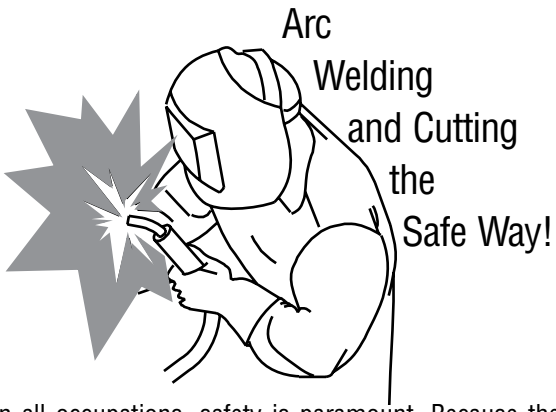
Topic 1.

Welding Process Training Series

Introduction To 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

- Topic 1. Introduction To Welding
- Topic 2. Welding Safety
- Topic 3. Basic Electricity For Welding
- Topic 4. Welding Power Source Design
- Topic 5. Engine Driven Power Sources
- Topic 6. Shielded Metal Arc Welding
- Topic 7. Gas Tungsten Arc Welding
- Topic 8. Gas Metal Arc Welding
- Topic 9. Flux Cored Arc Welding
- Topic 10. Metal Cutting
- Topic 11. Troubleshooting Welding Processes
- Topic 12. Submerged Arc Welding

Filler Metals

- Topic A. Introduction To Metals
- Topic B. Tubular Wires
- Topic C. Low Alloy Steel
- Topic D. Stainless Steel
- Topic E. Aluminum
- Topic F. Hard Surfacing

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.

Table of Contents

Material Joining Processes

Many products made today by manufacturing and construction companies require some type of joining process be used in the production of that product. There are three main categories of material joining processes; mechanical fastening, adhesive bonding, and welding.

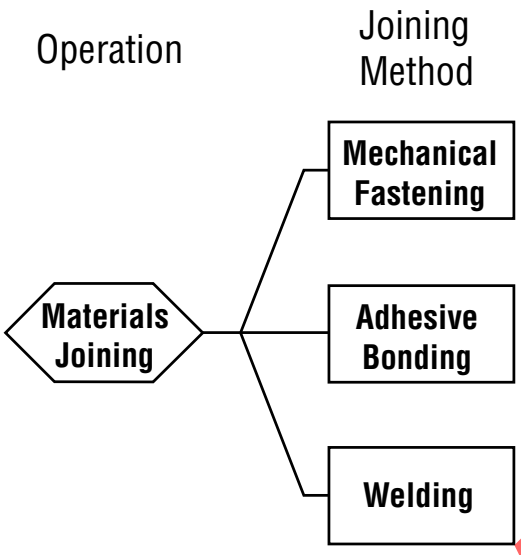


Figure 1 – Material Joining Processes

Mechanical Fastening

Mechanical fastening joins two materials together by using a clamping force. Screws, bolts, nails, and rivets are examples of different types of mechanical fasteners. This method allows for the materials to be disassembled if necessary.

Adhesive Bonding

Adhesive bonding joins materials together using a nonmetallic material. Adhesives are available in several different forms including gels, liquids, pastes, and drops. This process is especially useful when joining dissimilar materials.

Welding

The American Welding Society (AWS) defines welding as a joining process that produces coalescence of materials by heating them to the welding temperature, with or without the application of pressure or by the application of pressure alone, and with or without the use of filler metal.

Welding differs from the other joining processes in that the joint created by welding is very strong and permanent. Parts that have been welded together cannot be easily separated. Welding is fast and is one of the most economical ways to join metal together permanently.

There are as many as 94 different types of welding processes recognized by the AWS that use different sources of energy to join metals. The welding processes covered in this book are some of the most commonly used electric arc welding processes today. These processes are Shielded Metal Arc Welding (SMAW), Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW), Flux-Cored Arc Welding (FCAW), and Submerged Arc Welding (SAW).

The term Arc Welding (AW) is defined by the American Welding Society (AWS) as a group of welding processes that produces coalescence of work pieces by heating them with an arc. The processes are used with or without filler metal.

The heat needed for welding is created by establishing an electric arc between an electrode and the metal to be welded. The type of current used may be either direct current (DC) or alternating current (AC).

The puddle of liquid metal created while welding must be protected from air to keep it from oxidizing (becoming brittle). This can be accomplished through the use of a flux contained on or inside the electrode, or by the use of an external shielding gas. In some cases, both flux and shielding gas are used.

In most cases, simply melting the pieces of metal together will not create a strong enough weld. For this reason, filler metal is typically added to increase the overall strength of the weld. Depending on the welding process being used, the filler metal may also be the electrode or is added separately.

Success in welding is achieved not only by the skill of the person performing the welding process, but also by carefully matching the filler metal chemistry to the base metal. This insures that the resulting weld will have the required physical and chemical properties to meet the service requirements of the part being welded.

