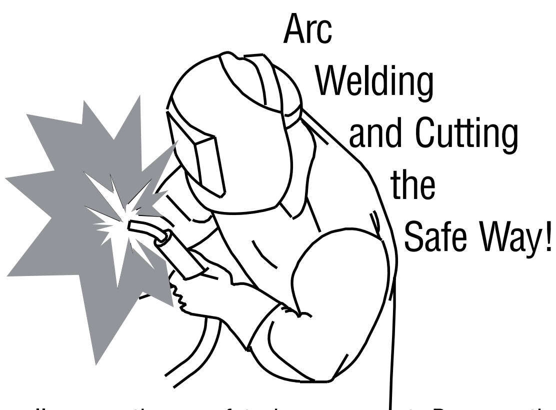
Miller

Topic 10.

Welding Process Training Series

Metal Cutting

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.

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Process Definition

Experiments with a plasma arc date back to early in the twentieth century, but it was in the 1950s when Plasma Arc Cutting (PAC) torches were introduced to the market. The equipment was large and bulky and used a variety of cutting and cooling gases.

Contrary to common belief, there are 4 states of matter rather then three. Plasma is known as the fourth state of matter. The four states in which physical matter may exist are solid, liquid, gas, and plasma. Changes from one physical state to another occur by either supplying or subtracting energy (in the form of heat). Water can be used as an example of these four states of matter. Water, in the solid state, is ice at temperatures of 32° F (0° C) or colder. With the addition of heat the ice melts and changes to water, the liquid state. The addition of more heat — to temperatures of 212° F (100° C) or hotter — converts this liquid to its gaseous state, steam. The fourth state of matter, plasma, looks and behaves like a high temperature gas, but with an important difference; it conducts electricity. The plasma arc is the result of the electrical arc heating gas to a very high temperature so that its atoms are ionized (an electrically charged gas due to an unequal number of electrons to protons) and enabling it to conduct electricity. The major difference between a neutral gas and plasma is that the particles in plasma can exert electromagnetic forces on one another.

If you happen to be reading this by the light emitted by a fluorescent lamp you see plasma in action. Within the glowing tube of the lamp is plasma consisting of low pressure mercury or sodium vapor, ionized by a high voltage across electrodes at the ends of the tube. As the plasma conducts an electric current it radiates which in turn causes the phosphor coating on the inner surface of the tube to glow.

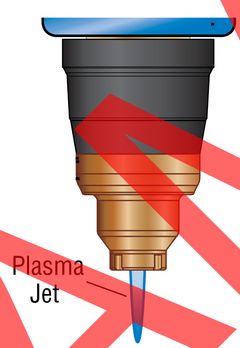

Figure 1 – Plasma Arc

The plasma arc torch has a space surrounding the electrode inside the torch tip or nozzle. It is in this plenum or chamber that the plasma gas is heated and ionized. This heat causes the plasma gas to greatly expand in volume and pressure. The plasma gas exits the constricting orifice of the torch nozzle or tip at very high speeds and temperatures, up to 30,000° F (16,000° C) at 20,000 ft/s (6000 m/s). The intensity and velocity of the plasma is determined by several variables including the type of gas, its pressure and volume, the flow pattern, the amount of electric current, the size and shape of the constricting tip or nozzle orifice, and the tip to work distance.

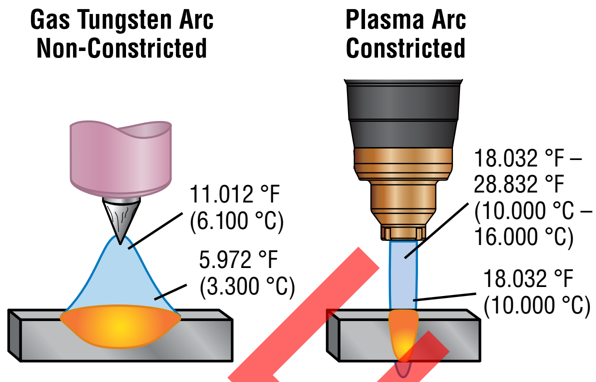

Figure 2 – TIG and Plasma Arcs

The Plasma Arc Cutting process uses this high temperature, constricted, high velocity jet of ionized gas exiting the orifice of the torch tip to melt a very restricted area. The force of the plasma jet pushes the molten metal through the workpiece and severs the material. Extremely clean and accurate cuts are possible with Plasma Arc Cutting. Because of the tightly focused heat energy, there's very little warping, even when cutting thin gauge sheet metal. Plasma Arc Cutting also offers quality gouging and piercing capabilities.

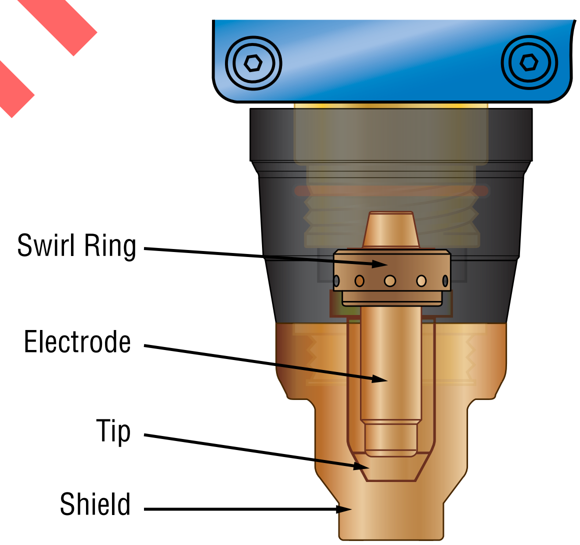

Figure 3 – Plasma Cutting Torch Cut-Away

Plasma Cutting vs Oxy-Fuel Cutting

Before the PAC process became commonplace, if you wanted to cut carbon steel, stainless steel, or aluminum, you would likely use several or methods. Perhaps you would likely use oxy-fuel gas flame cutting for steel, but that process is not recommended for cutting stainless steel and aluminum. Band saws could also be used, or shears, abrasive cut-off wheels, or power hacksaws. And you'd need special blades to cut the stainless steels and alloy steels.

