WLD 222
Gas Tungsten Arc Welding
Aluminum

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

Course Assignments

Required text book and Reading:

Welding Principles and Applications, By Larry Jeffus

- Gas Tungsten Arc Welding Equipment, Setup, Operation and Filler Metals
- Gas Tungsten Arc Welding of Plate

Information Sheets:

Introduction to GTAW
Power Sources
Welding Torch
Tungsten Electrodes
Shielding Gas
Filler Material
Set up procedures
Craftsmanship expectations
Visual inspection

Video Training:

Hobart videos on PCC Library

Writing Work Sheets:

Power Sources
Welding Torch
Tungsten Electrodes
Shielding Gas
Sheet Metal Shear

Welding Projects:

Flat Position (1F or 1G)	**Horizontal Position (2F or 2G)**	**Vertical Position (3F or 3G)**	**Overhead Position (4F or 4G)**
Edge Joint	T-Joint	T-Joint	T-Joint
Corner Joint	Lap Joint	Lap Joint	Lap Joint
Bead Plate	Corner Joint	Corner Joint	Corner Joint
T-Joint	Butt Joint	Butt Joint	

INTRODUCTION TO ALUMINUM
PROPERTIES AND WELDABILITY OF ALUMINUM

Aluminum has several properties that make welding it different from welding steels. These are:

Aluminum oxide surface coating (melting temperature of approximately 3,300F).

- High thermal conductivity
- High thermal expansion
- Low melting point 1100 to 1200 F depending upon alloy content.
- The absence of color change as temperature approaches melting points.

1. The rapid formation of oxides in aluminum make material preparation a critical step in the welding procedures. After the surface is cleaned, welding should be performed within eight hours to ensure weld quality. Surface should be cleaned prior to welding and then welded immediately.

2. Aluminum conducts heat three to five times faster than steel. This means that higher currents are required during welding even though the melting point of aluminum is less than half that of steel. Because of the high thermal conductivity, preheat is often used on thicker sections. The high heat conductivity of aluminum is helpful in that heat leaves the weld area quickly, causing the weld pool to solidify rapidly. This helps hold the weld metal in position and makes all position welding easier.

3. The thermal expansion of aluminum is twice that of steel. In addition, aluminum welds decrease about 6% in volume when solidifying. This may cause distortion and cracking.

4. Aluminum is light weight, very ductile, malleable, non-magnetic, highly reflective, and may be heat treated, work hardened, and alloyed with other elements to improve its properties for a wide variety of applications.

Science on Aluminum

CLASSIFICATION OF ALUMINUM

Aluminum alloys are broadly classified as castings or wrought material. Our focus will be on the wrought alloys. This group includes alloys that are designed for mill products whose final physical forms are obtained by working the metal mechanically, rolling, forging, extruding, and drawing. These products include: sheet, plate, wire, rod, bar, tube, pipe, forgings, angles, structural channels, and rolled and extruded shapes.

The Aluminum association has designed a four digit index system for designating wrought aluminum and its alloys.

The first digit identifies the alloy group:

Aluminum Alloy	Designation
Aluminum - 99.0%	1xxx
Copper	2xxx
Manganese	3xxx
Silicon	4xxx
Magnesium	5xxx
Magnesium and Silicon	6xxx
Zinc	7xxx
Other elements	8xxx
Unused series	9xxx

Second digit indicates modification or impurities, last two digits indicate minimum aluminum percentage, i.e. 1075 is 75% pure aluminum.

Example:

6061 Aluminum

6 = Magnesium and Silicon is the major alloy group
0 = no modifications or significant impurities
61 = percent aluminum

Nonheat-Treatable Alloys

The initial strengths of the nonheat-treatable alloys depend primarily upon the hardening effect of alloying elements such as silicon, iron, manganese, and magnesium. These elements increase the strength of aluminum by formation of dispersed phases in the metal matrix or by solid solution. The nonheat-treatable alloys are mainly found in the 1XXX, 3XXX, 4XXX and 5XXX series depending upon their major elements. Iron and silicon are the major impurities in commercially pure aluminum, but they do contribute to its strength. Magnesium is the most effective solution-strengthening addition. Aluminum magnesium alloys of the 5XXX series have relatively high strength in the annealed condition. All of the nonheat-treatable alloys are work hardenable.

The nonheat-treatable alloys may be annealed by heating to an elevated temperature to remove the efforts of cold working and improve ductility. The proper annealing schedule to use will depend upon the alloy and its temper. When welding the nonheat-treatable alloys, the heat affected zone may lose the strengthening effects of cold working. Thus, the strength in this zone may decrease to near that of annealed metal.

Heat-Treatable Alloys

The heat-treatable alloys are found in the 4XXX, 6XXX and 7XXX series. The strength of any of these alloys depend only upon the alloy composition, in the annealed condition as do the nonheat-treatable alloys. However, copper, magnesium, zinc, and silicon, either singularly or in various combinations, show a marked increase in solid solubility in aluminum with increasing temperature. Therefore, these alloys can be strengthened by appropriate thermal treatments.

Heat-treatable aluminum alloys develop their improved strength by solution heat treating followed by either natural or artificial aging. Cold working before or after aging may provide additional strength. Heat-treated alloys may be annealed to provide maximum ductility with a sacrifice in strength properties. Annealing is achieved by heating the component at an elevated temperature for a specified time, and then cooling it at a controlled rate.

During welding, the heat-affected zone will be exposed to sufficiently high temperatures to overage heat-treated metal. As a result, this zone will be softened to some extent.

Reprinted from American Welding Society Welding Handbook, Seventh Edition, Volume 4, Metals and Their Weldability.

Weld Cleanliness and Porosity

Aluminum and aluminum alloys are extremely susceptible to porosity resulting from the formation hydrogen gas trapped in the molten weld pool. Unlike other metals, liquid aluminum (and liquid copper) is capable of dissolving large volumes of hydrogen into the molten weld pool. The problem occurs during solidification of the weld. The solubility of hydrogen in solidified aluminum drops precipitously to zero. Thus, all of the hydrogen which was dissolved in the molten weld metal, must now form gas bubbles and float out of the weld pool. Unfortunately, the weld cooling rates are so fast that most of the bubbles are trapped in the solidifying weld, leaving gas porosity. Small, fast-cooling welds produce many small pores while large slower-cooling welds produce fewer but larger pores. In any case, eliminating porosity from aluminum welds can only be achieved by good workmanship and clean welding practice.

Unlike steel, it takes very little hydrogen to cause porosity in aluminum. Of course, if there were no source of hydrogen in GTAW of aluminum, there would be no porosity. As a result, it may seem like the plate, consumables and welding practice are “clean”, but, a great deal of porosity can still occur.

Compared to SMAW, FCAW and GMAW, weld metal deposited by GTAW can be free of porosity and contamination of any kind. GTAW is an extremely clean and hydrogen-free process. The tungsten electrode and the molten metal pool are protected by the argon shielding gas used in welding. If the welder uses an extra long arc (higher voltage) on a humid day, moisture from the air can be entrained into the arc particularly if the gas flow through the gas lens is turbulent. Once moisture reaches the high temperature arc, the water molecule immediately dissociates into hydrogen (H) and oxygen (O) as shown below:

$$H_2O \Rightarrow 2H + O$$

Because of the high arc temperature, the hydrogen and oxygen atoms are not only immediately dissociated into monatomic H and O, but also ionized. That is, the hydrogen and oxygen atoms exist as single atoms with their outer valence electron lost to the arc plasma atmosphere (plasmas are discussed in the next section). Ionized H and O are in an activated state. H diffuses into the molten pool, while O forms the chemical stable aluminum oxide, Al_2O_3. The aluminum oxide remains at the top of the weld pool. Since aluminum can never form a stable aluminum hydride compound, the H in the arc atmosphere simply dissolves in the molten aluminum in a liquid solution. Just like salt dissolves in water, the hydrogen gas is dissolved in molten aluminum.

What is the Arc Plasma in GTAW?

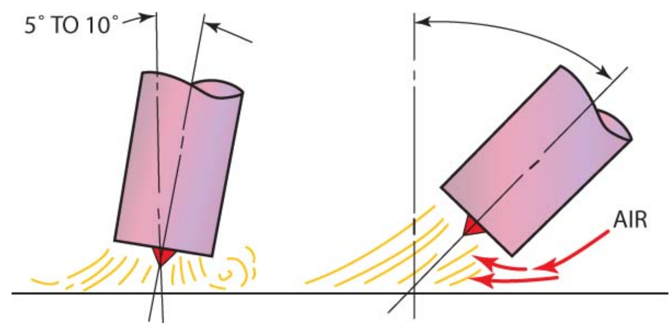
In order to have a steady sustained arc during GTAW, electricity must be transferred through an electrical conducting "plasma" between the tungsten electrode and the aluminum work-piece. How can this be accomplished if only argon gas is a non-conducting insulator. Argon and helium are inert gaseous elements, which have a full outer shell of electrons. Because argon and helium are considered "inert", they do not undergo any chemical reaction. Argon and helium will not conduct electricity at room temperature. How then is electricity conducted across the arc?

Fortunately, at elevated temperatures above about 5,000º C, the electrode generates copious electrons by thermionic emission. These energetic electrons collide with the shielding gas (argon or helium) atoms as well as the aluminum atoms in the workpiece causing the stripping away of their outer electrons. Even though argon and helium are normally inert, high energy electrons from the thermionic emitter provides enough energy to knock out electrons from the outer electron shell of both argon and helium atoms. These gas atoms are now in an "ionized" state. These electrons are now free to contribute to current flow during GTAW. The ease with which a gas can be ionized is called the ionization potential or voltage for welding. For example, argon ionizes more readily than helium, so argon has a lower ionization voltage (potential) than helium. At the same time that free electrons are being produced by collisions with thermionic electrons, positive argon ions are also produced. When argon loses an electron, the argon atom becomes a positively charged ion. Since the electrons are small and mobile (compared to the heavy ions), electrons support most of the current conduction. When GTAW with DC-EN, the flow of electrons is from the tungsten cathode to the anode aluminum work-piece. Conversely, the flow of positively charge ions is from the anode to the cathode. For steady arc characteristics, the establishment of a neutral plasma occurs when the net positive ions and negative electrons are equal. Thus, the plasma is the state of high temperature ionized gas in the arc containing a balance of positive and negative charges.

