



Franklin W. Olin
College of Engineering

Weld Training Packet



Gas Metal Arc Welding

Introduction

Goals

This course seeks to introduce students to welding principles and safety, good welding practices, and the use of the Olin College GMA/MIG welding equipment. It is our goal to train competent welders who understand the proper use and limitations of welding, and who when given practice and time will be able to reliably produce quality welds

Course Structure

The training process is student-initiated and student-motivated; it is the responsibility of the student to work at his or her own pace to complete all the course materials. The course is presented in three sections: theory and background knowledge, GMAW equipment training, and weld testing. Students are only checked off on the use of the GMAW equipment once all three sections have been completed.

Theory and background knowledge

- Working at own pace, student completes readings and quizzes:
 - Readings, packet, and quiz covering welding safety
 - Readings, packet, and quiz covering welding practices
 - Readings, packet, and quiz covering GMAW theory and practices
- Quizzes are submitted to instructor for correction and feedback

Safety & Operation training

- Upon completion of quizzes, students form a group of 2-3 trainees and contact the instructor to schedule a training session
- Auxiliary machine training session (horizontal bandsaw, angle grinder, gritblaster) is scheduled if necessary
- Students are trained on the safety and proper use of the Olin GMAW equipment
- *Student is allowed to weld for test sample production only*

Weld Testing

- Students come in during open shop hours to practice welding
- Students present samples of the five basic welded joints
 - Sample welds are examined for integrity, and feedback is given through inspection and testing
- *Student is cleared to use the Olin College GMA/MIG welding equipment .*

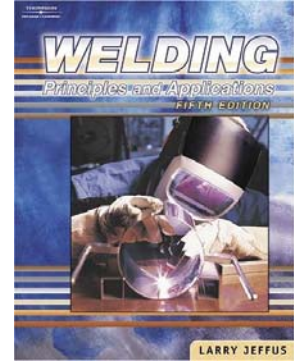
Training Packet Contents:

<i>Basic Welding Safety</i>	4
<i>GMAW / MIG Training Guide</i>	6
Appendix 1: Improving GMAW Skills	14
Appendix 2: Changing Welding wire	17
Appendix 3: Gas Selection Table	18
<i>Testing Welds</i>	19
<i>Welding Safety Quiz</i>	25
<i>General Welding Knowledge Quiz:</i>	28
<i>GMAW Theory Quiz:</i>	31

Basic Welding Safety

Note on the text: This is meant as an introductory guide for beginner welders, for greater depth see the book Welding Principles and Applications in the library, or for specific questions please feel free to ask the staff of the machine shop. For suggestions on how to improve this guide, comments about the text, or corrections, please e-mail eric.munsing@students.olin.edu

Required Reading: Chapter 2, Safety in Welding



General Welding Safety

As a welder you directly control enough energy to melt metal—more than dangerous enough to burn off a finger or deliver a heart-stopping electric shock. Control your tool carefully, being aware of it and others around you at all times

Pay attention to what you are doing, and ask questions whenever you are unsure of what to do—the machine shop staff is here to assist you.



Personal Protective Equipment:

- **Welding helmet:** Your eyes can be severely burned by the intense light associated with all welding, and particularly the strong UV rays of arc welding. At Olin, we have a set of fixed-lens helmets with #10 lenses, as well as one auto-darkening helmet with a variable lens. Know what lens is appropriate for the welding you are doing.
- **Welding jacket:** Always wear slow-burning materials, such as leather or cotton, when welding. When fully buttoned up, the welding jackets offer good protection both from sparks and from UV burns.
- **Gloves:** Leather gloves act solely to protect you from sparks and spatter—they are not insulating, and do not allow you to pick up hot metals. In fact, they will shrink and harden when used to pick up hot metals. Instead, always have a pair of pliers at hand to grasp cooling metal.
- **Welding curtains:** The yellow curtains at the end of the welding booth shield observers from the UV rays of arc welding. Always pull them closed when welding, and make sure that others aware that you are welding.

Prior to welding, it is necessary to:

- Check welding equipment for any signs of damage before use
- Clear the area of any flammables, and never weld on anything which contains, or has contained, volatiles
- Cover all exposed skin, and wear slow-burning materials to protect from sparks or hot metal

- Alert any others in the area before welding, and make sure that they are also wearing appropriate safety equipment.
- Be sure that the welding area is well ventilated, as any contaminants will burn off and produce fumes.

General precautions:

- Do not carry lighters or matches in your pockets.
- Never weld with the flame or arc near compressed gas cylinders or any pressure vessels.
- Always be sure that you and everyone in the area is wearing proper protective equipment
- Always use pliers to handle cooling parts; the leather gloves will shrink and harden when handling hot metal.
- Hold your hand over a part and feel whether it is cool before picking it up. Metal will remain hot long after it stops glowing.

Gas Cylinder Use & Safety:

The gas cylinders used to store fuel or shielding gas are essential to all welding operations, but also contain an immense amount of stored energy. If knocked over or compromised they are explosive, and if improperly set up they can leak expensive and possibly dangerous gas.

The gas tanks for shielding gases use double-seated valves, like the one shown at right. The valve must be opened until it rests against the back seat to guarantee full flow. Additionally, the valve has a safety valve to bleed off potentially dangerous gas pressures.

When using the cylinders,

- Always keep the cylinders upright, and when not moving them keep them chained to the wall.
- Ask for assistance if you ever need to remove or replace the valve or regulator
- When opening or closing a high-pressure cylinder, keep twisting the valve handle until you feel it stop against its gasket

Always, always, *always* double-check to make sure that gas cylinders are fully closed before leaving the work area. Even a slow leak can empty the cylinder overnight.

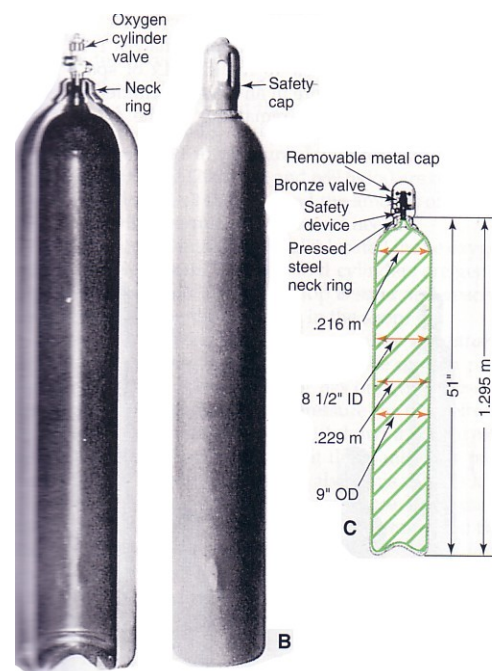


Figure 1: Pressurized gas tank parts

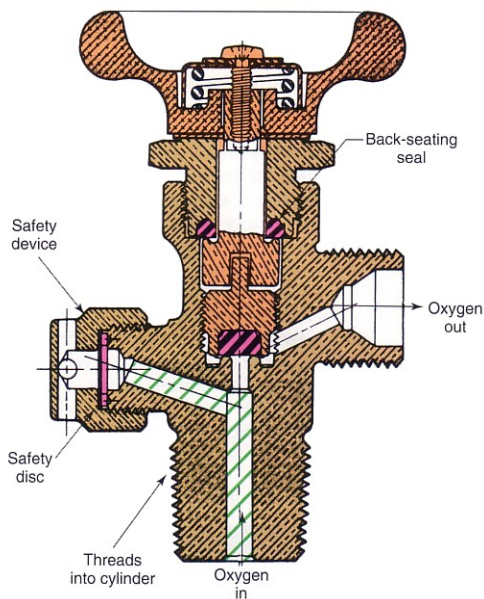
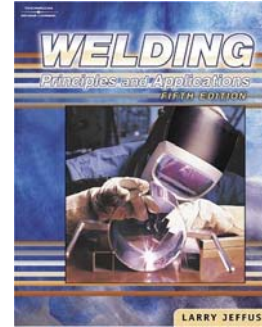


Figure 2: Cross-section of double-seated valve

GMAW / MIG Training Guide

Note on the text: This is meant as a guide to GMAW practices in the Olin College machine shop, and is a work in progress. For greater depth see the book Welding Principles and Applications in the library, or for specific questions please ask the staff of the machine shop.

