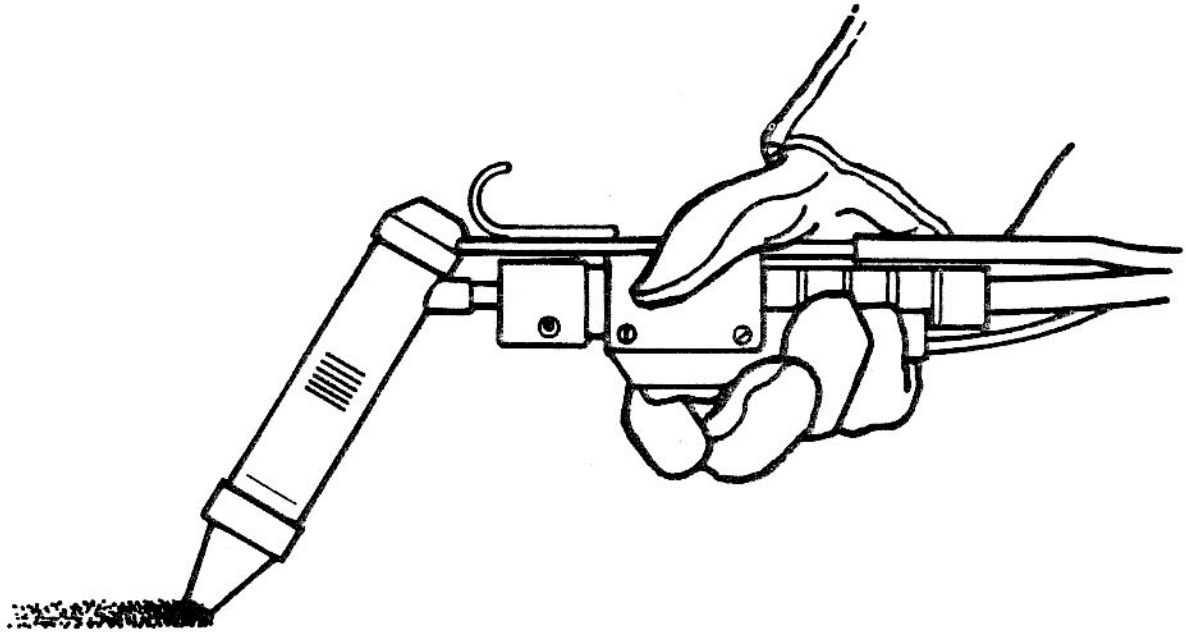
LINCOLN ELECTRIC®

SEMIAUTOMATIC SUBMERGED ARC WELDING GUIDE



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PROCESS DESCRIPTION

The process consists of a hand held welding gun which feeds in a solid wire and a source of flux supplied to the arc area. The flux may be supplied by gravity feed through a cone, or a pressurized tank system.

The arc melts the wire, the base metal and flux into a common pool. The molten flux acts as a cleansing agent and floats to the top of the weld to form a protective slag while the weld solidifies.

Process advantages are noted below.

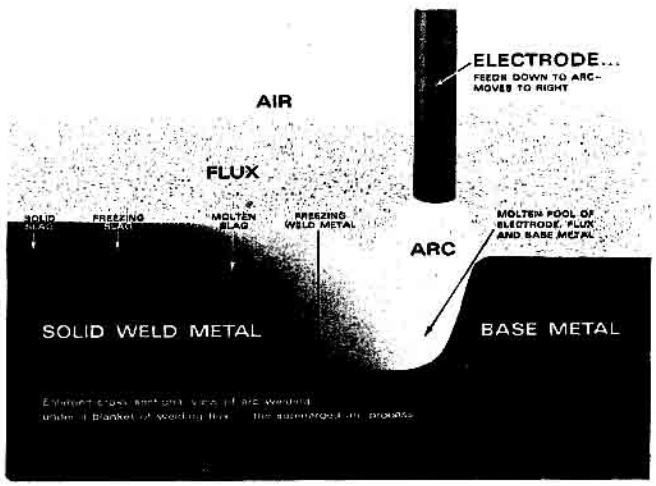


FIGURE 1

PROCESS ADVANTAGES

Semiautomatic submerged arc welding can produce consistent, high quality welds. Note the following advantages:

1. *Exceptional "Fast-Fill" ability* of submerged arc welding results in low cost welding. The deposition rate for 1/16" diameter electrode is about 16-18 lbs/hr while 5/64" diameter electrode may reach 24 lbs/hr using DC( ) (LN-50 980 and LN-9, DC-600 CV Sub-arc mode).
2. *Outstanding "Fast-Follow" characteristics* make submerged arc welding an economical process for small welds. Welding travel speed is limited primarily by the operator's ability to follow a seam at high travel speeds — by adding a travel speed mechanism the "Fast-Follow" characteristics may be a greater advantage.
3. *Deep penetration* [DC(+)] minimizes the amount of weld metal required for full strength and sometimes reduces joint preparation requirements.
4. *Greater operator comfort* results because of reduced exposure to smoke, spatter, glare and heat.
5. *Excellent slag removal* (with proper procedures) means little or no chipping and, since there is no spatter and the beads are smooth and ripple-free, they require minimum cleaning time. Overall appearance is virtually unsurpassed when compared to other semiautomatic processes.
6. *Consistent quality* weld metal when using proper procedure:
   a. Mechanical properties are equal to or better than the base metal.
   b. Low hydrogen deposits are dense, crack resistant and free of inclusions.
   c. X-ray and code quality welds are easily made with standard procedures.

REQUIRED EQUIPMENT

Lincoln LN-8 and LN-9 semiautomatic wire feeders are recommended for submerged arc welding. The LN-7 may also be used.

The Idealarc DC-400 and DC-600, combination variable voltage and constant voltage DC power sources are recommended for semiautomatic, submerged arc welding. The constant voltage sub-arc output characteristic is recommended.

Other power sources such as the R3S-400, R3S-600, SAF-600, SA-800, SAM-400 and SAM-650 welders are also satisfactory for semiautomatic submerged arc welding.

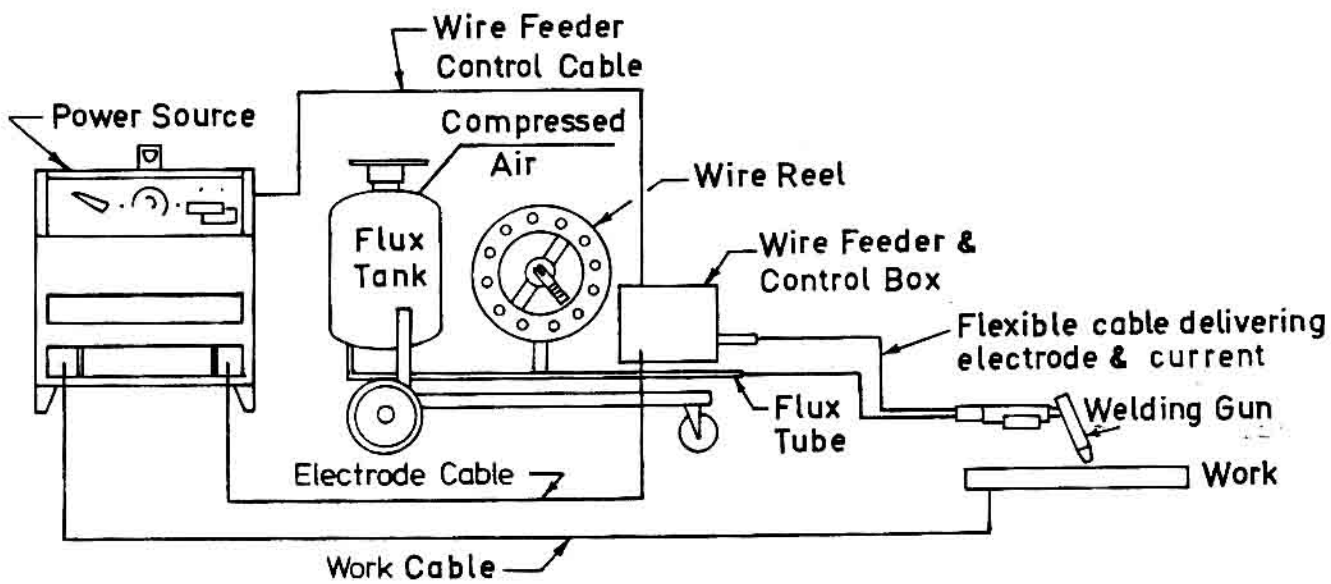


FIGURE 2 — Schematic of Required Equipment.

WELDING PREPARATIONS

ELECTRODE

Two types of Lincoln solid electrode are available for use with 980 flux. These electrodes are coated with a very thin layer of copper which is carefully controlled for thickness. The copper coating gives significantly improved electrical contact between the electrode and the contact tip. Better electrical contact results in more uniform quality, increased tip life and better weld bead appearance.

L-50 (EM13K) is a low carbon (.07-.19 C), medium manganese (.90-1.40), high silicon (.45-.70 Si) electrode which is preferred for better wetting action, straighter bead edges, easier slag removal and greater porosity resistance due to rust or mill scale. It is recommended for single and multiple pass welding when used with 980 flux. L-50 is available in 1/16, 5/64 and 3/32" diameter sizes.

L-61 (EM12K) is a low carbon (.07-.15 C), medium manganese (.85-1.25), medium silicon (.15-.35 Si) electrode which is preferred for reduced cracking tendencies on single pass welds in conditions of restraint, particularly when the plate is high in carbon or sulfur. It is also recommended for multiple pass welds with 980 flux when improved notch toughness or increased resistance to back blow porosity is desired. L-61 is available in 5/64 and 3/32" diameter sizes.

LC-72, a tubular electrode, is recommended for higher deposition rate welding. Deposition rates of up to 23 lbs/hr with 5/64 LC-72 and 25 lbs/hr with 3/32 LC-72 are practical when used with 980 flux. The combination of LC-72 electrode and 980 flux produces excellent single and multiple pass welds and is recommended when the higher productivity associated with increased deposition rates is required.

980 in combination with either L-50, L-61, or LC-72 is recommended for the majority of semiautomatic welds on plain carbon steel. 980 flux is not recommended for welding with electrodes or steels containing over 0.3% chromium. Request bulletin S-210 for more information on Lincoln's complete line of solid electrodes. For additional information on LC-72 request bulletin S-220.

FLUX

980 flux has been especially designed for semiautomatic welding. A high degree of wetting ability plus extremely low flash through characteristics make this flux especially suited for semiautomatic operation. 780 L-60 is second only to 980 L-50 for general semiautomatic welding. It is possible to make good semiautomatic welds with many combinations of flux and electrode. A brief descriptin of our other submerged arc fluxes is listed below. For further information see bulletin S210.

760* — Best for arc blow porosity.
761* — Slower freezing slag — excellent crack resistance.
780* — Most versatile — excellent deep groove slag removal.
781* — Best for high speed sheet steel — clean plate.
860 — High impact properties — unlimited thickness.
880 — A neutral flux designed for use with flux cored and solid alloy electrodes in hardsurfacing and alloy steel welding applications. 880 flux and the Lincore™ flux cored electrodes may be used with automatic or

K-112 'SQUIRTGUN' AND CABLE: For LN-4, -5, -6, -7, -8 and -9. Gun and cable capacity 500 amperes, 60% duty cycle. Designed for 1/16 electrode. Gun includes one 1/16" contact tip and one each flux cone with 1/2" and 3/4" opening. This gun does not have flux valve or receptacle for mechanized travel attachment. Cannot be used on ML-2 or ML-3 machines.

K-119 FLUX CONE ASSEMBLY
Fits Squirtguns K-112 & K-113. Hopper type flux feeding replaces the continuous flux feed system.