Causes of Porosity in Aluminum Welds

Porosity in aluminum and aluminum alloy weld metal is always caused by hydrogen gas contamination, despite attempts by welders to maintain good workmanship. The common sources of porosity are:

a. Long arc length
b. High heat input
c. Inadequate inert gas shielding
d. High humidity
e. Porous oxide layer in aluminum filler metal and plate
f. Oil, paint, and other hydrocarbons in area to be welded
g. High dew point temperature of the inert gas shielding.



Long arc length provides added opportunity for moisture or humidity in the atmosphere to contaminate the gas stream. As mentioned in the previous section, the water moisture forms hydrogen gas in the arc.

High heat input also provides added opportunity for hydrogen atoms to dissolve in the molten aluminum pool. Because the size or surface area of the weld pool increases with increasing heat input, more hydrogen atoms can meet the top of the molten weld pool.

Inadequate shielding gas can occur because the argon gas line is crimped or there is a hole or leak in the gas line. Very little contamination can cause porosity in aluminum welds. If the torch does not have a gas lens, the gas flow may not be laminar. Instead, the flow may become turbulent which easily permits humid air to contaminate the gas stream.

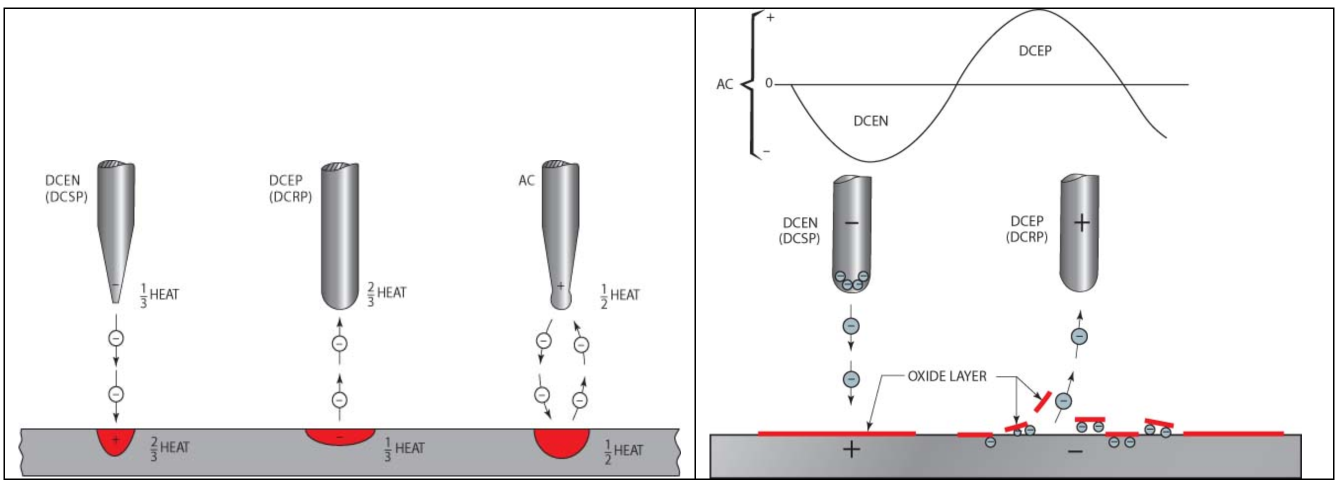
High humidity means that the amount of water vapor or moisture in the air is very high. Thus, humid air contamination can cause more severe porosity than similar contamination of the gas stream by relatively dry air. In manual welding, the arc length varies depending upon the welder's skill and the opportunity for contamination from the atmosphere is always possible.

The oxide layer on the surface of aluminum is always growing in thickness even at room temperature. This oxide is a dull color and it is porous. In fact, the oxide layer acts like a sponge and absorbs moisture from the air as well as oil, grease, and dirt from the surrounding shop. If these faying surfaces are not adequately cleaned before welding, porosity will develop in the aluminum weld metal.

The purity and quality of welding-grade shielding gases are governed by the specification from the American Welding Society, AWS 5.32, as shown in Table 1. This specification not only provides an identification system for shielding gases, but also, it specifies required purity and dew point for individual gases. For example, the required maximum dew point temperature for pure argon is -60°C (-76°F) and the minimum purity of argon gas is 99.997%. The dew point is the temperature below which moisture (impurity) in gas begins to condense into droplets of water. So, argon having a high dew point will contain a large volume of moisture, whereas argon having a low dew point temperature will contain very little water.

AC Power to Weld Aluminum

For most hand-held GTAW applications, AC power is used for the very practical reason of oxide removal or "cleaning action". If GTAW with DC power is used on aluminum, which has not been chemically and/or mechanically cleaned immediately before welding, the thick and porous oxide layer of Al_2O_3 can have a detrimental effect on both integrity and code-acceptability of the joint. DC welding of aluminum is covered in the next section.



When welding aluminum alloys for both flat and out-of-position GTAW, a strong cleaning action is achieved by using AC power. The reason why this cleaning effect takes place only when the electrode is positive is not fully understood. The cleaning action is possibly due to the presence of the thick refractory Al_2O_3 oxide layer protecting the aluminum acts as a capacitor. During GTAW, electrical charge builds up below and above the oxide layer, which is an electrical insulator. When the Al_2O_3 oxide layer has accumulated sufficient electrical charge, the layer physically explodes leaving a clean surface protected by the argon shielding gas. This action not only takes place above the melting point of aluminum (660°C) but also well below its melting point. In fact, the heat-affected zone of the aluminum weld is usually completely cleaned by this action. This dynamic cleaning action is clearly visible by the welder during the GTAW operation. After the weld is finished, the weld and heat-affected zone areas are smooth and brightly cleaned.

Craftsmanship Expectations for Welding Projects

Your instructor will be evaluating your welding projects by the following standards. Read carefully and apply these standards to your project before asking for the instructor's approval.

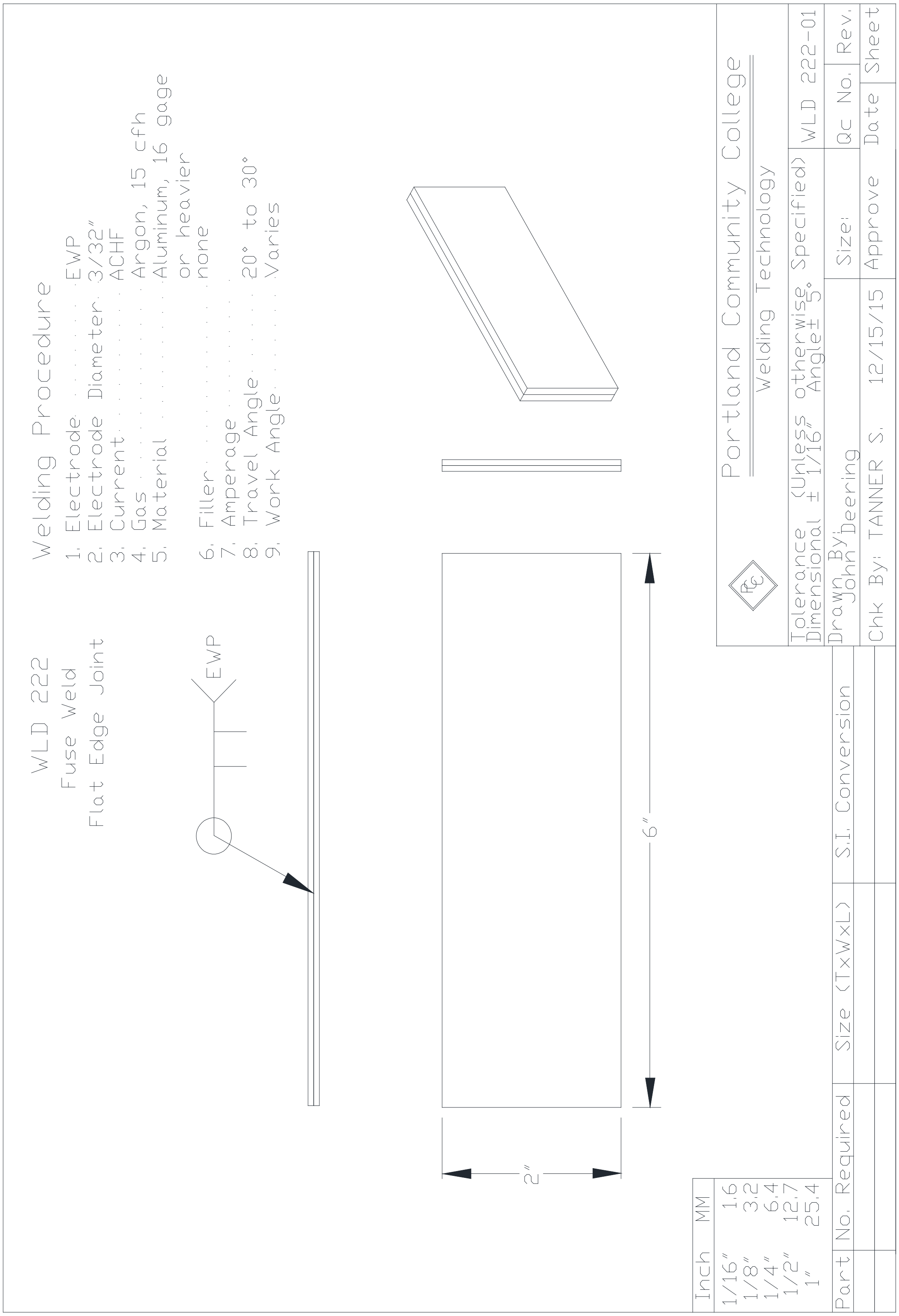
Factors for grading welding projects are based on the following criteria

Metal Preparation	***Project Layout***	***Weld Quality***
Thoroughly clean metal	Correct joint assembly (+/- 1/16")	See chart below