For suggestions on how to improve this guide, comments about the text, or corrections, please e-mail eric.munsing@students.olin.edu



Required Reading: Chapter 11, Gas Metal Arc Welding

Suggested Reading: Chapter 10, GMAW Equipment & Setup

Introduction

Gas Metal Arc Welding (GMAW), or Metal Inert Gas (MIG) welding, is an arc welding process in which a thin wire electrode is continuously fed into the workpiece. An arc between the electrode and the workpiece melts both the base metal and the tip of the electrode, which becomes deposited as filler material. Shielding gas from the welding gun protects the weld and allows for welding without smoke or slag.

GMAW is an easy, fast welding method for use in many projects. Because of the thin electrode, it may not be as appropriate as SMAW for thick materials, and does not allow as much control as TIG for precision welds. Additionally, with the current setup at Olin we are only able to use GMAW on steels.

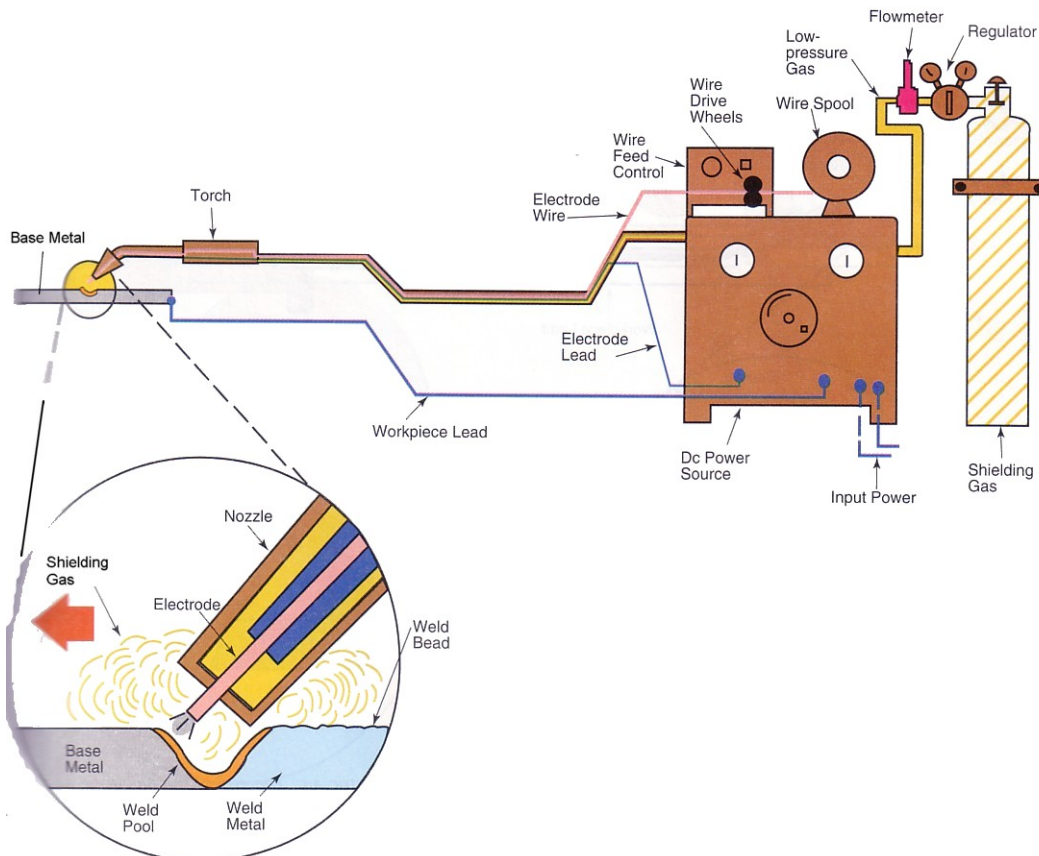


Figure 3: GMAW setup, with enlargement of welding gun tip

Equipment

Arc welding uses resistance heating to melt the base metal, sending a very high current (~50 amps) through a tiny area (the width of the electric arc). This resistive heating also melts the consumable electrode, and droplets of molten metal are deposited on the base metal. To protect the molten metal from porosity, oxidation, or contamination, and to cool the weld pool, a stream of inert gas bathes the weld region.

GMAW Welding Machine

Like all arc welders, the welding machine is built around a variable transformer/inverter which acts as a constant voltage power source. The output voltage of the transformer can be adjusted via a dial on the front of the machine, *but because of the high power load on the inverter, the voltage and wire speed settings should never be adjusted while actively welding.*

The wire feed system at the side of the welder forces the wire electrode down the welding cable at a constant rate, controllable with the knob at the front of the welder. Most frustrations with the welding machine will probably be related to this system; see the appendix on changing wires for an explanation of its use and care.

Welding Gun

Everything comes together at the tip of the welding gun, where the electrode is charged with electricity and gas flows out to protect the weld. The only control on the welding gun is the trigger, which sends a signal to the welding machine to start the wire feed, turn on the gas, and connect the power circuit.

At the center of the nozzle is the contact tube, which needs to fit snugly with the wire to transfer current from the cable to the electrode. Whenever changing the wire, switch this for an appropriately-sized tip, as a loose fit may create an arc and spot weld the wire to the contact tube.

The copper nozzle directs gas flow onto the weld, and should be kept clean for smooth gas flow and a good weld. Clean off spatter with a wire brush and pliers, and check the tip every few minutes of welding.

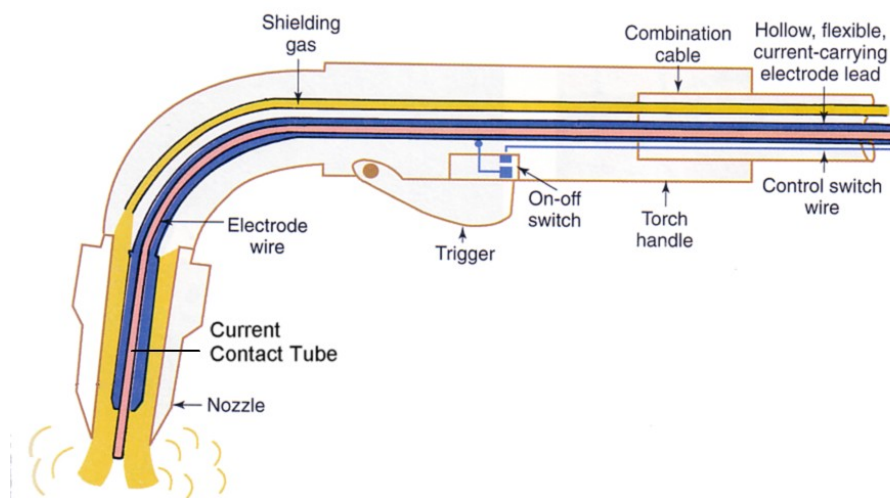


Figure 4: Cross-section of welding gun

Compressed Gas Tank

A variety of shielding gasses can be used in GMAW, and choice of gases effects the type of metal transfer at the tip (see appendix).

