LINCOLN ELECTRIC

WELDING
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GMAW
(MIG Welding)
During this overview, we will discuss the following topics:

- Safety
- GMAW Basics
- Equipment Set-Up
- Welding Variables
- Process Advantages and Limitations
- AWS Connection
- National Academic Standards Connection
Unit Objectives

- Upon successful completion of the GMAW Unit of Study, you will have learned about:
  - Properly protecting yourself and others while welding
  - Setting up and operating GMAW equipment
  - Striking and maintaining an arc
  - Welding in four positions using various electrodes
  - Weld Inspection

- The AWS electrode classification system
- Taking the next step to becoming a certified welder
GMAW Safety
‘GMAW Safety’ is supplemental and does not replace the information found in ‘Arc Welding Basics’

Understand and follow all safety precautions listed in ‘Safety in Welding, Cutting and Allied Processes’ (ANSI Z49.1), and Arc Welding Safety (E205)

Understand and follow all warning labels found:
- On welding equipment
- With all consumable packaging
- Within instruction manuals

Read Material Safety Data Sheets (MSDS)

If you ever have a question about your safety or those around you, PLEASE ASK YOUR INSTRUCTOR!
**GMAW Safety**

- **Fumes and Gases** can be dangerous
  - *Keep your head out of the fumes*
  - *Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area*
  - *Local exhaust and mechanical ventilation can be used without reducing weld quality*

- **Electric Shock** can kill – to receive a shock your body must touch the electrode and work or ground at the same time
  - *Do not touch the electrode or metal parts of the electrode holder with skin or wet clothing*
  - *Keep dry insulation between your body and the metal being welded or ground*
  - *The coil of wire is ‘electrically hot’ when the trigger is pulled*

- **Arc Rays** can injure eyes and skin - Choose correct filter shade (See chart below)

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**Table 1**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Electrode Size 1/32 in. (mm)</th>
<th>Arc Current (A)</th>
<th>Minimum Protective Shade</th>
<th>Suggested* Shade No. (Comfort)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas metal arc welding and flux cored arc welding</td>
<td>Less than 60</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60—160</td>
<td>10</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>160—250</td>
<td>10</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>250—500</td>
<td>10</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

*As a rule of thumb, start with a shade that is too dark to see the weld zone. Then go to a lighter shade which gives sufficient view of the weld zone without going below the minimum. In oxyfuel gas welding or cutting where the torch produces a high yellow light, it is desirable to use a filter lens that absorbs the yellow or sodium line in the visible light of the (spectrum) operation.

**These values apply where the actual arc is clearly seen. Experience has shown that lighter filters may be used when the arc is hidden by the workplace.

** Information taken from ANSI Z49.1:2005**
• REMEMBER – Gas Cylinders require SPECIAL safety precautions
  – *Cylinders must be secured in an upright position*
  – *Cylinders should be located in an area away from arc welding, cutting, heat, sparks, and flame*
  – *Refer to ‘Safety in Welding, Cutting, and Allied Processes’ (ANSI Z49.1) or Arc Welding Safety (E205) for more information on the handling of gas cylinders*
GMAW Principles
GMAW Definition

- GMAW stands for Gas Metal Arc Welding
- GMAW is commonly referred to as MIG or Metal Inert Gas welding
- During the GMAW process, a solid metal wire is fed through a welding gun and becomes the filler material
- Instead of a flux, a shielding gas is used to protect the molten puddle from the atmosphere which results in a weld without slag

GMAW is the most widely used arc welding process in the United States
Three things happen when the GMAW gun trigger is pulled:

- **The wire electrode begins to feed**
- **The circuit becomes electrically ‘hot’**

Current flows from the power source through the gun cable, gun, contact tip to the wire and across the arc. On the other side of the arc, current flows through the base metal to the work cable and back to the power source.

- **Shielding gas flows through the gun and out the nozzle**
Let’s look a little closer at the GMAW process.

- **Travel direction**
  - Generally, drag on thin sheet metal and push on thicker materials.

1. **Electrode**
2. **Arc**
3. **Weld Puddle**
4. **Shielding Gas**
5. **Solidified Weld Metal**
6. **Base Metal**
A GMAW electrode is:
- A metal wire
- Fed through the gun by the wire feeder
- Measured by its diameter

GMAW electrodes are commonly packaged on spools, reels and coils ranging from 1lb to 1000lbs.
An electric arc occurs in the gas filled space between the electrode wire and the work piece.

Electric arcs can generate temperatures up to 10,000 F.
As the wire electrode and work piece heat up and melt, they form a pool of molten material called a weld puddle.

This is what the welder watches and manipulates while welding.