Weld Quality per Industry Standards

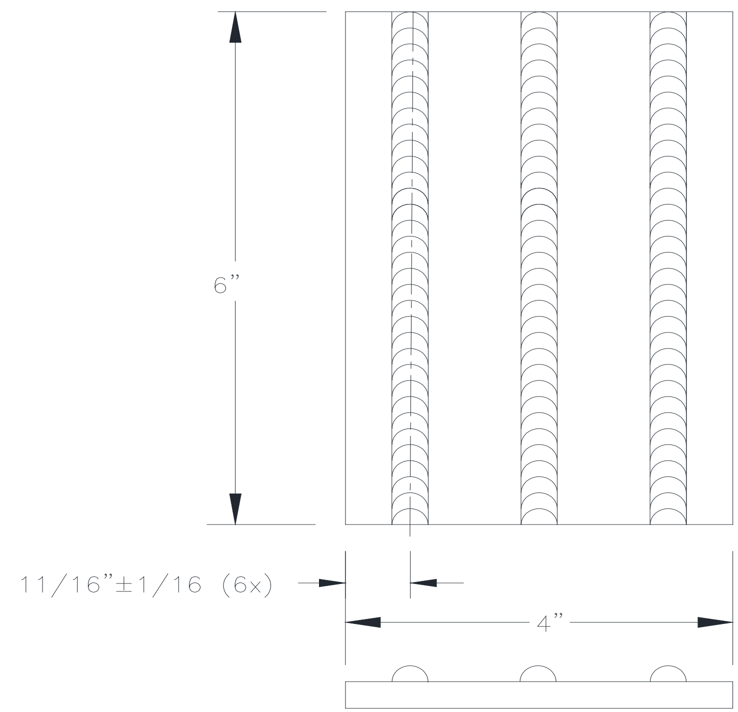
VT Criteria	**Cover Pass**
Weld Size	See specification on drawing
Undercut	1/32" deep
Weld Contour (Chevron spacing)	Smooth Transition
Penetration	N/A
Cracks	None Allowed
Arc Strikes	None Allowed
Fusion	Complete Fusion Required
Porosity	None Allowed
Overlap	None Allowed
Heat Input	Weld's shininess vs haziness

GTAW Flat Position Edge Joint (Autogenous/Fuse Weld) Project #1



GTAW Flat Position Corner Joint (Autogenous/Fuse Weld) Project #2

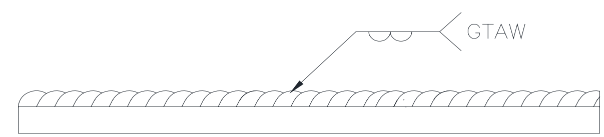
WLD 222
Flat Position
Bead Plate with Filler



Welding Procedure

1. Material .... 12 Gauge Aluminum
2. Electrode/dia. .... EWP / 3/32"

3. Polarity .... ACHF
4. Gas .... 100% Argon
5. Filler Metal .... ER4043 (3/32" diameter)
6. Travel Angle .... 35°–40°
7. Work Angle .... 90°
8. Welding Position .... Flat
9. Amperage 100–120



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°

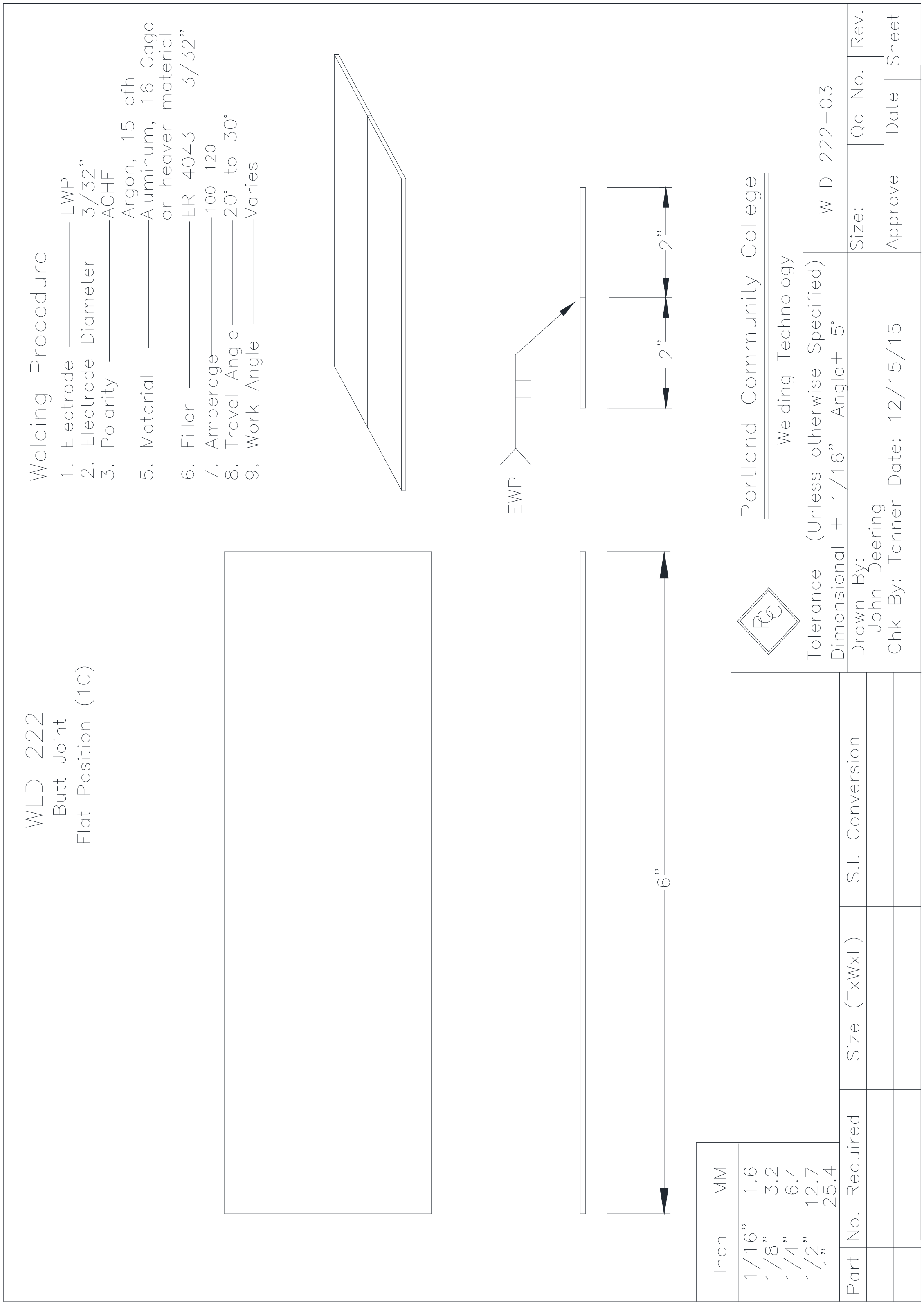
WLD 222-03

Drawn By: John Deering

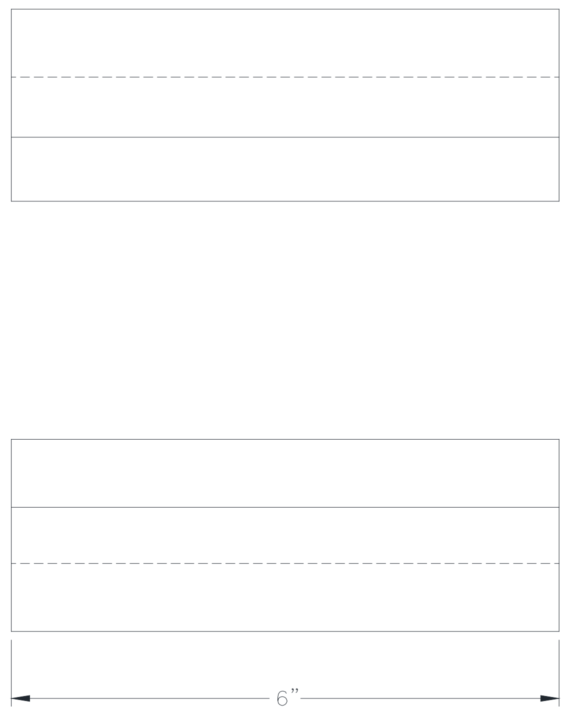
Size: | Qc No. | Rev.

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

Approve | Date | Sheet

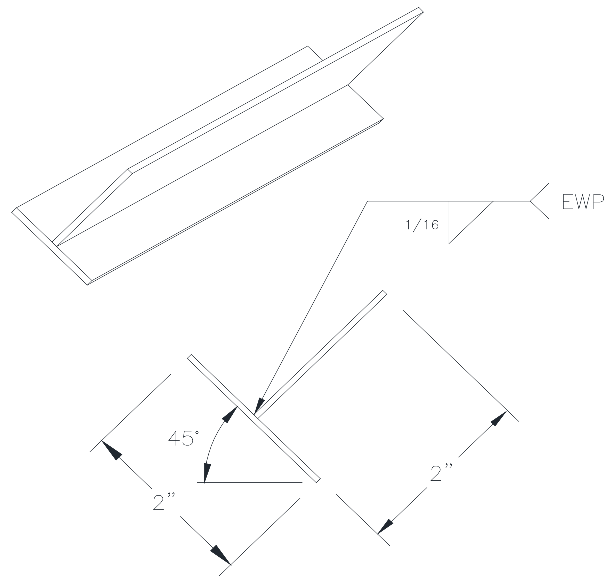

WLD 222
Butt Joint
Flat Position (1G)
Welding Procedure
1. Electrode — EWP
2. Electrode Diameter — 3/32”
3. Polarity — ACHF
Argon, 15 cfh
5. Material — Aluminum, 16 Gage or heaver material
6. Filler — ER 4043 - 3/32”
7. Amperage — 100-120
8. Travel Angle — 20° to 30°
9. Work Angle — Varies
EWP
2”
2”
6”
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 222-03
Drawn By: John Deering
Chk By: Tanner Date: 12/15/15
Size:
Qc No.
Rev.
Approve
Date
Sheet
Part No. Required
Size (TxWxL)
S.I. Conversion

WLD 222
T–Joint
Flat Position (1F)



Welding Procedure

1. Electrode — EWP
2. Electrode Diametere — 3/32”
3. Polarity — ACHF
4. Gas — Argon, 15 cfh
5. Material — Aluminum, 16 Gage or heavier
6. Filler — 1/16”–3/32” 4043
7. Amperage — 100–120
8. Travel Angle — 20° to 30° lead
9. Work Angle — Varies



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 222–04

Drawn By:
John Deering

Size: | Qc No. | Rev.

