

***WLD 114***  
***Shielded Metal Arc Welding:***  
***Mild Steel III (E6011)***



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 114

Course Title:  
Shielded Metal Arc Welding: Mild Steel III (E6011)

Credit Hours:  
4

Lecture Hours:  
0

Lecture/Lab Hours:  
80

Lab Hours:  
0

Special Fee:  
\$24.00

## Course Description

Develops knowledge and skills in the use of E6011 mild steel electrodes when performing various welds in the flat, horizontal and vertical positions. Prerequisites: Department approval required. Audit available.

## Addendum to Course Description

This is a outcome based course utilizing a lecture/lab format. This course includes classroom discussions, computer based instruction, and lab demonstrations covering 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 fundamentals of SMAW E6011 operations.
- Interpret blueprints to accurately lay out, prepare, and assemble weld joints.
- Weld common joint assemblies with the E6011 electrode to AWS D1.1 Structural Steel Welding Code.
- Apply visual 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, observation, written assignments, visual inspection techniques, 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, operation and shutdown procedures for oxy-fuel hand cutting
- Demonstrate correct setup, operation and shutdown procedures for oxy-fuel track cutting

Understand and apply fundamentals of SMAW E6011 operations.

- Describe and demonstrate equipment setup, shut down and operation
- Identify Electrode Characteristics
- Demonstrate proper Arc Length and Travel speed
- Demonstrate correct starting, stopping and restarting techniques
- Demonstrate proper bead placement

Interpret blueprints to accurately layout, 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 specifications

Weld common joint assemblies with the E6011 electrode to AWS D1.1 Structural Steel Welding Code in the following joint configurations and positions.

- Flat Position
  - Bead plate
  - T-joint
  - Corner joint
- Horizontal position:
  - T-joint
  - Lap joint
  - Outside corner joint
  - Single V groove
- Vertical position:
  - T-joint

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

- Evaluate welds using appropriate welding inspection tools
- Assess weld discontinuities causes and corrections

## Science On Steel

### Contents of this Packet

- Characteristics of E6011 Electrodes
- Why is E6011 a High-Hydrogen Electrode?
- How is Heat-Affected Zone Cracking Possible?
- Mechanical Properties of Weld Metal deposited by SMAW with E6011
- Codes Accepting E6011 Cellulosic Electrodes
- Hydrogen Designators by AWS
- Flux Composition of E6011 Electrode
- Baking of E6011 Electrodes is Forbidden

### Characteristics of E6011 Electrodes

E6011 is a fast-freeze, all-position AC-DC electrode. For most applications, E7011 is used with AC current primarily to avoid arc blow problems. This electrode is typically used with a medium to short arc length, with a travel angle of 5° to 15° in the direction of travel. It is a low-slag electrode for tack welding, for vertical-down welding, making stringer beads, bridging gaps, AC pipe welding, square edge butt welding, welding on galvanized steel, sheet metal edge, corner and butt welding, and many other applications. The molten weld metal is protected from the surrounding air primarily by the rapidly expanding gases and a thin slag layer, which must be removed after each pass. The gas component of shielding is provided by 20%-40% cellulose in the flux coating of E6011 electrodes, as shown in Table 1. With substantial gaseous protection, open roots can be welded with E6011, even though E6011 does not have the deep penetration power of the E6010 electrode.

Although E6010 can penetrate steel greater than similar E6011 electrodes, both E6010 and E6011 electrodes are considered to be deep-penetration electrodes, because of the high cellulose content in the flux cover. As shown in Table 1, E6011 contains much more potassium than does E6010 because E6011 is designed for AC welding. The potassium provides arc stability during the arc-off times during the AC current cycle. Potassium is added to the E6011 flux cover in the form of potassium titanate and potassium silicate as shown in Table 1. Potassium provides outstanding arc stability for AC welding because potassium has such a low ionization potential that it remains conductive in the arc atmosphere even though the arc shut off 120 times per second.

**Table 1** Ingredients in Flux Covering on E6011 Electrodes for SMAW  
(Olson et al, ASM International Handbook, 1993, Vol. 6, pp. 55-63)

Ingredient	Purpose
25-40% Cellulose	gas shielding
10-20% Rutile	slag former & arc stabilizer
2-5% Potassium titanate	arc stabilizer for AC current
10-20% Asbestos	slag former & extrusion
5-10% Ferromanganese	alloying & deoxidizer
20-30% Potassium silicate	arc stabilizer & binder

In the arc, the cellulose immediately breaks down into carbon dioxide (CO<sub>2</sub>) and hydrogen (H<sub>2</sub>) gases, which both promote deep penetration. CO<sub>2</sub> and particularly H<sub>2</sub> have

high ionization voltages to provide the highest penetration. That is, CO<sub>2</sub> and H<sub>2</sub> require high voltages to establish a stable conducting arc. As a result, this higher voltage provides substantially increased arc energy input (or heat input) during welding. Arc energy input (H) is defined as:

$$H = EI / v$$

Where:  
“E” is the arc voltage in volts  
“I” is the arc current in amps  
“v” is the travel speed in mm/s

Using E6011 and E6010 electrodes, the penetration increases with increasing cellulose content. Since E6011 is designed to be used primarily with AC power, the cellulose content and resulting penetration provided by E6011 is less than that for E6010. As mentioned above, potassium is absolutely necessary to provide arc stability for AC welding with E6011. Although E6011 is primarily an AC electrode, it can still be used in many open root pipe welding applications and is immune to arc blow situations.

#### ***Why is E6011 a High-Hydrogen Electrode?***

Although cellulosic electrodes have excellent operability, arc characteristics, and “welder appeal”, many codes ban the use of E6010 and E6011 electrodes because of their uncontrollably high hydrogen content. Unlike low-hydrogen electrodes like E7018, the high-hydrogen E6011 electrodes may cause hydrogen-assisted cracking in the weld metal and heat-affected zone of thick and high strength steels.

The single greatest source of hydrogen in welds deposited by E6011 electrodes is the cellulose flux covering. Other less voluminous sources of hydrogen contamination, which are avoidable with good workmanship practices, include: oil, grease, paint, dirt, moisture-absorbing rust and other hydrogen-containing materials. Cellulose as well as oil and grease are hydrocarbons, which dissociate into atomic hydrogen and carbon dioxide during welding. Although hydrogen improves penetration and arc stability, it does cause serious cracking in the heat-affected zones of welds deposited on thick and/or high strength steels. Thus, E6011 electrodes can only be used on low carbon mild steels particularly in thin sections.

#### ***How is Heat-Affected Zone Cracking Possible?***

Although most hydrogen enters the weld metal via the cellulosic flux, hydrogen cracking usually takes place in the higher strength heat-affected zone. How is it possible for the heat-affected zone to crack when the hydrogen comes from the weld metal? Hydrogen is the smallest atom in the universe and is “interstitial” in iron, so hydrogen can diffuse in steel rapidly even at room temperature. In a matter of minutes large quantities of hydrogen atoms diffuse into the heat-affected zone during and after welding. These interstitial hydrogen atoms are so small compared to the iron atoms that they can diffuse between the iron atoms. That is, the iron atoms do not move while the hydrogen atoms diffuse between the iron atoms even at room temperature. As a result, both the weld metal and heat-affected zone of a steel weld are susceptible to hydrogen-assisted cracking. Usually, the heat-affected zone is much higher hardness than the weld metal so

the heat-affected zone is more susceptible to hydrogen assisted cracking. Because it takes time for hydrogen to diffuse through the weld and heat-affected zone, cracking is usually “delayed” and may take place up to 72 hours after welding. Thus, hydrogen-assisted cracking is also called “delayed cracking”.

### ***Mechanical Properties of Weld Metal deposited by SMAW with E6011***

The specified composition and mechanical properties of weld metal deposited by E6011 are listed in Table 2. Weld metal deposited by SMAW using E6011 electrodes provides excellent strength, ductility and soundness, but not Charpy v-notch impact toughness and not resistance to hydrogen-assisted cracking. As a result, the specification AWS A5.1 does not specify either Charpy impact toughness or weld metal composition as shown in Table 2.

### ***Codes Accepting E6011 Cellulosic Electrodes***

Most pipe welding codes and AWS D1.1 Structural Welding Code allow E6011 electrodes for SMAW applications in fabrication, construction and pipe welding. Because E6011 is a “high” hydrogen electrode, weld metal and heat-affected zones will be susceptible to hydrogen assisted cracking. To prevent such cracking, preheating of thick sections must be performed in strict accordance with Table 3. From Table 3, only the steels listed are permitted to be welded by E6011 electrodes. For example, if E6011 is used to weld 1-inch thick A36 steel, the required preheat temperature in Table 3 is 150°F (minimum). If this same steel were welded with a low hydrogen electrode like E7018, no preheating would be required (as long as ambient temperature is 50°F or greater).

**Table 2** Composition and Mechanical Properties of Weld Metal Required by AWS A5.1 deposited by SMAW using E6011 Electrodes

<b>E6011 Composition of Weld Metal (wt %)</b>	<b><u>Required by AWS A5.1</u></b>	<b><u>Typical</u></b>
<b>Mechanical Properties of Weld Metal</b>	Tensile Strength: 62ksi (430MPa) min Yield Strength: 50ksi (340MPa) min % Elongation: 22% min CVN Toughness: Not Specified	Tensile Strength: 77 ksi (531MPa) Yield Strength: 67 ksi (462MPa) % Elongation: 22% CVN Toughness: 25ft-lbs @ -20° F

Cellulose is a major ingredient in the flux coating of the E6011 electrode. Unlike E7018 low-hydrogen electrodes, E6011 electrodes provide substantial gaseous shielding but little slag shielding. E6011 is designed primarily for AC welding; however, it can be use with DCRP (DCep) when additional penetration is needed.

Welding codes, that require high toughness weld metal, strictly prohibit the use of any cellulosic electrodes. For example, the use of E6010 and E6011 are forbidden in bridge construction per AASHTO/AWS D1.5 Bridge Welding Code. Cellulosic electrodes are allowed in pipe lines for two important reasons: (1) outstanding operability of E6010 and E6011 electrodes particularly for root passes, and (2) preheating in pipeline welding is commonly applied to eliminate the possibility of hydrogen-assisted cracking.

***Hydrogen Designators by AWS***

Currently, there is no definition that specifies the amount of hydrogen that is permitted in cellulosic as-deposited weld metal. Cellulosic electrodes like E6011 typically produce large volumes of hydrogen; for example, 35ml/100g of weld metal. For comparison, “Low hydrogen” electrodes can actually mean a wide range of hydrogen from 2 to more than 12ml/10g. It has been shown that “low” hydrogen levels as high as 12 ml/100g can cause extensive severe cracking in high strength steels; while, similar welds deposited with electrodes containing only 4ml/100g of hydrogen is crack-free. As a result, the American Welding Society (AWS) developed a new optional Hydrogen Designator System. These designators, however, do not apply to high hydrogen electrodes like E6010 and E6011.

**Table 3** Steel Types and Minimum Preheat/Interpass Temperatures for SMAW with

E6011 Electrodes specified by AWS D1.1 Structural Welding Code

Steel Specification and Grade	Thickness Range	Minimum Preheating Temperature
ASTM A36; ASTM A53; B ASTM A106; B ASTM A131; A, B, CS, D, DS, E ASTM A139; B ASTM A381; Y35 ASTM A500; A, B ASTM A501 ASTM A516 ASTM A524; I, II ASTM A529 ASTM A570; all grades ASTM A573; 65 ASTM A709; 36 ASTM A808 API 5L; B, X42 ABS; A, B, D, CS, D, DS, E	Up to ¾ in. (19mm)  Over ¾ in. (19mm) thru 1 ½ in. (38.1mm)  Over 1 ½ in. (38.1mm) thru 2 ½ in. (63.5mm)  Over 2 ½ in (63.5mm)	None  150° F (66° C)  225° F (107° C)  300° F (150° C)

***Baking of E6011 Electrodes is Forbidden***

Unlike E7018 low hydrogen electrodes, baking of E6010 and E6011 electrodes is forbidden. The cellulose and moisture in E6011 are degraded with baking. Baking causes the flux cover to shrink and crack excessively. This is why E6010 and E6011 electrodes are stored in open-air containers. Conversely, E7018 electrodes are stored in baking ovens to maintain low hydrogen.



## *Information Sheet on Selecting an Electrode*

### Things to Consider

#### Metal Thickness

- Position
- Condition (oily, greasy, painted)
- Joint design

#### Service Application

- Part goes into a static or dynamic situation (i.e. how does it handle vibration stresses).

#### Bead Appearance

#### Metal's Susceptibility to Cracking

- High carbon content (above 0.35% Carbon)

What does the Welding Procedure Specification (WPS) specify

### Electrode Characteristics Chart

	<b>6010 or 6011</b>	<b>7018</b>	<b>7024</b>
<b>As Welded Strength</b>	60,000 psi tensile strength	70,000 psi tensile strength	70,000 psi tensile strength
<b>Welding Positions</b>	All Position	All Position	Flat and Horizontal
<b>Flux Type</b>	Cellulose	Lime - Fluorine	Rutile
<b>Current</b>	6010 = DCRP 6011 = AC or DCRP	DCRP	DCRP
<b>Arc Characteristics</b>	Aggressive	Medium	Soft
<b>Slag Consistency</b>	Light	Medium	Heavy
<b>Toughness vibratory stress</b>	Good	Excellent	Good

## ***EXX10 and EXX11 Fast Freeze Electrode Information***

### **General Uses**

- Welding Carbon Steel (mild steel)
- General purpose fabrication and maintenance welding
- Out of position welding
- X-ray quality
- Pipe welding - cross-country, in-plant, and non-critical small diameter piping
- Best choice for the following steel conditions: Galvanized, plated, dirty, painted, or greasy material
- Joints requiring deep penetration

### **Arc Characteristics**

- Truly all-purpose: particularly good for vertical and overhead.
- Light slag with little slag interference for easy arc control.
- Deep penetration with maximum admixture.
- Appearance: flat beads with distinct ripples.

### **Welding Techniques**

#### **Polarity**

Unless otherwise specified, use DCEP, with Exx10 and DCRP or AC with Exx11. The Exx11 electrodes can also be used with AC. Always adjust current for proper arc action and control of weld puddle.

#### **Flat Position**

Hold a 1/8" or shorter arc or touch the work lightly with the electrode tip. Move fast enough to stay ahead of the molten pool. Use currents in the middle and higher portion of the range.

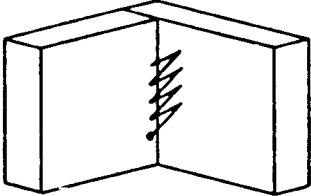
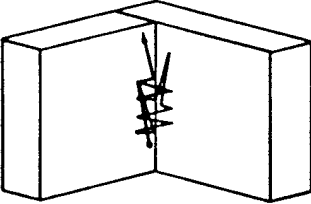
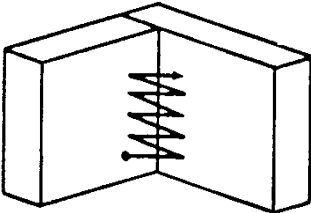
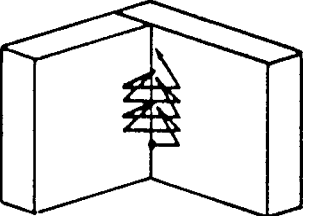
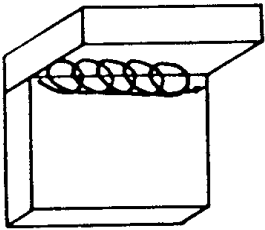
#### **Vertical Position**

Use 3/16" or smaller electrodes. Vertical down drag techniques are used by pipeliners and for single pass welds on thin steel. Vertical up is used for most plate welding applications. Make the first vertical-up pass with the whip and pause technique. Apply succeeding passes with a box or straight weave, pausing slightly at the edges to ensure penetration and proper wash-in. Use currents in the lower portion of the range.

#### **Overhead and Horizontal Butt Welds**

Use 3/16" or smaller electrode. These welds are best made with a series of stringer beads using a whip and pause technique.

## *Common EXX10 and EXX11 Electrode Oscillation Techniques*

Technique	Diagram	Typical Application
<b>Whip and Pause</b>		Used with fast freeze electrodes to make welds in all positions
<b>Whip and Pause</b> (using a side to side motion in the crater)		Used with fast freeze electrodes primarily in the vertical position.
<b>Straight side to side weave</b>		Used with fast freeze electrodes to make a fill pass in the vertical position.
<b>Triangular Weave</b>		Used with fast freeze electrodes for the root pass on fillet welds and groove welds
<b>Circular Motion</b>		Used with fast freeze electrodes to make overhead welds. A Whip and Pause technique can be incorporated into this technique too, to help control the puddle.

## *Restarting Technique for Sound Welds*

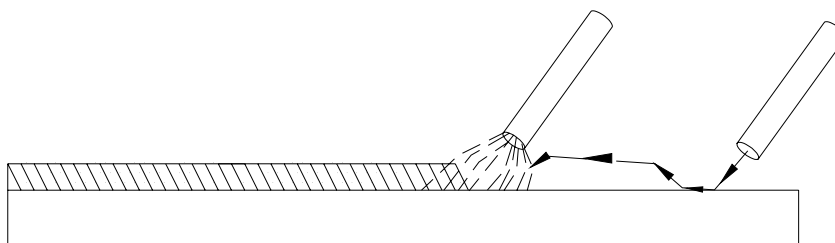
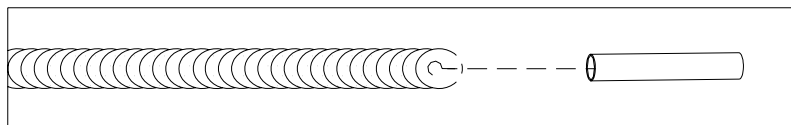
Strike the arc directly ahead of the crater in line with the “new weld.” Once the arc is started, establish an extended arc length (long arc). The purpose of this is to:

- Preheat the base metal.
- Allow gaseous shield to be established.
- Allows the amperage to flow so the heat will build up.
- Gives off light to find the crater (flash light effect).

Once the arc is established, go back to the and drop the electrode into its normal arc length and circle in the crater and then start to travel with the normal travel speed. By circling in the crater you accomplish two things:

1. It’s a timing device used to fill the crater flush with the bead.
2. It will help drive out any slag/porosity that may have otherwise become entrapped.

REMEMBER practice makes perfect.



## *Helpful Hints for Preventing Common Flaws*

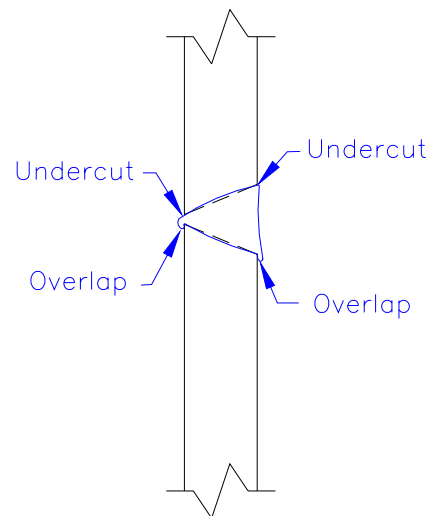
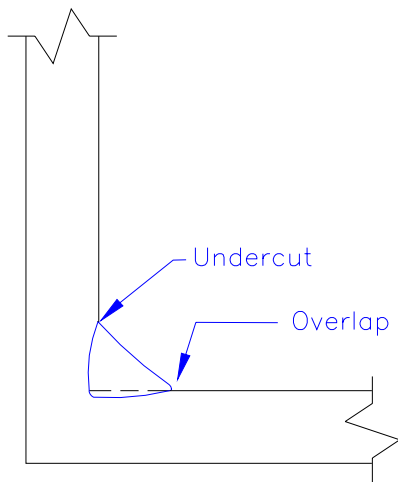
### **Eliminating Undercut**

Undercut is a condition where the base metal has been melted away during the welding operation and there is insufficient filler metal deposited to adequately fill the resulting depression. These grooves will vary in depth and length. Undercut can be present at a weld to weld junction or a weld to base metal junction (toe of weld). Undercut causes a stress concentration point (stress riser) which is a potential starting point for weld cracking.

Undercut is common with the EXX10 and EXX11 electrodes due to their aggressive (digging) arc. One or more of the following items can aid in controlling undercut:

- Reducing arc length
- Reducing travel speed
- Reducing amperage
- Pausing at the sides of the puddle
- Changing work angle
- Avoiding excessive weaving
- Allowing base metal to cool

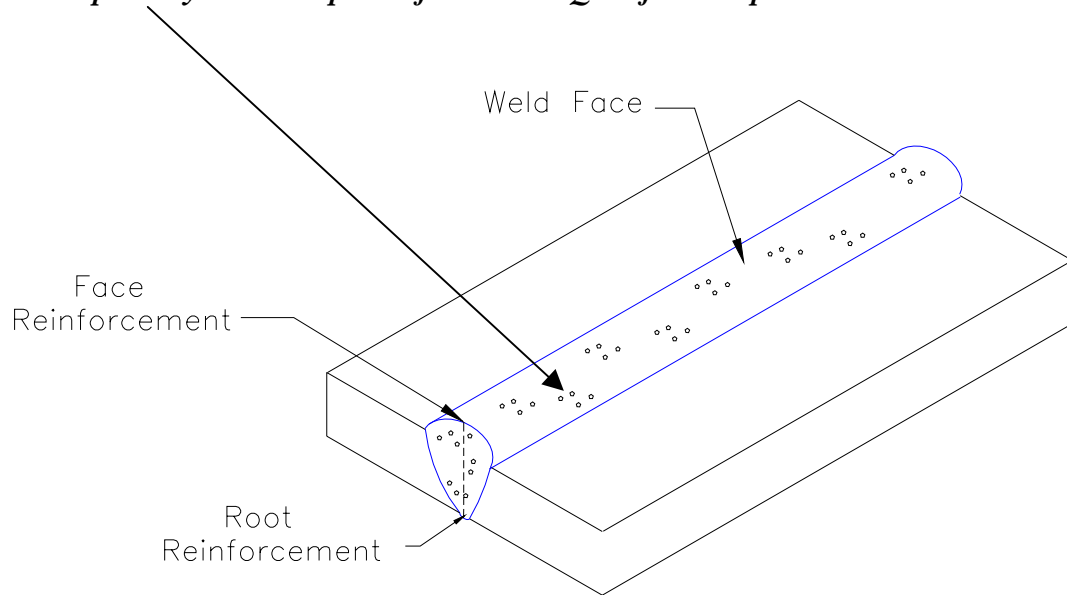
***Maximum allowed is 1/32" in depth for Welder Qualification per AWS D1.1.***



## Surface Porosity

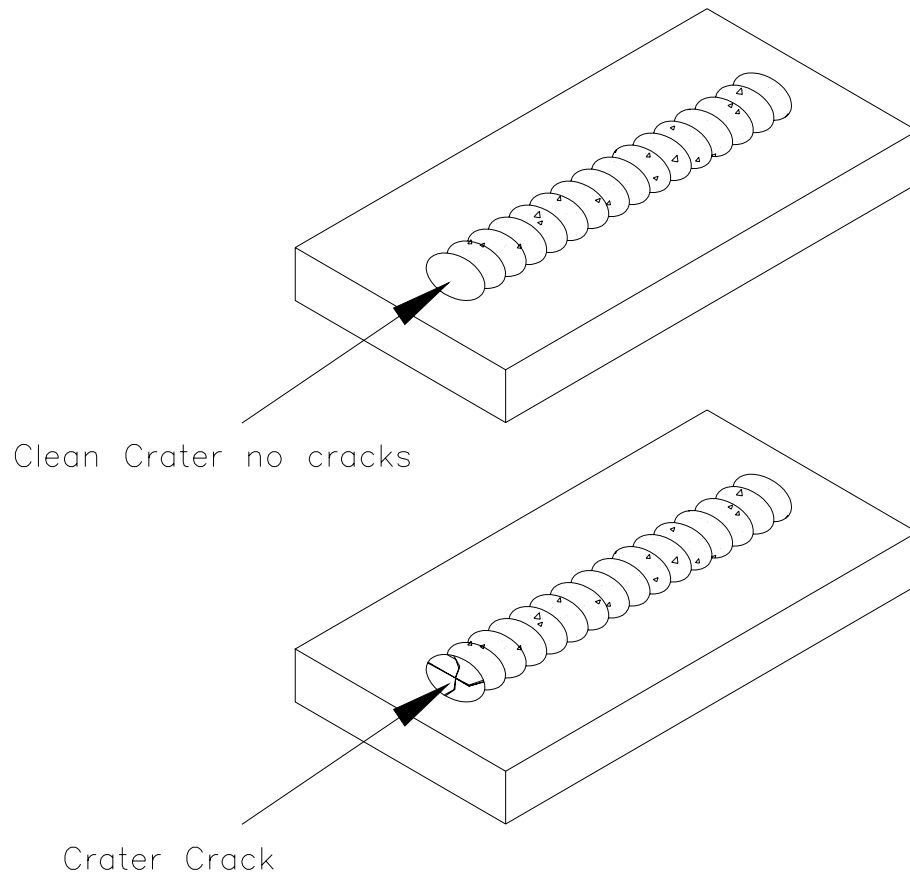
Fast Freeze electrodes have a tendency to develop surface porosity at the top of the chevrons (freeze lines) upon weld solidification. This is due to the weld metal solidifying while gas is still escaping from the metal. This leaves *surface porosity*. This can be corrected while welding by simply “popping” the electrode back into the puddle and re-melting the puddle. This technique requires a “watchful eye.”

*Visual porosity is unacceptable for Welder Qualification per AWS D1.1*



## Ending or Stopping the Weld (also known as Terminating or Cratering Out)

With the fast freeze electrode, the welder must watch out for crater cracks when ending the weld. Crater cracks are due to terminating the weld too quickly. To help eliminate this problem, the welder should whip back into the crater twice before terminating. This “double pumping” will help ensure that the crater is filled, and allow the crater to solidify without a crack.



## *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**

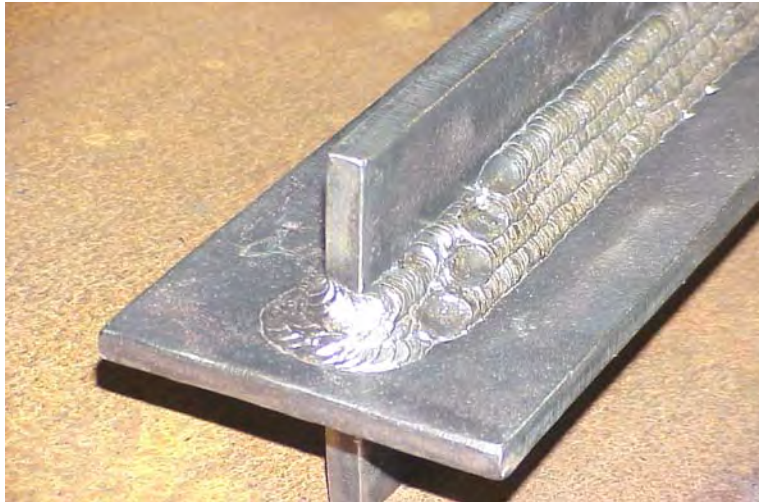
Oxyacetylene Cut quality  
Grind all cut surfaces clean

**Project Layout**

Accurate (+/- 1/16")  
Limit waste

**Post Weld Clean-up**

Remove Slag/Spatter  
Remove sharp edges



**An example of a High Quality weld.**

### **Weld Quality per AWS D1.1 Welder Qualification**

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



**Technique**

Use a straight *whip and pause* technique. Allow the puddle to obtain a 3/8" to 1/2" width and step/surge rod in and out of puddle in a rhythm to keep puddle size consistent. The step distance should be approximately 1/2 the puddle length and no more than 1 1/2 the puddle length.

**Welding Sequence**

Alternate directions of welding for each pass.

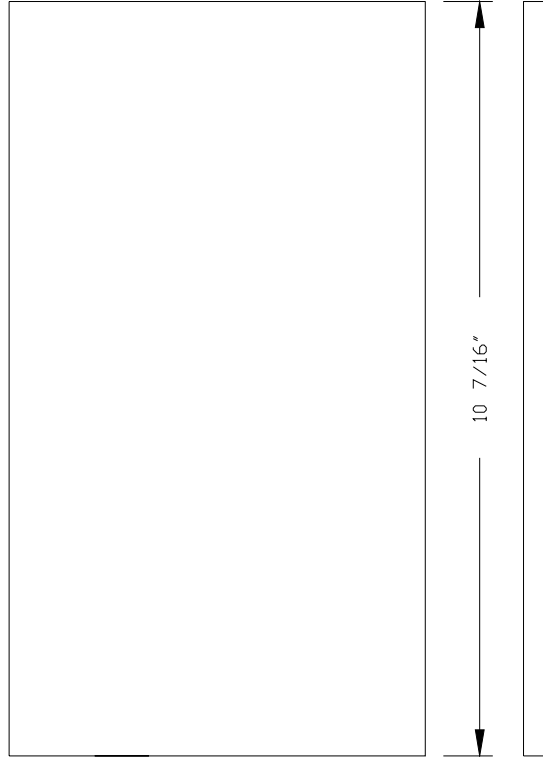


**Flat Position Bead Plate**

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

E6011  
Flat Position  
Bead Plate

- Welding Procedure:
1. Electrode 6011
  2. Diameter 1/8"
  3. Polarity DCRP
  4. Amperage 80 to 95 Amps
  5. Arc Length 1/16"-1/8"
  6. Welding Position Flat
  7. Travel Angle 20°
  8. Work Angle 90° to 75°
  9. Technique Stringer bead "whip and pause."
  10. Weld Size 5/16" to 5/8" wide



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



Portland Community College  
Welding Technology

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

WLD 114-01

Drawn By:  
John Deering

Size: GC NO. Rev.

Date: 03/01/04

Approve

Date

Sheet

1

**Technique**

When running the first pass (root pass) it is important to center the weld so that it has equal legs on each side. This is accomplished by adjusting the work angle so that the bead centers itself.

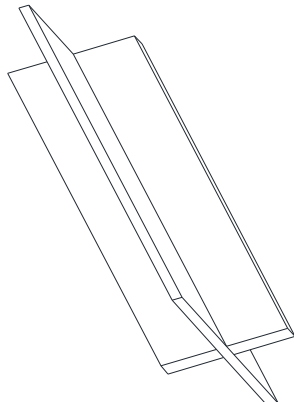
**Welding Sequence**

1. Weld the root pass on all four sides of the joint. Rotate the work so that all the welding is completed in the flat position. Select your best bead and do not weld over it.
2. Weld two bead layer over the three remaining sides. Select your best layer and do not weld over it.
3. Weld three bead layer over the remaining two sides. Select your best layer and do not weld over it.
4. Weld four bead layer over the last side. Inspect your work based on the criteria listed in the inspection criteria section.



<b>VT Criteria</b>	<b>Student Assessment</b>	<b>Instructor Assessment</b>
<b>Reinforcement (0" -1/8")</b>		
<b>Undercut (1/32")</b>		
<b>Weld Bead Contour</b>		
<b>Penetration</b>		
<b>Cracks (none)</b>		
<b>Arc Strikes (none)</b>		
<b>Fusion (complete)</b>		
<b>Porosity (none)</b>		
		<b>Grade      Date</b>

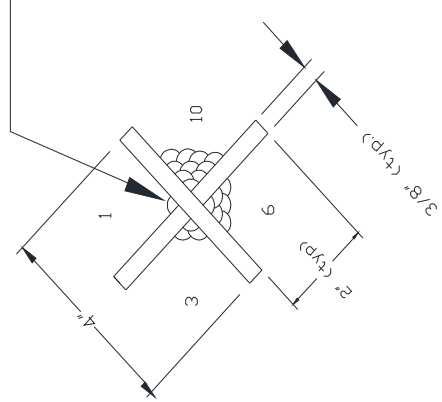
**E6011**  
Flat Position (1F)  
T-Joint



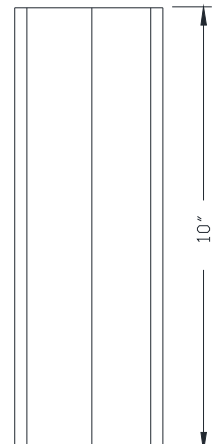
**Welding Procedure**

1. Electrode ..... E6011
2. Diameter ..... 1/8"
3. Polarity ..... DCRP
4. Amperage ..... 90 to 125
5. Arc Length ..... Drag technique
6. Welding Position ..... Horizontal (1F)
7. Travel Angle ..... 20° to 30°
8. Work Angle ..... 90° to 65°
9. Technique ..... Stringer-Bead

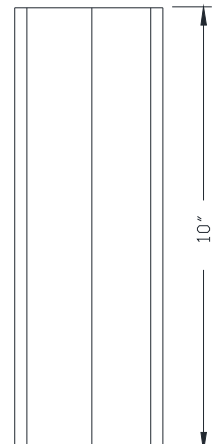
Top View




Front View



Right Side (end View)






E6011  
(1,3,6,10 Weld sequence)

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	WLD 114-02
Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle ± 5°		Size:      Qc No. Rev.
Drawn By: John Deering		Approve      Date
Chk By: TANNER SCOTT		Date: 12/15/15

## Corner Joint 1F

## Project #3

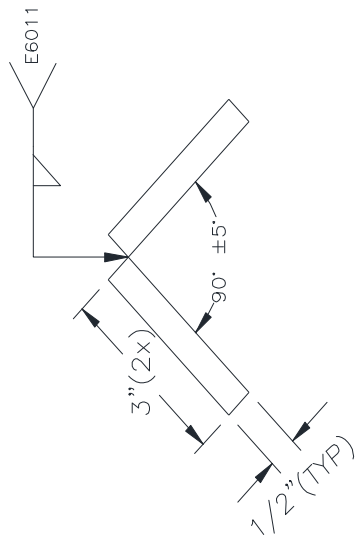
### Technique:

Use a straight *whip and pause* technique. Center the weld in the first pass (root pass) so that it is equally distributed on to each piece of metal.

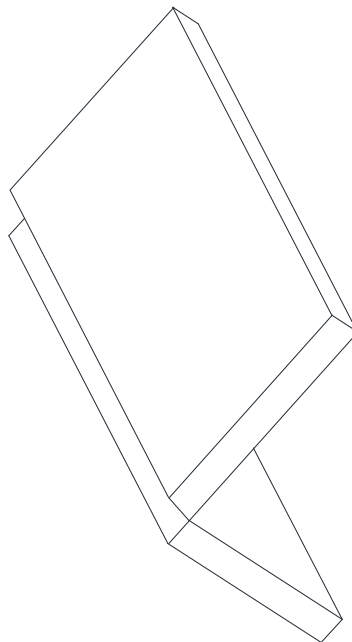
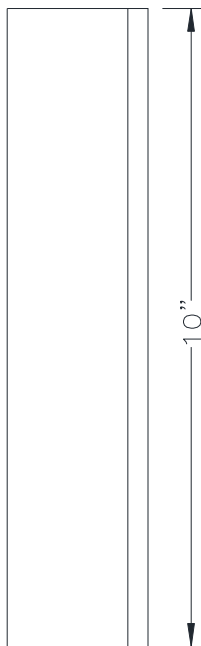


VT Criteria	Student Assessment	Instructor Assessment
Reinforcement (0" -1/8")		
Undercut (1/32")		
Weld Bead Contour		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade      Date

E6011  
Flat Position (1F)  
Corner Joint




- Welding Procedure
1. Electrode .....E6011
  2. Diameter .....1/8"
  3. Polarity .....DCRP
  4. Amperage .....90-125
  5. Arc Length .....1/16"
  6. Welding Position .....Flat
  7. Travel Angle .....20°
  8. Work Angle .....Varies
  9. Technique .....Stringer



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

WLD 114- 03

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

Drawn By: John Deering

QC NO.      Rev.

Size:      Approve

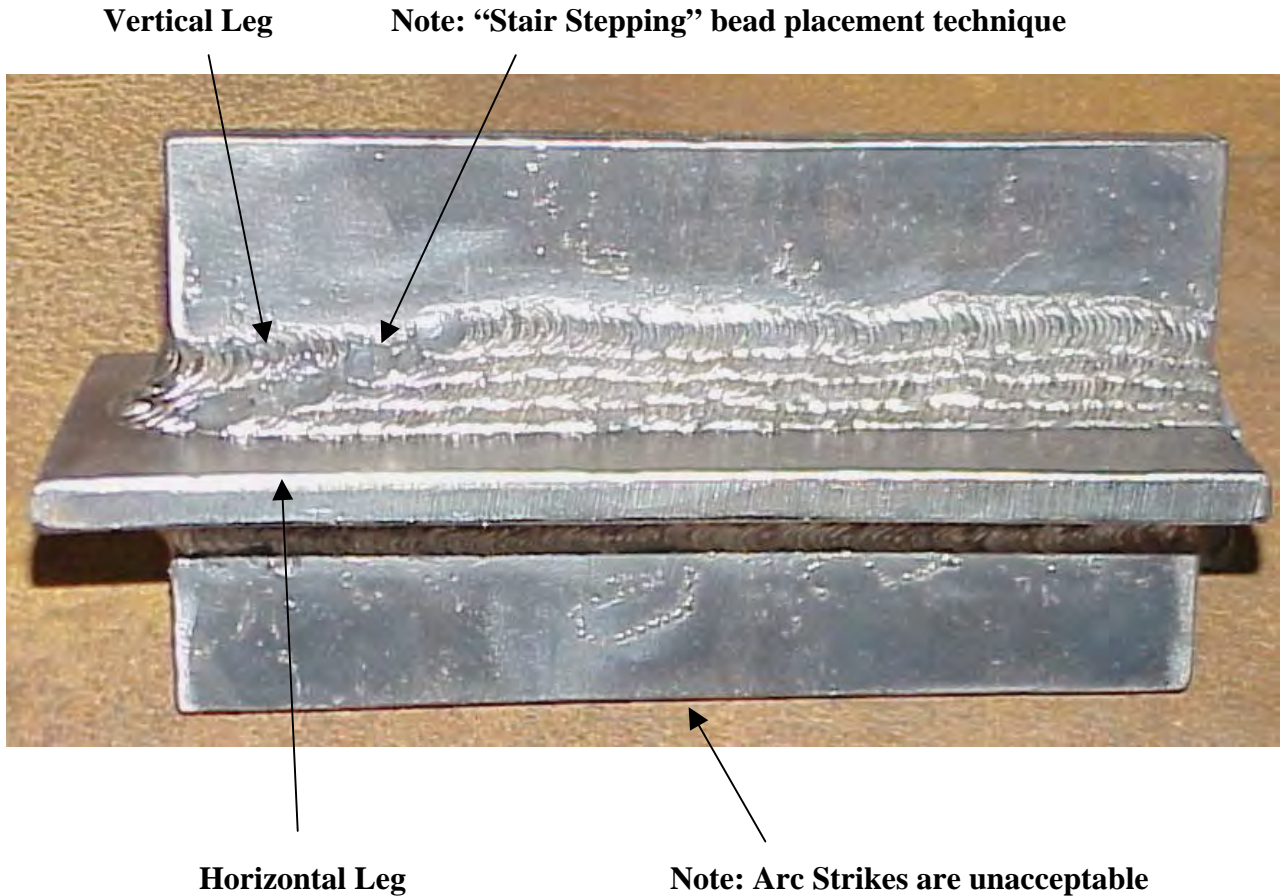
Chk By: TANNER SCOTT      Date: 12/15/15      Sheet

**E6011 T-Joint**

**Project #4**

**Welding Sequence**

When welding in the horizontal position, start your welding sequence from the horizontal leg of the joint and work up the vertical leg of the joint (stair stepping). Wrap the weld around the corner. Use the boxing technique, and do not stop or restart at the corner.



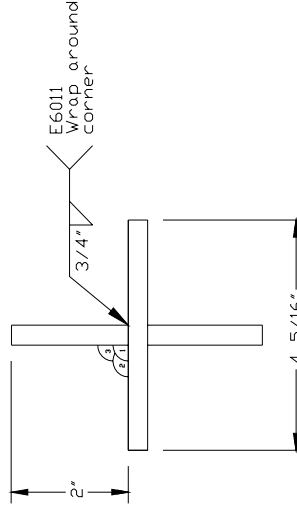
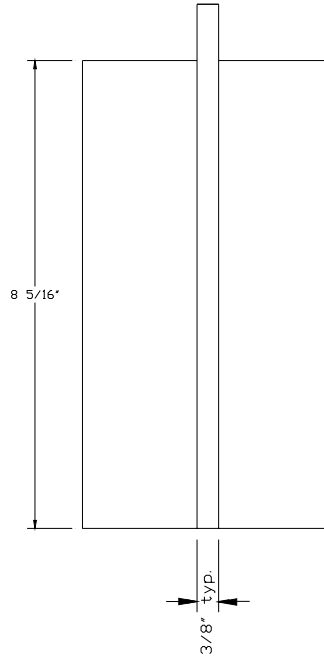
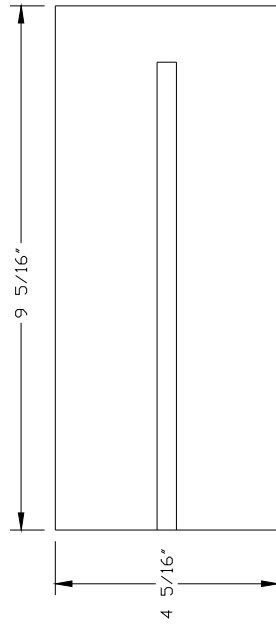
VT Criteria	Student Assessment	Instructor Assessment
Reinforcement (0" -1/8")		
Fillet Wed Size		
Undercut (1/32")		
Bead Contour (smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade      Date

E6011  
Horizontal Position (2F)  
T-Joint

Welding Procedure

1. Electrode 6011
2. Diameter 1/8"
3. Polarity DCRP
4. Amperage 70 to 90 Amps
5. Arc Length 1/16" to 1/8"
6. Welding Position Horizontal (2F)
7. Travel Angle 20° to 30°
8. Work Angle Varies
9. Technique Stringer Bead

NOTE: WRAP THE CORNER



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 (T x W x L)	S.I. Conversion

**Portland Community College**  
 Welding Technology

Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle ± 5°		WLD 114-02	
Drawn By: John Deering	Size:	Doc No.	Rev.
Chk By:	Date: 03/01/04	Approve	Date
			Sheet



**Welding Sequence**

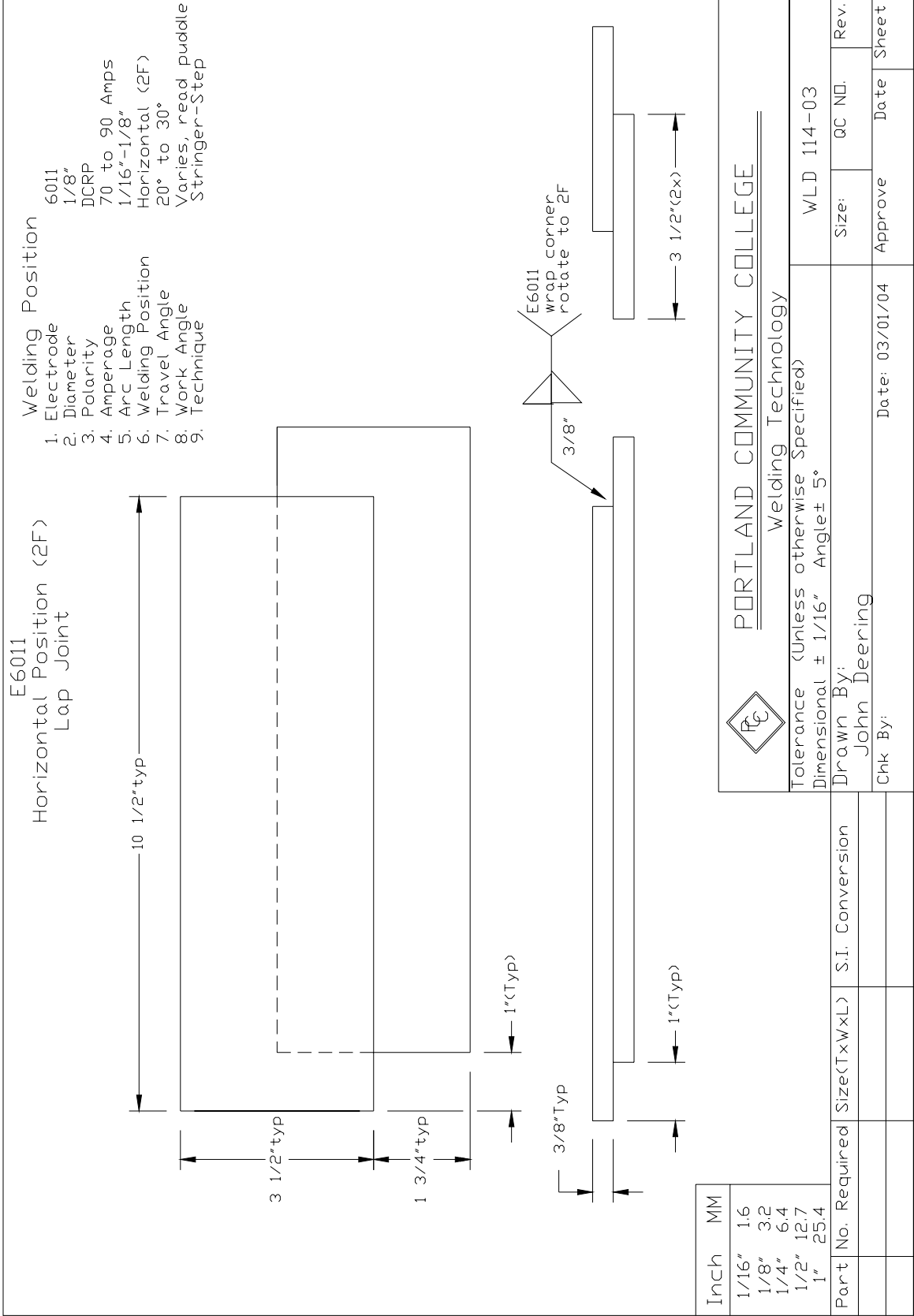
When welding the lap joint in the horizontal position remember to start your welding sequence from the horizontal leg of the joint and work up the vertical leg of the joint (stair stepping). Wrap the weld around the corner. Use the boxing technique and do not stop and restart at the corner.

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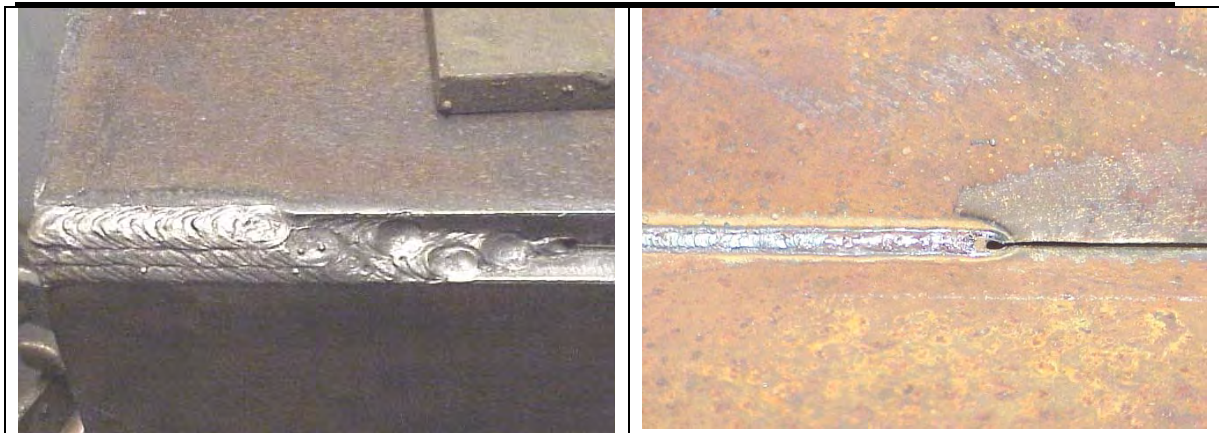
**Horizontal Lap Joint**

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



**Welding Sequence**

Use the “key hole” technique when welding the root pass to obtain complete joint penetration (CJP).



**Front Side**

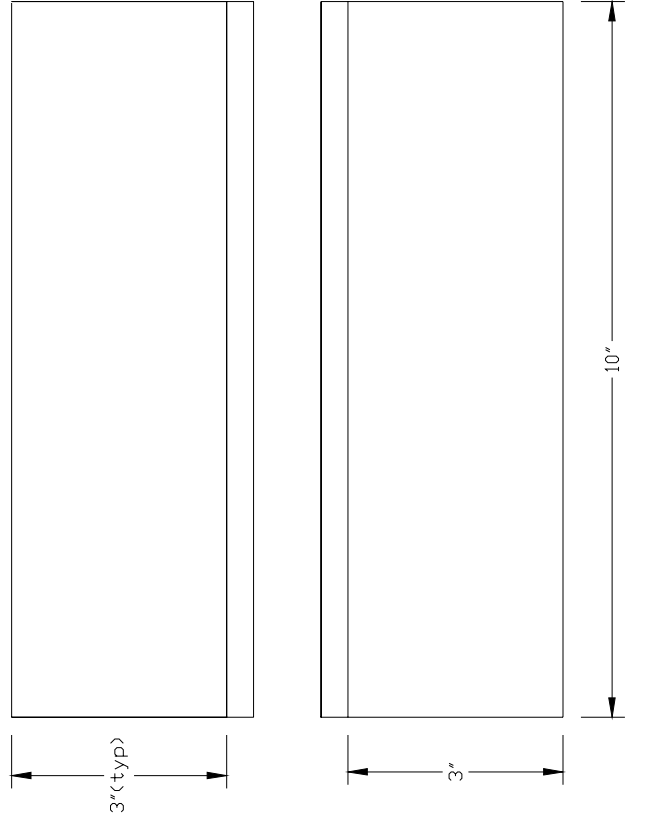
**Back Side (Root Pass)**

**Corner Joint**

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

E6011  
Horizontal Position  
Corner Joint (2F)

- Welding Procedure
1. Electrode 6011
  2. Diameter 1/8"
  3. Polarity DCRP
  4. Amperage 70 to 90 Amps
  5. Arc Length 1/16"-1/8"
  6. Welding Position Horizontal (2F)
  7. Travel Angle 20° to 30°
  8. Work Angle 20° to 70°
  9. Technique Stringer bead



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



PORTLAND COMMUNITY COLLEGE

Welding Technology

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

Wld 114-04

Drawn By: John Deering	QC NO.	Rev.
Chk By:	Approve	Date
Date: 03/01/04		Sheet

**Welding Sequence**

When running the first pass (root weld) it is important to center the weld so that it has equal distribution into each piece of metal. This is accomplished by adjusting the work angle so that the bead centers itself.



<b>VT Criteria</b>	<b>Student Assessment</b>	<b>Instructor Assessment</b>
<b>Reinforcement (0" -1/8")</b>		
<b>Undercut (1/32")</b>		
<b>Weld Bead Contour</b>		
<b>Penetration</b>	<b>N/A</b>	<b>N/A</b>
<b>Cracks (none)</b>		
<b>Arc Strikes (none)</b>		
<b>Fusion (complete)</b>		
<b>Porosity (none)</b>		
		<b>Grade          Date</b>

**E6011 Horizontal Groove (2G)  
Complete Joint Penetration (CJP)**

**Welding Procedure**

1. Electrode \_\_\_\_\_ E6011
2. Diameter \_\_\_\_\_ 1/8"
3. Polarity \_\_\_\_\_ DCRP
4. Amperage \_\_\_\_\_ 90 - 125
5. Air \_\_\_\_\_ N/A
6. Arc Length \_\_\_\_\_ 1/16"
7. Welding Position \_\_\_\_\_ 2G
8. Travel Angle \_\_\_\_\_ 20° to 30°
9. Work Angle \_\_\_\_\_ Varies, read puddle
10. Technique \_\_\_\_\_ Stringer Bead

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  $\pm 1/16"$  Angle  $\pm 5^\circ$

Drawn By: John Deering  
Chk By: TANNER SCOTT      Date 12/15/15

WLD 114-06	Size: _____	QC NO. _____	Rev. _____

Approve _____	Date _____

**Technique**

When welding in the vertical position, it is important to control the heat input into the base metal. Three primary ways to accomplish this is by:

- using lower amperage
- quench the project often
- exaggerate the step technique to allow the puddle to solidify quickly.

**Welding Sequence**

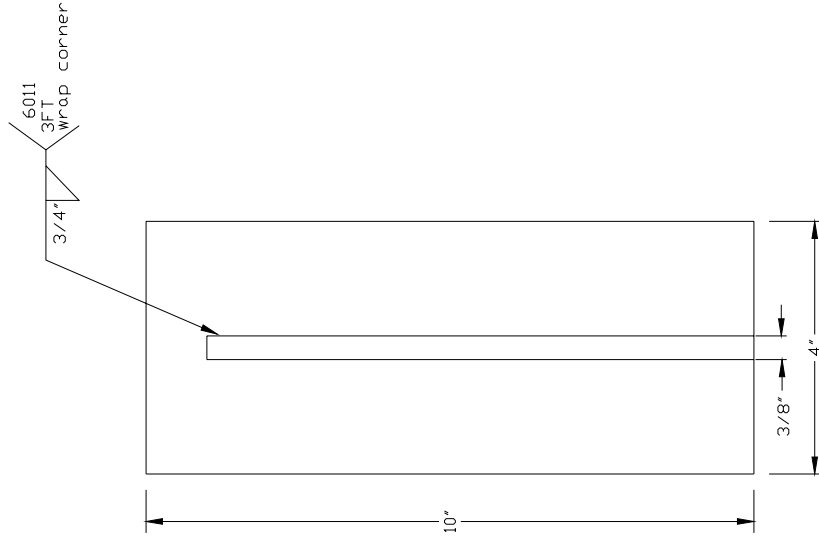
Wrap the weld around the corner.



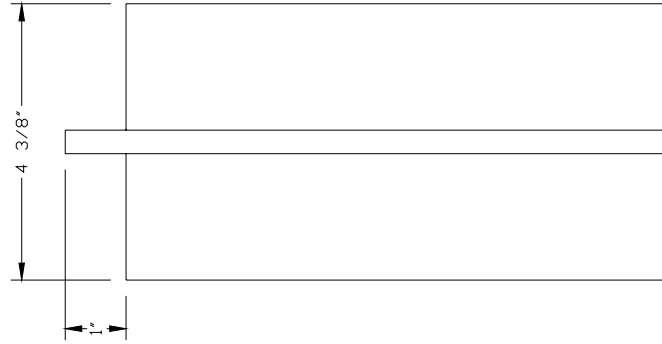
**Vertical Up T-Joint**

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

E6011  
Vertical Position (3F)  
T-Joint




- Welding Procedure  
6011  
1/8"  
DCRP  
70 to 90 Amps  
1/16"-1/8"  
VERTICAL-UP (3F)  
20° to 30°  
8. Work Angle  
9. Technique  
Stringer-  
Whip and Pause



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 $\pm$ 1/16", Angle $\pm$ 5°	
Welding Technology	WLD 114-05	Size:	Qc No.
Drawn By: John Deering	Rev.	Approve	Date
Chk. By:	Date: 03/01/04	Sheet	Sheet



## ***Welding Vocabulary--WLD 114***

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Directions:

Define the following terms. Use this training packet and/or the textbooks in the resource room (Bldg 2/132a) if these terms are not in Welding Principles and Applications.

Complete Joint Penetration (CJP)

Deposition Rate

Fillet Weld Leg

Fillet Weld Size

Base Metal (also known as Parent Metal)

Circular Oscillation Technique

Weld Face

## *Welding Vocabulary Continued – WLD 114*

Travel Angle

Define the following welding positions:

1F

2F

1G

2G

Whip and Pause Oscillation Technique (also known as the Step Technique)

Work Angle

Keyhole Welding

## *Welding Vocabulary Continued – WLD 114*

Actual Throat

Effective Throat

Theoretical Throat



5. Define E6011 by its AWS electrode classification.
  
6. What type of oscillation technique is used to weld vertical up with a fast-freeze electrode?
  
7. List common electrodes classified in the F4 group.
  
8. List three applications for F4 group electrodes.
  
9. Compare and contrast E7024 to E6011
  
10. What polarity is required for the following electrodes:  
E6010  
E6011  
E7010

11. List 3 types of oscillation techniques to use with fast freeze electrodes.
  
12. List 4 ways to control undercut with the 6011 electrode.
  
13. What is the preferred oscillation technique for overhead welding according to the packet information?
  
14. List 2 factors that can prevent slag inclusions.
  
15. How does arc length effect welding?
  
16. Why is “baking” 6011/6010 electrodes forbidden?
  
17. Why is 6011 a High Hydrogen Electrode?

18. How is cracking prevented with 6011 electrodes?
  
19. Why are cracks considered a serious weld and/or base metal defect?
  
20. Describe 2 ways to minimize porosity.
  
21. List 2 reasons for excessive weld spatter.







**Final Grading Rubric for practical exam**  
**Class Name: WLD 114**

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.***

<b>Points Possible</b>	<b>Hold Points</b>	<b>Instructor's Evaluation</b>
<b>5 points</b>	<b>Blueprint Interpretation and Material Cut List</b> 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	
<b>10 points</b>	<b>Material Layout and Cutting (Tolerances +/- 1/16")</b> 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	
<b>10 points</b>	<b>Fit-up and Tack weld (Tolerances +/- 1/16")</b> 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	
<b>15 points</b>	<b>Weld Quality</b> Subtract 1 point for each weld discontinuity, incorrect weld size and incorrect spacing sequence.	
<b>28 points</b>	<b><i>Minimum points acceptable. This equates to the minimum AWS D1.1 Code requirements.</i></b>	
	<b>Total Points</b>	<b>/40</b>

# WLD 114 SMAW: Project Assessment Form

Student Name: \_\_\_\_\_ Date \_\_\_\_\_

Flat Position	Assessment	Instructor Signature/Date
Bead Plate		
T-Joint		
Corner Joint		

Horizontal Position	Assessment	Instructor Signature/Date
T-Joint		
Lap Joint		
Outside Corner		
V-groove		

Vertical Position	Assessment	Instructor Signature/Date
T-Joint		