.045” ER70S-6 at 400 ipm wire feed speed and 28.5 Volts with a 90% Argon/10% CO2 shielding gas.
• GMAW welding requires a shielding gas to protect the weld puddle
• Shielding gas is usually CO2, argon, or a mixture of both

The gauges on the regulator show gas flow rate and bottle pressure
• The welder “lays a bead” of molten metal that quickly solidifies into a weld
• The resulting weld is slag free

An aluminum weld done with the GMAW process
Application Activity
Let’s review the GMAW process

Travel direction

Generally, drag on thin sheet metal and push on thicker materials

1. _________
2. _________
3. _________
4. _________
5. _________
Equipment Set Up
1. Connect work clamp
2. Select electrode
   a. Type
   b. Diameter
3. Select shielding gas
4. Turn power supply on
5. Adjust machine output
   a. Wire feed speed
   b. Voltage
6. Adjust gas flow rate

Why would GMAW be a better choice than SMAW for this job?
GMAW Process Variables

- **Welding variables**
  - Wire Feed Speed (WFS)
  - Voltage

- **Operator controlled variables**
  - Travel speed
  - Gun angles
  - Contact tip to work distance (CTWD)
  - Gas flow rate

What is the relationship between WFS and amperage?
Striking an Arc and Making a Weld
Striking an Arc

• Position the gun over joint
• Position the face shield to protect eyes and face
• Pull the gun trigger and begin welding

What are some things to consider before striking an arc?
Laying a Bead

- Maintain a Contact Tip to Work Distance (CTWD) of 3/8” to 1/2”
- Use a uniform travel speed
- Most Importantly – Watch the Puddle!

The appearance of the puddle and ridge where molten metal solidifies indicates correct travel speed. The ridge should be approximately 3/8” (10 mm) behind the wire electrode. Most beginners tend to weld too fast resulting in a ropey bead which means SLOW down!
Fill the Crater

- Fill the crater by pausing or using a slight back step
- Release gun trigger and pull gun away from the work after the arc goes out
- Large craters can cause weld cracking

Crater cracks cannot be tolerated on NASCAR radiators.
• Restart the weld bead by back stepping into the last weld’s crater and then continue moving forward.

• This technique should result in a seamless transition from one weld to the next.
• GMAW is a process that features several distinctive, individual methods and types of metal transfer
• The mode of metal transfer is determined by a number of welding variables
  – Voltage
  – Amperage
  – Shielding Gas
• By changing one or more variables, you can go from one metal transfer mode to another
Two common conventional modes of metal transfer are:

- **Short arc**
- **Axial spray arc**

The application, joint design, base material thickness, and properties determine the appropriate mode to use.
In short arc transfer...

- The arc is initiated and a droplet is formed on the end of the wire
- The wire touches the work piece and produces a short circuit
- The droplet is then transferred to the weld puddle
In axial spray arc transfer …
- Very high currents are used
- A point forms at the end of the electrode and the fine droplets
- The puddle is very fluid making out of position welding difficult
Troubleshooting Welds
Troubleshooting Welds

- **GOAL** - Make Good Welds
- Eliminate Porosity
- Eliminate Ropey Convex bead
- Eliminate Excessive Spatter
Advantages and Limitations
Advantages of GMAW

- High operating factor
- Easy to learn
- Limited cleanup
- Use on many different metals: stainless steel, mild (carbon) steel, aluminum and more
- All position
- Great for home use with 115V and 230V units
Limitations of GMAW

- Less portable with shorter gun lengths (15 foot guns)
- GMAW equipment is more expensive than SMAW equipment
- External shielding gas can be blown away by winds
- High radiated heat
- Difficult to use in out of position joints
AWS Classification of GMAW Electrodes
ER70S-X

Electrode

Rod

70,000 psi Min. Tensile Strength

Solid

Chemistry, Amount of Deoxidizers (Silicon, Manganese and/or Aluminum, Zirconium and Titanium) X=2,3,4,6,7 or G

AWS Classification of GMAW Electrodes
Lesson Plans
Objective: To run a stringer (straight) bead using short arc transfer and to fill the crater

Equipment:
- Single Process - Constant Voltage Power Source & Wire Feeder
  - Power MIG 215 or Power MIG 255C
- Multi-Process
  - Composite: Power MIG 350 MP
  - Combination: V-350/ LF-72 package

Material:
- Mild Steel Plate – 3/16” or thicker
  - .035” SuperArc L-56 (ER70S-6)
  - 100% CO2 or 25% CO2/ 75% Argon blend shielding gas
Objective: To make a fillet weld on a lap joint in the horizontal position (AWS position 2F)

Equipment:
- Single Process - Constant Voltage Power Source & Wire Feeder
  - Power MIG 215 or Power MIG 255C
- Multi-Process
  - Composite: Power MIG 350 MP
  - Combination: V-350/ LF-72 package

Material
- Mild Steel Plate – 10 gauge
- .035” SuperArc L-56 (ER70S-6)
- 100% CO2 or 25% CO2/ 75% Argon blend shielding gas
Objective: To make a fillet weld on a tee joint in the horizontal position (AWS position 2F)

Equipment:
- **Single Process - Constant Voltage Power Source & Wire Feeder**
  - Power MIG 215 or Power MIG 255C
- **Multi-Process**
  - Composite: Power MIG 350 MP
  - Combination: V-350/ LF-72 package

Material:
- Mild Steel Plate – 10 gauge
- .035” SuperArc L-56 (ER70S-6)
- 100% CO2 or 25% CO2/ 75% Argon blend shielding gas
Objective: To make a fillet weld on a lap joint in the vertical position welding down (AWS position 3FD)

Equipment:
- **Single Process - Constant Voltage Power Source & Wire Feeder**
  - Power MIG 215 or Power MIG 255C
- **Multi-Process**
  - Composite: Power MIG 350 MP
  - Combination: V-350/ LF-72 package

Material:
- **Mild Steel Plate – 10 gauge**
- .035” SuperArc L-56 (ER70S-6)
- 100% CO2 or 25% CO2/ 75% Argon blend shielding gas
Objective: To make a fillet weld on a tee joint in the vertical position welding down (AWS position 3FD)

Equipment:
- **Single Process - Constant Voltage Power Source & Wire Feeder**
  - Power MIG 215 or Power MIG 255C
- **Multi-Process**
  - Composite: Power MIG 350 MP
  - Combination: V-350/ LF-72 package

Material:
- **Mild Steel Plate** – 10 gauge
- **.035” SuperArc L-56 (ER70S-6)**
- **100% CO2 or 25% CO2/ 75% Argon blend shielding gas**
Objective: To make a butt weld with a gap in the vertical position welding down

Equipment:
- **Single Process - Constant Voltage Power Source & Wire Feeder**
  - Power MIG 215 or Power MIG 255C
- **Multi-Process**
  - Composite: Power MIG 350 MP
  - Combination: V-350/ LF-72 package

Material:
- **Mild Steel Plate – 10 gauge**
- .035” SuperArc L-56 (ER70S-6)
- 100% CO2 or 25% CO2/ 75% Argon blend shielding gas
Objective: To make a fillet weld on a tee joint in the overhead position (AWS position 4F)

Equipment:
- Single Process - Constant Voltage Power Source & Wire Feeder
  - Power MIG 215 or Power MIG 255C
- Multi-Process –
  - Composite: Power MIG 350 MP
  - Combination: V-350/ LF-72 package

Material:
- Mild Steel Plate – 10 gauge
- .035” SuperArc L-56 (ER70S-6)
- 100% CO2 or 25% CO2/ 75% Argon blend shielding gas
Objective: To make a three pass fillet weld on a tee joint in the horizontal position (AWS position 2F)

Equipment:
- Single Process - Constant Voltage Power Source & Wire Feeder
  - Power MIG 215 or Power MIG 255C
- Multi-Process –
  - Composite: Power MIG 350 MP
  - Combination: V-350/ LF-72 package

Material:
- Mild Steel Plate – ¼”
- .035” SuperArc L-56 (ER70S-6)
- 100% CO2 or 25% CO2/ 75% Argon blend shielding gas
• Objective: To run a horizontal fillet weld on a tee joint using axial spray transfer (AWS position 2F)

• Equipment:
  – Single Process - Constant Voltage Power Source & Wire Feeder
    ▪ Power MIG 225C
  – Multi-Process –
    ▪ Composite: Power MIG 350 MP
    ▪ Combination: V-350/ LF-72 package

Material:
  – Mild Steel Plate – ¼”
  – .045” SuperArc L-56 (ER70S-6)
  – 90% Argon/ 10% CO2 blend shielding gas
AWS Connection
The GMAW unit of study covered information related to the following AWS requirements for certification:

- Setting up for GMAW operations on carbon steel
- Operating GMAW equipment on carbon steel
- Making GMAW fillet welds on carbon steel
English, Math, and Science Connection
This unit covered academic content listed in the National Academic Standards as follows:

- **NM-MEA.9-12.1**: Understands measurable attributes of objects and the units, systems, and processes of measurement
- **NM-PROB.CONNECT.PK-12.3**: Recognizes and applies mathematics in contexts outside of mathematics.
- **NS-PHYSICAL SCIENCE**: (Understands) structure and property of matter
- **NS-PHYSICAL SCIENCE**: (Understands) chemical reactions
- **NLA-STANDARD 3**: Uses grammatical and mechanical conventions in written compositions
- **NLA-STANDARD 10**: Understands the characteristics and components of the media