Methods of Arc Welding

In manufacturing, the welding processes may be performed using the manual, semi-automatic, automatic, and robotic methods. In manual welding all aspects of the arc and weld deposit are controlled by hand.

Semiautomatic Welding

Semiautomatic welding is defined by the American Welding Society (AWS) as manual welding with equipment that automatically controls one or more of the welding conditions.

The wire feeder and the constant voltage aspect of the power supply make the continuous wire processes such as GMAW and FCAW semiautomatic. The wire feeder controls the filler metal addition and the arc voltage controls the arc length, hence two parts are being controlled automatically. The operator physically manipulates the gun or torch angles and travel speeds while welding.

Automatic Welding

Automatic Welding is defined by the American Welding Society (AWS) as welding with equipment that requires only occasional or no observation of welding, and no manual adjustment of the equipment controls.

Figure 2 – A Seam Welding System

Automatic welding can be performed with a number of welding processes in three basic ways: Fixed Automation, Flexible Automation and Robotic Welding (Programmable Automation).

Fixed Automation utilizes a dedicated machine specifically designed for arc welding the same specific parts on a continuous production basis. An operator loads a part into a fixture, presses a Start button and the part is automatically welded. The operator will unload the welded part, inspect the part, load a new part, and start the process again (typically GMAW or GTAW processes).

The parts to be welded may be rotated under the welding torch or the welding torch may move across or around the part, usually in just one axis of movement. Parts to be welded are usually of a simple design requiring a single weld These welding methods are often used:

- Arc spot weld
- Plug or slot weld
- Linear weld
- Circumferential weld

Flexible Automation is simply a variation of Fixed Automation but allows for some part variation such as a diameter change on a circumferential weld or a length adaptation on a longitudinal weld.

Robotic Welding (Programmable Automation)

Robotic welding is defined by the American Welding Society (AWS) as welding that is performed and controlled by robotic equipment.

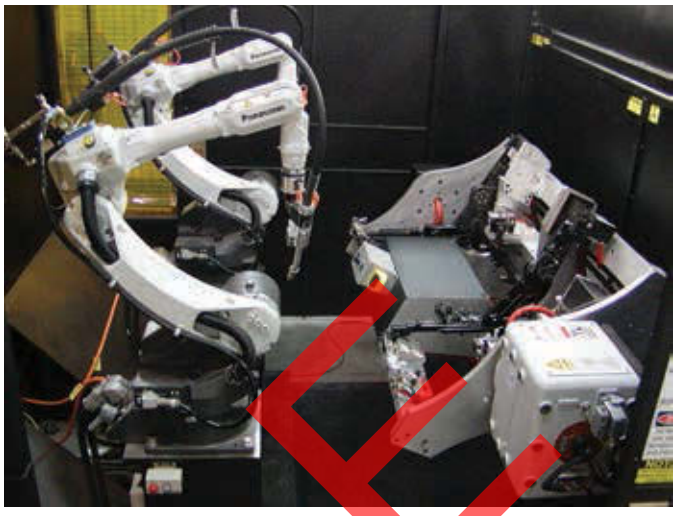


Figure 3 – A Robotic Arc Welding Cell

Robots offer quick movement over a work envelope to weld small component parts or large part assemblies. The robot can make the proper sized weld accurately and consistently with optimal speed and repeatability.

Robots offer the capability of making small production runs that can quickly be retooled for changeovers, or they can be dedicated to making large volume production runs operating 24 hours a day / 7 days a week.

Robotic Welding offers the following advantages:

- Minimizes hazards to the operator.
- Minimizes labor and material waste, through greater accuracy and consistency.
- Faster part cycle times.
- Capable of welding in all positions.
- Capable of quickly adapting to welding a variety of production parts as needed and/or parts changes.

Robotic welding is programmable and highly flexible to adapt and quickly change the movement of the welding arc to produce high quality welds on complex part designs.

Electrical Terms for Welding

Primary Voltage

Primary voltage is the voltage input to the machine that is supplied by the power company, or by an auxiliary electrical power generator unit. This voltage has a constant voltage or potential at every receptacle. This voltage could be 120 (110/115), 208 (200), 230 (220/240), 460 (440/480), 575 (600), etc, VAC (volts of alternating current) with a frequency of 50 or 60 Hz. Welding power source transformers are designed to work with these voltages.

Primary voltage may be single or three-phase (Figure 4 and Figure 5). Primary Voltage is measured at the electrical panel or line disconnect device, receptacle, or the terminal strip inside the welding machine.

