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

Index

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Opinions expressed are those of the authors
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Course Assignments

Reading

Welding Principles and Applications 7th edition By Larry Jeffus
Chapter 14, Other Constant-Potential Welding Processes
Chapter 13, Flux Cored Arc Welding

Math

Practical Problems in Mathematics 6th edition by Robert Chasan
Chapter 33, Volume of Cylindrical and Complex Containers
Chapter 34, Mass (Weight) Measure

Recommended assignments

Complete review question following each assigned chapter

Quizzes

Complete Interactive Quiz in CourseMate for each assigned chapter

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
- **Flux Cored Arc Welding Handbook** by William H. Minnick
- **D1.1 Structural Steel Code Book** by the American Welding Society

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.

Accessing the Interactive ebook for Principles and Applications and Practical Problems in Mathematics

Here is a link to the publishers website that goes over some “getting started” procedures with CourseMate.
http://www.cengage.com/tlconnect/client/product/fcis.do?productId=535

For New Students

Your book bundle will contain an access code for both your Principles and Applications book and the Practical Problems in Mathematics.

For Returning Students

If you have the Seventh Edition of the Principles and Applications book you should have an access code. If not see your instructor. For the math book you will have to go to this site **http://www.cengagebrain.com/shop/isbn/9781111313593** and rent the ebook for either a six month or one year option.
Your math quizzes will be accessible through Desire 2 Learn. Your Instructor will assist you in accessing this.

Course Key There will be a master course key containing all of the courses available on CourseMate. You will find the course you are currently taking and enter the corresponding number in the appropriate area in CourseMate.

Note For each class there will be separate Access code and course key for Principles and Applications and Practical Problems in Mathematics

Science

on

Steel

The Welding Fabrication Industry needs qualified welder fabricators who can deal with a variety of situations on the job. This portion of the training packet explores science as it relates to industry requirements.

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

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

E71T-8 Electrode Technique and Parameters

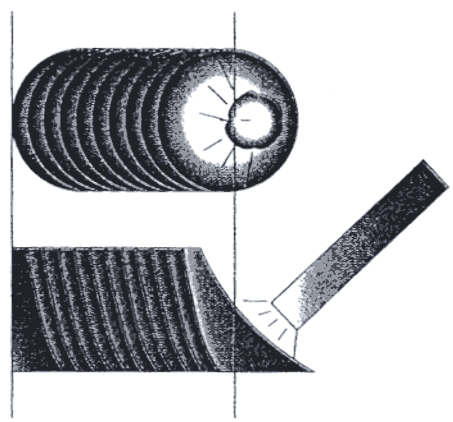
The electrode characteristics of the E71T-8 are:

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

Welding Technique Tips:

- Machine setting with a "balanced arc" is critical
- A minimal weave technique can be used but it can't be too wide, or advancement on the zigzag can't be too large either.
- When welding in the horizontal position it is best to use no weave unless absolutely necessary.
- ***Run the plate HOT***! *This helps activate the flux and the wire becomes more user friendly.*

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. Hence, the welder will burry slag and will not be able to pass a bend test.

The following information is courtesy of The Lincoln Electric Company.

INNERSHIELD NR-233 AWS A5.20-95: E71T-8

NR-233 is an advanced technology, self-shielded flux-cored electrode, designed for high deposition rate welding, even when out-of-position. The electrode is welder-friendly, making it easier to pass tough qualification tests and deposit great looking beads. It does all this while delivering Charpy V-Notch properties that meet many of the more stringent codes and specifications.

ADVANTAGE LINCOLN

- NR-233 uses Lincoln's proprietary Microflux™ technology that delivers outstanding "state-of-the-arc" performance.This ensures user-friendly results:
- **User-friendly for the engineer:** meets many of the more stringent codes and standards for Charpy V-Notch requirements, such as those listed in FEMA 353.
- **User-friendly for the superintendent:** higher deposition rates mean faster building erection, quicker launch of the barge, or more throughput in fabrication. In short: less cost and more profit.
- **User-friendly for the welder:** a more forgiving arc with greater penetration makes it easier to pass qualification tests, and makes for better quality welds in production - and the welds look great.
- NR-233 has been formulated to minimize gas marking, even after the electrode has been exposed to the atmosphere.
- A stiffer electrode than competitive alternatives, NR-233 feeds better with fewer production interruptions.

TYPICAL APPLICATIONS

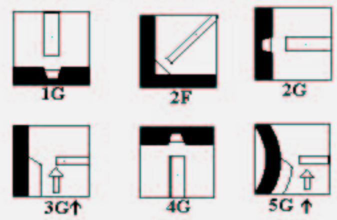
NR-233 performs best where self-shielded electrodes are ideal: windy field conditions where gas-shielded processes are impractical. And NR-233 outperforms the competition when high deposition rates are important - the bigger the weld, the better. Thus, typical applications include the following:

- Vertical up fillet and groove welds
- Overhead fillet and groove welds
- Seismic structural steel erection
- General structural steel erection
- Ship and barge fabrication

CONFORMANCE

AWS A5.20-95: E71T-8
ASME SFA-5.20: E71T-8

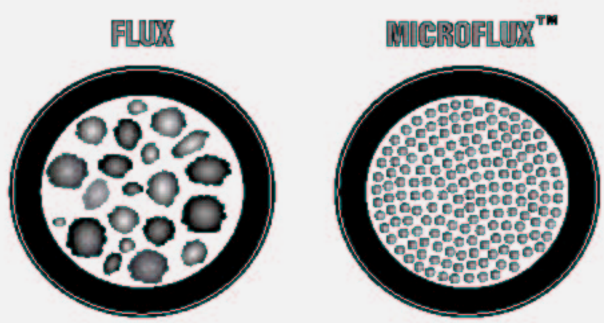
WELDING POSITIONS



WHAT IS MICROFLUX™

microflux

Forty years of Innershield™ technology and demand for ultra-high deposition rates come together in this revolutionary technology. Microflux technology consists of smaller, uniform particles with more surface area to pack more flux into less space. Precise control of flux sizing, flux delivery and flux chemistry delivers "state-of-the-arc" performance and user-friendly results.



DIAMETERS/PACKAGING

Diameter Inches (mm)	12.5 lb. (5.6 kg) Plastic Spool [50 lb. (22.6 kg) Master]	25 lb. (11.3 kg) Steel Spool
1/16 (1.6)	ED030933	ED030934

INNERSHIELD NR-233 AWS A5.20-95: E71T-8

MECHANICAL PROPERTIES [(1)] - *As Welded per AWS A5.20*

	Yield Strength psi (MPa)	Tensile Strength psi (MPa)	Elongation (%)	Charpy V-Notch ft-lbs (Joules) @ -20°F (-29°C)
Requirements AWS E71T-8	58,000 (400) min.	70,000 (480) min.	22 min.	20 (27) min.
Test Results	62,300 - 71,000 (430-490)	73,200 - 92,200 (505-635)	22 - 32	23 - 48 (31-65)

(1) The strength and elongation properties reported were obtained from a .505" tensile specimen artificially aged at 220° F (104° C) for 48 hours, as permitted by AWS A5.20-95. A naturally aged tensile specimen may take months to achieve the specified properties. See AWS A5.20-95, paragraph A8.3. The time required for the natural aging of weld deposits is dependent upon ambient conditions, weldment geometry, the metallurgical structure of the weld deposit and other factors.

TYPICAL OPERATING PROCEDURES [(1)]

Wire Diameter Polarity Wire Weight Shielding Gas CTWD [(1)]	Wire Feed Speed in/min (m/min)	Arc [(2)] Voltage (volts)	Approx. Current (amps)	Melt-Off Rate lbs/hr (kg/hr)	Deposition Rate lbs/hr (kg/hr)	Efficiency (%)
1/16"	150 (3.8)	17-19	220	5.3 (2.4)	4.2 (1.9)	80
DC-	200 (5.1)	19-21	245	7.1 (3.2)	5.4 (2.5)	76
0.582 lbs/1000" (10.3 g/m)	250 (6.4)	21-23	270	8.9 (4.0)	6.6 (3.0)	74
N/A	300 (7.6)	23-25	295	10.4 (4.7)	7.7 (3.5)	75
1" (25mm)	350 (8.9)	25-27	315	12.3 (5.6)	9.4 (4.3)	77

(1) To estimate ESO, subtract 1/4" (6mm) from CTWD.
(2) For horizontal welding, subtract 1 volt.

DEPOSIT COMPOSITION

	%C	%Mn	%P	%S	%Si	%Al
Requirements AWS E71T-8	Report Only	1.75 max.	0.04 max.	0.03 max.	0.90 max.	1.8 max.
Test Results	0.17-0.23	0.45-0.66	0.006-0.009	0.003	0.14-0.25	0.47-0.71

FEMA 353

This electrode has been tested in accordance with FEMA 353 - *Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications* and is capable of depositing weld metal that delivers minimum CVN properties of 40 ft-lbs. at 70° F (54 Joules at 21° C) at low and high heat input levels. As required by the AWS classification, it meets a minimum CVN of 20 ft-lbs. at -20° F (27 Joules at -29° C), when tested in accordance with AWS 5.20. This electrode will also deposit metal that will meet the requirements for H16 as tested according to AWS A4.3. FEMA certificates are available upon request.

TEST RESULTS

Test results for mechanical properties, deposit or electrode composition and diffusible hydrogen levels were obtained from a weld produced and tested according to prescribed standards, and should not be assumed to be the expected results in a particular application or weldment. Actual results will vary depending on many factors, including, but not limited to, weld procedure, plate chemistry and temperature, weldment design and fabrication methods. Users are cautioned to confirm by qualification testing, or other appropriate means, the suitability of any welding consumable and procedure before use in the intended application.

CUSTOMER ASSISTANCE POLICY

The business of The Lincoln Electric Company is manufacturing and selling high quality welding equipment, consumables, and cutting equipment. Our challenge is to meet the needs of our customers and to exceed their expectations. On occasion, purchasers may ask Lincoln Electric for advice or information about their use of our products. We respond to our customers based on the best information in our possession at that time. Lincoln Electric is not in a position to warrant or guarantee such advice, and assumes no liability, with respect to such information or advice. We expressly disclaim any warranty of any kind, including any warranty of fitness for any customer's particular purpose, with respect to such information or advice. As a matter of practical consideration, we also cannot assume any responsibility for updating or correcting any such information or advice once it has been given, nor does the provision of information or advice create, expand or alter any warranty with respect to the sale of our products.

Lincoln Electric is a responsive manufacturer, but the selection and use of specific products sold by Lincoln Electric is solely within the control of, and remains the sole responsibility of the customer. Many variables beyond the control of Lincoln Electric affect the results obtained in applying these types of fabrication methods and service requirements.

Subject to Change – This information is accurate to the best of our knowledge at the time of printing. Please refer to www.lincolnelectric.com for any updated information.

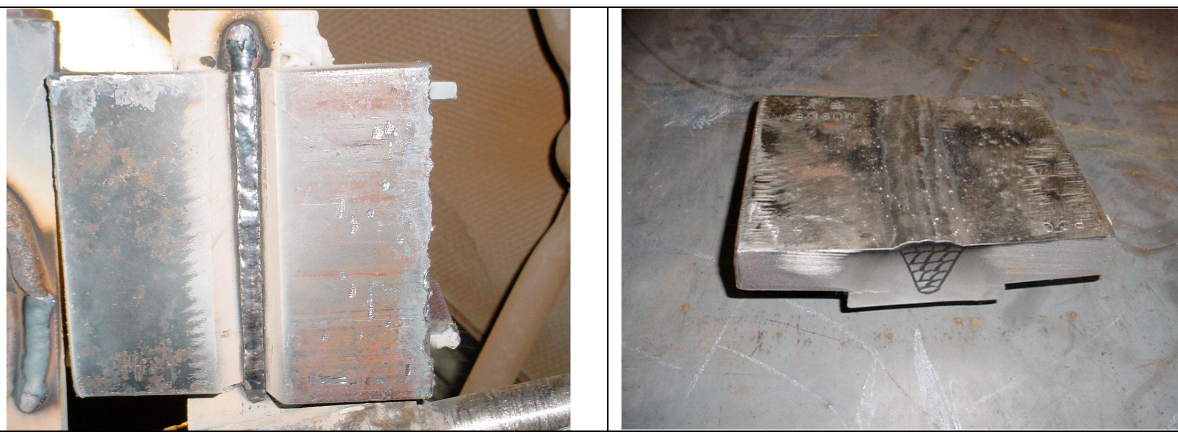
Craftsmanship Expectations for Welding Projects

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

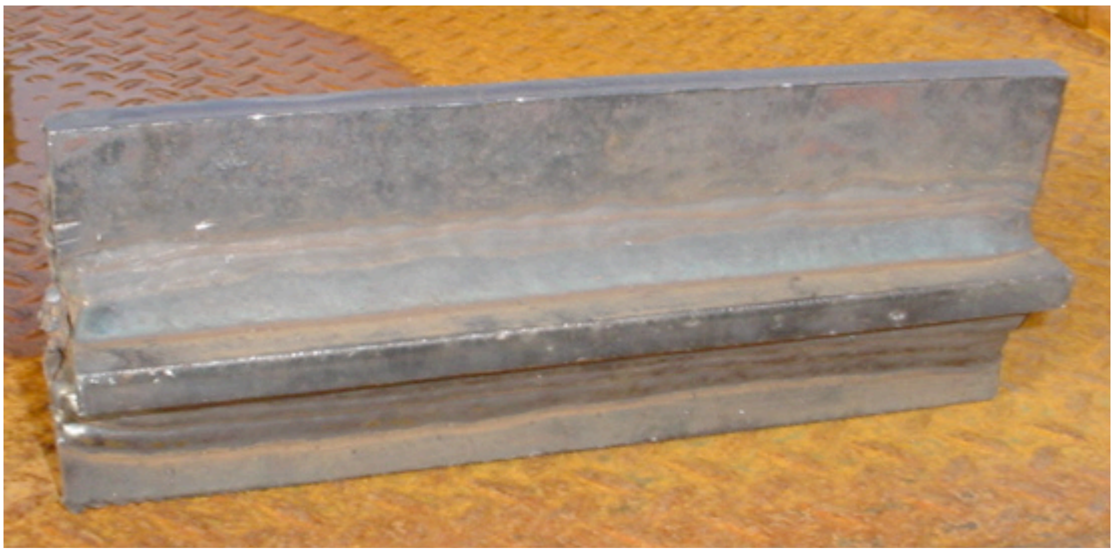
Weld Quality per AWS D1.1 Welder Qualification Tests

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 Horizontal T-Joint (2F) — Project #1

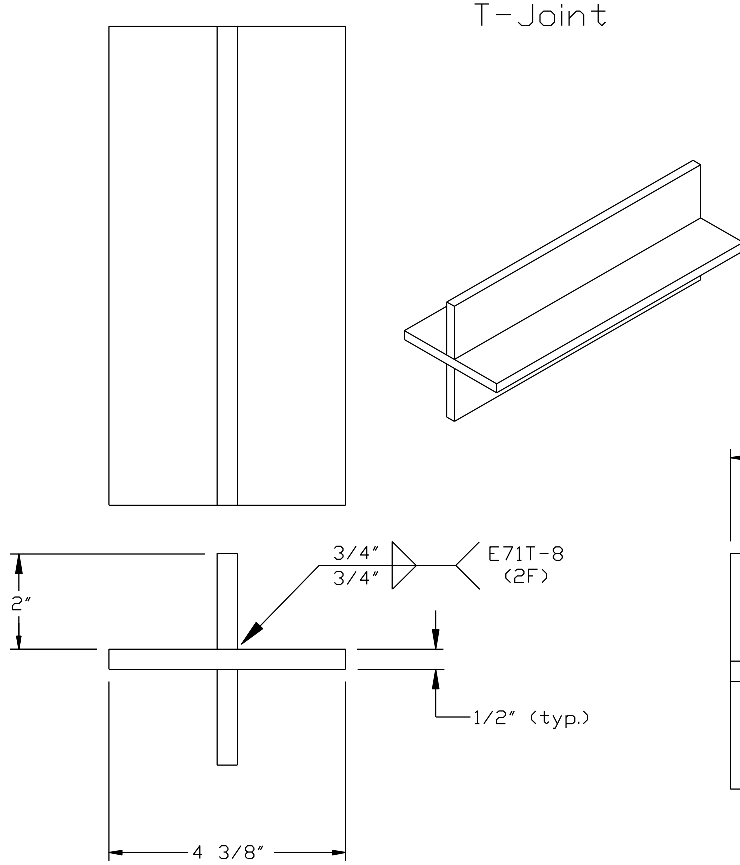
Welding Sequence

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.



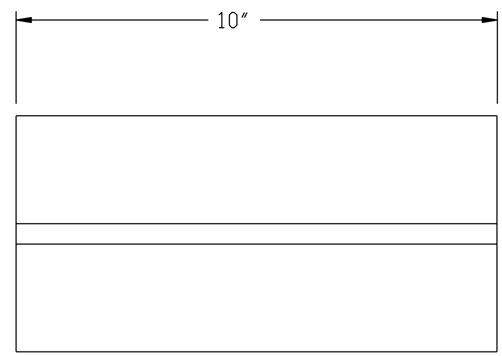
VT Criteria	Student Assessment	Instructor Assessment
Reinforcement (0" –1/8")		
Fillet Weld Size		
Undercut (1/32")		
Bead Contour (smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade Date

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 ———— 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 (WxHxL)	S.I. Conversion

Portland Community College
Welding Technology

Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Chk By: Tanner Scott Date: 6/29/09

WLD 142-01 HORIZONTAL (2F)

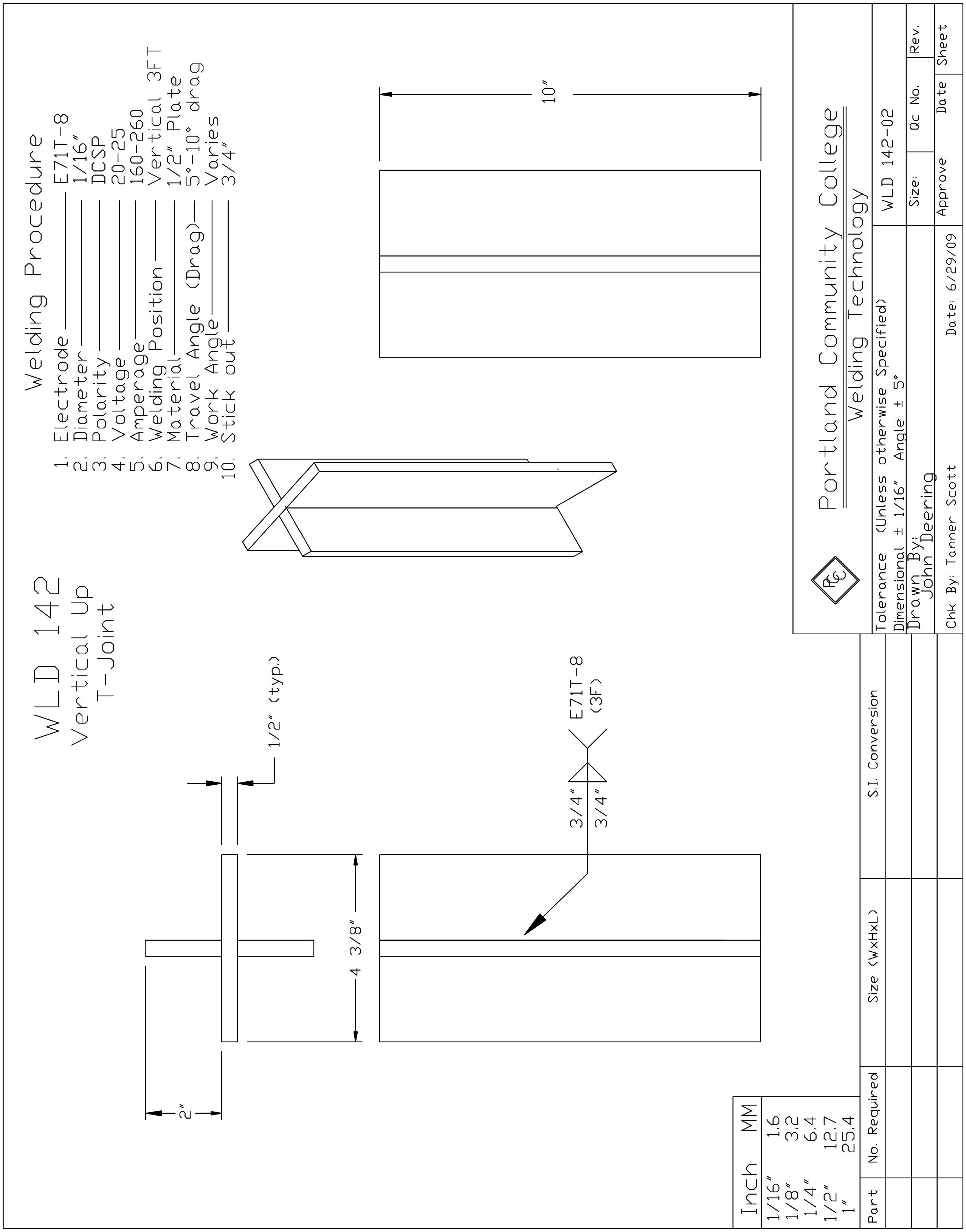
Size:	Qc No.	Rev.
Approve	Date	Sheet

E71T-8 Vertical T-Joint (3F) 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
Vertical Up
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 3FT
7. Material — 1/2" Plate
8. Travel Angle (Drag) — 5°-10° drag
9. Work Angle — Varies
10. Stick out — 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 (WxHxL)
S.I. Conversion
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By:
John Deering
Chk By: Tanner Scott
Date: 6/29/09
WLD 142-02
Size:
Qc No.
Rev.
Approve
Date
Sheet

E71T-8 Overhead T-Joint (4F) Project #3

Welding Sequence

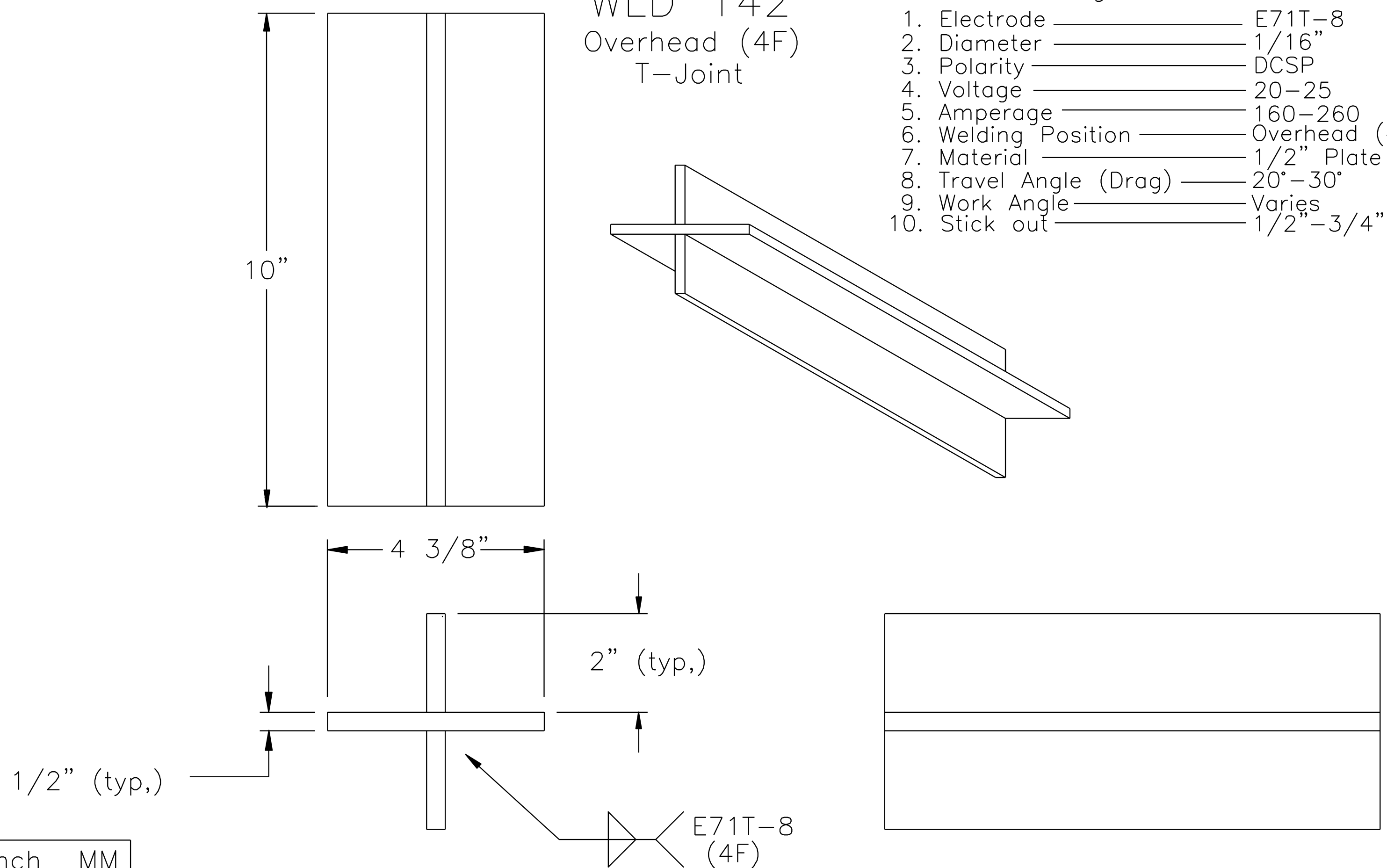
E71T-8-- Root Pass	Single pass technique with slight weave to ensure the weld metal is fusing into both pieces of metal.
E71T-8—Fill	Use the split bead technique with stringer beads ensuring even fill.
E71T-8—Finish Beads	Use stringer bead technique keeping the electrode in the puddle at all times.

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
Overhead (4F)
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 — Overhead (4F)
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 (WxHxL)	S.I. Conversion

Portland Community College
Welding Technology

Tolerance (Unless otherwise Specified) Dimensional ± 1/16” Angle ± 5°	WLD 142–03		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Date: 10/01/03	Approve	Date	Sheet

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.

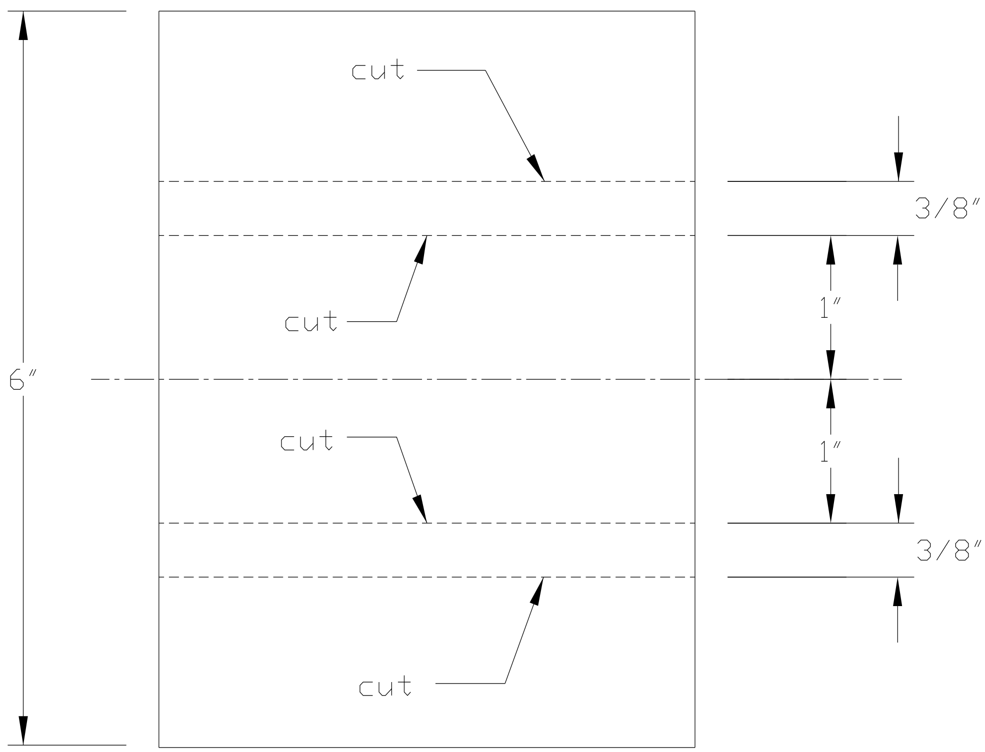
10. Actuate the machine by the lever on top of the machine and stand clear of end where the coupon will exit.

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

Bend Test Procedure
For 1" Test Plate

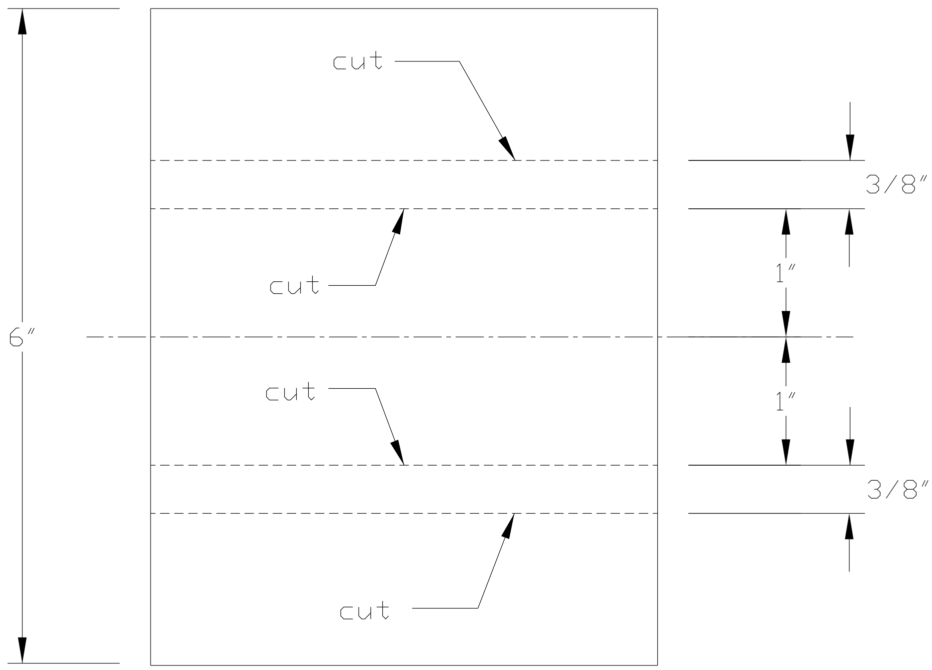
Bend tests are used to determine the ductility and soundness of a weld joint. The test will allow the welder to determine if she or he has obtained fusion in the weld joint. Use the following procedure in preparing and bending your coupons.

1. Flush back up strip off of the plate at the flushing station.

2. Layout four 3/8" coupons and cut using the track burner**. Do Not Bend** coupons greater than 3/8 " thick it will damage the dies in the bending machine!

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

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

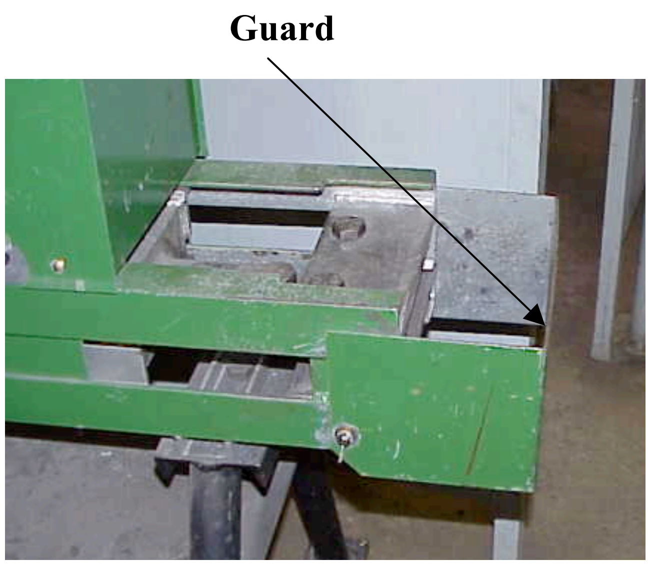
3. Grind coupon's smooth, ensuring grinding marks are going with the length of the coupon's and all edges are rounded.

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

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

Watts Bend Test Machine

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

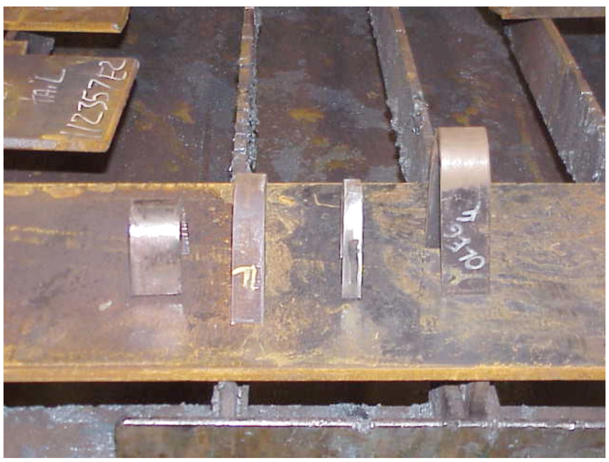


8. Place coupon in the machine taking care not to position your hands/fingers in the way. Locate weld in the center of the die. Bend one coupon (from each plate) to test the face and one to test the root.

9. Actuate the ram by the lever on top of machine and stand clear of the guard area where coupon will exit.

10. Inspect the convex surface of the bend specimen for fusion type defects.

<u>Reference the AWS D1.1 Structural Welding Code for Acceptance Criteria for Bend Tests</u>.



Four types of bend samples are shown above. Left to right are: face bend, face bend, root bend and a side bend

The bend samples shown above differ in the radius that they were bent. This is a requirement set forth by the code or standard that is being used.

E71T-8 Horizontal Groove Weld (2G) — 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.

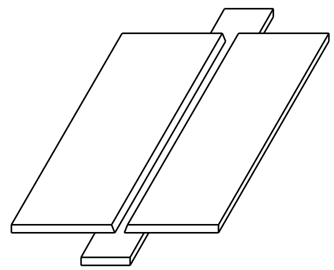
VT Criteria	Visual Inspection	Bend Tests
Reinforcement (0" –1/8")		
Fillet Weld Size		
Undercut (1/32")		Acceptable
Bead Contour (smooth)		
Penetration		
Cracks (none)		Not Acceptable
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade Date

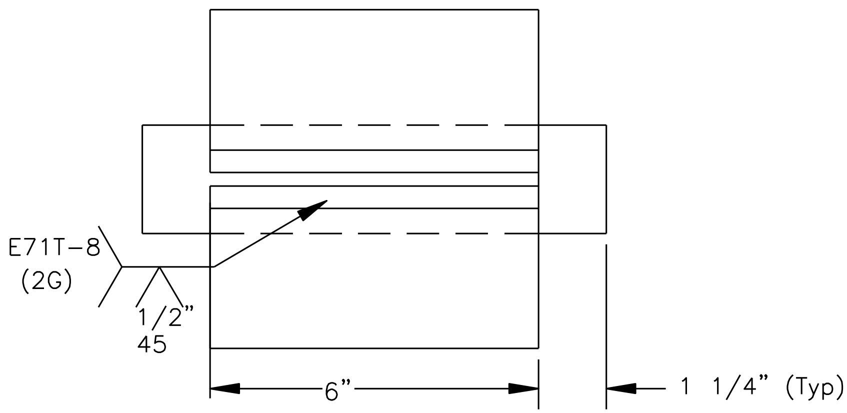
WLD 142

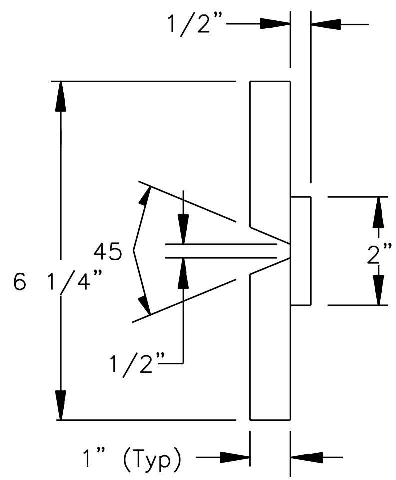
Horizontal Groove (2G)

Welding Procedure

1. Electrode — E71T-8
2. Diameter — 1/16"
3. Polarity — DCSP
4. Voltage — 19-25
5. Amperage — 160-240
6. Welding Position — Horizontal (2G)
7. Material — 1" Plate
8. Travel Angle (Drag) — 20°-30°
9. Work Angle — Varies
10. Stickout — 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 (WxHxL)	S.I. Conversion

Portland Community College
Welding Technology

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

WLD 142-06

Size:	Qc No.	Rev.
Approve	Date	Sheet

Drawn By:
John Deering

Chk By: Tanner Scott Date: 6/29/09

E71T-8 Vertical Groove Weld (3G) — Project #5

Welding Sequence

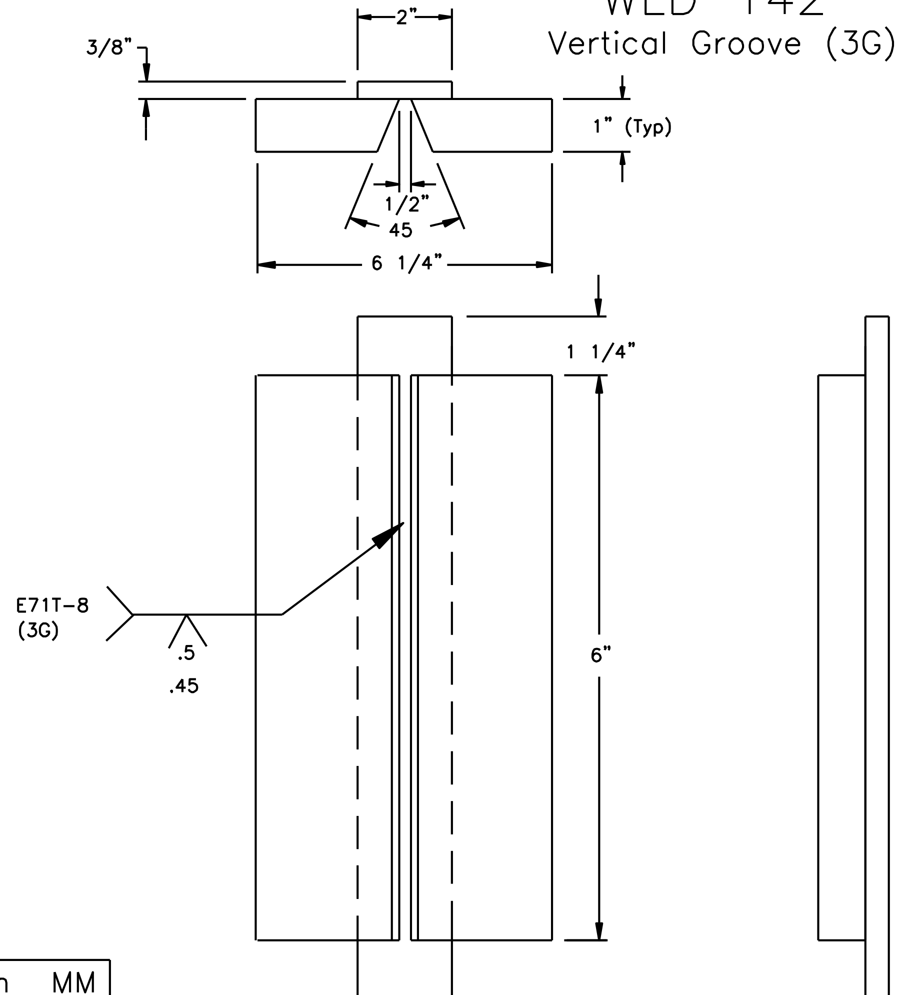
E71T-8-- Root Pass	Single pass technique with slight weave to ensure the weld metal is fusing into both pieces of metal.
E71T-8—Fill	Use the split bead technique with stringer beads ensuring even fill.
E71T-8—Finish Beads	Use stringer bead technique keeping the electrode in the puddle at all times.

<table>
<tr><th>VT Criteria</th><th>Visual Inspection</th><th>Bend Tests</th></tr>
<tr><td>Reinforcement (0” –1/8”)</td><td></td><td rowspan="9">Acceptable

Not Acceptable</td></tr>
<tr><td>Fillet Weld Size</td><td></td></tr>
<tr><td>Undercut (1/32”)</td><td></td></tr>
<tr><td>Bead Contour (smooth)</td><td></td></tr>
<tr><td>Penetration</td><td></td></tr>
<tr><td>Cracks (none)</td><td></td></tr>
<tr><td>Arc Strikes (none)</td><td></td></tr>
<tr><td>Fusion (complete)</td><td></td></tr>
<tr><td>Porosity (none)</td><td></td></tr>
<tr><td></td><td></td><td>Grade   Date</td></tr>
</table>

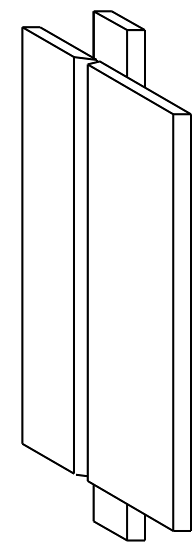
WLD 142

Vertical Groove (3G)



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 (3G)
7. Material —— 1" Plate
8. Travel Angle (Drag) —— 20°-30°
9. Work Angle —— Varies
10. Stick out —— 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 (WxHxL)	S.I. Conversion

Portland Community College

Welding Technology

Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle ± 5°	WLD 142-04		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Tanner Scott Date: 6/29/09	Approve	Date	Sheet

E71T-8 Overhead Groove Weld (4G) 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.

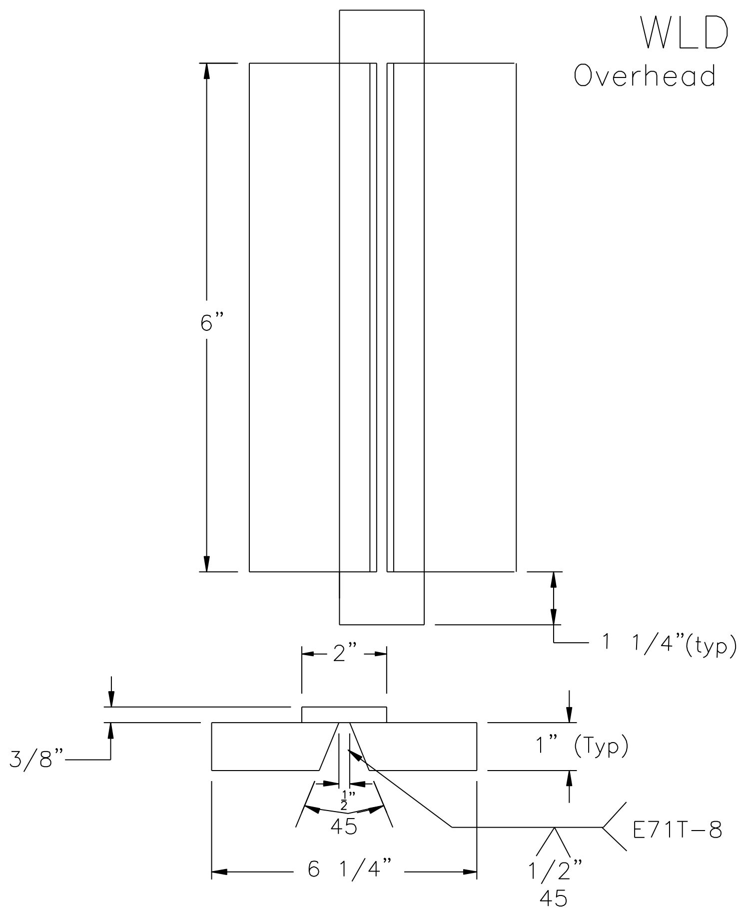
VT Criteria	Visual Inspection	Bend Tests
Reinforcement (0" –1/8")		Acceptable Not Acceptable
Fillet Weld Size		
Undercut (1/32")		
Bead Contour (smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade Date

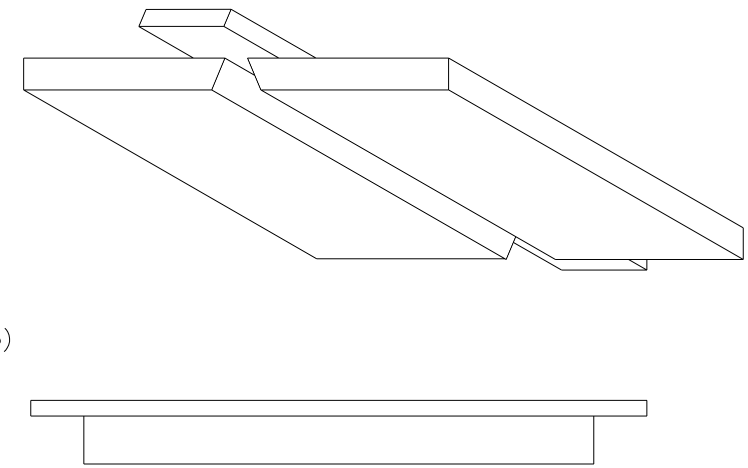
WLD 142

Overhead Groove (4G)

Welding Procedure

1. Electrode — E71T-8
2. Diameter — 1/16”
3. Polarity — DCSP
4. Voltage — 20-25
5. Amperage — 160-260
6. Welding Position — Overhead (4G)
7. Material — 1” Plate
8. Work Angle — Varies
9. Root Opening — 5/8”
10. Stick out — 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 (WxHxL)	S.I. Conversion

Portland Community College
Welding Technology

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

Drawn By:
John Deering

Chk By: Tanner Scott Date: 9/29/09

WLD 142-05

Size:	Qc No.	Rev.
Approve	Date	Sheet

Final Exam

Part One
This portion of the final exam is a closed book test. You may use the review questions you completed at the end of the assigned chapters as a cheat sheet. Consult with your instructor to determine items that you may need to review. Once you determine that you are ready for the exam, see your instructor.

Study Guide

Safety

- Oxyacetylene safety
- FCMAW safety
- Hand Tool Safety

FCAW and OAC Processes

- Power source specifics
    - Polarity
    - Current out put
    - Welding gun components
    - Wire feed components
    - Types of transfers
    - Electrode Extension
    - Shielding gases
- AWS electrode classification
- OAC
    - Theory of cutting
    - Flame types
    - Safety

Welding Symbols and Blueprints

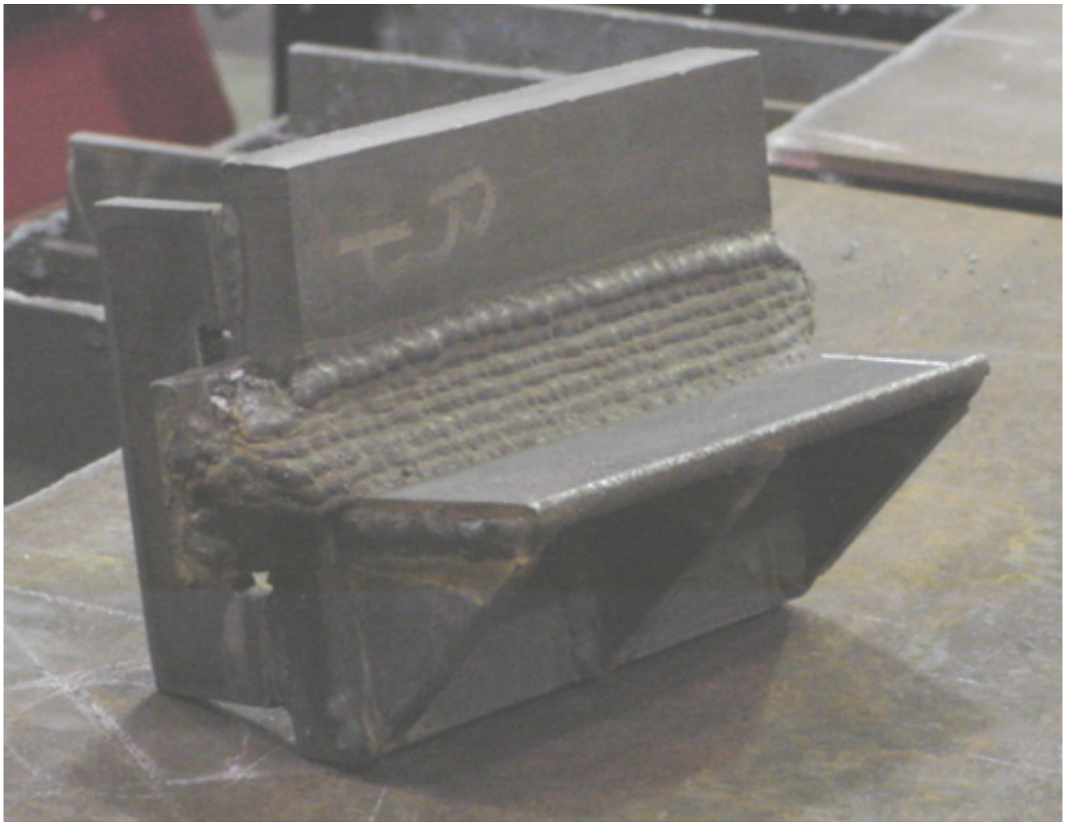
- Orthographic views
- Isometric views
- Welding symbol
    - Weld symbols
    - Reference line
    - Tail

Math and Math conversions

- Adding and subtracting fractions
- Reading a tape measure
- Metric conversions

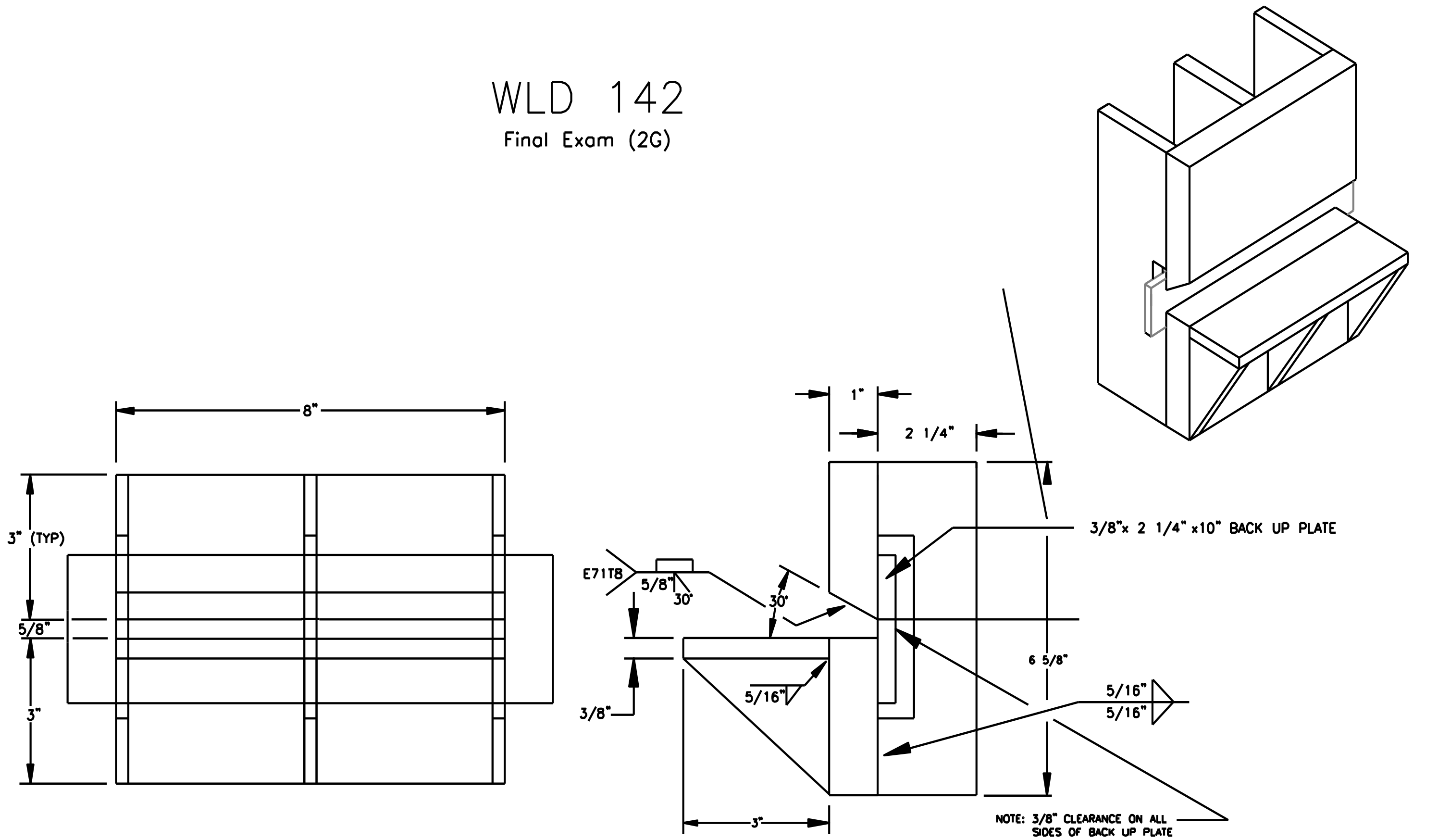
Part Two

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 ***Traveler.***



WLD 142

Final Exam (2G)



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: Tanner Scott

Date 6/29/09

WLD 142–Final Exam

Size: Qc No. Rev.

Approve Date Sheet

Grading Traveler for the WLD 142 Practical Exam

Name:________________________________ Date______________________

Hold Points are mandatory points in the fabrication process, which require the inspector to check your work. You will have the following hold points that you instructor will check

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 or more rework required (max points)	
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" 5 points (Rework required max points) Layout and cutting to +/-3/16" Smoothness of cut edge to 3/32"	
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" 5 Points (Rework required - Max points) Tolerances +/- 3/16" Straight and square to +/-3/16"	
15 points	**Weld Quality** Subtract 1 point for each weld discontinuity, incorrect weld size and incorrect spacing sequence.	
35 points	***Minimum points acceptable. This equates to the minimum AWS D1.1 Code requirements.***	
	Total Points	**/40**

Final Grades - WLD 142

Name: __________________ Instructor: ____________________ Date: ___________________

Name: __________________ Instructor: ____________________ Date:

Welding Projects = 40%

Out of 10	Out of 10	Out of 10
Out of 10	Out of 10	Out of 10
Out of 10	Out of 10	~~Out of~~
Out of 10	Out of 10	~~Out of~~
Out of 10	Out of 10	~~Out of~~
Out of 10	Out of 10	~~Out of~~

A Total Project pts. _________ / Total pts. Possible _______ X 40 = **_______ %**

Quizzes = 20%

Out of	Out of	Out of
Out of	Out of	Out of
Out of	Out of	Out of

B Total Project pts. _________ / Total pts. Possible _______ X 20 = **_______ %**

Attendance = 10% The following attributes will be assessed - attendance, attitude, time management, team work, interpersonal skills, etc.. Daily points (there are no excused absences, hence no points earned for days missed) 3 pts = present and working for the entire shift; 2 pts = late; 1 pt = late and left early; 0 pts = no show.

Final Exams 30%

Out of	Out of	Out of	Out of	Out of	Out of
Out of	Out of	Out of	Out of	Out of	Out of
Out of	Out of	Out of	Out of	Out of	Out of

D Total pts. earned _________ / Total pts. Possible _______ X 10 = **_______ %**

Written Exam	Out of
Practical Exam	Out of

E Total Project pts. _________ / Total pts. Possible _______ X 30 = **_______ %**

Total %	
Final Grade	