When using the welding equipment, use all precautions associated with all gas cylinders. Additionally, as this is a double-seating valve, you must be sure that it is fully opened and stopped against the opposite gasket before continuing welding. *Be sure to turn off the gas when finished welding!*

Pliers & Clipper

Also handy at the welding table is a pair of pliers, to handle cooling pieces of metal, and a pair of clippers to shorten the electrode.

Do not use gloves to handle hot metal—the leather will shrink and harden, and they do not provide enough thermal insulation to prevent burns.

Welding Variables

Pre-selected variables

It's impossible to make a good weld with improper equipment; to avoid frustration and wasted material, check these factors before setting up to weld. If unsure what equipment to use for a project, please ask the machine shop staff—we're here to help.

Gas Type: Though at Olin you will probably not be changing gas cylinders, the choice of gas constrains the selection of weldable metals, and also determines the type of metal transfer which takes place (see appendix A, Gas Selection Table). Because we normally use the GMAW setup only for welding carbon steels, we work with a CO₂ / Argon mixture, which creates short-circuit metal transfer—a robust metal transfer process which also gives our MIG welder its characteristic “sizzling” sound.

Wire type: Because the welding wire melts and mixes with the base metal, the two metals must be the same; welding aluminum with a steel electrode unfortunately won't work. Olin's MIG setup is suited for steels, and the shop's ER70S (Electrode **R**-length, **70** KSI tensile strength, **S**olid) can be used on most carbon steels.

Wire diameter: Thicker wires allow for a higher metal deposition rate, and more net current through their thicker cross-section: both conditions which make them well-suited for welding on thicker metals. For thinner materials, thinner wire is necessary, and will make the welding job much easier.

For most applications, the school's 0.035" wire should be appropriate. If you notice that your welds are consistently getting poor penetration, or are always burning through, you may need to change to a different wire size.

When changing wires, be sure to follow the procedure in Appendix 1—this part of the process can cause you the most frustration.

Welding machine variables

Warning: Do not change machine settings while welding!

The two dials on the front of the welding machine control wire speed and arc voltage, which help control the weld pool characteristics. On the inside of the panel over the wire spool is a chart of recommended settings for these two variables; they should be considered as a good recommendation, but a little bit of experimentation on scrap metal of the type to be welded will help make sure that you have the right “fit” for a particular welding project.

Wire speed: This dictates metal deposition rate, and thus affects welding rate and the size of the possible bead. Higher speeds also demand the machine output higher currents to melt all the filler metal, and thus can be used to put more power into a weld pool. Wire speed is only really meaningful, however, when combined with a particular weld pattern and travel speed.

Voltage: Thanks to Ohm’s Law, this is the best control we have the welding machine’s power output. This voltage is mainly dissipated in the resistance of the protruding welding wire (with a net resistance proportional to the electrode’s extension) and in the voltage drop across the actual arc.

Higher voltage settings allow for a greater tip-to-work length while still maintaining an arc, but more importantly if the tip-to-work distance is kept constant, higher voltages will represent more power dissipated in the molten metal, resulting in more penetration.

Again, for both of these settings, it is wisest to start with the manufacturer’s guidelines and then adjust when necessary.

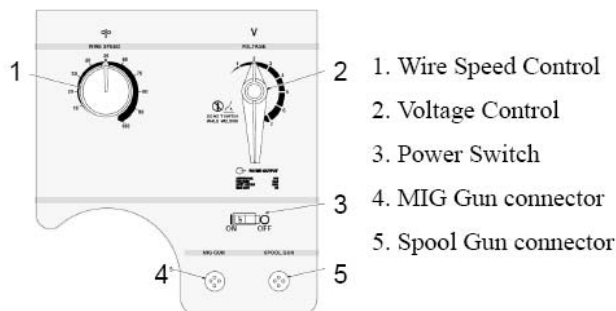


Figure 5: MillerMatic Welding Machine Controls

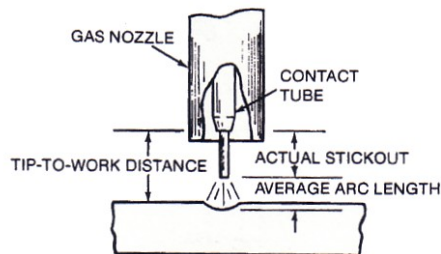
Weldor Variables

Even once the machine variables are set, human variables have an immense impact on weld characteristics, and a consistent weld requires a consistent weldor.

Understanding the impact of these variables is important, but is no replacement for practice.

Tip-to-work distance

By controlling the distance between the welding gun and the workpiece, you control both the welding wire stickout, and the arc length—both of which represent voltage/power drops. Thus, by pulling slightly away from the piece, you decrease the energy put into the weld pool; by moving in closer you can heat the piece



and achieve deeper penetration.

Moving too far from the work piece may drop the arc voltage below the amount required to sustain an arc, momentarily extinguishing the arc. As the electrode continues to be fed towards the piece, it will re-start the arc with a loud pop—a good sign you need to move in closer.

Weld direction

As with other types of welding, you can direct the energy of the welder by pointing the gun tip. In most applications, the weld gun should be in line with the weld line, but the orientation of the gun, pointing towards or away from unwelded metal, can impact the cooling of the weld pool.

Pointing the weld gun tip towards unwelded metal, as in forehand welding or “pushing”, concentrates arc energy on fresh metal and leaves the weld pool undisturbed behind the tip, so that it cools in a smooth, flat bead.

Backhand welding or “dragging” points the gun tip at the weld pool, concentrating weld energy on making the weld pool hotter for more penetration, and pushing up the weld pool behind the gun in a higher, rougher bead.

The angle between the weld piece’s normal and the axis of the gun tip determines the extent to which these effects are seen.

Travel rate and tip motion

When coordinated with wire feed rate, travel speed can be used to effectively control energy input, while keeping bead characteristics the same. Varying the travel rate without changing wire speed acts to control the size of the weld pool and thus of the bead; spending more time in an area deposits more metal (and generally with more penetration), while a higher travel rate decreases bead size and reduces penetration.

Additionally, heat and penetration can be controlled with the motion of the welder tip, with a circular or stitching motion being used to evenly heat and melt together both pieces of base metal, and to distribute the heat of welding. Thus, travel rate can be thought of as not just linear travel, but net weld gun movement—wider circles traced in the tip pattern will act to spread the heat out, decreasing penetration and making a smoother, flatter weld bead.