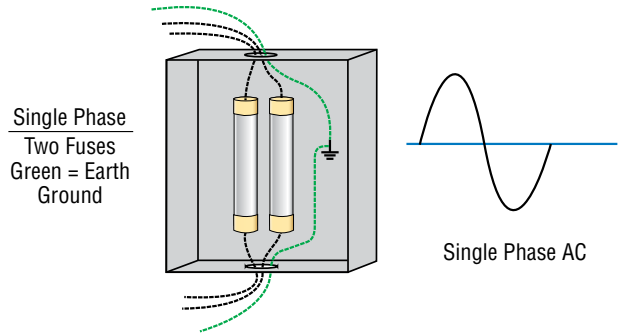


Figure 4 – Single Phase Primary Power (1Ø)

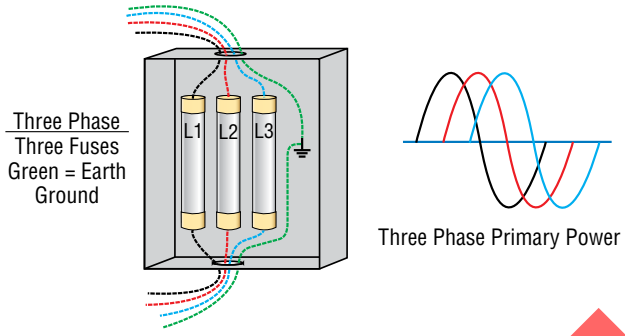


Figure 5 – Three Phase Primary Power (3Ø)

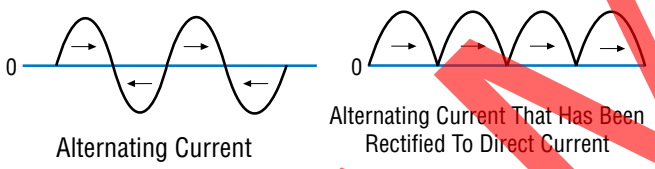


Figure 6 – Alternating Current Converted to Direct Current

Welding Current Types

There are two types of Electrical Current: direct current (DC) and alternating current (AC).

Direct Current

Direct current is an electrical current that flows in one direction and has either a negative or positive polarity. A battery, either a flashlight (dry cells) or an automobile (wet cells), is a source of Direct Current and has a positive and a negative terminal (pole). The conventional theory of electrical current flow, credited to Benjamin Franklin, states that electrons flow from the positive (+) terminal to the negative (–) terminal.

A Direct Current output welding machine also has a positive and a negative terminal. Polarity of the electrical current (or the direction of current flow) is selected by connecting the electrode cable, holder, and an electrode to either the positive or negative terminal. The work cable, and its clamp, is connected to the opposite terminal. The current flows from the negative (–) terminal to the positive (+) terminal in a single direction. This is the electron theory that is credited to Thomas Edison and is used in arc welding theory.

Polarity

The polarity of the direct current welding arc, or the direction of electrical current flow, is very important. The shielded metal arc welding (SMAW) process was first used with bare or lightly flux-coated metallic electrodes connected to the negative (-) terminal (pole). The work connection was then made to the positive (+) terminal (pole) of the welding power source. This is Electrode Negative and is also called “Straight Polarity” (Figure 7). When the electrode is connected to the positive (+) terminal (Electrode Positive) and the work cable to the negative (-) terminal, the connection is referred to as Electrode Positive or “Reverse Polarity” (Figure 8). It is important to make the connections so the current flow is in the correct direction for the specific welding process and procedure.

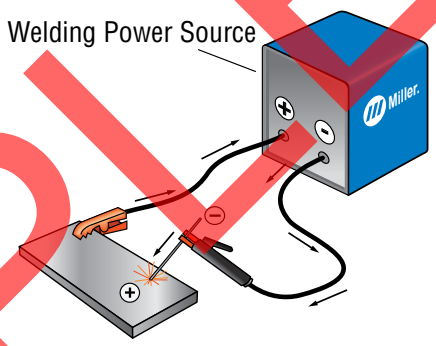


Figure 7 – Direct Current Electrode Negative (DCEN)

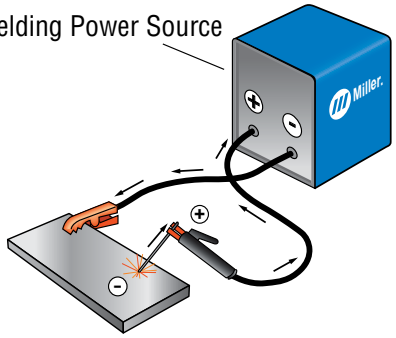


Figure 8 – Direct Current Electrode Positive (DCEP)

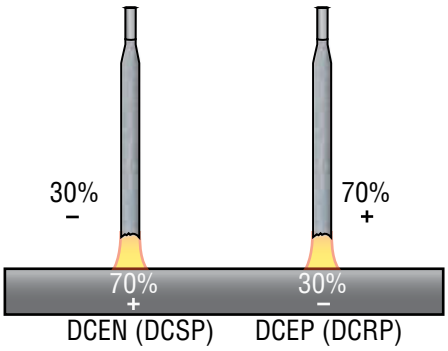


Figure 9 – Direct Current Heat Distribution