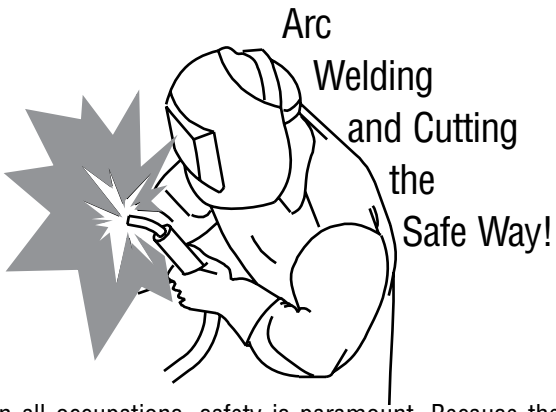
Miller®

Topic 8.

Welding Process Training Series

Gas Metal 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

- 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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- **Neck -** The neck carries the electrical current from the welding cable to the consumables. Loose connections at either end can cause poor electrical conductivity, which can lead to weld defects and further equipment failures due to the heat generated by electrical resistance. Check for tight neck connections on a daily basis.
- GMAW gun necks also feature external insulators that protect the electrically-live components from being exposed. Exposed electrical components near the handle are a shock hazard, and exposed components near the consumables could arc to the workpiece and damage both the gun and the workpiece. The insulators should be checked weekly and replaced as needed.
- **Consumables -** Because of their exposure to heat, spatter, and general abuse the consumables require frequent replacement. That doesn't mean, however, that you can't save time and money through some simple maintenance.

In addition to providing gas flow to the weld pool, the gas diffuser connects to the neck and carries the electrical current to the contact tip. Loose connections between the diffuser and the neck or between the diffuser and the contact tip can cause gas leaks, and weld quality and equipment problems (related to poor conductivity and built up electrical resistance). These components should be checked during nozzle changes and tightened to the manufacturer's specifications.

Many diffusers also use o-rings to seal in the shielding gas and, like their counterparts at the back end of the gun, you should check these for cracks, cuts or other damage whenever you remove the nozzle and replace them as necessary.

The nozzle's main role is to focus the shielding gas around the weld pool. Spatter can build up inside the nozzle and obstruct the gas flow, resulting in porosity, excessive spatter, and other problems related to inadequate shielding gas coverage. The nozzle and nozzle insulator can also become damaged from cleaning out the built-up spatter.

Depending on the amount of spatter created while welding, you should check and clean the nozzle several times per day. A pair of welding pliers is the most common tool for cleaning nozzles, but there are other specialized tools designed specifically for removing spatter from the nozzles.

The nozzle insulator keeps the copper or brass nozzle body separate from the electrically-live consumable components, so a damaged insulator could cause the nozzle to arc to the workpiece. A visual inspection of the nozzle insulator is usually sufficient to determine its condition. Damaged insulators require replacement of the entire nozzle.

The contact tip is the final piece of the consumables set and the last point of contact between the welding equipment and the welding wire. As the wire passes through the contact tip, it can erode the inside of the tip bore, leading to interruptions in the electrical current and poor arc control. The tip can also become covered with spatter and cause inadequate gas coverage.

Welding operators often wait to change the contact tip until a weld problem develops. However, the time and cost to correct a weld problem can be considerably greater than the time and cost to inspect and replace the contact tip on a regular basis as a standard maintenance procedure.

GMAW Welding Variables

The Gas Metal Arc Welding process requires a number of elements to work together to perform the welding process. When just one of the variables is out of adjustment the process may appear to be performing correctly, but it may not be producing a sound weld. It is important to recognize these variables and to understand how they may interact with the other but also to understand what each variable does on its own.

Another very important thing to understand for GMAW is the nomenclature shown in Figure 48. Many times these terms are misstated so a clear understanding of the terminology used to describe the relationship between the nozzle, contact tip, electrode and the workpiece is necessary. The physical proximity of these components to each other is an additional variable that can have an affect on the weld quality and the ability to deposit repeatable welds, especially for the various modes of transfer and for the Flux Cored Arc Welding (FCAW) Process.

Most of the GMAW gun nomenclature is pretty straight-forward in the illustration. However, to understand the terms used to describe these relationships, some clarification is needed. We know about the contact tip, gas nozzle, workpiece, and electrode but the other relationships require some additional clarification.

- **Stickout -** Stickout is the distance that the electrode extends beyond the gas nozzle to the point where the electrode melts off at the arc. It is NOT the distance from the end of the contact tip to the point that the wire melts off. The term stickout is often misused to describe electrode extension or contact tip setback when the contact tip actually extends past the nozzle rather than being flush or recessed. If there is no nozzle, such as when performing Self-Shielded Flux Cored Arc Welding (FCAW-S) then there is essentially no stickout to measure.
- **Electrode Extension -** Electrode extension is the distance from the end of the contact tip to the point where the wire melts off at the arc. This is an important variable for the operator to understand and monitor. The electrode extension length is critical to performing the GMAW transfer mode correctly and it can be even more important for Flux Cored Arc Welding as each FCAW wire specifies (on it's data sheet) the appropriate electrode extension.

This distance can have an effect on the resistance in the circuit and cause the amperage to vary. Just as importantly, this resistance helps FCAW wires become slightly "preheated" to ensure they perform as designed to produce the "alloyed" weld deposit. Shortening this distance can make the amperage slightly increase and lengthening this distance can cause the amperage to slightly decrease. Having too long of an electrode extension can also contribute to inadequate gas coverage, leading to porosity or poor weld strength as the nozzle is too far away to ensure proper shielding gas coverage.

- **Arc Length -** Arc length is the distance from where the electrode melts to the surface of the weld pool. Arc length is controlled by the arc voltage. If the arc length is too short the weld can have a crowned "rope" like appearance. If the arc length is too long,porosity, underfill, and undercut can occur (Figure 58 on page 37).
- **Standoff Distance (Nozzle-to-Work Distance) -** The nozzle-to-work distance is critical to ensure there is adequate shielding gas for the weld pool. If the nozzle is too close it can drag on the weld puddle as it solidifies and cause weld defects. If the nozzle is too far away, inadequate shielding can cause weld discontinuities that require rework.
- **Contact Tip to Work Distance -** This measurement is simply the total distance from the end of the contact tip to the weld pool. It is the sum of electrode extension plus arc length.
- **Contact Tip Setback -** The distance from the end of the nozzle to the contact tip is called contact tip setback. It is also referred to as tip recess. For GMAW arc transfer modes like spray and pulse ed spray that require an electrode extension from 1/2 in. to 3/4 in. (12 to 18 mm) and gas shielding, the tip is often recessed into the nozzle. This ensures adequate shielding by keeping the nozzle close to the weld pool but creating the longer electrode extension required to perform the transfer mode correctly. For short circuit transfer where a 1/4 in. to 3/8 in. (6 to 10 mm) electrode extension is required, the contact tip setback is usually 0 in., or flush, to allow the nozzle to be close enough for adequate gas coverage.

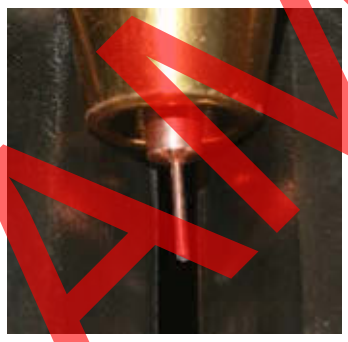

Figure 47 – A Tapered Nozzle with the Contact Tip Setback Extended Past the Nozzle in a Pipe Groove.

Sometimes the contact tip setback is actually not setback in the nozzle it may extend past the nozzle slightly to get the proper electrode extension for the root pass on groove welds where the groove face helps to ensure adequate gas shielding (Figure 47). This scenario is often referred to as an extended tip.

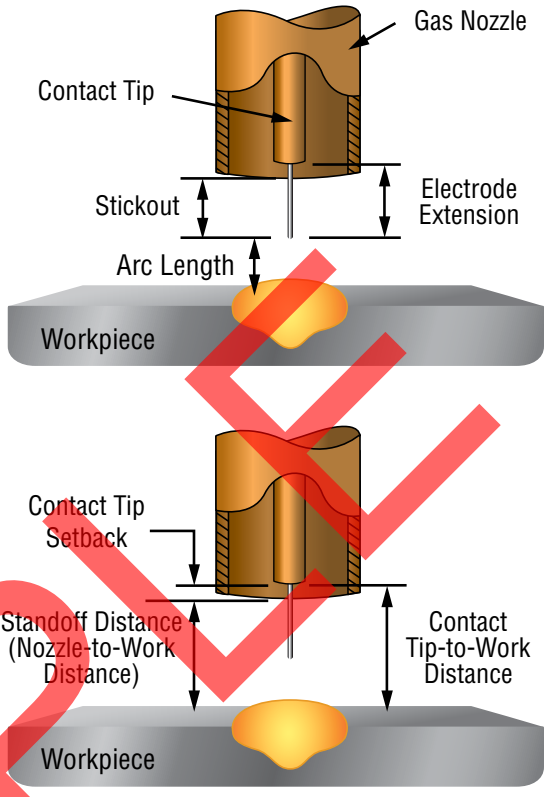

Figure 48 – GMAW and FCAW Gun Nomenclature

It is important to understand that these terms (as illustrated in Figure 48) may appear to change when the tip is extended past the nozzle. However the terms remain the same reguardless of tip extension. Keeping these distances consistent will ensure consistency in the arc and weld quality and are just as important as things like wire feed speed and arc voltage.

Wire Feed Speed (Amperage)

Wire feed speed has a direct effect on welding amperage for the semi-automatic GMAW process. Increasing wire feed speed increases amperage and reducing wire feed speed will reduce welding amperage. This phenomenon is explained by Ohm's Law as discussed on page 5. Increasing the wire feed speed slightly decreases the resistance and causes the amperage to increase. Decreasing the wire feed speed increases resistance, slightly decreasing amperage. Wire feed speed is measured in inches per minute (IPM or in./min) or as meters per minute (m/min). Wire feed speed is also referred as WFS.