



OPENING NOTES FOR THE TEACHER:

The Facilitator's Manual is to be used as a reference tool for teachers to plan lessons related to the SMAW Units of Study.

The following lesson plans are based around the lesson slides in the SMAW PowerPoint presentations and should be used in conjunction with the units of study.

Print-outs can be made of each lesson if teachers want to hand hard copies to the students in the class.

Arc Welding Safety

Safe welding practices shall always be used.

- Teachers and students should read and understand the following before welding:
 - *Warning Labels* on welding equipment, with consumable packaging and in instruction manuals
 - *Material Safety Data Sheets (MSDS)* available with consumable packaging and online at <http://www.lincolnelectric.com/en-us/support/msds/Pages/sds-search.aspx>
- Teachers and students should also be familiar with the following information
 - 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1) free download available at www.aws.org/technical/facts/Z49.1-2005-all.pdf
 - Lincoln Electric's Arc Welding Safety (E205) and additional arc welding safety information available at <http://www.lincolnelectric.com/en-us/education-center/welding-safety/Pages/welding-safety.aspx>

ELECTRIC SHOCK

Contact with metal parts which are “electrically hot” can cause injury or death because of the effect of the shock upon your body or a fall which may result from your reaction to the shock. The electric shock hazard associated with arc welding may be divided into two categories which are quite different:

- Primary Voltage Shock (i.e. 230, 460 volts); and
- Secondary Voltage Shock (i.e. 20-100 volts).

The **primary voltage shock** is very hazardous because it is much greater voltage than the welder secondary voltage. You can receive a shock from the primary (input) voltage if you touch a lead inside the welder with the **power to the welder** “on” while you have your body, or hand, on the welder case or other grounded metal. Remember that turning the welder power switch “off” does not turn the power off **inside the welder**. Your welder should be installed by a qualified electrician so it will be correctly wired for the primary voltage which supplies it power and so the case will be connected to an earth ground. The case must be grounded so that if a problem develops inside the welder a fuse will blow, disconnecting the power and letting you know that repair is required. Never ignore a blown fuse because it is a warning that something is wrong.

A **secondary voltage shock** occurs when you touch a part of the **electrode circuit** — perhaps a bare spot on the electrode cable — at the same time another part of your body is touching the metal upon which you’re welding (work). To receive a shock your body must touch both sides of the welding circuit — electrode and work (or welding ground) — at the same time. To prevent secondary voltage shock, you must develop and use safe work habits. Remember the voltage at the electrode is highest when you are **not** welding (open circuit voltage).

- Wear **dry** gloves in good condition when welding.
- Do not touch the electrode or metal parts of the electrode holder with skin or wet clothing.
- Keep **dry** insulation between your body (including arms and legs) and the metal being welded or ground (i.e. metal floor, wet ground).
- Keep your welding cable and electrode holder in good condition. Repair or replace any damaged insulation.

Keep your gloves **dry** even if you have to keep an extra pair. Use plywood, rubber mats, or some other **dry** insulation to stand or lie upon. Insulate your body from the metal you are welding. Don’t rest your body, arms, or legs on the workpiece, especially if your clothing is wet or bare skin is exposed (and it should not be if you are dressed properly). In addition to the normal safety precautions, if welding must be performed under electrically hazardous conditions (in damp locations or while wearing wet clothing; on metal structures such as floors, gratings or scaffolds; when in cramped positions such as sitting, kneeling or lying, if there is a high risk of unavoidable or accidental contact with the work piece or ground) use the following equipment:

- Semiautomatic DC Constant Voltage Welder
- DC Manual (Stick) Welder
- AC Welder with Reduced Voltage Control

Always inspect your electrode holder before turning the welder on. Replace the holder if it is damaged. Remember, a stick electrode is always “electrically hot” when the welder is on — treat it with respect. If you do experience a shock, think of it as a warning — check your equipment, work habits and work area to see what is wrong before continuing to weld.

FUMES AND GASES

The **fume plume** contains solid particles from the consumables, base metal, and base metal coating. For common mild steel arc welding, depending on the amount and length of exposure to these fumes, most immediate or short term effects are temporary, and include symptoms of burning eyes and skin, dizziness, nausea, and fever. For example, zinc fumes can cause metal fume fever, a temporary illness that is similar to the flu.

Long-term exposure to welding fumes can lead to siderosis (iron deposits in the lungs) and may affect pulmonary function. Bronchitis and some lung fibrosis have been reported.

Some consumables contain certain compounds in amounts which may require special ventilation and/or exhaust. These Special Ventilation products can be identified by reading the labels on the package. If Special Ventilation products are used indoors, use local exhaust. If Special Ventilation products are used outdoors, a respirator may be required. Various compounds are sometimes found in welding fume, for example:

Chromium: Chromium is on the IARC (International Agency for Research on Cancer) and NTP (National Toxicology Program) lists chromium as posing a carcinogenic risk to humans. Fumes from the use of stainless steel, hardfacing and other types of consumables contain chromium and/or nickel. Some forms of these metals are known or suspected to cause lung cancer in processes other than welding, asthma has also been reported. Therefore, it is recommended that precautions be taken to keep exposures as low as possible. OSHA recently adopted a lower PEL (Permissible Exposure Limit) for chromium.

Manganese: Manganese overexposure may affect the central nervous system, resulting in poor coordination, difficulty in speaking, and tremor of arms or legs. This condition is considered irreversible.

There is one easy way to **reduce the risk** of exposure to hazardous fumes and gases: **keep your head out of the fume plume!** As obvious as this sounds, the failure to follow this advice is a common cause of fume and gas overexposure because the concentration of fume and gases is greatest in the plume. Keep fumes and gases from your breathing zone and general area using natural ventilation, mechanical ventilation, fixed or moveable exhaust hoods or local exhaust at the arc. Finally, it may be necessary to wear an approved respirator if adequate ventilation cannot be provided.

There are also steps that you can take to identify hazardous substances in your welding environment. First, read the product label and material safety data sheet for the electrode posted in the work place or in the electrode or flux container to see what fumes can be reasonably expected from use of the product and to determine if special ventilation is needed. Secondly, know what the base metal is, and determine if there is any paint, plating, or coating that could expose you to toxic fumes and/or gases. Remove it from the metal being welded, if possible. If you start to feel uncomfortable, dizzy or nauseous, there is a possibility that you are being overexposed to fumes and gases, or suffering from oxygen deficiency. Stop welding and get some **fresh air** immediately. Notify your supervisor and co-workers so the situation can be corrected and other workers can avoid the hazard. Be sure you are following these safe practices, the consumable labeling and MSDS and improve the ventilation in your area. Do not continue welding until the situation has been corrected.

You should understand a few basic terms that will be used in this section:

Natural Ventilation is the movement of air through the workplace caused by natural forces. Outside, this is usually the wind. Inside, this may be the flow of air through open windows and doors.

Mechanical Ventilation is the movement of air through the workplace caused by an electrical device such as a portable fan or permanently mounted fan in the ceiling or wall.

Source Extraction (Local Exhaust) is a mechanical device used to capture welding fume at or near the arc and filter contaminants out of the air.

The ventilation or exhaust needed for your application depends upon many factors such as:

- workspace volume
- workspace configuration
- number of welders
- welding process and current
- consumables used (mild steel, hardfacing, stainless, etc.)
- allowable levels (TLV, PEL, etc.)
- material welded (including paint or plating)
- natural airflow

Your work area has **adequate ventilation** when there is enough ventilation and/or exhaust to control worker exposure to hazardous materials in the welding fumes and gases so the applicable limits for those materials is not exceeded. See Supplement 1 for the legal limits, the OSHA PEL (Permissible Exposure Limit), and the recommended guideline, the ACGIH TLV (Threshold Limit Value), for many compounds found in welding fume.

Important Safety Note:

When welding with electrodes which require special ventilation such as stainless or hardfacing (see instructions on container or MSDS) or on lead or cadmium plated steel and other metals or coatings which produce hazardous fumes, keep exposure as low as possible and below exposure limit values (PEL and TLV) for materials in the fume using local exhaust or mechanical ventilation. In confined spaces or in some circumstances, for example outdoors, a respirator may be required if exposure cannot be controlled to the PEL or TLV. Additional precautions are also required when welding on galvanized steel.

Source Extraction Equipment

Mechanical ventilation is an effective method of fume control for many welding processes. Because it captures fume near the arc or source of the fume, which is more efficient in most cases, local exhaust, also called "source extraction", is a very effective means to control welding fume.

Source extraction of welding fumes can be provided by mobile or stationary, single or multi-station, exhaust and/or filtration equipment designed with adjustable fume extraction arms nozzles or guns, by fixed enclosures, booths or tables with extraction canopies also known as down-draft, or by back-draft or cross-draft tables/booths. Source extraction of weld fume falls into two categories: low vacuum/high volume, or high vacuum/low volume.

Fume extraction is only one component in reducing welding fume. Users should also consider the selection of the welding process, welding procedure, or consumable. Many times a combination of fume extraction, training, process change, and/or consumable change is needed to reduce the amount of fume to acceptable levels. Solutions to a particular application may involve one or all of these factors and the user must determine which solution best fits their application.

OSHA regulations include specific requirements for exhaust systems which should be reviewed when selecting fume extraction systems.

Working in Confined Spaces

When arc welding in a confined area, such as a boiler, tank, or the hold of a ship, bear in mind that all the hazards associated with normal arc welding are amplified, so the precautions mentioned here are even more important. This subject is very complicated and only these precautions related to arc welding will be discussed in this brochure. Per OSHA document 29 CFR 1910.146, a particular area is considered a confined space if it:

- 1) Is large enough and so configured that an employee can bodily enter and perform assigned work; and
- 2) Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry.); and
- 3) Is not designed for continuous employee occupancy.

There is a greater danger that enough **flammable gases** may be present in the confined space to cause an explosion. The metal of the enclosure can become part of the welding circuit, so any metal you touch (the walls, floor, ceiling) is **electrically "hot"**. Welding fumes can accumulate more rapidly, with a higher concentration; gases can force out the **breathable air**, suffocating you in the process.

Per OSHA document 29 CFR 1910.146(d)(5)(iii); after an area has been deemed a confined space, the existence of the following atmospheric hazards are to be determined:

- 1) Test for oxygen
- 2) Test for combustible gases and vapors
- 3) Test for toxic gases and vapors

The workplace and OSHA rules regarding confined spaces must be followed. Make sure that your body is insulated from the work-piece using dry insulation. Wear dry gloves and only use a well-insulated electrode holder. Semiautomatic constant voltage welders with cold electrode or stick welders equipped with a device to lower the no-load voltage are recommended, especially when the work area is wet. Make sure that there is adequate ventilation and exhaust (a respirator or an air-supplied respirator may be necessary depending on the application), and that there are no flammable coatings, liquids or gases nearby.

Lastly, you must have someone outside the enclosure trained to handle emergencies, with rescue procedures and a means to disconnect power to your equipment and pull you out if danger arises.

For more information on environmental products and solutions:

1. Lincoln Environmental Systems (E13.40)
2. Environmental System Selection Guide (MC05-183)
3. www.lincolnelectric.com Quick Link: "Safety"

Supplement 1

LISTED BELOW ARE SOME TYPICAL INGREDIENTS IN WELDING ELECTRODES AND THEIR TLV (ACGIH) GUIDELINES AND PEL (OSHA) EXPOSURE LIMITS

INGREDIENTS	CAS No.	TLV mg/m ³	PEL mg/m ³
Aluminum and/or aluminum alloys (as Al)*****	7429-90-5	10	15
Aluminum oxide and/or Bauxite*****	1344-28-1	10	5**
Barium compounds (as Ba)*****	513-77-9	****	****
Chromium and chromium alloys or compounds (as Cr)*****	7440-47-3	0.5(b)	.005(b)
Fluorides (as F)	7789-75-5	2.5	2.5
Iron	7439-89-6	10*	10*
Limestone and/or calcium carbonate	1317-65-3	10	15
Lithium compounds (as Li)	554-13-2	10*	10*
Magnesite	1309-48-4	10	15
Magnesium and/or magnesium alloys and compounds (as Mg)	7439-95-4	10*	10*
Manganese and/or manganese alloys and compounds (as Mn)*****	7439-96-5	0.2	5.0(c)
Mineral silicates	1332-58-7	5**	5**
Molybdenum alloys (as Mo)	7439-98-7	10	10
Nickel*****	7440-02-0	1.5	1
Silicates and other binders	1344-09-8	10*	10*
Silicon and/or silicon alloys and compounds (as Si)	7440-21-3	10*	10*
Strontium compounds (as Sr)	1633-05-2	10*	10*
Zirconium alloys and compounds (as Zr)	12004-83-0	5	5

Supplemental Information:

(*) Not listed. Nuisance value maximum is 10 milligrams per cubic meter. PEL value for iron oxide is 10 milligrams per cubic meter. TLV value for iron oxide is 5 milligrams per cubic meter.

(**) As respirable dust.

(****) Subject to the reporting requirements of Sections 311, 312, and 313 of the Emergency Planning and Community Right-to-Know Act of 1986 and of 40CFR 370 and 372.

(b) The PEL for chromium (VI) is .005 milligrams per cubic meter as an 8 hour time weighted average. The TLV for water-soluble chromium (VI) is 0.05 milligrams per cubic meter. The TLV for insoluble chromium (VI) is 0.01 milligrams per cubic meter.

(c) Values are for manganese fume. STEL (Short Term Exposure Limit) is 3.0 milligrams per cubic meter. Values are those proposed by OSHA in 1989. Present PEL is 5.0 milligrams per cubic meter (ceiling value).

(****) There is no listed value for insoluble barium compounds. The TLV for soluble barium compounds is 0.5 mg/m³.

TLV and PEL values are as of April 2006. Always check Material Safety Data Sheet (MSDS) with product or on the Lincoln Electric website at <http://www.lincolnelectric.com>

Supplement 2
BIBLIOGRAPHY AND SUGGESTED READING

ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*, American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

Arc Welding and Your Health: A Handbook of Health Information for Welding. Published by The American Industrial Hygiene Association, 2700 Prosperity Avenue, Suite 250, Fairfax, VA 22031-4319.

NFPA Standard 51B, *Cutting and Welding Processes*, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9146, Quincy, MA 02269-9959.

OSHA General Industry Standard 29 CFR 1910 Subpart Q. OSHA Hazard Communication Standard 29 CFR 1910.1200. Available from the Occupational Safety and Health Administration at <http://www.osha.org> or contact your local OSHA office.

The following publications are published by The American Welding Society, P.O. Box 351040, Miami, Florida 33135. AWS publications may be purchased from the American Welding society at <http://www.aws.org> or by contacting the AWS at 800-854-7149.

ANSI, Standard Z49.1, *Safety in Welding, Cutting and Allied Processes*. Z49.1 is now available for download at no charge at <http://www.lincolnelectric.com/community/safety/> or at the AWS website <http://www.aws.org>.

AWS F1.1, *Method for Sampling Airborne Particulates Generated by Welding and Allied Processes*.

AWS F1.2, *Laboratory Method for Measuring Fume Generation Rates and Total Fume Emission of Welding and Allied Processes*.


AWS F1.3, *Evaluating Contaminants in the Welding Environment: A Strategic Sampling Guide*.

AWS F1.5, *Methods for Sampling and Analyzing Gases from Welding and Allied Processes*.

AWS F3.2, *Ventilation Guide for Welding Fume Control*

AWS F4.1, *Recommended Safe Practices for the Preparation for Welding and Cutting of Containers and Piping That Have Held Hazardous Substances*.

AWS SHF, *Safety and Health Facts Sheets*. Available free of charge from the AWS website at <http://www.aws.org>.



WELDING
connects your world

SMAW Lesson #1

- Objective: Strike and establish an arc
- Equipment:
 - Single Process –
Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate 1/8" or thicker
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC

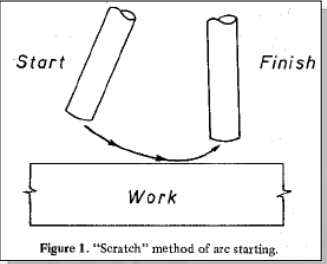


Figure 1. "Scratch" method of arc starting.

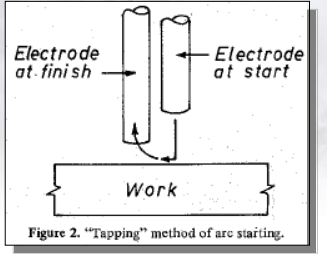



Figure 2. "Tapping" method of arc starting.


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UNIT: SMAW

PROBLEM AREA

- How do I strike and establish an arc?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Learn to strike and establish an arc

TIME: INSTRUCTION TIME FOR THIS LESSON: 1 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)
- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate 1/8" or thicker
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC

KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

- Strike
- Arc
- Constant Current
- Multi-Process
- Mild Steel

TEACHER NOTES: Suggested discussions include information regarding the following:

An **arc** is maintained when the welding current is forced across a gap between the electrode tip and the base metal. Two general methods of **striking an arc** are scratching and tapping. The scratch start method is easier for beginners and when using an AC machine. In the tap start method, the electrode is moved downward to the base metal in a vertical direction. The principal difficulty encountered in **striking the arc** is "freezing" when the electrode sticks or fuses to the work. Remind students to never remove the shield from the face if the electrode is frozen. Free the electrode with the shield in front of the eyes, as it will "flash" when it comes loose.

Constant Current (CC) power sources are used in the SMAW process. A **CC** power source is one in which current or amperage remains constant even for changes in welding voltage. The welding voltage changes as changes in arc length occur. **Constant current** SMAW machines are either AC, DC or AC/DC. Welding polarity is determined by the preferred polarity of the electrode used or the capability of the welding power source. Some examples of **constant current** welding machines include the Idealarc 250 and the AC-225.

Multi-process welding machines have the ability to perform many different welding processes (i.e. Stick and MIG welding). These machines are very popular in welding schools due to their ability to change over from one welding process to the next. Some examples of **multi-process** welding machines include the Power MIG 350MP and the Invertec V-350.

Mild steel is a common term for low carbon steels which have good weldability.

Tips for easier **arc** starts: Recommend DC- polarity and amperage settings in the higher end of the recommended amperage range (90-100 Amps). This makes **striking an arc** easier and allows students to gain confidence.

Fleetweld 5P+ (E6010) is classified as a fast freeze, mild steel electrode. It is ideal for welding on dirty, rusty, greasy, or painted steel. It's a first choice for pipe welding as well as for vertical-up and overhead plate welding. Fleetweld 5P+ is a long-time favorite among operators who handle cross-country and in-plant pipe welding. A whipping technique is commonly used with this electrode. Preferred polarity: DC+

Fleetweld 180 (E6011) Classified as a Fast Freeze, Out-of-Position, Mild Steel Stick Electrode, this electrode offers excellent arc stability for performance with AC power sources. A great stick electrode with the ability to start easily on low open circuit voltage (OCV) welders. A whipping technique is commonly used with this electrode. Preferred polarity: AC

INTEREST APPROACH:

- Assemble the students into the shop area. Demonstrate both methods of striking an arc making sure to follow proper safety guidelines. Have the students make observations about how each method begins and how to establish the correct arc length. Lead a discussion on the correct process for each method.

To gain practical knowledge of classroom content, allow 1 hr. for the students to practice the following exercises:

LESSON INSTRUCTIONS

Exercise A: Strike an arc using the scratch start method.

1. Clean the base material by brushing the metal free of dirt and scale.
2. Position your work piece flat on metal table top or plate.
3. Attach work clamp securely to work or table.
4. Set the polarity and amperage on the machine: DC+ at 85-125A for 1/8" E6010 electrode.
5. Place bare end of electrode in holder so that it is gripped securely at a 90-degree angle to the jaws.
6. Turn welder "ON".
7. Assume a natural position and grasp holder firmly but comfortably by using either one or both hands. Using both hands helps to steady electrode and reduce fatigue. To use both hands, rest left elbow on work table and, with the left hand, steady the right hand by holding the right wrist. (Directions given for a right handed welder.)
8. Hold electrode above plate and move it down until it is about an inch above plate. Hold it upright to the plate, inclined at an angle of 65 to 70 degrees in the direction of travel.
9. Place the shield in front of your eyes.
10. **Strike** the **arc** like a large match by gently and quickly scratching the electrode on the metal with a wrist motion. A sudden burst of light will be produced on contact with the plate.
11. Withdraw electrode to form an excessively long **arc**, about 3/16". This long **arc** is held only a second or two after which a normal **arc** length of 1/16" to 1/8" is assumed. The long **arc** prevents the large drops of metal that pass across the **arc** from shorting out the arc causing it to "freeze" and stick to the plate. It also establishes the weld puddle, eliminates excessive

build-up of filler metal, and helps to tie in more smoothly with the previously deposited bead. Practice starting the **arc**, holding it, and breaking it, until it is easy to **strike** an **arc** on the first try.

Exercise B: Strike an arc using the tap start method.

1. Follow steps 1-7 above in Exercise A using the same polarity and amperage settings.
2. Hold electrode above plate in a vertical position, and lower it about an inch above the point where you wish to **strike** the **arc**.
3. Place shield in front of eyes.
4. Touch the electrode gently to the plate by a downward motion of the wrist.
5. With the first burst of light, quickly withdraw it to form a long **arc**, about 3/16". Hold the long **arc** for a second or two, and then assume a normal **arc** length, 1/16" to 1/8".
6. Incline electrode 65 to 70 degrees in direction of travel as step 8 of Exercise A.
7. Practice **striking** the **arc**, holding it, and breaking it.

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- What happens when electric current is forced across an open gap? What two methods are used to strike an arc?
- Which method is easier for a beginner? Which method works better with an AC welder? When an electrode "freezes", what should be done? What should be done as soon as the arc appears at the tip of the electrode?
- What is normal arc length? What electrode angle is used?
- What can you do to warn others around you that you are ready to strike an arc? Why?
- What is penetration?

APPLICATION:

Extended Classroom Activity:

- Have the students fold a piece of blank paper in half. Label the top half "scratching method" and the bottom half "tapping method". Have students practice both methods of striking an arc by using the eraser end of a pencil or a felt tip marker. The marks left on the paper will help determine students' understanding of both methods. Observe each student for proper technique and arc length.

SAE Activity:

- Ask each student to identify situations in their SAE in which welding plays an essential role. Next, have the students determine which method for striking an arc would best suit each situational need and why they would use that particular method. Have them share their list with another student.


EVALUATION:

Students will be evaluated on the successful completion of the two exercises.

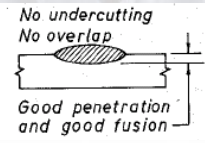
WELDING
connects your world

SMAW Lesson #2

- Objective: To run a straight bead on flat plate and to fill the crater
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate 3/16" or thicker
 - 1/8" Fleetweld 37 (E6013)

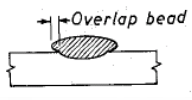


No undercutting
No overlap
Good penetration
and good fusion



Good

Overlap bead



Poor

LINCOLN
ELECTRIC

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UNIT: SMAW

PROBLEM AREA

How do I run a straight bead on a flat plate and correctly fill the crater?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Run a straight bead on a flat plate and fill the crater

TIME: INSTRUCTION TIME FOR THIS LESSON: 1 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
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 - 1/8" Fleetweld 37 (E6013)

KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

- Bead
- Arc Length
- Crater
- Fleetweld 37 (E6013)
- Penetration
- Fill freeze

TEACHER NOTES: Suggested discussions include information regarding the following:

The **bead** is a continuous deposit of weld metal formed by the arc on the surface of the base metal. It is this **bead**, composed of a fused mixture of base metal and filler metal, which forms the weld. Move the electrode along the plate at the correct speed to make smooth, uniform **beads** with adequate **penetration**. During welding, observe the appearance of the **bead** and the characteristics of the arc. See how the arc digs into the metal for **penetration**, how it fills the **crater** and builds up the **bead**. Learn to recognize a good **bead** while you are making it. Keep your eye on the back of the weld puddle as the arc force deposits and builds up the **bead**, so that you can quickly vary the **arc length**, electrode angle, or speed of travel to correct a poor **bead**.

Normal **arc length** should be slightly less than the diameter of the electrode and is usually considered to be 1/16" to 1/8". Correct **arc length** will be developed by proper judgment of the weld deposit. If the **arc length** is too long there will be:

- a noticeable increase in spatter
- a noticeable overlap of weld metal
- a hissing arc sound rather than a crackle
- poor weld **penetration**
- difficulty removing slag from the completed **bead**

When the travel speed is too fast, the **bead** will be thin and stringy with poor penetration. If the travel speed is too slow, weld metal will pile up and roll over with excessive overlap. Correct amperage setting for any given electrode is important to secure proper **bead** shape, proper **penetration**, and minimum spatter. When amperage is set too high, the **bead** will be flat with excessive spatter and some porosity and the electrode becomes overheated. If amperage setting is too low, striking the arc and maintaining the correct **arc length** is difficult. Low amperage settings also cause the weld metal to pile up with excessive overlap and poor **penetration**.

Fleetweld 37 (E6013) is classified as a **fill freeze**, high speed, and mild steel stick electrode. It is an all-position electrode and a good choice for low amperage welding on sheet metal – especially in applications

where appearance is important. Lincoln Electric has designed **Fleetweld 37** for excellent performance with smaller AC welders with low open circuit voltages. It's an excellent choice for jobs involving irregular or short welds that require a change in position. Preferred polarity: AC

Fill freeze electrodes are generally characterized by their fast follow characteristics which makes them an excellent choice for high speed welding on sheetmetal. These electrodes include E6012, E6013, and E7014.

Tips for easier arc starts: Recommend AC polarity and amperage settings in the higher end of the recommended amperage range (125 Amps). These tips make striking an arc easier and allow students to gain confidence.

INTEREST APPROACH:

- Begin the lesson by saying "Last time we met, we learned the proper methods for striking and maintaining an arc. What are the two methods?" (elicit student responses) "Good! What would be the next logical step in the welding process?" (elicit student responses) "Excellent! Now that we know the next step, let's brainstorm a list of general guidelines to follow when creating a bead." Lead a discussion of the brainstormed items emphasizing shape, penetration, uniformity, speed, and arc length.

To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise A: Run short beads

1. Clean base metal and position flat on the table.
2. Check work connection to table or work piece.
3. Set the polarity and amperage: AC at 100-135A for 1/8" E6013 electrode.
4. Hold the electrode upright to the base metal, inclined at a 65 to 70 degree angle in the direction of travel.
5. Strike and establish the arc. Maintain a normal **arc length**, 1/16" to 1/8", and move the electrode across the plate at a uniform rate. A right-handed welder works from left to right. Observe the back of the molten puddle, or **crater**, as the arc builds up the **bead**. Allow the arc force to penetrate the base metal and deposit filler metal. Correct speed will be indicated by the proper shape and size of the **bead**.
6. Make **beads** one to two inches long and extinguish the arc by withdrawing the electrode.
7. Re-strike the arc and run another **bead**. Move over the plate, increasing the length of the beads until you are able to stop and start as desired.
8. Practice until you can make uniform beads 3 or 4 inches long.
9. Clean the slag off each bead by chipping with the chipping hammer and brush clean with the wire brush. Always chip slag away from you.
10. Visually inspect the bead for shape, penetration, and uniformity.

Exercise B: Run long beads with correct rate of deposition.

1. Follow steps above in Exercise A.
2. Run parallel beads about 12" in length.
3. Chip off the slag and inspect the **bead** for shape, penetration, and uniformity.
4. Check the length of the weld with the length of the electrode used. With an E6013 electrode, correct speed will produce approximately 1 inch of bead for each inch of electrode consumed. An electrode should be used so that about 1-1/2" remains. Longer electrode stubs result in excessive waste, and shorter stubs may result in damage to the electrode holder.
5. After you are able to run straight **beads**, weld in one direction to the end of the plate, move slowly to one side and reverse the direction of travel.
6. Keep the correct electrode angle when changing the direction of travel.
7. Try the same job, welding toward and away from you.
8. Visually inspect

**** Sample shown on slide: Fleetweld 37 (E6013), AC at 125A****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- Why is it important to be able to run a sound bead?
- What electrode angle is used when running a bead on flat plate?
- What are the results of an arc length that is too long?
- What are the results if the travel speed is too fast?
- How is a weld cleaned?
- A 14" E6013 electrode should produce approximately what length of bead?
- How long should the stub of an electrode be when it is thrown away?

APPLICATION:

Extended Classroom Activity:

- Create multiple weld beads on a single piece of steel that contain various bead qualities – travel speed too fast, travel speed too slow, amperage too high, amperage too low, arc length too long, arc length too short and one good weld bead. Cut the pad in half and compare your sample to SMAW slide # 31. Assemble the students into pairs, having the students visually inspect each others piece and determine the cause of each poor bead.
 - Have each pair summarize their observations on flip chart paper and report to the entire class. Lead a discussion on welding variables and their effect on bead appearance.
 - Advanced activity: Take the pieces, grind and polish smooth and etch with a dilute solution of nitric acid*. Reassemble the students into pairs, again, having them visually inspect each piece.

**Caution:* Nitric acid causes stains and severe burns. Extreme care must be taken when storing and using acid. Use one part of acid to three parts water. Always pour the acid into the water when diluting. Apply the solution with a glass stirring rod. After a few seconds, wash off in warm running water. (See Procedure Handbook for more information)

SAE Activity:

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- Have the students observe someone welding as it relates to their SAE area. Students should observe safe procedures. They should then observe welding variables like arc length, angles, speed, how the weld is cleaned, penetration, and position. Have students ask any clarification questions. Students should report their observations to the class.


EVALUATION:


Students will be evaluated on the successful completion of the two exercises.

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SMAW Lesson #3

- Objective: To run a bead with the whip technique
- Equipment:
 - *Single Process - Constant Current Power Source*
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - *Multi-Process*
 - Power MIG 350 MP
- Material:
 - *Mild Steel Plate 3/16" or thicker*
 - *1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC*





LINCOLN
ELECTRIC

40

UNIT: SMAW

PROBLEM AREA

- How do I run a bead using a whipping technique?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Run a bead using a whipping technique

TIME: INSTRUCTION TIME FOR THIS LESSON: 1 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)
- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate 3/16" or thicker
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC

KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

- Whipping Technique
- Fleetweld 5P+ (E6010), Fleetweld 180 (E6011)

TEACHER NOTES: Suggested discussions include information regarding the following:

Whipping is an oscillating motion lengthwise with the direction of the bead. A similar motion may be used to obtain two opposite results, keeping the puddle "hot" or keeping it "cool". **Whipping** may be used on down hand work to keep the puddle "hot" or in a fluid state to obtain good penetration with even ripples and uniform buildup. For vertical and overhead work or in joints where burn through is a problem, the **whipping** technique is used to keep the puddle "cool" and prevent it from sagging or running down. In the case of thin metal, it keeps the puddle from penetrating too deep.

Fleetweld 5P+ (E6010) is classified as a fast freeze, mild steel electrode. It is ideal for welding on dirty, rusty, greasy, or painted steel. It's a first choice for pipe welding as well as vertical-up and overhead plate welding.

Fleetweld 5P+ is a long-time favorite among operators who handle cross-country and in-plant pipe welding. A whipping technique is commonly used with this electrode. Preferred polarity: DC+

Fleetweld 180 (E6011) Classified as a Fast Freeze, Out-of-Position, Mild Steel Stick Electrode, this electrode offers excellent arc stability for performance with AC power sources. A great stick electrode with the ability to start easily on low open circuit voltage (OCV) welders. A whipping technique is commonly used with this electrode. Preferred polarity: AC

INTEREST APPROACH:

- Run two beads next to one another using the techniques learned in lessons #2 and #3. Weld the first bead by using the whipping technique and make the second a straight bead. Place the students in small groups and prompt them with the following questions.
 - What are the characteristics of the beads?
 - Which bead do you think was easier to make?
 - In what situations would each method be used? Explain.
- When students are finished, have the group share answers and lead them in a discussion about each method.

To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise A: Run a bead with a **whipping technique** to keep the puddle “hot”.

1. Clean the base metal and position flat.
2. Set the polarity and amperage: DC+ at 70-110A for 1/8” **E6010 electrode**.
3. Hold electrode upright, inclined 65 to 70 degrees in the direction of travel.
4. Assume a position that permits you to see behind and ahead of the arc so that corrections can be made while welding.
5. Strike the arc and carry the bead with a normal arc length during the entire **whipping motion**. The **whipping motion** to keep the puddle “hot” or fluid should be about 5/16” forward and 1/8” to 1/4” back toward the crater, depending upon the size of the bead desired. When the backward motion is completed, hesitate in the electrode motion. Penetration is obtained on the “hesitation” of the backward motion. The longer the hesitation, the larger the weld deposit. The length of the backward motion controls the ripple appearance of the weld. With the exception of the hesitation, the motion is rapid.
6. Practice the motion using different length of return strokes, until you can build up a heavy or light bead.
7. Visually inspect

Exercise B: Run a bead with the **whipping technique** used to keep a puddle “cool”.

1. Follow steps 1 to 4 in Exercise A.
2. Strike the arc and carry the bead with a normal arc length on the backward stroke, and a long arc, 3/8” to 1/2”, at the hesitation point of the forward stroke. Move the arc ahead with a forward stroke of approximately 3/8”, hesitate, holding the long arc, then move backward approximately 1/4” to the front half of the partially solidified crater, assuming a normal arc length. The long arc on the forward stroke reduces penetration, as well as the amount of metal deposited, and allows the welder to see how the puddle is solidifying. Shortening the arc on the backward stroke allows a normal deposition of the metal. A longer hesitation will allow the crater to solidify more. Returning the arc to the partially solidified crater will not cause slag to be trapped in the weld, because it has not had time to completely solidify.
3. Visually inspect

****Sample shown on slide: 1/8” Fleetweld 5P+ (E6010), DC+, 85A****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICE AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- What are the two reasons for using a whipping technique?
- When keeping the metal fluid, what motion provides penetration?
- Why is a long arc used on the forward stroke to keep the puddle “cool”?
- Is the hesitation movement in the same place on each type of whipping technique?

APPLICATION:



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Extended Classroom Activity:

- On a half sheet of blank sheet of paper, have the students draw five sets of lines that run the length of the paper. Each line set should be a $\frac{1}{2}$ " apart. Have the students use a writing utensil to simulate the whipping motion paying particular attention to the proper incline, correct motion, speed, and uniformity.

SAE Activity:

- Have the students identify situations in their SAE in which they would need to keep the puddle "hot" and keep the puddle "cool". Have them explain why they would use each method.


EVALUATION:

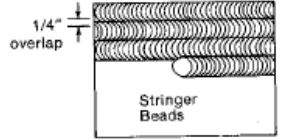
Students will be evaluated on the successful completion of the two exercises.

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SMAW Lesson #4

- Objective: To build a pad
- Equipment:
 - *Single Process - Constant Current Power Source*
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - *Multi-Process*
 - Power MIG 350 MP
- Material:
 - *Mild Steel Plate 3/16" or thicker*
 - *1/8" Fleetweld 37 (E6013)*





1/4"
overlap

Stringer
Beads

LINCOLN
ELECTRIC

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UNIT: SMAW

PROBLEM AREA

- How do I build a pad?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter
- **NLA-STANDARD 3:** Uses grammatical and mechanical conventions in written compositions
- **NLA-STANDARD 10:** Understands the characteristics and components of the media.

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Practice building a pad
- Identify applications for padding

TIME: INSTRUCTION TIME FOR THIS LESSON: 2 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)
- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

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TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate 3/16" or thicker
 - 1/8" Fleetweld 37 (E6013)

KEY TERMS:

THE FOLLOWING TERM IS PRESENTED IN THIS LESSON AND APPEARS IN BOLD:

- Pad
- Build up

TEACHER NOTES: Suggested discussions include information regarding the following:

Padding is a common welding application. It is often necessary to **build up** a metal surface with one or more layers of weld deposit. Rebuilding a worn surface, or repairing a machining, error are two such applications. This work may be done on either flat or curved surfaces by depositing overlapping straight beads or weave passes.

Fleetweld 37 (E6013) is classified as a fill freeze, high speed, mild steel stick electrode. It is an all position electrode and a good choice for low amperage welding on sheet metal – especially in applications where appearance is important. Lincoln Electric has designed Fleetweld 37 for excellent performance with smaller AC welders with low open circuit voltages. It's an excellent choice for jobs involving irregular or short welds that require a change in position.

INTEREST APPROACH:

- Have students brainstorm applications where padding techniques could be used. Consider the following areas:
 - Hardfacing for impact and abrasion
 - Rebuild and repair
 - Machining applications

To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise: Padding on a flat surface.

1. Clean the base metal and position flat.
2. Set the polarity and amperage: AC at 100-135A for 1/8" E6013 electrode.

3. Hold electrode inclined at 65 to 70 degrees in the direction of travel.
4. Run a straight bead along the edges of the plate.
5. Chip the bead free of slag before running succeeding passes. This must be done for each pass so that excess slag will not be trapped in the deposit.
6. Run a second bead parallel to the first, overlapping it about one third. Make certain that complete fusion is obtained with the plate and with the previous bead. Beads should be the same height with no excessive depression or "valley" between them. As successive beads are run, a smooth weld surface should result.
7. After the first layer has been deposited, the oxide and scale should be completely removed from the surface by using a chipping hammer and wire brush.
8. Inspect completed layer for smoothness and penetration (advanced activity below).
9. Run the second layer of passes at right angles to the first layer. This is called lacing. Straight overlapping beads without weaving may be laid when padding. Then, alternate layers of weaving and straight passes. Both methods produce a sound **pad**. Build up the **pad** to a height of $\frac{3}{4}$ " to 1". As the plate is built up, a larger size electrode may be used.
10. Control the electrode deposits so that the **pad** is dense and the edges are built up square and straight. The last layer of passes should be the same length and width as the first layer.
11. Visually inspect
12. To check a **pad** for dense buildup, it may be sawed through. Check visually for pinholes, pores, and slag inclusions. Do not quench in water. Instead, allow it to cool normally.
13. Advanced Activity: To provide a more thorough method of visual inspection, etching may be used. Grind the cut surface until its smooth and etch with a dilute solution of nitric acid. You can then get a comparison of the weld deposit with the base metal. Observe the lines of fusion between the beads, layers, and plate. Check for porosity. *Caution:* Nitric acid causes stains and severe burns. Extreme care must be taken when storing and using acid. Use one part of acid to three parts water. Always pour the acid into the water when diluting. Apply the solution with a glass stirring rod. After a few seconds, wash it off in warm running water.

****Sample shown on slide: 1/8" Fleetweld 37 (E6013), 120A, AC****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- What is padding?
- What are some typical applications of padding?
- Is it necessary to clean the slag from each pass before running the next?
- How may a practice pad be inspected?

APPLICATION:

Extended Classroom Activity:

- Have the students create a one page educational brochure targeting local farm store customers. The brochure should include details on how to create a pad, how to visually inspect one, and where and when a pad should be used.

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SAE Activity:

- Have students take pictures of a piece of equipment where padding could be used. Have the students assess whether the application would be used for rebuilding a worn surface or repairing a machining error. Next, have the students create a detailed plan as to how they would go about repairing the part.

EVALUATION:

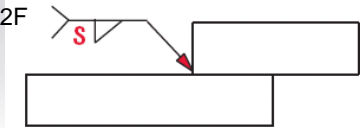
Students will be evaluated on the successful completion of the two exercises.

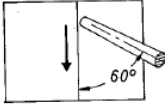
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SMAW Lesson #5

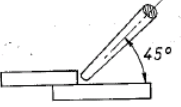
- Objective: To make a fillet weld on a lap joint in the horizontal position (AWS Position 2F)
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate - 10 gauge
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC

2F






Top View



Side View


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UNIT: SMAW

PROBLEM AREA

- How do I make a fillet weld on a lap joint in the horizontal position (AWS Position 2F) using an E6010/ E6011 electrode?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter
- **NLA-STANDARD 7:** Uses reading skills and strategies to understand and interpret a variety of informational texts.

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Make a fillet weld on a lap joint in the horizontal position with E6010/ E6011 electrode.

TIME: INSTRUCTION TIME FOR THIS LESSON: 2.5 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)

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- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate - 10 gauge
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC

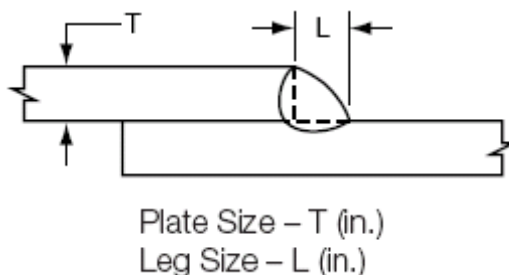
KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

- Lap joint
- Horizontal fillet weld (AWS position 2F)

TEACHER NOTES: Suggested discussions include information regarding the following:

The **lap joint** is welded with the bead made on the surface of one plate and the edge of the other. Fit up work so there is no appreciable gap. Speed of welding, amperage and quality of weld vary directly with fit up. Fleetweld 7 is recommended for joints with poor fit up because it runs on DC- polarity. Most fillet welds on **lap joints** will be made in the **horizontal position** (AWS position 2F), with both base material pieces positioned **horizontally**. The ideal fillet weld has equal legs and a flat or slightly convex bead. Excess convexity wastes weld metal. A concave bead is susceptible to cracking. The following is an example of a fillet weld made on a **lap joint** in the **horizontal position**:



INTEREST APPROACH:

- Place the five types of joints on a table in the front of the room. Using a textbook, have each student draw and name the five types of joints. When completed, hand a student a label with the name of one of the five joint types. Have that student place the label on the correct joint type and describe the joint characteristics to the class. Begin lesson by saying “Today we are going to learn about the specifics of the horizontal lap weld.”

To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS**Exercise: Horizontal fillet weld on a lap joint.**

1. Clean the base metal, and position the two pieces of plate on the table with a 2-inch overlap.
2. Set the polarity and amperage: DC+ at 80-100 amps for a 1/8" E6010 electrode.
3. Hold the electrode at about 45 degrees from horizontal, inclined 60 degrees in the direction of travel.
4. Tack weld the joint at each end so that it will not move during welding.
5. Hold electrode lightly against both plates with the arc directed into the corner.
6. Use a whipping technique. Keep electrode at a 90 degree angle to the plate while whipping. If the lead angle is too large, the puddle will overheat. Observe the bead carefully as it builds up. Change the electrode angle or speed if the bead sags or there is a tendency for undercut.
7. Clean the bead and visually inspect it. It should be uniform without overlap or undercut, penetrating evenly into each plate.
8. Break the plates apart if the weld is less than 5 inches long. This can be done by placing one plate in a sturdy vise and hammering on the back of the other plate. The bead should have even penetration into each plate and completely into the corner.

**** Sample shown on slide: 1/8" Fleetweld 5P+ (E6010), DC+, 80A****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- Why is it advisable to have good fit up?
- What electrode should be used for poor fit up joints?
- What electrode technique is commonly used when welding with Fleetweld 5P+ (E6010)?
- What does the bead on a broken fillet weld on a lap joint look like?

APPLICATION:

Extended Classroom Activity:

- Take the students on a tour of the maintenance building or a place where welding can be observed. Have the students identify joint types, where each type of welding joint could be used and what the easiest welding position would be.

SAE Activity:

- Develop a mentoring programming using community members, local businesses, or farmers who have a strong agriculture mechanics background. Assign students with similar SAEs to a mentor. Mentors should meet at least once a month to discuss applying what the students learn in the classroom to their SAE, how to expand their SAE, business opportunities, and leadership development.


EVALUATION:

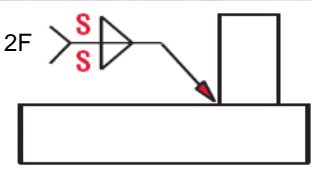
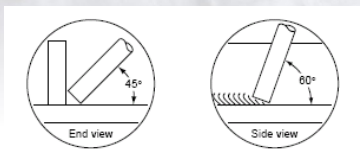
Students will be evaluated on the successful completion of the exercise.


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SMAW Lesson #6

- Objective: To make a fillet weld on a tee joint in the horizontal position (AWS Position 2F)
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate - 10 gauge
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC




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UNIT: SMAW

PROBLEM AREA

- How do I make a fillet weld on a tee joint in the horizontal position (AWS position 2F) using an E6010/E6011 electrode?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter
- **NLA-STANDARD 7:** Uses reading skills and strategies to understand and interpret a variety of informational texts.

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Make a fillet weld on a tee joint in the horizontal position with an E6010/E6011 electrode.

TIME: INSTRUCTION TIME FOR THIS LESSON: 2.5 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)
- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

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TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate - 10 gauge
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC

KEY TERMS:

THE FOLLOWING TERM IS PRESENTED IN THIS LESSON AND APPEARS IN BOLD:

- Fillet weld
- Tee joint

TEACHER NOTES: Suggested discussions include information regarding the following:

Joining a **tee joint** (plates coming in at a 90-degree angle to each other) with a **fillet weld** is the most commonly used joint in welded fabrication. The lap joint also used the **fillet**-type bead. Most **fillet welds** are made in the horizontal position. The arc is directed into the corner if the plates are of the same thickness. If the plates are of unequal thickness, the arc is directed more onto the thicker plate, to heat both plates equally. The ideal **fillet weld** has equal legs and a flat or slightly convex bead. Excess convexity wastes weld metal. A concave bead is susceptible to cracking.

INTEREST APPROACH:

Place examples of different types of welds (fillet, square, bevel, Vee, J, and U) on a table in front of the classroom. Prompt students with questions that lead them to make general inquiries about the characteristics of each. Record all observations and discuss. Begin lesson by saying "Today we are going to learn about the specifics of the fillet weld."

To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercise:

LESSON INSTRUCTIONS

Exercise: Make a horizontal **fillet weld** on a **tee joint**.

1. Clean base metal and position plates.
2. Set polarity and amperage: DC+ at 65-130 A for a 1/8" E6010 electrode.
3. Tack-weld each end of the **tee joint** in position with a good fit-up.
4. Hold electrode lightly against both plates with the arc directed into the corner.
5. Use a whipping technique. Observe the bead carefully as it forms under the arc. There may be some tendency to undercut the vertical plate. Vary the electrode angle specified above

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- slightly to get the correct bead shape. If travel speed and electrode angle are correct, the bead will not undercut.
6. Clean the bead and examine it for signs of overlap and undercut.
 7. Visually inspect.
 8. Break the weld to see if penetration is equal into both plates and completely into the corner. Heavier horizontal **fillet welds** require more than one bead.

**** Sample shown on slide: 1/8" Fleetweld 5P+ (E6010), DC+, 80 Amps****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- What other weld form is similar to a fillet weld on a tee joint?
- What arc length is used on fillet welds?
- How are plates of unequal thickness welded?
- What does a good fillet weld look like when broken?

APPLICATION:

Extended Classroom Activity:

- For one week, have student's record observations where a fillet weld has been used. Make sure they address why a fillet weld was used instead of a different type of weld. Items could include chairs, desks, cars, home furniture, etc.

SAE Activity:

- Have student look at different types of welds that they used in their SAE project. Students should assess whether they used the correct weld, joint, and position. Next, have each student determine what the correct weld, joint, and position should have been and if applicable, instruct students to make the necessary changes.


EVALUATION:

Students will be evaluated on the successful completion of the exercise.

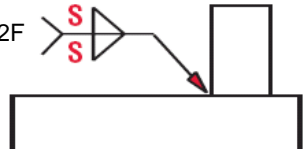
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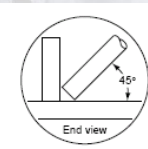
SMAW Lesson #7

- Objective: To make a fillet weld on a tee joint in the horizontal position (AWS Position 2F)
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate - 10 gauge
 - 1/8" Excalibur 7018 (E7018) for DC or Lincoln 7018AC (E7018) for AC

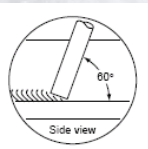


2F






End view



Side view


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UNIT: SMAW

PROBLEM AREA

- How do I make a fillet weld on a tee joint in the horizontal position (AWS Position 2F) using an E7018 electrode?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter
- **NLA-STANDARD 10:** Understands the characteristics and components of the media

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Make a fillet weld on a tee joint in the horizontal position with an E7018 electrode

TIME: INSTRUCTION TIME FOR THIS LESSON: 2.5 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)
- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

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TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate - 10 gauge
 - 1/8" Excalibur 7018 (E7018) for DC or Lincoln 7018AC (E7018) for AC

KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

- Low Hydrogen
- Excalibur 7018 (E7018)

TEACHER NOTES: Suggested discussions include information regarding the following:

Joining a tee joint with a fillet weld is the most commonly used joint in welded fabrication. The lap joint also used the fillet-type bead. Most fillet welds are made in the horizontal position. The arc is directed into the corner if the plates are of the same thickness. If the plates are of unequal thickness, the arc is directed more onto the thicker plate, to heat both plates equally.

Excalibur 7018 (E7018) is classified as a mild steel, **low hydrogen** stick electrode. This electrode has an exceptionally clean puddle, square coating burnoff, easy all-position handling and excellent wash-in characteristics. It's a good choice for jobs that involve steels with poor weldability. Refer to Lincoln Electric's Stick Electrode Product Guide for more information on storing low hydrogen electrodes.

The electrode used in this lesson is classified by the AWS as **E7018**. This electrode is classified as '**low hydrogen**'. **Low hydrogen** electrodes are recommended for three broad areas of application:

1. On steels with poor weldability: low alloy, high carbon, high sulfur, or other steels where cracking is a problem.
2. When specified by governing codes.
3. For lowest costs on vertical, overhead and horizontal groove welds on heavy plate.

Since **low hydrogen** electrodes rely on the molten slag for shielding never hold a long arc, whip the arc, leave the crater, or move rapidly in any direction. Failure to follow these techniques may result in porosity and/or reduced mechanical properties. For Clean Tie-Ins – Strike the arc ahead of the crater, move quickly back into the crater, then proceed in the direction of welding. This technique welds over the striking area, eliminating porosity or tendency for poor starting bead shape.

INTEREST APPROACH:

Show students two broken horizontal fillet welds made with an E 7018 electrode, one that was created using good welding technique and the other created using incorrect techniques. (Poor techniques includes holding a long arc, leaving the crater, or rapid movement in any direction.) Note the differences between the two welds. Discuss the characteristics of the E7018 and how it is different from the E6010 and E6011.

To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise: Make a horizontal fillet weld on a tee joint.

1. Clean the base metal and position plates.
2. Set polarity and amperage: DC+ at 65-130 A for a 1/8" E7018 electrode.
3. Tack-weld each end of the joint in position with a good fit up. After each tack with E7018 electrode, take the electrode out of the holder and gently tap the electrode to remove crystallized end. This will improve the re-strike of this electrode on the next tack or bead.
4. Hold electrode lightly against both plates with the arc directed into the corner.
5. Observe the bead carefully as it forms under the arc. There may be some tendency to undercut the vertical plate. Vary the electrode angle specified above to get the correct bead shape. If travel speed and electrode angle are correct, the bead will not undercut.
6. Clean the bead and examine it for signs of overlap and undercut.
7. Visually inspect.
8. Break the weld to see if penetration is equal into both plates and completely into the corner. Heavier horizontal fillet welds require more than one bead or pass.

****Sample shown on slide: Excalibur 7018 MR (E7018), DC+, 95 Amps****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- How is a low hydrogen electrode different from other types of electrodes?
- What are low hydrogen electrodes recommended for?
- Should a low hydrogen electrode ever be long arced?

APPLICATION:

Extended Classroom Activity:

- Explain to the students that they hypothetically work for Lincoln Electric in their marketing department. Senior management would like to increase the sales of electrodes. It is determined that a marketing piece explaining the difference between the various types of electrodes would help increase sales. The marketing team's task (i.e. the students') is to develop the piece comparing and contrasting the E7018, E6010/E6011 and E6013. The team should keep in mind the message, the media avenue, and the audience.

SAE Activity:

- Have the students run a cost comparison between several different types of electrodes and between several different locations. Using this information, have the students determine which electrode(s) would be the most cost effective for their SAE based on the cost comparison and its intended use.

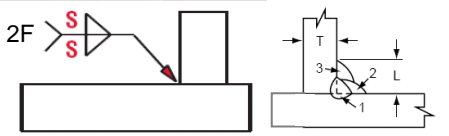

EVALUATION:


Students will be evaluated on the successful completion of the exercise.

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SMAW Lesson #8

- Objective: To make a three pass fillet weld on a tee joint in the horizontal position (AWS Position 2F)
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate – 1/4"
 - 1/8" Excalibur 7018 (E7018) for DC or Lincoln 7018AC (E7018) for AC


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UNIT. SMAW

PROBLEM AREA

How do I make a three pass fillet weld on a tee joint in the horizontal position (AWS Position 2F) using an E7018 electrode?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter
- **NLA-STANDARD 7:** Uses reading skills and strategies to understand and interpret a variety of informational texts.

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Make a three pass fillet weld on a tee joint in the horizontal position (AWS Position 2F).

TIME: INSTRUCTION TIME FOR THIS LESSON: 2.5 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)

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- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate – 1/4"
 - 1/8" Excalibur 7018 (E7018) for DC or Lincoln 7018AC (E7018) for AC

KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

- Multiple pass/ Three pass

TEACHER NOTES: Suggested discussions include information regarding the following:

Multiple pass fillets are used when a single pass weld does not meet size requirements due to base metal thickness, print requirements, etc.

The electrode used in this lesson is classified by the AWS as E7018. This electrode is classified as 'low hydrogen'. Low hydrogen electrodes are recommended for three broad areas of application:

1. On low alloy, high carbon, high sulfur, or other steels where cracking is a problem.
2. When specified by governing codes.
3. For lowest costs on vertical, overhead and horizontal groove welds on heavy plate.

Since low hydrogen electrodes rely on the molten slag for shielding, never hold a long arc, whip the arc, leave the crater, or move rapidly in any direction. Failure to follow these techniques may result in porosity and/or reduced mechanical properties.

For Clean Tie-Ins – Strike the arc ahead of the crater, move quickly back into the crater, then proceed in the direction of welding. This technique welds over the striking area, eliminating porosity or tendency for poor starting bead shape.

INTEREST APPROACH:

- Place several pieces of metal, each with varying thickness, in front of the students. Explain to the students that if a fillet weld was made on the various metals, the weld would run the same length and width. Ask the students to brainstorm ideas on how they can strengthen the T joint on the thickest pieces of metal. Once ideas have been given, explain that thicker pieces of metal often require more than one bead.

To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise: Make a **three pass** fillet weld.

1. Clean base metal and place plates.
2. Set the polarity and amperage: DC+ at 90-160 A for an 1/8" E7018 electrode.
3. Tack-weld each end of the joint in position with a good fit up. After each tack with E7018 electrode, take the electrode out of the holder and gently tap the electrode to remove crystallized end. This will improve the re-strike of this electrode on the next tack or bead.
4. Hold electrode lightly against both plates with the arc directed into the corner. Observe the bead carefully as it forms under the arc. There may be some tendency to undercut the vertical plate. Vary the electrode angle specified above slightly to get the correct bead shape. If travel speed and electrode angle are correct, the bead will not undercut.
5. Clean the bead and examine it for signs of overlap and undercut.
6. Create the second pass by directing the arc on the lower toe of the first bead and using a 60 degree angle to the horizontal plate. While welding the second pass, the top toe of the bead should cover 75 - 90% of the first pass.
7. Put the **third pass** on the shelf created by the first two passes using a 30 degree rod angle to the horizontal plate. While welding the **third pass**, the bottom toe of the bead should cover about 50% of the second pass.
8. Visually inspect. The finished weld should have a flat face.

****Sample shown on slide: Excalibur 7018 MR (E7018), DC+, 120 Amps****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED, AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- What is one reason a multiple pass weld may be required?

APPLICATION:

Extended Classroom Activity:

- Have the students bring articles, news items, etc. to class that pertain to information about welding. Assemble the students into small groups, discuss the articles, and have each group share their top two articles with the class.

SAE Activity:

- Assemble students with similar SAE's into groups. Have each group develop a common list of questions or concerns that they have encountered in their SAE. Each student will use the same set of questions developed to go to a local businesses to solicit answers to their questions. Have students report their findings back to the class within a few weeks.

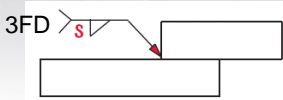
EVALUATION:

Students will be evaluated on the successful completion of the exercise.

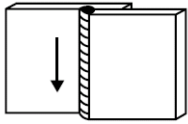
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SMAW Lesson #9


- Objective: To make a fillet weld on a lap joint in the vertical position welding down (AWS Position 3FD)
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate - 10 gauge
 - 1/8" Fleetweld 37 (E6013)




3FD



Vertical (welded down)




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UNIT: SMAW

PROBLEM AREA

- How do I make a fillet weld on a lap joint in the vertical position welding down (AWS Position 3FD) using an E6013 electrode?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter
- **NLA-STANDARD 1:** Uses the general skills and strategies of the writing process

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Make a fillet weld on a lap joint in the vertical position welding down with a E6013 electrode

TIME: INSTRUCTION TIME FOR THIS LESSON: 1.25 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)
- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

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TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate - 10 gauge
 - 1/8" Fleetweld 37 (E6013)

KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

- Vertical down fillet weld (AWS position 3FD)
- High speed electrodes

TEACHER NOTES: Suggested discussions include information regarding the following:

The weld made in this exercise is done in the **3FD position** or **vertical position welded down (Vertical down)**. It is accepted that when the 'D' is not present in the AWS position (i.e. 3F), the direction of welding should be up. **Vertical down** is recommended for the fast welding of 18 gauge to 3/16" thick steel. When welding with **High Speed electrodes** (such as E6013) deposit the entire weld in one pass using non-weave beads or a slight weave. Fast travel speeds result in less distortion in the base material. Drag the electrode on the joint and stay ahead of the molten pool. Use enough drag angle so the arc force pushes the weld metal back. Use currents in the high portion of the electrode's range (125 Amps for a 1/8" Fleetweld 37 E6013 electrode).

INTEREST APPROACH:

- Begin the lesson by placing a horizontal lap joint and a vertical down lap joint next to each other. Each joint should be placed next to each other in the same direction. Have the students look at each and make observations about similarities and differences. Discuss each and explain that although beginners may prefer horizontal welding, it is not always the best choice. When might you choose to weld vertical down?

To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise: Make a fillet weld on a lap joint in the **vertical position welded down**.

1. Clean the base material
2. Set the polarity and amperage: AC at 90-130 amps for 1/8" E6013 electrode.
3. Tack-weld two plates together in a lap joint and secure in the **vertical position**.
4. Hold the electrode pointing upward 60 degrees from the vertical plate and directly into the corner, 45 degrees from the plate surface.
5. Strike the arc at the top and weld down keeping a short arc length.

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6. Use a straight bead technique. Travel downward should be at such a rate that the slag does not run ahead of the crater.
7. Visually Inspect

**** Samples shown on slide: 1/8" Fleetweld 37 (E6013), AC, 120 Amps****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- For what thickness of material is vertical down welding recommended?
- What does the 'D' signify in the AWS position 3FD?

APPLICATION:

Extended Classroom Activity:

- Hand out an index card to each student. Have each student write a question about the process of creating a vertical down lap weld. For example, a student could write, "Compare the amperage setting for a vertical down lap weld to a horizontal lap weld. Explain the difference". Trade cards and on the back have another student answer the question. Collect the cards and review the questions and answers with the entire class.

SAE Activity:

- Have the students write a brief case study based on a welding situation they have encountered in their SAE. The case study should include background information on the type of item(s) that needed to be fixed, the location of the weld, the type of metal, thickness of metal, and a drawing. Once the case study has been created, have another student who has a similar SAE use the case study to determine what type of weld to use, which type of joint will be used, the number of passes, electrode selection, and possible solutions to fix the item(s).

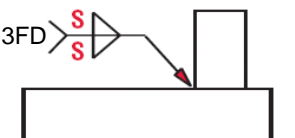
EVALUATION:

Students will be evaluated on the successful completion of the exercise.

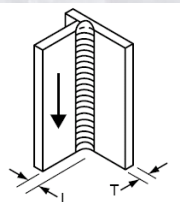
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SMAW Lesson #10


- Objective: To make a fillet weld on a tee joint in the vertical position welding down (AWS Position 3FD)
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate - 10 gauge
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC



3FD






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UNIT: SMAW

PROBLEM AREA

- How do I make a fillet weld on a tee joint in the vertical position welding down (AWS Position 3FD) using an E6010/E6011 electrode?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter
- **NLA-STANDARD 7:** Uses reading skills and strategies to understand and interpret a variety of informational texts.

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Make a fillet weld on a tee joint in the vertical position welding down with a E6010/E6011 electrode

TIME: INSTRUCTION TIME FOR THIS LESSON: 1.25 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)
- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate - 10 gauge
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC

KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD ITALICS:

- Arc Force

TEACHER NOTES: Suggested discussions include information regarding the following:

Vertical down fillet welds on lap joint and tee joints are similar. The bead form is the same, as is the arc length, electrode angle, and welding technique. The weld made in this exercise is done in the 3FD position or vertical position welded down. It is accepted that when the 'D' is not present in the AWS position (i.e. 3F), the direction of welding should be up. Vertical down is recommended for fastest welding of 18 gauge to 3/16" thick steel. Use currents in the high portion of the electrode's range. Drag the electrode on the joint and stay ahead of the molten pool. Use enough drag angle so the **arc force** pushes the weld metal back. **Arc force** is defined as 'the axial force developed by a plasma arc'. This force is used during vertical down welding to help support the weld puddle.

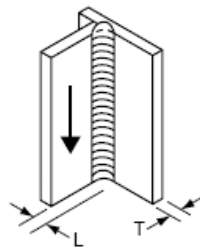


Plate Size – T (in.)
Leg Size – L (in.)

INTEREST APPROACH:

- Begin this lesson by taking students into the shop. Demonstrate the proper procedures for making a vertical down fillet weld with little or no explanation. Have each student observe and create a checklist of the procedures. Place students into groups to discuss the checklist and make any necessary corrections. Have student perform the procedures.

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To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise: Make a fillet weld on a tee joint in the vertical position welding down.

1. Clean the base material.
2. Set the polarity and amperage: DC+ at 110-120 amps for 1/8" E6010 electrode. Tack-weld two plates together in a lap joint and secure in vertical position.
3. Hold the electrode directly pointing upward 60 degrees from the vertical plate and directly into the corner, 45 degrees from the plate surface.
4. Strike the arc at the top and weld down keeping a short arc length.
5. Use a straight bead. Travel downward should be at such a rate that the slag does not run ahead of the crater.
6. Clean slag
7. For a three pass weld - Repeat placing the bead on the toe of the first weld. This will result in a slightly heavier bead. Using a slightly longer arc length will let the bead wash out better at the toes. Repeat again, clean the bead well, and lay a second bead over the initial bead. Make certain you are getting penetration into the corner and evenly into each plate.
8. Visually Inspect

**** Sample shown on slide: Fleetweld 5P+ (E6010), DC+, 110Amps****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- How are vertical down fillet welds on lap joints and tee joints similar?
- How are they different?

APPLICATION:

Extended Classroom Activity:


- Create a group of questions pertaining to the lesson that can be answered by searching for information in welding publications, handouts, or the internet. Make sure that several questions cause the students to derive answers.

SAE Activity:

- Ask a former student who had an agriculture mechanics SAE to speak to the class. Make sure they address how their SAE began, what impact their SAE had on their current career, what difficulties they encountered in growing their SAE, and what outside resources they used.

EVALUATION:


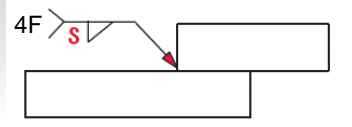
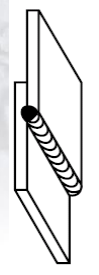
Students will be evaluated on the successful completion of the exercise.




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SMAW Lesson #11

- Objective: To make a fillet weld on a lap joint in the overhead position (AWS Position 4F)
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate - 10 gauge
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC


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UNIT: SMAW

PROBLEM AREA

- How do I make a fillet weld on a lap joint in the overhead position (AWS Position 4F) using an E6010/E6011 electrode?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter
- **NLA-STANDARD 7:** Uses reading skills and strategies to understand and interpret a variety of informational texts.

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Make a fillet weld on a lap joint in the overhead position with an E6010/E6011 electrode

TIME: INSTRUCTION TIME FOR THIS LESSON: 1.25 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)
- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

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TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate - 10 gauge
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC

KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

- Overhead fillet weld (AWS position 4F)
- Stringer beads

TEACHER NOTES: Suggested discussions include information regarding the following:

Overhead fillet welds (AWS position 4F) are welded as a series of straight beads using a slight circulation motion. A whipping technique is used when Fleetweld 5P+ (E6010) and Fleetweld 180 (E6011) electrodes are used. Weaving techniques cannot be used because the weld puddle becomes too fluid and will spill from the joint.

INTEREST APPROACH:

- Pass out an instructional article from a welding publication that deals with making a fillet weld in a lap joint in the overhead position. Have the students read the article and in pairs have them formulate questions. Use the questions to lead into your lesson.

To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise: Make a fillet weld on a lap joint in the **overhead** position

1. Clean the base material
2. Set the polarity and amperage: DC+ at 85-100A for 1/8" E6010 electrode.
3. Tack-weld plates for lap joint, and secure in the **overhead** position so that the underside may be easily reached with the electrode.
4. Hold electrode 40 to 45 degrees out from the vertical plate and inclined 85 degrees in the direction of travel.
5. Strike an arc and establish a puddle evenly on both pieces. Place a single bead in the corner using a whipping motion.
6. Visually Inspect

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7. Break the plates apart and inspect for complete penetration into the corner. There should be no undercutting on the horizontal plate or overlapping on the vertical plate.

****Sample shown in slide: Fleetweld 5P+ (E6010), DC+, 85 Amps****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- What technique should be used when welding with an E6010/E6011 electrode overhead?
- What is the AWS designation for a fillet weld made in the overhead position?

APPLICATION:

Extended Classroom Activity:

- Develop a checklist of correct procedures on making an overhead fillet weld on a lap joint. Assemble students of different welding skill levels into pairs. Have each student observe the other making an overhead lap joint. Students should make observation in conjunction with the checklist. When the weld is completed, the pair will discuss the results and coach each other on how to improve.

SAE Activity:

- Have students determine the amount of money they spent during their previous SAE fiscal year on welding supplies, custom welding work, or metal fabrication. Now that the student understands the process of welding better, have the student develop a plan of action that can reduce their welding and metal fabrication costs.


EVALUATION:

Students will be evaluated on the successful completion of the exercise.

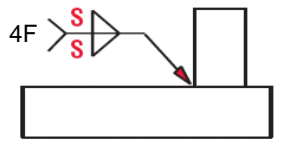
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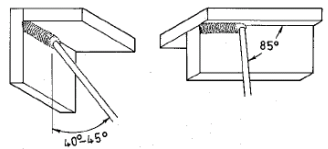
SMAW Lesson #12


- Objective: To make a fillet weld on a tee joint in the overhead position (AWS Position 4F)
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate - 10 gauge
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC



4F






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UNIT: SMAW

PROBLEM AREA

How do I make a fillet weld on a tee joint in the overhead position (AWS Position 4F) using an E6010/E6011 electrode?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter
- **NLA-STANDARD 7:** Uses reading skills and strategies to understand and interpret a variety of informational texts.

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Make a fillet weld on a tee joint in the overhead position with an E6010/ E6011 electrode.

TIME: INSTRUCTION TIME FOR THIS LESSON: 1.25 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)
- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

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TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate - 10 gauge
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC

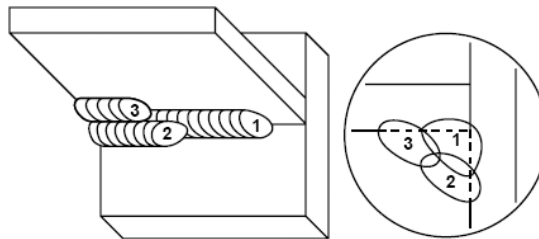
KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

- Stringer Beads

TEACHER NOTES: Suggested discussions include information regarding the following:

Overhead fillet welds on lap joints and tee joints are made in a similar manner. Weld overhead as a series of **stringer** (straight) **beads** using a slight circular motion. Weave beads are too fluid and will spill. The term **stringer bead** applies to any bead made in a straight line (no weave) regardless of electrode or technique being used.



INTEREST APPROACH:

- Create a list of statements about this lesson, half that are true and half that are false. Write each statement on a separate index card. Distribute one card to each student. Students need to determine if the statement is true or false by using any method necessary. Once completed, have each student read the statement and answer. Record the answers by creating two columns on the chalk board one for true statements and one for false statements. Explain how to make the false statements true or what would happen if the false statements were performed.

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To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise: Make a fillet weld on a tee joint in the overhead position

1. Clean base material
2. Set polarity and amperage: DC+ at 85-100A for 1/8" E6010 electrode.
3. Tack-weld plates for a tee joint, and secure in the overhead position so that the underside may be easily reached with the electrode.
4. Hold electrode 20 - 22 degrees out from the vertical plate and inclined 85 degrees from the horizontal plate in the direction of travel.
5. Strike an arc and establish a puddle evenly on both pieces. Place a single bead in the corner using a whipping motion.
6. Visually Inspect
7. Break the plates apart and inspect for complete penetration into the corner. There should be no undercutting on the horizontal piece or overlapping on the vertical plate.

****Sample shown on slide: 1/8" Fleetweld 5P+ (E6010), DC+, 85 Amps****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- How are multiple pass overhead fillet welds made?
- What is a stringer bead?

APPLICATION:

Extended Classroom Activity:

- On index cards, write down the step by step procedures for making an overhead fillet weld on a tee joint. Make sure to put one step per card. Arrange the students into groups. Each group will assemble the cards into the correct procedure order.

SAE Activity:

- Bring in several different recruiters from a variety of four year institutes, junior colleges, and technical schools to discuss with students career options, skills need for admission, and job placement.

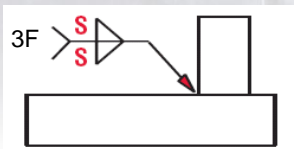
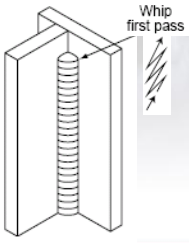

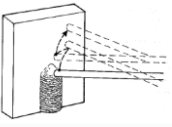
EVALUATION:


Students will be evaluated on the successful completion of the exercise.

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SMAW Lesson #13

- Objective: To make a single pass fillet weld on a tee joint in the vertical position welding up (AWS Position 3F)
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate – 1/4"
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC


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UNIT: SMAW

PROBLEM AREA

How do I make a single pass fillet weld on a tee joint in the vertical position welding up (AWS Position 3F) using an E6010/ E6011 electrode?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Make a single pass fillet weld on a tee joint in the vertical position welding up with a E6010/ E6011 electrode

TIME: INSTRUCTION TIME FOR THIS LESSON: 5 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)
- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

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TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate – 1/4"
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC

KEY TERMS:

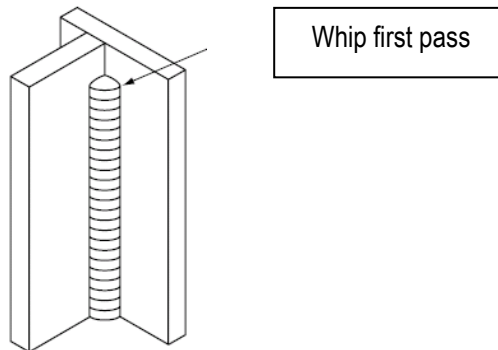
THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

- Vertical up fillet weld (AWS position 3F)

TEACHER NOTES: Suggested discussions include information regarding the following:

Vertical up techniques provide deeper penetration and lower overall welding costs on plate over 1/4" thick. When welding with an E6010/E6011 electrode in the **vertical up** position, make sure the puddle has solidified before returning to the weld crater to add another bead. If the puddle is not allowed to solidify before more material is added, the molten metal can spill out of the joint.

It is important to maintain a constant rod angle all the way up the plate. Typically, when students are learning to weld **vertical up**, fingernailing or uneven burn off of the electrode can occur. This is the result of a large lead angle being used.



INTEREST APPROACH:

- Ask the class an intriguing question that some students would know the answer to, but most would not. For example, "Why are fillet welds 1/4" and over welded vertically up?" Encourage students to take their best guesses. Use the question to lead into your lesson, only answering the question as the lesson progresses.

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To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise: Make a fillet weld on a tee joint in the **vertical position welding up**.

1. Clean base material
2. Set the polarity and amperage: DC+ at 90-100A for 1/8" E6010.
3. Tack-weld plates for a fillet weld and secure in a **vertical** position.
4. Use a whipping motion to lay the first bead. Whip the electrode tip out of the molten crater and up for a short time to let the crater cool before returning the electrode tip to the crater area to add more weld metal.
5. Visually inspect

****Sample shown on slide: Fleetweld 5P+ (E6010), DC+, 100 Amps****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- Why is plate 1/4" and over welded vertically up?
- Why is the whipping technique used when welding vertically up?

APPLICATION:

Extended Classroom Activity:

- Have the students work on equipment brought in by members of the community. Focus the efforts of repairing the equipment using skills learned in class.

SAE Activity:

- Have the chairman of the county, city, or regional economic development team speak to the class on community trends and the need for small business growth in the agriculture mechanics, welding, and metal fabrication sectors.


EVALUATION:

Students will be evaluated on the successful completion of the exercise.

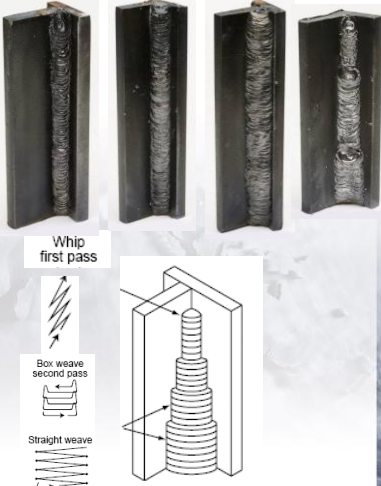
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SMAW Lesson #14

- Objective: To make a three pass fillet weld on a tee joint in the vertical position welding up (AWS Position 3F)
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate – 1/4"
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC




3F



Whip first pass

Box weave second pass

Straight weave


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UNIT: SMAW

PROBLEM AREA

- How do I make a three pass fillet weld on a tee joint in the vertical position welding up (AWS Position 3F) using an E6010/ E6011 electrode?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter
- **NLA-STANDARD 7:** Uses reading skills and strategies to understand and interpret a variety of informational texts.

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Make a three pass fillet weld on a tee joint in the vertical position welding up with a E6010/ E6011 electrode

TIME: INSTRUCTION TIME FOR THIS LESSON: 5 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)

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- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)
- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate – 1/4"
 - 1/8" Fleetweld 5P+ (E6010) for DC or Fleetweld 180 (E6011) for AC

KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

- Root pass bead

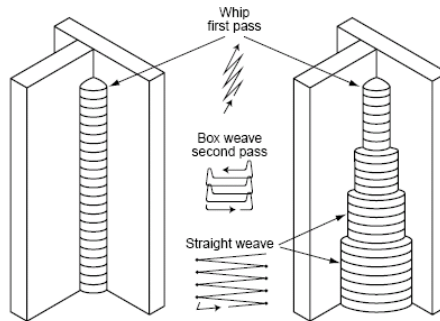
TEACHER NOTES: Suggested discussions include information regarding the following:

Maximum penetration on vertical joints in metal 1/4" or thicker is obtained by welding up. The first pass of a three pass fillet weld made vertically up is done using a whipping technique. Whip the electrode tip out of the molten crater and up for a short time to let the crater cool before returning the electrode tip to the crater area to add more weld metal (As seen in Lesson #12).

These **root pass beads** (the bead that extends into the root of the joint) have a tendency to be convex or humped in the middle, particularly when made with a whipping technique. Therefore, a box weave is often needed for the second pass to assure good fusion along the edge of the first bead. The box weave is similar to the straight weave except a slight upward motion is made at both sides of the weld. (See figure below) Emphasize to the students that this technique is a weave before it is a whip. Keep the rod in a box progression. If the student uses a U pattern as opposed to the box weave, undercutting can occur.

Use a straight weave for the final passes. Move the electrode tip back and forth across the surface of the weld pausing at both edges. Reinforce the importance of pausing at the corners of the weld on both the second and third passes. Generally, the operator wants to let the puddle grow slightly larger than the electrode before moving to the other side. This is done to ensure penetration and wash-in without undercut. Movement across the middle of the puddle should be quick to produce a flat bead and to avoid weld metal spilling from the joint.

Vertical Up Techniques for Fillet and Groove Welds

**INTEREST APPROACH:**

- Draw several different weave patterns including a box weave, whip, straight weave, and a triangular weave on the board. Ask students to identify and name the different types of weave patterns, the advantages and disadvantages of each and when should each weave pattern be used.

To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise: Make a three pass fillet weld on a tee joint in the vertical position welding up.

1. Clean the base material
2. Set the polarity and amperage: DC+ at 90-100A for 1/8" diameter E6010 electrode.
3. Tack-weld plates for a fillet weld and secure in a vertical position.
4. Use a whipping technique to lay the first bead. Whip the electrode tip out of the molten crater and up for a short time to let the crater cool before returning the electrode tip to the crater area to add more weld metal.
5. Create 2nd pass – The **root pass** bead will tend to be humped in the middle. Use a box weave for the second pass. The box weave is similar to the straight weave except a slight upward motion is made at both sides of the weld.
6. Create 3rd pass - Use a straight weave for the final pass. Move the electrode tip back and forth across the surface of the weld pausing slightly at both edges. Pause at the outer corners until the weld puddle is slightly larger than the electrode. Move across the center of the weld quickly. Slow speeds across the center will result in excess build up and a convex bead appearance.
7. Visually Inspect

****Sample shown on slide: Fleetweld 5P+ (E6010), DC+, 100 Amps****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- Why is a box weave used during the second pass with this electrode?
- How are a box weave and a straight weave similar? How are they different?

APPLICATION:

Extended Classroom Activity:

- On a half sheet of blank sheet of paper, have the students draw five sets of lines that run the length of the paper. Each line set should be a 1/2" apart. Have the students use a writing utensil to practice each weave pattern paying particular attention to the proper incline, correct motion, speed, and uniformity.

SAE Activity:

- Using the information presented by the regional economic development chairman, have the students develop and implement a community assessment piece. The community assessment should focus on infrastructure, location of business, type of business (welding shop, metal fabrication, etc.), suppliers, zoning, tax structure, etc.

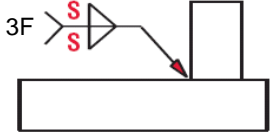
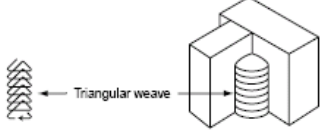

EVALUATION:


Students will be evaluated on the successful completion of the exercise.

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SMAW Lesson #15

- Objective: To make a single pass fillet weld on a tee joint in the vertical position welding up (AWS Position 3F)
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate – 1/4"
 - 1/8" Excalibur 7018 (E7018) for DC or Lincoln 7018AC (E7018) for AC


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UNIT: SMAW

PROBLEM AREA

- How do I make a single pass fillet weld on a tee joint in the vertical position welding up (AWS Position 3F) using an E7018 electrode?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Make a single pass fillet weld on a tee joint in the vertical position welding up with an E7018 electrode

TIME: INSTRUCTION TIME FOR THIS LESSON: 5 HRS.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)
- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate – 1/4"
 - 1/8" Excalibur 7018 (E7018) for DC or Lincoln 7018AC (E7018) for AC

KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

- Triangular weave

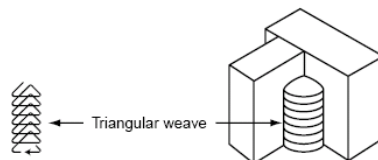
TEACHER NOTES: Suggested discussions include information regarding the following:

The electrode used in this lesson is classified by the AWS as E7018. This electrode is classified as 'low hydrogen'. Low hydrogen electrodes are recommended for three broad areas of application:

1. On low alloy, high carbon, high sulfur, or other steels where cracking is a problem.
2. When specified by governing codes.
3. For lowest costs on vertical, overhead and horizontal groove welds on heavy plate.

Since low hydrogen electrodes rely on the molten slag for shielding, never hold a long arc, whip the arc, leave the crater, or move rapidly in any direction. Failure to follow these techniques may result in porosity and/or reduced mechanical properties. For Clean Tie-Ins – Strike the arc ahead of the crater, move quickly back into the crater, then proceed in the direction of welding. This technique welds over the striking area, eliminating porosity or tendency for poor starting bead shape.

A **triangular weave** is used to make the first pass vertical up with an E7018 electrode. The weave is named for the shape that the electrode makes when using the technique. (See below). Pause at each point of the triangle to ensure good fusion and move across the face of the weld quickly to produce a flat bead appearance.

**INTEREST APPROACH:**

- Have the students develop a comparison between the different requirements for storing E6010/ E6011 electrodes versus E7018 low hydrogen electrodes. Topics can include: storing, redrying, and packaging.

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To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise: Make a single pass fillet weld on a tee joint in the vertical position welding up.

1. Clean base material.
2. Set the polarity and amperage: DC+ at 90-120A for 1/8" diameter E7018 electrode.
3. Tack-weld plates for a fillet weld and secure in a vertical position.
4. Use a **triangular** motion to lay the bead
5. Visually Inspect

****Sample shown on slide: Excalibur 7018 MR (E7018), DC+, 115 Amps****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- Describe a triangular weave.
- Why isn't the whipping technique used in this lesson?

APPLICATION:

Extended Classroom Activity:

- Have the students weld two sample tee joints on 1/4" plate to determine how bead placement affects the strength of a weldment.

Have the students draw the weld symbols for both samples.

Sample one: Make a double pass weld on one side approximately 4" long.

Sample two: Make a single pass weld on each side approximately 4" long.

Break both welds in a vice and determine which is stronger.

Discuss the importance of weld placement.

SAE Activity:

- Bring in a loan officer from the local bank. Have him/her discuss how to obtain a loan, how to grow a small business, items to consider when beginning a small business, traps, pitfalls, and opportunities.


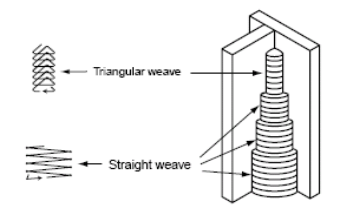
EVALUATION:

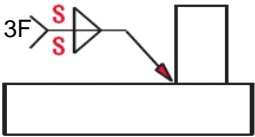
Students will be evaluated on the successful completion of the exercise.


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SMAW Lesson #16

- Objective: To make a three pass fillet weld on a tee joint in the vertical position welding up (AWS Position 3F)
- Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Material:
 - Mild Steel Plate – 1/4"
 - 1/8" Excalibur 7018 (E7018) for DC or Lincoln 7018AC (E7018) for AC




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UNIT: SMAW

PROBLEM AREA

- How do I make a three pass fillet weld on a tee joint in the vertical position welding up (AWS Position 3F) using an E7018 electrode?

NATIONAL STANDARDS:

- **NM-MEA.9-12.1:** Understand measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONN.PK-12.3:** Recognize and apply mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE:** Interactions of energy and matter
- **NLA-STANDARD 7:** Uses reading skills and strategies to understand and interpret a variety of informational texts.

STUDENT LEARNING OBJECTIVES: AS A RESULT OF THIS LESSON, THE STUDENT WILL ...

- Make a three pass fillet weld on a tee joint in the vertical position welding up with an E7018 electrode

TIME: INSTRUCTION TIME FOR THIS LESSON: 5 HR.

RESOURCES:

- AWS 'Safety in Welding, Cutting, and Allied Processes' (ANSI Z49.1)
- Lincoln Electric's 'Safety in Arc Welding' (E205)
- Stick Electrode Welding Guide (C2.410)

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- Stick Electrode Product Catalog (C2.10)
- New Lessons in Arc Welding

TOOLS, EQUIPMENT, AND SUPPLIES:

- Tools and Equipment:
 - Single Process - Constant Current Power Source
 - Idealarc 250 and accessories
 - Precision TIG 225 and accessories
 - Multi-Process
 - Power MIG 350 MP
- Supplies:
 - Mild Steel Plate – 1/4"
 - 1/8" Excalibur 7018 (E7018) for DC or Lincoln 7018AC (E7018) for AC

KEY TERMS:

THE FOLLOWING TERMS ARE PRESENTED IN THIS LESSON AND APPEAR IN BOLD:

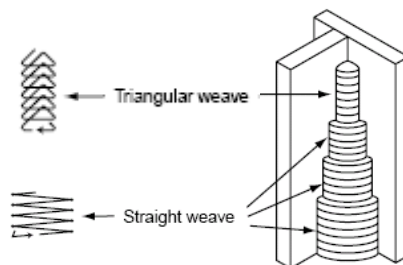
- Weld size

TEACHER NOTES: Suggested discussions include information regarding the following:

(See Lesson #15 for more information on Low Hydrogen electrodes) Multiple Pass Welds – For multi-pass welds, deposit a first pass bead using a triangle weave. Emphasize the importance of moving into the corner to assure penetration into the corner. Clean the slag after each bead. Weld additional layers with a straight weave (side-to-side) hesitating at the sides long enough to melt out any small slag pockets, ensure penetration and minimize undercut. Use travel speeds slow enough to maintain the shelf without spilling weld metal.

Weld size

Multiple pass welds are used to create a **weld** that **size** requirements cannot be met by a single pass. The general rule of thumb for welding mild steel is that the leg of a weld should be three quarters the thickness of the thinnest member being welded provides the weld is made on both sides. This ensures that the weld is stronger than the base material it connects.



INTEREST APPROACH:

- Pose a series of questions that taps into the student's gained knowledge about welding. For example, "At this point you have learned how to make a horizontal, vertical up, vertical down, overhead, and three pass fillet welds on lap and tee joints. Today we are going to make a three pass fillet weld in the vertical position, welding up. Using your welding knowledge, what do think the process for making a

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three pass fillet weld in the vertical position welding up should be?" Continue to ask questions to pull answers from the students while keeping the teacher interaction to a minimum. Record the procedures.

To gain practical knowledge of classroom content, allow 1 hr. for the students to do practice using the following exercises:

LESSON INSTRUCTIONS

Exercise: Make a three pass fillet weld on a tee joint in the vertical position welding up (3F).

1. Clean base material
2. Set polarity and amperage: DC+ at 90-120A for 1/8" E7018 electrode.
3. Tack-weld plates for a fillet weld and secure in a vertical position.
4. Use a triangular motion to lay the first bead. Pause at each point in the triangle to ensure that there is not undercut.
5. For multi-pass welds, weld additional layers with a side-to-side weave hesitating at the sides long enough to melt out any small slag pockets to ensure penetration and to minimize undercut.
6. Visually Inspect

****Sample shown on slide: Excalibur 7018 MR (E7018), DC+, 115 Amps****

SUMMARY OF CONTENT TEACHING STRATEGIES

ASK THE FOLLOWING REVIEW QUESTIONS REGARDING THE LESSONS PRACTICED AND HAVE THE STUDENTS LOG THE INFORMATION IN A NOTEBOOK FOR FUTURE REFERENCE:

- When using a straight weave in this exercise, why is it important to hesitate at the corners?
- E7018 is classified as what type of electrode?
- What is the rule of thumb for the sizing of steel welds?

APPLICATION:

Extended Classroom Activity:

- Develop several different scenarios in which students must determine: electrode selection, which welding position to use, which joint to create, ideal weave pattern, etc. Make the scenarios as applicable to real life situations as possible.

SAE Activity:

- Have students develop a future plan of action sheet. Questions should focus on how they plan to apply this course to their SAE. Students should assess several specific situations and how they plan to apply the skills they learned to that situation. Students should also record what they want to do to continue learning about welding and specific steps in expanding their SAE.

EVALUATION:

Students will be evaluated on the successful completion of the exercise.

**RESOURCES AVAILABLE FROM LINCOLN ELECTRIC:
(www.lincolnelectric.com)**

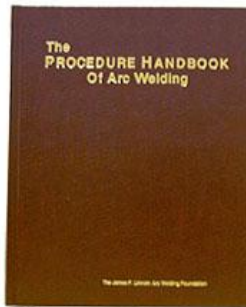
Arc Welding Safety Poster (E201) - http://www.lincolnelectric.com/assets/en_US/Products/literature/E201.pdf
Arc Welding Safety (E205) - http://www.lincolnelectric.com/assets/en_US/Products/literature/E205.pdf
Stick Electrode Welding Guide (C2.410) <http://www.lincolnelectric.com/assets/US/EN/literature/c2410.pdf>
Stick Electrode Product Catalog (C2.10) <http://www.lincolnelectric.com/assets/US/EN/literature/c210.pdf>

ADDITIONAL INFORMATION REGARDING ALL REFERENCED EQUIPMENT CAN BE ACCESSED AT:

PM 216 - <http://www.lincolnelectric.com/assets/US/EN/literature/e752.pdf>
PM255XT - http://www.lincolnelectric.com/assets/en_US/Products/literature/e754.pdf
PM350MP - http://www.lincolnelectric.com/assets/en_US/Products/literature/e757.pdf
Idealarc 250 - http://www.lincolnelectric.com/assets/en_US/Products/literature/e270.pdf
V-350 - http://www.lincolnelectric.com/assets/en_US/Products/literature/e591.pdf

ENVIRONMENTAL:

Selection Guide <http://www.lincolnelectric.com/assets/US/EN/literature/mc05183.pdf>

**ADDITIONAL RESOURCES AVAILABLE FROM THE JAMES F. LINCOLN FOUNDATION:
(www.jflf.org)**

The Procedure Handbook – #1 Choice among Welding Instructors

New Lessons in Arc Welding

How to Read Shop Drawings

Metals and How to Weld them

Arc Welded Projects (Vol ii,iii, iv)

Welding Safely (DVD/VHS)

Basic Electricity for Arc Welding (DVD/VHS)