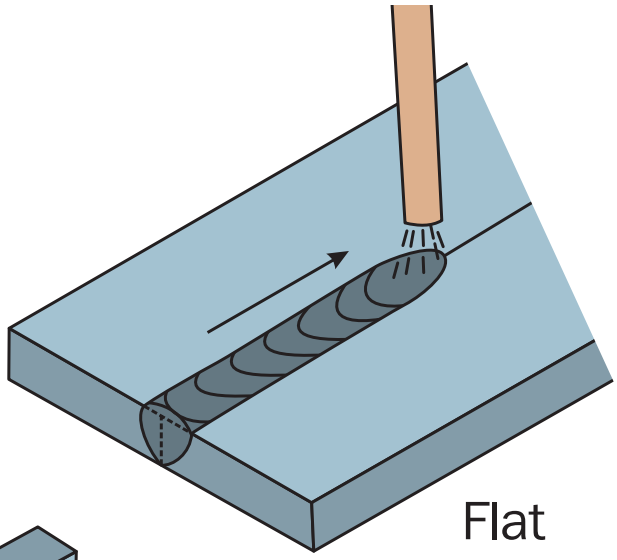
MAJOR TYPES OF WELDS

Major Types of Welds	Example	Other Common Joints
Fillet		Tee Lap
Groove		Single V Double V Single Bevel Double Bevel Single U Double U Single J Double J
Plug		
Slot		
Surfacing		

