WLD 142
Flux Cored Arc Welding II
(Self-Shielded)

This project was supported, in part, by the *National Science Foundation*
Opinions expressed are those of the authors And not necessarily those of the Foundation

PCC/ CCOG / WLD

Course Number:
WLD 142

Course Title:
Flux-Cored Arc Welding II (Self Shielding)

Credit Hours:
4

Lecture Hours:
0

Lecture/Lab Hours:
80

Lab Hours:
0

Special Fee:
$24.00

Course Description

Develops knowledge skills in the self-shielded flux cored arc welding process in the flat, vertical, horizontal and overhead positions. Prerequisites: Department permission required. Audit available.

Addendum to Course Description

This is an outcome based course utilizing a lecture/lab format. This course includes classroom discussions, videotapes, and lab demonstrations of technical skills. Course outcomes will include: theoretical concepts, lay out, fabrication, welding, oxy-fuel cutting and safety.

Intended Outcomes for the course

Upon completion of the course students will be able to:

- Function safely in the PCC Welding Lab.
- Operate oxy-fuel portable and track cutting systems in accordance with industry standards.
- Understand and apply code requirements for FCAW E71T-8.
- Interpret blueprints to accurately lay out, prepare, and assemble weld joints.
- Weld single V-groove welds with E71T-8 to AWS D1.1 Structural Steel Welding Code.
- Operate an CAC-A (Carbon Arc Cutting - Air) system in accordance with industry standards.
- Apply visual and destructive examination principles and practices in accordance with AWS D1.1.

Course Activities and Design

Welding lec/lab courses are Open Entry and Open Exit (OE/OE) and are offered concurrently. Courses are designed to meet the needs of the students with flexible scheduling options. Students may attend full time or part time. This is an OE/OE course which does not align with the normal academic calendar.

Outcome Assessment Strategies

The student will be assessed on his/her ability to demonstrate the development of course outcomes. The methods of assessment may include one or more of the following: oral or written examinations, quizzes, written assignments, visual inspection welding tests and task performance.

Course Content (Themes, Concepts, Issues and Skills)

Function safely in the PCC Welding Lab.

- Understand and practice personal safety by using proper protective gear
- Understand and practice power tool safety
- Understand and practice equipment safety for welding and oxy-fuel cutting systems
- Understand and maintain a safe work area
  - Recognize and report dangerous electrical and air/gas hose connections
  - Understand and practice fire prevention

Operate oxy-fuel portable and track cutting systems in accordance with industry standards.

- Demonstrate correct setup and shutdown procedures for the hand cutting and track cutting systems.
- Perform oxy-fuel cutting with guided practice.

Understand and apply code requirements for FCAW E71T-8.

- Demonstrate proper stick out and Travel speed
- Demonstrate correct starting, stopping and restarting techniques
- Demonstrate proper bead placement for single V-groove welds

Interpret blueprints to accurately lay out, prepare, and assemble weld joints.

- Interpret lines, symbols, views and notes
- Lay out material per specifications
- Use the oxy-fuel cutting process to cut material to specified dimensions
- Assemble project per welding procedure specifications (WPS)

Weld single V-groove welds with E71T-8 to AWS D1.1 Structural Steel Welding Code in the following joint configurations and positions:

Demonstrate correct welding techniques in the following joints:

- Flat Position-T Joint
- Horizontal Position-T Joint+Single V groove
- Vertical Position:T Joint+Single V Groove
- Overhead Position:T Joint+Single V Groove

Operate an CAC-A (Carbon Arc Cutting - Air) system in accordance with industry standards

- Demonstrate the effects of the following variables in position: electrode angle, amperage setting, air pressure, and travel speed.

Demonstrate correct CAC-A gouging techniques on single V-groove welds.

Apply visual and destructive examination principles and practices in accordance with AWS D1.1

- Explain visual inspection criteria

Evaluate welds using appropriate welding inspection tools

Assess weld discontinuities causes and corrections

Course Assignments

Required Text Book

Welding Principles and Applications (5th Edition) by Larry Jeffus

Reference Reading List

- **The Procedures Handbook of Arc Welding** by Lincoln Electric
- **IPT's Metal Trades Handbook** (Revised Edition-1993) by Ronald G. Garby and Bruce J. Ashton
- **Gas Metal Arc Welding Handbook** by William H. Minnick
- **D1.1 Structural Steel Code Book** by the American Welding Society

IMPORTANT

VIEW THE "DELMAR" FCAW VIDEOS BEFORE STARTING THIS COURSE WORK

Welding Training Videos: (Located in classroom 132/a) Delmar's Flux Cored Arc Welding Video Series parts 1,2,3,and 4

Also Miller training videos for FCAW

Timeline

The Welding Department's open-entry, open-exit instructional format allows the students to work at their own pace. It is the student's responsibility to complete all assignments in a timely manner. See your instructor if you need assistance.

Outcome Assessment Policy

The student will be assessed on his/her ability to demonstrate the development of course outcomes. The methods of assessment may include one or more of the following: Oral or written examinations, quizzes, written assignments, visual inspection techniques, welding tests, safe work habits, task performance and work relations.

Grading Criteria

The student's assessment will be based on the following criteria:

20% of grade is based on Safe work habits and shop practices
20% of grade is based on Completion of written and reading assignments
20% of grade is based on demonstrating professional work ethics
40% of grade is based on the completion of welding exercises

Review of
Checking and Adjusting Your Wire Feed Speed

Last class in 141 we spent a little time making sure we understood the interrelationship between wire feed speed and amperage; we also did a few calculations to determine our WFS's on different dial settings. Because of the importance of wire feed speed (WFS/IPM) in achieving a balanced arc condition, we are going to take a little time and space here to review the procedures you use in calculating and adjusting it.

You need to be able to measure the speed you get and adjust your dial to a setting that actually gets your speed within range.

Let's go over that procedure:

1. First, cut the wire flush to the nozzle on your gun

2. If the dial has IPM settings, set the WFS dial to a number within the WFS range given in the procedures of one of your projects.
   If the dial has 0 - 10 or another non-IPM setting, adjust it mid-range, e.g. "5."

3. Squeeze the trigger for exactly 6 seconds.

4. Measure the amount of wire that came out of the nozzle, to the nearest 1/16".

5. Multiply this number by 10 to get the number of inches for a full minute (6 sec x 10). You may need to use the fraction (**a b/c**) key on your calculator as you will probably be dealing with a mixed number. Round to the nearest whole number, that is, to the nearest inch.

6. Check to see if this number lies between the numbers given in the Procedure range, and if it doesn't, adjust your setting accordingly.

7. Until you get good at this, you may need to measure and adjust a few times to get your speed right, especially if you're working on a machine which does not have an IPM dial. Ideally, you should be within the range given. There are certain circumstances in which you can be outside the range, but until you're an expert welder, you should focus on getting within the range parameters.

Okay, let's look at an example of this. Suppose your Welding Procedure gives you a range of 160 - 260 WFS/IPM. You can use this range for Inner Shield welding, in case your Welding Procedure gives only volts and amps and not the wire feed speed (WFS). Say you set your old welding equipment dial to a mid-range, like "5," and squeeze the trigger. In 6 seconds,

The contents of this packet include

- ***Introduction***
- ***Flux Composition for Self-Shielded Electrodes***
- ***Importance of Electrode Extension and DCEN Current***
- ***Comparing SMAW with Self-Shielded FCAW***
- ***Forbidden: Self Shielded E71T-11 and E71T-8 Electrodes with External Gas Shielding***
- ***Composition and Mechanical Properties of Weld Metal***
- ***Fume Generation***

Introduction

Flux cored arc welding (FCAW) is perhaps the most used welding processes in the United States today. The self-shielded FCAW process can be used as a semi-automatic process or a fully automatic process. FCAW can be used for all-position welding. FCAW has the flux-shielding advantages of shielded metal arc welding and a higher productivity than gas metal arc welding. Compared to gas shielded FCAW, the advantage of self-shielded FCAW is it can be used for welding outdoors. Since there is no externally supplied shielding gas, the self-shielded FCAW process has about the same tolerance for outdoor weather conditions as shielded metal arc welding electrodes. Thus, self-shielded FCAW as well as shielded metal arc welding are the only processes specified by many structural welding codes for outdoor use.

Flux Composition for Self-Shielded Electrodes

Unlike fluxes used for gas-shielded electrodes like E71T-1, the compositions for self-shielded fluxes are much more proprietary. The self-shielded electrodes like E71T-8 and E71T-11 are designed to function without a shielding gas. The weld metal still must be protected from the oxygen (O) and nitrogen (N) in the atmosphere. If the weld pool is left unprotected, the O and N in the air will chemically combine with the metallic elements in the weld. For example, iron will form FeO and FeN. Carbon in the weld pool will form CO gas and CN gas. Therefore, the electrode manufacturers add powerful deoxidizers, denitrifiers, and gas formers to the flux core. The most common deoxidizer and denitrifier is aluminum (Al) and titanium (Ti). For example, the chemical ingredients used in the flux for E70T-8 electrode are given in Table 1. Note that 15.4% Al is required in E70T-8 self-shielded electrodes to cleanse the molten weld pool by forming Al_2O_3 and AlN non-metallic particles that are lighter than the molten weld metal and float out of the molten pool with the slag. Without the aluminum deoxidizer in the flux core, the weld metal would be too brittle for practical use in construction.

Two very popular all-position self-shielded electrodes are E70T-8 and E70T-11. The E70T-8 electrode is designed for high toughness applications, while the E70T-11 electrode is designed for excellent welder appeal but not for applications requiring Charpy impact toughness. To achieve high toughness, the flux in the E70T-8 electrode must contain substantial amounts of CaF_2 (fluorspar) to reduce the presence non-metallic oxide type inclusions in the weld pool. These oxides are a byproduct resulting from the excellent flux action of fluoride-based slags. From Table 1, E71T-8 contains 63.5% CaF_2. E71T-11 contains more oxides ingredients to enhance out-of-position capability and weld bead appearance. In both E71T-8 and E71T-11, arc stabilizers such as potassium in the form of potassium oxide (K_2O) are used to provide smooth arc action. The E70T-8 CaF_2-based electrode sacrifices some welder appeal for excellent mechanical properties such as Charpy impact toughness.

The weight of flux in the core of a flux-cored wire comprises about 20% to 40% of the total weight of the whole wire (iron sheath and flux core). From Table 1, the major flux ingredients in E71T-8 are CaF_2 and MgO, which are two excellent slag formers. Gas producers and easily vaporized fluorides are used to provide ample gas and slag coverage.

The flux for self-shielded electrodes must provide several important functions: arc stabilization, gas/vapor shielding, slag to protect the weld pool, slag of proper viscosity to support the weld pool for out-of-position welding, deoxidizers to cleanse the weld pool, slag detachability, smooth weld contour, reduced spatter, and alloying to achieve desired mechanical properties. As mentioned earlier, the flux formulations for E71T-8 and E71T-11 (as well as all other self-shielded fluxes) are company-proprietary.

Table 1 Flux ingredients in E71T-8 self-shielded flux cored electrodes.
Olson et al, ASM International Handbook, 1993, Vol. 6, pp. 55-63)

Flux Ingredient	Typical %	Purpose
SiO_2	0.5	Slag former
Al	15.4	Strong Deoxidizer
MgO	12.6	Slag former
K_2O	0.4	Arc stabilizer
Na_2O	0.2	Arc stabilizer
CaF_2	63.5	Slag former, fluxing agent
CO_2 (as carbonate)	0.4	Gas shielding
C	1.2	Alloying
Metallics (Fe, Mn, others)	Balance	Deposition rate

Importance of Electrode Extension and DCEN Current

Unlike GMAW with solid wire and FCAW with E71T-1 gas shielded wire, most self-shielded flux cored electrodes require substantial preheating before the wire is melted, in order to activate the gas-forming flux ingredients above the weld pool. The self-shielding flux will liberate its CO_2 shielding gas and volatile fluorides as high above the weld pool as possible to protect the molten metal droplets as well as the weld pool. Depending of the flux formulation, the incoming flux cored wire will need to be preheated by two means:

1. Increasing the electrode extension up to 3 ¾ inch
2. Using DCEN current

Increasing the electrode extension (which is the distance from the contact tube to the work piece) is the most efficient method of preheating the incoming wire before it reaches the arc and melts. The electrode extension provides resistance heating of the wire before it melts. The resistance heating (Hres) is defined as:

$$Hres = I^2 R$$ where I is the current and R is the resistance of the wire.

Resistance heating works like an electric toaster. The heater elements resist the flow of electricity to produce heat. The wire in the electrode extension region is also being heated to very high temperatures. During resistance heating, the flux ingredients are being chemically activated. The flux ingredients do not conduct electricity since they are insulators, so the flux core does not respond directly to electrical resistance heat. However, the flux is preheated by contact with the resistance-heated metallic materials in the electrode, which include: the iron sheath and the metallic deoxidizers mixed in with the flux. The most important flux ingredients that require resistance heating for activation are the gas forming and volatile ingredients. These ingredients require substantial heat to decompose into CO_2 shielding gas or to volatilize as a protective fluoride vapor. Furthermore, it is important that the protective gas be chemically liberated high above the molten metal pool for maximum protection of the molten droplets.

Secondly, both E71T-8 and E71T-11 require the use of DCEN for best results. DCEN provides another means to help heat the electrode and activate the flux ingredients before they reach the molten weld pool. DCEN produces far greater electron heating of the electrode than DCEP. By combining long stick-out with DCEN, the electrode has ample heat to activate the gas-shielding elements of the flux core.

The primary disadvantage of using a long stick-out and DCEN with E71T-8 and E71T-11 electrodes is that the base metal receives insufficient heat, resulting in poor penetration. For example, the penetration of CO_2-shielded E71T-1 electrode (using DCEP) is far superior to that of either E71T-8 or E71T-11 electrodes.