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

Approve | Date | Sheet

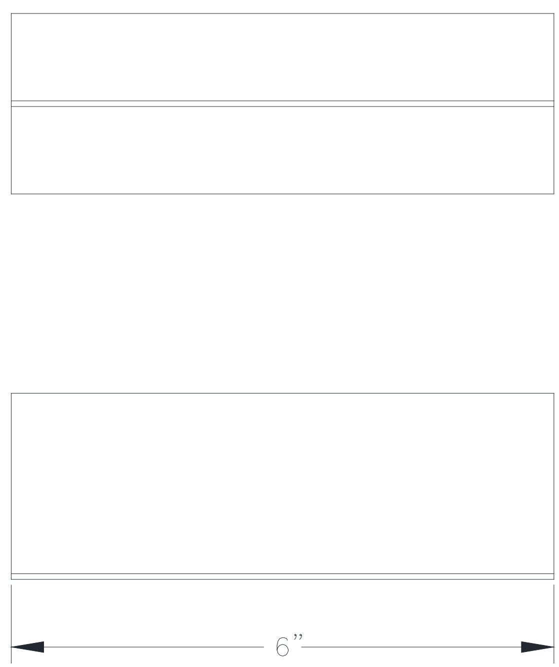
WLD 222

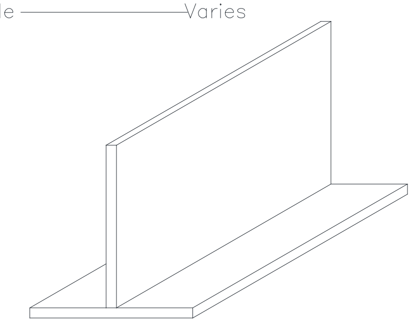
T–Joint

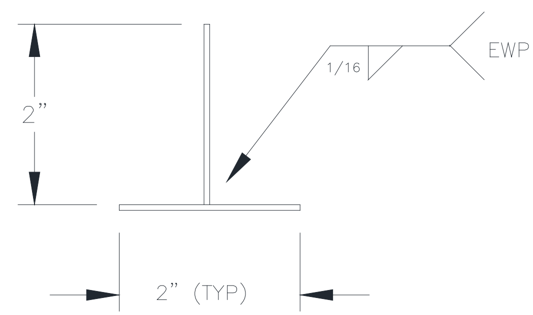
Horizontal Position (2F)

Welding Procedure

1. Electrode — EWP
2. Electrode Diametere — 3/32 or 1/8"
3. Polarity — ACHF
4. Gas — Argon, 15 cfh
5. Material — Aluminum, 16 Gage or lighter material
6. Filler metal — 1/16"–3/32" 4043
7. Amperage — 100–120
8. Travel Angle — 20° to 30° lead
9. Work Angle — Varies





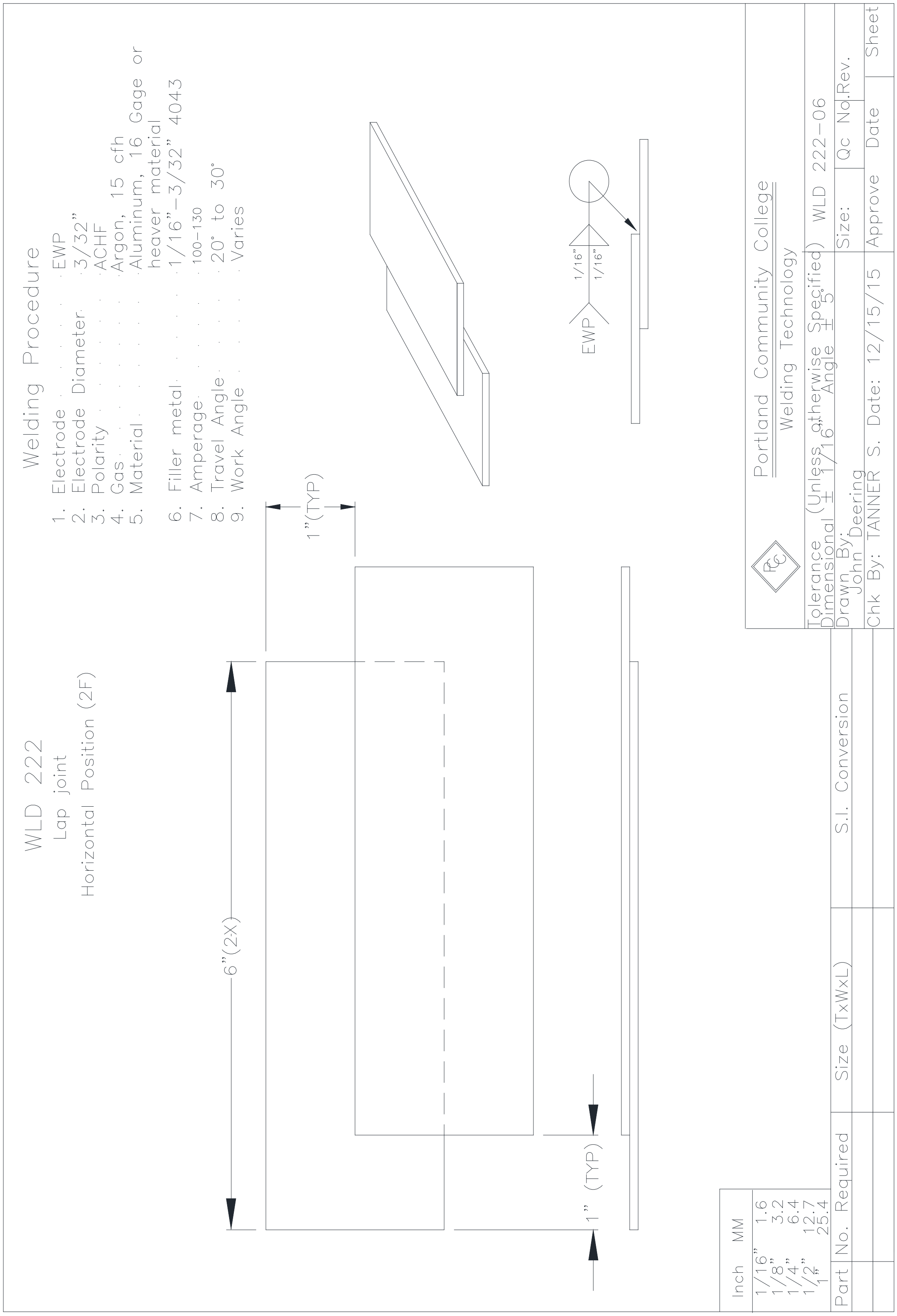


Inch	MM
1/16"	1.6
1/8"	3.2
1/4"	6.4
1/2"	12.7
1"	25.4

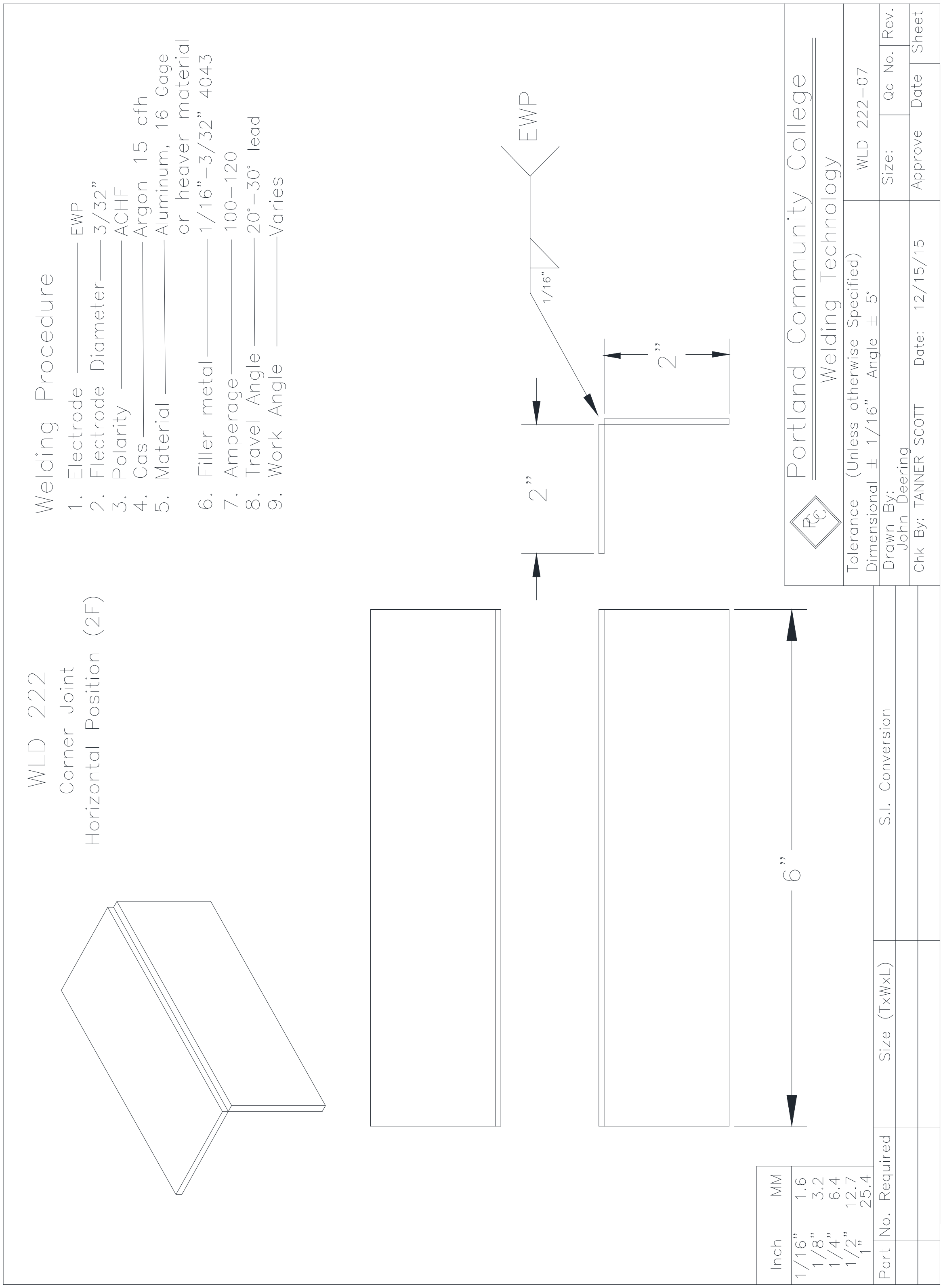
Part	No. Required	Size (TxWxL)	S.I. Conversion

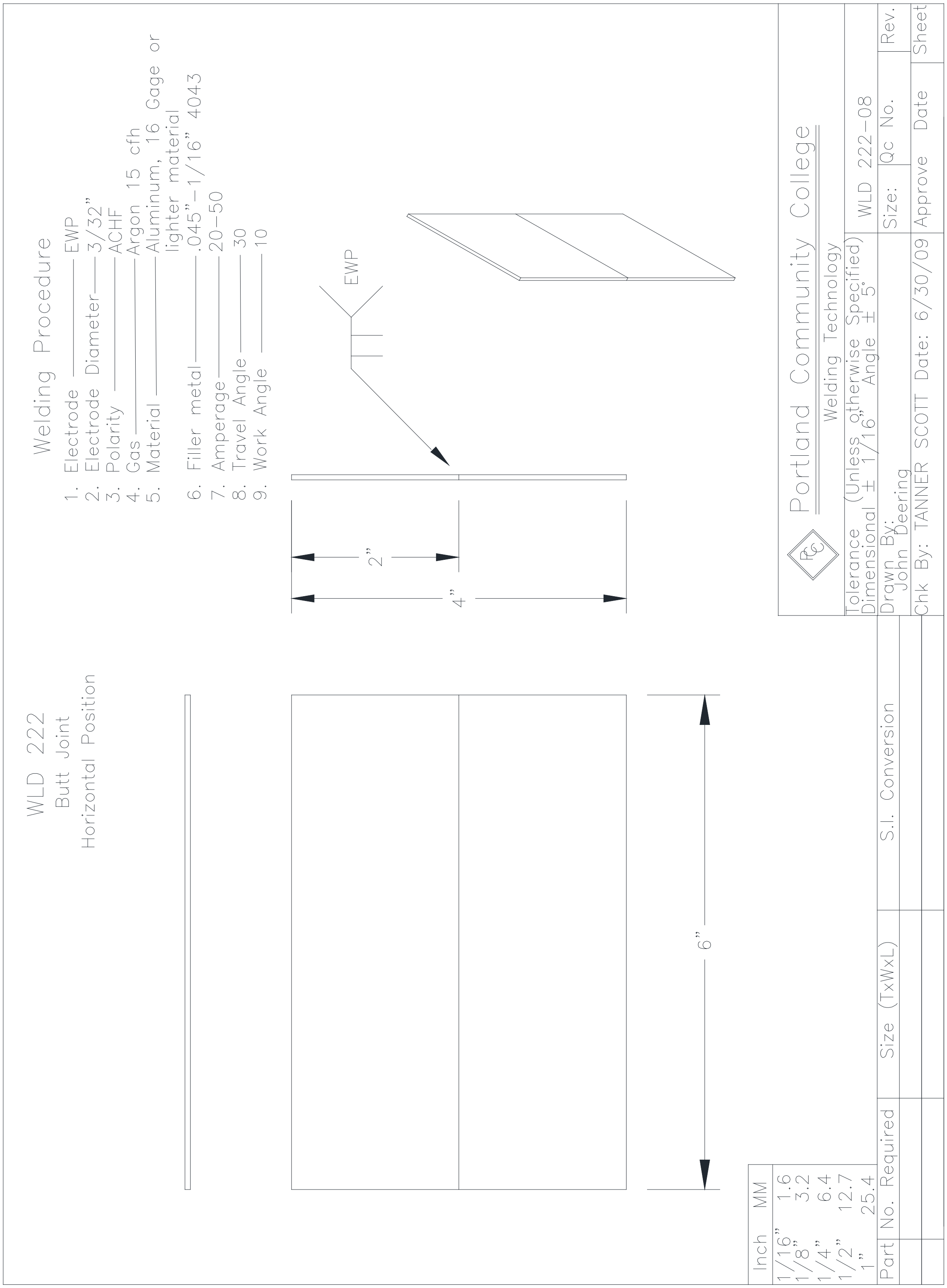
Portland Community College Welding Technology			
Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle± 5°	WLD 222–05		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: TANNER Date: 12/15/15	Approve	Date	Sheet

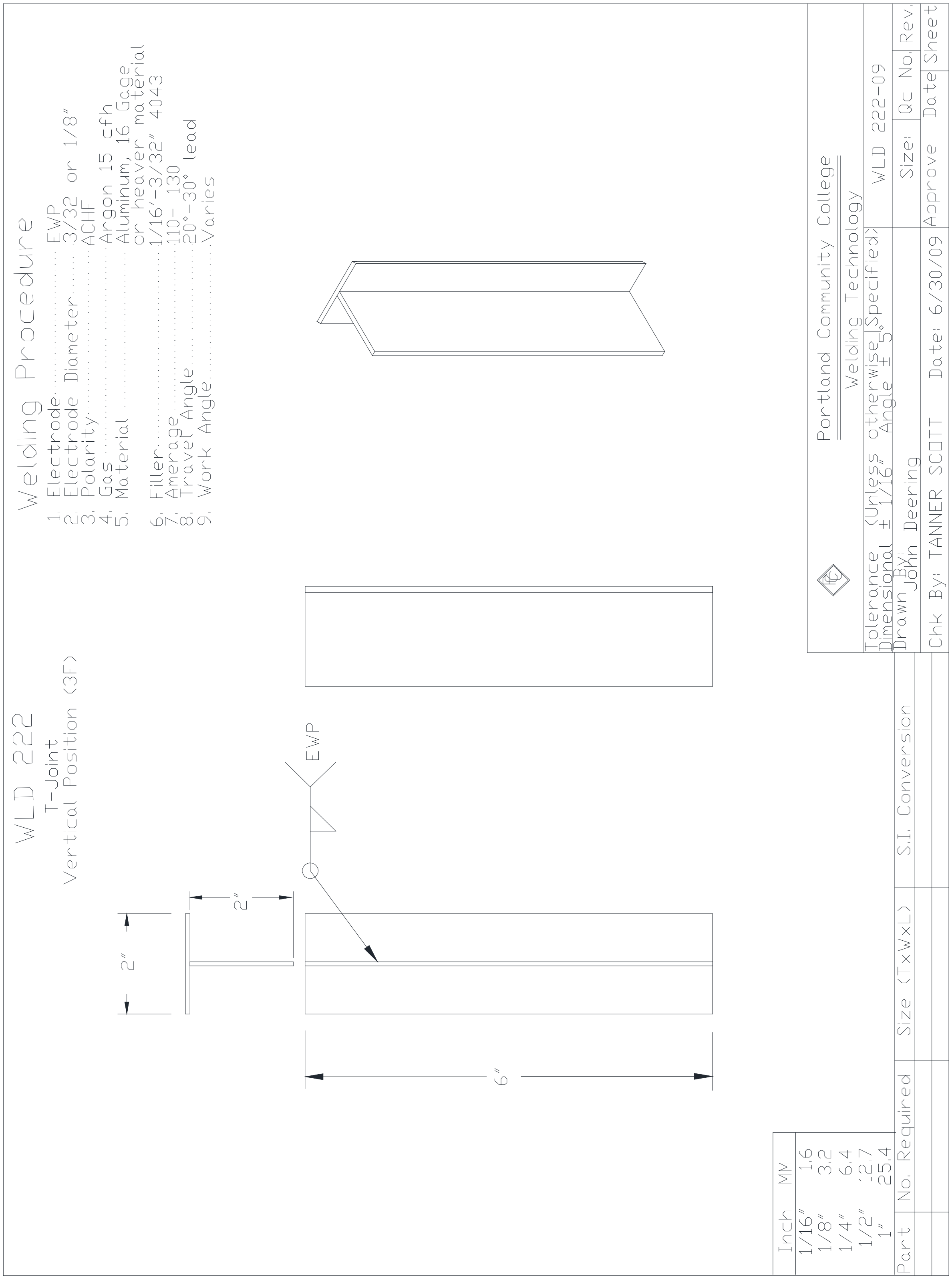
GTAW Horizontal Lap Joint Project #7



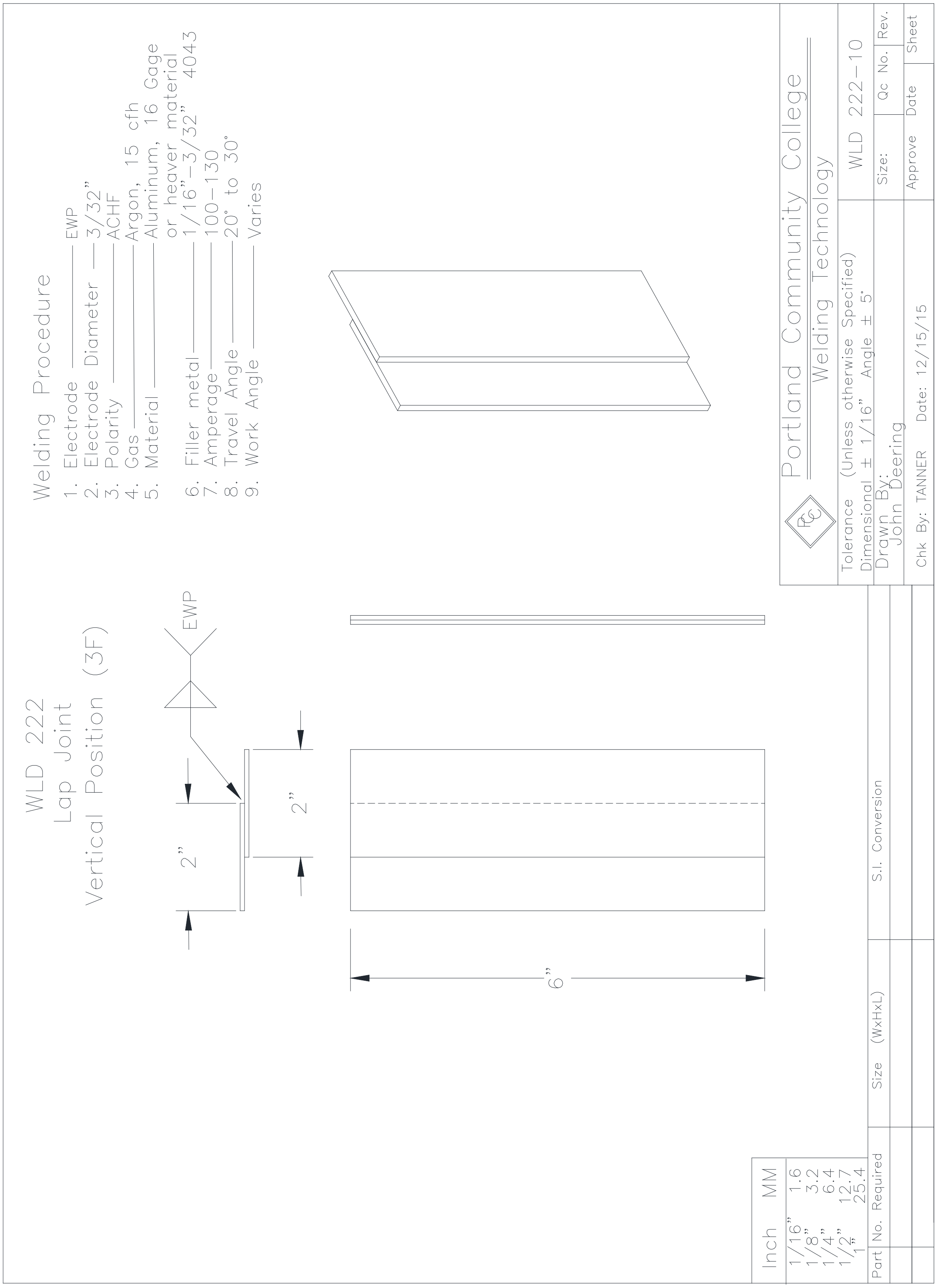
GTAW Horizontal Corner Joint — Project #8

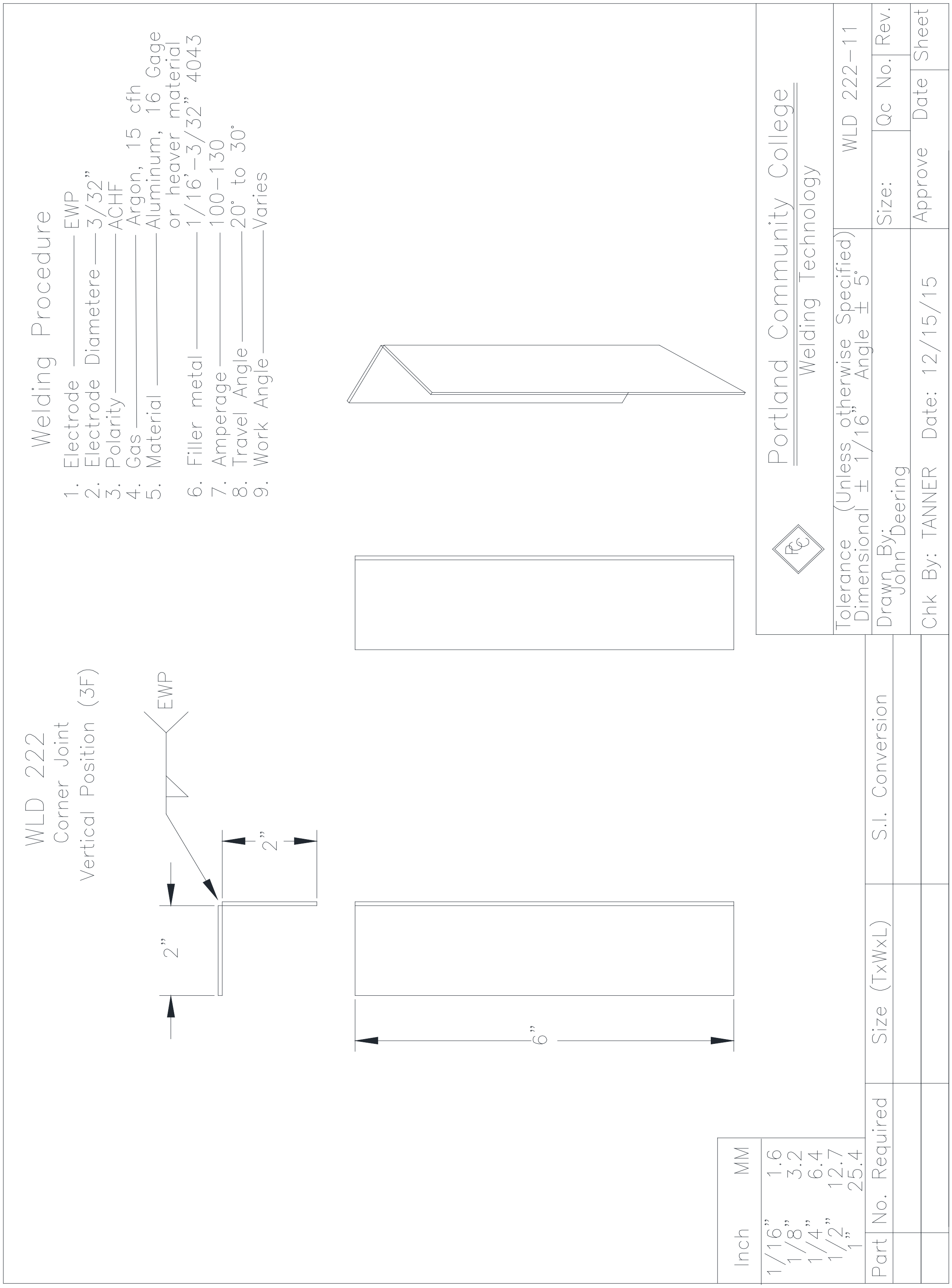



Welding Procedure
1. Electrode — EWP
2. Electrode Diameter — 3/32"
3. Polarity — ACHF
4. Gas — Argon 15 cfh
5. Material — Aluminum, 16 Gage or lighter material
6. Filler metal — .045"–1/16" 4043
7. Amperage — 20–50
8. Travel Angle — 30
9. Work Angle — 10
EWP
2"
4"
WLD 222
Butt Joint
Horizontal Position
6"
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
WLD 222-08
Drawn By: John Deering
Size:
Qc No.
Rev.
Chk By: TANNER SCOTT Date: 6/30/09
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 (TxWxL)
S.I. Conversion

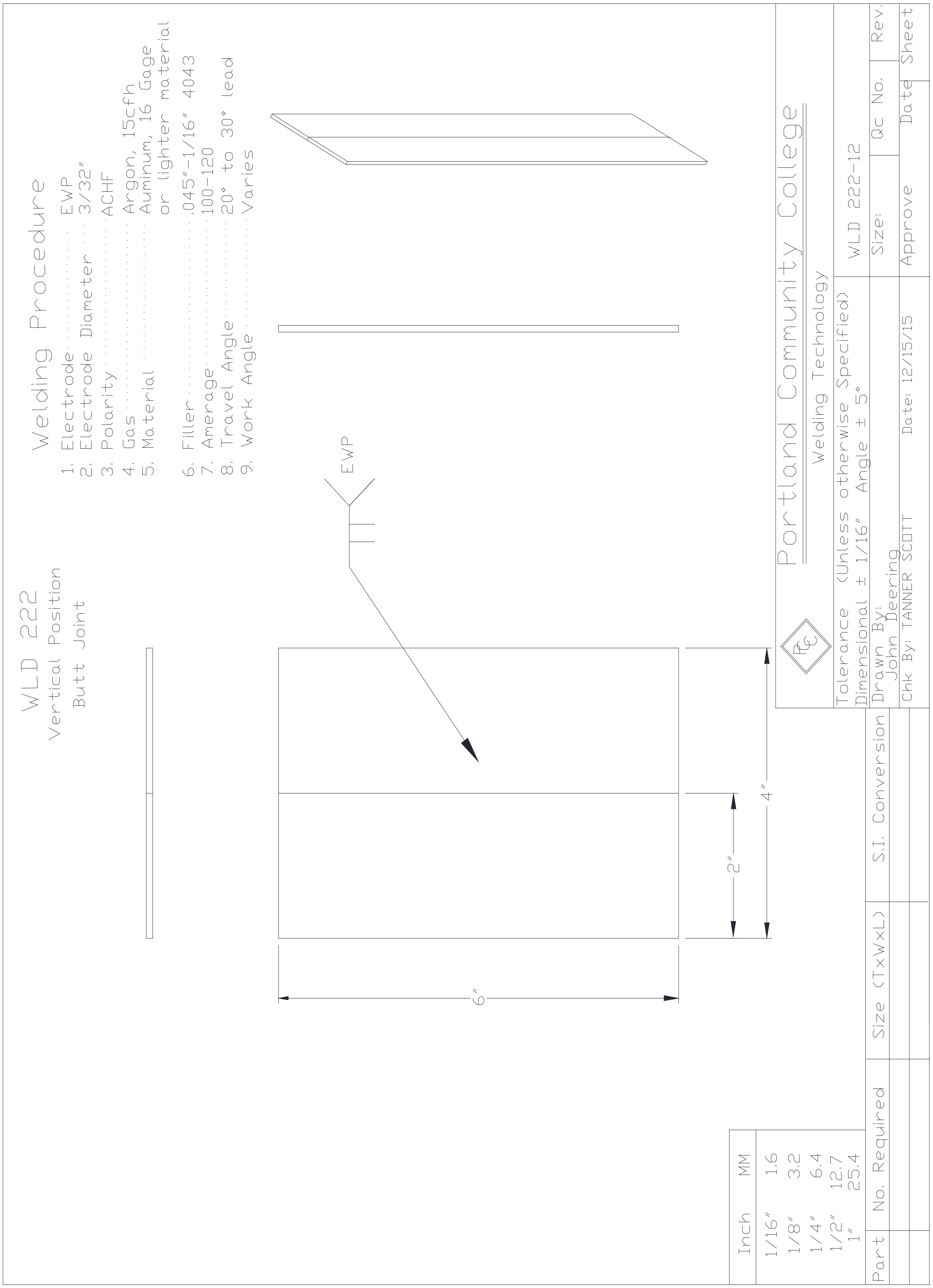

WLD 222
T-Joint
Vertical Position (3F)
2"
2"
6"
EWP
Welding Procedure
1. Electrode ... EWP
2. Electrode Diameter ... 3/32 or 1/8"
3. Polarity ... ACHF
4. Gas ... Argon 15 cfh
5. Material ... Aluminum, 16 Gage or heaver material
6. Filler ... 1/16'-3/32" 4043
7. Amerage ... 110- 130
8. Travel Angle ... 20°-30° lead
9. Work Angle ... Varies
Portland Community College
Welding Technology
WLD 222-09
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Size:
Qc No.
Rev.
Chk By: TANNER SCOTT
Date: 6/30/09
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 (TxWxL)
S.I. Conversion

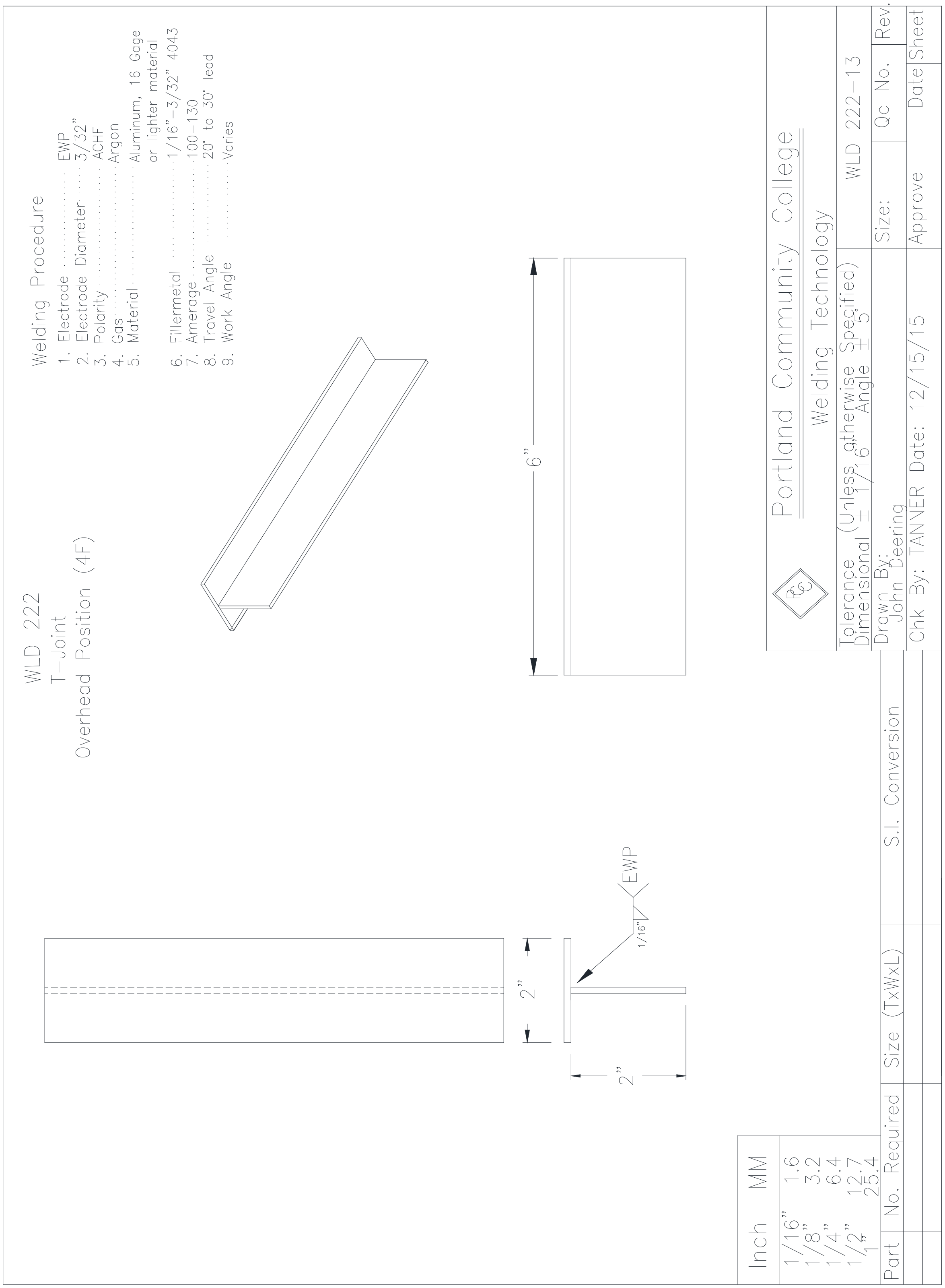
GTAW Vertical Lap Joint Project #11



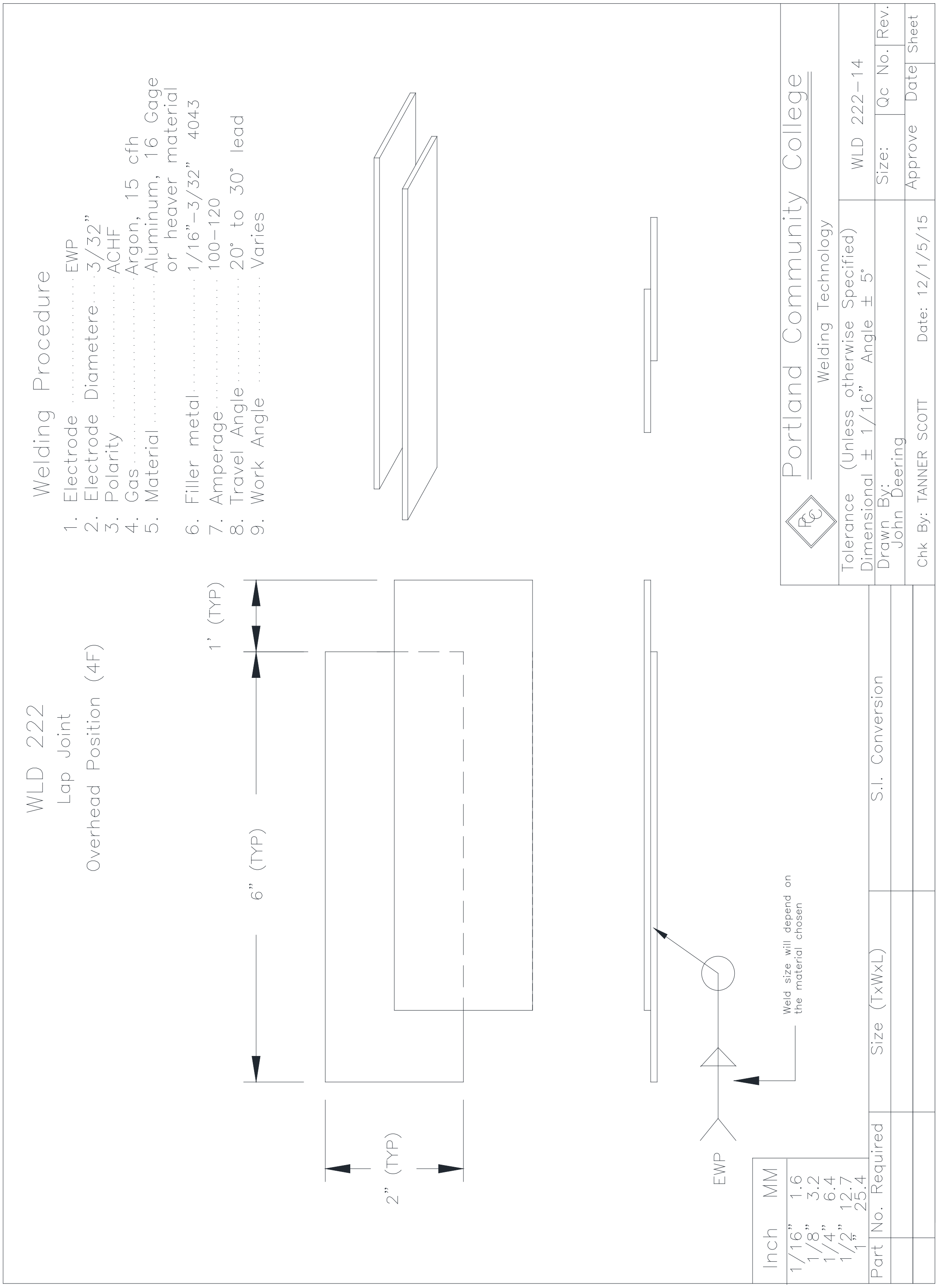

Welding Procedure
1. Electrode — EWP
2. Electrode Diametere — 3/32"
3. Polarity — ACHF
4. Gas — Argon, 15 cfh
5. Material — Aluminum, 16 Gage or heaver material
6. Filler metal — 1/16"-3/32" 4043
7. Amperage — 100-130
8. Travel Angle — 20° to 30°
9. Work Angle — Varies
WLD 222
Corner Joint
Vertical Position (3F)
EWP
2"
2"
6"
Portland Community College
Welding Technology
PCC
WLD 222-11
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Size:
Qc No.
Rev.
Chk By: TANNER Date: 12/15/15
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 (TxWxL)
S.I. Conversion