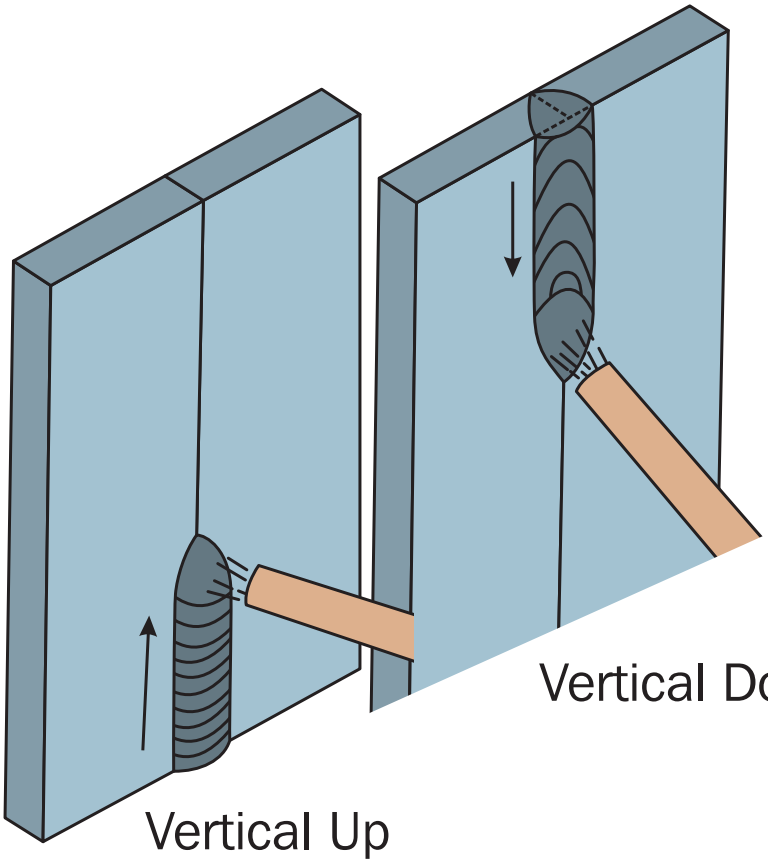
BASIC WELDING POSITIONS



Horizontal

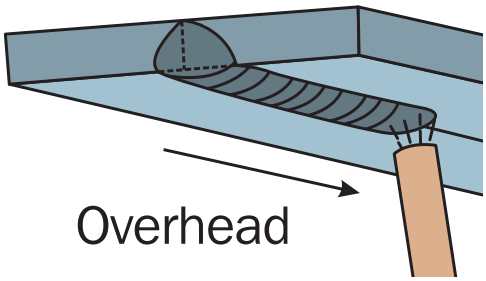


Flat



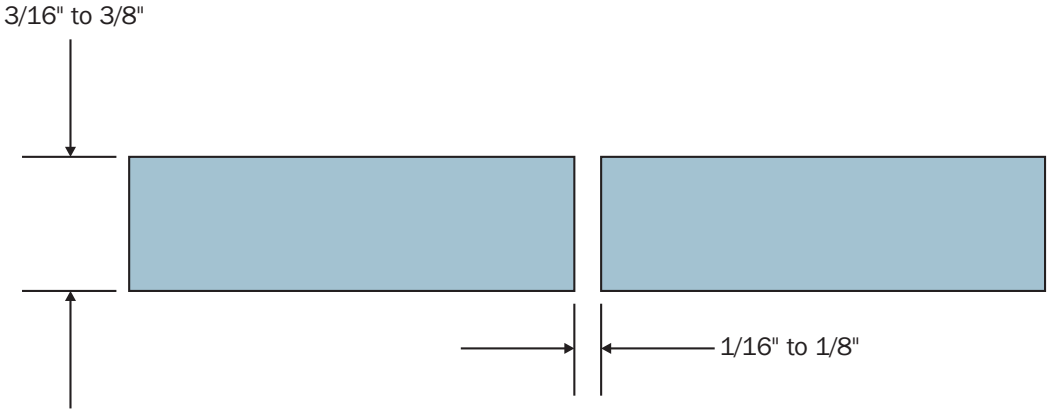
Vertical Up

Vertical Down

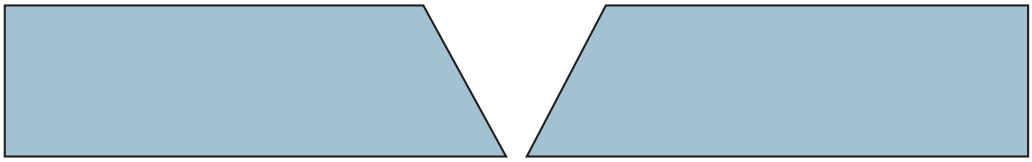


Overhead

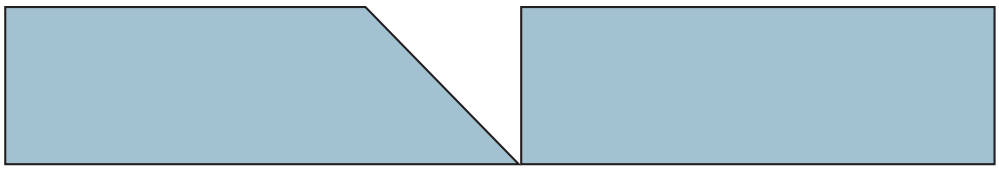
COMMON JOINTS USED IN WELDING



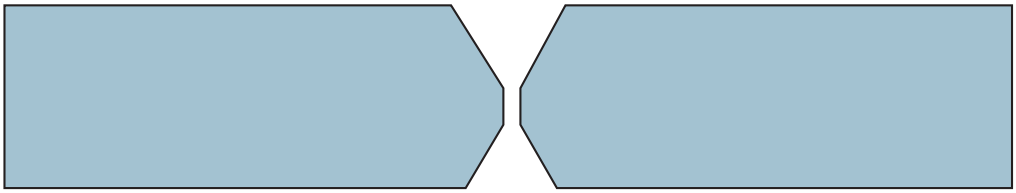
Square butt joint with a 1/16" to 1/8" root gap.



Single-V butt joint.

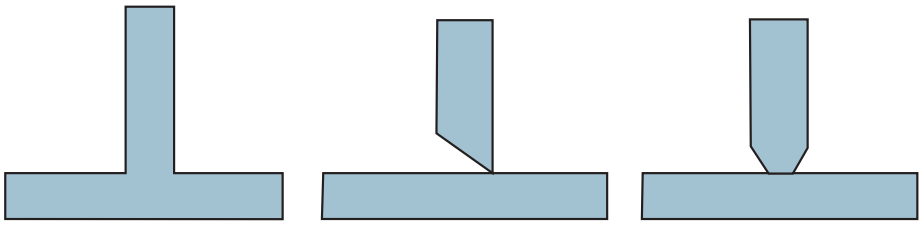


Single-bevel butt joint.

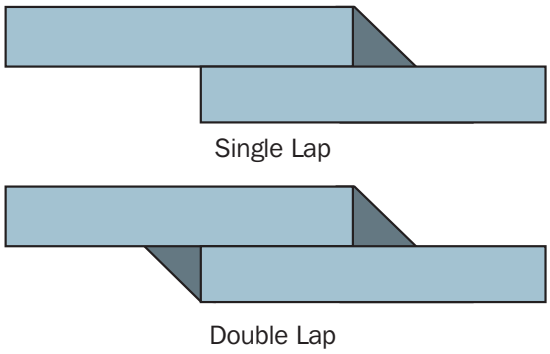


Double-V butt joint.

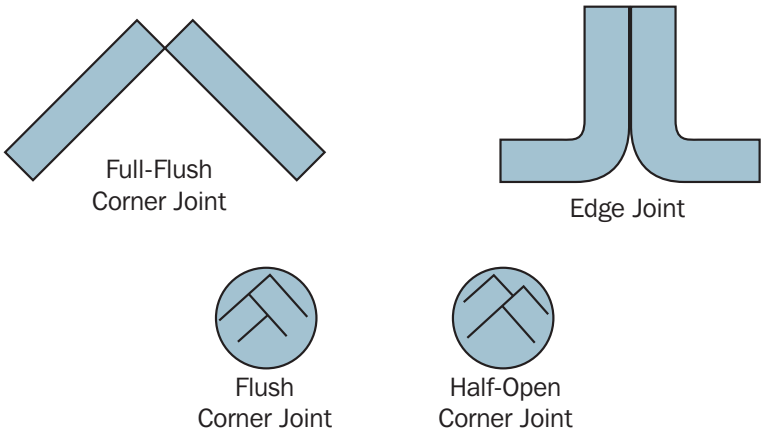
COMMON JOINTS USED IN WELDING (CONTINUED)



TYPES OF FILLET WELDS



LAP JOINTS



CORNER AND EDGE JOINTS

BEAD COMPARISON

A B C D E F

A. Welding current too low.

B. Welding current too high.

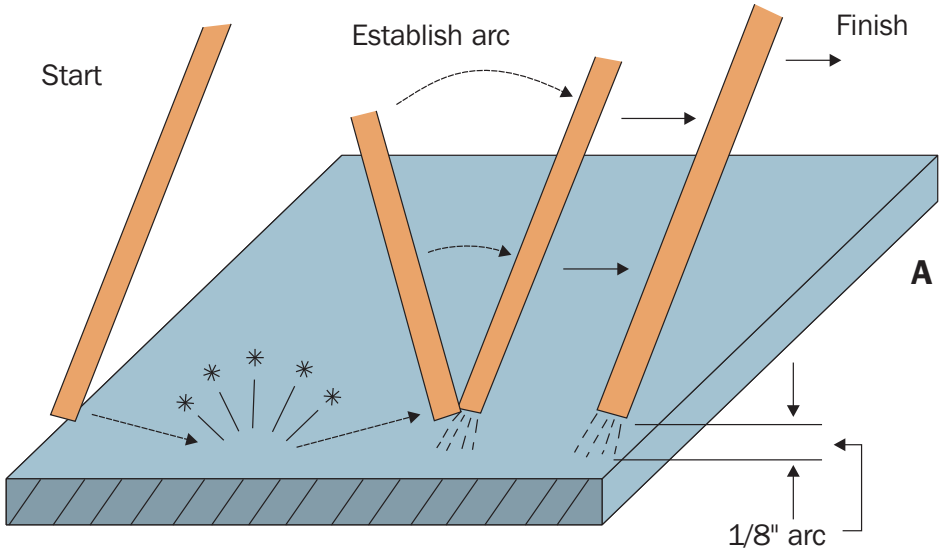
C. Arc too long.