K-113-5/64" 'SQUIRTGUN' AND CABLE: For LN-4, -5, -6, -7, -8 and -9. Gun and cable capacity 600 amps., 60% duty cycle. Designed for 5/64" electrode. Gun includes 5/64" nozzle contact tip, and one each flux cone with 5/8 and 3/4" opening. This gun does not have flux valve or receptacle for mechanized travel attachment. For 1-3/4" electrical stickout order S-13027-4 extension and S-12957-15/16 flux cone, if required.

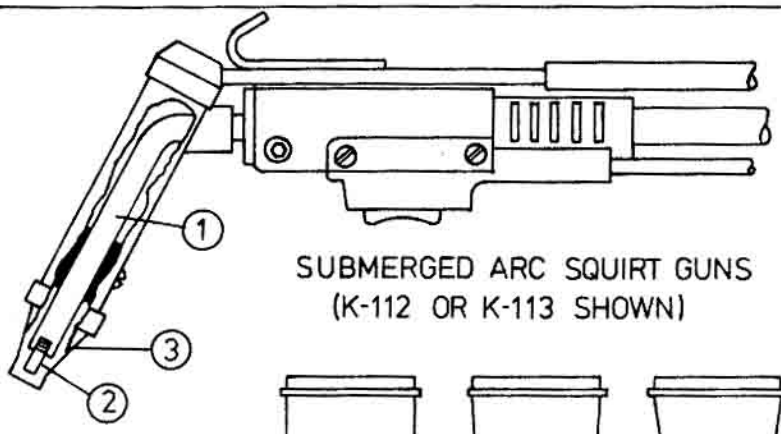
K-113-3/32" 'SQUIRTGUN' AND CABLE: For LN-4, -5, -6, -7, -8 and -9. Gun and cable capacity 600 amps., 60% duty cycle. Designed for 3/32" electrode. Gun includes 3/32" nozzle contact tip and one each flux cone with 5/8 and 3/4" opening. This gun does not have flux valve or receptacle for mechanized travel attachment. For 2-1/8" electrical stickout order S-13027-3 extension and S-12957-15/16 flux cone, if required.

K-114 'SQUIRTGUN' AND CABLE: For LN-4, -5, -8 and -9. Gun and cable capacity 600 amps., 60% duty cycle. Designed for 3/32" electrode (may also be used on 5/64" electrode). This gun has a flux valve, and receptacle for mechanized travel attachment. Gun includes one 3/32" nozzle contact tip, and one each flux cone with 5/8 and 3/4" opening. For 2-1/4" electrical stickout order S-12891-1 and S-12957-15/16 flux cone, if required.

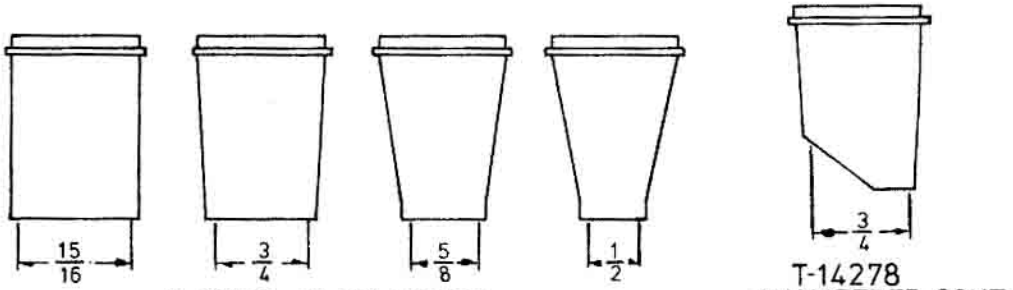
FIGURE 3

*700 series fluxes and L-60 combinations can be used on plate up to 1" thick if voltage is limited. 700 series fluxes and all electrodes other than L-60 are limited to single pass procedures.

REPLACEMENT PARTS FOR SQUIRTGUNS



SUBMERGED ARC SQUIRT GUNS
(K-112 OR K-113 SHOWN)



S-12957 FLUX CONES

T-14278
CHAMFERED CONE

Squirtguns™	K-112 (500)	K-113-5/64"	K-113-3/32"	K-114
1. Nozzle	S-13813-1	S-13813-4	S-13813-3	S-13816
2. Contact Tip	T-14050-1/16	T-12011-5/64	T-14050-3/32 T-12011-3/32*	T-12236-3/32 T-12236-5/64
3. Flux Cones Opening 1/2 5/8 3/4 13/16 15/16	S-12957-1/2 S-12957-5/8 S-12957-3/4 S-12957-13/16 S-12957-15/16			
Chamfered 3/4	T-14278	T-14278	T-14278	T-14278
Guide Tips for Long Stickout Attachment	not available	T-14435-5/64	T-12328-3/32 T-14435-3/32*	T-12328-3/32 T-12328-5/64
Long Stickout Attachment	None	S-13027-4 (for 1¾" S.O.)	S-13027-3 (for 2⅛" S.O.) S-13027-5* (for 1¾" S.O.)	S-12891-1 (for 2" S.O.) S-12891-2 (for 3" S.O.)

FIGURE 4

semiautomatic procedures. For further information see Bulletin S-261.

882 A neutral flux producing very high impact properties with carbon steel and low alloy electrodes. Can be used with electrodes containing low silicon.

CHOICE OF PROPER WELDING GUN

The following four Squirtgun™ and 15-foot cable assemblies are available for semiautomatic submerged arc welding.

For optional gun and mechanized travel equipment request Lincoln bulletin E863 or E864.

FLUX FEEDING SYSTEM

In addition to the K-119 flux cone assembly, Lincoln supplies a "Continuous Flux Feeding System" as standard equipment. The system consists of the following components: A 100-pound capacity steel flux tank which meets ASME Boiler Code specifications. The tank has a large screw cap type opening for quick and easy loading of flux. An internal screen at the tank input prevents large foreign particles from getting into the interior of the tank. (Used flux must be pre-screened through a .065 to .075" opening. The K-310 vibrated screen is available for this purpose.) A large drain orifice at the bottom of the tank permits quick and easy discharge of the flux for cleaning purposes and for changing to different fluxes.

The second part of the flux feeding system consists of the flux tank air system. The air, which provides a positive pressure inside the flux tank, enters first through a fine mesh screen cup and then through the air line filter which will remove normal amounts of moisture present in the air from the plant system. If excess moisture is present, a primary strainer or trap may be required in addition to the air line filter. Next, the air will enter the pressure regulator which reduces the pressure to 30 pounds. The 30 pound pressure is satisfactory for feeding flux through

an 18' flux tube, which is a standard hose used under normal situations. When a 64' flux hose is used, it is recommended that the air pressure in the tank be raised to 45 psi (for 1 2" I.D. hose and 55 psi for 3 8" I.D. hose). The tank is protected from over-pressure by a safety valve.

The "Continuous Flux Feeding System" normally supplies a sufficient amount of flux to cover the arc. On very rare occasions stoppages may occur from pieces of paper (from flux bags) or other objects which were picked up by reclaiming used flux.

WIRE FEEDER ADJUSTMENTS

CHECKING THE DRIVE ROLLS

The drive rolls and guide tubes in the wire feeding mechanism are designed to feed certain electrode diameters. These sizes are stenciled on the parts.

When installing new equipment or changing electrode size, be sure the proper drive rolls and guide tubes are being used. See the wire feeder operating manual for the procedures for changing these parts.

When properly adjusted the drive rolls in Lincoln wire feeders slip before the wire can be jammed into the cable. If the drive rolls are slipping, check the gun, gun cable, the drive mechanism, and the wire reel to determine the reason why the electrode is not feeding properly. A wire that has been milled by slipping drive rolls may cause additional feeding problems as it goes through the gun cable. When changing to a new coil of electrode the operator should inspect the drive rolls and guide tubes and clean as necessary.

When the drive rolls become worn, reverse or replace them according to instructions in the wire feeder operating manual.

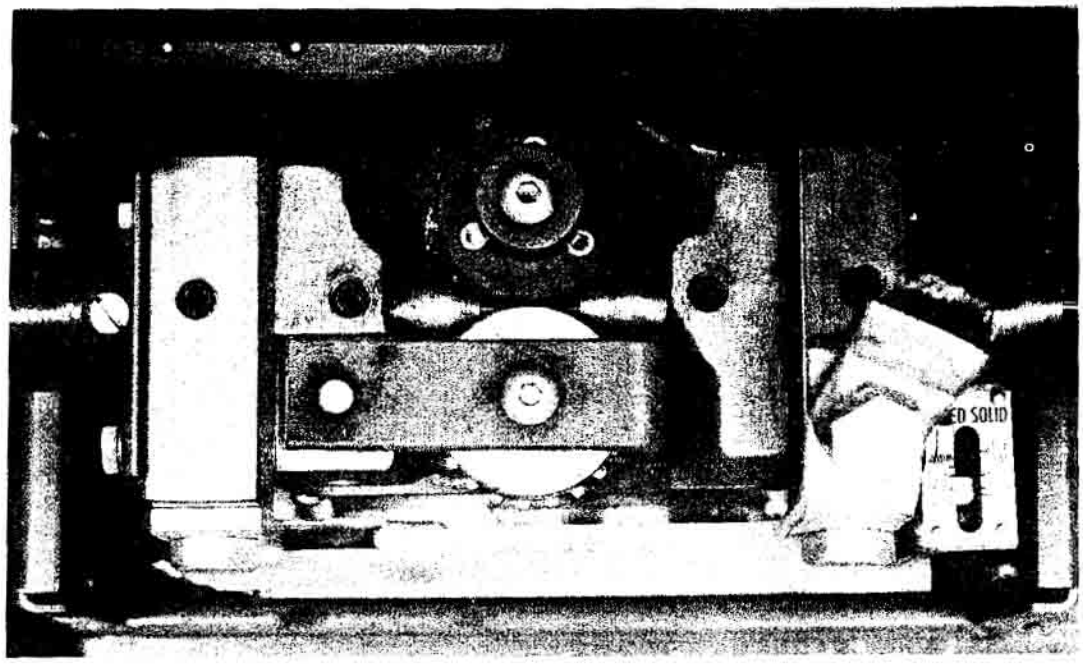


FIGURE 5 — LN-8 and LN-9 Drive Roll Assembly.

SETTING THE DRIVE ROLL SPRING PRESSURE ON THE LN-8 AND LN-9

The idle roll pressure should be adjusted as follows:

a. For 1 16 diameter electrode with wire in the system, the idle roll pressure indicator should be set to the proper size shown on the "solid" side of the nameplate. This setting is a starting point and may have to be changed depending upon type of electrode, surface condition, lubrication and hardness. The optimum idle roll setting can be determined when there are wire stoppages. If the electrode "bird nests" between the drive roll and the guide tube the idle roll spring pressure is set too high. When properly set, during a stoppage the drive rolls will slip and if the electrode is removed from the cable there will be a slight waviness in the electrode for about a foot beyond the slip marks on the electrode. If there is no waviness the pressure is set too low.

b. For electrode sizes 5 64 and 3 32" idle roll pressure should be set with electrode in the system. For solid electrode the indicator should be lined up with the "solid" electrode settings. For cored electrode the indicator should be lined up with the "cored" electrode settings. The indicator settings for these larger diameters are accurate enough so that there is no need to readjust unless the electrode is unusually soft.

SETTING THE DRIVE ROLL SPRING PRESSURE ON THE LN-7

The tension nut should normally be tightened (with wire in rolls) until it bottoms for wire sizes 1/16" and larger. For smaller wire sizes and aluminum wire, the tension nut should be loosened if the wire tends to buckle between the drive rolls and outgoing tube.

LOADING THE WIRE REEL

1. To remove the wire reel from a Lincoln wire feeder, grasp the spring loaded knob and pull it out. This straightens the knob so it seats into the shaft when released.
2. Lay the reel flat on the floor and remove the cover plate.

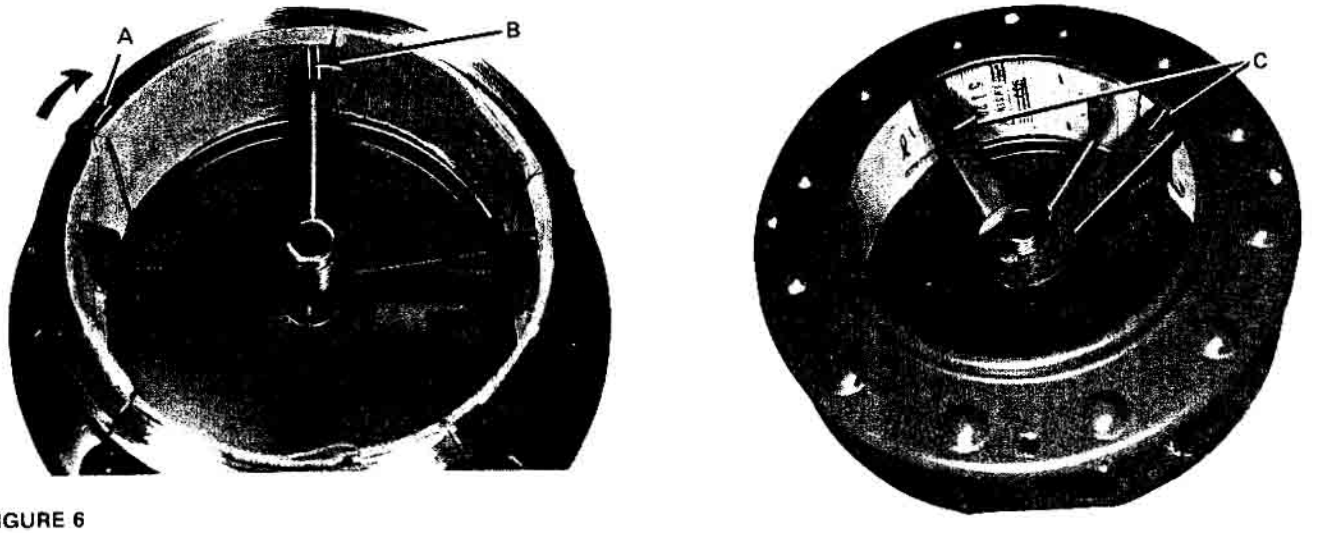


FIGURE 6

3. Place the coil of electrode on the reel so it unwinds as the reel rotates clockwise. Also:
   a. Be sure the coil is placed so the spring loaded arms will not interfere with the later removal of the coil tie wires.
   b. Put the cover plate on the reel so the arms of the cover straddle and are in line with the spring loaded arm of the reel proper. (See Figure 6) The Lincoln wire reel is specially designed to hold the coil symmetrically and to keep the coils sides tightly compressed so wire cannot "slip" to the sides.
4. Tighten the cover as much as possible by hand. *Do not* hammer on the spinner nut arms.
5. Cut and remove the tie wire holding the free end of the coil. Insert the free end into one of the holes in the cover and secure it by bending it over the rim of the cover. Cut and remove the remaining tie wires.

NOTE: Always be sure the free end of the coil is securely held while the tie wires are being cut and until the wire is feeding through the drive rolls. Failure to do this will result in "backlashing" of the coil and may allow the end of the electrode to get underneath one or more turns of wire, tangling the coil. A tangled coil will not feed, so it must be untangled or scrapped.

6. Replace the reel on the Lincoln wire feeder. Grasp the shaft knob, pull it out and swing it across the reel hub.
7. Remove the old electrode from the wire feeder.
   a. *Cut* the end of the electrode off at the gun end. Do not break it off by hand since this puts a slight bend in the wire and makes it difficult or impossible to pull it back through the nozzle.
   b. Uncouple the gun conductor cable from the wire feeder.
   c. Lay the cable out straight.
   d. Using pliers to grip the electrode, pull it out of the cable from the connector end. Do not pull it from the gun end. **CAUTION:** Do not attempt to drive the old electrode out by pushing it through with the new electrode.
   e. Put the conductor cable back on the wire drive unit after the electrode has been removed.
8. Turn the reel until the free end of the electrode is accessible. While tightly holding the electrode, cut off the bent end. Straighten the first 6" and cut off the first inch. Insert the free end thru the incoming guide tube. Press the gun trigger and push the electrode into the drive roll. Inch the electrode thru the gun. (If the electrode is not properly straightened, it may not feed or may not enter the outgoing guide tube causing a "birdnest".) The gun cable should be reasonably straight. **WARNING: The electrode and wire feed system are "hot" electrically when the trigger is pressed.**

BASIC REQUIREMENTS FOR GOOD WELDS

CLEANLINESS

Organic contaminants, (oil, grease, paint, and so forth), rust and scale, or moisture can cause porosity. Therefore:

1. Use only clean, rust-free electrode.
2. Screen used flux through a K-310 vibrated screen (.065 to .075" openings) to remove large particles of slag or other debris. If used flux is contaminated with excess fine mill scale, remove the mill scale with a Lincoln Magnetic Separator (K-58).
3. Always remove heavy rust or scale from the joint and clean off oil, grease or moisture. If any contaminants are present, welding speeds slower than maximum must be used to permit gas to bubble out of the weld before it solidifies. Therefore, it is often most economical to degrease the joint area or drive off moisture with a preheating torch.

JOINT DESIGNS AND FITUP

Submerged arc welding is a deep-penetrating process. To avoid burn through, the plates being welded are generally either butted tight together, or a back-up strip is used. Gaps of any kind increase penetration and may cause burn through. As a

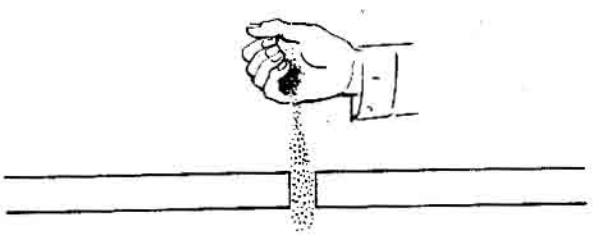


FIGURE 7 — If flux spills through the gap, support is needed.

rule of thumb, if the gap is large enough for loose flux to spill through, either a back-up or a manual seal bead is required to support the flux.

SQUARE EDGE BUTTS

Full penetration butt welds can be made from one side on steel up to 3/8" thick by using a gap and a steel or grooved copper backup bar.

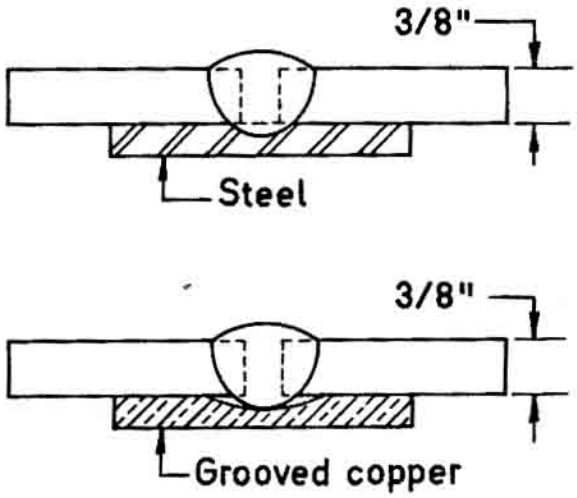


FIGURE 8

DEEP GROOVE WELDS MULTIPLE PASS

Some special consideration should be given to deep groove welds:

1. The first pass deserves the same consideration as square edge butt welds relative to burn through tendencies and methods of avoiding it.
2. Avoid excessive flux buildup in a deep groove. Use only enough flux to prevent excessive flashing. Excessive flux depth will result in a very poor bead shape. (See Figure 9) The weight of the flux bears on the liquid weld metal and will deform the finished bead.

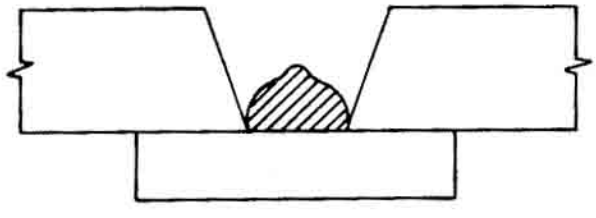


FIGURE 9 — Result of Excessive Flux.

3. Work should be level or slightly uphill to prevent slag "running".
4. Slag removal can be a problem in deep groove welding. Small, slightly convex beads clean much more easily than large, concave beads. The ease of cleaning more than compensates for the fact that more passes are needed. Bead widths should be restricted to approximately one inch. Excessive weaving is not recommended.

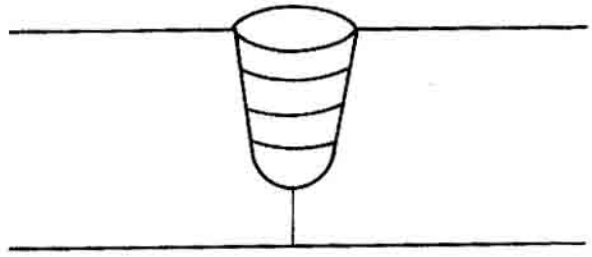


FIGURE 10 — Difficult to clean. Also wide beads made at high arc voltages pick up more manganese and silicon.

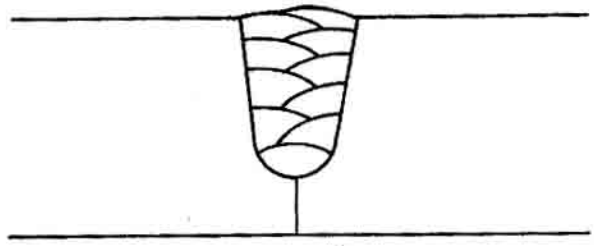


FIGURE 11 — Easy to clean. Small, well shaped beads that do not completely bridge across the groove are easier to clean than large concave beads.

5. When the arc voltage is too low, the edges of the weld bead will not wet out. Poor wetting will result in a convex bead and difficult slag removal.

FILLET WELDS

A 5/16" leg size is usually the maximum single pass fillet that can be made in the horizontal position. Single pass, flat position welds as large as 1/2" are practical.

Multiple pass horizontal fillets may be made by using the gun angles shown to maintain proper bead placement and bead shape. (See Figure 12.)

FLUX COVERAGE

Excessively deep flux produces a narrow humped bead. In semi-automatic welding, flux coverage is controlled by proper flux cone selection and in some cases by the height of the cone above the work. When making large single pass welds (3/8" and larger), a 3/4" cutaway flux cone (see illustration, Figure 4) may be used to obtain additional flux coverage and minimize flash through.

A 15/16" flux cone may be used to minimize flash through on any fill pass welds made at greater than 200 in/min WFS.

LOCATION OF WORK CONNECTION

Generally, best results are obtained by welding away from the work connection. Clamp the work lead directly to the work. A poor location of the work lead connection can cause or increase arc blow and result in porosity and poor bead shape. Unfortunately, it is not always possible to predict the effect of location and some experimenting may be necessary. In some cases, better results are obtained by splitting the work lead and connecting it to two or more places on the work. (See Figure 13.)

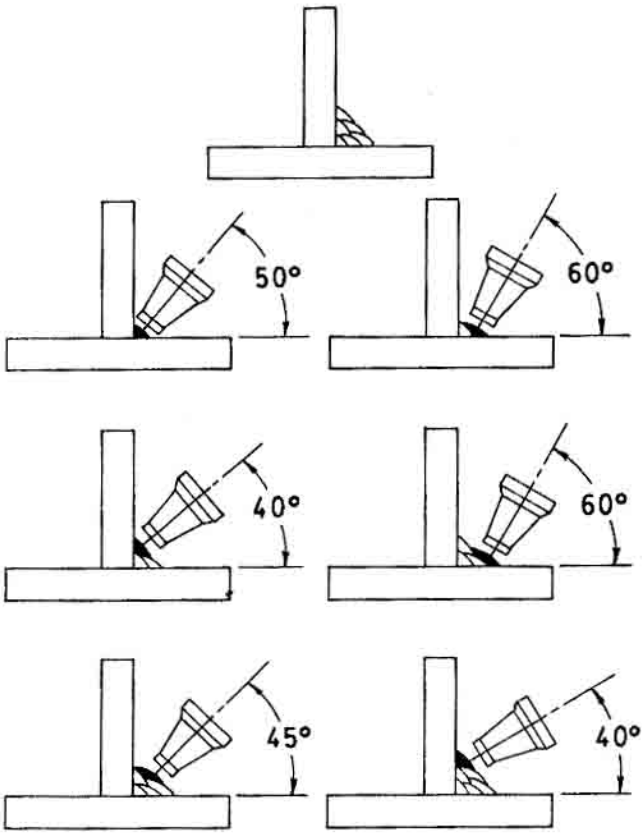


FIGURE 12 — Multiple Pass Step-Up Fillets.

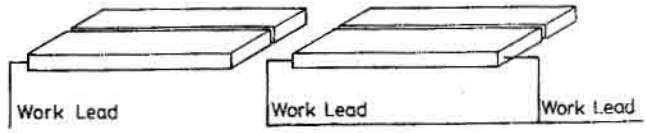


FIGURE 13 — Work Lead Connections.

PREHEAT AND INTERPASS TEMPERATURE

Preheat may be required when welding low alloy high strength steels in order to obtain good mechanical properties. The amount of preheat needed increases with thicker plate, rigid joints, higher carbon and higher alloy content. On multiple pass welds, maintain an interpass temperature equal to the required preheat temperature until all passes are complete.

Preheat may improve first pass slag removal by causing better wetting of the weld bead edges. Also, the capping pass may appear flatter because of better wetting between the weld and the parent plate when the temperature of the plate is maintained at the designated interpass temperature. The minimum required preheat can be estimated using the preheat table in AWS Code D1.1 or the "Preheat and Interpass Temperature Calculator" (WC-8) available from The Lincoln Electric Company.

WELDING TECHNIQUES

FIXTURING

Semiautomatic submerged arc welding requires at least the same amount of clamping or tacking as manual arc welding. Proper fixturing produces the following advantages:

1. Better welds are produced on light plate because of good back bead reinforcement and freedom from burn through.

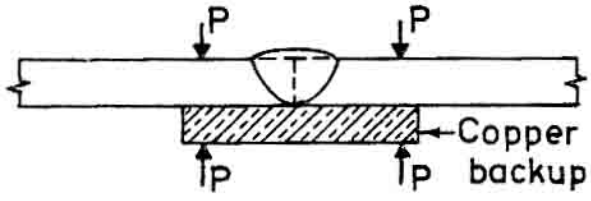


FIGURE 14

2. It is easier to follow the seam to be welded when mechanical guides are available to the weldor.

A combination of clamping and tacking is necessary for intermediate thickness material.

INCLINATION OF WORK

Practically all submerged arc welding must be done with the work nearly level. However, there are two cases where welding on inclined planes is advantageous:

1. On some light plate welding, the speed can be increased by positioning the work for welding downhill. The maximum downhill angle is 10-20°.
2. Heavy deep groove welding and large single pass fillets are sometimes done at a 2-5° uphill angle. This helps keep the molten metal from runnning ahead of the arc. Slag running ahead of the arc can reduce penetration even if the slag is not trapped under the bead.

CIRCUMFERENTIAL WELDS

Excellent circumferential welds can be made with the semiautomatic submerged arc welding process by controlling the following parameters:

1. **Electrode Position** — To prevent spillage or distortion of the bead shape, welds must solidify as they pass over the vertical center of the part. (See Figure 15.)
2. **Current and Travel Speed** — If the molten pool is too big the metal will spill because it simply cannot freeze fast enough. Reducing current (WFS) and/or increasing travel speed will decrease the size of the molten pool.
3. Since the flux is granular, a means of flux support will be necessary to maintain the proper flux depth at the arc area, particularly on smaller diameters.

For further information on making circumferential welds see bulletin S632.

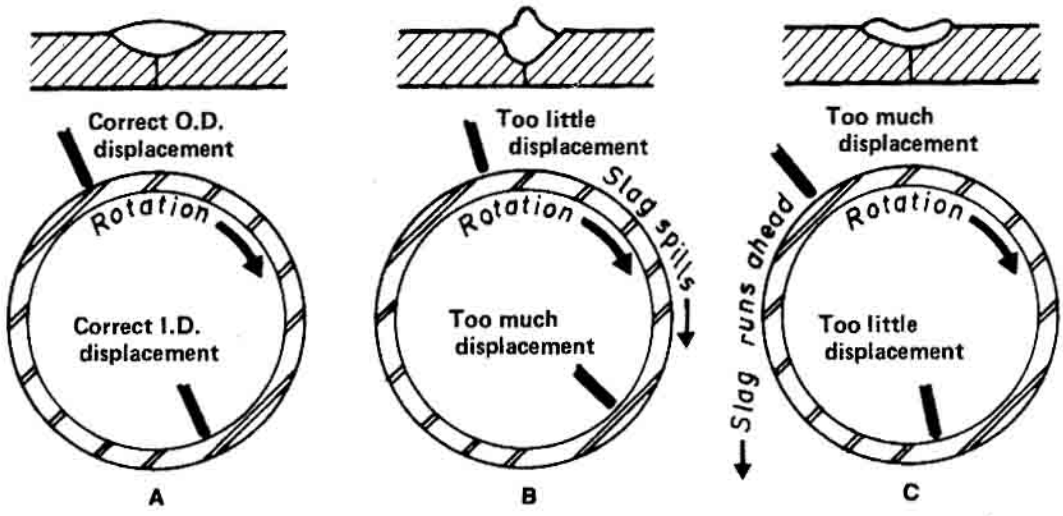


FIGURE 15

ELECTRODE POSITION

Most submerged arc welds are made by maintaining a 15° to 30° drag angle between the vertical and the welding gun axis. The drag angle is the angle seen when looking at the side view of the nozzle. Increasing the drag angle causes a small increase in the arc force back into the puddle. However, changing the drag angle to correct welding defects should be used only as a fine adjustment after voltage, wire feed speed, travel speed and electrode work angle are adjusted.

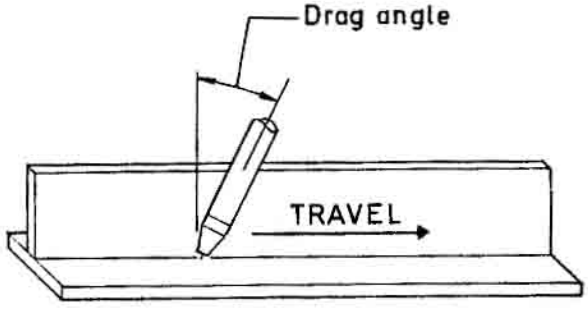


FIGURE 16 — Drag Angle.

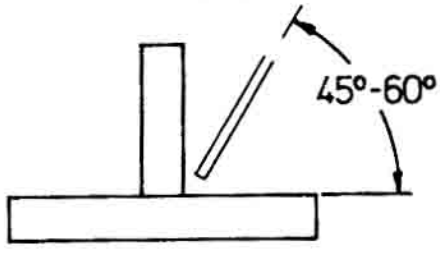


FIGURE 17 — Electrode Angle.

The electrode angle to the joint is measured from the bottom plate, therefore, on horizontal fillets the electrode angle is between 45° and 60° from the horizontal member. (See Figure 17.) The electrode drag angle is maintained at 15-30°.

Flat fillets are made with the electrode bisecting the angle and with a drag angle of 15-30°.

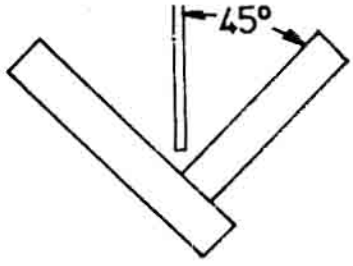


FIGURE 18

Nozzle location in Lincoln submerged arc guns is fixed so the electrode exits at the center of the flux cone tip. This allows the operator to aim for good weld placement. Different diameter cone tips shipped with each gun minimize flash throug' and flux consumption regardless of weld size.

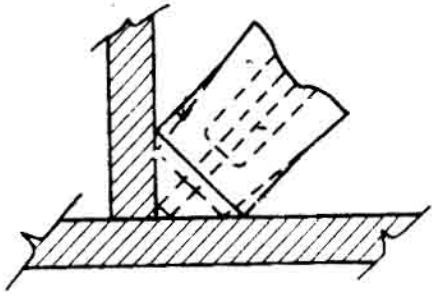


FIGURE 19

Positioning of the electrode is critical in lap welding. Experimentation is necessary in order to obtain good fusion of top and bottom plate without burn through. The thickness of the plate will determine degree of tilt from the vertical.

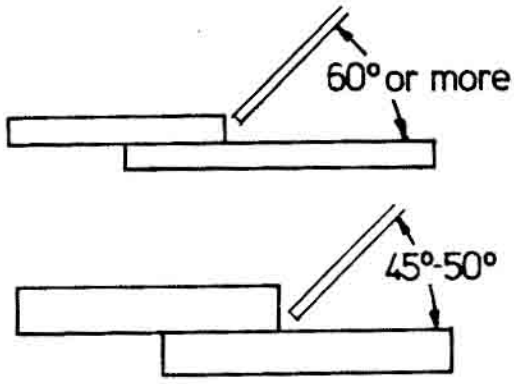


FIGURE 20

ELECTRODE POLARITY

980 flux and L-50 or L-61 electrode combinations may be used with either DC negative or DC positive. DC negative will require 2 to 3 volts more than DC positive (for a given current). Most fill applications will specify DC negative because of greater deposition rate. However, DC positive polarity will produce a weld bead with greater penetration. Greater penetration will frequently permit a reduced weld size. However, fitup becomes very important since burn through may result. The choice of polarity will depend upon the type of joint to be welded and the fitup that is available.

Negative polarity indicates that the electrode welding lead is connected to the negative output stud on the power source. The work lead is connected to the posititve output stud on the power supply. With positive polarity the opposite is true.

LINC-FILL™ LONG STICKOUT WELDING

For semiautomatic welding, an electrical stickout of 3/4" to 1-1/8" is normally recommended. The stickout is automatically set by using the appropriate flux cone size with the drag technique. Linc-Fill insulated extensions are available for the K-113 and the K-114 guns. These extension guides will increase the stickout to the lengths shown in the table on page 4. (When changing to a long stickout, the arc voltage must be increased, generally in the order of 4 to 5 volts.) Linc-Fill results in increased deposition rates.

LINC-FILL™ GUIDES

These extension guides increase stickout to preheat the electrode for up to 50% higher deposition rates.

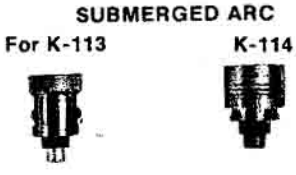


FIGURE 21

STARTING THE ARC

With a pair of diagonal or side cutters, clip the end of the electrode to a sharp point close to the end of the flux cone. Improperly clipped electrode may result in poor starts and arcing of the contact tip. Do not let the clipped end fall back into the gun.

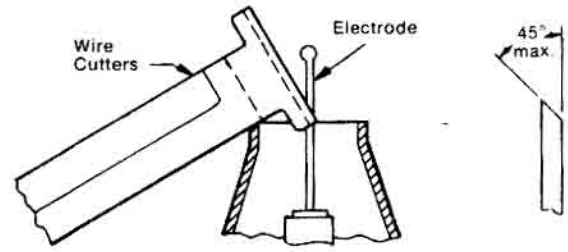


FIGURE 22

Set the wire feed speed (current) and voltage as needed for the specific job.

Position the gun over the joint as described under "Gun Operating Positions". Allow the mound of flux to form, press the trigger and touch the electrode to the work by lightly scratching through the flux. A slow acceleration start with the LN-7, LN-8 and LN-9 improves most starts and reduces flash through. Allow the arc to become firmly established before beginning travel.

If the electrode hits the work, pushing the gun up without starting the arc, immediately release the trigger, raise the gun and turn the nozzle up. The welding arc probably has not been established because of a poor electrical circuit. The electrical circuit may be partially open because of (1) loose mill scale or dirt under the tip of the electrode, (2) a loose work lead connection, (3) worn or damaged welding cables, or (4) trying to arc on slag or flux. Be sure the work lead is properly connected and the work is clean at the starting point, clip the electrode end and try again.

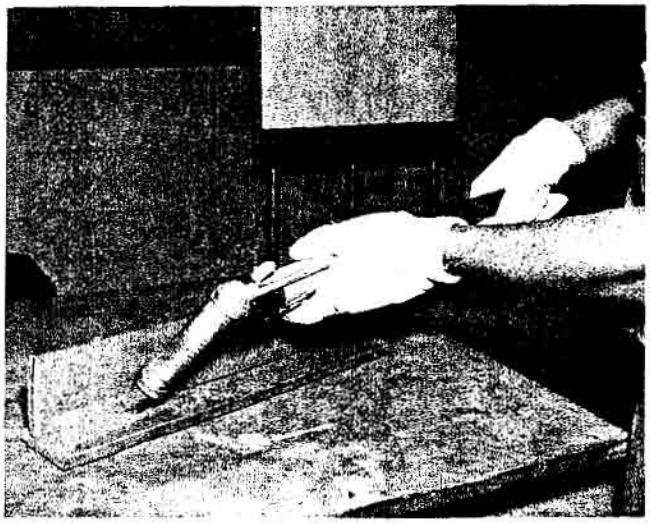
GUN OPERATING POSITIONS

Hand Held "Squirt" Guns — K-112 and K-113

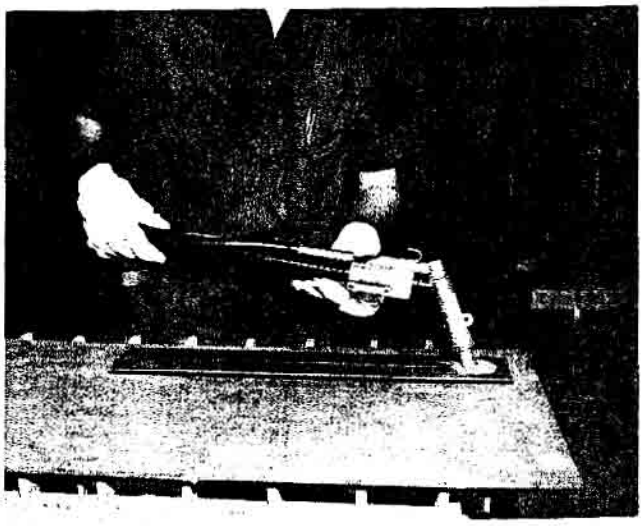
Hold the gun handle parallel to the joint and with the gun barrel not greater than 45° from the vertical. With the flux cone lightly touching the work, be sure an adequate supply of flux surrounds the striking area, press the trigger and proceed with the weld, lightly dragging the flux cone over the work.

Hold the trigger in until the weld is finished. Release the trigger to stop the arc. At the same time, lift the gun from the work and turn the nozzle up to stop the flux flow. Always set the gun down with the nozzle tipped up to avoid wasting flux and losing the back-up pressure which provides proper flux feeding.

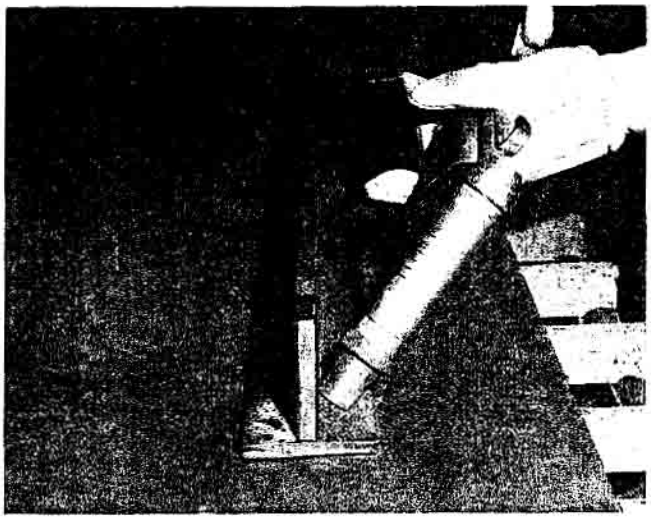
The LN-8 and LN-9 wire feeders are equipped with a Trigger Interlock switch. When the switch is turned "on", the trigger can be released after the arc has started. An optional burn back kit, K-202, may be desirable for contactor dropout delay to prevent sticking the electrode in the crater when using high WFS.



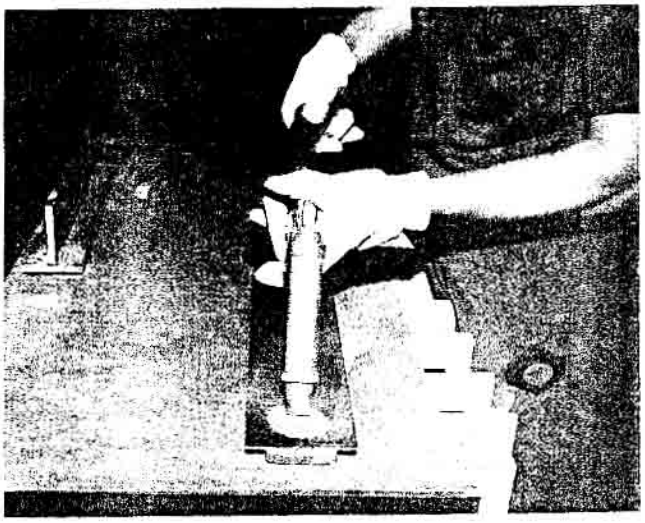
Fillet Weld — Front View. Gun in Position.



Butt Weld — Side View. Gun in Position.



Fillet Weld — End View. Gun in Position.



Butt Weld — End View. Gun in Position.

FIGURE 23 — Hand Held Squirt Guns — K-112 and K-113.

Mechanized "Squirt" Welding Gun — K-114 with K-110 Mechanized Hand Travel Unit

For highly repetitive applications, mechanized travel may be desirable. Hold the gun in the position shown in the photos with the electrode perpendicular to the joint. Additional details for arranging the joints are given in the LN-8 and LN-9 wire feeder operating manuals. Although the gun is designed to be traveled at a preset travel speed on the motor driven wheel, it can also be hand traveled. For proper flux feeding the same gun position should be maintained when it is hand carried. (See Figure 25.)

SETTING THE VOLTAGE

The arc voltage may be adjusted at the wire feeder and / or at the power source depending upon the type of equipment being used. There is a difference between the output voltage at the power source and the arc voltage or welding voltage which is being applied to the electrode. This difference is the summation of the voltage drops in the system. When holding very close arc welding voltages, it is very important to connect the Lincoln wire feeder exactly as shown on the connection diagram to ensure measuring the voltage in an accurate manner.

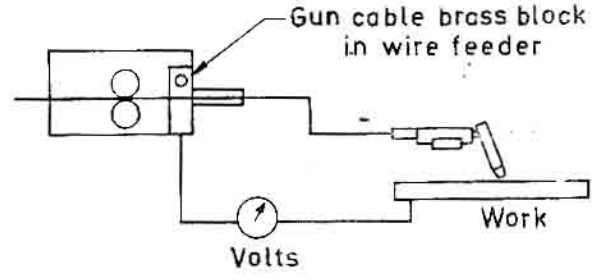
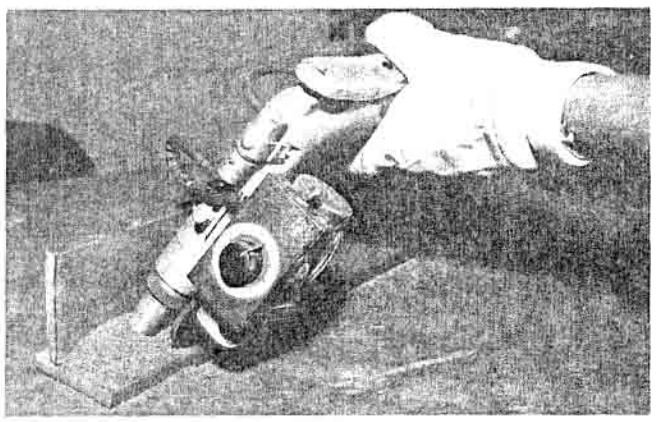


FIGURE 24



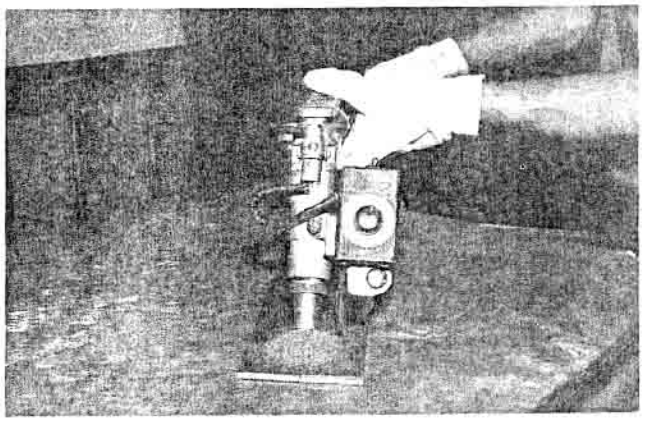
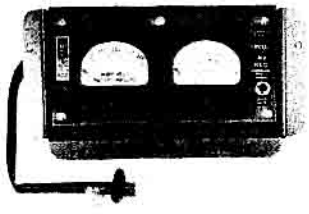


FIGURE 25 — Mechanized Squirt Welding Gun — K-114.

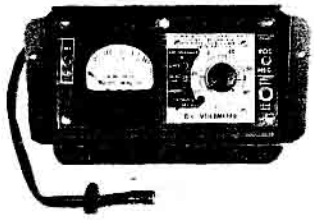
In order to get accurate welding voltage readings it is necessary to use the optional equipment described below.

A. **LN-7** — When connected to an Idealarc DC-600 or R3S with a K-775 Remote Control or a SAM, the operator can fine tune the voltage from the welding site.

- For Type K-290 and K-379 LN-7's, two meter kits are available.



K-293



K-294

FIGURE 26

Choice of Meter Kits — Both kits contain:

1. Wire feed speed meter with "Hi" (0-600 in min) and "Lo" (0-300 in min) speed ranges.
2. Voltmeter.
3. Voltmeter polarity swtich.

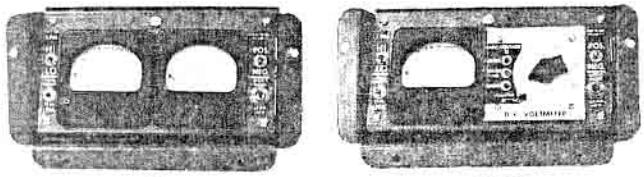
K-293 contains an Analog Voltmeter which indicates welding voltage directly on a 0-60 volt scale.

K-294 contains an Electronic Voltmeter for monitoring voltage when arc voltage must be precisely maintained. It has a voltage preset on the 12-60 volt scale and red lights to indicate when voltage is above or below the preset value.

LN-7 with Digital Meter

The K-375 and K-380 LN-7's include a factory installed and calibrated digital meter kit. The meter has a three digit LED display. A meter reading switch selects either wire speed (50-600 IPM) or volts (0-80 V). A polarity switch selects either positive or negative electrode. A hold feature freezes the display for approximately 6 seconds at the reading just prior to when welding is stopped. This feature allows the operator to easily check his procedures at the end of welding and make adjustments if required.

B. LN-8 — Standard equipment controls, when using the DC-600, R3S and SAM power sources, allow the operator to adjust the voltage at the wire feeder. Two optional meter kits are available in order to read the welding voltage directly.



K-261 K-262

FIGURE 27

Choice of Two meter Kits — Both contain:

1. Combination ammeter (0-600 amps range) and wire feed speed meter with "Hi" (0-600 in./min) and "Lo" (0-300 in./min) speed ranges.
2. Voltmeter polarity switch.
3. Jack to accept the jack plug of the 15' lead (Part No. S-15636) which can be connected directly to the work for precise arc voltage readings.

K-261 contains an Analog Voltmeter which indicates welding voltage directly on a 0-60 volt scale. Does not include the 15' S-15636 voltmeter lead.

K-262 contains an Electronic Voltmeter for monitoring voltage when arc voltage must be precisely maintained. It has a green light to indicate when welding voltage matches the voltage preset on the 12-60 volt scale and red lights to indicate when voltage is above or below the preset value. Also includes the 15' S-15636 voltmeter lead.

A portable K-185 voltage indicator is also available when it is necessary to accurately monitor the arc voltage on a number of different wire feeders.

C. LN-9 — The arc voltage is preset at the wire feeder when using the Lincoln LN-9 digital readout wire feeder. The LN-9 is recommended when very precise procedures are required. **NOTE:** follow the instructions in IM-294, LN-9 operating manual, for arc voltage setting and control.

To obtain good bead shape on most applications, set the voltage specified in the procedures on Page 14 through 20 for the electrode and current being used. An excessively convex or ropy bead indicates that the voltage is too low; excessive concavity or flash through indicates it is too high.

SETTING THE WIRE FEED SPEED (CURRENT)

The following procedure applies to constant voltage power sources only. If a variable voltage power source is used, current instead of wire feed speed must be used as the controlling parameter.

When using the LN-7 and the LN-8, the inching wire feed speed is equal to the welding wire feed speed. The following procedure will produce an accurate wire feed speed setting. Cut the electrode as close to the end of the tip as possible, pull the trigger and start the clock simultaneously. Continue inching for a minimum of 30 seconds. Stop inching and record the time. Cut the electrode at the same point as near to the tip end as possible. Measure the electrode length; if the electrode was inched for 30 seconds, the wire feed speed will be two times the length measured. **WARNING: The electrode and wire feed system are electrically hot while inching takes place.**

(Length Measured) × 2 = WFS (in./min)

Optional equipment is available for measuring the WFS on the LN-7 (Type K-290 and K-379) and the LN-8 wire feeders. (Type K-375 and K-380 LN-7's include a digital meter kit as standard equipment.) See the section on K-293 and K-294 meters for the LN-7 (Type K-290 and K-379) and the section on the K-261 and K-262 meters for the LN-8. Also the K-283 portable wire feed speed meter may be used for any wire feeder where the wire is accessible during welding.

FIGURE 28 — K-283 Portable Wire Feed Speed Meter.

The Lincoln LN-9 digital readout wire feeder can be preset for WFS at the wire feeder. Simply dial in the proper wire feed speed in inches per minute. Of course, this is the simplest and most convenient way to read and to set the wire feed speed and wherever possible this wire feeder should be used.

Recommended wire feed speeds are listed in the procedures on Page 14 through 20. WFS ranges for each electrode size appear in the table on Page 23. The approximate current and amps corresponding to each wire feed speed when welding at the specified electrical stickout is also listed on Page 23.

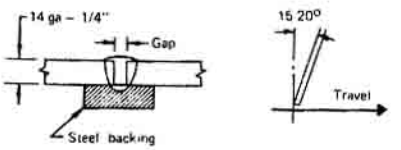
A recommended machine setting for making different types of welds without changing the voltage or the WFS (amps) for a 5/64 diameter electrode, is 34 volts and 150 WFS (375 amps), DC(-). Different sizes of butts, fillets and laps can be welded with this machine setting by changing the travel speed and the electrode angle.

When using 980 flux and 5/64" diameter L-50 electrode on 1/2" and thicker plate, an alternate machine setting is 37-38 volts, 225 WFS (425 amps), DC(-).

TYPICAL SEMIAUTOMATIC SUBMERGED ARC WELDING PROCEDURES USING SOLID ELECTRODE

SQUARE EDGE BUTTS — STEEL BACK UP, 10 ga. — 1/4" Plate

Welding Position: Flat
Weld Quality Level: Commercial
Steel Weldability: Good



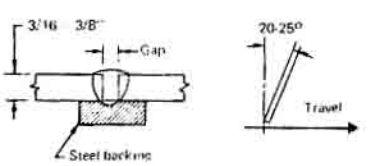
Weld Size, L (in)			
Plate Thickness, L (in)	0.135 (10 ga)	3/16	1/4
Pass	1	1	1
Electrode Size	1/16	1/16	1/16
WFS (amps) DC(+)	210 (375)	265 (425)	265 (425)
Volts	28-30	32-34	35-37
Arc Speed (in/min)	35-40	26-30	14-18
Electrode Angle, E (deg)			
Electrical Stickout (in) *			
Gap (in)	5/64	3/32	1/8
Flux Cone Size (min)	1/2"	1/2"	1/2"

* See note, page 22.

Because design, fabrication, erection and welding variables affect the results obtained in applying this type of information, the serviceability of a product or structure is the responsibility of the builder/user.

SQUARE EDGE BUTTS — STEEL BACK UP, 3/16" — 3/8" Plate

Welding Position: Flat
Weld Quality Level: Commercial
Steel Weldability: Good

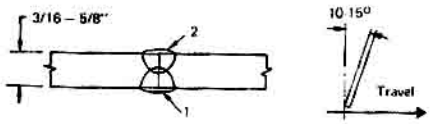


Weld Size, L (in)				
Plate Thickness, L (in)	3/16	1/4	5/16	3/8
Pass	1	1	1	1
Electrode Size	5/64	5/64	5/64	5/64
WFS (amps) DC(+)	135 (425)	145 (450)	160 (475)	170 (500)
Volts	30-32	31-33	33-35	34-36
Arc Speed (in/min)	20-22	15-17	13-15	10-12
Electrode Angle, E (deg)				
Electrical Stickout (in) *				
Gap (in)	1/8	5/32	5/32	3/16
Flux Cone Size (min)	5/8"	5/8"	3/4"	3/4"

* See note, page 22.

SQUARE EDGE BUTTS — NO BACK UP, 3/16" — 5/8" Plate

Welding Position: Flat
Weld Quality Level: Commercial
Steel Weldability: Good
Welded From: Two sides



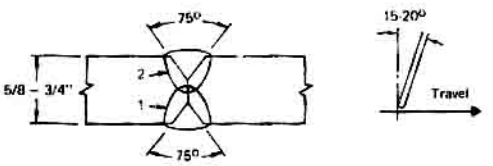
Weld Size, L (in)										
Plate Thickness, L (in)	3/16		1/4		3/8		1/2		5/8	
Pass	1	2	1	2	1	2	1	2	1	2
Electrode Size	5/64	5/64	5/64	5/64	5/64	5/64	5/64	5/64	5/64	5/64
WFS (amps) DC(+)	85 (300)	105 (350)	105 (350)	125 (400)	135 (425)	160 (475)	160 (475)	170 (500)	170 (500)	170 (500)
Volts	29-31	32-34	30-32	33-35	32-34	34-36	33-35	35-37	34-36	36-38
Arc Speed (in/min)	40-44		37-41		27-30		20-23		15-17	
Electrode Angle, E (deg)										
Electrical Stickout (in) *										
Flux Cone Size (min)	5/8"		5/8"		3/4"		3/4"		3/4"	

* See note, page 22.

Because design, fabrication, erection and welding variables affect the results obtained in applying this type of information, the serviceability of a product or structure is the responsibility of the builder/user.

BUTT WELDS — PREPARED EDGES, 5/8" — 3/4" Plate

Welding Position: Flat
Weld Quality Level: Commercial
Steel Weldability: Good
Welded From: Two sides

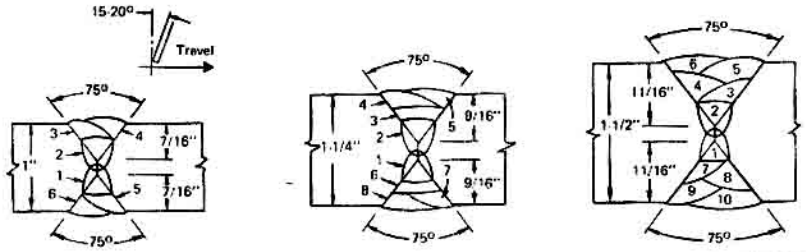


Weld Size, L (in)				
Plate Thickness, L (in)	5/8		3/4	
Pass	1	2	1	2
Electrode Size	5/64	5/64	5/64	5/64
WFS (amps) DC(+)	160 (475)	170 (500)	160 (475)	170 (500)
Volts	34-36	35-37	34-36	35-37
Arc Speed (in/min)	16-18	16-18	11-13	11-13
Electrode Angle, E (deg)				
Electrical Stickout (in) *				
Flux Cone Size (min)	3/4		3/4	

* See note, page 22.

BUTT WELDS — PREPARED EDGES, 1" — 1-1/2" Plate

Welding Position: Flat
Weld Quality Level: Commercial
Steel Weldability: Good
Welded From: Two sides



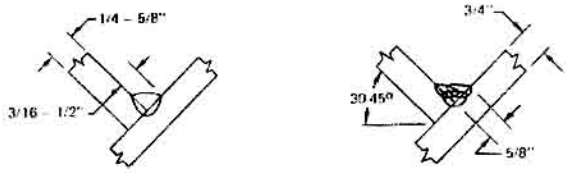
Weld Size, L (in)	1			1-1/4			1-1/2		
Plate Thickness, L (in)									
Pass	1	2	3-6	1	2	3-8	1	2	3-10
Electrode Size	5/64	5/64	5/64	5/64	5/64	5/64	5/64	5/64	5/64
WFS (amps) DC(−)	240 (450)	265 (500)	265 (500)	240 (450)	265 (500)	265 (500)	240 (450)	265 (500)	265 (500)
Volts	33-35	33-35	32-34	33-35	33-35	37-39	33-35	33-35	37-39
Arc Speed (in/min)	15-17	15-17	21-23	17-19	17-19	18-20	15-17	15-17	15-17
Electrode Angle, E (deg)									
Electrical Stickout (in) *									
Flux Cone Size (min)	3/4"			3/4"			3/4"		

* See note, page 22.

Because design, fabrication, erection and welding variables affect the results obtained in applying this type of information, the serviceability of a product or structure is the responsibility of the builder/user.

3/16" — 5/8" LEG — POSITIONED FILLETS

Welding Position: Flat
Weld Quality Level: Commercial
Steel Weldability: Good

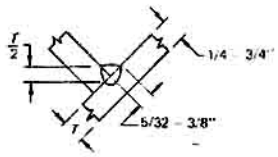


Weld Size, L (in)	3/16	1/4	5/16	3/8	1/2	5/8
Plate Thickness, L (in)	1/4	5/16	3/8	1/2	5/8	3/4
Pass	1	1	1	1	1	1,2&3
Electrode Size	5/64	5/64	5/64	5/64	5/64	5/64
WFS (amps) DC(−)	190 (375)	215 (400)	225 (425)	225 (425)	225 (425)	240 (450)
Volts	35-37	36-38	37-39	38-40	38-40	39-41
Arc Speed (in/min)	31-32	22-24	17-19	13.5-14.5	7.5-8.5	14-15
Electrode Angle, E (deg)						
Electrical Stickout (in) *						
Flux Cone Size (min)	5/8"	5/8"	5/8"	5/8"	5/8"	5/8"

* See note, page 22.

5/32" — 3/8" LEG — POSITIONED FILLETS, DEEP PENETRATION

Welding Position: Flat
Weld Quality Level: Strength only
Steel Weldability: Good



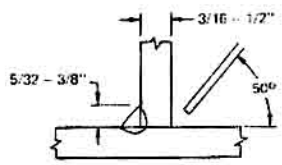
Weld Size, L (in)	5/32	3/16 (-)	3/16	1/4	5/16	3/8
Plate Thickness, L (in)	1/4	5/16	3/8	1/2	5/8	3/4
Pass	1	1	1	1	1	1
Electrode Size	5/64	5/64	5/64	5/64	5/64	5 64
WFS (amps) DC(+)	105 (350)	125 (400)	130 (410)	135 (425)	135 (425)	135 (425)
Volts	29-31	32-34	34-37	34-36	34-36	35-37
Arc Speed (in/min)	36-40	33-36	24-27	16-18	11.5-12.5	8.5-9.5
Electrode Angle, E (deg)						
Electrical Stickout (in) *						
Flux Cone Size (min)	5/8"	5/8"	5/8"	3/4"	3/4"	3/4"

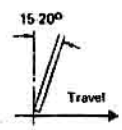
* See note, page 22.

Because design, fabrication, erection and welding variables affect the results obtained in applying this type of information, the serviceability of a product or structure is the responsibility of the builder/user.

5/32" — 5/16" LEG — HORIZONTAL FILLETS

Welding Position: Horizontal
Weld Quality Level: Commercial
Steel Weldability: Good



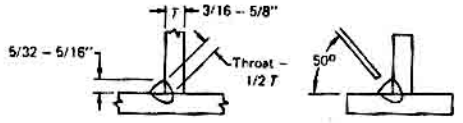


Weld Size, L (in)	5/32	3/16	1/4	5/16
Plate Thickness, L (in)	3/16	1/4	5/16	3/8
Pass	1	1	1	1
Electrode Size	5/64	5/64	5/64	5/64
WFS (amps) DC(−)	150 (310)	165 (340)	190 (375)	215 (400)
Volts	30-32	32-34	33-35	34-36
Arc Speed (in/min)	41-43	32-34	21-23	14-16
Electrode Angle, E (deg)				
Electrical Stickout (in) *				
Flux Cone Size (min)	5/8"	5/8"	5/8"	3/4"

* See note, page 22.

5/32" — 5/16" LEG — HORIZONTAL FILLETS, DEEP PENETRATION

Welding Position: Horizontal
Weld Quality Level: Strength only
Steel Weldability: Good



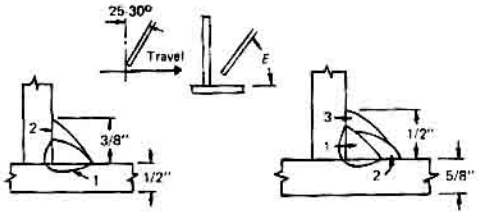
Weld Size, L (in)	1/8	5/32	3/16	1/4 (-)	1/4 (+)	5/16 (+)
Plate Thickness, L (in)	3/16	1/4	5/16	3/8	1/2	5/8
Pass	1	1	1	1	1	1
Electrode Size	5/64	5/64	5/64	5/64	5/64	5/64
WFS (amps) DC(+)	95 (325)	95 (325)	105 (350)	115 (380)	125 (400)	125 (400)
Volts	25-27	25-27	27-29	30-32	31-33	31-33
Arc Speed (in/min)	38-40	33-35	27-29	20-22	12.5-14.5	7.5-9.5
Electrode Angle, E (deg)						
Electrical Stickout (in) *						
Flux Cone Size (min)	5/8"	5/8"	5/8"	5/8"	5/8"	3/4"

* See note, page 22.

Because design, fabrication, erection and welding variables affect the results obtained in applying this type of information, the serviceability of a product or structure is the responsibility of the builder/user.

3/8" and 1/2" LEG — HORIZONTAL FILLETS

Welding Position: Horizontal
Weld Quality Level: Commercial
Steel Weldability: Good

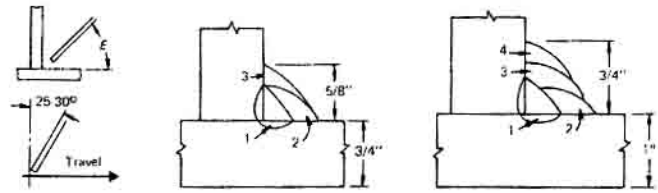


Weld Size, L (in)	3/8		1/2		
Plate Thickness, L (in)	1/2		5/8		
Pass	1	2	1	2	3
Electrode Size	5/64	5/64	5/64	5/64	5/64
WFS (amps) DC(–)	225 (425)	225 (425)	225 (425)	225 (425)	225 (425)
Volts	34-36	34-36	34-36	34-36	34-36
Arc Speed (in/min)	22-24	22-24	19-21	19-21	19-21
Electrode Angle, E (deg)	65	50	50	60	40
Electrical Stickout (in) *					
Flux Cone Size (min)	3/4"	3/4"	3/4"	3/4"	3/4"

* See note, page 22.

5/8" and 3/4" LEG — HORIZONTAL FILLETS

Welding Position: Horizontal
Weld Quality Level: Commercial
Steel Weldability: Good



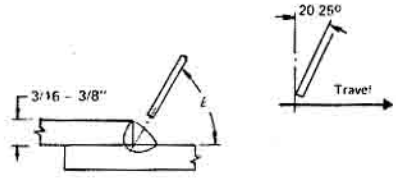
Weld Size, L (in)	5/8			3/4			
Plate Thickness, L (in)	3/4			1			
Pass	1	2	3	1	2	3	4
Electrode Size	5/64	5/64	5/64	5/64	5/64	5/64	5/64
WFS (amps) DC(–)	225 (425)	225 (425)	225 (425)	225 (425)	225 (425)	225 (425)	225 (425)
Volts	34-36	34-36	34-36	34-36	34-36	34-36	34-36
Arc Speed (in/min)	11.5-13.5	11.5-13.5	11.5-13.5	11-13	11-13	11-13	11-13
Electrode Angle, E (deg)	50	60	45	50	65	50	45
Electrical Stickout (in) *							
Flux Cone Size (min)	3/4"	3/4"	3/4"	3/4"	3/4"	3/4"	3/4"

* See note, page 22.

Because design, fabrication, erection and welding variables affect the results obtained in applying this type of information, the serviceability of a product or structure is the responsibility of the builder/user.

3/16" — 3/8" PLATE — HORIZONTAL LAPS

Welding Position: Horizontal
Weld Quality Level: Commercial
Steel Weldability: Good



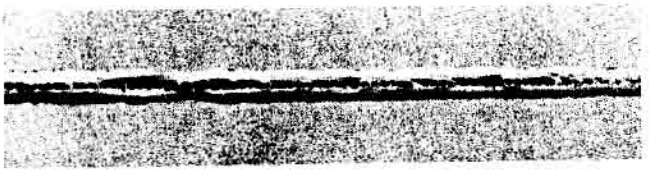
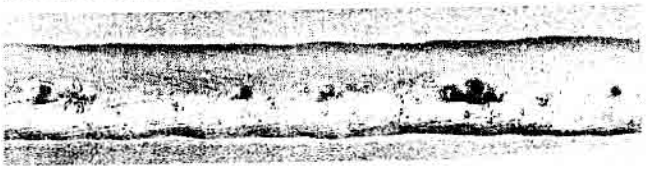
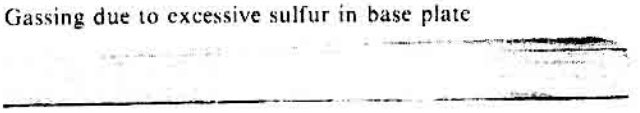
Weld Size, L (in)	3/16	1/4	5/16(-)	5/16(+)
Plate Thickness, L (in)	3/16	1/4	5/16	3/8
Pass	1	1	1	1
Electrode Size	5/64	5/64	5/64	5/64
WFS (amps) DC(–)	205 (400)	225 (425)	240 (450)	240 (450)
Volts	35-37	36-38	37-39	37-39
Arc Speed (in/min)	40-44	31-34	22-24	16-18
Electrode Angle, E (deg)	65	60	55	55
Electrical Stickout (in) *				
Flux Cone Size (min)	5/8"	5/8"	3/4"	3/4"

* See note, page 22.

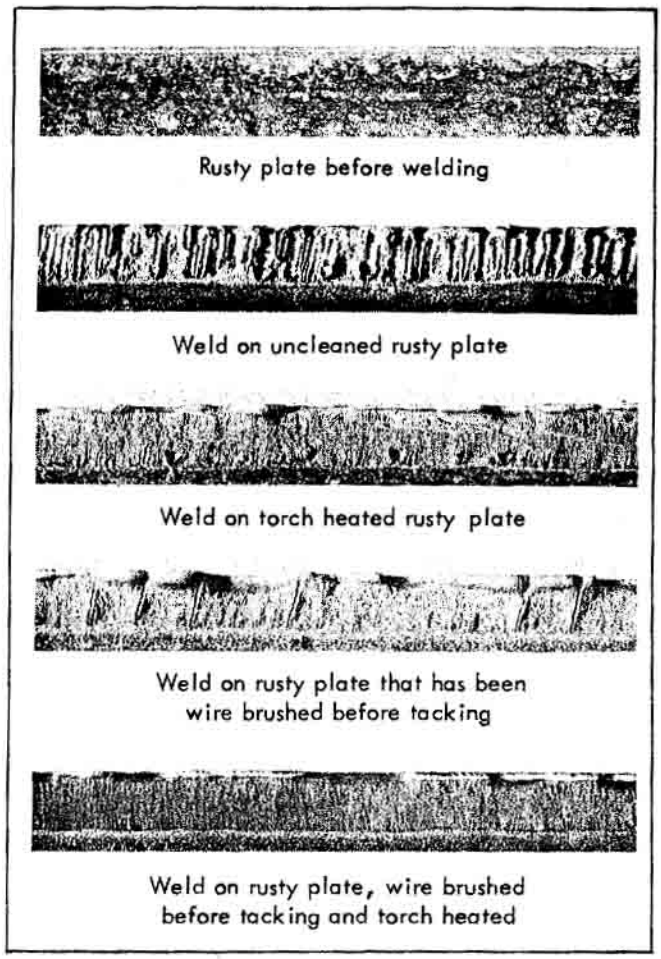
PROBLEM SOLVING

POROSITY IN SUBMERGED ARC WELDS

The following suggestions will help reduce porosity. These examples are butt welds but the problems are similar on all types of welded joints.

Problem	Cause	Solution
Arc blow 	Improper attachment of end tabs	End tabs should be large enough to suit the size of the weldment and should be welded completely to the weldment, not merely tacked.
	Poor work lead connection.	Attach work lead securely to weldment.
	Open joint	Weld toward closed end of joint or fixture.
	Location of work lead connection.	Weld away from work lead connection.
	Excessive drag angle.	Use less drag angle.
Inadequate protection 	Insufficient flux coverage	Using the proper cone size and travel speed will result in sufficient flux coverage. Too large a drag angle may interfere with flux feeding
Porosity due to contamination 	Water or oil in feed air; clogged air exit slots, recycled flux contaminated with organic material or mill scale.	Filter air, clean gun, redry flux to 500° F or magnetically separate flux to remove mill scale.
	Oily plate	Degrease and wash before welding.
Gassing due to excessive sulfur in base plate 	Sulfur in steel	Scarf joints, reduce travel speed. Use multiple pass procedures.

Problem	Cause	Solution
Excessive oxides and moisture introduced into weld pool	Rusty plate	Power brushing and torch heating will produce sound welds.



Fracture surfaces of welds on rusty plates.

Excessively fluid puddle	Interpass temperature too high	Interpass temperature should be maintained to a level consistent with accepted practice for obtaining optimum physical properties. Limiting interpass temperature also helps to control porosity and increases operator comfort.
Loss of protection when welding out of position	Beads too large causing porosity or loss of slag coverage	Use smaller passes (lower settings or higher travel speeds).

CRACK SENSITIVITY

The root pass of a 45° single vee bevel illustrates the problem of crack sensitivity due to joint geometry. A weld which provides adequate joint penetration may be deeper than it is wide, thus making it a candidate for centerline cracking. A bead which gets to the corner but not necessarily beyond it has a reasonable chance of not cracking.

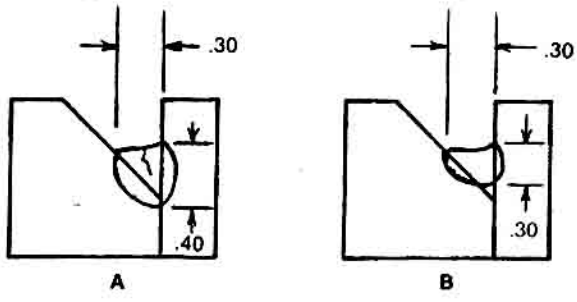


FIGURE 29

NOTE: An adequate root opening with the proper included angle and/or a back-up is recommended to avoid this problem.

MISCELLANEOUS PROBLEMS

1. Tack welds, when necessary, should be made with E6010, E6011, E7016 or E7018. Avoid rutile and iron powder type electrodes such as E6012 and E7024. Gas metal arc may be used. This helps avoid porosity and or poor slag removal.
2. Press fits may trap any lubricant or slip agent which may cause gas holes when welded with the submerged arc welding process. Avoid press fits and allow a 1/32" gap.
3. Excessive travel speed tends to aggravate porosity. Slower travel speed will usually help reduce porosity.

EFFECT OF OPERATING VARIABLES

WIRE FEED SPEED (WFS)

If the other variables are held constant, changing WFS changes the current and also has the following effects:

1. Increasing WFS increases penetration and deposition rate.
2. Excessively high WFS produces an erratic arc, undercut or a high narrow bead.
3. Excessively low WFS produces an unstable arc.

VOLTAGE

Voltage is primarily used to control bead shape. If the other variables are held constant, changing voltage has the following effects:

1. Increasing voltage:
   a. Produces a flatter and wider bead.
   b. Improves slag removal on square edge butts and fillets.
   c. Increases flux consumption.
   d. Increases resistance to porosity caused by rust or scale.
   e. Helps bridge gaps when fitup is poor.
2. Excessively high voltage:
   a. Produces a "hat shaped" bead which is subject to cracking.
   b. Produces poor slag removal.
   c. Produces a concave fillet weld which will be subject to cracking.
   d. Reduces resistance to arc blow porosity.
3. Lowering the voltage produces a stiffer arc needed for getting penetration in a deep groove and to resist arc blow on high speed or multiple pass work. It also improves slag removal in deep groove welds.
4. An excessively low voltage produces a high, narrow bead with poor slag removal.

TRAVEL SPEED

Changing the travel speed, like changing the WFS, will change weld size and penetration. Basically:

1. In single pass welds, set the WFS and travel speed as high as possible and still get the correct weld size and desired penetration without burn through.
2. For multiple pass welds, set the travel speed to get the desired bead size.

If the other variables are held constant, changing travel speed has the following effects:

1. Excessively high travel speeds decrease wetting action and increase the tendency for undercut, arc blow, porosity and uneven bead shapes.
2. Slower travel speeds give gaseous material time to boil out of the molten weld, reducing porosity.
3. Excessively slow speeds produce:
   a. "Hat shaped" bead that is subject to cracking.

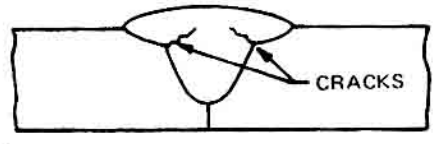


FIGURE 30

   b. Excessive flash through which is uncomfortable for the operator.
   c. A large molten pool that flows around the arc resulting in a rough bead, spatter and slag inclusions.
   d. Less penetration.

ELECTRICAL STICKOUT

The Lincoln semiautomatic submerged arc welding gun, when used with a drag technique, automatically sets the electrical stickout. The typical electrical stickout range is approximately 5 8" to 1-3 8" for most fillet and butt welding applications. However, on the first pass in a deep groove butt weld the electrical stickout will be longer because the flux cone is restricted by the included angle (less than 90°) of the joint. The smaller the included angle of the joint or the larger the flux cone used for the root pass, the longer the electrical stickout will be. Therefore, in any given joint the electrical stickout could vary over the entire typical stickout range and in some instances be outside this range, both longer or shorter.

The flux cone size listed in these procedures was the best all-around cone size for these weldments. However, for a particular application a change in flux cone size for various parts of the joint might be considered to control the length of the electrical stickout for the root pass of the joint or to increase the flux volume on the cap passes.

ELECTRODE SIZE

Guns, cables, drive rolls and guide tubes will utilize a limited range of electrode sizes. Therefore, changing the electrode size often requires installation of parts proper for the size being used.

Only three different electrode sizes are commonly used:

1. The 5/64 diameter electrode is the most versatile size electrode. This electrode is used for single and multiple pass positioned fillets and butt welds. The 5/64 diameter electrode can also be used for many smaller single pass welds.
2. The 1/16 diameter electrode is normally used for, but not restricted to, small (1/4 and under) single pass welds where maximum penetration is required and for maximum operator appeal on single pass and multiple pass welds. This size offers the greatest cable flexibility.
3. The 3/32 diameter electrode is used mostly for mechanized semiautomatic welding with the **K-110** Hand Travel Unit or the **K-62** Squirtmobile, and in installations where the gun is mounted rather than hand held, except for 3/32 diameter Lincore electrodes with 880 flux which require either the K-114 or K-113-3/32 gun and cable.

DEPOSITION RATES

The stickouts listed are the approximate stickouts which result when a drag technique is used with the recommended flux cone or the recommended flux cone with the extension guide.

SINGLE WIRE DC(+) POLARITY

	Wire Feed Speed (in/min)	Approximate Current (amps)	Weld Metal Deposition Rate (lbs/hr)
1/16" Diameter 7/8" Electrical Stickout	85 150 235	200 300 400	4.3 7.5 12.0
5/64" Diameter 1-1/8" Electrical Stickout	85 125 170	255 350 440	6.8 10.0 13.5
Weight of Electrode (lbs/ft)			
1/16" — .010 5/64" — .016			

SINGLE WIRE DC(-) POLARITY

	Wire Feed Speed (in/min)	Approximate Current (amps)	Weld Metal Deposition Rate (lbs/hr)
1/16" Diameter 7/8" Electrical Stickout	105 215 330	200 300 400	5.3 11.0 16.5
5/64" Diameter 1-1/8" Electrical Stickout	135 215 265	250 385 465	11.0 17.0 21.0
5/64" Diameter 1-3/4" Electrical Stickout	160 240 335	285 395 515	13.0 19.0 27.0
Weight of Electrode (lbs/ft)			
1/16" — .010 5/64" — .016			

SUBMERGED ARC TROUBLE SHOOTING GUIDE

Semiautomatic, Single Electrode		
Joint	**Problem**	**Corrective Action (In Order of Importance)**
Any	Low Penetration	1. Increase welding current 2. Use electrode positive. 3. Lower voltage on fillets or V-joints 4. Use short stickout 5. Decrease arc speed. 6. Increase included angle on V-joints.
Fillet	Cracking	1. Use EM12K electrode. 2. Use electrode negative. 3. Lower voltage. 4. Decrease welding speed. 5. Preheat joint. 6. Increase electrode diameter and lower voltage.
Root Pass in Groove	Cracking	1. Lower current and voltage. 2. Use electrode negative. 3. Increase root opening or included angle. 4. Preheat joint. 5. Make sure back gouging is not narrow and deep.
Multiple Pass Weld	Transverse Cracking	1. Increase interpass temperature. 2. Decrease welding speed. 3. Decrease voltage. 4. Decrease current and voltage.
Square Butt Weld	Cracking	1. Check fixture for plate movement. 2. Decrease welding speed. 3. Check for proper pick-up from backup.
Fillet Lap or Square Butt	Pock Marking or Slag Sticking	1. Use EM13K electrode. 2. Increase voltage. 3. Decrease current. 4. Decrease speed. 5. Position fillet, if possible. 6. Heavier plate than normal will cause pocking. 7. Clean all mill scale, rust and oil off plate.
Deep Groove	Slag Sticking	1. Decrease voltage. 2. Decrease current and voltage.
Any	Undercutting	1. Use electrode negative. 2. Decrease voltage. 3. Decrease current. 4. Increase electrode diameter and lower voltage. 5. Decrease speed.

Semiautomatic, Single Electrode		
Joint	**Problem**	**Corrective Action (In Order of Importance)**
Any	Porosity Caused by Rust	1. Use EM13K electrode. 2. Increase voltage. 3. Lower current. 4. Use electrode positive. 5. Use torches in front of arc. 6. Clean joint completely (butting edges also). 7. Decrease speed.
Any	Porosity Caused by Organic Contaminants	1. Use electrode positive. 2. Decrease speed. 3. Degrease joint and dry completely.
Any	Porosity Caused by Arc Blow	1. Use electrode positive. 2. Lower voltage. 3. Lower current and voltage. 4. Increase electrode diameter and lower voltage. 5. Use lower silicon electrode.
Any	Back Side Porosity	1. Usually caused by improper tie-in. 2. Increase welding current to tie-in. 3. Decrease welding speed to tie-in. 4. If 100% joint not required, then decrease penetration.
Any	Surface Metal Spots	1. Lower voltage. 2. Use electrode negative. 3. Decrease current and voltage. 4. Increase arc speed.
Out of Position	Metal Spillage	1. On roundabouts, move further off center opposite to direction of travel. 2. Lower voltage. 3. Lower current and voltage. 4. Increase speed on horizontal fillets. 5. On roundabouts, increase speed — lower current and voltage.
Any	Bead Shape	1. Increase voltage to get wider, flatter bead. 2. Decrease current to get flatter bead. 3. Decrease speed to get flatter bead on fillets. 4. Use electrode diameter that is proper for welding current. 5. Use electrode positive on square butt welds and fillets smaller than 1/4.