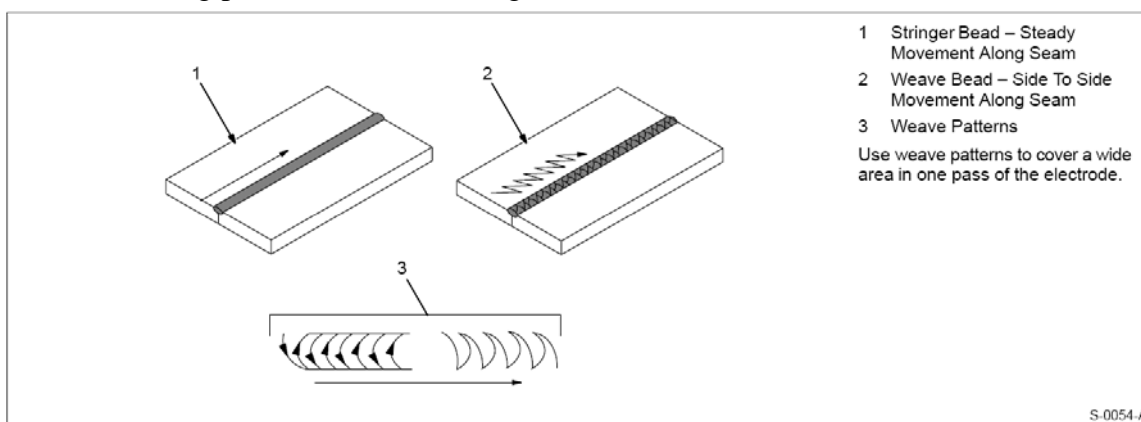


Figure 6: Welding gun tip motions

GMAW-Specific Safety Principles:

Personal Protective Equipment

- Welding Helmet: always use a #10 (or higher) lens to protect your eyes from UV radiation and intense light
- Cover all skin, particularly hands and neck, to avoid UV burns.
- Respect the welding machine; it is a powerful tool.



Safe welding practices:

- Never strike an arc near any flammable material, or on containers which have been used to store flammables.
- Avoid standing on a damp or wet floor.
- Never adjust the settings on a machine under load.
- Check the insulation on the welding gun and cables before use.
- Shut off the arc welder before laying the welding gun on top of the machine or a short may occur and melt the case.
- Keep electrode holders away from cylinders containing compressed gas and **NEVER** strike an arc on a cylinder.

Welding Checklist

Prepare Workspace

- Prepare weld piece: Any contaminants on your weld piece will be contaminants in your weld piece after welding. Wire-brush or gritblast surfaces clean and wipe with acetone.
- Secure weld piece: To prevent warpage (see Welding Introduction), clamp or otherwise secure the weld pieces before tack welding
- Collect tools: Lay out all safety equipment, and any tools—particularly pliers for handling hot metal, and clippers for cutting the welding wire.

Finally, turn on the ventilator and remove the cardboard baffle, checking to make sure that air is flowing.

Set up Welding Machine

- Attach the ground clamp: Check for a good electrical path between the weld piece and the ground clamp.
- Check wire size: If unsure what wire size to use, ask one of the shop staff, and if necessary change the welding wire, referring to Appendix 1.

- Clean welding gun: Slide off the copper welding gun nozzle, and look at it and the connecting tip, checking to see that both are clean of spatter and contamination. Use a wire brush or pliers to clean these parts. Replace the gun nozzle.
- Set machine variables: Using the chart on the inside of the side flap, or based on experience, set welding machine variables.

Turn on welding machine

Set up gas tank

- Open gas tank: Unscrew the main valve of the shielding gas cylinder, unscrewing until it seats against the back stop.
- Check flow rate: Briefly squeeze the trigger to start gas flow, and check the flow rate, which should be between 20-30 cfh. Adjust the regulator accordingly.

When done, clip the welding wire so that about ¼ inches sticks out beyond the nozzle.

Check safety equipment

- Check helmet lens for any cracks, and turn auto-dimming helmet on. Check lens setting-- should be a #10 or higher.
- Put on welding jacket, helmet, and gloves, checking for any bare skin.
- Clear the area of all potentially flammable materials
- Pull the yellow UV curtains closed, and warn any others in the area that you are about to weld.

Ready to weld

Tack Welding

Tack welds are small initial welds that hold the piece in place while welding, and which can be broken easily if the weld piece warps too much.

To tack weld, hold the welding gun about ¾ inches away from the weld area, flip down the welding helmet (if not using the electric helmet), and briefly squeeze the trigger.

Alternately, you can place the wire in contact with the work, hold the gun steady, and squeeze the trigger.

After each tack weld, check for warping and bend the piece back into position, breaking the tack welds if necessary. Strategically tack weld until the piece is fully dimensionally constrained.

Laying a bead

Hold the gun about $\frac{3}{4}$ inches above one end of the work piece, flip down the helmet, and pull the trigger (alternately, place the electrode tip on the piece, lower the helmet, and pull the trigger). You may need to travel slowly at the beginning of the weld, but focus on keeping a smooth, steady weld pattern that will lay an even bead with full penetration.

Most beginner welders are anxious and rush through welds, resulting in poor penetration and an uneven weld. Focus on working smoothly and steadily, keeping up constant tip distance, motion, and travel rate.

At the end of the weld, release the trigger and lift the welding mask. Congratulations!

Do *not* grasp the piece with your gloves until you know it is cool.

Post-weld cleanup checklist

- Return all equipment and materials: The welding table should be cleaner than when you arrived.
- Turn off the welding machine
- Turn off the gas, tightening the valve until it fully seats against its stop.

Check again, to make sure the gas is turned off!

Appendix 1: Improving GMAW Skills

A good weld...

- ...Has full penetration
- ...Isn't dirty
- ... "Looks like a stack o' dimes"

Penetration:

As in all welding, good penetration is a question of heat control. With steady hands and good tip control, the welding gun can be used to do most heat control—move the gun away to reduce the heat, and “aim” it at one workpiece to focus the arc and hot gasses on that area. Spending more time in an area heats it up more, allowing more penetration—to do this, change the wire speed to lay a consistent bead at your desired speed. And finally, by Ohm's law, the voltage setting controls the power applied to the weld, and thus can be thought of as a very powerful temperature control for the weld.

Note that most beginner welders are afraid of burning through, and instead lay superficial beads with little penetration. To be effective, a weld has to melt all the way through the workpiece— so try burning through a few times, and then back it up just a bit to get full penetration.

Too little penetration:

- Slow down wire speed, and spend more time in a spot
- Use slower, larger tip movements to heat more metal
- Increase voltage setting

Too much penetration (burning through)

- Move faster, possibly increasing wire speed
- Use quicker, broader tip movements to distribute the heat
- Decrease the voltage setting

Bead appearance

This is a secondary issue to penetration— it's tempting to strive for weak but beautiful welds. Bead appearance is largely controlled by good gun control, and thus will come through practice— but focus first on penetration!

Bead size (height above base metal) – function of penetration

Tall bead (insufficient penetration or excess material):

- Increase voltage to get bead to “sink” into metal
- Decrease wire speed to take away some material

Flat or concave bead (insufficient material or too much penetration)

- Increase wire speed to deposit more material

- Decrease voltage to decrease penetration

Bead shape (viewed from above)

Stretched or diamond-shaped bead: Tip moving too fast

- Decrease wire speed to allow for more time spent in one area
- Use a wider tip movement to smooth out bead

Smooth sausage shape, without ridges

- Use a broader tip movement to get “stacked dimes”

CHANGE REQUIRED		WELDING VARIABLE	ARC VOLTAGE	WELDING CURRENT (SEE FOOTNOTE)	TRAVEL SPEED	NOZZLE ANGLE	STICK-OUT OR TIP-TO-WORK DISTANCE	WIRE SIZE	GAS TYPE
DEEPER PENETRATION				1 INCREASE		3 TRAILING MAX. 25°	2 DECREASE	5 SMALLER ^a	⁴ CO ₂
SHALLOWER PENETRATION				1 DECREASE		3 LEADING	2 INCREASE	5 LARGER ^a	⁴ Ar + CO ₂ ^c
BEAD HEIGHT	LARGER BEAD			1 INCREASE	2 DECREASE		3 INCREASE	^a	
	SMALLER BEAD			1 DECREASE	2 INCREASE		3 DECREASE	^a	
AND BEAD WIDTH	HIGHER NARROWER BEAD	1 DECREASE				2 TRAILING	3 INCREASE		
	FLATTER WIDER BEAD	1 INCREASE				2 90° OR LEADING	3 DECREASE		
FASTER DEPOSITION RATE				1 INCREASE			2 INCREASE	^a 3 SMALLER ^b	
SLOWER DEPOSITION RATE				1 DECREASE			2 DECREASE	^a 3 LARGER ^b	

FOOTNOTE: SAME ADJUSTMENT IS REQUIRED FOR WIRE FEED SPEED.