With engineering advances in PAC equipment, all metals that conduct electricity, whether they are common or exotic metals, can be cut economically with one process. Since the Plasma Arc Cutting process is capable of hand-held or machine torch cutting metals ranging from thin gauge aluminum to 2 in. (51 mm) carbon or stainless steel, it can be used in many applications. These applications include stack cutting, beveling, shape cutting, gouging, and piercing in all positions. The PAC process is used in industries such as metal fabrication, construction, maintenance, metal salvage (scrap and recycling), automotive repair, metal art and sculpting.

The PAC process is primarily compared to the oxy-fuel gas (OFC) cutting process. The OFC cutting process severs or removes metal by the chemical reaction of oxidation or burning. This occurs when pure oxygen is applied to the hot, preheated metal. The metal is maintained at elevated temperatures with a flame from the burning oxy-fuel gas mixture. The OFC process requires high purity oxygen and fuel gas, which comprises an explosive fuel gas mixture. The oxygen and fuel gases are usually supplied in high-pressure compressed-gas cylinders.

The advantage of OFC is the capability of cutting up to seven-ft (2 m) thick carbon steel with relatively inexpensive equipment requiring no electricity. The major disadvantage of OFC is its limitation to carbon steel cutting only.

PAC requires minimum training to operate the equipment safely and efficiently. One of the major advantages of PAC is speed. Because PAC operates at a much higher heat energy level, it can cut faster than OFC. This is especially true on metal that is less than 2 in. (51 mm) thick. Cutting speed makes a significant difference in production time and operator comfort. Besides the faster cutting speeds, a major advantage of PAC is that it requires no preheating of the metal like the OFC process. Because of this, PAC results in less distortion of the metal being cut. This is also due to a very narrow heat-affected zone (area changed in characteristics near the cut). The clean, dross-free cut produced with the PAC process can eliminate the secondary operations of other cutting methods, such as cleaning up rough edges and dross on the bottom or backside of the cut. Dross is the oxidized material that melts during cutting.

Payback-per-cut with PAC can be better with compressed air or nitrogen than oxy-fuel gas and other cutting methods. Besides the faster cutting speeds, air and consumables are relatively inexpensive versus, for example, the cost of gases for OFC.

Many of the limitations or disadvantages of PAC can be overcome by using the proper equipment or procedure. The initial cost of PAC equipment may be greater than other cutting methods, but the ease of operation and the cutting speed will often make the equipment pay for itself. When compared to OFC, PAC in some areas will not be as portable, due to its dependence on primary electrical power from a utility line or engine driven generator.

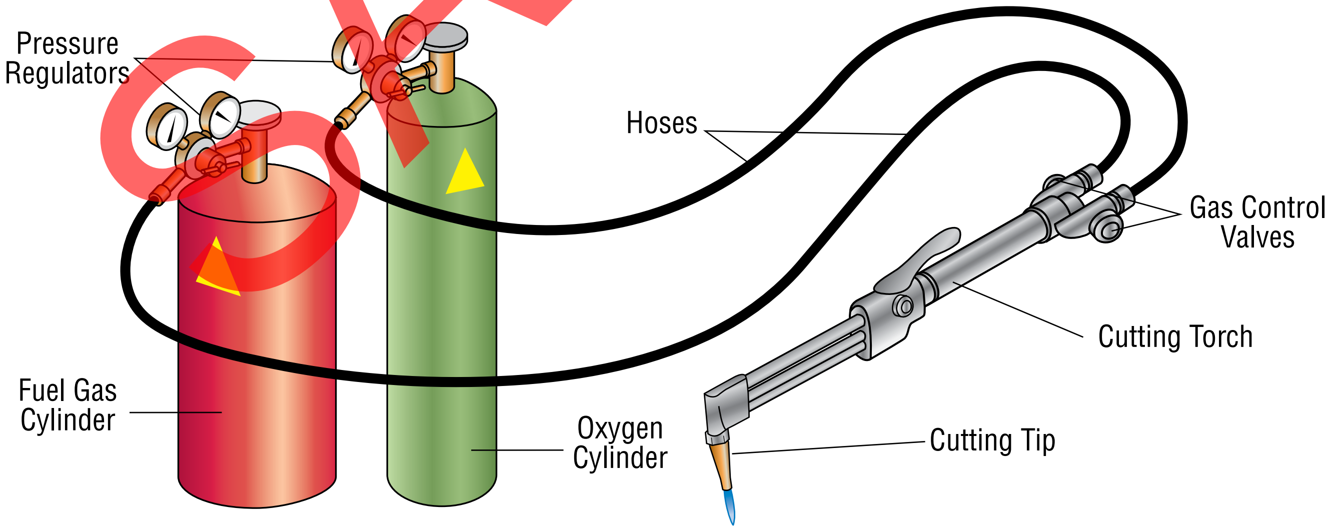

Figure 4 – Oxy-Fuel System