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Volume III

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UNIT I - OXY-GAS AND OTHER CUTTING/ WELDING PROCESSES

Job Sheet 1.1: Air Carbon-Arc Cutting

Objective

At the completion of this job sheet, the student will be able to cut metal using the air carbon-arc cutting processes.

Tools and Equipment Needed

1. Arc welding machine
2. Electrode lead
3. Ground lead with clamp
4. Air carbon-arc torch
5. Compressed air supply with regulator
6. Air hose
7. Chipping hammer
8. Equipment and supplies for cleaning metal
9. Protective clothing
10. Safety glasses*
11. Welding helmet*

* CAUTION: Welding helmets and safety glasses must be worn by the operator and all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed

1. Mild steel plate - size to be determined by the instructor
2. Air carbon-arc cutting electrode

Precutting Procedure

1. Clean all dirt, grease, and foreign materials from the surface of the metal.

2. Remove all flammable materials from the work area. Provide proper ventilation.

3. Expose the air and power connections by pushing back the insulated boot on the air carbon-arc torch. See Figure 1.1.

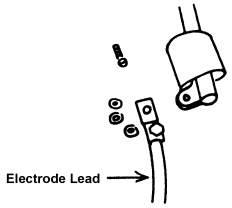


Figure 1.1

4. Attach the torch to the power assembly. The air hose should be attached to the air hose connection. Replace the insulated boot over the air and power connections. See Figure 1.2.

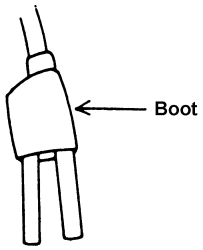


Figure 1.2

5. Attach the regulator to the compressed air supply and attach the air hose to the regulator. CAUTION: Do not use oxygen as the compressed air supply because it is flammable.

6. Adjust the regulator to 60-100 psi. Spray air on a piece of metal to make sure the air is free of moisture and abrasive particles. If moisture collects on the metal or if abrasive particles are present, the compressed air supply should be checked.

7. Insert the electrode into the jaws of the torch with approximately 6" of electrode extending beyond the torch. Note: Burning the electrode to less than 2" in length can damage the torch.

8. Attach the clamp on the ground lead to the workpiece.

9. Set the arc welding machine to DC, reverse polarity. Adjust the amperage according to the electrode diameter.

Cutting Procedure

1. Position the air jets on the torch between the electrode and the base metal.

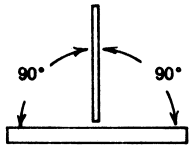


Figure 1.3

2. Position the electrode at a 90-degree work angle and a 45-degree travel angle, opposite the direction of travel. See Figures 1.3 and 1.4.

3. Turn the arc welding machine on.

4. Turn on the air jet with the air valve located on the torch. Make sure the welding helmet is lowered over the face.

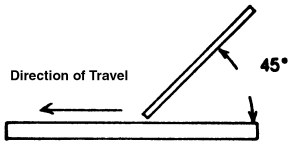


Figure 1.4

5. Strike an arc and move the electrode in the direction of the cut, just as the arc exits the back side of the base metal. Make sure to keep the torch at a consistent angle and speed.

6. Finish the cut. Turn off the air jet by using the air valve on the torch. Place the torch in a safe position where the electrode will not come in contact with metal.

Postcutting Procedure

1. Turn off the air supply and the arc welding machine.
2. Remove the air carbon-arc torch from the air hose.
3. Clean the work area.
4. When the metal is cool, chip slag and remove other residue from the cut.
5. Examine the cut for accuracy and appearance.
6. Give the cut to the instructor for grading.

UNIT I - OXY-GAS AND OTHER CUTTING/ WELDING PROCESSES

Job Sheet 1.2: Plasma-Arc Cutting

Objective

At the completion of this job sheet, the student will be able to cut metal using the plasma-arc cutting process.

Tools and Equipment Needed

1. Plasma power sources
2. Plasma torch and leads
3. Gases (as required by manufacturer)
4. Safety glasses*
5. Welding helmet*
6. Protective clothing
7. Straightedge

* CAUTION: Welding helmet and safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed

1. Piece of ferrous or nonferrous metal

Precutting Procedure

1. Connect the torch to the power source.

2. Attach the gas lines from the machine to the required cylinder or gas line. (Some machines operate on compressed air while others require gases stored in cylinders or bulk storage tanks.)

3. Set the power level on the machine to the required level.

4. Set the regulators or flow meter to the required amount.

5. If applicable, attach the torch coolant lines to water or radiator sources.

6. Using a straightedge, mark several lines on the metal to be cut.

7. Align the straightedge with the mark so that the plasma torch will cut evenly along the line.

Cutting Procedure

1. Start the machine and move along the side of the straightedge for the complete length of the desired cut, as shown in Figure 1.1.

2. Stop the cutting action and position the tip of the plasma torch in a safe direction. Repeat the cutting procedure for each line.

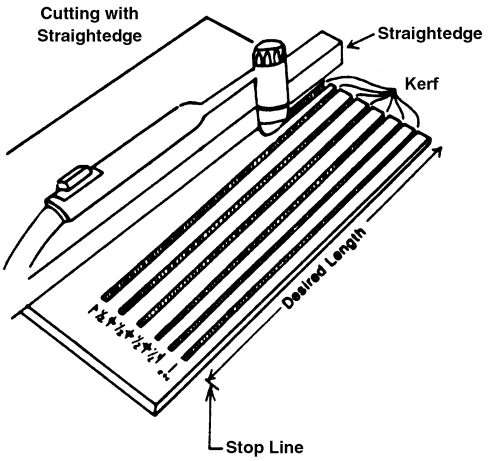


Figure 1.1

Postcutting Procedure

1. Turn the machine off.

2. Examine the cut for accuracy and appearance.

3. Give the cut to the instructor for grading.

4. Clean the work area.

UNIT II - ARC WELDING

Job Sheet 2.1: Prewelding and Postwelding Procedures for GMAW

Objective

At the completion of this job sheet, the student will be able to set up, adjust, and shut down the machine used for gas metal arc welding.

Tools and Equipment Needed

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*

* **CAUTION:** All students performing and observing this procedure must wear proper eye protection. Safety precautions must be observed while working in the shop.

Materials Needed

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

1. Set the machine to Direct Current Reverse Polarity.
2. Plug the welding gun cable into the medium slope terminal located on the welding machine.
3. Plug the ground cable into the negative terminal on the welding machine.
4. Connect the ground cable to the table or metal to be welded.
5. Turn the welding machine power switch to “on.”
6. Turn the wire feed control mechanism power switch to “on.”
7. Adjust the wire feed speed to zero while setting gas flow, amperage, and voltage.
8. Open the cylinder valve on top of the gas tank.
9. Gas flow should be adjusted to 20 to 25 cubic feet/hour (cfh). Slowly open the flow meter valve located at the top of the cylinder to adjust the amount of shielding gas being delivered to the weld area. The trigger on the welding gun should be depressed while turning the valve on the flow meter to get a reading.
10. Voltage should be adjusted to 19 to 21.
11. Adjust the wire feed control to provide 100 to 120 amps. A trial setting of 5 should be used for wire feed speed and adjusted accordingly in a constant voltage machine.
    a) In a machine that provides constant current, the amperage is adjusted through the voltage setting. Check the manufacturer’s manual to determine if your machine provides constant current or constant voltage.

b) Run a practice bead to check if the correct amperage is being received.
c) To strike an arc, squeeze the trigger on the gun at the same time that the tip of the wire touches the metal to be welded. The assistance of another person will be required to take a reading of the amperage while you are welding.
d) You should also check for the correct voltage at this time. Increasing the wire speed will increase the amount of current provided for welding. Decreasing the wire speed will decrease the amount of current.
e) When running a test bead, the arc should make a sizzling sound if the proper amount of shielding gas is being used.

12. Adjust the wire stickout to 1/4 to 3/8 inches. The length of stickout is measured from the welding tip to the surface of the metal to be welded.
13. Be sure all equipment is in safe working condition and that proper safety precautions are followed at all times.

Postwelding Procedure

1. When welding is complete, shut off the valve on the top of the gas cylinder.
2. Bleed the gas from the line by depressing the trigger on the welding gun. If the machine you are using has a button, depressing it will also bleed the gas from the line.
3. Close the flowmeter valve on the top of the gas cylinder to finger tight. This prevents damage to the flow meter the next time the cylinder valve is opened.
4. Turn off the wire feed speed switch.
5. Turn off the power switch on the welding machine.
6. Return cables to the proper storage position.
7. Clean the work area of scrap metal.

UNIT II - ARC WELDING

Job Sheet 2.2: Welds in the Flat Position

Objective

At the completion of this job sheet, the student will be able to perform butt, lap, and t-fillet welds in the flat position using a GMAW welder.

Tools and Equipment Needed

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*

* **CAUTION:** All students performing and observing this procedure must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to JS 2.1 for prewelding procedures needed to prepare for welding in a flat position.

Welding Procedure

BUTT JOINT

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a butt joint. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space of no more than 1/8 inch should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded is in the flat position. (See Figure 2.1.)
3. The electrode should be positioned at a 90° work angle and a 25° to 30° drag angle to perform the weld. (See Figure 2.2.)
4. Lower the helmet. Strike an arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease

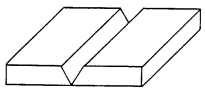
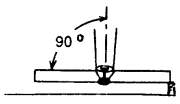


Figure 2.1



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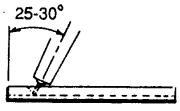
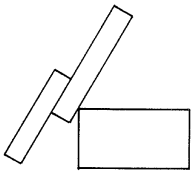


Figure 2.3

penetration, whereas decreasing wire stickout will increase the amount of penetration.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.
6. Examine the weld for penetration and bead appearance.
7. Give the weld to the instructor for grading.

LAP JOINT

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a lap joint. If the metal exceeds 1/8 inch in thickness, the edges of the joint should be beveled to increase penetration.
2. Position the metal so that the joint to be welded is in the flat position. (See Figure 2.4.)
3. The electrode should be positioned at a 90° work angle and a 25° to 30° drag angle to perform the weld. (See Figures 2.5 and 2.6.)
4. Lower the helmet. Strike an arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, whereas decreasing wire stickout will increase the amount of penetration.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.
6. Examine the weld for amount of penetration and bead appearance.
7. Give the weld to the instructor for grading.



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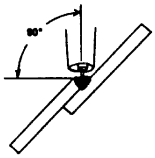

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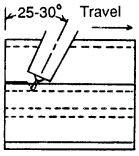
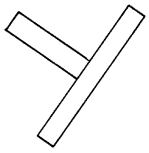


Figure 2.6

T-FILLET JOINT

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a T-joint. If the metal exceeds 3/8 inch in thickness, the edge of the vertical plate should be beveled to increase penetration.
2. Position the metal so that the joint to be welded is in the flat position. (See Figure 2.7)
3. The electrode should be positioned at a 45° work angle and a 10° drag angle to perform the weld. (See Figures 2.8 and 2.9.)
4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will increase penetration, whereas decreasing wire stickout will decrease the amount of penetration.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.
6. Examine the weld for amount of penetration and bead appearance.
7. Give the weld to the instructor for grading.



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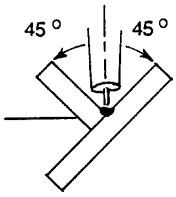

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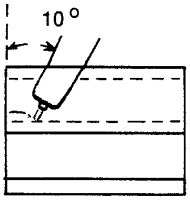


Figure 2.9

Postwelding Procedure

Refer to JS 2.1 for correct postwelding procedures.

UNIT II -ARC WELDING

Job Sheet 2.3: Welds in the Horizontal Position

Objective

At the completion of this job sheet, the student will be able to perform a butt and T-fillet weld in the horizontal position using a GMAW welder.

Tools and Equipment Needed

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*

* **CAUTION:** All students performing and observing this procedure must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed

1. E70S-3 & E71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to JS 2.1 for prewelding procedures needed to prepare for welding in the horizontal position.

Welding Procedure

BUTT JOINT

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a butt joint. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, no more than 1/8 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in the horizontal position. (See Figure 2.1.)
3. The electrode should be positioned at an 85° work angle and a 5° drag angle to perform the weld. (See Figure 2.2.)
4. Lower the helmet. Strike an arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease

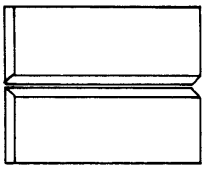


Figure 2.1

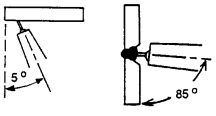
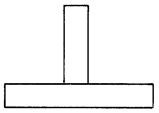


Figure 2.2

penetration, whereas decreasing wire stickout will increase the amount of penetration.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.
6. Examine the weld for penetration and bead appearance.
7. Give the weld to the instructor for grading.

T-FILLET JOINT

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a T-joint.
2. Position the metal so that the joint to be welded will be in the horizontal position. (See Figure 2.3.)
3. The electrode should be positioned at a 45° work angle and a 10° to 15° drag angle to perform the weld. (See Figures 2.4 and 2.5.)
4. Lower the helmet. Strike an arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, whereas decreasing wire stickout will increase the amount of penetration.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.
6. Examine the weld for amount of penetration and bead appearance.
7. Give the weld to the instructor for grading.



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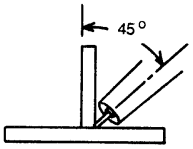

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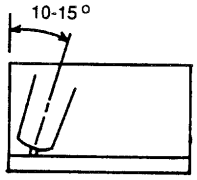

Figure 2.5

Postwelding Procedure

Refer to JS 2.1 for correct postwelding procedures.

UNIT II - ARC WELDING

Job Sheet 2.4: Welds in the Vertical Position

Objective

At the completion of this job sheet, the student will be able to perform a butt, lap, and T-fillet weld in the vertical position using a GMAW welder.

Tools and Equipment Needed

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*

* **CAUTION:** All students performing and observing this procedure must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to JS 2.1 for prewelding procedures needed to prepare for welding in the vertical position.

Welding Procedure

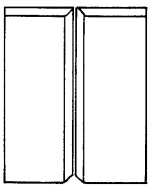

Figure 2.1

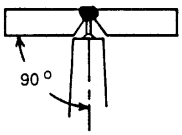

Figure 2.2

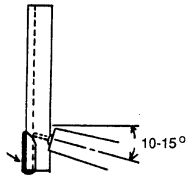

Figure 2.3

BUTT JOINT - VERTICAL UP

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a butt joint. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, no more than 1/8 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded is in the vertical position. (See Figure 2.1.)
3. The electrode should be positioned at a 90° work angle and a 10° to 15° push angle to perform the weld. (See Figure 2.2 and 2.3.)
4. Lower the helmet. Strike an arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease

penetration, while decreasing wire stickout will increase the amount of penetration received.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.
6. Examine the weld for penetration and bead appearance.
7. Give the weld to the instructor for grading.

BUTT JOINT - VERTICAL DOWN

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a butt joint. The vertical-down position should only be used when welding thin-gauge metal because the speed of welding required will not allow for adequate penetration of thicker metals.
2. Position the metal so that the joint to be welded is in the vertical position. (See Figure 2.4)
3. The electrode should be positioned at a 90° work angle and a 10° to 15° drag angle to perform the weld. (See Figures 2.5 and 2.6.)
4. Lower the helmet. Strike an arc and adjust the wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, whereas decreasing wire stickout will increase the amount of penetration.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld. A faster welding speed should be used when making a vertical-up weld. Welding too slowly will result in loss of control of the weld puddle and will increase the chance of burnthrough. Welding too quickly will make it difficult to maintain a stable arc, resulting in poor penetration.
6. Examine the weld for penetration and bead appearance.
7. Give the weld to the instructor for grading.

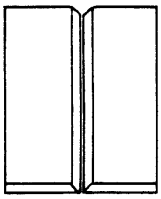

Figure 2.4

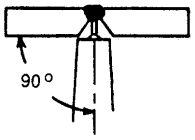

Figure 2.5

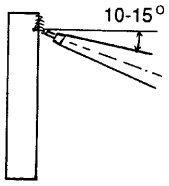

Figure 2.6

LAP JOINT - VERTICAL UP

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a lap joint.
2. Position the metal so that the joint to be welded is in the vertical position. (See Figure 2.7.)
3. The electrode should be positioned at a 45° work angle and a 10° to 15° push angle to perform the weld. (See Figures 2.8 and 2.9.)
4. Lower the helmet. Strike an arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, whereas decreasing wire stickout will increase the amount of penetration.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.
6. Examine the weld for penetration and bead appearance.
7. Give the weld to the instructor for grading.

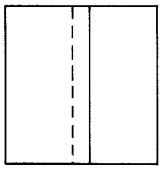

Figure 2.7

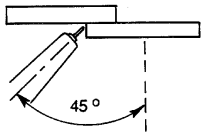

Figure 2.8

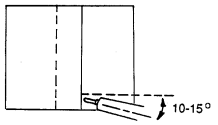

Figure 2.9

LAP JOINT - VERTICAL DOWN

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a lap joint. The vertical-down position should only be used when welding thin-gauge metal because the speed of welding required will not allow for adequate penetration of thicker metals.
2. Position the metal so that the joint to be welded is in the vertical position. (See Figure 2.10.)

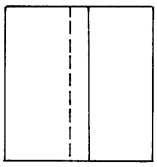
Figure 2.10

3. The electrode should be positioned at a 45° work angle and a 10° to 15° drag angle to perform the weld. (See Figures 2.11 and 2.12.)
4. Lower the helmet. Strike an arc and adjust the wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, whereas decreasing wire stickout will increase the amount of penetration.

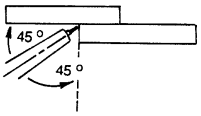

Figure 2.11

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld. A faster welding speed should be used than when making a vertical up weld. Welding too slowly will result in loss of control of the weld puddle and will increase the chance of burnthrough. Welding too quickly will make it difficult to maintain a stable arc, resulting in poor penetration.
6. Examine the weld for penetration and bead appearance.
7. Give the weld to the instructor for grading.

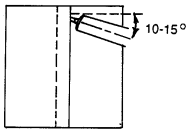

Figure 2.12

T-FILLET JOINT - VERTICAL UP

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a T-joint.
2. Position the metal so that the joint to be welded will be in the vertical position. (See Figure 2.13.)

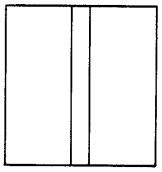
Figure 2.13

3. The electrode should be positioned at a 45° work angle and a 10° to 15° push angle to perform the weld. (See Figures 2.14 and 2.15.)
4. Lower the helmet. Strike an arc and adjust the length of wire to provide the desired penetration. Lengthening wire stickout will decrease penetration, whereas decreasing wire stickout will increase the amount of penetration.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.
6. Examine the weld for penetration and bead appearance.
7. Give the weld to the instructor for grading.

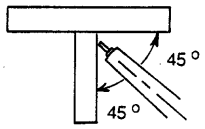

Figure 2.14

T-FILLET JOINT - VERTICAL DOWN

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a T-joint.

   The vertical-down position should only be used when welding thin-gauge metal because the speed of welding required will not allow for adequate penetration of thicker metals.

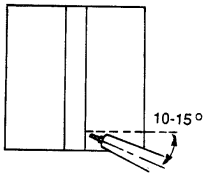

Figure 2.15

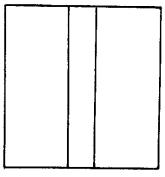
Figure 2.16

2. Position the metal so that the joint to be welded is in the vertical position. (See Figure 2.16.)
3. The electrode should be positioned at a 45° work angle and a 10° to 15° drag angle to perform the weld. (See Figures 2.17 and 2.18.)
4. Lower the helmet. Strike an arc and adjust the wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, whereas decreasing wire stickout will increase the amount of penetration.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld. A faster welding speed should be used than when making a vertical-up weld. Welding too slowly will result in loss of control of the weld puddle and will increase the chance of burnthrough. Welding too quickly will make it difficult to maintain a stable arc, resulting in poor penetration.
6. Examine the weld for penetration and bead appearance.
7. Give the weld to the instructor for grading.

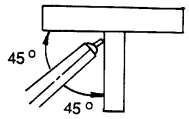

Figure 2.17

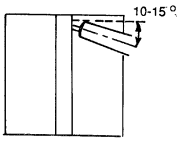

Figure 2.18

Postwelding Procedure

Refer to JS 2.1 for correct postwelding procedures.

UNIT II - ARC WELDING

Job Sheet 2.5: Welds in the Overhead Position

Objective

At the completion of this job sheet, the student will be able to perform a butt and T-fillet weld in the overhead position using a GMAW welder.

Tools and Equipment Needed

1. GMAW welder
2. Protective clothing
3. Safety goggle*
4. Pliers
5. Helmet*
6. Weld positioner

* **CAUTION:** All students performing and observing this procedure must wear the proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed

1. E-70S-3 & E71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to JS 2.1 for prewelding procedures needed to prepare for welding in the overhead position.

Welding Procedure

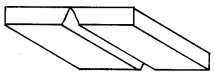
Figure 2.1

BUTT JOINT

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a butt joint. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, no more than 1/8 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded is in the overhead position. (See Figure 2.1.)
3. The electrode should be positioned at a 90° work angle and a 10° to 15° drag angle to perform the weld. (See Figures 2.2 and 2.3.)
4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease

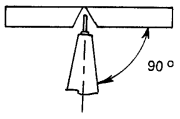

Figure 2.2

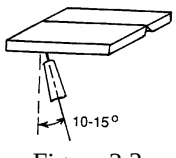

Figure 2.3

penetration, whereas decreasing wire stickout will increase the amount of penetration.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.
6. Examine the weld for penetration and bead appearance.
7. Give the weld to the instructor for grading.

LAP JOINT

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a lap joint. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration.
2. Position the metal so that the joint to be welded is in the overhead position. (See Figure 2.4.)
3. The electrode should be positioned at a 45° work angle and a 10° to 15° drag angle to perform the weld. (See Figures 2.5 and 2.6.)
4. Lower the helmet. Strike an arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, whereas decreasing wire stickout will increase the amount of penetration.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.
6. Examine the weld for penetration and bead appearance.
7. Give the weld to the instructor for grading.

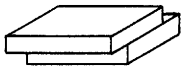
Figure 2.4

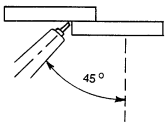

Figure 2.5

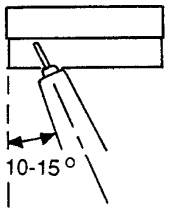

Figure 2.6

T-FILLET JOINT

1. Lower the helmet. Before striking an arc, tell persons in the area to cover themselves. Tack weld two pieces of mild steel together to form a T-joint.
2. Position the metal so that the joint to be welded is in the overhead position. (See Figure 2.7.)
3. The electrode should be positioned at a 45° work angle and a 10° to 15° drag angle to perform the weld. (See Figures 2.8 and 2.9.)
4. Lower the helmet. Strike an arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, whereas decreasing wire stickout will increase the amount of penetration.
5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.
6. Examine the weld for amount of penetration and bead appearance.
7. Give the weld to the instructor for grading.

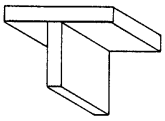
Figure 2.7

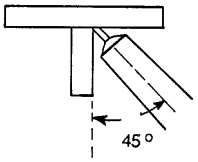

Figure 2.8

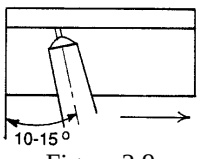

Figure 2.9

Postwelding Procedure

Refer to JS 2.1 for correct postwelding procedures.

UNIT III - ARC WELDING

Job Sheet 3.1: Prewelding and Postwelding Procedures for GTAW

Objective

At the completion of this job sheet, the student will be able to set up, adjust, and shut down the machine used for gas tungsten arc welding.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing this procedure should wear appropriate protective eyewear. Safety precautions should be observed while in the shop area.

Materials Needed

1. Metal plates - type and size to be determined by the instructor
2. Filler metal - per instructor

Prewelding Procedures

1. Be sure all equipment is in safe working condition and that proper safety precautions are followed at all times.
2. With the power off, attach the torch hoses to the machine.
3. Check that the gas cylinder is safely secured in an upright position. Remove the cylinder cap. Crack the cylinder to clear the cylinder valve fitting.
4. Attach the flowmeter and regulator to the cylinder valve. Tighten the regulator fitting nut with the wrench, but do not overtighten.
5. Attach the gas hose from the flowmeter to the machine.
6. With the power still off, switch the machine to GTAW, select the type of current, and set the current range according to metal thickness.
7. Set the high frequency switch.
8. Set the spark control for soft start. Set up the remote control, depending on the machine's accessories.
9. Set the shielding gas postflow timer according to electrode size.

10. Check to be sure that the flowmeter adjusting valve is shut off. If it isn't, turn it clockwise until it is tight.
11. Stand to one side and turn on the cylinder valve.
12. Adjust gas flow according to the size of the electrode.
13. Check for proper and complete circulation in the cooling system and verify that there are no leaks.
14. Select the correct size collet body, collet, and nozzle according to the electrode size.
15. Select and prepare the tungsten.
16. Adjust electrode extension (the length the electrode extends beyond the nozzle opening).
17. Attach the ground clamp to the base metal.
18. Switch on the machine.
19. Position the base metal and hold the torch with the dominant hand. Move the torch so that the nozzle rests on the metal with the electrode about 3/16 in. off the surface.
20. Cover up and remind others in the area to do so as well. Depress the foot control until an arc jumps the gap. Correct the electrode angle as soon as the arc is established.
21. Preheat the starting point until a small molten puddle is formed.
    Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
22. Withdraw the filler rod about 1/2 in. from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
23. Move the puddle forward while using the torch to maintain a uniform bead width, then reinsert the filler rod into the center of the molten puddle at the point of the arc, letting a drop or two of filler metal fill the puddle.
24. Repeat the procedure until the stringer bead is completed.
25. Stop at the edge of the plate and release the foot control. Keep the torch in place for a few seconds after the weld is completed.
26. Ask the instructor to check the results of the procedure.

Postwelding Procedure

1. When welding is complete, close the gas cylinder valve. Depress the foot control to bleed the gas line.
2. Shut off the flowmeter, cooling system, and power switch.
3. Remove the electrode from the torch and return it to its proper storage.
4. Remove the collet, collet body, and nozzle and return them to their proper storage.
5. Disconnect the ground clamp.
6. Roll cables neatly. Return any remaining materials and equipment to their proper places.
7. Clean the work area.
8. Ask the instructor to check the results of the procedure.

UNIT III - ARC WELDING

Job Sheet 3.2: Welds in the Flat Position

Objective

At the completion of this job sheet, the student will be able to perform butt, lap, and T-fillet welds in the flat position using a GTAW welder.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the procedure should wear appropriate protective eyewear. Safety precautions must be observed while in the shop area.

Materials Needed

1. Filler metal - per instructor
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to JS 3.1 for prewelding procedures.

Welding Procedure

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, approximately 1/16 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in flat position.
3. The electrode should be perpendicular to the surface of the weld and pointed forward with the torch approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.

5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in flat position.
3. The electrode should be held at a 45 degree angle to the surface of the weld and pointed forward at approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in flat position.
3. The electrode should be held at a 45 degree angle to the surface of the weld and pointed forward at approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.

7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

Postwelding Procedure

Refer to JS 3.1 for postwelding procedures.

UNIT III -ARC WELDING

Job Sheet 3.3: Welds in the Horizontal Position

Objective

At the completion of this job sheet, the student will be able to perform a butt, lap, and T-fillet weld in the horizontal position using a GTAW welder.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the procedure should wear appropriate protective eyewear. Safety precautions must be observed while in the shop area.

Materials Needed

1. Filler metal - per instructor
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to JS 3.1 for prewelding procedures needed to prepare for horizontal position welding.

Welding Procedure

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. “Cover” should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, approximately 1/16 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in the horizontal position.
3. The torch should be held 75 to 80 degrees to the surface of the weld and the back of the torch should be tipped downward so that the electrode is pointing up toward the weld at a 15 degree angle. The filler rod is held at a 20 degree angle to the plate.
4. Lower the helmet and strike the arc.

5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the horizontal position.
3. The electrode should be held 45 degrees to the surface of the weld and pointed forward at 70 to 80 degrees from the weld axis. The filler rod is held at a 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the horizontal position.
3. The electrode should be held 45 degrees to the surface of the weld and pointed forward at 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.

7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

Postwelding Procedure

Refer to JS 3.1 for postwelding procedures.

UNIT III - ARC WELDING

Job Sheet 3.4: Welds in the Vertical Position

Objective

At the completion of this job sheet, the student will be able to perform a butt, lap, and T-fillet weld in the vertical position using a GTAW welder.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the procedure should wear appropriate protective eyewear. Safety precautions must be observed while in the shop area.

Materials Needed

1. Filler metal - per instructor
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to JS 3.1 for prewelding procedures.

Welding Procedure

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. “Cover” should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, approximately 1/16 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in the vertical position. For thicker metal, it is best to weld with the weld pool moving from the bottom to the top, or vertically up. For thinner metal, it is best to weld with the pool moving from the top to the bottom, or vertically down.
3. The torch should be held perpendicular to the surface of the weld and tipped down so that the torch is 75 to 80 degrees from the base metal. The filler rod is held at an angle of approximately 35 to 45 degrees to the plate.

4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in weld to the instructor for grading.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the vertical position. For thicker metal, it is best to weld with the weld pool moving from the bottom to the top, or vertically up. For thinner metal, it is best to weld with the pool moving from the top to the bottom, or vertically down.
3. The torch should be centered over the root of the weld and tipped down so that the torch is 75 to 80 degrees from the base metal. The filler rod is held at an angle of approximately 35 to 45 degrees to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in weld to the instructor for grading.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the vertical position. For thicker metal, it is best to weld with the weld pool moving from the bottom to the top, or vertically up. For thinner metal, it is best to weld with the pool moving from the top to the bottom, or vertically down.
3. The torch should be centered over the root of the weld and tipped down so that the torch is 75 to 80 degrees from the base metal. The filler rod is held at an angle of approximately 35 to 45 degrees to the plate.

4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in weld to the instructor for grading.

Postwelding Procedure

Refer to JS 3.1 for postwelding procedures.

UNIT III - ARC WELDING

Job Sheet 3.5: Welds in the Overhead Position

Objective

At the completion of this job sheet, the student will be able to perform a butt, lap, and T-fillet weld in the overhead position using a GTAW welder.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the procedure should wear appropriate protective eyewear. Safety precautions must be observed while in the shop area.

Materials Needed

1. Filler metal - per instructor
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to JS 3.1 for prewelding procedures.

Welding Procedure:

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. “Cover” should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, approximately 1/16 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in the overhead position.
3. The electrode should be perpendicular to the surface of the weld and pointed forward with the torch approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.

5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in weld to the instructor for grading.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration.
2. Position the metal so that the joint to be welded will be in the overhead position.
3. The electrode should be held at a 45 degree angle to the surface of the weld and pointed forward at approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the overhead position.
3. The electrode should be held at a 45 degree angle to the surface of the weld and pointed forward at approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.

6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in weld to the instructor for grading.

Postwelding Procedure

Refer to JS 3.1 for postwelding procedures.