KEY: 1 FIRST CHOICE, 2 SECOND CHOICE, 3 THIRD CHOICE, 4 FOURTH CHOICE, 5 FIFTH CHOICE.

^a WHEN THESE VARIABLES ARE CHANGED, THE WIRE FEED SPEED MUST BE ADJUSTED SO THAT THE WELDING CURRENT REMAINS CONSTANT.

^b SEE DEPOSITION RATE SECTION OF WELDING VARIABLES SECTION.

^c THIS CHANGE IS ESPECIALLY HELPFUL ON MATERIALS 20 GAGE AND SMALLER IN THICKNESS.

GMAW Recommended Welding Variable Adjustments

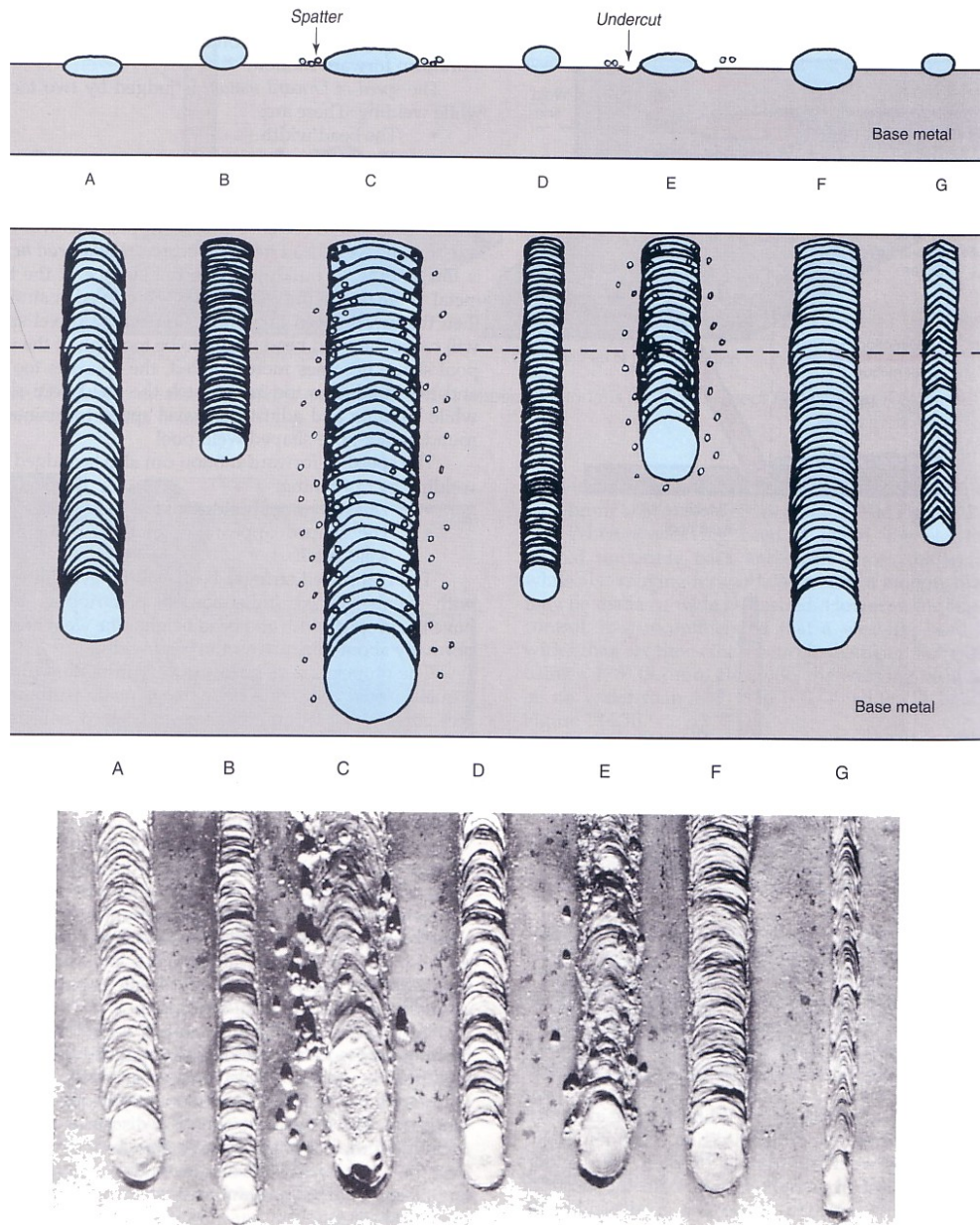


Figure 7: Reference for trouble-shooting welds

- A = Correct current
- B = Amperage too low
- C = Amperage too high
- D = Too short an arc length
- E = Arc length too long
- F = Travel speed too slow
- G = Travel speed too fast

Appendix 2: Changing Welding wire

These guidelines are meant to help you avoid the frustration of snagged or improperly feeding wire. If you have any questions, please ask a staff member, rather than risk damaging the equipment or your weld piece.

All equipment for changing welding wire should be left in the parts tray built into the side of the welder.

Remove old spool

- Clip off end of wire to remove the globule left by welding
- Flip down drive wheel lock to relieve pressure on the wire.
- Slowly wind in the wire
- As tension drops off near the end of the wire, let the wire run through your fingers to keep up the tension
- Grab the end of the wire and stick it through a hole in the side of the spool, maintaining tension to avoid a “bird’s nest” or tangling.
- Remove the locking ring or bolt to free the spool

Slide off the spool and set it aside

Change equipment

- Removing the welding gun nozzle, unscrew the connecting tube.
- Twist the locking nuts to free the drive rollers and slide them off, replacing them with the set in the parts bin. The text indicating the desired size should face towards you.

Put on new spool

- Remove or replace the plastic hub adapter, if necessary, and use the set of springs to space the spool to be on the middle of the support arm
- Thread wire through the brass wire guides and into the wire conduit.
- Flip down the top drive wheel and flip the lock into place, adjusting tension if necessary.
- Squeeze trigger and wait for wire to feed through conduit. Watch for any snagging or irregularity that would indicate a tangle.
- After wire shows at gun tip, screw on a connecting tube of the proper size, and replace gun nozzle

Begin welding!

Appendix 3: Gas Selection Table

Process Variation	MIG	CO ₂	Fine Wire	Spray Arc
Type of shielding gas	Inert (usually Argon)	CO ₂	CO ₂ or CO ₂ & argon (C25)	Argon & Oxygen (1 – 5%)
Metal transfer	Various types	Globular	Short circuiting	Spray
Metals to be welded	Aluminum, stainless steel, many non-ferrous metals.	Low, medium carbon and low alloy steels	Low, medium carbon and low alloy steels. Some stainless steels.	Low, medium carbon and low alloy steels
Metal thickness	12 gage to 3/8" wo/edge prep. Any thickness w/edge prep.	10 gage to 1/2" wo/edge prep. Any thickness w/edge prep.	20 gage to 1/4" in flat & horizontal position. Any thickness in vertical and overhead positions.	1/4" to 1/2" wo/edge prep. Any thickness w/edge prep.
Welding positions	All	Flat (and horizontal fillets)	All	All position w/small electrode diameter. Flat and horizontal (larger wire)
Major advantages	An excellent method for joining relatively thick non-ferrous metals.	Deep penetration, high travel speed, least cost shielding gas	Excellent for thin material. Much easier out of position welding than SMAW.	High travel speed with deep penetration and almost no spatter.
Process limitations	Expensive shielding gas. May require pull type guns.	Spatter removal is time consuming and costly.	The cost of such fine diameter electrode limits this to relatively thin material (unless out of position).	Cannot be used on thin base metals.
Amount of spatter	Little	Lots	Little	Least amount
Travel speed	≤ 100 IPM	≤ 250 IPM	≤ 50 IPM	≤ 150 IPM
Electrode diameters	.035, .045, 1/16, 3/32	.035, .045, 1/16, 3/32	.030, .035, .045	.035, .045, 1/16, 3/32

Testing Welds

Reading: Chapter 20, Testing and Inspection of Welds

As one step in the Olin check-off process, you are asked to make a set of basic welds and test them for structural integrity. When just beginning to weld, it is good to learn heat management and gun control by simply running beads on the surface of metal stock. However, as welding is a joining technique, real practice comes from welding two pieces together.

Attached are a set of standard weld types which will help you develop a variety of welding techniques and skills. Practice them on a variety of metals, in different weld positions (flat, angled, vertical) to build experience.

To get real quantitative evaluation of your weld quality, these test welds can be put through destructive testing, which simulate critical loading and will demonstrate the type of deformation or failure that your weld may go through.

When testing these welds, most failures will come from poor penetration, which create such a stress concentration that your welds will crack next to the weld. If your weld goes through the complete bend test, you can examine it further by grinding down the welded area and inspecting it for any voids (inclusions, cracks, or porosities).



Figure 8: Bend test of a butt weld specimen

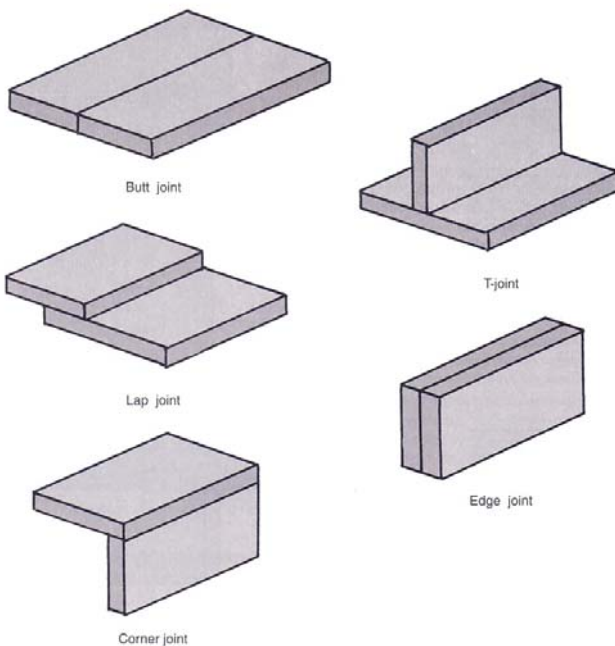
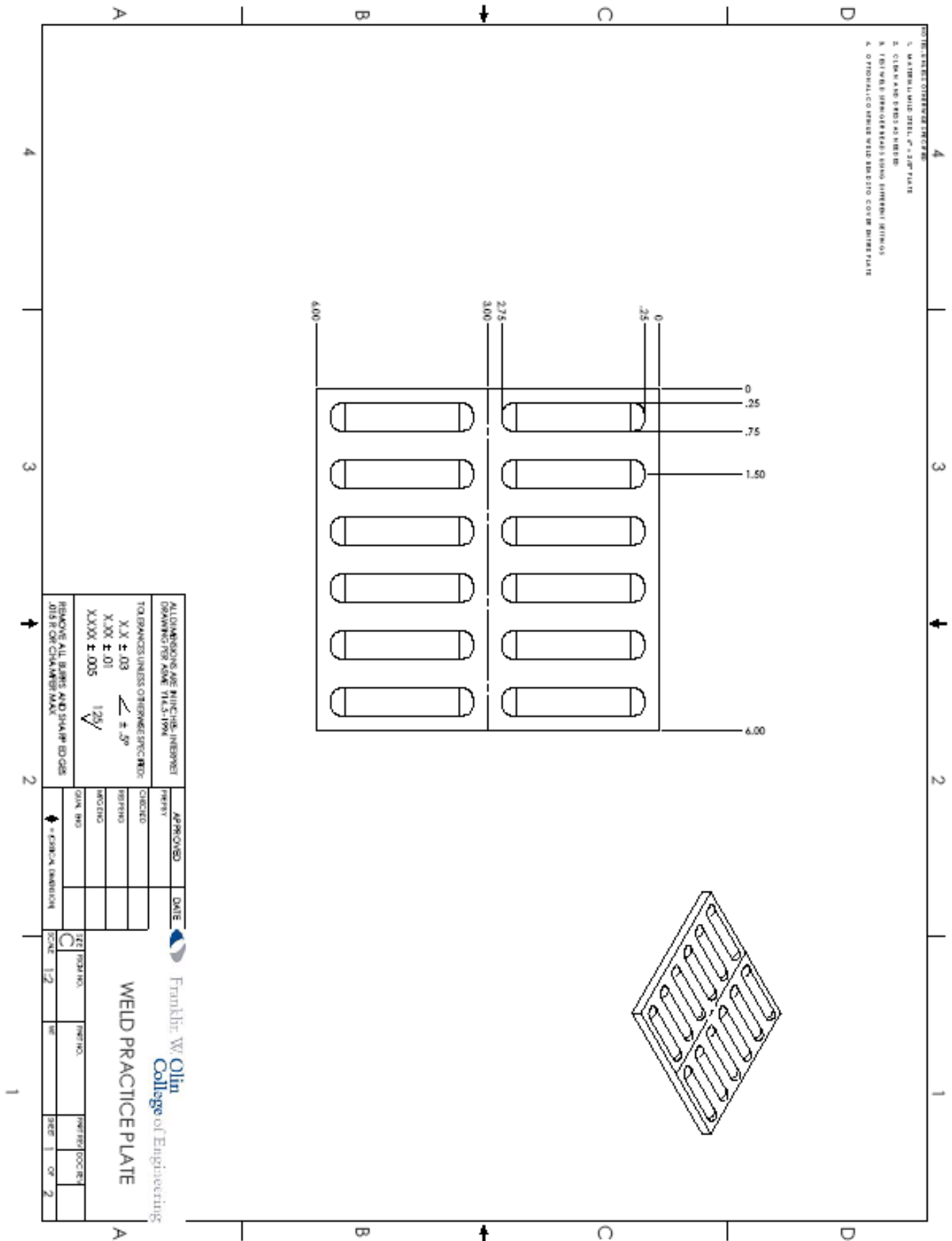
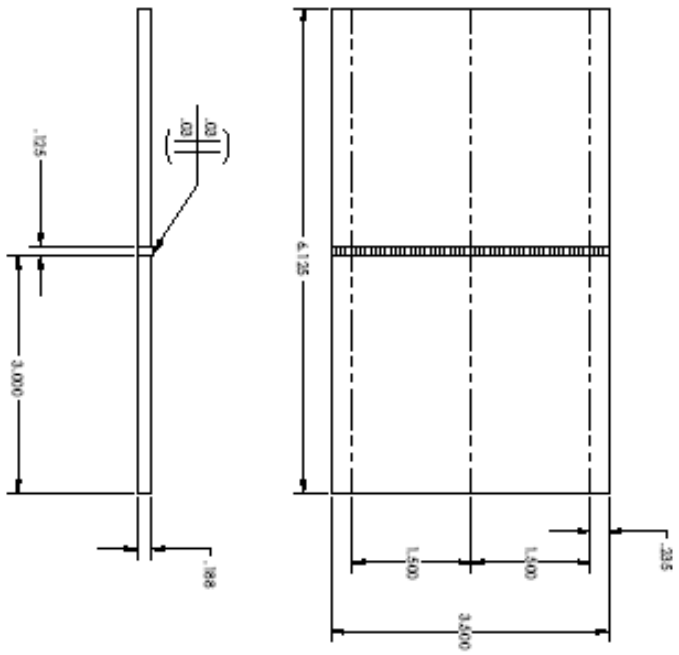


Figure 2: Basic joint welds

This form of testing is similar to the testing required for official welder certification. If you are interested in becoming a certified welder, talk to the machine shop staff and we can work together to arrange testing.



- NOTES: UNLESS OTHERWISE SPECIFIED
1. MATERIAL: MILD STEEL.
 2. CUT QTY OF 2 BEND TEST SPECIMENS FROM SAMPLE AS NOTED.
 3. MACHINE WELD TO BE FLUSH WITH SURFACE BEING TESTED.

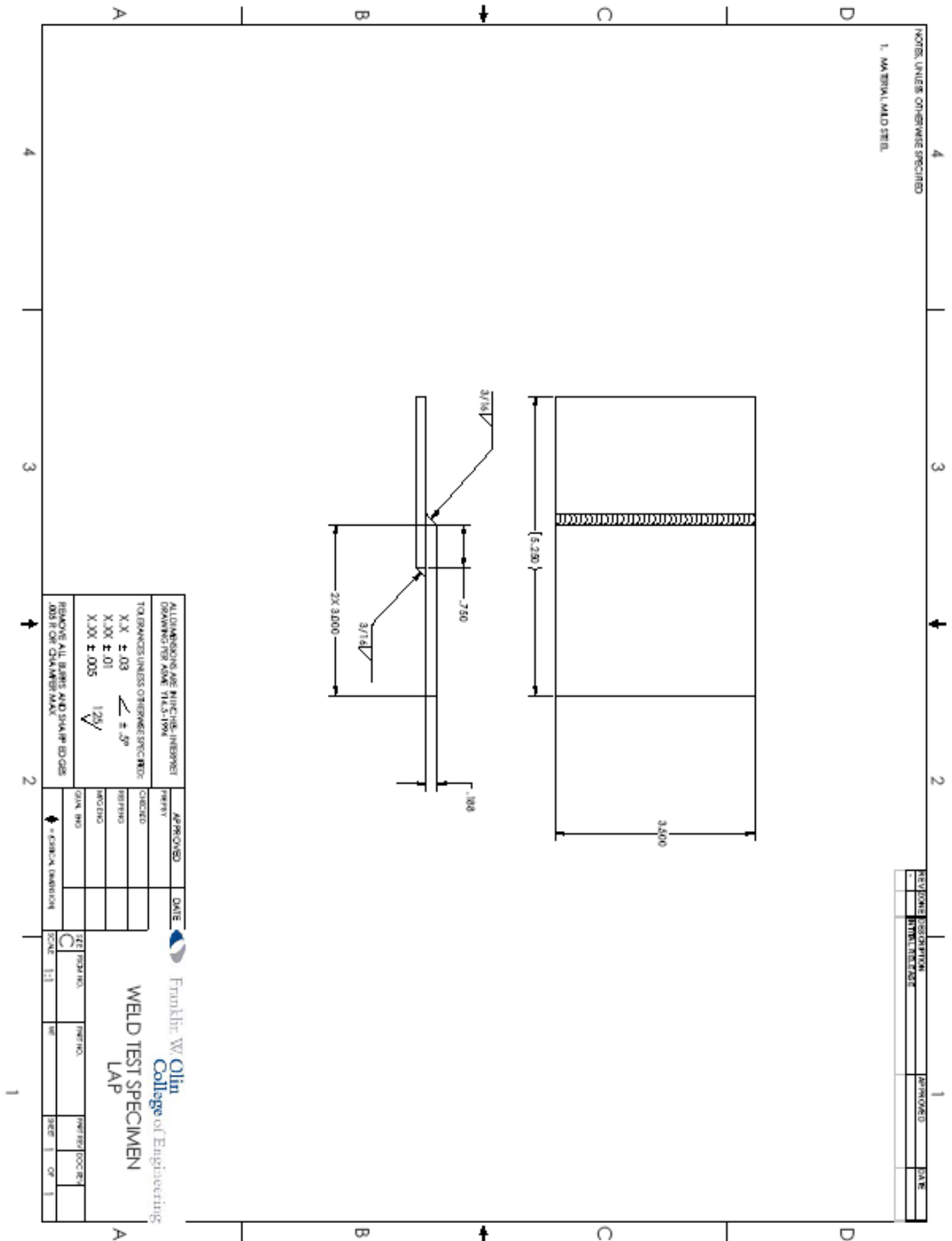


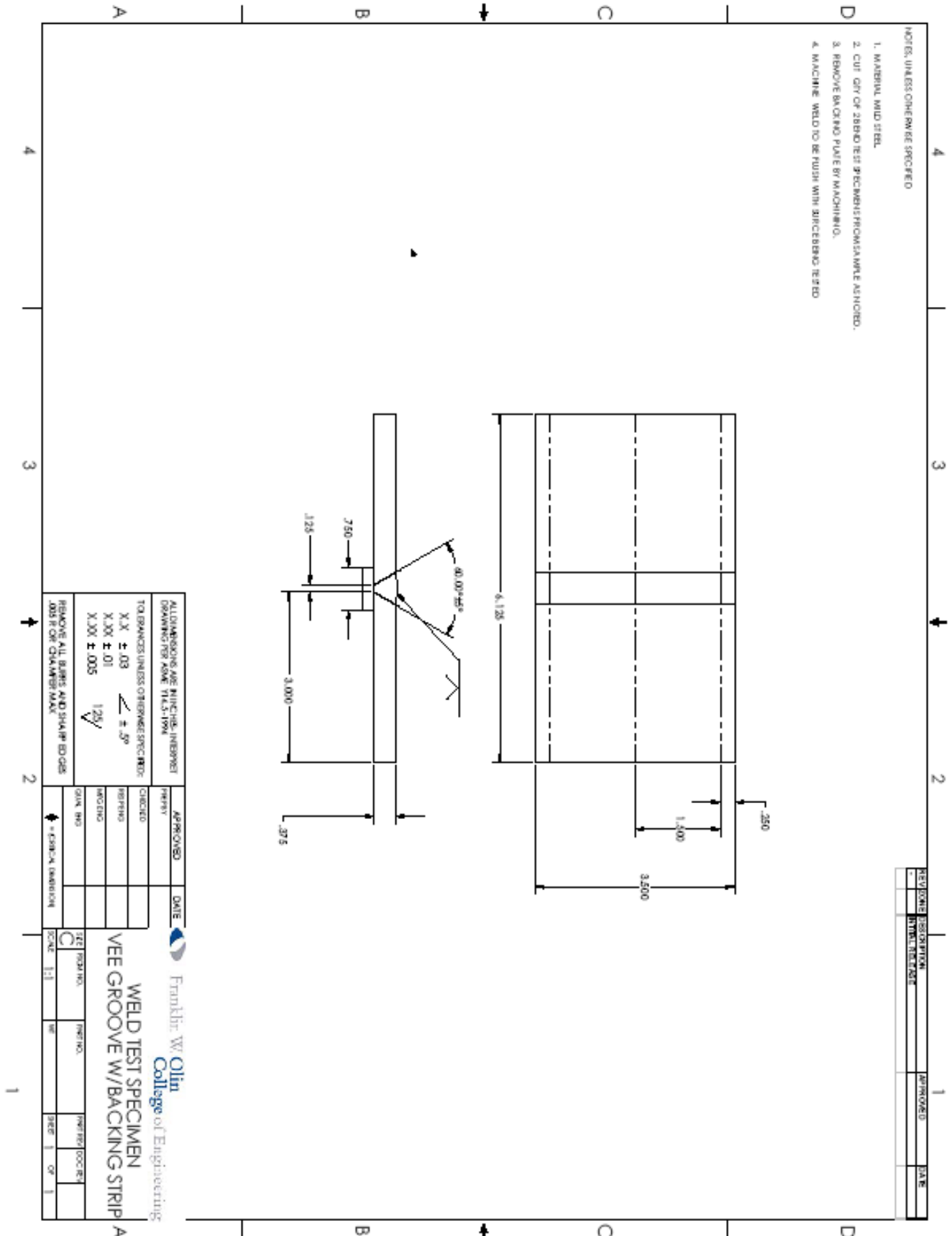
ALLOWANCES ARE IN CHILDS, INTERMET DRAWINGS FOR ASME Y14.5-1994		APPROVED _____ DATE _____
TOLERANCES UNLESS OTHERWISE SPECIFIED:		CHECKED _____
X.X ± .03	∠ ± .5°	DESIGNED _____
X.XX ± .01		DRAWING _____
X.XX ± .005	12%	DATE _____
REWORK: ALL BEAMS AND SHARP EDGES TO BE CHAMFERED		DATE _____

Franklin W. Olin
College of Engineering
WELD TEST SPECIMEN
SQUARE

121	122	123	124	125	126	127	128	129	130
DATE	TIME	DATE	TIME	DATE	TIME	DATE	TIME	DATE	TIME

REVISION	DESCRIPTION	DATE
1	INITIALS	





Welding Safety Quiz

- Reading: Chapter 2 of *Welding Principles and Applications*
- This quiz is closed-book, and should take about 15 minutes.
- When done, use the book to review your answers, marking corrections in a different color.
- Return the corrected quiz to Eric Munsing, and wait for instructions for the next stage of the training process.

General Safety:

1. What is the key to preventing accidents in a welding shop?
2. Describe first-, second-, and third-degree burns, and the first aid that would be administered for each type of burn
3. What type of light is the most likely to cause burns? Why?
4. Why must eye protection be worn at *all* times in the welding shop?
5. What type of eye burn can occur within seconds?
6. Why is it important to seek medical treatment with eye burns?
7. List four metals that can cause hazardous fumes when welded:
8. What is an MSDS, and how is it used?
9. Why is ventilation important when welding in a confined space?

-
10. What special precautions would you need to take if welding on a large project outside of a welding shop?

 11. List three conditions that would require forced ventilation in a weld shop:

 12. When is a fire watch needed?

 13. What type of fire extinguisher would be used on each of the following items:
 - a. Paint
 - b. Motor
 - c. Trash
 - d. Zinc

Personal Protective Equipment:

14. From which material must the inside lens in a welding helmet be made?

15. Why should a welder wear earmuff-type protection?

16. What types of clothing material should be avoided in the welding shop, and why?

17. Describe the best type of clothing to be worn in a welding shop:

18. A welding cable must not have a splice within _____ of the welder

Gas Cylinder Safety:

19. How must oxygen and acetylene cylinders stored near each other be separated?

20. How must gas cylinders be prevented from accidentally being knocked over?

21. What can happen if a high-pressure gas cylinder has its valve knocked off?

General Welding Knowledge Quiz:

- Readings: Chapters 18 & 20, *Welding Principles & Applications*
- This quiz is closed-book, and should take about 15 minutes.
- When done, use the book to review your answers, marking corrections in a different color.
- Return the corrected quiz to Eric Munsing, and wait for instructions for the next stage of the training process.

Identifying weld problems:

1. What is a discontinuity?
2. What are inclusions, and how are they caused?
3. What is a defect?
4. Draw or explain what overlap is:
5. Draw or explain what undercut is:
6. Draw or explain what underfill is:

12. Sketch a V-grooved butt joint and dimensioning callout, as it would appear on a mechanical parts drawing. Show how dimensions on the callout relate to dimensions of the part.

Weld Testing:

13. What are three methods of destructive testing of a welded butt joint?
14. Which nondestructive test is most commonly used to inspect welds?
15. Using what you know of welding metallurgy, how will a weld joint fail, and what can you do as a welder to prevent that?

GMAW Theory Quiz:

- Reading: Chapters 10 & 11 of *Welding Principles & Applications*
- This quiz is closed-book, and should take about 15 minutes.
- When done, use the book to review your answers, marking corrections in a different color.
- Return the corrected quiz to Eric Munsing, and wait for instructions for the next stage of the training process.

General:

1. Why is the term GMAW preferable to MIG for describing this process?
2. What components make up a GMA welding system?
3. What equipment variables would you have to consider when planning a welding project?
4. What metals does the current Olin setup allow us to weld?

GMAW Equipment:

5. Why must GMA welders have a 100% duty cycle?
6. What parts of a typical GMA welding gun can be replaced?
7. What can be done to determine the location of a problem that stops the wire from being successfully fed through the conduit?
8. What parts need to be changed when changing wire sizes?

-
9. Why should the feed roller drag prevent the spool from coasting to a stop when the feed stops?
 10. What are the advantages of adding oxygen or CO₂ when welding on steel?
 11. What are the advantages of using CO₂ when making GMA welds on steel?
 12. Why is CO₂ added to argon when making GMA spray transfer welds?
 13. Why should CO₂ not be used to weld stainless steel?
 14. What three conditions are required for the spray transfer process to occur?

GMAW Welding:

15. What are the two machine variables?
16. How is amperage adjusted on a GMAW welder?
17. What happens to the weld as the electrode extension is lengthened?
18. List five ways of decreasing spatter:
19. List five ways of increasing penetration:
20. What happens if the electrode is allowed to strike the base metal outside of the molten weld pool?

21. Describe the weld produced by a forehand welding angle, and contrast it with the weld produced by a backhand welding angle:

22. Equipment identification: fill in the blanks:

