Gas Metal Arc Welding Basics
Course Overview

The Gas Metal Arc Welding Basics Course is designed to provide students with a basic understanding of the GMAW process and provide hands-on experiences that improve their welding skills. This course provides the basics students need to develop an understanding of:

- Safety requirements and importance of safety in the GMAW process.
- Gas Metal Arc Welding Process
- Setup of the equipment, operation of the equipment, and the insight and knowledge needed to successfully create welds using the GMAW process.
- Use of shielding gases and the types of metal transfer processes used with GMAW.
- Variables that affect the quality of welds.

Recommended Safety Equipment and Tools

The safety equipment and tools needed for the exercises in this course consist of, but are not limited to:

- Safety Glasses (ANSI Z87.1)
- Closed-Toed Leather Shoes – Steel-Toed are best
- Welding Coat – Long sleeved coat that is fire resistant
- Long Pants (no cuffs)
- Leather Gloves - Thickness of Gloves is dependent on the welding transfer process used
- Welpers – A welding plier that can be used to handle hot material and trim the wire
- Nozzle Cleaner – This is used to clean the GMAW Nozzle
- Wire Brush

Equipment can be purchased from Airgas, Minneapolis Oxygen, or any local welding supply store or farm store. L&M Supply, Fleet Farm, Menards all carry welding gear. You can also get it from Lincoln Welding (They have an education center in Ohio for buying goods).

Amazon is where you will find some of your best pricing for safety equipment and tools.

Welding Equipment

Some options for welders:

- Lincoln Power MIG 210 – Multi-process welder capable for all processes – except GTAW Aluminum
- Miller Multimatic 215 – Multi-process welder capable for all processes – except GTAW Aluminum
- Hobart Multi-Handler 200 – Multi-process welder capable for all processes – except GTAW Aluminum

These are all multi process welders. There are lots of choices. Talk to your local welding supply stores for ideas on what will work best for you. How much you want to spend will affect what you are able to buy.

Buying a welder that is capable of welding 220 volts will make welding thicker material a lot easier to learn. Machines that have 220 and 110 outputs are very versatile.

Welding Supplies – Wire, Tips, and Rods

These are available at all the places I listed for safety gear. Lincoln has a website schools can sign up and get reduced pricing on welding supplies. You will need to verify that you work for a school district. They also have the education division in Ohio. They have been great at getting welding equipment at a discounted cost.

Welding Gas

Airgas has been the best pricing for schools. They have an agreement worked out with the state to make up the difference in cost to be able to sell it to schools at cost. Other places might have the same setup. You will have to reach out to your local welding supply companies to find out more details.

Metal Supplies

Talk with your local Trade schools. They are usually picking up donations from local companies and are always looking to make connections to high schools. Otherwise ask and beg from local industry.

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Curriculum and Assessment Guide

General Outcomes	Assessment Criteria and Conditions	Suggested Emphasis
The Student will:	Possible basis for assessment of student achievement:	
• Recognize health and safety hazards associated with GMAW welding process and understand preventative measures to avoid accidents and injuries.	• Observed performance in a classroom, lab, or work setting: ➢ Selecting appropriate Personal Protective Equipment. ➢ Maintaining a clean, tidy, and safe working environment. ➢ Safe use of equipment and materials.	10%
• Perform safe gas metal arc welding set-up and take down procedures.	• Demonstration of consistent safe set-up and shut-down procedures using the equipment used for GMAW.	20%
• Demonstrate Basic GMAW competencies.	• The creation of successful stringer and weave beads using the GMAW process: ➢ Activity 1 – Surface Pad of Beads ➢ Activity 2.1 – Tack Weld Placement ➢ Activity 2.2 – Lap and T-Joint Fillet, Square Groove Butt Joint ➢ Activity 3 – Practice Project X-Block • The completion of weldments using fillet welds in the flat position: ➢ Activity 1 – Surface Pad of Beads ➢ Activity 2.1 – Tack Weld Placement ➢ Activity 2.2 – Lap and T-Joint Fillet, Square Groove Butt Joint ➢ Activity 3 – Practice Project X-Block • The completion of weldments groove welds in the flat position: ➢ Activity 1 – Surface Pad of Beads	70%

	➢ Activity 2.1 – Tack Weld Placement ➢ Activity 2.2 – Lap and T-Joint Fillet, Square Groove Butt Joint ➢ Activity 3 – Practice Project X-Block	
• Demonstrate basic behavior and soft skills competencies	• Observation of individual effort and interpersonal interaction during the learning process.	Integrated throughout

Concepts	Specific Outcomes	Notes
Topic 1 • Health and Safety	• Demonstrate how PPE is used to protect eyes, skin, and body. • Describe a safety plan in case of an emergency. • Describe the hazards associated with GMAW.	Students should realize: Ongoing expectations for safety: • The importance of protecting yourself. • A plan of action in case of a fire or accident. • How to choose and operate a fire extinguisher. • Control exposure to radiation and nose levels. • Prepare a safe working environment. • Inspection and controls of exposure to fumes, vapors, and dust. • Ensures correct procedures for storing and transporting cylinders.
Topic 2 • GMAW Welding Basics	• Identify and describe the GMAW process using the approved nomenclature. • Identify common base metals used for GMAW. • Describe how an arc is produced and controlled using the GMAW process.	• Students should define and realize how to use the correct names and approved terminology used in the GMAW process. • Students should be able to describe metallurgy and understand the weldability of metals used in the GMAW process. • Discuss the need for the correct arc length, current, travel speed, and electrode angle.
Topic 3 • Principles of Electricity in GMAW.	• Describe Alternating Current and Direct Current	• Student should be able to describe how electricity flows in the GMAW process.

	• Describe the different power sources and their use with GMAW.	• DCEP • DCEN • Constant Current Power Source • Constant Voltage Power Source.
Topic 4 • GMAW Equipment	• Identify the proper equipment used for GMAW. • Demonstrate the proper setup and tear down of GMAW equipment. • Setting proper welding parameters and determining proper weld specifications	It is understood that students will require practice time: • To practice setup and tear down of GMAW equipment.

Topic 5
• Weld Joints and Types
• Weld Preparation
	• Identify typical weld types:
	  • Fillet
	  • Groove
	• Identify typical weld types:
	  • Flat
	  • Horizontal
	  • Vertical
	  • Overhead
	• List and describe the basic weld joints:
	  • Butt
	  • Lap
	  • Tee
	  • Corner
	  • Edge
		• To develop their material prep and layout skills using coupons and scrap material.
		• Students are expected to setup material to be welded in all positions and types.
		• welding skills by running beads and fabricating introductory level projects.

Topic 6 • Metal Transfer Processes used in GMAW	• Student should be able to describe the metal transfer processes used in GMAW. • Students should be able to describe when and each process should be used.	

	• Students should be able to describe advantages and disadvantages of each transfer process.	
Topic 7 • Shielding Gases and protecting the weld joint.	• Describe the proper procedure for setting up, purging, and setting the pressure for shielding gas used in the GMAW process. • Explain the need for shielding gas and the effects different shielding gases have on welds. • Describe and Explain the defects caused by insufficient shielding gas and how to adjust the shielding gas to obtain good welds.	• Students will demonstrate the proper selection of shielding gas, the proper transportation of shielding gas, and the installation and setup of shielding gas for the GMAW process. • Students will produce good quality welds using the correct shielding gas aligned with the procedure. • Activity 1 • Activity 2 • Activity 3
Topic 8 • Quality of Welds • Quality Control	• Students will be able to setup all the variables in completing good quality welds. • Be able to describe the characteristics of good welds and how to adjust the variables to make good welds. • Describe weld defects and weld	• Students will complete visual inspections of welds. - Overall appearance - Size and Shape of beads • Students will make adjustments on voltage, current, wire speed, amperage, electrode size, stick out, and all variables to produce quality welds.
Optional Units • Careers in Welding • Career Preparation	• Research and describe examples of personal and trade-specific application of GMAW. • Prepare a portfolio consisting of completed activities and welds.	• Students explore colleges, trades schools, and trades unions for potential careers. • Students build portfolios that demonstrate work completed to gain access into a career.

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Introduction to GMAW Basics Activity 1 Instructions

Topic: **Surface Welds in the FLAT Position**

Introduction: Students in this lesson begin to lay down their first row of beads. Students setup the entire welding machine, adjust the settings, and begin practicing running beads.

Objectives: To properly setup the welding equipment, adjust the power source settings, start the arc, manipulate the welding gun, read the puddle, and create quality welds in the flat position.

Study Questions: The following questions are being presented to alert course participants to some of the main ideas embedded in the assigned reading.

- What are some key issues to remember when setting up the equipment?
- Why is it important to clean the metal on practice welds?
- What do you as the student anticipate as an issue that you will have? (Most likely issue will be welding too fast.)

Resources for Building a Knowledge Base - Videos/Reading:

Welding Tips and Tricks: www.youtube.com/user/weldingtipsandtricks - great videos for showing students a quality weld. Jody uses a camera that captures a great picture. It is easier to show the entire class a picture or video of a good bead than to try and squeeze everyone around a welding booth. Once in the lab, then you can run around, demonstrate, and help students individually in each welding booth.