D. Welding speed too fast.

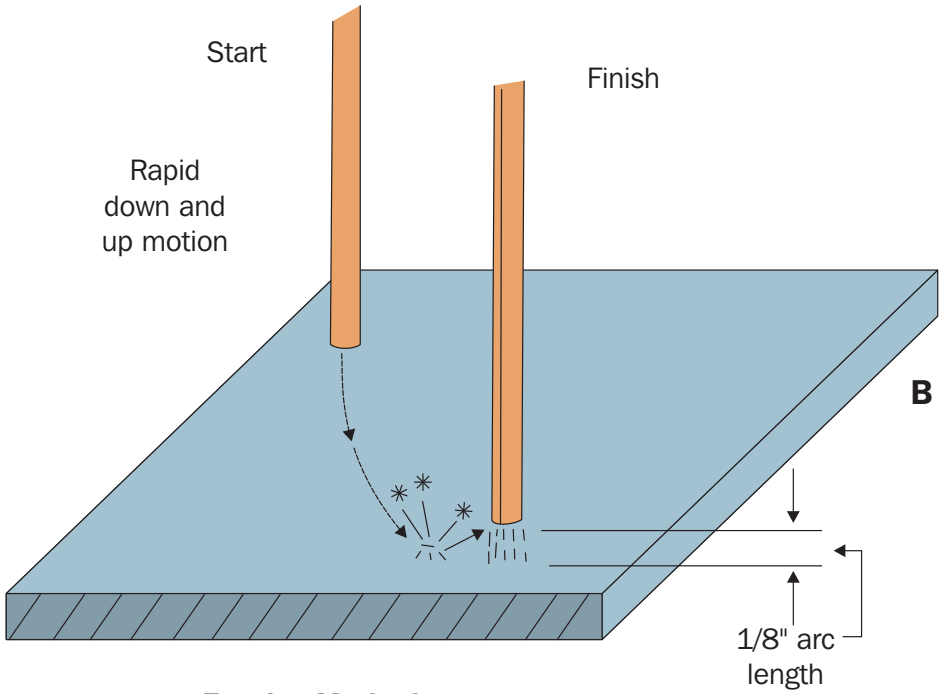
E. Welding speed too slow.

F. Proper amperage, voltage, and speed.

METHODS OF STARTING THE ARC

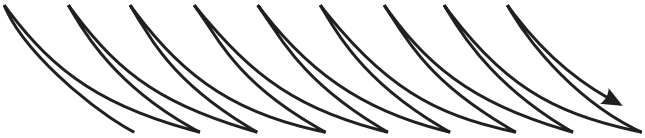


Scratching Method

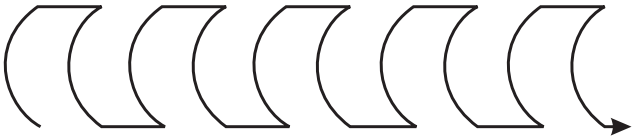


Tapping Method

ELECTRODE MOVEMENT

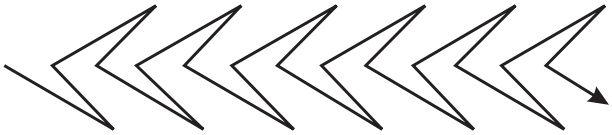


Whipping Motion

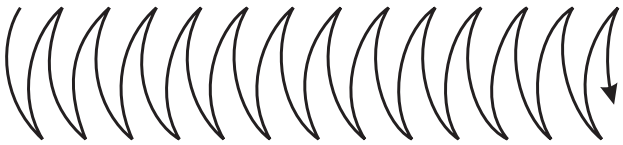


"U"-shaped Motion

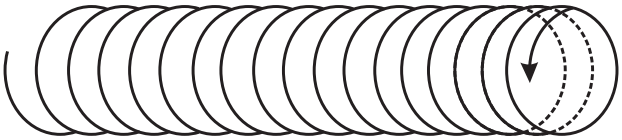
Back-and-Forth, or "N" Motion



"V"-shaped Motion



Semicircular Motion



Circular Motion

LS–A

Name _____

Arc Welding Exercises

Purpose

The purpose of this activity is to perform arc welding exercises.

Objective

Demonstrate arc welding techniques.

Materials

- arc welding equipment
- welding safety equipment
- steel
- five copies of lab sheet (per student)

Procedure

Complete the following lab exercises in the order shown. A lab sheet should accompany each exercise. Before moving to the next exercise, receive instructor approval and directions.

#2	6011 Butt weld	#5	6013 Bead	#8	6013 Tee (fillet) weld
#3	6011 Lap weld	#6	6013 Butt weld		

1. Lab exercise no. and type of weld: _____
2. Welding position: _____
3. Type and size of rod used: _____
4. Type and thickness of base metal: _____
5. Current setting: _____

6. SCORECARD:

a. General appearance (smooth, uniform ripples)	5	4	3	2	1	0
b. Width (uniform)	5	4	3	2	1	0
c. Height (uniform)	5	4	3	2	1	0
d. Penetration	5	4	3	2	1	0
e. Starting	5	4	3	2	1	0
f. Stopping	5	4	3	2	1	0
g. Safety procedures followed	5	4	3	2	1	0
h. Other	5	4	3	2	1	0

i. TOTAL POINTS EARNED: _____

7. Comments:

8. Grading scale

36 to 40	A– to A+
32 to 35	B– to B+
28 to 31	C– to C+
24 to 27	D– to D+
1 to 23	F
0	0