Comparing SMAW with Self-Shielded FCAW

Both SMAW with "stick" electrodes and self-shielded FCAW with E71T-8 or E71T-11 electrodes are suitable of welding outdoors at construction sites. There is no question that the FCAW process is much more cost effective than SMAW for production welding. However, because the flux is on the outside of the stick electrode, the SMAW process provides much greater protection of the molten droplets and molten weld pool than self-shielded FCAW. For this reason, the E71T-8 and E71T-11 electrodes must contain large quantities (15.4%) of aluminum for deoxidizing and denitrifying, while the stick electrodes contain very little deoxidizer, in comparison. As a result, the self-shielded E71T-8 and E71T-11 electrodes have three major disadvantages compared to SMAW:

(1) E71T-8 and E71T-11 can not penetrate as well as E7010 stick electrodes,
(2) E71T-8 and E71T-11 require much closer control of weld settings than stick electrodes, and
(3) Stick electrodes like E7018 provide higher toughness than E71T-8 and E71T-11.

Unlike gas shielded FCAW, the self-shielded electrodes E71T-8 and E71T-11 must use controlled weld settings to exactly use up all of the aluminum deoxidizer and denitrider in the electrode. The manufacturers of E71T-8 and E71T-11 electrodes assume than the weld metal will be contaminated with a certain amount of oxygen and nitrogen from the air, when these electrodes are used properly. So, a precise amount of deoxidizer and denitrider is added to the flux cored wire to combine with the oxygen and nitrogen in the molten pool. If the weld settings are improper, they will upset this delicate balance and the weld metal properties will deteriorate. For example; if the welding voltage is too high (causing a long arc), less of the aluminum deoxidizer in the E71T-8 and E71T-11 wire will transfer across the arc, while excessive oxygen and nitrogen will contaminate the weld. Because there will be too much oxygen and nitrogen contamination, the weld mechanical properties will suffer. Since self-shielded FCAW is very sensitive to weld settings, manufacturer's recommendations must be followed for best performance.

Despite the disadvantages, the great cost benefits and increased productivity of self-shielded electrodes make them the overwhelming favorite for outdoor welding.

Forbidden: Self Shielded E71T-11 and E71T-8 Electrodes with External Gas Shielding

E71T-11 and E71T-8 electrodes must never be used with an external shielding gas like CO_2 or argon. Often welders think that argon or CO_2 gas shielding will make the self-shielded E71T-11 and E71T-8 flux cored wire perform better because of the added protection of an external gas shield. This is absolutely false. The reason why external shielding gas like argon should never be used with E71T-11 and E71T-8 is because the large addition of 15.4% aluminum (Table 1) added to the flux core is designed to be consumed by reacting with nitrogen and oxygen in the air. If shielding gas is used, this large amount of aluminum would then form a brittle intermetallic compound Fe_3Al and deteriorate the mechanical properties of the weld. These wires must be used in a manner designed by manufacturer and specified by AWS.

Composition and Mechanical Properties using E71T-11 and E71-T-8 Electrodes

Although both E71T-11 and E71T-8 are all-position electrodes, the metallic chemical requirements for these electrodes are very different. The E71T-8 electrode is used when minimum Charpy v-notch (CVN) impact toughness must be met. The E71T-11 electrode is used for general purpose mild steel welding applications, particularly for plates up to ½ inch thick. E71T-11 has excellent welder appeal by producing smooth arc action, easy slag removal, low spatter and excellent weld appearance. E71T-11 can be used where poor fit-up and windy conditions exists. Because the flux in E71T-8 contains more basic ingredients such as CaF_2, the welder appeal of E71T-8 is not as good as E71T-11, which uses more acid flux ingredients. For example, welds produced with E71T-11 electrodes have better slag detachability, smoother arc action, and bead appearance than as those produced with E71T-8. However, the CVN impact toughness of weld metal deposited with E71T-8 are excellent. Tables 2 and 3 compare the composition and mechanical properties of weld metal deposited with E71T-11 and E71T-8 electrodes, respectively. The E71T-8 electrode in Table 2 produces welds with high carbon content (0.26% typical), while the E71T-8 produces weld metal with low carbon content (0.06%C in Table 3). Also, the aluminum (Al) content of welds deposited by E71T-11 is greater than those deposited with E71T-8 electrodes. In addition, the manganese (Mn) content of the E71T-11 electrode is lower than that for the E71T-8 electrode. The combination of higher C and Al contents and lower Mn content in the weld metal deposited with E71T-11 deteriorates the CVN impact toughness of steel weld metal. Furthermore, the high carbon content of the E71T-11 electrode will require that thick plates over ½ inch thick be preheated to prevent hydrogen assisted cracking. Conversely, the beneficial combination of lower C and Al and higher Mn content in weld metal deposited with E71T-8 electrodes provides excellent CVN toughness, as shown in Table 3. As a result, the American Welding Society specification

AWS A-20 specifies a Charpy impact requirement for E71T-8 (Table 3), but does not specify such requirements for E71T-11 (Table 2)

Table 2 Composition and mechanical properties of weld metal deposited with E71T-11 all-position, self-shielded electrode

	E71T-11 (per AWS A5.20)	Typical E71T-11
C Mn Si P S Al	none 1.75max 0.8max 0.03max 0.03max 1.8max	0.26 0.8 0.40 0.009 0.008 1.60
Tensile Strength Yield Strength % Elongation CVN Toughness (at -20º F)	70 ksi min 58 ksi min 20 % min none	92 ksi 70 ksi 22 %

Table 3 Composition and mechanical properties of weld metal deposited with E71T-8 all-position, self-shielded electrode

	E71T-8 (per AWS A5.20)	Typical E71T-8
C Mn Si P S Al	0.15max 0.5 - 1.75 0.8max 0.03max 0.03max 1.8max	0.06 1.25 0.50 0.009 0.008 1.00
Tensile Strength Yield Strength % Elongation CVN Toughness (at -20º F)	70 ksi min 58 ksi min 22 % min 20 ft-lbs	84 ksi 64 ksi 26 % 32 ft-lbs

Fume Generation

As a general rule, the amount of fume generation with self-shielded electrodes is far greater than that produced with gas shielded flux cored electrodes. Thus, self-shielded electrodes are ideally suited for outdoor construction site welding in shipyards, on bridges, etc. The reason for the increased fume production is the need to produce both liquid slag and gaseous products that will protect the molten metal droplets and the weld pool. As soon as the arc is struck, flux ingredients either volatilize to produce CO_2 or melt to produce the slag shield with deoxidizers. Generally, the advantages of gas shielded FCAW with E71T-1 electrodes make this process ideal for indoor welding. If self-shielded electrodes are used for indoor welding, adequate ventilation will be needed to reduce fumes to acceptable levels.

INTRODUCTION TO THE SELF-SHEILDED FLUX-CORED ARC WELDING PROCESS
SAFETY AND SHOP PRACTICES - FCAW PROCESS

Although you may have already been exposed to the hazards of **SMAW**, there are hazards that are peculiar to the FCAW process due to differences in the basic operating characteristics of the equipment and the techniques used. Since the equipment used will have additional controls, it would be possible to encounter a great deal of spatter or to have molten globules of material fall on you if the machine is not properly adjusted. Therefore, it becomes even more important that you are properly equipped with protective clothing. In many cases, especially with the **FCAW** process, considerably more heat is involved and experienced welders prefer to wear heavy leather gloves, mittens, or other protective devices in addition to the usual leather gloves

Safety glasses must be worn in the shop at all times. When welding, if you find that your eyes are feeling strained or that the arc seems unusually bright, a darker lens in the welding helmet may be necessary for protection from the increased intensity of the rays associated with the welding process.

Adequate ventilation is very important to avoid fume poisoning or excessive smoke inhalation. Prior to starting work, always check to make sure that ventilation sources are adequate.

Since the gasses in the cylinders are under pressure, care must be taken when moving or changing cylinders. Always make certain that cylinders are securely anchored to avoid accidentally knocking them over. When the gun is not being used, it should be hung in such a manner that the trigger is not activated causing the wire to be discharged. When this happens, the wire becomes red hot very quickly and could give you severe burns or cause a fire. Inflammable materials must be removed from the area or suitably protected from sparks or slag. Keeping scraps, debris, and tools or equipment out of the welder’s way may prevent tripping or falling.

GLOSSARY

ARC LENGTH

Minus arc length	Is the result of low voltage and/or high electrode feed speed (current) which gives a shorter arc length. The tip of the electrode is below the surface of the base metal.
Plus arc length	Is the result of high voltage and/or slow electrode feed speed (current) which gives a longer arc. The tip of the electrode and a portion of the arc stream is clearly visible above the surface of the base metal.
Zero arc length	Or balanced arc is a condition obtained when the electrode feed speed is adjusted so that the current being supplied by the power source melts the electrode at a rate to maintain the tip of the electrode very nearly level with the surface of the base metal.
Inner Shield Electrode	Trade name for Self Shielded Flux Core electrode manufactured by The Lincoln Electric Company
Contactor	A device for repeatedly establishing and interrupting electric power circuit.
Flow Meter	A metering device developed to control the flow of shielding gases. The flow of shielding gases is indicated on a flow meter tube which is calibrated for the gas being used in cubic feet per hour (cfh).
Gas diffuser	A device located in the gun that disperses the shielding gas into the nozzle. It also holds one end of the wire conduit firm and it a receptacle for the contact tip.
Gun (Arc Welding)	In semiautomatic, machine and automatic welding, a manipulating device to transfer current and guide the electrode into the arc. It may include provisions for shielding and arc initiation.
Gun conductor tube	(FCAW and GMAW)--A hose-like device through which the electrode, current, shielding gas (if any), and coolant (when used) travels from the power source or wire feeder to the gun.
Travel Speed	Is the relative speed between the electrode and the work surface.

VOLTAGE

Arc Voltage	The voltage across the welding arc.
Open Circuit Voltage	The voltage between the output terminals of the welding machine when no current is in the welding circuit.
Weld Reinforcement	The weld metal on the face of the weld in excess of the original surface of the base metal.
Fusion Line	The junction of the weld metal with the unmelted base material.
Wire Conduit	A round tube located in the gun conductor tube through which the electrode travels from the wire feeder to the gun. This conduit may or may not be removable depending upon the manufacturer of the equipment.
Wire feeder	An assembly unit that provides the driving or pulling power to transport the electrode through the gun conductor tube and the gun to the work. There are three types of systems:

1. PUSH: Where the drive rolls push the wire through the conductor tube.
2. PULL: Where the drive rolls are located in the gun and pulls the electrode through the conductor tube.
3. PUSH-PULL: Where a system of drive rolls are located at both ends of the conductor tube, one set in the gun that pulls and one set at the base of the conductor tube that pushes. Used mostly for soft or small diameter wires.

SELF SHIELDED FLUX-CORE PROCESS AND WELDING VARIABLES

The self shielded flux-core process involves welding with a flux core fabricated electrode. Welding current is supplied from a constant voltage power source. Normally, direct current with electrode negative (straight polarity) is used. This process offers many advantages, the greatest of which is no gas cover making it ideal for outdoor use.

The self shielded flux-core process results in a deeply penetrating arc. This deep penetration has great economic advantages. It reduces edge penetration for butt joints to a minimum, allowing considerably less weld metal with less welding time. The greater penetration of the arc permits small fillet welds which require much less welding time to have comparable strength and load-carrying capacity.

High deposition rates of weld metal are available with the flux-core process. High current density on the electrode and continuous welding make the high deposition rates possible. The greater amounts of weld metal deposited in a given length of time result in remarkable cost savings in the finished weldment.

All-position electrodes are available in .045", 5/64" and 1/16" diameters. These small diameter electrodes have been developed to produce excellent welds in out of position work with very little spatter.

JOINT DESIGN

The self shielded flux-core arc welding process is capable of producing weldments with great savings of time and weld metal. Part of the savings results from the continuous welding with high deposition rates which are inherent to the process. The other part of the savings is achieved from the proper design of the weld joints to make full advantage of the deep penetration of sound weld metal.

The volume of weld metal required to complete a butt joint can be effectively reduced by reducing the root opening, by increasing the root face, and by using smaller bevel angles.

Because of the deep penetration of the arc, fillet welds can be reduced in exterior size and retain comparable or greater strength.

However, it should be kept in mind that it would be undesirable to obtain deep penetration when welding some of the alloy steels because of the resultant admixture of parent metal and filler metal.

SELF SHIELDED FLUX-CORE WELDING VARIABLES

When the variables by which the process is operated are understood and controlled, consistently good welds throughout a wide range of welding conditions are easily obtained. Each variable listed below is important in obtaining a balanced welding condition .

Metal thickness, types of joint, and joint geometry must be taken into consideration when using the following variables:

EFFECT OF WELDING VOLTAGE

Arc voltage determines the arc length. The best or balanced arc voltage for the self shielded flux-core process is achieved when the arc length is such that the tip of the electrode is about level with a flat plate surface. The weld metal transfer across the arc is confined (or buried) below the plate surface, resulting in a spatter-free welding condition with good penetration, and weld bead appearance. A balanced arc condition is referred to as "Zero-Arc Length."

Higher arc voltage results in a longer arc. The tip of the electrode and a portion of the arc stream are above the surface of a flat plate when the arc voltage is high. The arc stream is cone-shaped with the vertex at the electrode tip. The base of the arc stream cone is larger with a longer arc. A larger area of the base metal is heated, resulting in a wider and flatter weld bead. Excessive arc length contributes to heavy spatter and gives an irregular weld bead appearance. This arc condition is called "Plus Arc Length."

Lower arc voltage results in a shorter arc. The tip of the electrode and the arc stream are below the surface of a flat plate when the arc voltage is low. The base of the arc stream cone has a smaller area and heats less base metal which gives a narrower and higher weld bead shape. This shorter arc is prone to weld metal spatter that splashes out of the molten pool and has a cutting, knife-like action at the leading edge of the arc (see appropriate drawing). This arc is referred to as "Minus Arc Length."

EFFECT OF WELDING CURRENT

The electrode feed speed is the variable that controls the welding current from a constant voltage power source. The power source supplies the amount of current (amperes) necessary to melt the electrode at the rate required to maintain the preset voltage and resultant arc length.