Weld.com is another great resource for videos:
https://www.youtube.com/c/Welddotcom

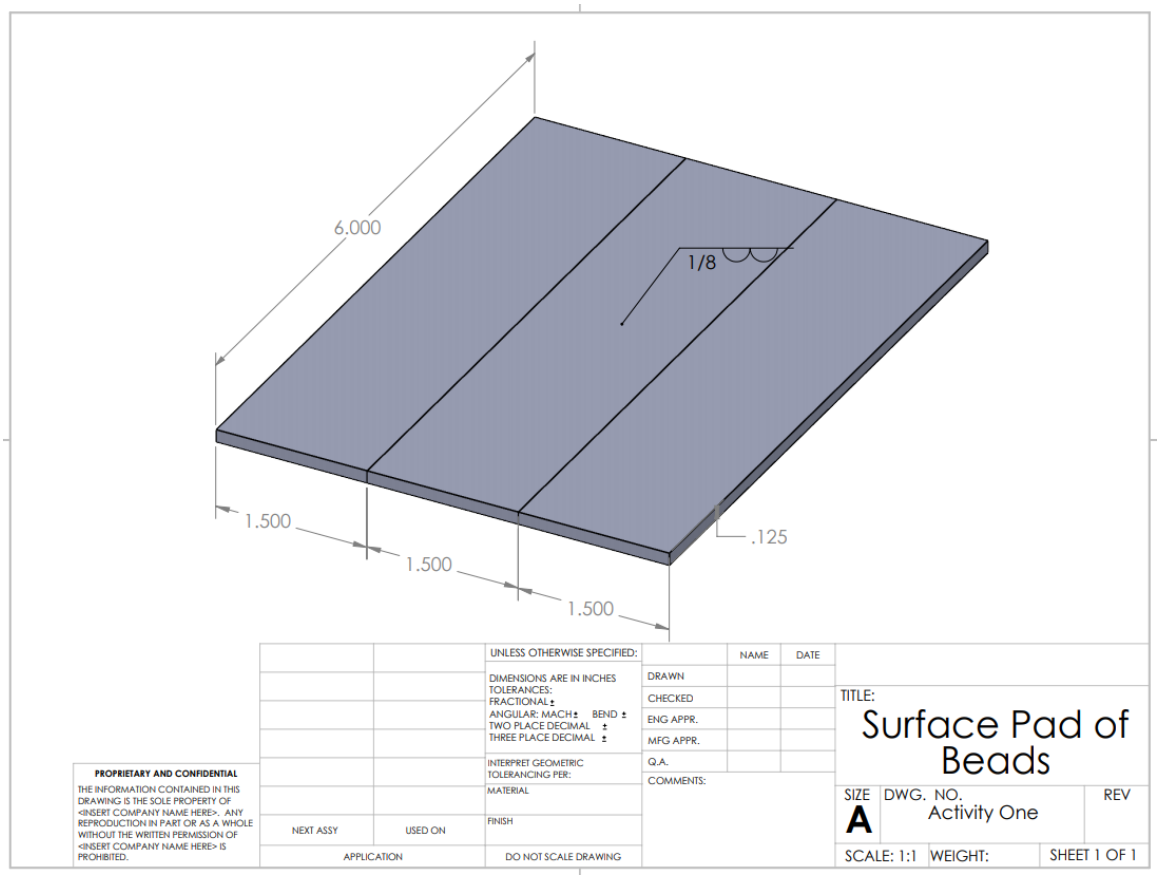
Application:

- Demonstrate your understanding of shop safety by wearing all PPE. Protect yourself, and others.

- Successfully strike an arc and run your first rows of beads.
- Visual inspection of welds. Evaluate for defects, discontinuities, or other quality issues and make the required decisions to make improvements.
- Follow the Weld Sheet shown below and as a full drawing at the end of this document.

Lab Activity 1

Pad of Beads - Surface Welds in the Flat Position (See page 5 for full drawing)



Materials:

- 3 pieces of metal
- 0.035 ER 70S-6 electrode welding wire.
- 100% Carbon Dioxide shielding gas

(Metal can be 1/8”, 3/16”, or any flat metal that you have available.)

STEP 1: Machine Settings:

Polarity: Electrode Positive (reverse polarity).
Amperage: 90-110
Voltage: 17-20
Gas Flow Rate: 15-25 CFH
Stickout: ¼" – 3/8"

STEP 2: Fine Tune Adjustments on the Settings

- Conduct test welds to fine tune the settings.
- Adjust ONE parameter at a time.

Remember – It's all relative - how fast the welder welds, the voltage, the wire speed, etc. If a person welds faster or slower will affect the overall settings on the machine.

Low Voltage

If the voltage is too low in relation to the wire feed (amperage):

- The weld bead will be narrow and convex with little penetration.
- The weld bead will be erratic, and the wire tends to push against the work.

High Voltage

If the voltage is too high in relation to the wire feed speed (amperage):

- The weld bead is flat and wide with poor penetration and excessive spatter.
- Globular transfer will start to occur as globs of metal drop onto the metal – the voltage is much too high.

STEP 3: Position Material and Tack Weld

- Cut and clean all pieces to be welded.
- Position the three pieces of flat stock together on the table and tack weld them at each end.
    - A tack weld is a spot weld that holds the material to be welded together. Put good solid tack welds on the welds so that they do not come a part when welding the final weld.

STEP 4: Deposit Pad of Weld Beads

Deposit first weld bead:

- Start the welding arc and move across the workpiece with a slight weaving motion.
- Do not pause at either toe (each side of the weld).

- Stay on the LEADING (front) edge of the puddle.

Deposit second weld bead:

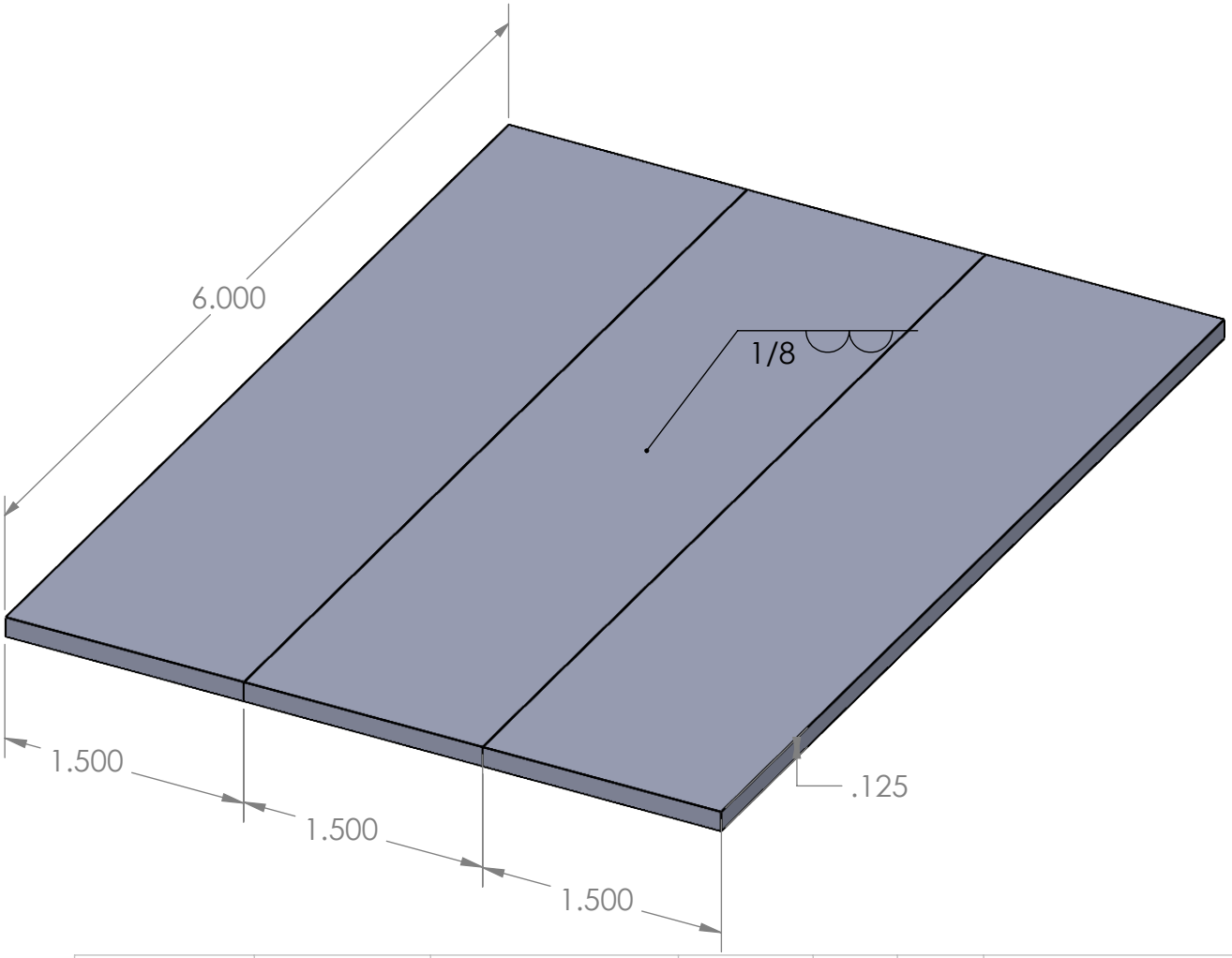
- Use an 85 – 90 degree work angle.
    - It is important to keep this close to 90
- Use a 15 – 30 degree drag travel angle.
- Overlap the previous bead by ½ the previous bead's width.
- Weld additional beads until the entire plate is covered.
- When plate gets hot, switch to another tacked assembly while the first one cools. (In practice, quenching the weld is acceptable. Remember to dry the weld coupon before continuing to weld.)

STEP 5: Inspect Welds and Continue Practice

This activity can be done in all the positions: flat, vertical, horizontal, and overhead. I would begin with flat and continue until the students run decent beads. I would stack the beads until the weldment reaches ½" thick.

MIG Welding Basics Part 5 - Practice - YouTube
https://www.youtube.com/watch?v=cY-jwPzCD8c

7:42 minutes into the video is a great picture of a pad of beads.



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TITLE:

Surface Pad of Beads

SIZE	DWG. NO.	REV
A	Activity One	

SCALE: 1:1 | WEIGHT: | SHEET 1 OF 1

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Introduction to GMAW Basics Activity 2 Instructions

Topic: **Square Groove & Fillet Welds Butt, Lap, and T-Joints**

Introduction: Students in this lesson begin to lay down their first row of beads on different joints. Students setup the entire welding machine, adjust the settings, and begin practicing running beads.

Objectives: To properly setup the welding equipment, adjust the power source settings, start the arc, manipulate the welding gun, read the puddle, and create quality square groove and fillet welds in the flat position.

Study Questions: The following questions are being presented to alert course participants to some of the main ideas embedded in the assigned reading.

- What are some key issues to remember when setting up the equipment?
- Why is it important to clean the metal on practice welds?
- What do you as the student anticipate as an issue that you will have? (Most likely issue will be welding too fast.)

Resources for Building a Knowledge Base - Videos/Reading:

Welding Tips and Tricks: www.youtube.com/user/weldingtipsandtricks - great videos for showing students a quality weld. Jody uses a camera that captures a great picture. It is easier to show the entire class a picture or video of a good bead than to try and squeeze everyone around a welding booth. Once in the lab, then you can run around, demonstrate, and help students individually in each welding booth.

Weld.com is another great resource for videos:
https://www.youtube.com/c/Welddotcom

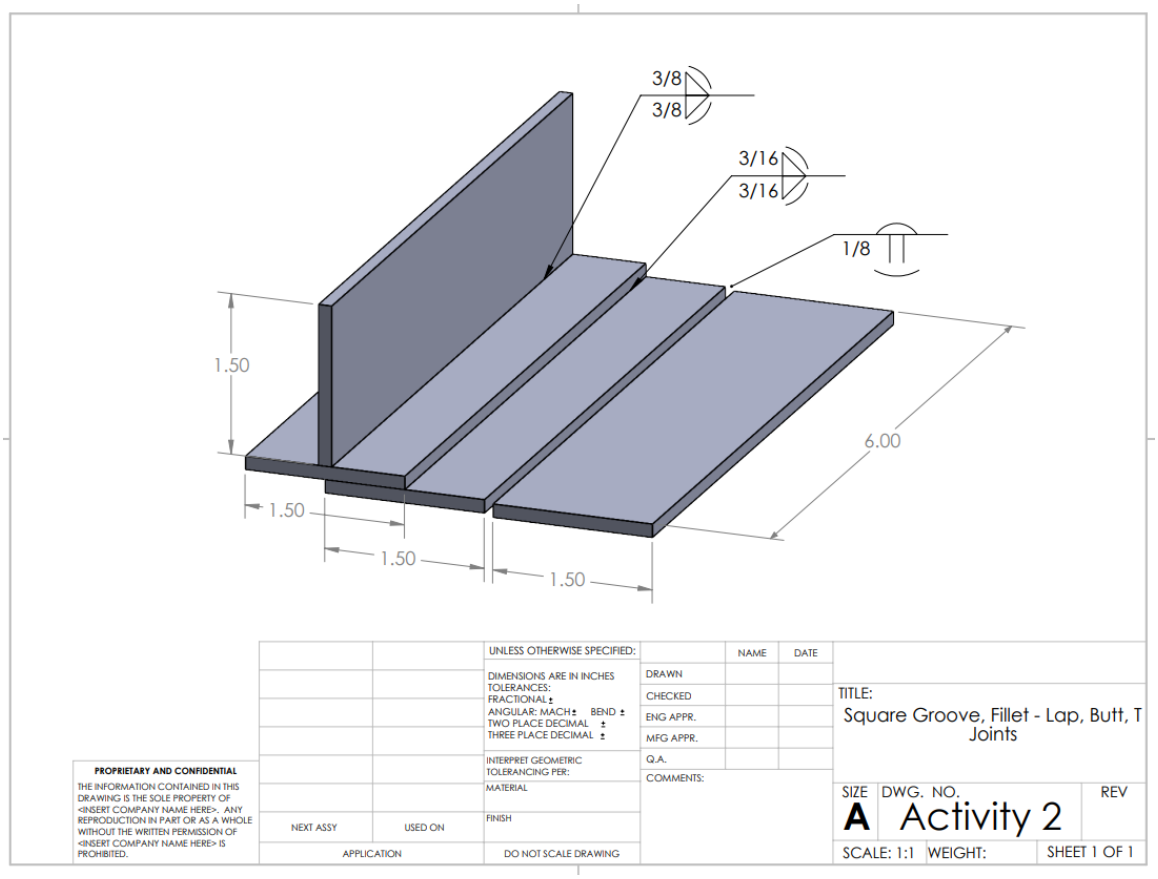
Application:

- Demonstrate your understanding of shop safety by wearing all PPE. Protect yourself, and others.
- Successfully strike an arc and run your first rows of beads.
- Visual inspection of welds. Evaluate for defects, discontinuities, or other quality issues and make the required decisions to make improvements.

- Follow the Weld Sheets shown below and as full drawings at the end of this document.

Lab Activity 2 and 2.1

Square Groove and Fillet Welds, Butt, Lap, and T- Joints in the Flat Position (See page 7 for full drawing)



Materials:

- 5 pieces of metal
- 0.035 ER 70S-6 electrode welding wire.
- 100% Carbon Dioxide shielding gas (can be a mix 75/25 or 80/20)

(Metal can be 1/8”, 3/16”, or any flat metal that you have available.)

STEP 1: Machine Settings:

Polarity: Electrode Positive (reverse polarity).
Amperage: 90-110
Voltage: 17-20
Gas Flow Rate: 15-25 CFH
Stickout: ¼" – 3/8"

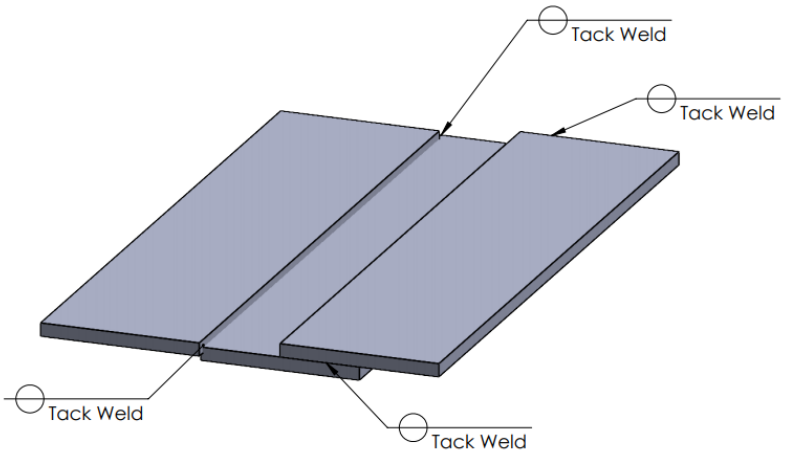
STEP 2: Fine Tune Adjustments on the Settings

- Conduct test welds to fine tune the settings.
- Adjust ONE parameter at a time.

STEP 3: Position Material and Tack Weld

- Cut and clean all pieces to be welded.
- Position 2 plates to form an open butt joint.
- Use a 1/8" spacer to make a 1/8" root opening.
- Tack Weld Both Ends – done to maintain the gap when welding.
- Place a third plate on the assembled butt joint to form a lap joint.
- Tack weld at both ends.
- Position a fourth plate perpendicular to the assembled lap joint to form a T-joint.
- Tack weld both ends.
- Tack the fifth plate to assembly so it can be clamped to the fixture.

(See page 8 for full Tack Weld drawing)



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APPLICATION		DO NOT SCALE DRAWING			

TITLE: Tack Weld Placement

SIZE	DWG. NO.	REV
A	Tack Weld	
SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

STEP 4: Weld the Butt Joint

Deposit first weld bead:

- Position the weldment so that the butt joint can be welded in the flat position.
- Start the welding arc and move across the workpiece with a slight weaving motion.
- Use a smooth, steady drag motion. (Watch the puddle)
- Stay on the leading edge of the puddle.
- Do NOT move out of the puddle or the wire will whisker through the root opening.
- Root penetration should be flush to slightly concave.
- If penetration is excessive, lengthen stickout, or increase travel speed.
- If excessive penetration is still a problem, decrease the amperage.
- If the problem continues, to root opening might be too large.

Deposit Cover Pass – the second weld bead:

- 90-degree work angle and a 15 – 30 degree drag travel angle.
- Use a steady weaving motion to produce about a 3/8" wide weld bead face with slight reinforcement.
- Face reinforcement should be slightly higher than the top surface of the workpiece.

STEP 5: Weld the Lap Joint

- Reposition the workpiece at 45 degree angle so the lap and t-joints are in the flat position.
- Use a slight weaving motion.
- Travel smoothly and evenly across the weldment to completely fill the joint.
- Watch that you do not melt more than a $1/16^{th}$ into the upper plate.
- Bead face will be slightly convex.

STEP 6: Weld the opposite joint using the same procedure as step 5

STEP 7: Weld the T-Joint

Deposit the root pass:

- Use a slight weaving motion.
- Weld bead should have equal leg dimensions
- Bead face should be flat to slightly convex.

Deposit second weld bead pass:

Work angle will be 55 degrees, travel angle 15-30 degrees - drag.

- Second weld bead should overlap root pass by ½ to 2/3.

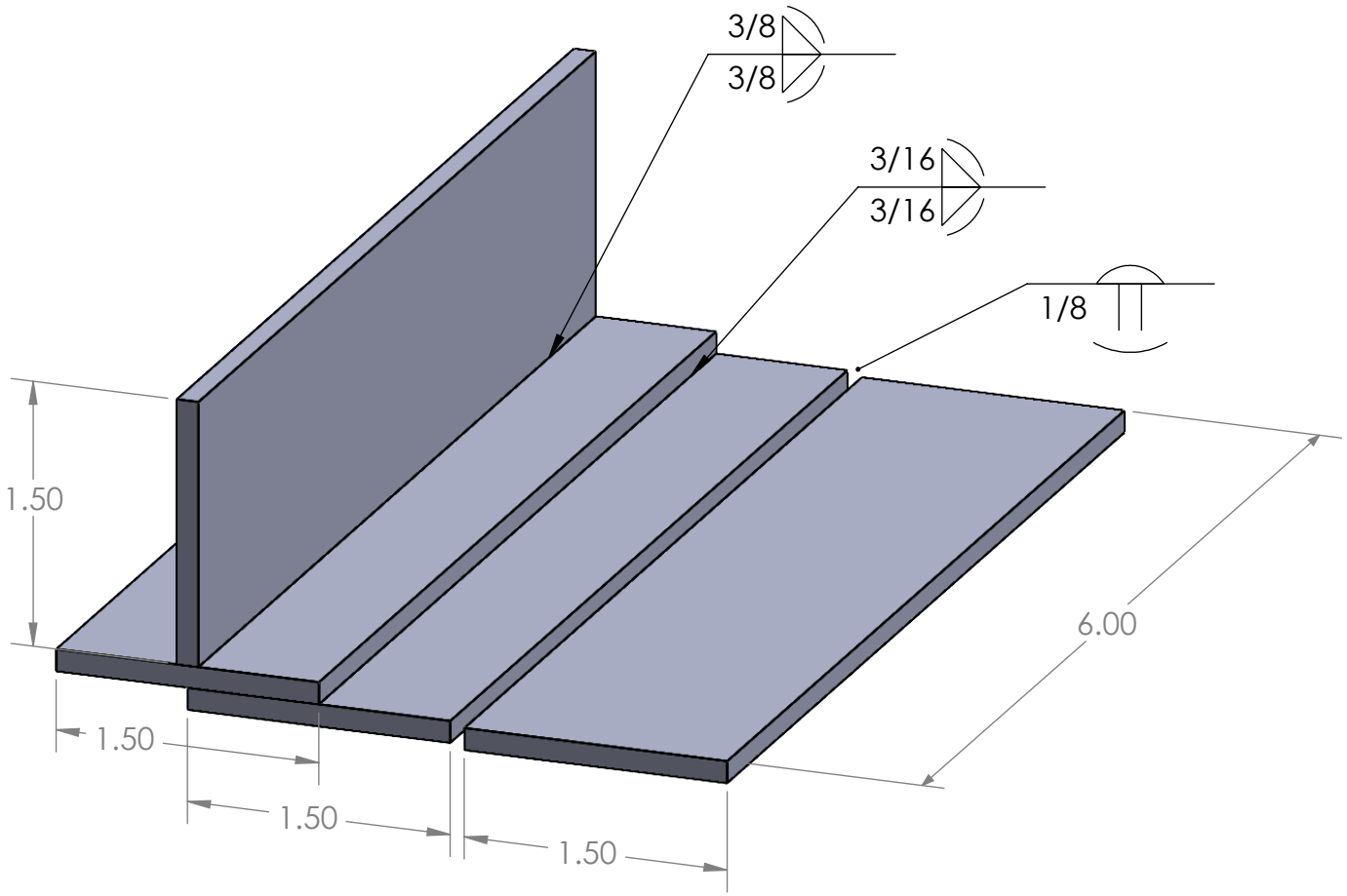
Deposit third weld bead:

- Work angle will 35 degrees, travel angle 15-30 degrees – drag.
- Third weld bead should overlap second pass 1/3 to ½.
- Final weld should have equal leg dimensions of 3/8" minimum.
- The weld face should be ½" wide and flat to slightly convex.

STEP 8: Weld opposite the T-Joint using the same procedure as Step 7

STEP 9: Inspect Welds and Continue Practice

This activity can be repeated in all positions: flat, horizontal, vertical, and overhead.



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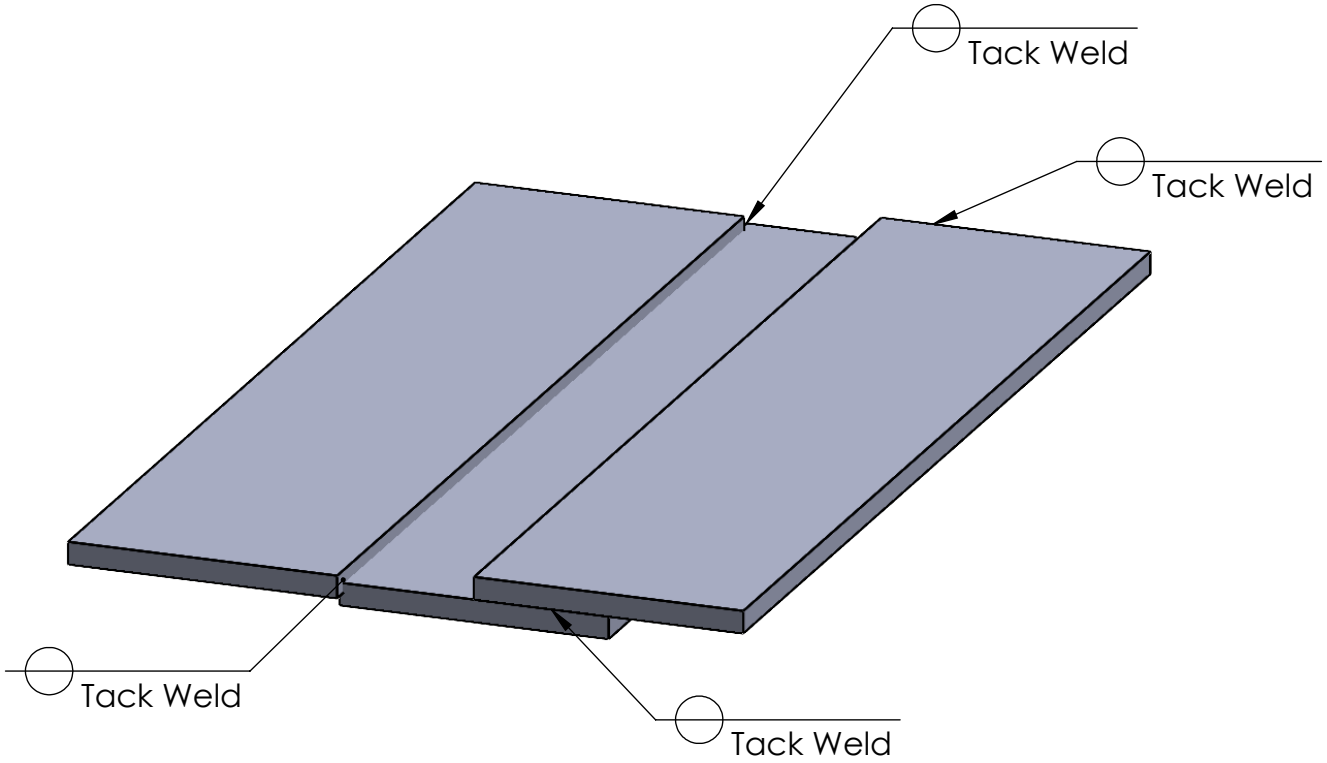
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

TITLE:
Square Groove, Fillet - Lap, Butt, T Joints

SIZE	DWG. NO.	REV
A	Activity 2	

SCALE: 1:1	WEIGHT:	SHEET 1 OF 1



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TITLE:
Tack Weld Placement

SIZE	DWG. NO.	REV
A	Tack Weld	
SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

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Introduction to GMAW Basics Activity 3 Instructions

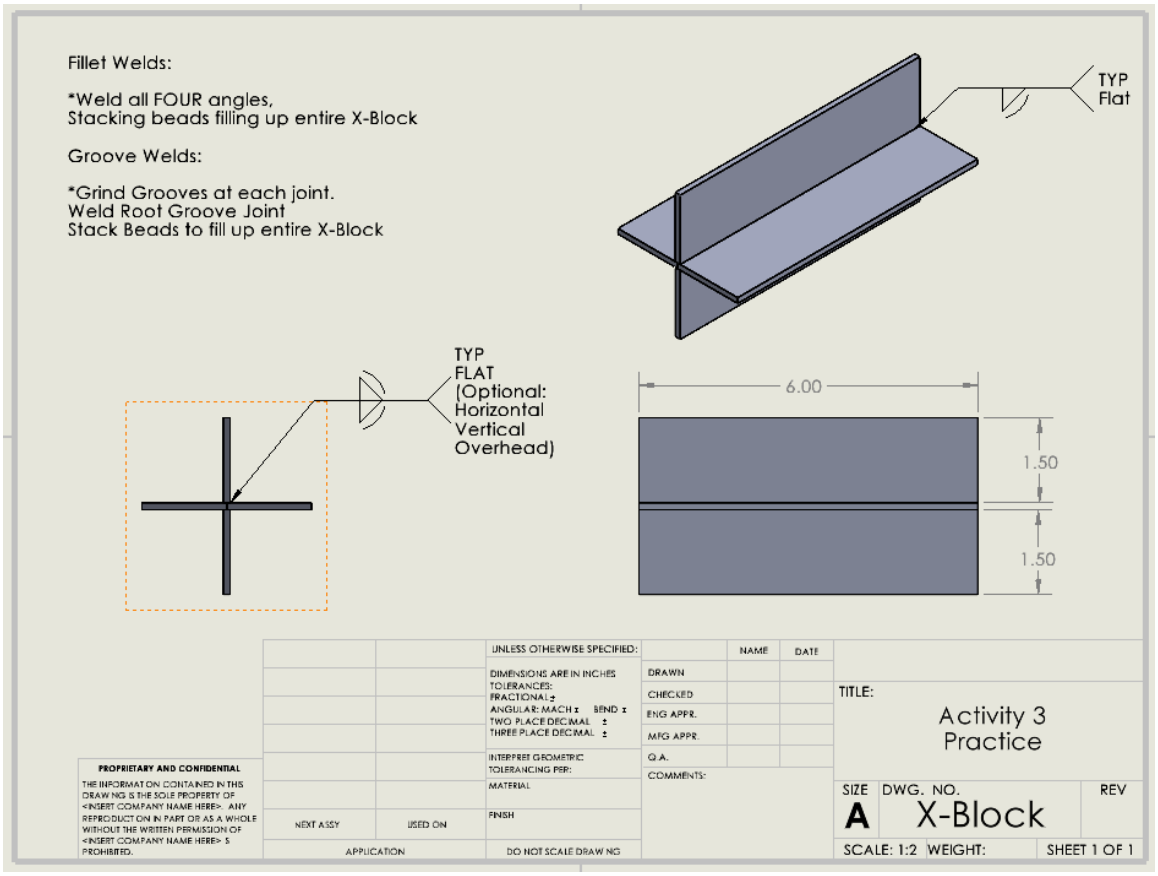
Topic: **Practice Project X-Block**

Introduction: Students in this lesson continue to develop and improve their welding skills by welding together an X-Block (see *Activity 3 – Practice Project X-Block* for full drawing). Students will clean the metal, setup the weldment into an X-Block, tack it together, and proceed to weld and fill in the X-Block.

Objectives: To properly setup the welding equipment, adjust the power source settings, start the arc, manipulate the welding gun, read the puddle, and continually improve their ability to weld using the GMAW process.

Lab Activity 3

Practice Project X-Block (Shown below and as a full drawing at the end of this document)



Materials:

- 4 pieces of metal
- 0.035 ER 70S-6 electrode welding wire.
- 100% Carbon Dioxide shielding gas (can be a mix 75/25 or 80/20)

(Metal can be 1/8”, 3/16”, or any flat metal that you have available.)

STEP 1: Machine Settings:

Polarity: Electrode Positive (reverse polarity).
Amperage: 90-110
Voltage: 17-20
Gas Flow Rate: 15-25 CFH
Stickout: ¼” – 3/8”

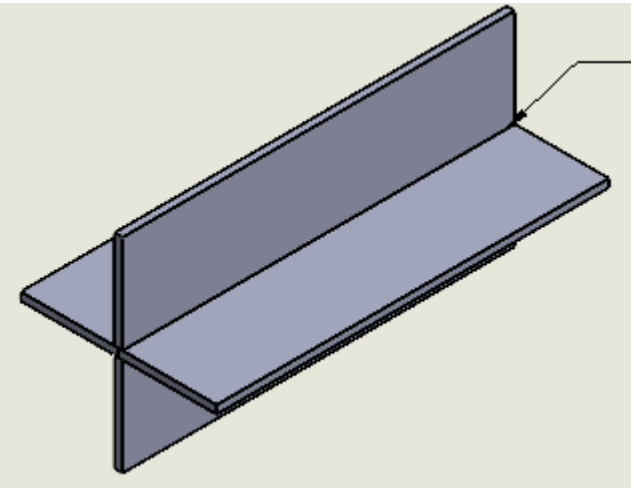
STEP 2: Fine Tune Adjustments on the Settings

- Conduct test welds to fine tune the settings.
- Adjust ONE parameter at a time.

STEP 3: Position Material and Tack Weld

- Cut and clean all pieces to be welded.
- Position 2 plates to form a butt joint.
- Tack Weld Both Ends – done to maintain the gap when welding.
- Place a third plate perpendicular on the assembled butt joint to form a t-joint joint.
- Tack weld at both ends.
- Position a fourth plate on the opposite side of the T-Joint, perpendicular to the assembled butt joint to form another T-joint.
- Tack weld both ends.

The weldment will look like an X.



STEP 4: Weld the ROOT PASS

Deposit first weld bead:

- Position the weldment so that the joint can be welded in the flat position.
    - Turn the weldment so that it is FLAT and sits with the V is pointing up towards you. This is the FLAT position.
- Start the welding arc and move across the workpiece with a slight weaving motion. STAY IN THE ROOT.
- Use a smooth, steady drag motion. Watch the puddle.
- Stay on the leading edge of the puddle.
- Do NOT move out of the puddle or the wire will whisker through the root opening.
- Root penetration should be flush to slightly concave.
- If penetration is excessive, lengthen stickout, or increase travel speed.
- If excessive penetration is still a problem, decrease the amperage.
- If the problem continues, the root opening might be too large.

Deposit the Next Pass – the second weld bead:

- 90-degree work angle and a 15 – 30 degree drag travel angle.
- Use a steady weaving motion to produce about a 3/8" wide weld bead face with slight reinforcement.
- Face reinforcement should be slightly higher than the top surface of the workpiece.

Deposit Cover Pass – the third, fourth, fifth, weld beads:

- Repeating the weld passes until the entire block is filled in.

STEP 5: Turn the X-Block

- Repeat the weld passes until all four sides of the X-Block are completely filled.

STEP 6: Inspect Welds and Continue Practice

This activity can be repeated in all positions: flat, horizontal, vertical, and overhead.

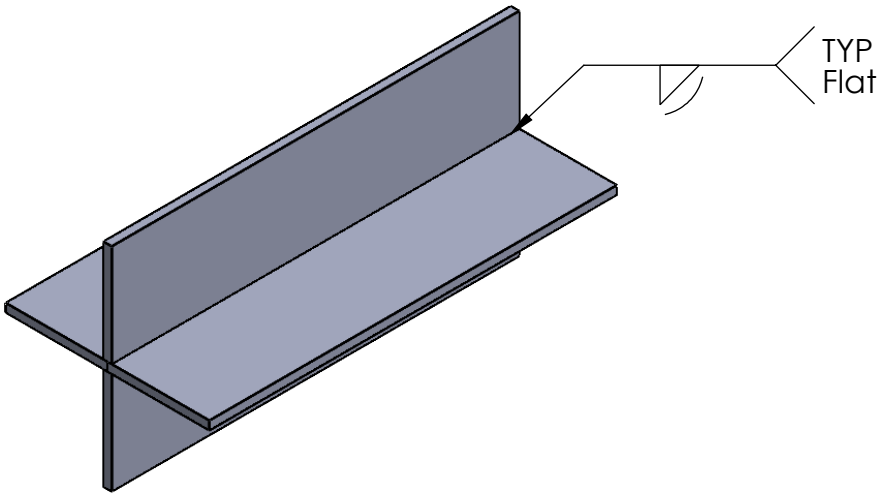
This activity can be repeated in all positions with both Fillet and Groove Welds. Students will have to grind the proper grooves for the groove welds prior to tacking it all together. Once the root is welded the activity becomes Fillet Welds. Students can cut the X-Block in half to visually inspect their welds on completion.

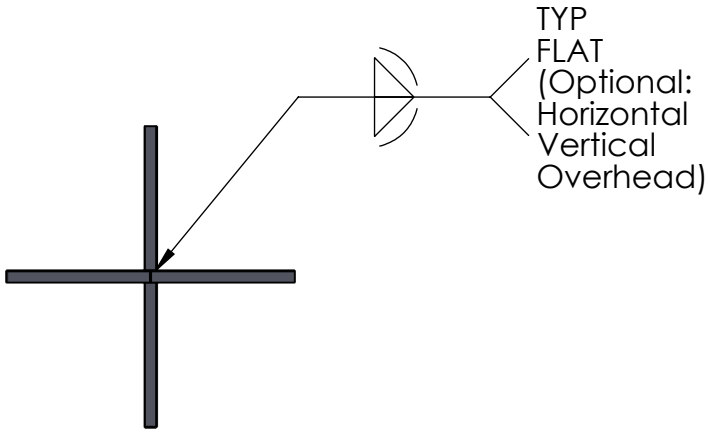
Fillet Welds:

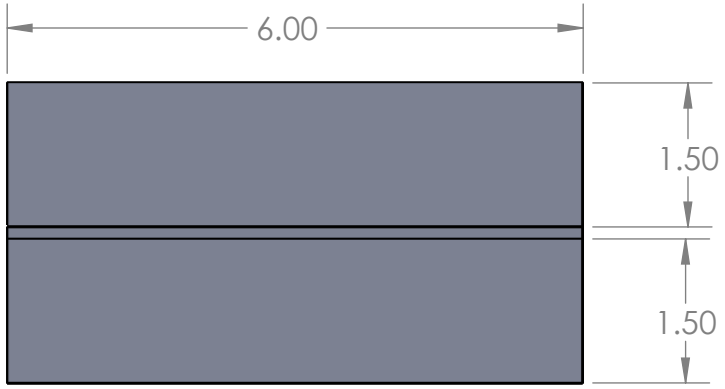
*Weld all FOUR angles,
Stacking beads filling up entire X-Block

Groove Welds:

*Grind Grooves at each joint.
Weld Root Groove Joint
Stack Beads to fill up entire X-Block







		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

TITLE:

Activity 3 Practice

SIZE	DWG. NO.	REV
A	X-Block	
SCALE: 1:2	WEIGHT:	SHEET 1 OF 1

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Topic 1: **Introduction and Safety in Gas Metal Arc Welding**

Introduction: Gas Metal Arc Welding has potential safety hazards. These hazards need not result in anyone being injured. There is no substitute for caution and common sense when it comes to your safety. A safe job is no accident. Safety is everyone's responsibility. Each person must do what it takes to keep the job safe. Your safety is your responsibility, and you must take that responsibility.

Objectives: To gain an understanding of the safety practices and rules used in the GMAW process.

On a written objective examination, and by demonstrating during lab time, students will be able to:

- Identify the purpose and demonstrate the proper use and fit of personal protective equipment (PPE) including eye protection (lens shade), clothing, hearing protection, and footwear while identifying the hazards from which they protect individuals.
- Analyze potential risk situations and solutions that apply specifically to slips and falls, as well as lifting heavy material, and identify safe solutions.
- Recognize hazards associated with welding equipment (i.e., tanks, hoses, cables, gauges) and take the necessary measures to avoid unintentional injuries, including those caused by welding flash and shock.
- Recognize hazards associated with the welding processes and how to properly ventilate a welding area and take the necessary measures to avoid unintentional injuries.
- To become familiar with the important safety rules associated with all phases of welding, including in the shop, in the classroom, and everything in between.

Support for Building a Knowledge Base - Videos/Reading:
The reading can be assigned from any Welding Textbook or online resource that you have access to. Lincoln Electric: http://safety.lincolnelectric.com/ has 6 safety videos that I use along with the textbook.

Summary of Safety for GMAW Welding

1. Always wear the appropriate safety glasses.
2. Always wear the appropriate safety clothing suitable for welding.
3. Keep the work area clean and free from potential hazards.
4. Carefully and appropriately handle and store compressed gas cylinders.
5. Correctly label used stored compressed gas cylinders.
6. Weld in appropriate areas, making sure not to weld in confined areas or spaces without taking appropriate measures.
7. Do not weld on containers that have held combustibles.
8. Do not weld on sealed containers without taking the appropriate safety measures.
9. Use mechanical exhaust at the point of welding.
10. Check the welding area for damp or wet ground and take the appropriate safety measures to reduce the chance for electric shock.
11. Check all welding equipment before beginning welding, to make sure that it is installed correctly, good working condition, grounded correctly, and has no frays or cuts in the wires and hoses.
12. Protect yourself from electric shock by following the rules involving welding.

Comprehension:

Safety Exam – I give general safety exams for students on all topics. Depending on the textbook that you have available will guide what exams you provide. I would match your safety tests to the books that you have access. I give daily safety grades for every student. If the student isn't wearing safety glasses, then they lose points. If they are goofing around and being unsafe, they lose points. I also put into place things that they can do to earn the points back. Extra cleanup, helping others, etc.

Possible Discussion:

Students take turns putting on PPE and demonstrating safety measures. Then discuss in small groups what they saw other students doing well with safety and what needs to be improved.

Application:

Throughout the semester students will demonstrate their understanding of safety and how it relates to all areas of welding. In the shop, you are required to demonstrate your understanding of shop safety by wearing all PPE. Protect yourself, and others.

Teaching Strategies for Instructor:

- Introduction: I speak around personal experiences and stories from industry. Everyday people get hurt and their lives are changed forever because safety precautions were not followed. The pressure to get the job done quickly can cause people to skip important safety measures. I remind students to always protect themselves by following safety measures.

- While speaking about safety, I include what to do when an accident occurs. This prepares students in how to react when an incident occurs. This helps them remain calm in a stressful situation.
- I provide samples and examples of safety equipment during the demonstration. I show students why frays are dangerous. (Using an old ripped pair of jeans you can explain how the frays are like candle wicks and burn really fast.)
- Explaining the lens shade for welding is important. The need to weld with a dark enough shade to keep from burning your eyes is as important as being able to see the weld puddle. The recommendations for shade can be found on OSHA's web page. https://www.osha.gov/sites/default/files/publications/OSHAfactsheet-eyeprotectionduring-welding.pdf
- Summarize key points – Ask Questions ○ Why should you wear safety glasses under your welding helmet? ○ How do you transport gas cylinders for welding?
    - Why is ventilation so important? ○ What are MSDS sheets and why are they important?
    - Why is water an issue when welding?
        - (Interesting – students quench their welds and then put it wet back on the table, when they begin welding again, they lean on the wet table. (Shocking))

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Topic 2: **Overview of the Gas Metal Arc Welding Process**

Introduction: GMAW is a versatile process used on everything from small parts to heavy fabrications. GMAW uses the intense heat of the arc to melt a continuous electrode wire and base metal. This week we are going to take a closer look at the Arc welding process.

Objectives: On a written objective examination, and by demonstrating during lab time, students will be able to:

- Define welding.
- Explain characteristics that set welding apart from other joining processes.
- Identify common base metals used for welding.
- Explain the importance of heat control in welding.
- Define fusion welding.
- Describe the properties of electricity.
- Identify the variables used to measure electricity.
- Describe the path of electricity in welding.
- Describe the gas metal arc welding process.
- Identify the major types of electrodes.
- Describe the advantages of welding.

Study Questions: The following questions are being presented to alert course participants to some of the main ideas embedded in the assigned reading.

- What Is Welding?
- Which metals can be welded using the GMAW process?
- What is heat control important in GMAW?
- What is Fusion Welding?
- Describe the properties of electricity, and identify the variables used to measure electricity.
- Describe the GMAW Process?
- What are Advantages and Disadvantages of Welding?

Resources for Building a Knowledge Base - Videos/Reading:

Gas Metal Arc Welding – Metal Transfer
https://www.youtube.com/watch?v=w_znOqL8a98&list=PL3TlG4e9blXPO7zqUDsudXybSF1AQL0l5&index=6

Chucke2009 presents "Teach yourself MIG Welding Part 1"
https://www.youtube.com/watch?v=hgGG-ifphkA

Application: Depending on what you have available and the time frame for your classes and lab, the application can be done at any time. Once the safety is complete, I will take students out into the lab and have them tear down and setup the equipment. This will provide them with some background information for the classroom lecture. You have the flexibility to setup and perform the applications as you want. These are basic ideas for you to use.

- Demonstrate your understanding of shop safety by wearing all PPE. Protect yourself, and others.
- Completely setup and tear down all the components used in the GMAW process.
- Successfully strike and arc and run your first rows of beads.

Instructor Guiding Principles

The American Welding Society (AWS) has identified 17 metal-joining processes with are used in industry. These processes are broken down into six categories:

1. Arc Welding
2. Resistance Welding
3. Oxyfuel gas Welding
4. Solid State Welding
5. High Energy Density Welding
6. Soldering and Brazing.

Resistance Welding is used to join sheet metal. The auto industry and home appliances. Spot welding, seam welding, projection welding and flash butt welding are variations of this process.

Oxyfuel Welding Processes are used for auto body repair and heavily in the farm industry. The cost of equipment is low and portable. Bare wire is used as filler metal. The metal is fed by hand.

Solid State Welding include diffusion welding, friction welding, hot and cold pressure welding, explosive welding, and ultrasonic welding. In these processes no melting takes place. The welding occurs by pressure and heat.

High Energy Density processes, such as electron beam and laser beam welding, can be used in a variety of applications. These produce a high-quality weld. These processes are quite expensive and are only used in large commercial settings.

Soldering and Brazing are used for joining a wide variety of alloys. These processes do not melt the base metal. Heating can be done by a torch, electric induction, or any process that will heat the filler enough to melt and weld the base metals together.
The major arc welding processes used by welders in industry are:

Gas Metal Arc Welding (GMAW)
Shielded Metal Arc Welding (SMAW)
Gas Tungsten Arc Welding (GTAW)
Flux Cored Arc Welding (FCAW)
Submerged Arc Welding (SAW)

Gas Metal Arc Welding (GMAW)

GMAW is a process for joining metal by heating them with an arc initiated between the workpiece and a continuously fed wire consumable electrode which is surrounded by a shielding gas. The shielding gas can be helium, argon, carbon dioxide, or mixtures of them. The shielding gas protects the molten metal pool from reacting with the constituents of the atmosphere. GMAW can be used with a variety of metals, carbon, alloys, stainless steels, aluminum, copper, iron, etc. This makes the process versatile in many different applications.

GMAW is known as MIG welding. MIG welding is not the approved term by the American Welding Society.

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Topic 3: **Electricity and the Gas Metal Arc Welding Process**

Introduction: GMAW is a versatile process used on everything from small parts to heavy fabrications. GMAW uses the intense heat of the arc to melt a continuous electrode wire and base metal. This week we are going to take a closer look at the Arc welding process.

Objectives: On a written objective examination, and by demonstrating during lab time, students will be able to:

- Explain basic electricity.
- Describe the three types of welding polarity.
- Differentiate between the various types of power sources.
- Identify the types of power source outputs.

Study Questions: The following questions are being presented to alert course participants to some of the main ideas embedded in the assigned reading.

- What is Alternating Current?
- Whether AC or DC current, what must a power supply have if it is to supply power to the welding electrode?
- What determines the size of the power supply needed and the type of power supply needed?
- What must present in the power supply to change AC input power to DC welding output?
- What is the negative pole and the positive pole of DC+ (direct current positive) current?
- How often does AC current in the United States reverse polarity?
- What is a Constant Voltage Power Source?
- What is a Constant Current Power Source?
- What determines welding amperage when using a CV welding machine?

Resources for Building a Knowledge Base - Videos/Reading:

Constant Current Vs Constant Voltage Differences - Cc Vs Cv In A Welder
https://www.youtube.com/watch?v=eGN2-LOqnvg/

Application: Depending on what you have available and the time frame for your classes and lab, the application can be done at any time. Once the safety is complete, I will take students out into the lab and have them tear down and setup the equipment. This will provide them with some background information for the classroom lecture. You have the flexibility to setup and perform the applications as you want. These are basic ideas for you to use.

- Demonstrate your understanding of shop safety by wearing all PPE. Protect yourself, and others.
- Completely setup and tear down all the components used in the GMAW process.
- Successfully strike and arc and run your first rows of beads.

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Topic 4: **Overview of the GMAW Equipment Setup**

Introduction: GMAW is a versatile process used on everything from small parts to heavy fabrications. GMAW uses the intense heat of the arc to melt a continuous electrode wire and base metal. This week we are going to take a closer look at the Arc welding process.

Objectives: Be able to correctly set up and adjust the welding equipment used in the GMAW process, successfully perform a weld, and tear down the welding equipment.

On a written objective examination and by demonstrating designed lab activities during lab time, students will be able to:

- Identify the equipment used in the GMAW process.
- Correctly assemble and disassemble the equipment.
- Choose, install, and set the working pressure for the shielding gas.
- Demonstrate all aspects of safety in the lab

Study Questions: The following questions are being presented to alert course participants to some of the main ideas embedded in the assigned reading:

- List and identify all the parts and equipment used in the GMAW process.

Resources for Building a Knowledge Base - Videos/Reading:

Welding Tips and Tricks.com "MIG Welding Basics"
https://www.youtube.com/watch?v=5KrwmK7df-s

Welding Tips and Tricks.com "MIG Welding Basics 2"
https://www.youtube.com/watch?v=AZbCTg8otRc&t=22s

Welding Tips and Tricks.com "MIG Welding Basics 3 – Setting Wire speed and voltage"
https://www.youtube.com/watch?v=sZuq4XQTHVs

Application: Depending on what you have available and the time frame for your classes and lab, the application can be done at any time. Once the safety is complete, I will take

students out into the lab and have them tear down and setup the equipment. This will provide them with some background information for the classroom lecture. You have the flexibility to setup and perform the applications as you want. These are basic ideas for you to use.

- Demonstrate your understanding of shop safety by wearing all PPE. Protect yourself, and others.
- Completely setup and tear down all the components used in the GMAW process.
- Successfully strike and arc and run your first rows of bead

Instructor Guide

Setting up the Power Connections

1. As a safety precaution,
    a. Turn all power off of the wire feeder and the power source before checking electrical connections.
    b. Plug-ins are difficult to pull in and out of the wall, 220 plugs especially, and need to make sure that the students do NOT accidentally touch the prongs on the plug while plugging in the machine. You will see that two fingers could easily make the connection and create a shock.
    c. Check all electrical connections to make sure that they are tight, that there are no cut or cracked cables, or exposed wires.
    d. The power sources set-up for GMAW is electrode positive (reverse polarity), the positive terminal which supplies the welding voltage and amperage is connected to the wire feeder.
    e. The work lead (Often called the Ground) is connected to the negative terminal. This is attached to what you are welding.

Welding Gun Assembly

1. The welding gun assembly is removed by disconnecting the gun trigger lead, loosening the retaining knob on the wire feeder, and pulling the gun cable from the wire feeder.
2. Check the "O" rings. Make sure that they are present and are not damaged.
3. Check the gun to make sure that it is in good working condition
4. Clean the Nozzle…. (Everyday, I remind the students to clean the nozzle. A dirty nozzle restricts gas flow and effects the weld.)
5. Inspect the Gas Diffuser and the Contact Tube.
6. Clean Liner

Wire Installation

1. Remove the contact tube.
2. Open the feed roll assembly.
3. Turn the wire back onto the wire roll (If changing wire type).

4. Replace the wire roll.
5. Replace the retaining ring. (It gets expensive when students drop rolls of wire.)
    a. I twist the wire into filler rod for GTAW welding.
6. Keep pressure on wire to prevent the wire from unspooling, until after the wire has been fed back into the liner and the feed roller assembly has been closed.
7. Set the tension of the roller on the wire. To much tension will pinch the wire and to little will cause the drive rolls to slip.
8. Jog the wire to get it to the end of the gun. Watch the tension as you job the wire to correctly adjust the tension.
9. Replace the contact tube and nozzle.

Amperage and Voltage Settings

1. Set Amperage and voltage to the settings recommended by the welding machine company. This is sometimes difficult as some welding machines have number 1-8, and do not show the actual wire speed and voltage. The American Welding Society and the companies that produce the equipment all provide recommended settings for different applications. Start with these numbers and adjust to your needs.
2. Fine tune during practice welds.
3. Welding is about getting the settings correct to the welder's ability to weld or using the weld procedure sheet (WPS) in industry. All in all, if the wire is burning back into the tip, the wire speed needs to increase or the voltage needs to decrease, and vice versa.

Birds Nest

1. Birds Nests occur when the wire is impeded somewhere between the drive roll and the work piece. The wire stops at the gun, the drive rolls keep driving the wire, and a net of wire spools up in the machine.
2. The most common cause of bird nests is having to much drive roll tension. Other causes are dirty equipment throughout the gun or burn back.
3. Cut the wire out, adjust or clean the machine, and reset up the wire.

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Topic 5: **Weld Positions used in GMAW**

Introduction: Producing good quality GMAW welds involves understanding the nomenclature of basic weld joints and positions.

Objectives: On a written objective examination, and by demonstrating during lab time, students will be able to:

- Describe the five basic joints used in welding.
- Describe a fillet weld.
- Describe a groove weld.
- Describe how to measure fillet and groove welds.
- Describe the factors that will affect the strength of a welded joint.

Study Questions: The following questions are being presented to alert course participants to some of the main ideas embedded in the assigned reading.

- List the five basic joints and a welding application that each joint would be used in.
- What determines the size of the weld?
- What considerations should be made in preparing a joint to be welded?
- What are the four weld types?

Resources for Building a Knowledge Base - Videos/Reading:

Welding Symbols, Weld Types, Weld Joint Design | Piping Analysis - YouTube
https://www.youtube.com/watch?v=AvGMK2G6YZg

Simple MIG Welding Technique - Flat, Horizontal, Vertical & Overhead | Welding Tips & Tricks #MIG
https://www.youtube.com/watch?v=ods6Jp7hEh0

Application:

- Demonstrate your understanding of shop safety by wearing all PPE. Protect yourself, and others.
- Students grind and set up each of the 5 joints to be welded.

- Students practice welding each of the 4 weld types.
- Successfully strike and arc and run your first rows of beads.

Instructor Notes

There are four basic weld positions:

1. Flat – Surfaces of the work lie parallel to the ground. The flat position is exactly how it sounds. Lay the pieces to weld down flat, parallel to the ground and weld.
2. Vertical – Both surfaces of the work the work and the line of the weld are perpendicular to the ground. Vertical is both up and down.
3. Horizontal – The surfaces of the work are perpendicular to the ground, but the weld line is parallel to the ground. Think of drawing a horizontal line on a wall.
4. Overhead – Surfaces of the work are parallel to the ground, but welding is performed from below the work instead of above it. Overhead does not necessarily mean the work to be welded is over your head.

Weld Types

1. Groove Weld: A groove weld is deposited in a groove.

2. Fillet Weld: Fillet welds is metal deposited in a right angle formed by the two plates.

3. Bead Weld: Bead welds are surface welds. They are single pass deposits of weld metal often used to build up a pad of metal to replace worn metal.

4. Plug Weld: Plug welds are used for filling slotted or circular holes.

Common Weld Joints and Positions

1. Butt Joint – A joint between edges of two pieces of material lying in the same plane. Simply put, the edges are butted together. The numerical value indicates the position. (1 = FLAT). The letter that follows identifies weld type.

2. Lap Joint – A joint made by overlapping one piece of material over another.

3. T-Joint – A joint between two pieces of material positioned at right angles (90 degrees) to each other in the form of the letter "T".

4. Corner Joint – A joint between two pieces of material positioned at right angles (90 degrees) to each other in the form of the letter "L".

5. Edge Joint – A joint between the edge of parallel plates.

Groove Welds

1G = is a Flat Groove Weld

2G = is a Horizontal Groove Weld

3G = is a Vertical Groove Weld

4G = is an Overhead Groove Weld

Fillet Welds

1F = indicates a Flat position with a Fillet Weld.

2F = indicates a Horizontal position with a Fillet Weld

3F = indicates a Vertical position with a Fillet Weld

4F = indicates an Overhead position with a Fillet Weld

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Topic 6: **Metal Transfer Processes used in GMAW**

Introduction: The gas metal arc welding process continually feeds a wire electrode into the weld. There are different processes for transferring metal into the weld joint. In GMAW an electric arc is established between the metal being welded and a consumable wire electrode that is fed continuously through a gun at a constant speed. Simultaneously, shielding gas is fed through the gun into the weld zone to protect the molten weld pool. The filler metal in GMAW is transferred directly through welding arc into the weld, referred to as metal transfer.

Objectives: On a written objective examination, and by demonstrating during lab time, students will be able to:

- Describe the types of metal transfer and the benefits of each.
- Describe short circuit transfer.
- Describe Globular transfer and the application sit would be used.
- Describe Spray transfer and in what applications it can be used.
- Develop an understanding of how to set up the equipment for each transfer process and explain how to do it.
- Describe what pulse is and how it improves the GMAW welding process in some application.

Study Questions: The following questions are being presented to alert course participants to some of the main ideas embedded in the assigned reading.

- How does the equipment differ for setting up each method of metal transfer?
- Which method of transfer would be best used for really thick steel?
- Which transfer methods can be used in all positions?
- Why can't some transfer methods be used in all positions?

Resources for Building a Knowledge Base - Videos/Reading:

Modes of Metal Transfer | Short Circuit vs Spray vs Globular
https://www.youtube.com/watch?v=XkbgXQ7Wl-Y

Different modes of metal transfer in GMAW or MIG MAG – YouTube
(I shut the sound off and lecture over this presentation.)
https://www.youtube.com/watch?v=KiWQa47r1O0

Application:

- Demonstrate your understanding of shop safety by wearing all PPE. Protect yourself, and others.
- Completely setup and tear down a welder for performing each of the metal transfer methods.
- Successfully strike and arc and run beads for each of the metal transfer methods.

Instructor Notes

Metal Transfer

Gas metal arc welding is one of the most versatile welding processes because of its ability to weld a wide range of metals and thicknesses. The flexibility stems from GMAW to use three different transfer methods. Short Circuit, Globular, and Spray aer the main three transfer methods.

The key variables that determine the type of metal transfer are:

- Amperage and Voltage
- Electrode Wire Diameter
- Type of Shielding Gas

Short Circuit Transfer

In short circuit transfer, a small bead of molten filler metal forms at the tip of the electrode. When the bead contacts the puddle, it causes a short-circuit that momentarily extinguishes the arc. The current in the wire increases until the wire pinches off and flows into the weld puddle, then the arc reignites. This happens several hundred times per second. Short circuit transfer occurs at lower amperage and voltage settings, with smaller diameter wires. The most commonly used diameters are 35 thousandths and 45 thousandths of an inch.

Short circuit transfer can be performed on all weld joint types in all positions. It can be used to weld ferrous and nonferrous metals.

Globular Transfer

In globular transfer, a droplet of filler metal forms at the end of the electrode and grows up to twice the diameter of the wire. It forms a giant glob. The force of gravity eventually causes the droplet to detach and transfer across the arc into the weld puddle. Globular transfer occurs at

higher amperage and voltage settings than short circuit. Globular transfer uses larger diameter electrode wires, typically 45 thousandths of an inch and bigger. It also requires a longer stick out as the wire has to have room to produce a glob. Globular transfer has a high deposition rate and produces a lot more spatter than short circuit. It is suitable for thicker metals and can only be performed in the flat and horizontal positions because of the large droplet size. This process is rarely used today.

Spray Transfer

In spray transfer, a combination of factors, including amperage, voltage, wire diameter, and shielding gas create an electromagnetic force or pinch force, around the electrode (wire). The pinch force squeezes down on the electrode from the contact tube to the tip of the wire. When the pinch force reaches the molten droplet at the end of the wire, it pinches off the droplet, and the droplet transfers across the arc into the puddle.

This pinch effect occurs several hundred times per second creating a spray of small droplets. The size of the spray is limited to the size of the wire being used. Spray transfer occurs at a higher amperage and voltage range. Spray transfer is restricted to flat and horizontal positions.

Pulsed Spray Transfer

Pulsed Spray transfer is a variation of spray transfer. It uses a pulsed current to alternate between a low "background" power level and a peak amperage above the spray transfer transition point. The low background power sustains the arc and heats the wire (electrode). As the amperage increases above the transition current for spray transfer, a small droplet forms at the tip of the electrode.

The electromagnetic pinch effect detaches the droplet, and the droplet transfers across the arc as the amperage returns to the background level. The cycle repeats hundreds of times per second. Pulsed spray can be used to weld in all positions and a wide range of metal thicknesses.

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Topic 7: **Shielding Gases – Protecting the Weld**

Introduction: During the GMAW welding process the molten metal has the potential to pull impurities from the atmosphere and into the weld. This causes defects in the weld. To prevent atmospheric contamination, the GMAW process uses shielding gas to protect the molten weld pool.

Objectives: On a written objective examination, and by demonstrating during lab time, students will be able to:

- Explain the purpose of shielding gas.
- Describe the two categories of shielding gases.
- Describe how to select the best shielding gas for the application.
- Describe how to safely change out a shielding gas cylinder tank.
- Describe how to choose the best working pressure for the shielding gas.
- Describe the discontinuity or defect a lack of shielding gas can create and how to fix it.

Study Questions: The following questions are being presented to alert course participants to some of the main ideas embedded in the assigned reading.

- Why is shielding gas needed for GMAW?
- What is the difference between a reactive gas and inert gas?
- A good starting working pressure for a shielding gas is between?

Resources for Building a Knowledge Base - Videos/Reading:

Tech Tips: Shielding Gas Selection for MIG Welding - YouTube
https://www.youtube.com/watch?v=TVM969GD44w

GMAW Metal Transfer
https://www.youtube.com/watch?v=w_znOqL8a98&list=PL3TlG4e9blXPO7zqUDsudXybSF1AQL0l5&index=6

Application:

- Demonstrate your understanding of shop safety by wearing all PPE. Protect yourself, and others.
- Completely setup of shielding gas. Perform a leak test.
- Successfully strike and arc and run rows of beads using different shielding gases and compare the differences.

Instructor Notes

Short Circuit Transfer

The most common shielding gas for short circuit transfer on carbon steel is 100% carbon dioxide. This is a great gas for getting students started in welding. The cost is much cheaper because it is not a mix. Students can work on getting the basic down to run the perfect bead knowing that their weld will not be quite as nice as it will be when they move to a mix.

The 75% argon (Ar) and 25% carbon dioxide (CO2) is also a very common mix. The weld will be cleaner in appearance with the addition of the argon. A mixture of 90% helium, 7% argon (Ar), and 2% carbon dioxide (CO2) is commonly used in industry on stainless steel.

Carbon dioxide: is a reactive gas. It interacts with the base metal and filler metal at high temperatures producing high electrode burn-off rates and a fast-freezing weld puddle with deep penetration. The fast-freezing keeps the atmosphere from contaminating the weld.

The deeper penetration and high electrode burn-off rates associated with carbon dioxide may cause some spatter. Industry will move to a mixture of argon and CO2 to get a cleaner weld with less clean up time.

Argon: Argon is an inert gas. It doesn't react with the filler metal or the base metal. This means that it does NOT change the chemical composition of the weld deposit. It has a much lower heat input than carbon dioxide.

Argon/CO2: A mixture of 75% argon and 25% CO2 exhibits less spatter and better arc stability than 100% CO2. This produces a nice smooth weld with a great appearance.

Helium: Helium is an inert gas. It is similar to CO2 in its ability to generate a lot of heat input. A tri-mix of 90% helium, 7% argon, and 2% CO2 promotes short circuit transfer on stainless steels. This mixture maintains the corrosion resistance of stainless steel, because it is over 97% inert. The low amount of CO2 does not promote carbon pickup, so there is not enough carbon in the gas mixture to change the chemical composition of stainless steel. In recent years helium has become very expensive. It is great to weld with but has become quite costly to use. There has been a shortage of helium for years.

Globular Transfer

Globular transfer uses the exact same shielding gases as short circuit transfer.

Spray Transfer

Spray transfer occurs in the presence of an argon-rich shielding gas. A mixture of argon and oxygen is used for shielding on ferrous metals such as low and medium carbon steel, high strength, low alloy, and stainless steels.
The most common mixtures are 95% argon, 5% oxygen / 98% argon, 2% oxygen / and 99% argon, and 1% oxygen.

Oxygen: Small amount of oxygen are added to the argon when welding to help stabilize the arc and minimize spatter. Oxygen is a reactive gas. It provides heat input that makes the puddle more fluid, which improves the uniformity of the weld. It also helps to limit the droplet size and increase rate of droplet transfer. The amount of oxygen is limited to 5% because higher levels create porosity problems and increase the risk of undercutting.

Argon/Helium: 100% Argon, or a mixture of argon and helium is used on aluminum and aluminum alloys, nickel and nickel alloys, copper alloys, and other nonferrous metals.

Oxygen is not used on nonferrous metals because it is a reactive gas, and in nonferrous metals the reactive gas would form porosity and other defects.

Spray transfer on ferrous metals is restricted to the flat and horizontal welds because the high amperage and voltage settings, combined with the shielding gas produce such a hot and fluid puddle.

Pulsed Spray Transfer is commonly welded with 92% argon, 8% CO2 / 98% argon, 2% Oxygen / or 95% argon, 5% oxygen.

MINNESOTA STATE
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Train-the-Trainer Workshops

Welding Curriculum

Topic 8: **Quality of Welds**

Introduction: GMAW is a versatile process used on everything from small parts to heavy fabrications. GMAW uses the intense heat of the arc to melt a continuous electrode wire and base metal. This week we are going to take a closer look at the Arc welding process.

Objectives: To discuss the gas metal arc welding process variables and their effect on the quality of welds.

On a written objective examination, and by demonstrating during lab time, students will be able to:

- Describe the proper joint preparation and set-up for the material to be welded.
- Demonstrate how to appropriately clean the metal prior to welding.
- Describe how to set the appropriate root opening and the effects that to narrow or wide of a root opening has on the weld.
- Describe what amperage is and how to set it up for the weld being made.
- Describe the issues of to high and low amperage has on the weld.
- Describe voltage, how and where to set it for the weld being made.
- Describe the issues of improper voltage settings on the weld.
- Describe the appropriate electrode angles for welding the GMAW process.
- Describe how travel speed changes the quality of the weld.
- Describe what "stick out" is and how it changes the quality of the weld.

Study Questions: The following questions are being presented to alert course participants to some of the main ideas embedded in the assigned reading.

- Why is fit-up important in GMAW?
- What is amperage and what are its effects on GMAW welds?

- What is voltage and what are its effects on GMAW welds?
- Why is it important to get the proper root opening?
- Does gun angle matter when pushing or pulling the weld, and why?
- How is travel speed, voltage, and amperage collaboratively affect the weld?
- What is "Stick out" and why is it important

Resources for Building a Knowledge Base - Videos/Reading:

Mig Welding Basics 4 - Avoiding LOF - Ice Bucket Words - YouTube
https://www.youtube.com/watch?v=lSNXTgmNbxk

Mig Welding Basics part 5 - Practice https://www.youtube.com/watch?v=cY-jwPzCD8c

MIG Welding Basics part 6 Tee Joint Drill
https://www.youtube.com/watch?v=nPxqErIVQ9I

Mig Welding Basics part 7 Vertical Tee Joint Drill
https://www.youtube.com/watch?v=JycdRwDLg58

Application:

- Demonstrate your understanding of shop safety by wearing all PPE. Protect yourself, and others.
- Successfully strike and arc and run your first rows of beads.
- Visual inspection of welds and evaluate for defects, discontinuities, or other quality issues and make the required decisions to make improvements.
- Practice running a bead with a high voltage setting, a good voltage setting, and a low voltage setting and compare the differences in weld appearance.
- Practice running a bead with to slow of wire speed. What happens?
- Practice running a bead on two pieces of metal that are not prepped correctly, a root opening to wide, and describe the quality of welds.

Instructor Notes

Gas Metal Arc Welding Variables

- Metal preparation and Set-up
- Amperage
- Voltage
- Electrode Angles
- Travel Speed
- Gun Manipulation
- Stick Out
- Welder

Material Preparation and Set-up

This is one of the most important step in GMAW welding. Taking the time to properly prepare the material, cleaning and aligning the pieces, will make the difference between a good weld and a poor weld.

- All joint fit-ups should be in alignment with the print for the weldment.
- The base metal should be thoroughly cleaned to minimize the chances of developing porosity from surface contamination.
- Pay attention to the root opening. Root openings that are too large may cause excessive penetration. Tight root openings may result in incomplete penetration.

Amperage and Voltage

Set amperage (wire feed speed) and voltage to the middle of the range specified in the welding procedure. Then make fine tunes using test or practice welds to dial in the settings that work best for you.

When all other welding variables are held constant, an increase in wire feed speed, or amperage, will increase the depth and width of weld penetration, and the size of the weld bead.

Too much amperage creates a large, deep penetrating weld bead that wastes filler metal and causes excessive penetration and poor appearance.

Too low an amperage setting produces a weld bead with insufficient penetration and incomplete fusion.

An increase in voltage produces a flatter, wider weld bead.

Too much voltage can cause excessive spatter, porosity, and undercutting.

A reduction in voltage produces a narrower weld bead with insufficient penetration and lack of fusion. Excessively low voltage may cause stubbing of the electrode against the base metal.

Electrode Angle (GUN ANGLE)

Work and travel angles affect the shape of the weld bead and the amount of penetration. The travel angle is the angle between the joint and the electrode along the axis of the weld.

A push angle exists when the electrode (wire) points in the direction of travel. In short circuit, a push angle decreases penetration and weld becomes wider and flatter. Too much push will cause insufficient penetration, lack of fusion, and spatter. Too much push angle on an open root weld can cause whisker (wires poking through weld) as the wire shoots through the molten metal.

A drag angle exists when the electrode points away from the direction of travel. A drag angle increases penetration and produces a narrower, more convex bead.

A drag angle greater than 30 degrees reduces penetration and may cause overlap.

The work angle is the angle between the electrode and work surface along the work plane. An incorrect work angle can cause you to favor one side of the joint more than another. This will result in undercut and lack of fusion.

Travel Speed

Travel speed is the rate at which the arc travels down along the workpiece. The best way to gauge your speed is to read the puddle, and travel at a rate that keeps the wire at the leading edge (front edge) of the puddle.

Traveling to fast, the wire gets ahead of the puddle causing insufficient penetration. You will hear a popping sound as the arc comes in contact with the cold metal. Moving too fast is the number one issue that new welders have. I am constantly telling them to slow down.

Gun Manipulation

The manipulation of the gun refers to the way that the welder moves the electrode (wire) along the workpiece. The manipulation of the gun will affect the shape and the size of the weld bead. "Z" weaves, Cursive E's, and U's are three patterns. A weaving motion will produce a flatter weld face because it spreads the puddle out from toe to toe. The toes are the sides of the weld. Remember to stay on the leading edge of the puddle, whether you trace the leading edge or move along in a straight line.

Issues:

The Z motion can cause the welder to pause too long at the toes, cause lack of fusion and excessive build up.

Coming out too far ahead of the puddle causes lack of fusion and insufficient penetration.

The small oval or E motion can cause the welder to move to far back in the puddle and not stay on the leading edge.

Stick Out

Stick out is the electrode extension beyond the contact tube. The length of the stick out affects the weld as it can increase or decrease the amperage. This can be used to the welder advantage. Maintaining the proper stick out is critical to producing a high-quality weld.
By lengthening the stick out, you decrease the amps slightly which reduces penetration.

By shortening the stick out, you increase the amps slightly and increase penetration of the weld.

Excessive stick out results in high deposition rates at low heat, which may produce poor weld bead shape and shallow penetration. It may also result in porosity because the shielding gas dissipates before it reaches the puddle.