GTAW Vertical Position Butt Joint   Project #13

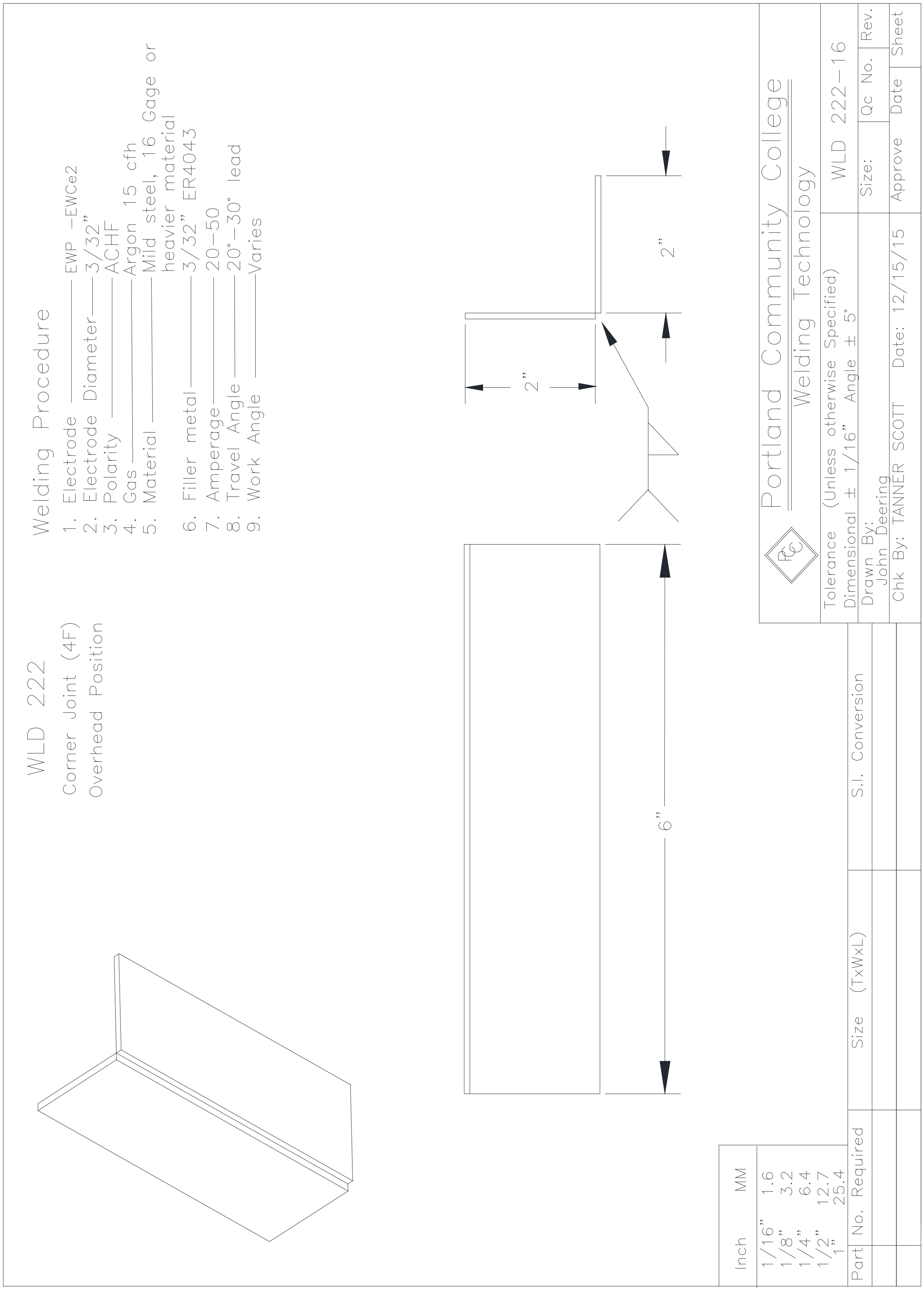



WLD 222
T–Joint
Overhead Position (4F)
Welding Procedure
1. Electrode ... EWP
2. Electrode Diameter ... 3/32"
3. Polarity ... ACHF
4. Gas ... Argon
5. Material ... Aluminum, 16 Gage or lighter material
6. Fillermetal ... 1/16"–3/32" 4043
7. Amerage ... 100–130
8. Travel Angle ... 20° to 30° lead
9. Work Angle ... Varies
6"
2"
2"
1/16"
EWP
Portland Community College
Welding Technology
WLD 222–13
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Chk By: TANNER Date: 12/15/15
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 (TxWxL)
S.I. Conversion

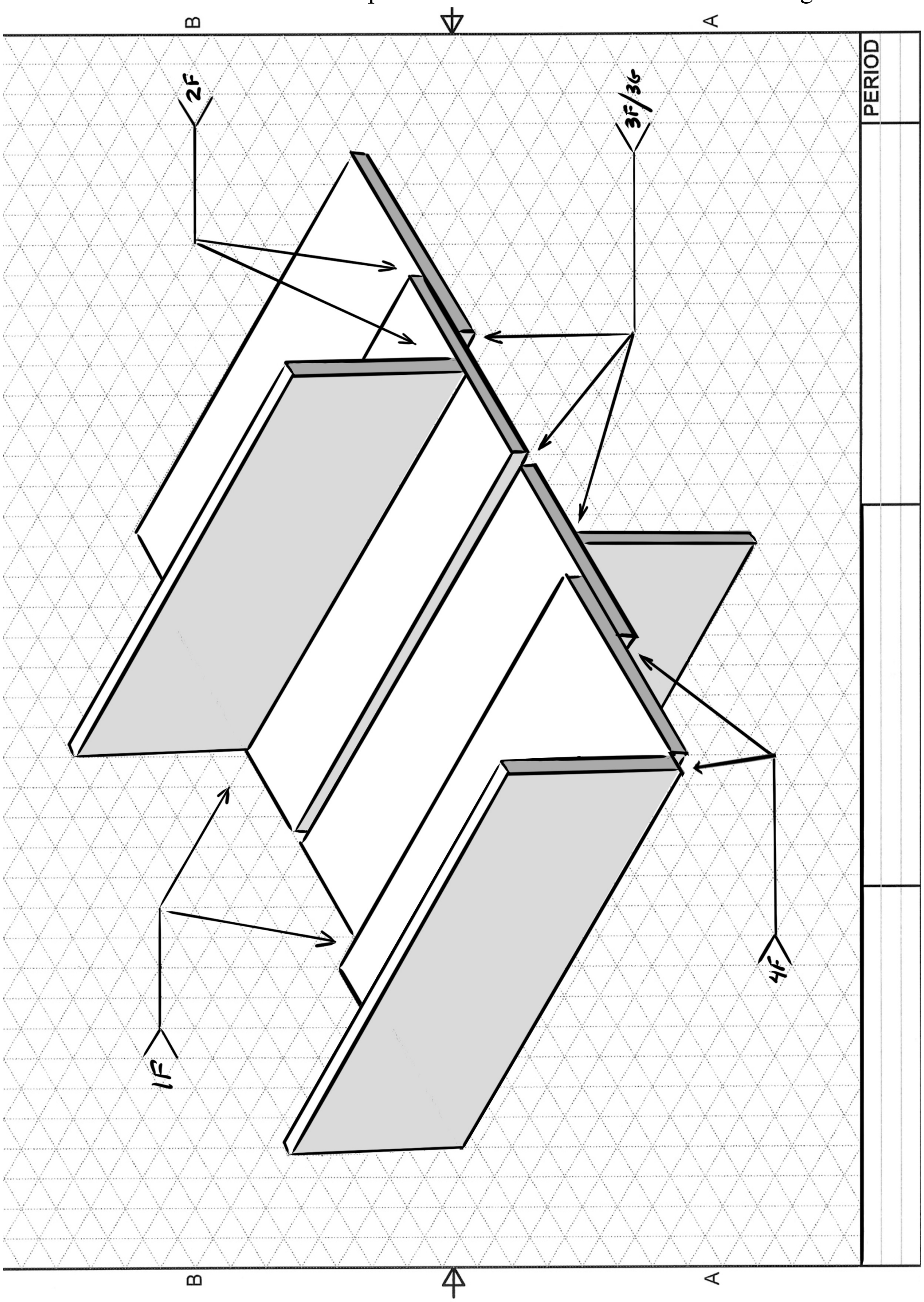
GTAW Overhead Position Lap Joint Project #15



GTAW Overhead Position Corner Joint Project #14



Practical Exam: This portion of the final will be evaluated using the standard rubric.



Gas Tungsten Arc Welding – Equipment, Setup, Operation, and filler Metals
– Welding principals and applications: Larry Jeffus

Name: ________________________________ Date: _________

SKIP to aluminum section if you have these questions completed for either 221 or 223

Introduction

1. GTAW is often referred to as TIG what do these two terms mean?

2. Why was the term Heliarc used in the past to describe the GTAW process?

3. What metals were weldable only with the GTAW process before GMAW was developed in the late 1940's?

Tungsten

4. What properties make tungsten the ideal non-consumable electrode for the GTAW process?

5. What is the melting temperature of tungsten?

6. What causes tungsten erosion?

7. Why can tungsten erosion be detrimental?

8. List eight ways to limit tungsten inclusion

9. What two ways can a collet be cooled?

10. Draw the three most common tungsten electrode shapes and label the polarity they are most commonly used for. (DCEP, DCEN, AC)

11. What are the drawbacks of using pure tungsten electrodes?

12. What are the benefits of adding Thorium the Tungsten electrode?

13. What is the benefit of adding Zirconium to the Tungsten electrode?

14. What is the benefit of adding Cerium to the Tungsten electrode?

15. Why were Cerium tungsten electrodes developed?

16. What is the befit of Lanthanum Tungsten?

17. What are the benefits of Rare Earth Tungsten electrodes?

18. How can the desired shape of the electrode end be obtained?

Torches

19. What are the benefits of a water-cooled welding torch?

20. What are the benefits of an air-cooled welding torch?

21. What material can a TIG welding nozzle or cup be made from?

22. What is the benefit of using a Gas Lens?

23. What is the purpose of a flow meter?

24. How is the rate of shielding gas flow measured?

Welding Current

25. What are the two standard types of welding current?

26. In what direction do electrons flow, negative to positive or positive to negative?

27. Describe the heat distribution between electrode and work while using DCEN.

28. Describe the heat distribution between electrode and work while using DCEP.

29. Describe the heat distribution between electrode and work while using AC.

30. What is the purpose of constant High Frequency when used with AC.

31. When welding with AC, which portion of the alternating current wave form provides a cleaning action, electrode positive or electrode negative?

32. It is often possible with newer welding power sources to change the EP and EN time of the welding current when welding with AC. Why might we adjust this balance?

33. Most manual GTAW is performed in what Hz range?

Gases

34. What are the two noble inert gasses used in the GTAW Process?

35. What two non-inert gasses can be added to argon?

36. What is “Hot Start”?

37. What is “pre-flow”?

38. What is “post-flow”?

39. What types of remote controls can be used with the GTAW process?

Gas Tungsten Arc welding of Plate
Welding Principals and Applications – Larry Jeffus

40. What is the ideal torch angle?

41. Can torch angle effect gas coverage? If so how?

42. Why must the filler rod end be kept inside the protective zone of the shielding gas?

43. What is the benefit of leaving the filler metal in the weld pool while breaking the arc?

44. Why should the filler rod enter the gas as close to the base metal as possible?

Aluminum
Larry Jeffus Textbook

1. What shape tungsten is most commonly used for welding aluminum with the GTAW process?

2. What property of aluminum allows large weld beads to be controlled easily?

3. What property of aluminum may make it difficult to weld on thick sections without first preheating the metal?

4. What is a common preheat temperature for thick aluminum?
5. What may happen to the filler rod if it is not kept inside the shielding gas.
6. What may happen to the filler rod if it is held too close to the arc?

Science on Aluminum Packet

7. Why is aluminum so prone to cracking?
8. Why is aluminum susceptible to porosity?
9. How could humidity effect the aluminum weld pool?
10. Define “Ionization potential”.
11. What is the arc plasma in GTAW welding?
12. What are the seven common sources of hydrogen contamination?

A

B

C

D

E

F

G

Final Grading Rubric for practical exam
Class Name: WLD 222

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 222 GTAW Aluminum: Project Assessment Form

Student Name:_______________Date_________

Flat Position	Assessment	Instructor Signature/Date
Edge Joint – Fuse Weld		
Corner Joint – Fuse Weld		
Butt Joint		
T-Joint		

Horizontal Position	Assessment	Instructor Signature/Date
T-Joint		
Lap Joint		
Corner Joint		
Butt Joint		

Vertical Position	Assessment	Instructor Signature/Date
T-Joint		
Lap Joint		
Corner Joint		
Butt Joint		

Overhead Position	Assessment	Instructor Signature/Date
T-Joint		
Lap Joint		
Corner Joint		

Welding Projects average:
Written packet work:
Final written score:
Final practical rubric score: