SMAW Techniques

Course: SMAW

Objective:

1. Compare and contrast the different weld positions typically used in SMAW.
2. Explain the arc starting techniques.
3. Outline and apply weave patterns to different joint designs and weld positions.
4. Correlate desirable and undesirable bead appearance with various bead running (welding) techniques.

Resources:

Handouts

- ☐ HO1: Types of Weave Techniques
- ☐ AQ1: SMAW Techniques Student Assessment

Reference Materials

- ☐ LP1: SMAW Techniques
- ☐ SR1: SMAW Techniques Student Reference
- ☐ PPT1: SMAW Techniques
- ☐ LA1: SMAW Welding on Plate Lab Activity
- ☐ LA2: Using Backing Strips with SMAW Lab Activity

Terms:

arc length: The distance from the electrode to the workpiece in an arc welding application.

cold lap: Lack of fusion, which is the result of applying too cold of a weld to a plate that is too thick. Cold lap is also called incomplete fusion.

electrode: A device that conducts electricity. In welding, the electrode also can act as the filler metal.

flux: A non-metallic material that prevents, dissolves or helps remove oxides and other unwanted substances from the surface of the base metal and used to protect the weld puddle and solid metal from atmospheric contamination.

oscillate: To move backwards and forwards with a steady rhythm.

overlap: The protrusion of weld metal beyond the weld toe or weld root.

penetration: The depth below the surface of the base metal to which welding heat is sufficient for the metal to melt and become liquid or semi-liquid. Also called the depth of fusion. The word “penetration” is also applied to the ability of arc or electrode to reach into the root of the groove between two members being welded.

porosity: Cavity type discontinuities or bubbles formed by gas entrapment during solidification of the weld metal.

spatter: Metal particles that splatter onto the base metal during welding but are not part of the weld.

Terms Cont'd.:

stringer bead: A type of weld bead formed by moving the electrode straight across the joint. A good stringer bead has good wash-in at the weld toes.

travel angle: The angle less than 90° between the electrode axis and a line perpendicular to the weld axis, in a plane determined by the electrode axis and the weld axis. This angle can also be used to partially define the position of guns, torches, rods and beams

undercut: A groove melted into the base metal at the weld toe or weld root that is left unfilled by weld metal. The groove concentrates stresses on the weld and is considered a defect if the undercut exceeds the part's tolerances.

weave bead: A type of weld bead made with transverse oscillation.

whipping: A technique typically used for forming a stringer bead that involves moving the electrode around in a circle and withdrawing it slightly, then repeating this technique to form a bead.

work angle: The angle less than 90° between a line perpendicular to the major workpiece surface and a plane determined by the electrode axis and the weld axis. In a T-joint or corner joint, the line is perpendicular to the nonbutting member. This angle can also be used to partially define the position of guns, torches, rods and beams.

Situation:

Prior to this lesson, students should have completed the SMAW Principles lesson.

Interest Approach (Motivation):

Ask students to answer the following three questions on a half sheet of notebook paper:

1. What do you **know** about discontinuities and defects?
2. What do you **think you know** about discontinuities and defects?
3. What do you **need to learn** about discontinuities and defects? (Use question format.)

These will be compared at the end of the class period.

Teaching Tip: Creating questions before reading or learning new material will increase comprehension. Students naturally seek out patterns to create a foundation for new ideas.

Instructional Directions/Materials	Content Outline, Instructional Procedures and/or Key Questions
Recommend student-inquiry method of instruction, including guided discussion, readings, and demonstration-performance.	
Use examples, real examples of welds, projects, tools, supplies.	
Keep it simple. The best instructors are able to clearly describe processes using basic terms, simple explanations and lots of applied examples.	
Distribute a copy of SR1: SMAW Techniques Student Reference and provide 12-15 minutes for reading and review.	
Supervised reading with questioning— Following reading, probe student thinking to determine the extent of student knowledge on the topic. Encourage students to analyze concepts and increase comprehension.	
Begin every lesson with a short review of previous learning—daily reviews strengthen previous learning and lead to fluent recall.  PPT1: SMAW Techniques Show slide #2.	Use the lines below to list previous material for review. • _____ • _____ • _____ • _____ • _____

Instructional Directions/Materials	Content Outline, Instructional Procedures and/or Key Questions
PPT1: SMAW Techniques Show slide #3.	**Objectives** 1. Compare and contrast the different weld positions typically used in SMAW. 2. Explain the arc starting techniques. 3. Outline and apply weave patterns to different joint designs and weld positions. 4. Correlate desirable and undesirable bead appearance with various bead running (welding) techniques.
Teaching Tip: Explain that it is necessary to occasionally pause during learning to think about what is being seen, heard or read. This allows you to store the information in long-term memory.	**Formative Assessment** • Ask students to have their student reference guide out during the lesson. • After each section of the lesson, instruct students to mark their student reference guide next to each paragraph as follows:  This information is totally clear to me.  This information is a bit muddy for me.  I am totally lost on this and could use help. Monitor the students as they are completing this activity, watching for the triangles and circles so that you can quickly remediate where necessary. Alternatively, you can have students share their notations in small groups to allow their peers to provide the help needed.
PPT1: SMAW Techniques Show slide #4.	**Arc Length** • Electric arc made between workpiece and the tip of the electrode • Electrode clamped in a holder and held in the hand • Welder completes the welding circuit by striking the electrode on the base material to be welded, then creating a gap in the welding circuit by holding the tip of the electrode 1/16 in. to 1/8 in. away from the base metal » Known as arc length • Electric current jumps gap and creates a very hot arc, which the welder guides along the joint to be welded, melting the metal as it's moved

Instructional Directions/Materials

Content Outline, Instructional Procedures and/or Key Questions

PPT1: SMAW Techniques

Show slide #5.

Work Angle and Travel Angle

- Electrode should be held in weld joint using proper work angle
  - » Used to provide adequate penetration into weld joint
  - » Work angle for flat welds: 90°
  - » Work angle for fillet welds: 45°
- Travel angle: The angle that the electrode is tilted either in or against the direction of travel
  - » Travel angle usually between 20-30°

PPT1: SMAW Techniques

Show slides #6-8.

Say, "The scratching method is easier for beginners and when using an AC machine."

If too long of an arc length is being used, the welder may notice an increase in spatter and the occurrence of undercut. An even longer arc length may cause the arc to go out.

Striking the Arc

- Scratching
  - » Move the electrode, inclined at an angle, across the plate and touch the electrode to the plate
  - » Motion similar to how a match is struck on a match box
  - » As the electrode scratches plate, circuit is completed, current begins to flow and an arc is struck
  - » When arc has formed, withdraw the electrode momentarily to form an excessively long arc of about 3/16 in.
  - » Return to a normal arc length of 1/16 in.-1/8 in.

Instructional Directions/Materials	Content Outline, Instructional Procedures and/or Key Questions
	• Tapping » Electrode is moved downward to the base metal in a vertical direction. » As soon as it touches metal, electrode is withdrawn momentarily to form an excessively long arc and then returned to a normal arc length • Most common difficulty: “sticking” » Happens when electrode tip sticks or fuses to the workpiece » Giving electrode holder a quick snap backward from the direction of travel or quickly moving it side to side will free the electrode » If it doesn’t, welder will have to open the circuit by releasing electrode from holder » Caution: The electrode can become red-hot if current continues to flow through the stuck electrode » **WARNING : Never remove the shield from your face if the electrode sticks. Free the electrode with the shield in front of your eyes, as it will “flash” when it comes loose.**
PPT1: SMAW Techniques **Show slide #9.**	**Running a Bead** • Maintain an arc length slightly less than the diameter of the electrode (1/16 in. to 1/8 in.) • Cues to judging arc length: » Noticeable increase in spatter » Sound of arc more of a hiss than a crackle » Metal will melt off the electrode in large wobbly drops » Slag difficult to remove from completed bead

Instructional Directions/Materials	Content Outline, Instructional Procedures and/or Key Questions
	• Travel speed too fast: bead thing and stringy with poor penetration • Travel speed too slow: weld metal will pile up and roll over, with excessive overlap • Correct amperage setting important for bead shape, proper penetration and minimal spatter » Amperage set too high: bead flat, electrode overheats, weld bead may have excessive spatter and some porosity » Amperage set too low: difficult to strike arc and maintain arc length, weld metal will pile up with excessive overlap and poor penetration.
 **PPT1: SMAW Techniques** **Show slide #10.**	**Steps for Running a Bead** 1. Clean base metal and position flat 2. Set polarity and amperage » AC at 125 amps ± 5 amps for a 1/8 in. E6013 electrode 3. Assume a position permitting you to see behind and ahead of the puddle so that corrections can be made while welding 4. Hold electrode upright incline. » Travel angle should be 10-15° inclined in the direction of travel » Work angle should be 90° 5. Strike arc and drag electrode the length of coupon » Maintain proper travel speed to create desired weld puddle size (approximately 1.5 times the electrode width) 6. Practice the stringer bead until you can run the full length of the plate keeping the weld straight and uniform 7. Clean weld and visually inspect » Weld should be uniform and straight

Instructional Directions/Materials	Content Outline, Instructional Procedures and/or Key Questions
PPT1: SMAW Techniques Show slide #11.	**Building a Pad** • Necessary to build up metal surfaces with one or more layers of weld deposit • Possible applications: rebuilding worn surface, repairing a machining error • May be done on flat or curved surfaces by depositing overlapping straight beads or weave passes • First layer welded using successive beads that slightly overlap • Second layer deposited with beads running 90° to previous pass
PPT1: SMAW Techniques Show slide #12.	**Steps to Building a Pad** 1. Clean base metal and position flat 2. Set the polarity and amperage » AC at 100±5A for 1/8 in. E6013 electrode 3. Assume a position that permits you to see behind and ahead of the puddle so that corrections can be made while welding 4. Hold electrode upright. » Travel angle should be 10-15° inclined in the direction of travel » Work angle should be 90° 5. Run a straight stringer bead along edge of plate 6. Chip the bead free of all slag before running succeeding passes » Done for each pass so excess slag will not be trapped in weld deposit 7. Run second bead parallel to first, overlapping about 1/3 » Beads should all be same height, with no excessive depression between 8. As you run succeeding beads, a smooth surface of weld metal should be obtained across entire surface of original plate 9. Run a second layer of passes at right angles (90°) to first layer

Instructional Directions/Materials

Content Outline, Instructional Procedures and/or Key Questions

PPT1: SMAW Techniques

Show slide #13.

Say, "Remember that weaving is meant to control the puddle and achieve the desired results. Welders should master a drag technique before attempting a weave."

Weave Beads

- An oscillating motion crosswise to the direction of travel
  - » Floats out slag
  - » Deposits a wider bead
  - » Secures good penetration at the edges of the weld
  - » Allows gas to escape
  - » Avoids porosity
  - » Pulls heat and metal from the center of the puddle and places it into the edges of the weld.
- Used with most processes on thicker materials when multipass welds are required
- Can be used in out-of-position welds
  - » Used to fight the effects of gravity on the weld puddle when welding out-of-position
- Important to develop an internal counting system to create smooth, even and consistent welds

PPT1: SMAW Techniques

Show slide #14.

Make sure that students understand that they should spend extra time on the shoulder of the bead.

Weave Beads Used to Create a Wide Bead

- Move the electrode from side to side
- At the same time, move forward to advance the bead
- Motion requires the electrode to pause on the sides of the weld, move across the middle, hold onto the sides, move back across the middle
- Most heat generated in the center of the weld
- If forward travel speed too slow or no pause on the sides of the weld, gravity will take over the puddle and crate tall, narrow beads with poor fusion at toes of weld
- Redistributes the heat and molten metal from center of weld to edges of the weld to counteract effects of gravity

Instructional Directions/Materials

Content Outline, Instructional Procedures and/or Key Questions

Distribute HO1: Types of Weave Techniques.

PPT1: SMAW Techniques

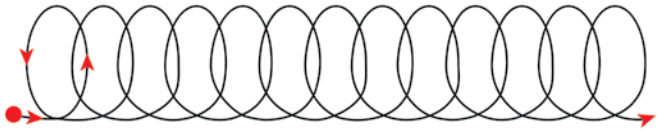
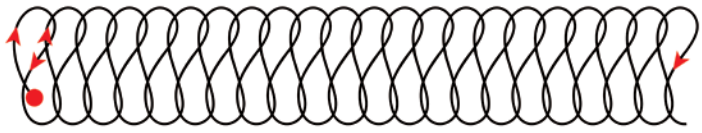
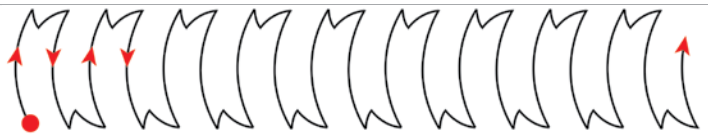
Show slide #15.

Say "Each weave has a specific use or application."

Types of Weave Techniques

Different weave patterns create the same results – welder's preference

- Z Weave
  - » Most commonly used
- Crescent Moon Weave
- Figure Eight Weave
- Circle Weave
- Others

NAME	APPLICATION	PATTERN	POSITION
Crescent Moon Weave	• Buildup • Hardfacing		• Flat Plate
Circle Weave	• Buildup • Hardfacing		• Flat Plate
Figure 8 Weave (Lace)	• Cap on Pipe/Plate in 2G Horizontal		• Pipe 2G Cap
Z Weave	• Lap • Fillet		• 2F Plate • 4F Plate
Straight Weave—Side to Side Motion	• Buildup • Hardfacing		• Flat Plate

Instructional Directions/Materials

PPT1: SMAW Techniques

Show slides #16-18.

Say, "The whipping technique is only used for fast freeze electrodes. Low hydrogen electrodes can trap slag causing porosity or slag inclusion, which can cause a weld to fail."

Content Outline, Instructional Procedures and/or Key Questions

The Whipping Technique

- An oscillating motion lengthwise in the direction of the bead.
- May be used to obtain two opposite results: keeping the puddle "hot" or keeping it "cool"
- Commonly done using a fast freeze electrode with cellulose-based flux
  - » Allows electrode to be quickly "whipped" away from the puddle
  - » Allows puddle to cool for a fraction of a second before electrode is moved back to the puddle, forming another level of fusion.
  - » E6010 most common electrode used with whipping
  - » E6010 are deep penetrating electrodes used for root passes in fillet welds and open root welds
- Whipping is a heat control technique
  - » Can be used to create more heat in puddle for better fusion
  - » Can be used for pulling heat from puddle when running open root welds that overheat easily
  - » Welder must be sure to keep a short arc length; twisting the wrist creates a long arc length that may cause overheating of the puddle
- May be used on downhand weld progression
  - » Keeps puddle hot to obtain good penetration, even ripples, uniform buildup
  - » For vertical and overhead work or in joints where burn through is a problem, used to keep puddle "cool" to prevent it from sagging or running down.
  - » With thin metal, keeps puddle from penetrating too deep

Instructional Directions/Materials

PPT1: SMAW Techniques

Show slides #19-21.

Say, "This weld is very common and typically yields the strongest joint. A welder should strive to weld in the flat position or 'in position.'"

Content Outline, Instructional Procedures and/or Key Questions

Butt Weld in the Flat Position

- Butt weld: A joint made by placing the edges of two plates together and fusing them to create a weld as strong as the base metal.
- Preparations depend on the thickness of metal
  - » Thicker materials require more plate edge preparation
  - » Thinner materials can simply be butted together and welded
  - » Other considerations: having equipment available to prep the edges and determining if the weld joint requires welding on both sides
- Very common; can be successfully welded in all positions with different electrodes from one side or both
- Most are performed on one side only if there is no access to the backside of the joint
  - » For example: pipe and tank welding
  - » Be sure first pass achieves 100% penetration
  - » Each bead must be cleaned well before subsequent passes are run
  - » Better penetration is ensured if metal 1/4 in. thick and over is beveled equally to form a 60° V-joint.
  - » Make enough passes on either type of joint to bring the weld bead slightly above the surface of the base metal
- Work angle for flat positioning is 90° to the joint
  - » Goal: Split the weld evenly between the two pieces
  - » Position the electrode straight into the joint for work angle
- Travel angle is angling the electrode 5-10° in the direction of travel
  - » The end of the electrode that is in the holder will point toward the direction of travel
  - » The end of the electrode touching the base metal will be slightly behind the electrode holder

- Arc length is important (especially when using the whipping technique)
  - » Even more important when performing open root joints
  - » Short arc length forces the weld puddle through the backside of the material, creating full penetration
  - » As arc length increases, penetration decreases

PPT1: SMAW Techniques

Show slides #22-23.

Running Stringer Beads in the Horizontal Position

Horizontal welds sometimes necessary

- Welds on a plate in the vertical position, but joint runs parallel to ground
- Examples: girth seams in large vertical storage tanks and butt welds on vertical pipelines
- Weave beads seldom used in horizontal position
  - » Effects of gravity on weld pool common in horizontal position
  - » Weave beads in horizontal position result in lack of fusion on lower leg of weld (cold lap)
- Electrode angles slightly different to compensate for effects of gravity on weld puddle
  - » Electrode work angle approximately 5° below perpendicular and inclined 70-75° in direction of travel
  - » Electrode angled slightly upward to fight effects of gravity
  - » If angle straight (or even pointing downward slightly), gravity will produce an uncontrollable weld with lack of fusion

To run a stringer bead:

- Strike arc on the vertical plate
- Draw the bead along in a horizontal line, holding a short arc while maintaining correct work angles, travel angles, travel speed and arc length

Instructional Directions/Materials

Content Outline, Instructional Procedures and/or Key Questions

- Sequence in multipass welds is important:
  - » Multipass welds in the horizontal position are always placed from the bottom to the top.
  - » The shelf created by one weld bead is necessary for the next bead to sit on in order to avoid cold lab or lack of fusion
  - » A correctly placed horizontal weld is often the more difficult weld to place correctly in the joint

PPT1: SMAW Techniques

Show slides #24-26.

Say, "Vertical down will typically have less penetration than vertical up."

Welding in the Vertical Position with a Downhand Progression

- Two ways to make vertical welds: top-down and bottom-up
- Vertical welding recommended on metals 3/16 in. or less in thickness
  - » Results in less penetration into base material
  - » Thinner materials don't require as much penetration
- Downward progression usually easier, since gravity is pulling the weld in the same direction that the weld is being deposited
- On full penetration welds, root pass done with vertical down progression; rest of weld done with upward progression
- Usually done with E6010 fast freeze electrodes
- Cover pass on heavier metal sometimes welded down to produce a smooth appearance
- Vertical butt welds on horizontal transmission pipelines usually welded down
- Less metal can be carried in a down pass, more passes are required to complete the joint on heavy metals
  - » Can cause excessive distortion
  - » Most time-consuming
  - » Results in higher costs
- Weld progression specified by WPS

Instructional Directions/Materials	Content Outline, Instructional Procedures and/or Key Questions
	Process • Strike the arc • Hold a short but visible arc • Draw the electrode down in a straight line • Move rapidly enough to keep slag from running ahead of molten pool » If slag runs ahead, extinguish the arc, chip the slag from around the crater, restart bead
 **PPT1: SMAW Techniques** **Show slides #27-28.**	**Welding a Butt Joint in the Vertical Position, Upward Progression** • Usually used on plate 1/4 in. or thicker • Greater penetration possible • More metal can be carried in each pass » Fewer passes needed » Speeds up welding » Reduces distortion • Operatory welds in opposite direction of gravitational pull » Electrode must be angled upward so arc force can help push the puddle up while gravity is trying to pull it down • Can be done with either stringers or weave beads • Amperage settings usually slightly less than flat welding or vertical-down welding • Puddle must be kept small for easy control • Beginners may find it easier to run beads on plate inclined 30-40°, gradually increasing angle until vertical • For open root passes, whipping technique is critical » E6010 designed for this » As puddle is trying to climb up weld joint, electrode is whipped off the puddle then back to give the puddle a second to cool
 **Say, "Using a keyhole technique requires you to burn through the joint, creating a hole called a keyhole. Whip the electrode upwards out of the puddle to freeze, then bring the electrode back into the puddle. Continue until root is complete. Do not pull the electrode out of joint when whipping. Keep a very short arc."**	

Instructional Directions/Materials	Content Outline, Instructional Procedures and/or Key Questions
	Process • To begin, strike arc at bottom of joint and use whipping motion to keep puddle “cool” • Move the electrode tip ahead of the puddle about 1/2 to 1 in. while holding a consistent arc • Hesitate and return it to the puddle to deposit more metal with a short arc • Bead uniformity depends on timing of whipping motion • If puddle is difficult to control or excessive spatter is obtained, may be necessary to reduce amperage • Practice whipping motion until a uniform bead is obtained
PPT1: SMAW Techniques Show slides #29-31.	**Fillet Welds in the Vertical Position Welding Upward** • Similar to making butt joints » Same weld form » Same electrode angle » Same electrode motion • Maximum penetration on vertical joints in metal 1/4 in. or thicker ensured by welding up Process • Hold electrode pointing upward 5°, directly into corner • For fillet joint, hold a short arc and establish a puddle penetrating evenly into each plate • Make first pass using the whipping technique » Whip electrode tip upward from crater about 1/2 to 1 in. » Holding a long arc, hesitate and return to crater with a short arc to deposit more metal

Instructional Directions/Materials

Content Outline, Instructional Procedures and/or Key Questions

- Bead uniformity depends on proper timing of whipping motions
- If puddle is difficult to control:
  - » Reduce amperage OR
  - » Increase travel speed and whipping motion
- Depending on thickness of material, single pass or multipass welds may be required
  - » The first pass of either is done with electrode angle pointing upward in the direction of travel
  - » Whipping motion is used to control the heat of the puddle
  - » After cleaning slag and wire brushing the weld joint, the rest of the welds in a multipass weld commonly done with weave beads.
  - » Weave beads require a smooth transition across the weld while holding onto the sides in order to let the puddle fill and fuse

Say, "The size of the first pass should be 3/8 the leg size, or two rods wide."

When running weaves, make sure to hold the sides of the weld to fill in the undercut, then move across the weld to the other size and repeat.

To ensure you are using proper speed, observe the weld bead. If the center of the weld is convex (humped up), you are moving too slowly across the center. If the center of the weld is caved in, you are moving too quickly across the center. The face should be flat to slightly convex.

PPT1: SMAW Techniques

Show slides #32-34.

Butt-Welds in the Vertical Position Welding Up with a Backing Bar Welding Upward

- Backing bars used to keep molten metal from falling through backside of material
  - » Very common in certification testing
  - » Specific to V-groove butt joints
- Weld done on material thicker than 1/4 in.
- Welding may be done from one side or both sides when possible

Instructional Directions/Materials

Content Outline, Instructional Procedures and/or Key Questions

- Typically done with E6010 electrode for open root pass and then completed with a different electrode
  - » If joint is not open root joint, such as V-groove with backing bar, the E6010 electrode not needed
  - » Open root welds and welds using a backing bar are done the same way except for root pass
  - » Size and type of electrode specified in welding procedure

Process

- Weld started at bottom
- Slight weave technique used to ensure good fusion between each piece and backing bar
- Hold electrode pointing upward 5° and directly into joint
- One common problem: Electrode travel angle increases as electrode moves up weld joint
  - » Increasing electrode angles at top of weld creates longer arc length, resulting in overheated welds
  - » As soon as weld becomes too hot, gravity begins to pull weld from the joint
  - » To prevent, be sure electrode angle stays consistent throughout the pass
- Next weld pass begins at bottom and is weaved only wide enough to wash into toes of previous weld
  - » If weld is weaved too wide, lack of fusion can result
- Final pass performed the same way until weld joint is completely filled to at least the original base metal thickness
- All weld layers must be cleaned well between each layer
  - » Chip the slag
  - » Wire brush each weld layer

Say, "Let air cool in between each weld pass. When welding the last pass, you want the plate to be cold so that you do not undercut and you have good control of the weld puddle."

Instructional Directions/Materials

Content Outline, Instructional Procedures and/or Key Questions

PPT1: SMAW Techniques

Show slides #35-37.

Welding with Stringers in the Overhead Position

- Requires short arc length to help force weld in opposite direction gravity is pulling weld
- Can be performed with stringers or weave beads, depending on joint type and thickness of material
- For fillet welds, root pass is performed first, and the rest of the weld beads are run from the bottom to the top in the same manner as a horizontal fillet weld
- When using a cellulose-based electrode such as 6010, whipping used
- With mineral-based electrodes, straight drag technique used

Say, "In overhead fillet welds, the work angle is half that of a horizontal work angle. Example: A horizontal fillet weld's first pass work angle is 45° For the same pass overhead, the angle is approximately 22 1/2. If the second pass horizontal work angle is 60°, the overhead pass angle will be 30° If the horizontal work angle on the third pass is 30°, the work angle for the overhead pass will be approximately 15°."

Process

- Begin by using a 0-45° work angle and 85° travel angle
- Be sure to keep arc length short
  - » Allows the force of the arc to push the molten metal upward more easily
- After root pass, second stringer placed on bottom half of root pass to create shelf for next weld bead to sit on
  - » Welds start on bottom and next weld placed on top, no matter how many passes required
  - » Like building a house, lay foundation first and build upward

Application/Activity:

Lab Preview

- In Lab 1, students will select and prepare material for welding and tack weld a joint.
- In Lab 2, students will make multiple pass groove welds in the 1G position on carbon steel plate with backing strips. They will then remove the backing bar material and back gouge.

Instructional Directions/Materials	Content Outline, Instructional Procedures and/or Key Questions
 **Supplemental Resources (Taking it Further)**	Have students compare and contrast the different positions. Instruct them label each in terms of difficulty. Why are some welds more difficult than others?
	**Summary Activity** 1. Instruct students to take out the half sheet of notebook paper they used for the first activity. 2. Ask students if they had any misconceptions for questions 1 and 2. Discuss these. 3. For the question 3, have students share the new information they learned from the lesson. Then, ask if there are any questions that were not answered. Use this as a springboard for further discussion.
Closure/Summary: **Teaching Tip: Research indicates that students who write out information tend to store and recall that material better.**	1. Say: "Imagine that you and your classmates will be quizzed about SMAW techniques. On a half sheet of paper, create a 'cheat sheet' with any material you feel would be helpful to use on a quiz." 2. After the allotted time, ask students to reflect on the back of the page: » What areas do you feel most comfortable with? » What areas do you feel you haven't quite grasped yet? » What specific questions do you have about the material? 3. Collect these and use them to assess understanding. Conference with students who need additional help. Re-teach any material that seems to be problematic for most students.

Instructional Directions/Materials

Assessment:

Hand out AQ1 and read over the directions with the students.

Content Outline, Instructional Procedures and/or Key Questions

Assessment Key:

1. True
2. True
3. False
4. True
5. False
6. False
7. True
8. False
9. True
10. True
11. False
12. True
13. False
14. True
15. True
16. D–All of the above
17. A–Fast freeze
18. B–Z (side to side) weave
19. B–Eliminate the open root weld
20. B–Stringer beads
21. D–All of the above
22. C–Travel speed is too fast
23. A–Arc length is too long
24. D–Both A and C
25. D–All of the above