An increase in the electrode feed speed (all other normal welding variables constant) requires more electrode to be melted to maintain the preset voltage and arc length. Higher current is automatically supplied by the power source and the deposition rate (lb./hr.) increases. More weld metal and more heat in the base metal are applied per unit length of weld, resulting in deeper penetration with larger weld beads.

A decrease in the electrode feed speed (all other welding variables constant) results in less electrode to be melted to maintain the preset voltage and arc length. Less current is automatically supplied by the power source and the deposition rate (lb./hr.) decreases. Less weld metal and less heat are applied per unit length of weld, resulting in less penetration and smaller weld beads.

EFFECT OF WELD TRAVEL SPEED

The relative speed between the electrode and the work surface is the "Weld Travel Rate" and has a marked effect on the weld penetration and bead appearance.

Slower travel rates give proportionally larger weld beads and more heat input in the base metal per unit length of weld. The longer heating time of the base metal increase the, depth of penetration and the increased weld deposit results in a higher and wider bead contour. The increase of weld metal and heat input continue until the speed is reduced to a point where the volume of the molten weld metal and slag becomes so great that the molten materials flow into the crater beneath the arc and give an insulating effect between the arc and the base metal. The heating of the base metal beneath the arc is reduced and the molten weld metal heats a wider area of the base metal, resulting in a wide bead with shallow penetration. This effect is readily visible during welding.

Progressively increased travel rates give opposite effects. Less weld metal is deposited with lower heat input per unit length of weld. This gives a narrower weld bead and less penetration. Excessively fast travel rates result in ropy, irregular bead shapes with difficult slag removal and undercut.

EFFECT OF CONTACT TIP-TO-WORK DISTANCE

The contact Tip-to-Work Distance, or "Electrode Stick-Out" is the length of the electrode extending from the tip of the contact tip to the work surface. This extended length is the part of the electrode that carries the welding current, and is subject to resistance heating, sometimes called "electrode preheat." **In the case of Self Shielded Flux Cored Electrodes the pre heating process is very important. Without pre heating of the electrode you will have weld defects.**

Low resistance and electrode preheat are encountered with1/2” electrode stick-out (minimum recommended). A ½ " stick out (maximum recommended) causes high resistance and electrode preheat. The constant potential power source, however, continuously supplies the correct amount of current to maintain the preset constant arc voltage and arc length at any fixed electrode feed speed

Penetration is slightly affected by the stick out length, and the deposition rate is constant provided the electrode feed speed is unchanged. The same amount of electrode is, melted per unit length of weld, and there is little or no change in the weld bead shape.

Reducing the electrode stick-out to1/2 " will require more current (amperes) that is automatically supplied by the power source to melt the electrode and maintain the preset arc length. The lower

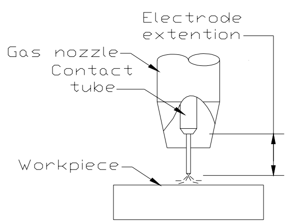


Figure 7-2. Electrode extenion. The actual electrode extenion is from the end of the ontact tip to the of the electrode. The proper term is "eltrical stickout" and is defined on weld procedure with the letters ESO.

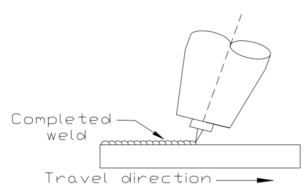


Figure 7-4. Backhand or pull welding technique. This technique requires more skill on the part of welder, since the weld joint is defficult to see because of the position of the gas nozzle.

welding current and smaller amount of weld metal deposited results in lower heat input (base metal heating) per unit length of weld and a smaller weld bead with reduced penetration.

Increasing the electrode stick-out to ½ " results in:

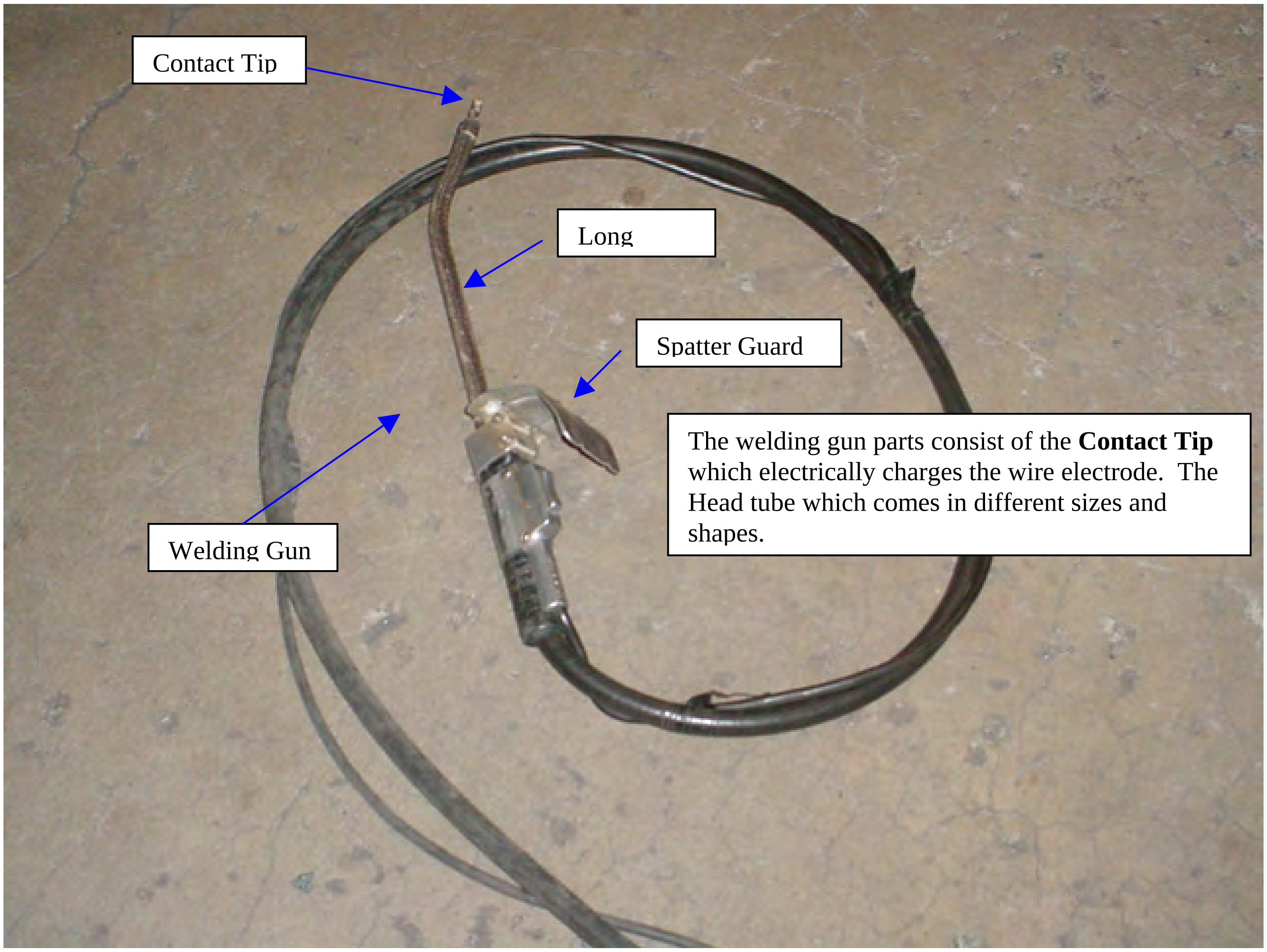
1. More preheating of the extended electrode
2. Less current required to melt the electrode while maintaining the preset arc length. The electrode feed speed was increased to give the original current value of bead 2.

Increased electrode feed speed results in a higher deposition rate (lb./hr.). Increased deposition and heat input (base metal) per unit length of weld results in a larger weld bead with greater depth of penetration.

Proper electrode stick out makes it possible to take advantage of the electrode preheating on the length extended. Proper attention to these dimensions will assure maximum weld quality, penetration, and deposition rate with a given set of balanced conditions.

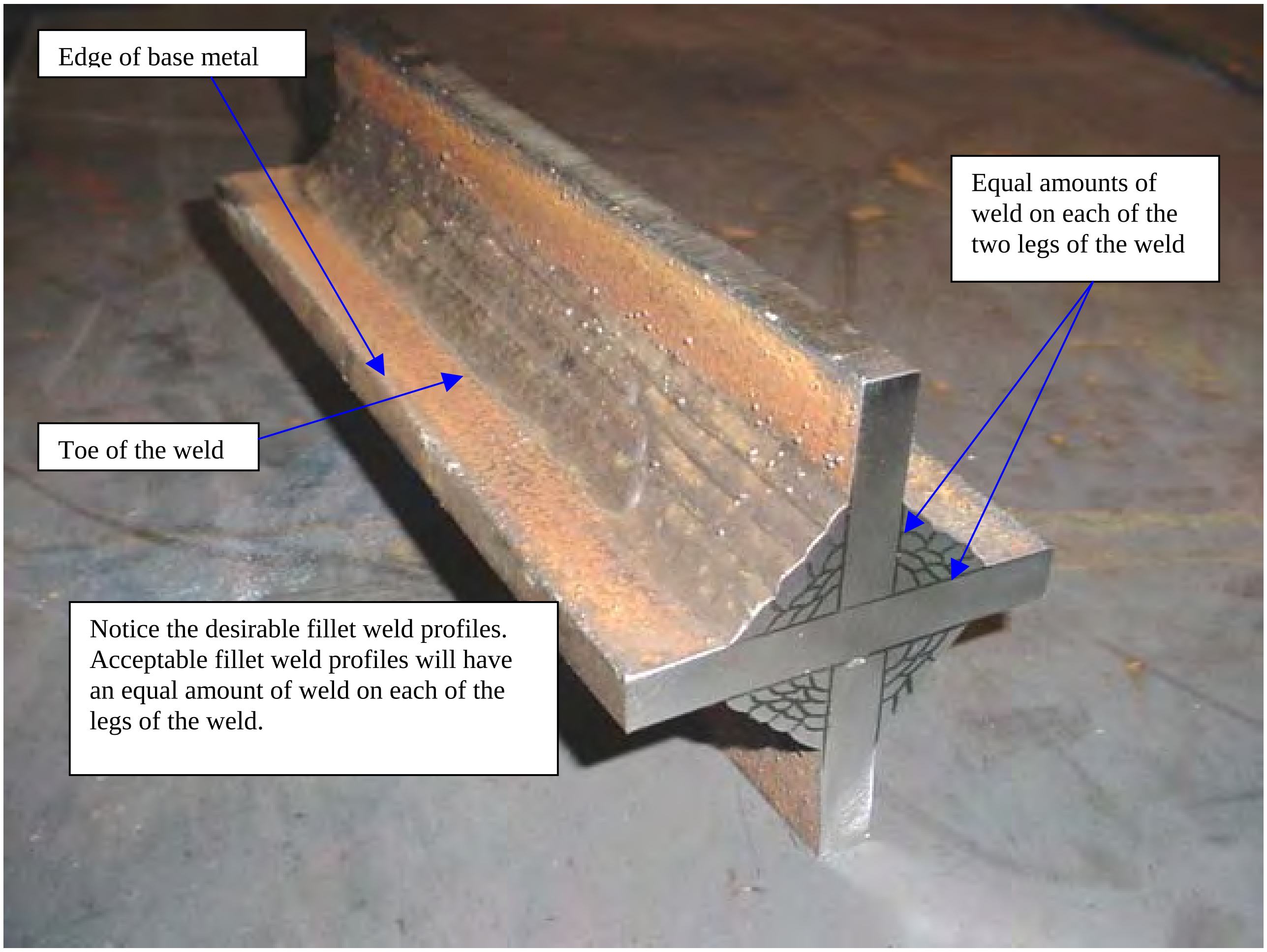
ELECTRODE FEED CONTROLS
WELDING GUNS

Welding guns used in the flux-core process serve the purpose of providing transfer of the welding current to the electrode, shielding gas coverage, and control of the arc. The guns may be air-cooled or water cooled depending upon the service conditions. Contact tips are subject to wear and should be changed periodically to insure correct size and reliable current pickup. Inside diameter tolerance on the contact tip is important to assure reliability of the process.



For more information on the welding gun and it's parts see Chapter 13 of "**Welding Principles and Applications**"

High Quality Multiple Pass Fillet Weld with Equal Legs



The distance between the edge of the base metal and the toe of the weld may be less than 1/16" provided the edge is clearly visible and the weld size clearly verifiable.

Convexity or concavity of the weld bead shall not exceed 0.1 times actual leg size.

.

(D) Acceptable butt weld or groove weld profile.

NOTE: Reinforcement R shall not exceed 1/8" per AWS D1.1.

COMMENTARY ON TECHNIQUES WITH PICTORIAL ILLUSTRATIONS

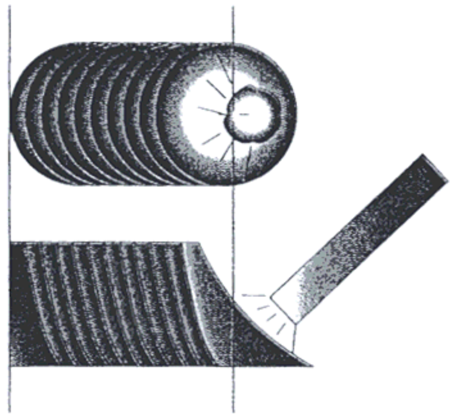
The practicality of multipass welding will depend upon many factors in each individual application. Multipass welding is usually done with smaller beads deposited at lower heat inputs than in a single pass weave bead techniques. This procedure is used when there is a need for rapid cooling in the heat affected zone and weld toughness which develops in a multipass weld deposit resulting from grain refinement and the tempering effect of stringer beads. The desirability of multipass welding and the finesse with which it must be applied is judged from the weldability of the steel and the toughness estimated to be required in the weld joint area. Small beads are more susceptible to stress cracking and cause more distortion than large beads. Stress cracking and distortion can be minimized by using procedures such as back stepping and alternating the stringer beads.

E71T-8 Electrode Technique and Parameters

The electrode characteristics of the E71T-8 are:

- Fast Freezing Slag
- High Deposition Rate
- Excellent as welded mechanical properties

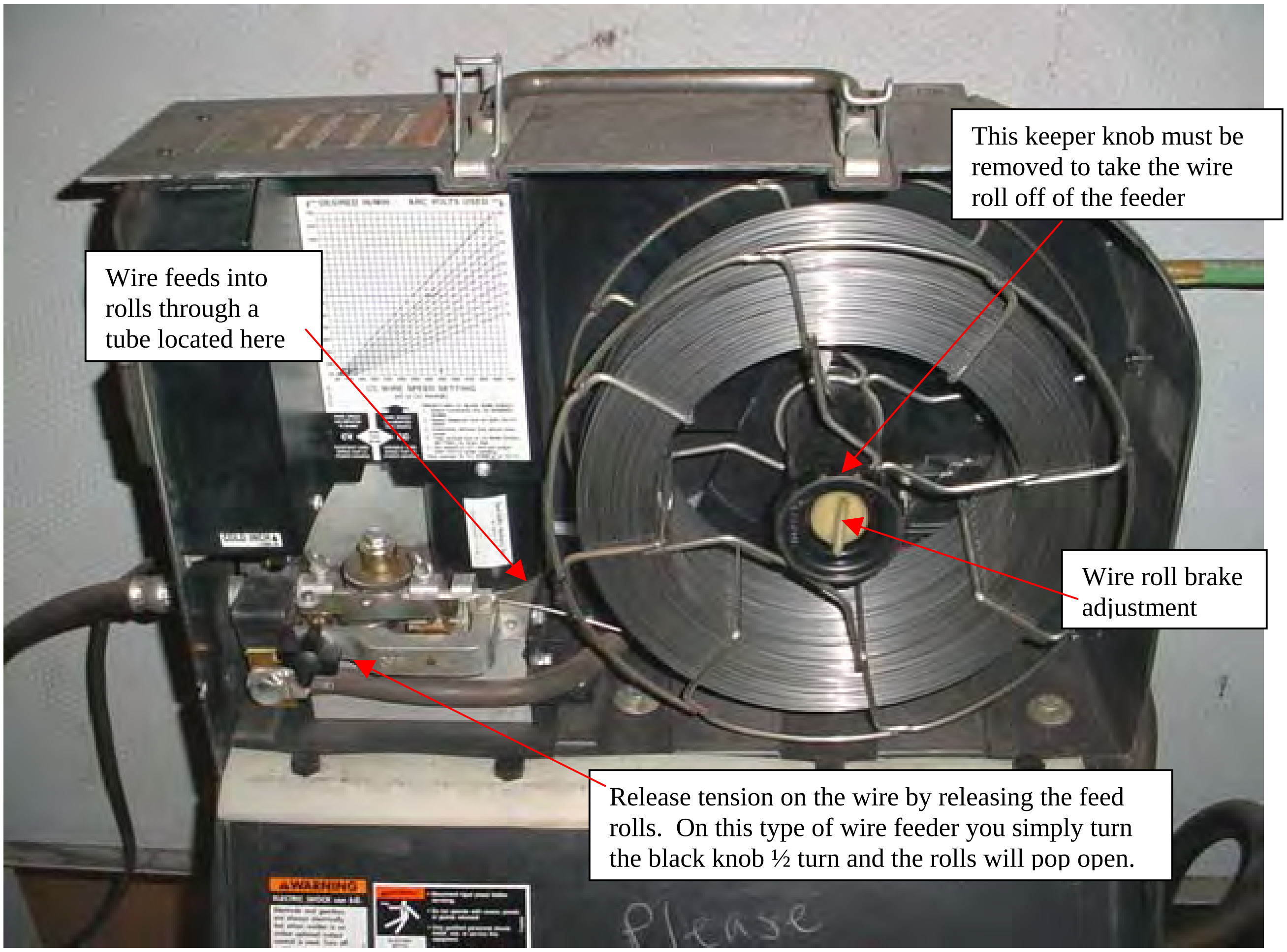
It is important to recognize that the slag act as a "mold" for the weld with E71T-8 electrodes. This means that the slag solidifies before the weld metal. This is just the opposite as compared to E7018. This is an important factor because if the welder has improper technique (i.e. weaving too wide) slag entrapment can result.



When welding with this electrode, the welder will need to learn how to read the slag as much as the puddle. This, again in SMAW terms, would be similar to reading the E7024 puddle. Excessive weaving of the electrode is prohibited because of the chances of trapping slag. If the weave is too wide, the bead will have ragged toes.

The following information is courtesy of The Lincoln Electric Company.

LN25


This keeper knob must be removed to take the wire roll off of the feeder
Wire feeds into rolls through a tube located here
Wire roll brake adjustment
Release tension on the wire by releasing the feed rolls. On this type of wire feeder you simply turn the black knob ½ turn and the rolls will pop open.
Please

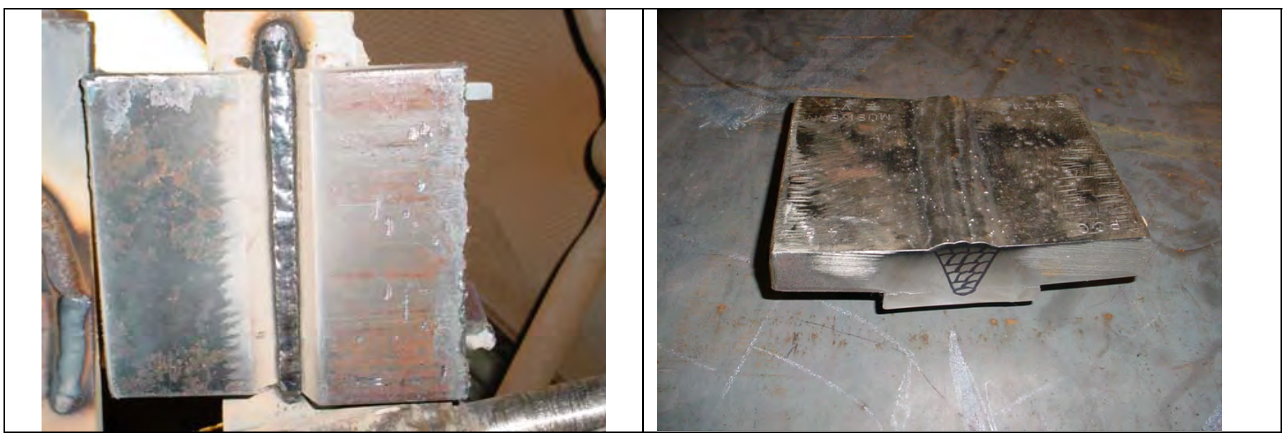
Craftsmanship Expectations for Welding Projects

The student should complete the following tasks prior to welding.

1. Thoroughly read each drawing.
2. Make a cutting list for each project. Cut at least two project assemblies of metal at a time. This will save a great amount of time.
3. Assemble the welding projects per drawing specifications.
4. Review the Welding Procedure portion of the prints to review welding parameter information.
5. See the instructor for the evaluation.

Factors for grading welding projects are based on the following criteria:

Metal Preparation	Project Layout	Post Weld Clean-up
Oxyacetylene Cut quality	Accurate (+/- 1/16")	Remove Slag/Spatter
Grind all cut surfaces clean	Limit waste	Remove sharp edges

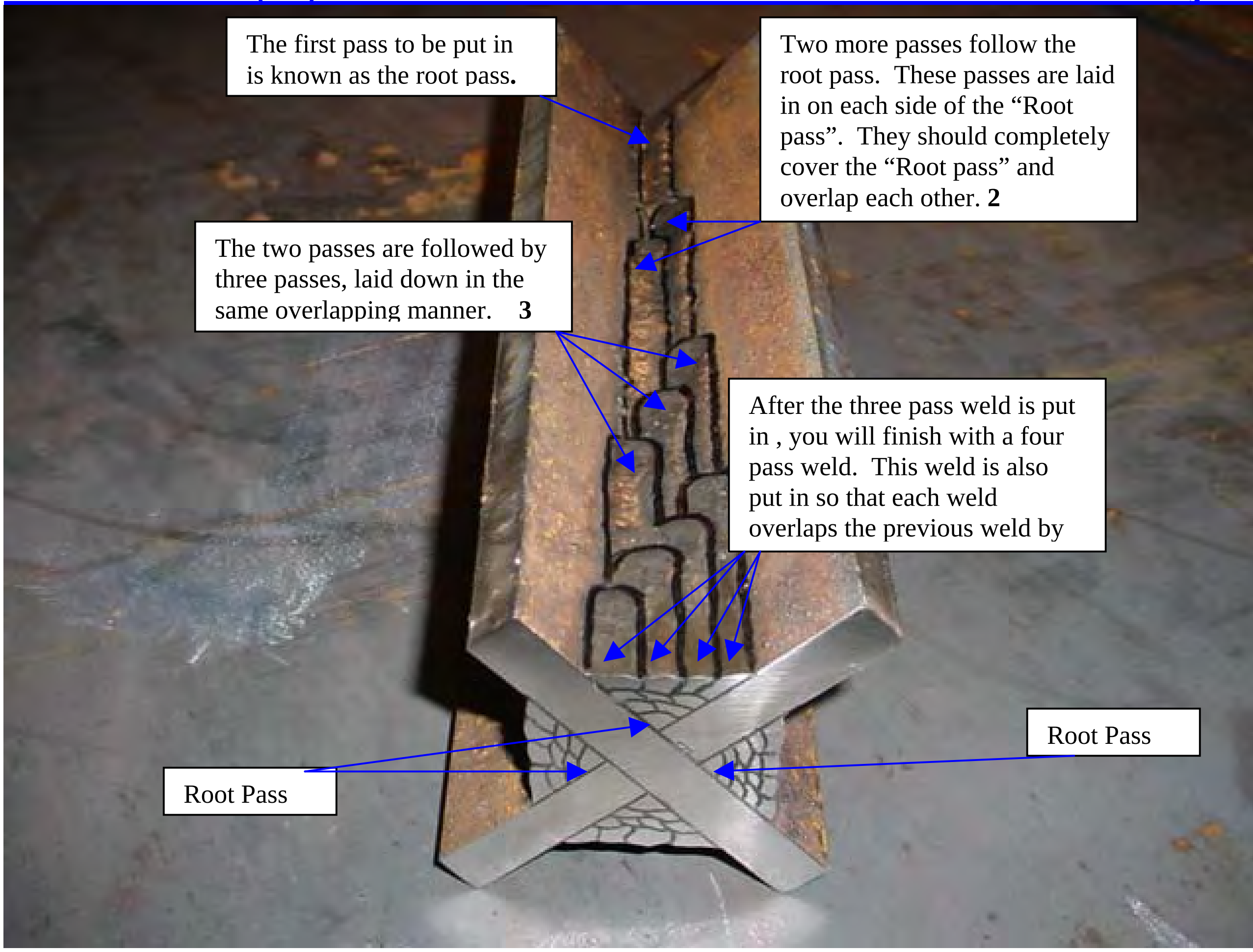


Example of a High Quality Weld

Weld Quality per AWS D1.1 Welder Qualification Tests

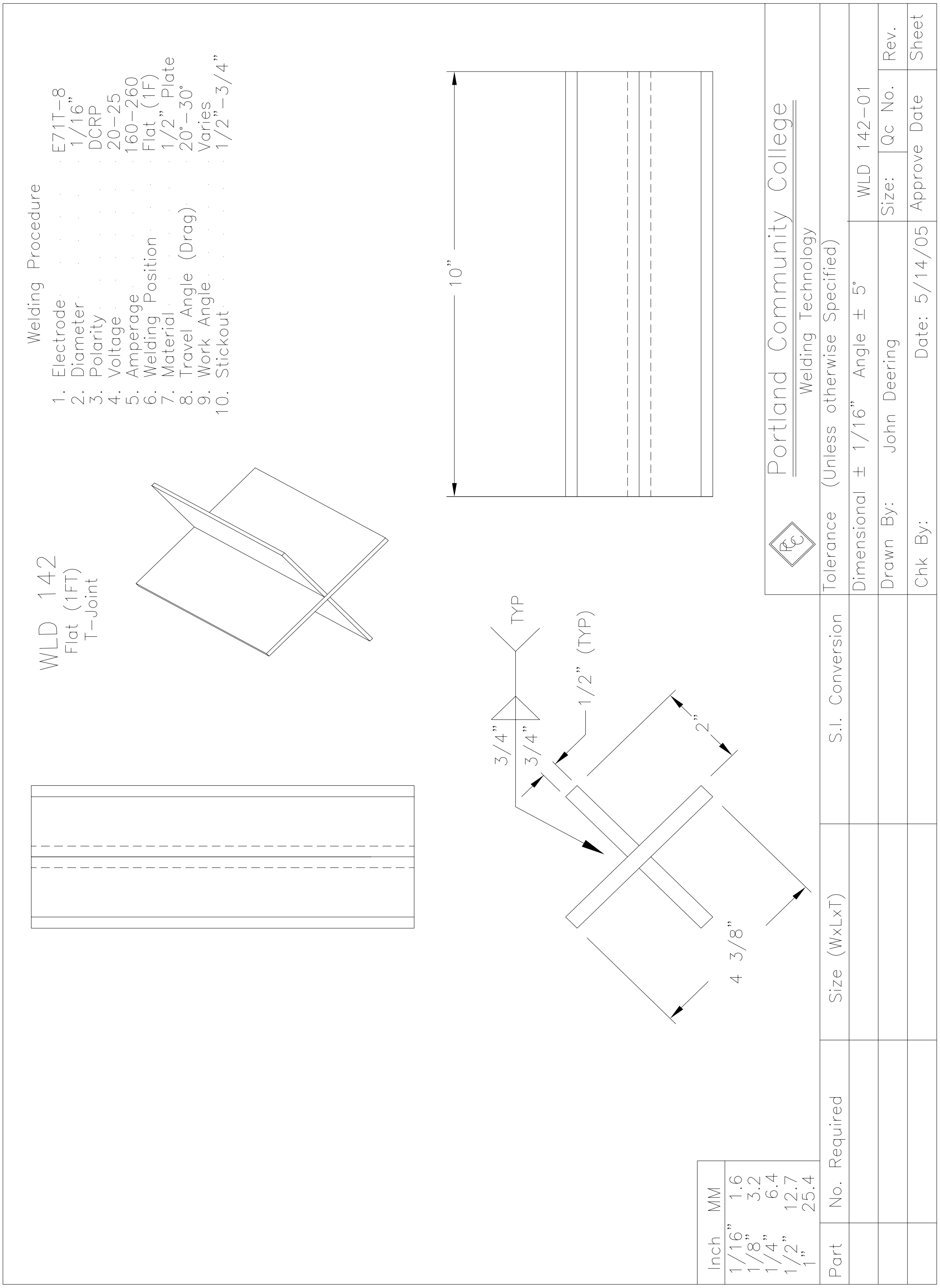
VT Criteria	**Cover Pass**
Reinforcement (groove welds)	Flush to 1/8"
Fillet Weld Size	See specification on drawing
Undercut	1/32" deep
Weld Contour	Smooth Transition
Penetration	N/A
Cracks	None Allowed
Arc Strikes	None Allowed
Fusion	Complete Fusion Required
Porosity	None Allowed
Overlap	None Allowed

E71T-8 T-Joint (1F) Project #1



In the weld joint pictured above the weld sequence and the outline of the weld beads has been highlighted to for better understanding. When you are working on your project **<u>all</u>** welds will be full length of the joint. Starting at the bottom of the "V" known as the root of the weld, put in one pass. Have your instructor look at the root pass you put in. After your instructor accepts the root pass, rotate the piece and put the root pass in each of the remaining three sides. When finished have your instructor check your work. Once you have been checked on the "Root passes" you will continue with the two-pass sequence.

VT Criteria	Student Assessment	Instructor Assessment
Reinforcement (0" –1/8")		
Fillet Weld Size		
Undercut (1/32")		
Bead Contour (smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade Date


WLD 142
Flat (1FT)
T–Joint
Welding Procedure
1. Electrode E71T–8
2. Diameter 1/16"
3. Polarity DCRP
4. Voltage 20–25
5. Amperage 160–260
6. Welding Position Flat (1F)
7. Material 1/2" Plate
8. Travel Angle (Drag) 20°–30°
9. Work Angle Varies
10. Stickout 1/2"–3/4"
10"
TYP
1/2" (TYP)
3/4"
3/4"
2"
4 3/8"
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Chk By:
Date: 5/14/05
WLD 142–01
Size:
Qc No.
Rev.
Approve Date
Sheet
Inch MM
1/16" 1.6
1/8" 3.2
1/4" 6.4
1/2" 12.7
1" 25.4
Part
No. Required
Size (WxLxT)
S.I. Conversion

E71T-8 Horizontal T-Joint (2F) Project #2

Welding Sequence

E71T-8-- Root Pass	Single pass technique with slight weave to ensure the weld metal is fusing into both pieces of metal.
E71T-8—Fill	Use the split bead technique with stringer beads ensuring even fill.
E71T-8—Finish Beads	Use stringer bead technique keeping the electrode in the puddle at all times.

VT Criteria	Student Assessment	Instructor Assessment
Reinforcement (0" –1/8")		
Fillet Weld Size		
Undercut (1/32")		
Bead Contour (smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade Date

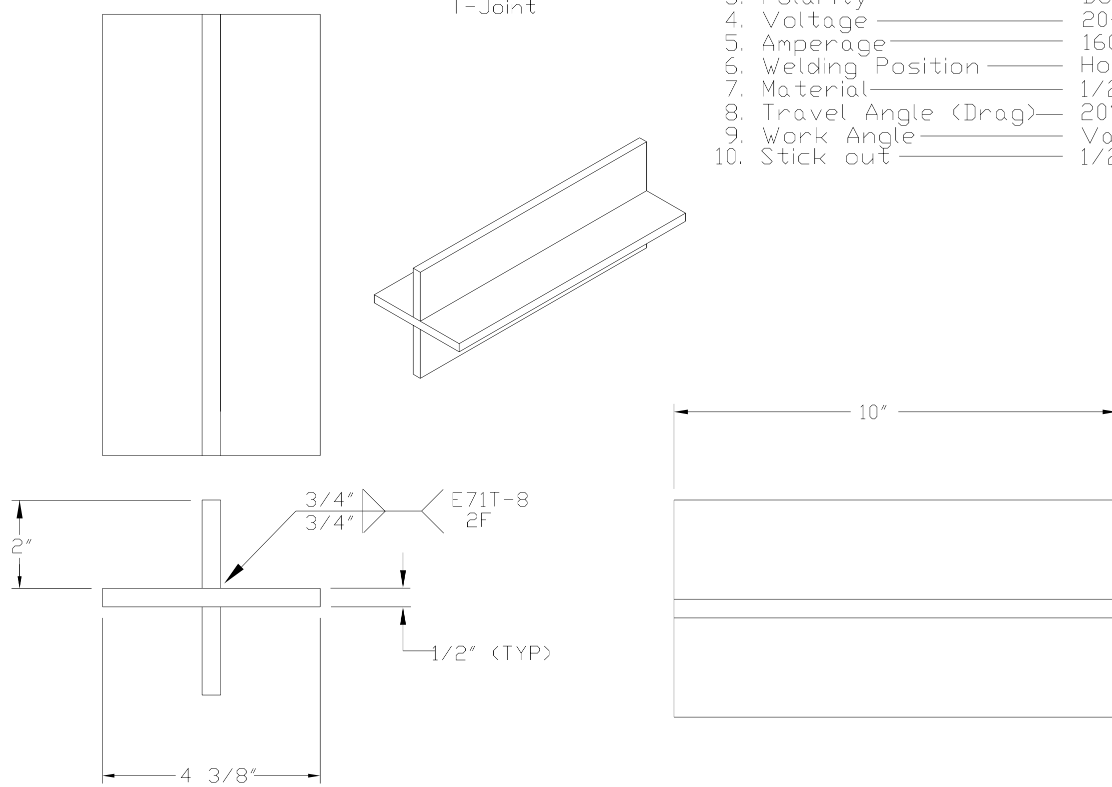
WLD 142

Horizontal (2F)

T-Joint

Welding Procedure

1. Electrode — E71T-8
2. Diameter — 1/16″
3. Polarity — DCSP
4. Voltage — 20-25
5. Amperage — 160-260
6. Welding Position — Horizontal (2F)
7. Material — 1/2″ Plate
8. Travel Angle (Drag) — 20°-30°
9. Work Angle — Varies
10. Stick out — 1/2″-3/4″



Inch	MM
1/16″	1.6
1/8″	3.2
1/4″	6.4
1/2″	12.7
1″	25.4

Part	No. Required	Size (WxHxT)	S.I. Conversion

Portland Community College

Welding Technology

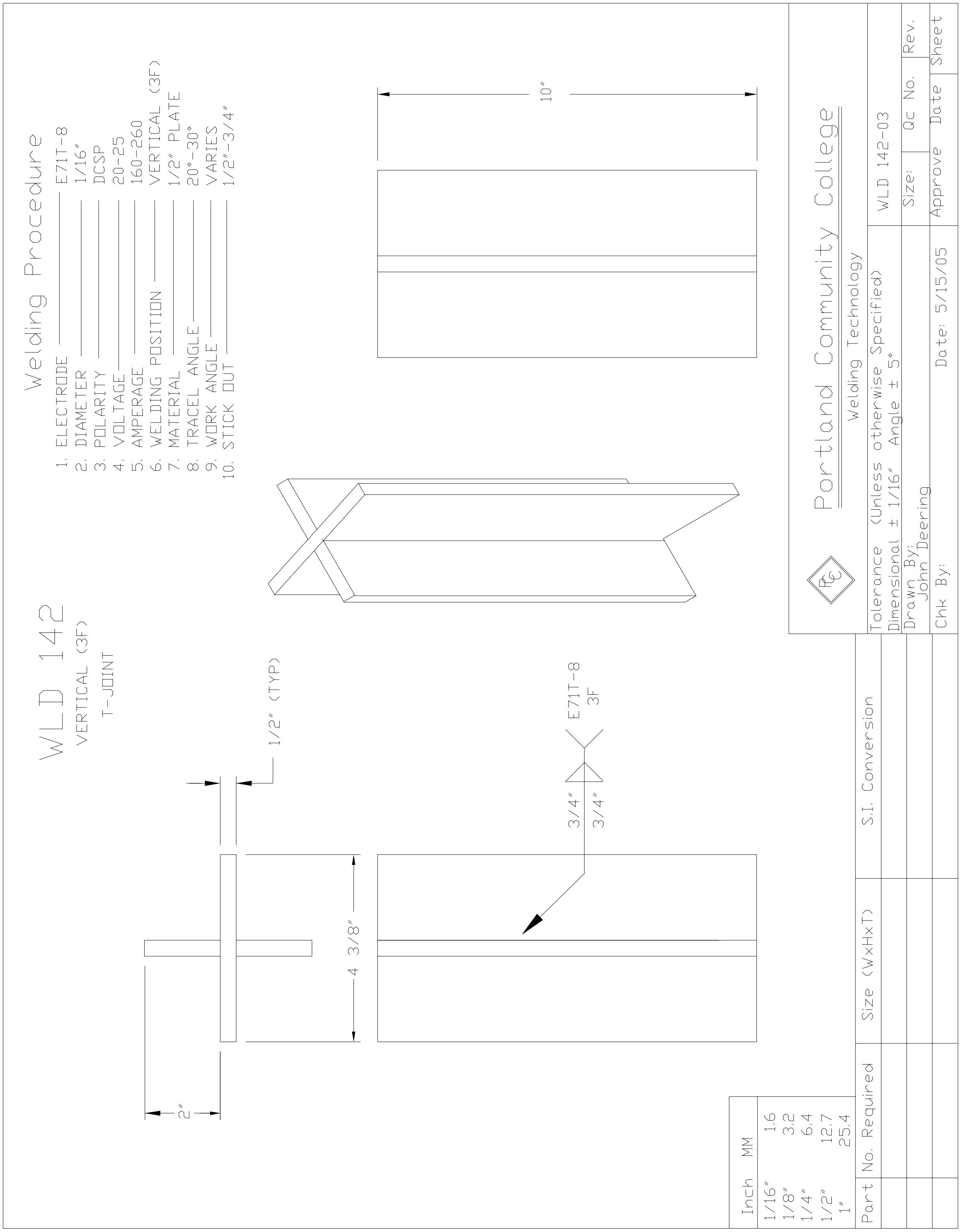
Tolerance (Unless otherwise Specified) Dimensional ± 1/16″ Angle ± 5°	WLD 142-02		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Date: 5/15/05	Approve	Date	Sheet

E71T-8 Vertical T-Joint (3F) Project #3

Welding Sequence

E71T-8-- Root Pass	Single pass technique with slight weave to ensure the weld metal is fusing into both pieces of metal.
E71T-8—Fill	Use the split bead technique with stringer beads ensuring even fill.
E71T-8—Finish Beads	Use stringer bead technique keeping the electrode in the puddle at all times.

VT Criteria	Student Assessment	Instructor Assessment
Reinforcement (0" –1/8")		
Fillet Weld Size		
Undercut (1/32")		
Bead Contour (smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade Date

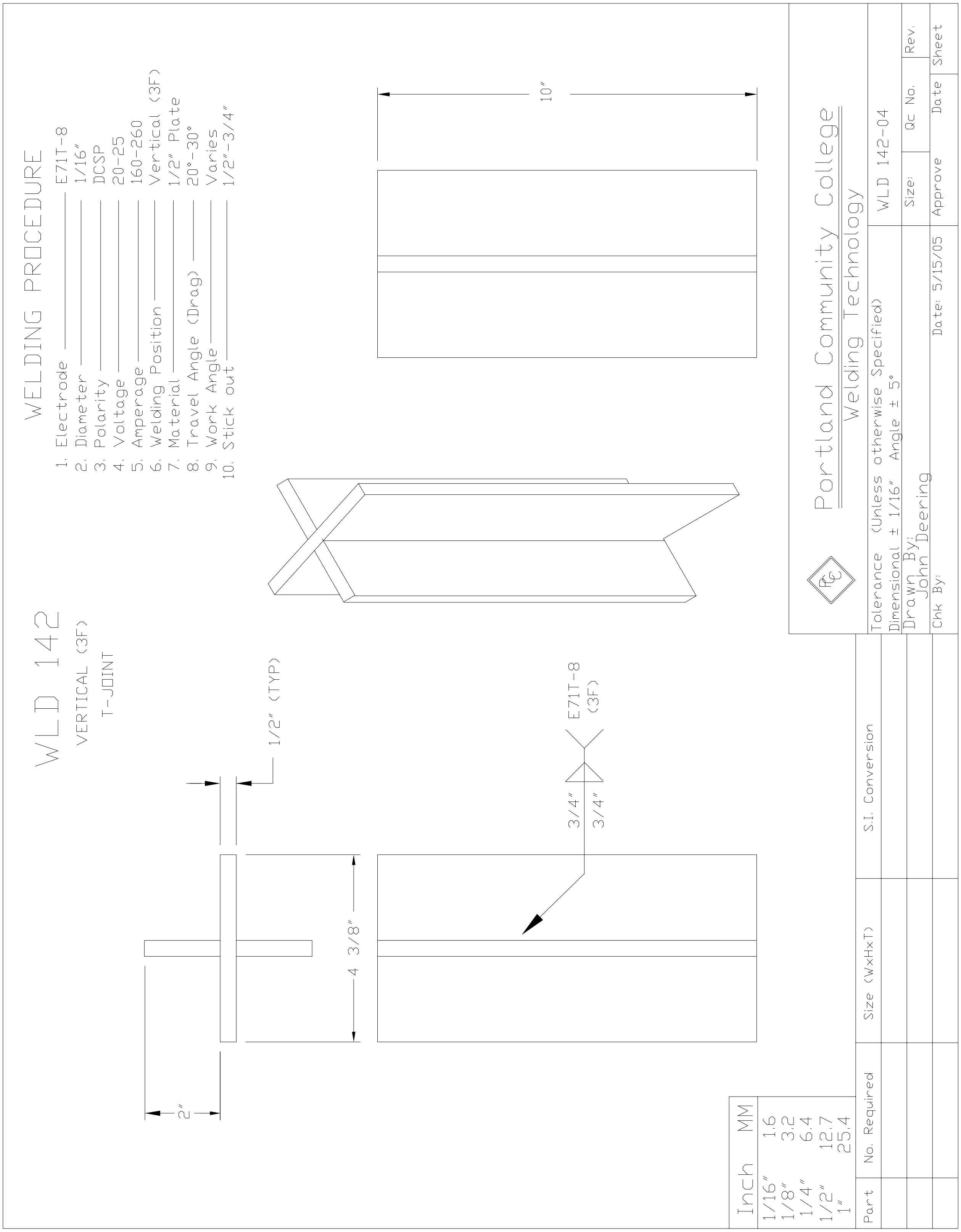

WLD 142
VERTICAL (3F)
T-JOINT
Welding Procedure
1. ELECTRODE — E71T-8
2. DIAMETER — 1/16"
3. POLARITY — DCSP
4. VOLTAGE — 20-25
5. AMPERAGE — 160-260
6. WELDING POSITION — VERTICAL (3F)
7. MATERIAL — 1/2" PLATE
8. TRACEL ANGLE — 20°-30°
9. WORK ANGLE — VARIES
10. STICK OUT — 1/2"-3/4"
10"
1/2" (TYP)
E71T-8
3F
3/4"
3/4"
4 3/8"
2"
Inch MM
1/16" 1.6
1/8" 3.2
1/4" 6.4
1/2" 12.7
1" 25.4
Part No. Required
Size (WxHxT)
S.I. Conversion
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Chk By:
Date: 5/15/05
WLD 142-03
Size: Qc No. Rev.
Approve Date Sheet

E71T-8 Overhead T-Joint (4F) Project #4

Welding Sequence

E71T-8-- Root Pass	Single pass technique with slight weave to ensure the weld metal is fusing into both pieces of metal.
E71T-8—Fill	Use the split bead technique with stringer beads ensuring even fill.
E71T-8—Finish Beads	Use stringer bead technique keeping the electrode in the puddle at all times.

VT Criteria	Student Assessment	Instructor Assessment
Reinforcement (0" –1/8")		
Fillet Weld Size		
Undercut (1/32")		
Bead Contour (smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade Date


WLD 142
VERTICAL (3F)
T-JOINT
WELDING PROCEDURE
1. Electrode — E71T-8
2. Diameter — 1/16"
3. Polarity — DCSP
4. Voltage — 20-25
5. Amperage — 160-260
6. Welding Position — Vertical (3F)
7. Material — 1/2" Plate
8. Travel Angle (Drag) — 20°-30°
9. Work Angle — Varies
10. Stick out — 1/2"-3/4"
10"
1/2" (TYP)
E71T-8
(3F)
3/4"
3/4"
4 3/8"
2"
Inch MM
1/16" 1.6
1/8" 3.2
1/4" 6.4
1/2" 12.7
1" 25.4
Part
No. Required
Size (WxHxT)
S.I. Conversion
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Date: 5/15/05
Chk By:
Approve
Date
Sheet
WLD 142-04
Size:
Qc No.
Rev.

Shop Pre-Test Bend Test Procedure for 1" Test Plate

Bend tests are used to determine the ductility and soundness of a weld joint. The test will determine if fusion was obtained in the weld joint. Use the following procedure in preparing and bending your coupons.

1. Reference the AWS D1.1 Structural Welding Code to determine the dimensional layout of the bend coupons (use this diagram for all positions).

2. Flush back up strip off of the plate. **Note: flushing of the backing strip maybe removed by flushing provided that at least 1/8 inch of its thickness is left to be removed by grinding.**

3. Layout four 3/8" thick coupons and cut using the track burner. **Do Not Bend coupons greater than 3/8" thick. This will damage the machine.**

4. Allow coupon to air cool. **Do Not Quench!**

5. Grind coupon's smooth, ensuring grinding marks are going with the length of the coupon's and all edges are rounded.

6. Request permission from your instructor to use the bend test machine.

7. **CAUTION**: ***Keep hands and fingers clear when operating equipment.***

8. Ensure guard is in the correct position. The coupons sometimes eject out the end of the machine rapidly.

9. Place coupon in the machine taking care to not position your hands/fingers in the way. Locate weld in the center of the die. Position coupons for side bends only.

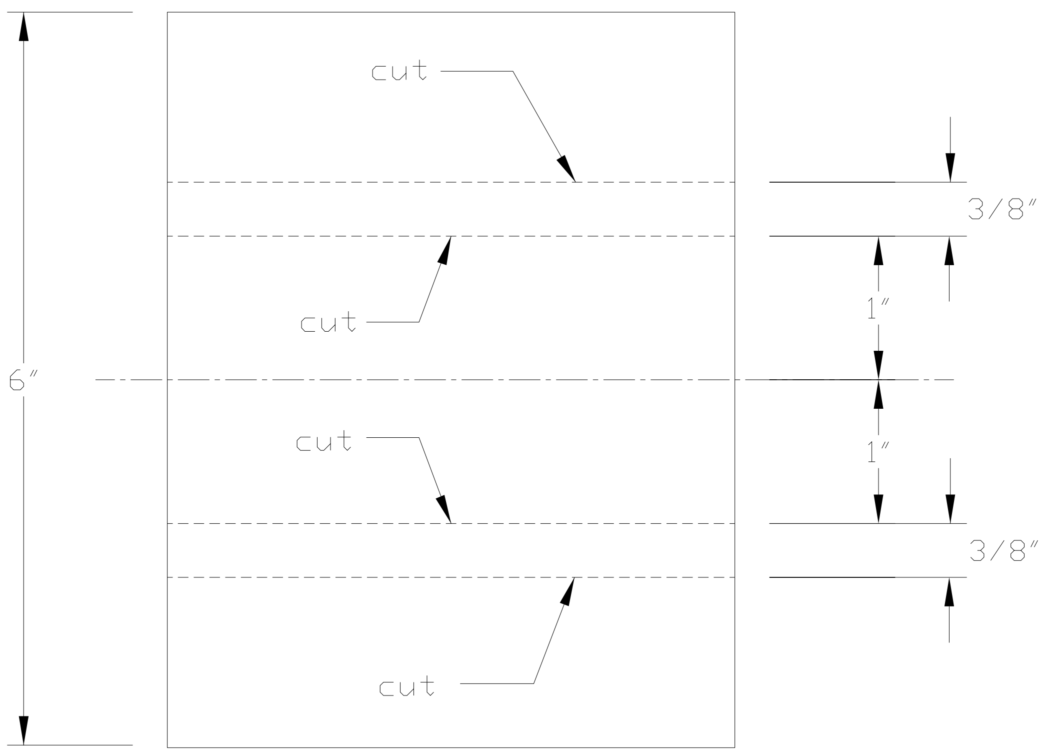
10. Actuate the machine by the lever on top of the machine and stand clear of end where the coupon will exit.

11. Inspect the coupon for fusion type defects. **Reference AWS D1.1 Structural Welding Code, for acceptance criteria**.

Inspection by instructor:	**Instructors signature:** ______________________________
Date: ________________	**Student signature:** ______________________________

SHOP TEST

BEND TEST COUPON PREPERATION FOR SHOP TEST



TEST COUPONS SHALL BE FREE OF ALL DEFECTS SUCH AS UNDERCUT, POROSITY, SLAG INCOMPLETE FUSION, AND OTHER DEFECTS PER AWS D1.1

Inch	MM
1/16″	1.6
1/8″	3.2
1/4″	6.4
1/2″	12.7
1″	25.4

Part No.	Required	Size(WxLxT)	S.I. Conversion

Portland Community College

Welding Technology

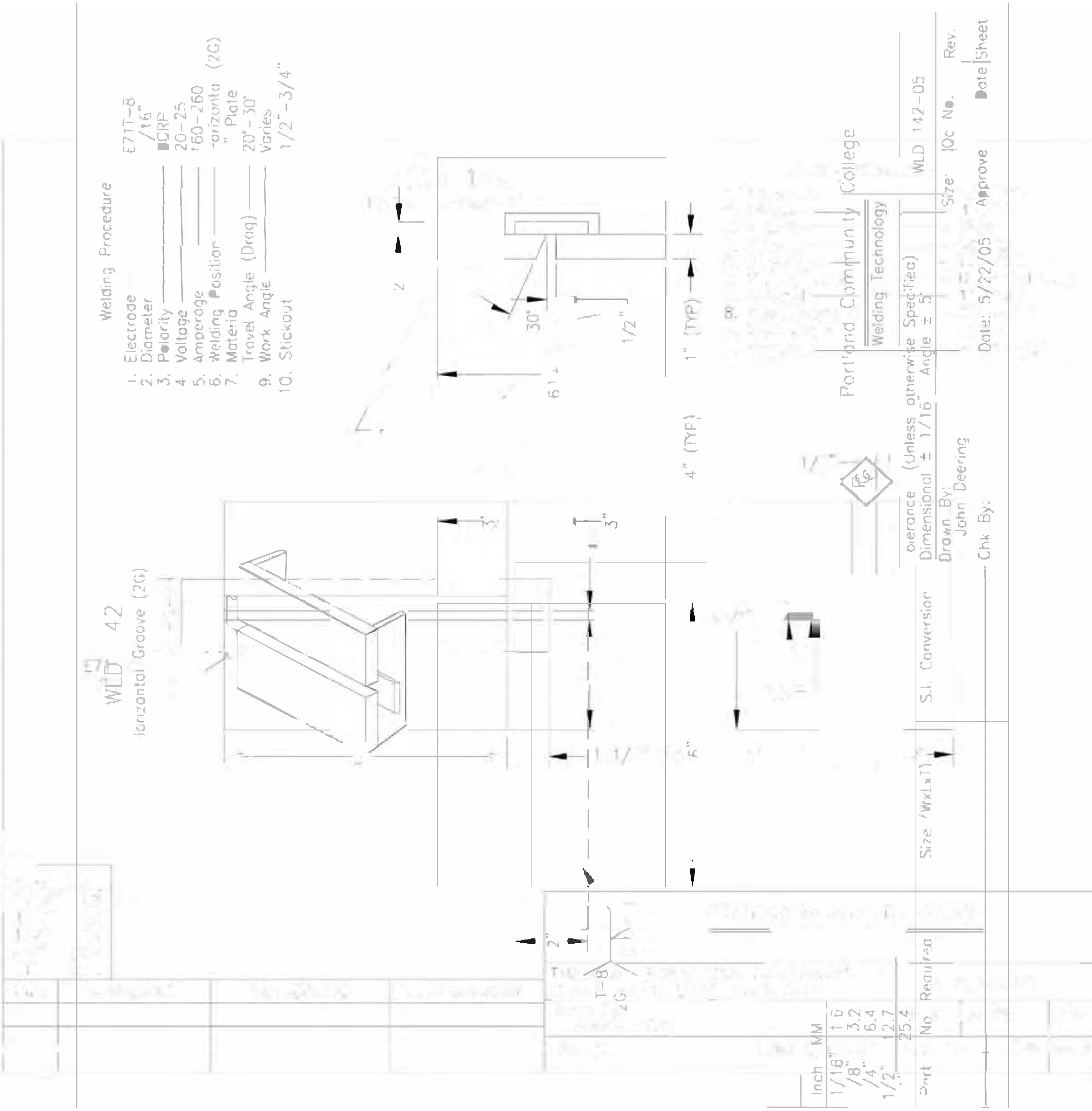
Tolerance (Unless otherwise Specified) Dimensional ± 1/16″ Angle ± 5°		WLD 142 Bend Test Layout	
Drawn By: John Deering		Size:	Qc No. / Rev.
Chk By:	Date: 5/22/05	Approve Date	Sheet

E71T-8 Horizontal Groove Weld (2G) Project #5

Welding Sequence

E71T-8-- Root Pass	Double pass technique will ensure the weld metal is fusing into both pieces of metal.
E71T-8—Fill	Use the split bead technique with stringer beads ensuring even fill.
E71T-8—Finish Beads	Use stringer bead technique keeping the electrode in the puddle at all times.

VT Criteria	Visual Inspection	Bend Tests
Reinforcement (0" –1/8")		Acceptable Not Acceptable
Fillet Weld Size		
Undercut (1/32")		
Bead Contour (smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade **Date**


Welding Procedure
1. Electrode — E71T-8
3. Polarity — DCRP
4. Voltage — 20-25
5. Amperage — 160-260
6. Welding Position — (2G)
7. Material — " Plate
8. Travel Angle (Drag) — 20°-30°
9. Work Angle — Varies
10. Stickout — 1/2"-3/4"
Horizontal Groove (2G)
30°
1/2"
1" (TYP)
4" (TYP)
Portland Community College
Welding Technology
WLD 142-05
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Chk By:
Date: 5/22/05
Approve
Size
Rev.
Date
Sheet
S.I. Conversion
Inch
MM
1/16"
1.6
3.2
6.4
12.7
25.4
No. Required
Size (WxLxT)

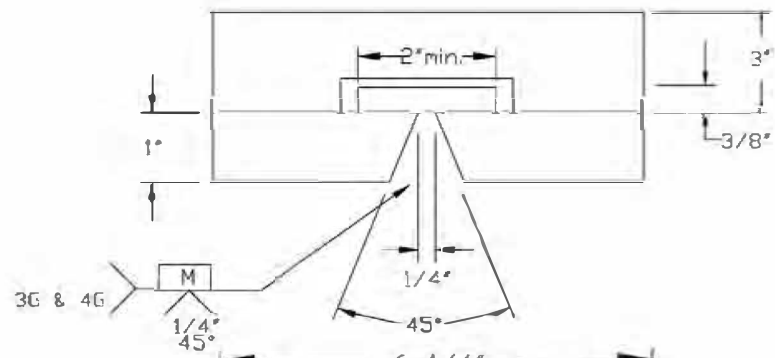
E71T-8 Vertical Groove Weld (3G) Project #6

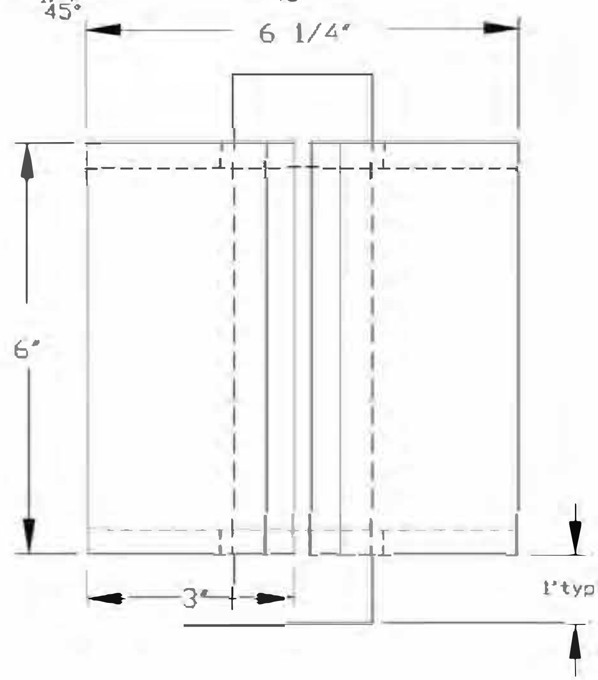
Welding Sequence

E71T-8-- Root Pass	Single pass technique with slight weave to ensure the weld metal is fusing into both pieces of metal.
E71T-8—Fill	Use the split bead technique with stringer beads ensuring even fill.
E71T-8—Finish Beads	Use stringer bead technique keeping the electrode in the puddle at all times.

VT Criteria	Visual Inspection	Bend Tests
Reinforcement (0" –1/8")		
Fillet Weld Size		
Undercut (1/32")		Acceptable
Bead Contour (smooth)		
Penetration		
Cracks (none)		Not Acceptable
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade **Date**

WLD 142
Single "V" Groove 3G

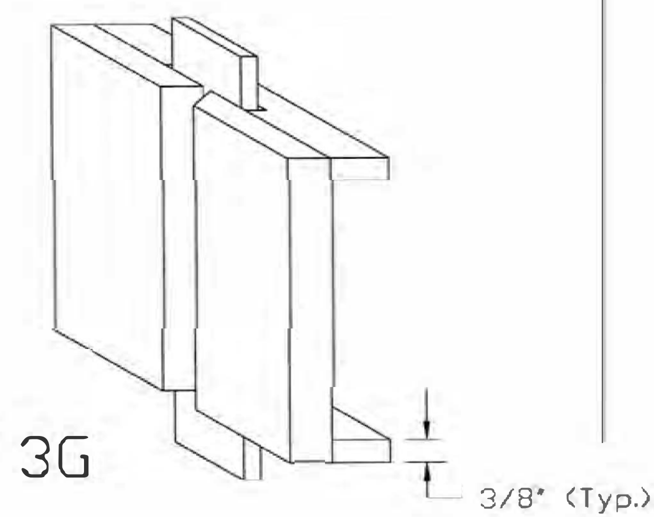




Welding Procedure for
Single "V" Groove 3G

1. Electrode
2. Diameter
3. Polarity
4. Amperage
5. Arc Length
6. Welding Position — Vertical and Overhead
7. Travel Angle
8. Work Angle
9. Technique

* Bend Test required Per AWS D1.1 for both 3G and 4G plates.



Inch	MM
1/16"	1.6
1/8"	3.2
1/4"	6.4
1/2"	12.7
1"	25.4

Part	No. Required	Size (TxWxL)	S.I. Conversion

Portland Community College
Welding Technology

Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°

Drawn By: John Deering

Chk By: Date: 7/23/05

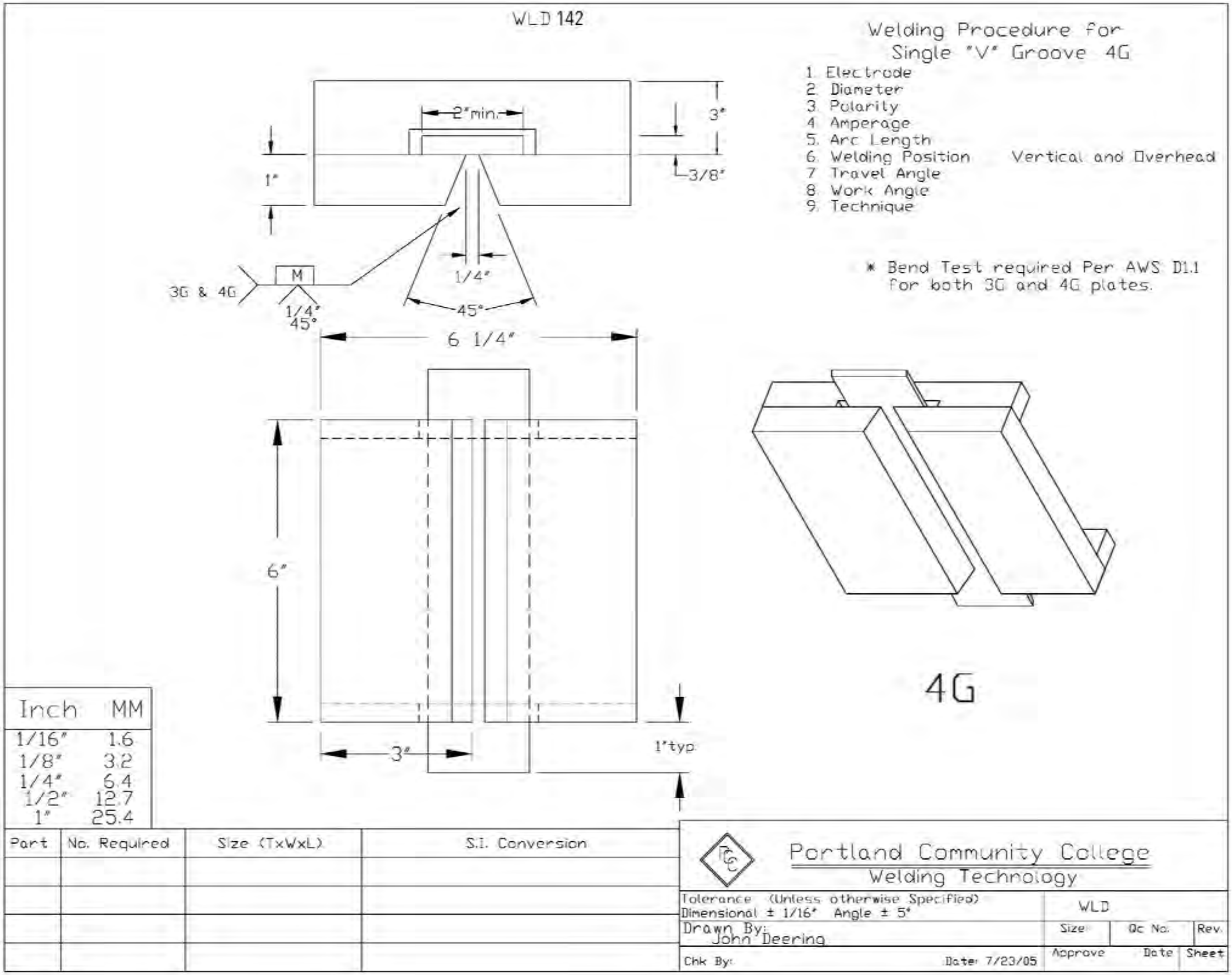
WLD		
Size	Dc No.	Rev.
Approve	Date	Sheet

E71T-8 Overhead Groove Weld (4G) Project #7

Welding Sequence

E71T-8-- Root Pass	Single pass technique with slight weave to ensure the weld metal is fusing into both pieces of metal.
E71T-8—Fill	Use the split bead technique with stringer beads ensuring even fill.
E71T-8—Finish Beads	Use stringer bead technique keeping the electrode in the puddle at all times.

VT Criteria	Visual Inspection	Bend Tests
Reinforcement (0” –1/8”)		
Fillet Weld Size		
Undercut (1/32”)		Acceptable
Bead Contour (smooth)		
Penetration		
Cracks (none)		Not Acceptable
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade **Date**


WLD 142
Welding Procedure for
Single "V" Groove 4G
1. Electrode
2. Diameter
3. Polarity
4. Amperage
5. Arc Length
6. Welding Position Vertical and Overhead
7. Travel Angle
8. Work Angle
9. Technique
* Bend Test required Per AWS D1.1 for both 3G and 4G plates.
2"min.
3"
3/8"
1"
M
3G & 4G
1/4"
45°
1/4"
45°
6 1/4"
6"
3"
1"typ
4G
Inch MM
1/16" 1.6
1/8" 3.2
1/4" 6.4
1/2" 12.7
1" 25.4
Part
No. Required
Size (TxWxL)
S.I. Conversion
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
WLD
Drawn By: John Deering
Size
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Chk By:
Date: 7/23/05
Approve
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Math On Metal

Fractions as Division Problems
-or-
Converting Fractions to Decimals

This is going to be a real quick lesson. **A fraction is a division problem.** A fraction is a division problem which reads from top to bottom. ½ can also be stated: "1 divided by 2." Note that if you input that into your calculator (***Don't forget to press*** "=" !!), you will get what you already know is true, which is that ½ equals .50 or .5, as in 50 cents or 5 tenths, etc. Now, this is the hard part. You must believe that all fractions work this way. If you divide the top by the bottom, you get the decimal equivalent. Try it for ¾ and ¼ and 1/8. You will get: .75, .25, and .125 respectively. Are you a believer yet?! Think of it this way. What you are saying is that 3 out of every 4 dollars is the same as 75 out of every 100 dollars, and that 1 out of every 8 people is the same as 125 out of every 1000 people.

¾ : " 3 [÷] 4 [=] "

Be sure to try your fraction key also on this. Use the 2nd function key and the key with F↔D above it on the TI 30 Xa. For some calculators, you just need to push the "=" key one or two times.

So what does this have to do with you? Well, it comes in real handy when we talk about ratios and proportion, which we'll do later. It also is important to know and be able to do when we talk about wire diameter sizes.

Have you ever seen the Inner Shield Wire labeled size "068" ? Do you know what this means? It means that this wire is 0.068 or 68 thousandths of an inch in diameter. But how does that compare with some of the common fractional inch diameter sizes? Convert the fractional inch diameter sizes below to decimal sizes and circle the one which you think is closest to "068."

Exercise:

5/32" = _______

5/64" = _______

3/32" = _______

1/16" = _______

1/8" = _______

You need to be able to convert fractions to decimals so that when you read prints with different modes of recording diameter sizes, you can relate them to each other, fractions to decimals and vice versa. *Then, it may be possible to substitute a 1/16" wire for a "068" in some circumstances*. Even though it is not exact, there may be times when it is close enough. But how will you know if you cannot convert them?

Reading decimals, which we did in WLD 141, helps you to have an understanding of just how big they are. In this class, we will work on comparing decimals, which you will also use when comparing fractions. If you cannot tell which fraction is bigger, you can convert the fractions to decimals and then compare more easily.

To convert decimal inches to fractional inches is a little more work, but you already have all the skills. You've already done it to convert to the most accurate decimal, but it might be useful to convert to the nearest 1/16 inch: (*We'll also look at this in WLD 131*)

Let's say that you want to know what .068 inch is to the closest 1/16 of an inch.

If there is a whole number in front of it, record it and drop it. (Example: for 4.32, write down 4 inches and use only the .32 part of the number). We don't have a whole number here, so we don't have to worry about it.

Input the part of the number which begins with the decimal point: **".068"**

This number tells you what part of an inch, in this case, how many 1000ths you are working with

Multiply by 16 to "*cut*" it into <u>*sixteenths*</u>, which is what you want.

This is the amount of 16ths you have in .068 = 1.088

Round the resulting number on your calculator <u>*to the nearest whole number*</u>.

This is the whole number of 16ths you have in .068 = 1

And there you have it! 1/16

To convert it to 32^{nds}, you just multiply it by 32, instead of 16.
To convert it to 64^{ths}, you just multiply by 64.

Exercise:

Convert the following decimals to the nearest 32nd or 64th of an inch; reduce as needed:

.035	***=***	***_______/32***			
.045	***=***	***_______/32***			
.035	***=***	***_______/64***	***.045***	***=***	***_______/64***

Why would it be good to convert 035 and 045 to 64th's instead of 32nd's?

.090	***=***	***_______/32***	***.025***	***=***	***_______/32***

Which one of the above is closest to "hogwire" = 3/32" DIA? Circle it.

Can You Tolerate This?

Use your understanding of tolerances and comparing decimals to complete the table below. Remember to subtract to get the minimum and add to get the maximum. Look at the given measurement in the fourth column and determine if a piece dimension of that size would fall within the range of tolerance you've calculated. If it does not fall within tolerance, then write whether it is ***too small*** or ***too large***.

Tolerance	**Minimum**	**Maximum**	**Given measurement**	***Yes/No*** **Is this measurement w/in tolerance?**
3.450 ± .0005			3.453	
12.000 ± .003			12.098	
39.055 ± .0002			39.0551	
0.5 ± .001			0.49	
22 ± .01			21.095	
18.875 ± .005			18.880	

Comparing Wire Diameters:
Fractional and Decimal Inch

There are times when it is important to compare wire diameter sizes, and this is a little trickier when they are recorded both in decimal inch sizes and in fractional inch sizes. But now that you have practiced converting fractions to decimals and comparing decimals, there is nothing more to learn. All we have to do is apply all that knowledge.

On #'s 1 and 2, make a guess:

1. Which is **bigger** in diameter, the .045 wire or the 1/16" wire?____________

2. Which is **bigger** in diameter, the 3/32 wire or the .035" wire?____________

3. Convert the following wire/stick diameter sizes into decimal numbers:

   1/16" ______________

   3/32" ______________

   1/8 " (stick only) ______________ *Were you right on #1 and #2?*

4. Now make a chart of the following 6 common wire/stick sizes. Put the smallest sizes first and the largest sizes on the bottom. Write them as they are normally written; in other words, do not write the decimal equivalent for the fractions.

   3/32

   1/16

   025 = .025

   035

   045

   1/8 (stick only)

Smallest to Largest:

5. What is the smallest size you use of these most commonly used wires? _______

6. What is the largest size you use of these most commonly used ***wires***? _______

7. What is the wire size closest to a 1-millimeter DIA (.03937 inch)? _______

WELDING TERMS

NAME:________________________________ DATE:___________________________________

DIRECTIONS: Define the terms listed below. Refer to the Glossary in the textbook. Failure to complete to the instructor's satisfaction will require additional study before attempting to re-do this Work Sheet. USE A PENCIL!

1. Spatter

2. Wire Conduit

3. Flow Meter

4. Regulator

5. Voltage

6. Welding current

7. Zero Arc Length

8. Plus Arc Length

9. Minus Arc Length

10. Work Angle

11. Electrode Stick-Out

12. Drag Gun Angle

13. Push Gun Angle

SELF SHIELDED FLUX-CORE PROCESS AND WELDING VARIABLES

NAME: ______________________________ DATE: __________________________

DIRECTIONS:
Answer the following questions. If necessary, refer to Information Sheet. Failure to complete to the Instructor's satisfaction, will require additional study before attempting to re-do this Work Sheet. USE PENCIL!!!

1. The shielded flux-core process uses a gas as well as the flux for shielding. What gas or mixture of gases are used?

2. Welding current is supplied by two types of power sources, constant current, and constant voltage.

   A. Which of the two would be used for the flux-core process?

3. The self shielded flux-core process results in a deeply penetrating arc. Name three advantages of this quality.

   A.

   B.

   C.

4.. There are five (5) important variables when using the flux-core process. Name all five variables:

A.

B.

C.

D.

E.

5. Describe when the best or balanced arc voltage for the flux-core process is achieved.

6. What is the term used for the balanced arc condition?

7. Describe the results of higher voltage in relation to the arc stream.

8. Describe what term is used with a higher arc voltage condition.

Final Exam

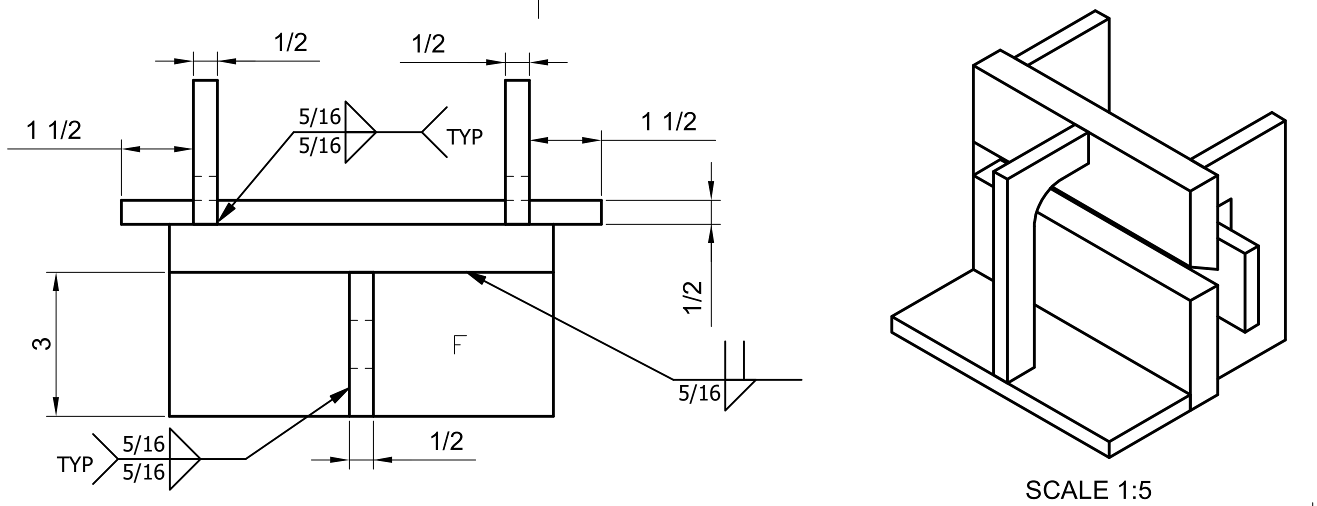
Part One

This portion of the final exam is a closed book test. Consult with your instructor to determine items that you may need to review. Once you determine that you are ready for the exam, request it from your instructor. Complete the exam and write all answers on the answer sheet provided. Once completed, return the exam to your instructor for grading.

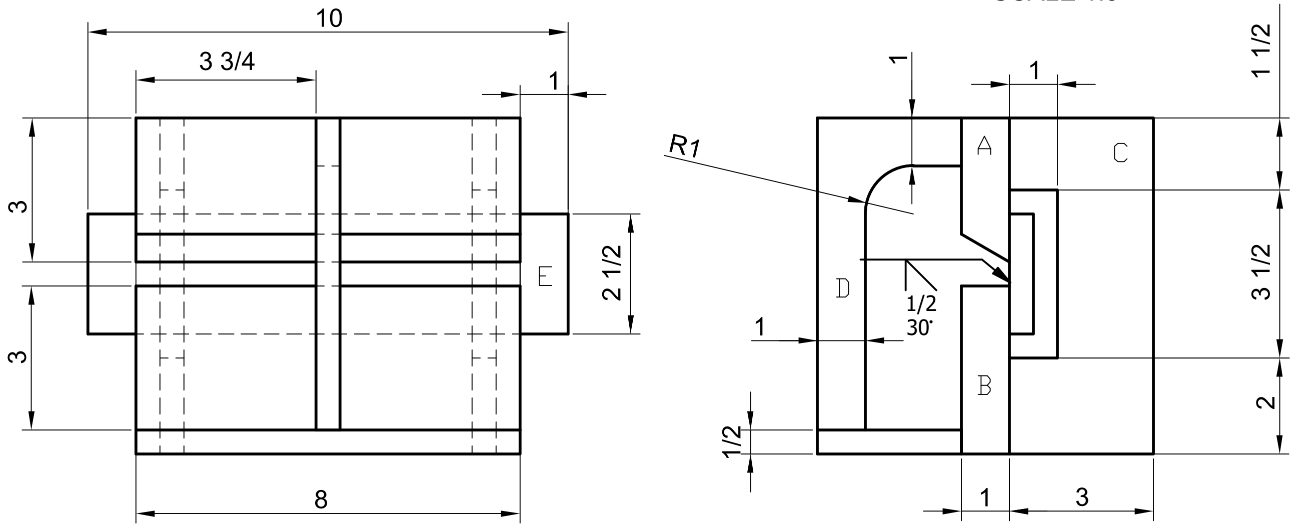
Part Two

This portion of the exam is a practical test where you will fabricate and weld a weldments from a "blue print." The evaluation of this portion of the exam will be based on the rubric.

GRADE	
TOLERANCES:	
DIMENTIONAL +/- 1/16 Angle +/- 5°	
ELECTRODE	
DIAMETER	
AMPERAGE	
VOLTAGE	
SHIELDING gas	N/A
POLARITY	



Note: Fillet welds and square groove can be welded in any position. Bevel groove to be welded in horizontal position



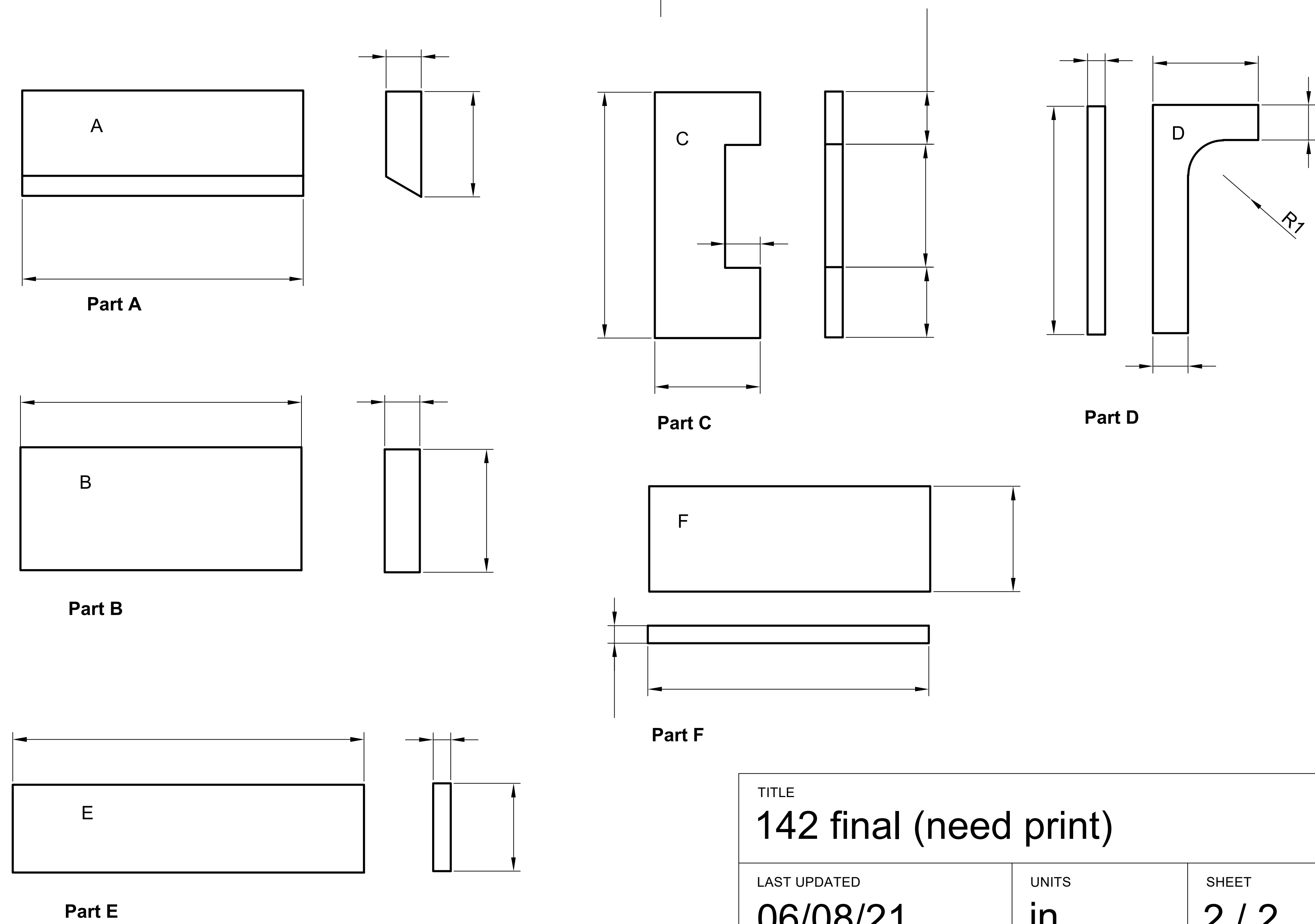
POSITION	2G

PROCESS	

PART LETTER	THICKNESS	WIDTH	TOLERANCE +/-	LENGTH	TOLERANCE +/-

TITLE
142 final - Horizontal Bevel Groove

LA ST UPDATED	UNITS	SHEET
06/07/21	in	1 / 1
THIRD ANGLE PROJECTION	SCALE 1:4	SIZE A



TITLE		
142 final (need print)		
LAST UPDATED 06/08/21	UNITS in	SHEET 2 / 2
THIRD ANGLE PROJECTION	SCALE 1:4	SIZE A

Final Grading Rubric for practical exam
Class Name: WLD 142

Name: ________________________________ Date: _______________________

Hold Points are mandatory points in the fabrication process, which require the inspector to check your work. You are required to follow the hold points.

Points Possible	***Hold Points***	***Instructor's Evaluation***
5 points	**Blueprint Interpretation and Material Cut List** 5 points = 0 errors, all parts labeled and sized correctly 3 points = 1 error in part sizing and/or identification 2 points = 2 errors 1 point = 3 errors 0 points = 4 or more errors	
10 points	**Material Layout and Cutting (Tolerances +/- 1/16")** 10 points Layout and cutting to +/-1/16" Smoothness of cut edge to 1/32" 7 points Layout and cutting to +/- 1/8" Smoothness of cut edge to 1/16 **REWORK REQUIRED IF OUT OF TOLERANCE BY MORE THAN 1/8 INCH**	
10 points	**Fit-up and Tack weld (Tolerances +/- 1/16")** 10 points Tolerances +/- 1/16" Straight and square to +/-1/16" 7 Points Tolerances +/- 1/8" Straight and square to +/-1/8" **REWORK REQUIRED IF OUT OF TOLERANCE BY MORE THAN 1/8 INCH**	
15 points	**Weld Quality** Subtract 1 point for each weld discontinuity, incorrect weld size and incorrect spacing sequence.	
28 points	***Minimum points acceptable. This equates to the minimum AWS D1.1 Code requirements.***	
	Total Points	**/40**

WLD 142 FCAW: Project Assessment Form
Student Name:_________________ Date_________

Flat Position	Assessment	Instructor Signature/Date
T- Joint		

Horizontal Position	Assessment	Instructor Signature/Date
T-Joint		
Single Bevel Groove		

Vertical Position	Assessment	Instructor Signature/Date
T-Joint		
V- Groove		

Overhead Position	Assessment	Instructor Signature/Date
T-Joint		
V-Groove		