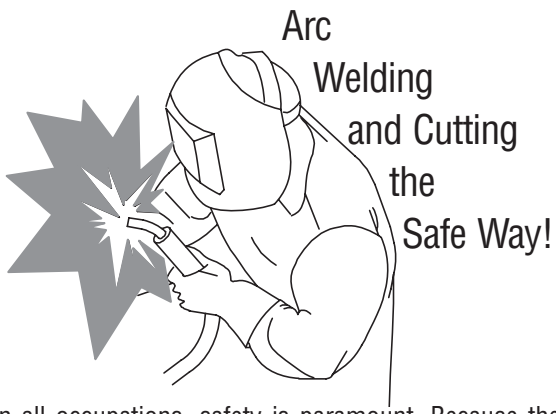
Miller®

Welding Process Training Series

Submerged Arc Welding

SAFETY



As in all occupations, safety is paramount. Because there are numerous safety codes and regulations in place, we recommend that you always read all labels and the Owner's Manual carefully before installing, operating, or servicing the unit. Read the safety information at the beginning of the manual and in each section. Also read and follow all applicable safety standards, especially ANSI Z49.1, Safety in Welding, Cutting, and Allied Processes.

ANSI Z49.1:, Safety in Welding, Cutting, and Allied Processes is available as a free download from the American Welding Society at: http://www.aws.org

Here is a list of additional safety standards and where to get them.

Safe Practices for the Preparation of Containers and Piping for Welding and Cutting, American Welding Society Standard AWS F4.1, from Global Engineering Documents (Phone: 1-877-413-5184, website: www.global.ihs.com).

National Electrical Code, NFPA Standard 70, from National Fire Protection Association, Quincy, MA 02269 (Phone: 1-800-344-3555, website: www.nfpa.org and www.sparky.org).

Safe Handling of Compressed Gases in Cylinders, CGA Pamphlet P-1, from Compressed Gas Association, 4221 Walney Road, 5th Floor, Chantilly, VA 20151 (Phone: 703-788-2700, website:www.cganet.com).

Safety in Welding, Cutting, and Allied Processes, CSA Standard W117.2, from Canadian Standards Association, Standards Sales, 5060 Spectrum Way, Suite 100, Ontario, Canada L4W 5NS (Phone: 800-463-6727, website: www.csa-international.org).

Safe Practice For Occupational And Educational Eye And Face Protection, ANSI Standard Z87.1, from American National Standards Institute, 25 West 43rd Street, New York, NY 10036 (Phone: 212-642-4900, website: www.ansi.org).

Standard for Fire Prevention During Welding, Cutting, and Other Hot Work, NFPA Standard 51B, from National Fire Protection Association, Quincy, MA 02269 (Phone: 1-800-344-3555, website: www.nfpa.org.)

OSHA, Occupational Safety and Health Standards for General Industry, Title 29, Code of Federal Regulations (CFR), Part 1910, Subpart Q, and Part 1926, Subpart J, from U.S. Government Printing Office, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954 (Phone: 1-866-512-1800) (There are 10 OSHA Regional Offices—phone for Region 5, Chicago, is 312-353-2220, website: www.osha.gov).

Booklet, *TLVs Threshold Limit Values*, from American Conference of Governmental Industrial Hygienists (ACGIH), 1330 Kemper Meadow Drive, Cincinnati, OH 45240 (Phone: 513–742–3355, website: www.acgih.org).

Towing a Trailer – Being Equipped for Safety, Publication from U.S. Department of Transportation, National Highway Traffic Safety Administration, 400 Seventh Street, SW, Washington, D.C. 20590

U.S. Consumer Product Safety Commission (CPSC), 4330 East West Highway, Bethesda, MD 20814 (Phone: 301-504-7923, website: www.cpsc.gov).

Applications Manual for the Revised NIOSH Lifting Equation, The National Institute for Occupational Safety and Health (NIOSH), 1600 Clifton Rd, Atlanta, GA 30333 (Phone: 1-800-232-4636, website: www.cdc.gov/NIOSH).

Prepared by the Miller Electric Mfg. Co. Training Department.

⚠ WARNING

This document contains general information about the topics discussed herein. This document is not an application manual and does not contain a complete statement of all factors pertaining to those topics.

The installation, operation, and maintenance of arc welding equipment and the employment of procedures described in this document should be conducted only by qualified persons in accordance with applicable codes, safe practices, and manufacturer's instructions.

Always be certain that work areas are clean and safe and that proper ventilation is used. Misuse of equipment and failure to observe applicable codes and safe practices can result in serious personal injury and property damage.

Welding Process and Filler Metals Training Series:

Welcome to the Welding Process and Filler Metals Training Series. This training series was developed for the purpose of providing a basic set of educational materials that can be used individually or in a classroom setting.

The topics covered in the series are:

Welding Processes

- Introduction To Welding
- Welding Safety
- Basic Electricity For Welding
- Welding Power Source Design
- Engine-Driven Power Sources
- Shielded Metal Arc Welding
- Gas Tungsten Arc Welding
- Gas Metal Arc Welding
- Flux Cored Arc Welding
- Metal Cutting
- Troubleshooting Welding Processes
- Submerged Arc Welding

Filler Metals

- Introduction To Metals
- Low Alloy Steel
- Stainless Steel
- Aluminum
- Hardfacing

Please note, this series was not developed to teach the skill of welding or cutting, but rather to provide a foundation of general knowledge about the various processes and related topics.

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Submerged Arc Welding Principles

Submerged Arc Welding (SAW) uses heat generated by an arc formed when an electric current passes between a welding wire and the workpiece. The tip of the welding wire, the arc, and the weld joint are covered by a layer of granular flux. The heat generated by the arc melts the wire, the base metal and the flux. The flux shields the molten pool from atmospheric contamination, cleans impurities from the weld metal, and shapes the weld bead. Depending on the design of the flux, it can also add alloying elements to the weld metal to alter the chemical and mechanical properties of the weld.

The American Welding Society defines Submerged Arc Welding (SAW) as "An arc welding process that uses an arc or arcs between a bare metal electrode or electrodes and the weld pool. The arc and molten metal are shielded by a blanket of granular flux on the workpieces. The process is used without pressure and with filler metal from the electrode and sometimes from a supplemental source (welding rod, flux, or metal granules)."

A continuous consumable electrode is inserted into the flux that covers the weld area and, when the arc starts, the base metal, electrode, and the flux in the immediate vicinity of the arc melt to form a molten pool. Wire is continually fed into the arc and flux is steadily replenished. The melted flux forms a protective layer and the metallic components flow together to create the weld. Pressure is not used, and filler metal is provided by the electrode(s) and sometimes from a supplemental source (welding rod, flux, or metal granules). Submerged Arc Welding has been used for years to produce high quality welds in compliance with ASME, AWS, API, and American Bureau of Shipping codes.

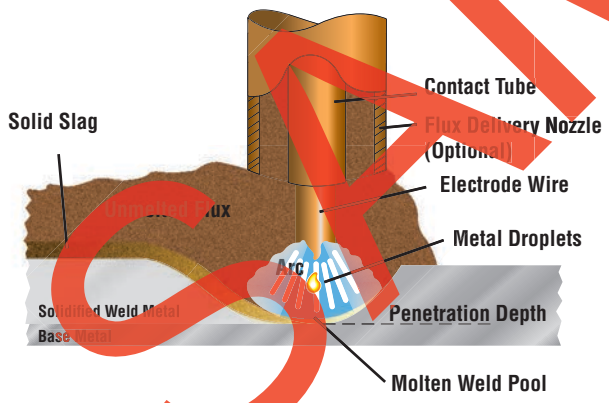


Figure 1 – SAW Welding Arc

The three main types of Submerged Arc Welding are automatic, semiautomatic, and mechanized:

- Automatic welding – Welding with equipment which performs the welding operation without adjustment of controls by a welding operator. The equipment may or may not perform the unloading and loading of the work.
- Semiautomatic welding – Arc welding with equipment where one or more of the process variables is controlled automatically, such as the voltage and filler metal feed rate. The remaining welding process conditions are manually controlled, such as travel speed, work and torch angles, etc.
- Mechanized welding – Arc welding with equipment that performs the entire welding operation. The process still must be monitored by an individual who positions the work, starts and stops the equipment, adjusts the controls, refills the flux, and sets the travel speed.

The primary advantages of the Submerged Arc Welding process are as follows:

- Higher deposition enhances welding speed and production.
- Deep penetration may eliminate joint preparation.
- Excellent mechanical properties to meet high-quality code and X-ray requirements.
- Easy slag removal, no spatter, and little smoke.
- Improved operator comfort.

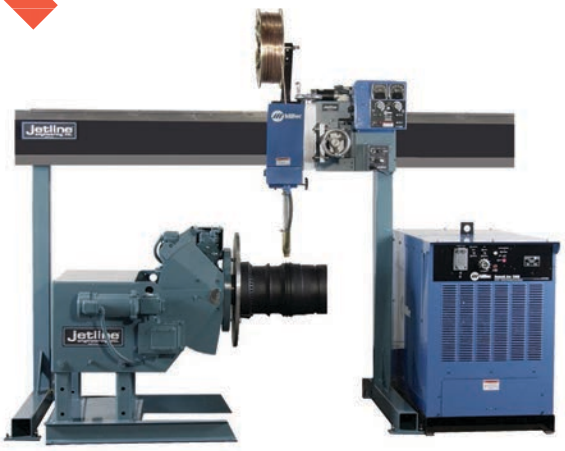


Figure 2 – Automatic Welding System

When the process is performed correctly, Submerged Arc Welding produces welds with good ductility, high impact resistance and uniform bead appearance. The weld's mechanical properties are at least equal to that of the base metal on a consistent basis. The base metal/filler metal dilution for single pass welds is greater than multi-pass welds. Thus, the filler metal will have a greater influence on the chemical and mechanical properties of the deposited weld when using only a single pass. Because of this, electrodes of the same chemical composition as the base metal are not always used. Multi-pass welds, however, are less affected by the base metal/filler metal dilution and rely more on the combination of the electrode, flux, and welding conditions to achieve acceptable results.

Commonly associated only with low carbon steel, Submerged Arc Welding is used with other metals such as low alloy steel, high carbon steel, stainless steel, nickel alloys, and many special alloys for surfacing applications.

System Components

The basic welding equipment requirements for the Submerged Arc Welding process are identified below and shown in Figure 3:

A. Welding power source.
B. Control unit.
C. Manipular system to hold and move the welding head.
D. Filler metal supply.
E. Flux delivery system.
F. Welding head/torch with wire drive assembly.
G. Weld tooling/fixturing/positioner.

Figure 3 – SAW System Components

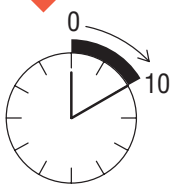
SAW Welding Power Sources

The Submerged Arc Welding power source is often the first piece of equipment selected. Because the process is usually automated or mechanized, the welding power sources must be capable of achieving 100% duty cycle at the required welding output. (Duty cycle is the number of minutes a welding power source can be operated at maximum rated output in a ten minute period (see Figure 5.) The thickness of the weld material will dictate the amperage requirements.

Figure 4 – Subarc DC 1000 Welding Power Source

Definition

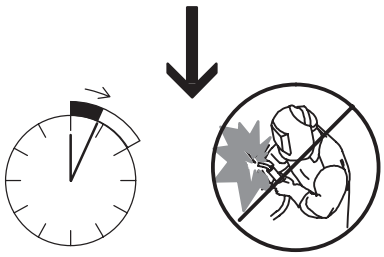
Duty Cycle is percentage of 10 minutes that unit can weld at rated load without overheating



Minutes

For example a 60% Duty Cycle
At 800 A DC

6 Minutes Welding



4 Minutes Resting

Figure 5 – Duty Cycle Definition

Here are some guidelines to follow when making Submerged Arc Welds on circumferential weldments:

- For outside diameter welds, position the wire/weld pool ahead of the point to where the weld pool will travel uphill to the vertical center line of the weldment. (For example, if making a weld on a pipe, the puddle would be at the 11 o'clock position for a clockwise rotation and the weld pool would be traveling to the 12 o'clock position as it solidifies [Figure 47].) For outside diameter welds, angle the electrode toward the direction of travel. The amount of displacement from the center line (12 o'clock position) will vary with each cylinder diameter (see Figure 46).
- For inside diameter welds position the wire/weld pool ahead of the point to where the weld pool will travel downhill to the vertical center line of the weldment. (For example, if making a weld on the inside of a pipe, the puddle would be at the 5 o'clock position for a clockwise rotation and the weld pool would be traveling to the 6 o'clock position as it solidifies [Figure 47].) For inside diameter welds, angle the electrode away from the direction of travel. The amount of displacement from the center line (6 o'clock position) will vary with each cylinder diameter (see Figure 46).
- Limit bead sizes by reducing the amperage (wire feed speed), reducing the voltage, using smaller diameter wire or using faster travel speeds. Small beads solidify faster and the fused flux cools quicker for easier slag removal.
- Support the flux with flux dams or shields to maintain proper flux depth at the arc.
- Consult the wire and flux manufacturers for information on fast-freezing wire and flux combinations.
- Small multiple passes in heavy metals reduce the possibility of undercutting and give better contour for easier slag removal.

Cylinder Diameter	Wire Displacement
1 in. - 3 in. (2.5 cm - 7.6 cm)	0.375 in. - 0.75 in. (10 mm - 19 mm)
3 in. - 18 in. (7.6 cm - 46 cm)	0.75 in. - 1 in. (19 mm - 25 mm)
18 in. - 36 in. (46 cm - 91 cm)	1.25 in. - 1.5 in. (32 mm - 38 mm)
36 in. - 42 in. (91 cm - 107 cm)	1.5 in. - 1.75 in. (38 mm - 44 mm)
42 in. - 48 in. (107 cm - 122 cm)	1.75 in. - 2 in. (44 mm - 50 mm)
48 in. - 72 in. (122 cm - 183 cm)	2 in. - 2.5 in. (50 mm - 64 mm)
72 in. + (183 cm +)	3 in. (76 mm)

Figure 46 – Displacement From The 12 Or 6 O'Clock Center Line For Circumferential Welds

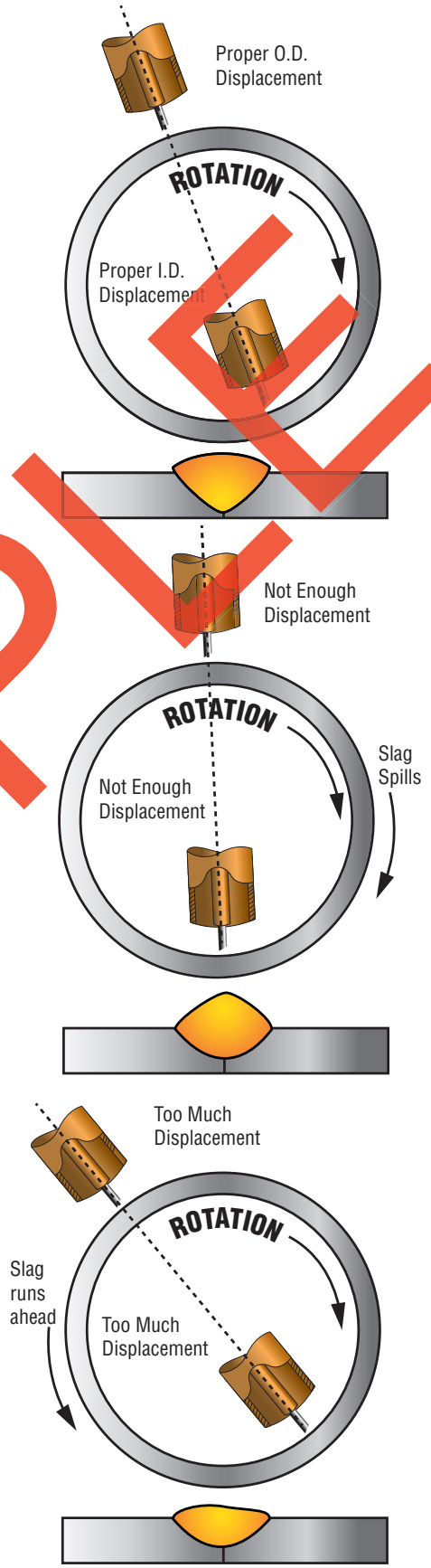


Figure 47 – Torch Placement For Circumferential SAW