WLD 223
Gas Tungsten Arc Welding
Stainless Steel

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 GTAW videos: PCC library site

Writing Work Sheets:

Stainless Steel

Welding Projects:

Flat Position	**Horizontal Position**	**Vertical Position**	**Overhead Position**
Edge Joint	Lap Joint	T-Joint	T-Joint
Corner Joint	T-Joint	Lap Joint	Lap Joint
Bead Plate	Corner Joint	Corner Joint	Corner joint
Butt Joint	Butt Joint	Butt Joint	
T-Joint			

Final Exam:

Part One (Closed Book Exam)
Part Two (Practical Exam)

Weldability and Welding Procedures

Austenitic Stainless Steels
This group is the most weldable of the stainless-steel group of alloys. They can be welded by a variety of welding processes. Our focus will be the use of the Gas Tungsten Arc process.

Although the austenitic group is more weldable than the other groups, special procedures are required. The following suggestions will be helpful:

- Do not preheat. This will increase the cooling time in the sensitization range (800 to 1600 degrees Fahrenheit).
- Use small. Diameter electrodes and low amperage to keep heat input to a minimum.
- Hold as short an arc length as possible, a long arc burns out chromium, reducing corrosion resistance and crack resistance.
- Always fill all craters at the ends of the beads.
- Always select a filler metal that matches or upgrades the base material.
- Controlling distortion
    - frequent tacks (peening the tacks will help relieve stresses)
    - use of fixtures
    - use chill bars, (copper, aluminum, or any high thermal conductive material)
- Use a weld sequence that disperses heat.
- Use a low carbon or stabilized filler metal.

Carbide Precipitation

We cannot discuss the welding of Austenitic stainless steel without discussing the problem of carbide precipitation.

Under certain conditions, carbon combines with Chromium forming carbides which have no corrosion resistance. ***Chromium carbides are formed when the steel slowly passes through the temperature range from 800° to 1600 °F***, such as during welding and slow cooling.

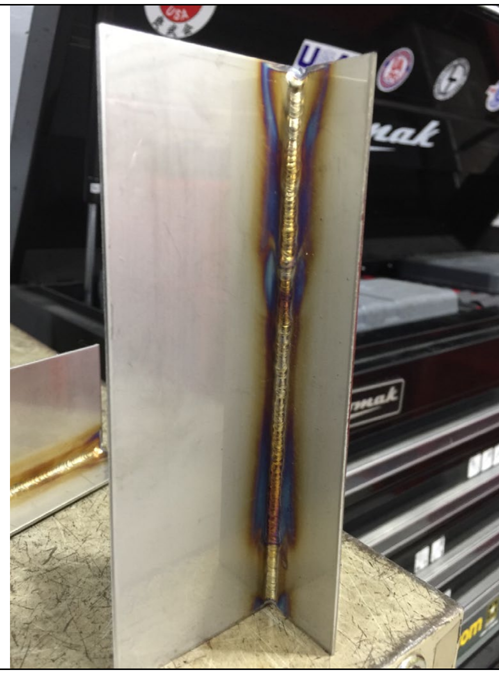
This occurs in the H.A.Z. (heat affected zone), the base metal adjacent to the weld, and can sometimes be seen by black discoloration in this area.

Color of the Welds

When welding stainless steel the after-weld color will tell the welder if s/he welding it with the correct amount of heat input. Factors in being able to control the heat input are:

1) Amperage
2) Travel speed
3) Shielding gas (cfh as well as the use of a gas lens)
4) Arc length
5) Filler metal dipping rhythm
6) Shape and cleanliness of tungsten

Color Formed	Temperature F
pale yellow	554
straw yellow	644
dark yellow	698
brown	734
purple brown	788
dark purple	842
blue	1004
dark blue	1112



Controlling Carbide Precipitation

1. Limit the carbon level to .03% or less in the base metal. These are referred to as ELC (extra low carbon) or L (low carbon) stainless steels. The lower the carbon the greater the weldability.
2. Add either of two elements, columbium or titanium. These two elements will combine with the carbon to form harmless carbides that do not affect the corrosion resistance of the stainless. These elements are called stabilizers. Base metals containing them are 347 (cb) and 321 (ti). They are called stabilized stainless steels.
3. Carbide precipitation can also be controlled to some extent by using smaller diameter electrodes, low heat input, close arc, and quenching between passes to reduce the time that the heat affected zone in the 800 ° to 1600 ° F range**.**
4. Another common practice used in foundry work, is to heat the completed weldment to 2100 ° F and then quench in cold water.

Science On Stainless

Contents of this Packet include

A. What are Stainless Steels
B. Production of the Arc Plasma in GTAW
C. Shielding Gasses for GTAW of Stainless Steel
D. Purpose of Pulsed GTAW
E. Stainless Steel Welding with 308L Electrodes
F. Welding with 309L Electrodes

What are Stainless Steels?

The single alloying element that is added to steel to make it "stainless" is at least 12% chromium (Cr). Although there are many varieties of stainless steel for particular applications, the five categories of stainless alloys are:

1 Austenitic stainless steel
2 Martensitic stainless steel
3 Ferritic stainless steel
4 Precipitation hardening (PH) stainless steel
5 Duplex austenitic-ferritic stainless steel

When 12%Cr is added to pure iron (Fe), binary alloys of Fe-Cr will not form austenite at any temperature. This is the basis of the ferritic type of stainless steels. Ferritic stainless steel offer excellent resistance to corrosion and oxidation. However, when 12%Cr and additions of carbon, nitrogen, nickel and copper are alloyed with Fe, the austenite range opens at elevated temperatures. The stainless steels which transform to austenite at elevated temperatures and form martensite upon quenching are the martensitic stainless steels. Martensitic stainless steels containing more than 0.6%carbon have outstanding cutlery applications (such as surgical tools and razor blades) because they can be hardened by heat treatment.

Austenitic stainless steels are Fe-based compositions that are a balance between austenite formers (like carbon, nitrogen, nickel and copper) and ferrite promoters (like Cr, molybdenum, niobium, titanium, aluminum and vanadium. Typically, austenitic stainless steels contain about 18%Cr and 8% nickel. Austenitic stainless alloys are by far the most popular. They are used for food processing industry, eating utensils, high temperature applications, and many other uses. The most popular austenitic stainless steels in the United States are types 304 and 316 austenitic stainless alloys.

Precipitation hardening (PH) stainless steels are those that are strengthened by age hardening reactions. There are basically three types: (1) martensitic PH stainless steels, (2) semi-austenitic stainless steels and (3) austenitic stainless steels. All the PH types steels are characterized by strength and corrosion resistance. For example, Type 630 (or 17-4PH) martensitic stainless steel contains 17%Cr, 4%Ni and 3%Cu. This steel can be solution heat treated and quenched to form a martensitic structure having a yield strength well over 100 ksi. When this quenched structure is then aged at elevated temperature, a fine copper precipitate forms and further increases yield strength to over 170ksi.

Duplex stainless steels contain an optimal balance of equal amounts of ferrite and austenite. Austenite provides outstanding high temperature strength and high ductility at low temperatures, but it is susceptible to stress corrosion cracking. The addition of ferrite, which is immune to stress corrosion cracking, provides a compromise alloy that has excellent mechanical properties as well as resistance to stress corrosion cracking.

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 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 an abundance of electrons by thermionic emission. These energetic electrons collide with the shielding gas (argon or helium) atoms as well as the atoms in the work piece 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 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.

Shielding Gases used in GTAW

In WLD 223, most welding is performed on austenitic stainless steels type 304 and type 316. In GTAW austenitic stainless steel, only inert gases like argon or helium can be used. However, small amounts of hydrogen can be added to mixtures of argon and helium because is a non-oxidizing gas. Generally, pure Ar is ideal for thin sheet; while mixtures of argon and helium are used for thicker plate because Ni makes weld pool sluggish. Also, argon and helium mixtures are used for automatic welding to take advantage of the greater travel speeds associated with a hotter gas (compared to argon).
Ar-He-Hydrogen mixtures for austenitic stainless only, because hydrogen is a reducing agent. A reducing agent "cleans" the weld area by reducing the oxides by to elemental metal as shown below:

$$FeO + H_2 = Fe + H_2O$$

Furthermore, hydrogen is a diatomic gas which increases the welding heat for joining thick sections. Hydrogen improves wetting and reduces surface oxides. Since austenitic stainless steel has a face-centered cubic crystal structure, the steel is immune to hydrogen-assisted cracking. Because hydrogen is flammable gas, mixtures of argon/helium and hydrogen are limited to no more than 15% hydrogen. Sometimes, it is best not to have argon-hydrogen mixtures in the welding shop; because, if, by accident, the argon-hydrogen gas is used to weld steel or martensitic stainless steel and many other hydrogen-susceptible materials, hydrogen-assisted cracking can occur.

Purpose of Pulsed GTAW

Although not as vitally necessary as GMAW, pulsing of GTAW is a valuable option for welding stainless steel. There are two types of pulsed current: (1) low frequency pulsing and (2) high frequency pulsed current. In low frequency, pulsed GTAW, the pulsed current is about 2 to 10 times that of the background current. The pulse frequency varies from once every 2 seconds to about 20 pulses per second. Compared to convention steady current GTAW, the advantages of low frequency pulsed GTAW include: greater penetration, minimal distortion, reduced heat input, excellent for welding thick-to-thin, can weld thin sheet, better all-position welding capability, and better to bridge gaps in open root welding. Experienced welders tend to use the pulses to time there torch movements to provide a very uniform-appearing weld deposit. Pulsed current is usually applied with DC-EN for stainless steel welding.

High frequency pulsed GTAW involves switching DC-EN current between low level to high level at a rapid fixed frequency of approximately 10,000 Hz or 10 kHz. One Hz (Hertz) of electrical current is one cycle per second. High frequency pulsing produces a stiff arc with relative low heat input.

Arc pressures can increase more than 4-times that of a steady arc. Because of the increased power density and directional properties of the arc during each pulse, high frequency pulsed GTAW is ideally suited for automatic or mechanized applications. Although the cost of pulsed power sources are more expensive than conventional GTAW power supplies, the advantages of enhanced power density, arc stiffness and reduced heat input bring added performance to pulsed GTAW. A disadvantage of pulsed power is the arc noise can be irritating because the frequencies used best welding are usually in the audible range. Simple ear plugs can prevent this distraction.

Stainless Steel Welding with 308L Filler Material

The two most popular wrought stainless steels are the 304 and 316 austenitic alloys. Type 304 stainless steel as well as 301, 302, 305 and the cast alloys CF-3 and CF-8 are commonly joined using 308L filler metal. Type 316L filler metal is used for welding wrought 316 and 316L base metals and cast alloys CF-3M and CF-8M. At PCC, most welding work will be conducted with type 304 stainless.

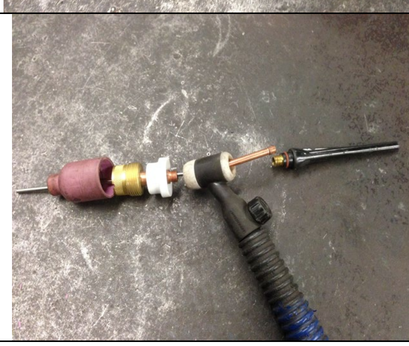
Type 304 austenitic stainless steel is welded with 308L filler by GTAW. The "L" in 308L indicates that the filler contains extra-low carbon content, typically less than 0.03%. It is very important that prescribed filler be used to weld a particular grade of stainless steel, because there is only a narrow range of acceptable compositions that are not susceptible to solidification cracking. Type 308L is designed to be used with 304 stainless steel so that excellent weld quality is achieved in all welding positions. If filler metal are used which are not recommended by the manufacturer or the American Welding Society, solidification cracking may occur. Because solidification cracking is problem in GTAW of stainless steel, the WRC-1992 diagram was developed to choose the correct filler to ensure crack-free welds. Using the WRC-1992 in Figure 1, the composition of the weld metal admixture must fall in the region marked "FA" for maximum immunity to solidification cracking. When using a ferrite gage, the ferrite number (FN) should read from 3 to 12% for maximum immunity to solidification cracking.

Welding with 309L Electrodes

Type 309L stainless steel electrode contains more Cr and more Ni than the 308L electrode. Type 309L filler metal is designed to weld mild steel (or low alloys steel) to stainless steel. Thus, for applications where steel plate is being welded to stainless steel plate, the use of 309L is needed to provide weld metal that is resistant to solidification cracking. The weld metal is designed to contain from 3 to 12FN (ferrite number, from Figure 1) to prevent solidification cracking.

Type 309L is also designed to join dissimilar stainless steels such as welding 409 to 304L using 309L filler metal. Again, the purpose of the 309L filler metal is to ensure that the weld metal contains from 3 to 12FN to prevent solidification cracking.

Torch Set Up for Stainless Steel

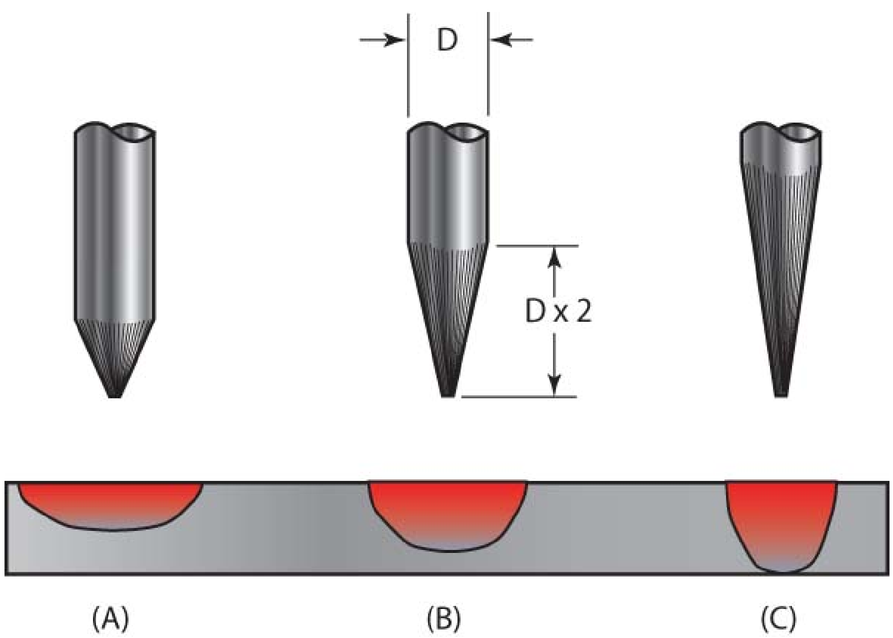
Tungsten Grind To maximize heat transfer with the least amount of amperage applied, the welder must grind the tungsten correctly. As seen in the picture, the grind lines are vertical, and the taper is long. Also, be sure to use a clean tungsten too. This will assist the welder in obtaining the best color.	
Gas Lens Gas lens are a great tool in the TIG welding application of stainless steel. This type of collet body is designed to force the shielding gas out of the cup in a stream lined direction. This provides for the most efficient gas coverage which means better cooling for stainless steel welds which equals better color.	
Gas Lens Assembly The picture clearly describes the assembly order of the gas lens parts.	

Benefits of a Gas Lens

As seen in the picture to the right, the benefit of a gas lens is the streamline flow. Overall less gas is needed and it provides for better weld coverage.

Tungsten Preparation

The way the tungsten is ground is a huge component to a successful weld. The sharper the grind the more focused the arc will be. You will need to determine your preference!



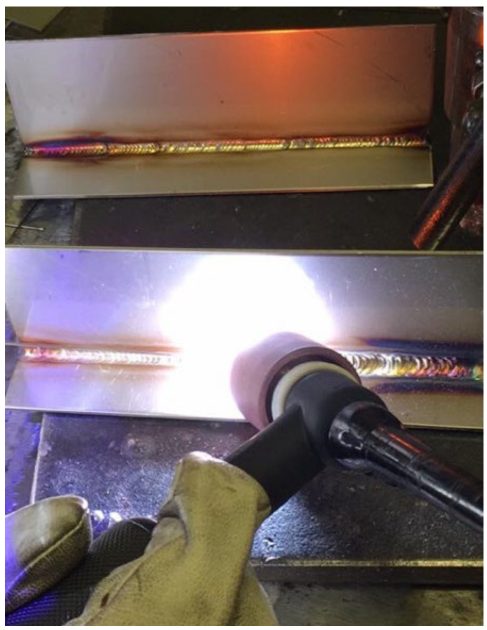
Craftsmanship Expectations for Welding Projects

Steps in completing welding projects:

1. Thoroughly read each drawing.
2. Utilize scrap material to adjust machine.
3. Assemble the welding projects per drawing specifications.
4. Review the Welding Procedure portion of the prints to review welding parameter information.
5. Complete welding project. Practice as needed to meet acceptance criteria listed below.
6. Complete the student assessment piece on the project sheet and submit.
7. Submit project to the instructor for the final grading.

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

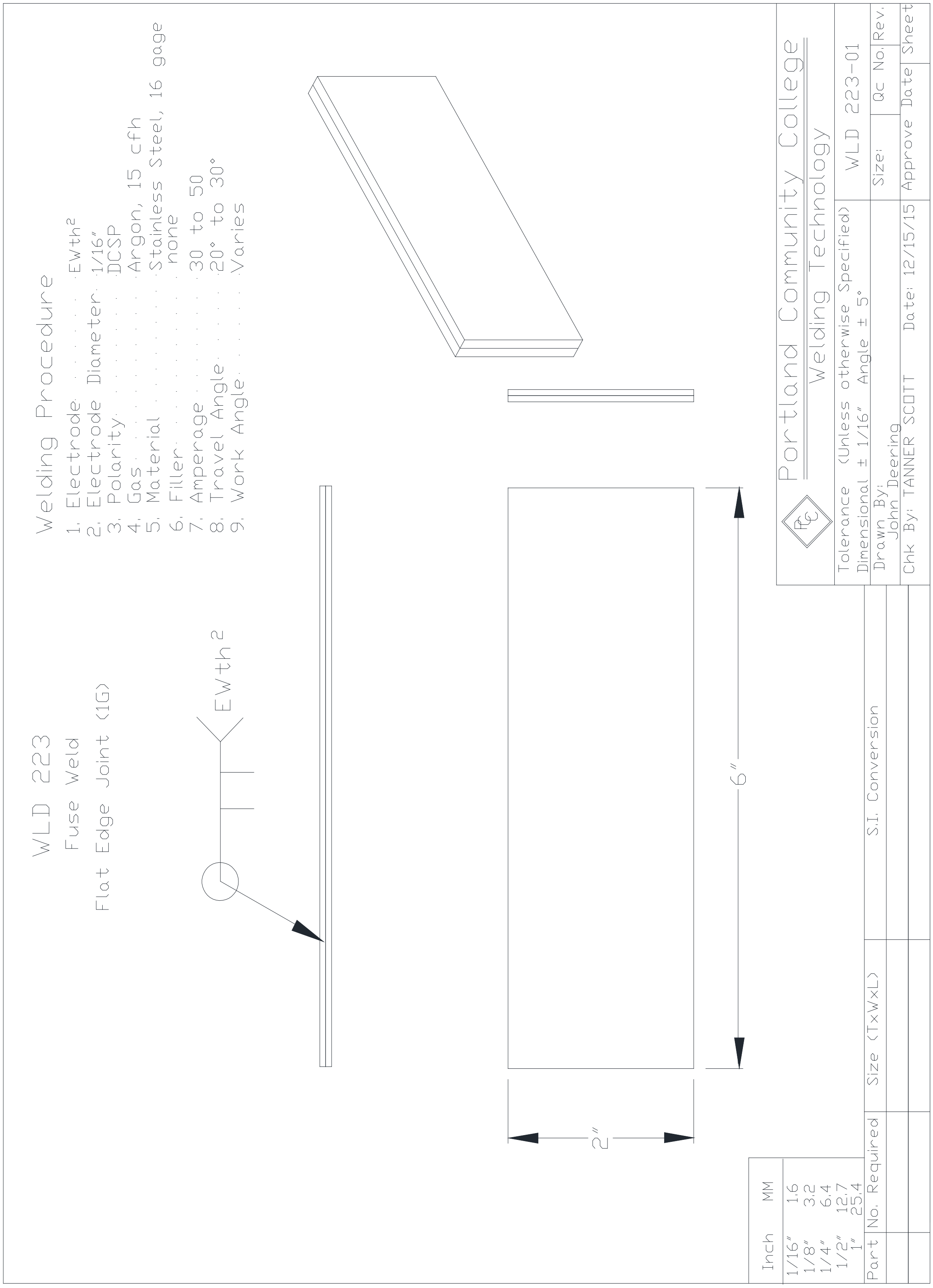


Example of a High-Quality Welds

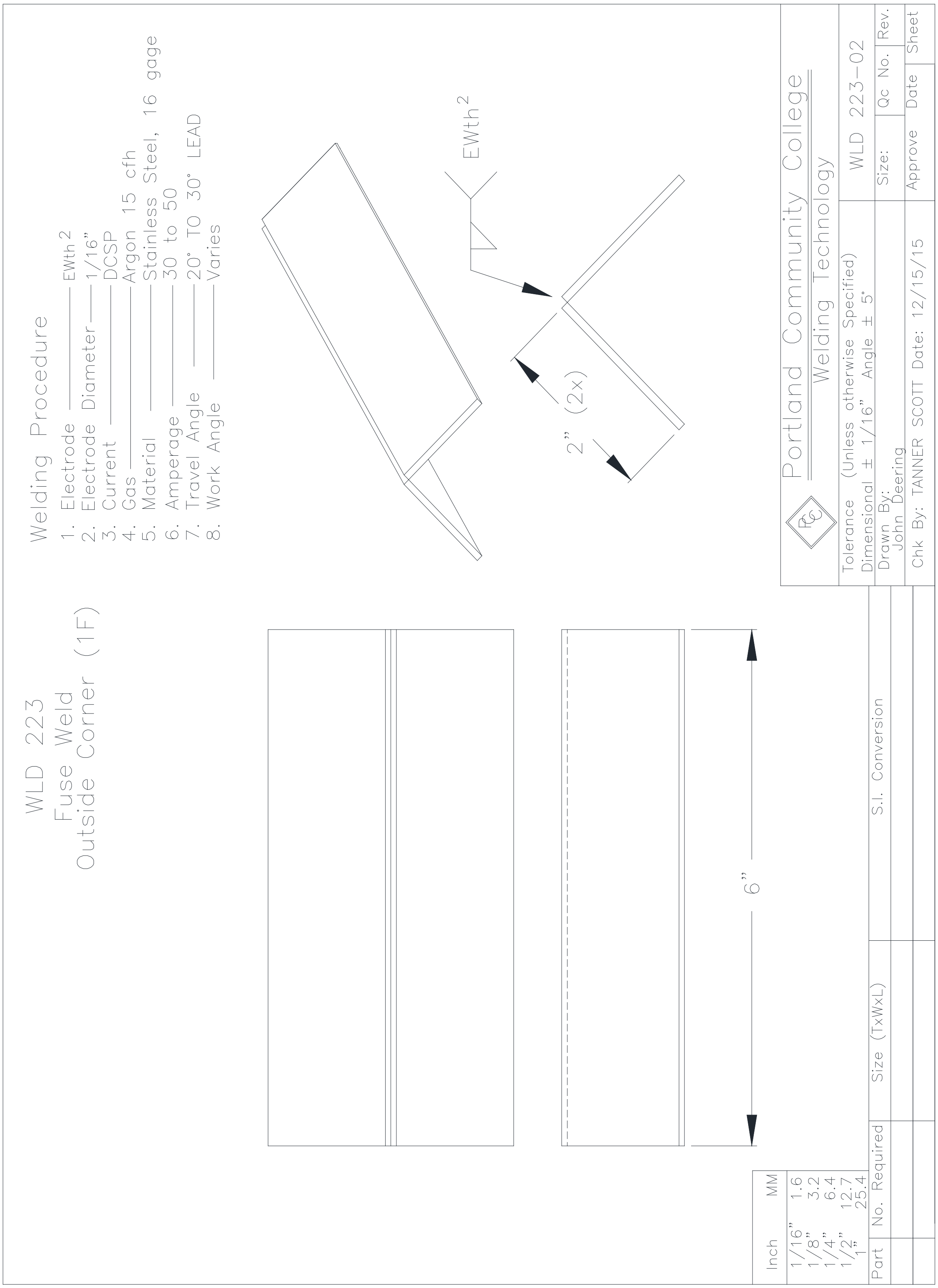
Weld Quality per Industry Standards

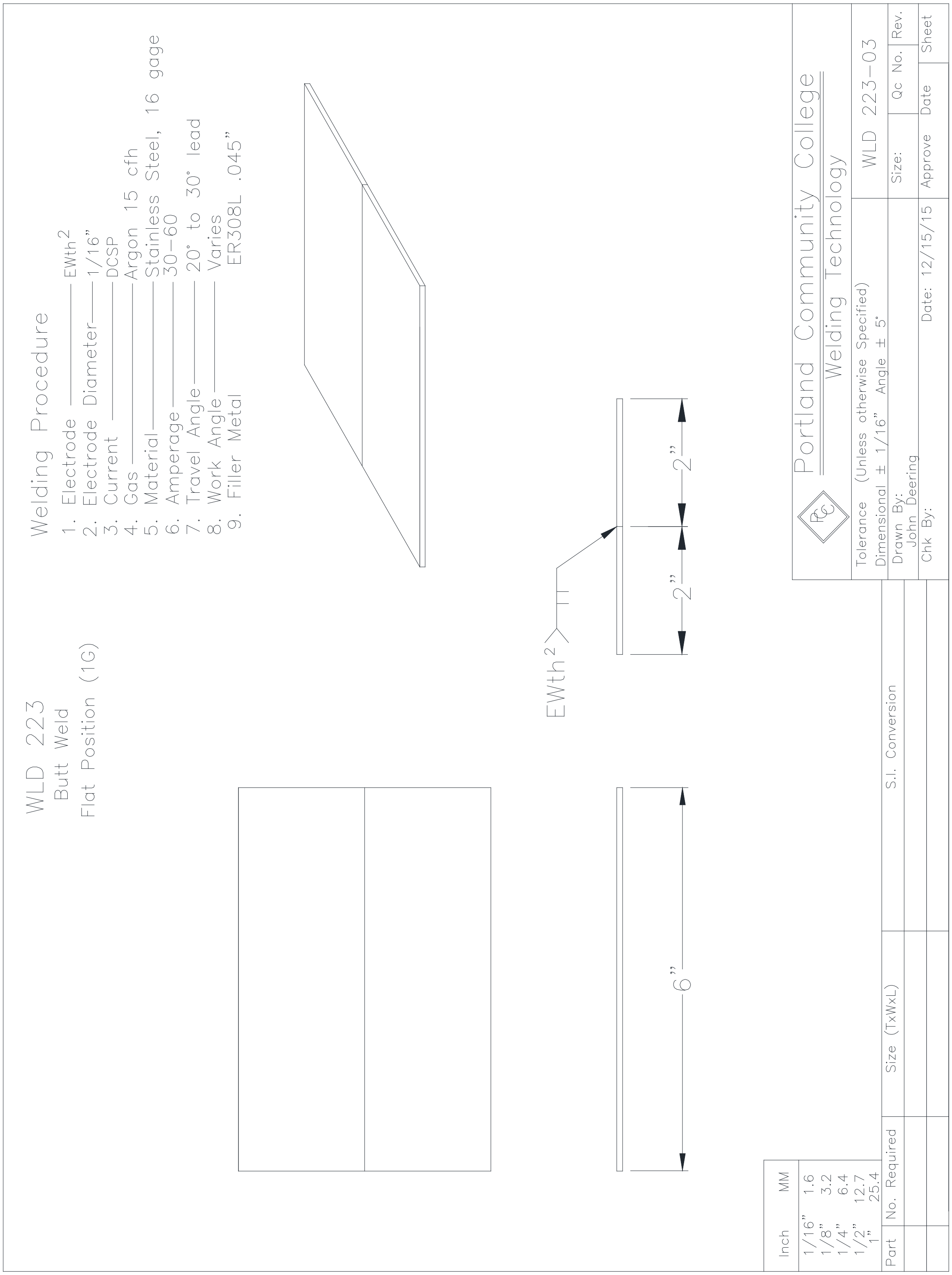
VT Criteria	**Cover Pass**
Weld Size	See specification on drawing
Undercut	1/32" deep
Weld Contour (Chevron spacing)	Smooth Transition
Penetration	N/A
Cracks	None Allowed
Arc Strikes	None Allowed
Fusion	Complete Fusion Required
Porosity	None Allowed
Overlap	None Allowed

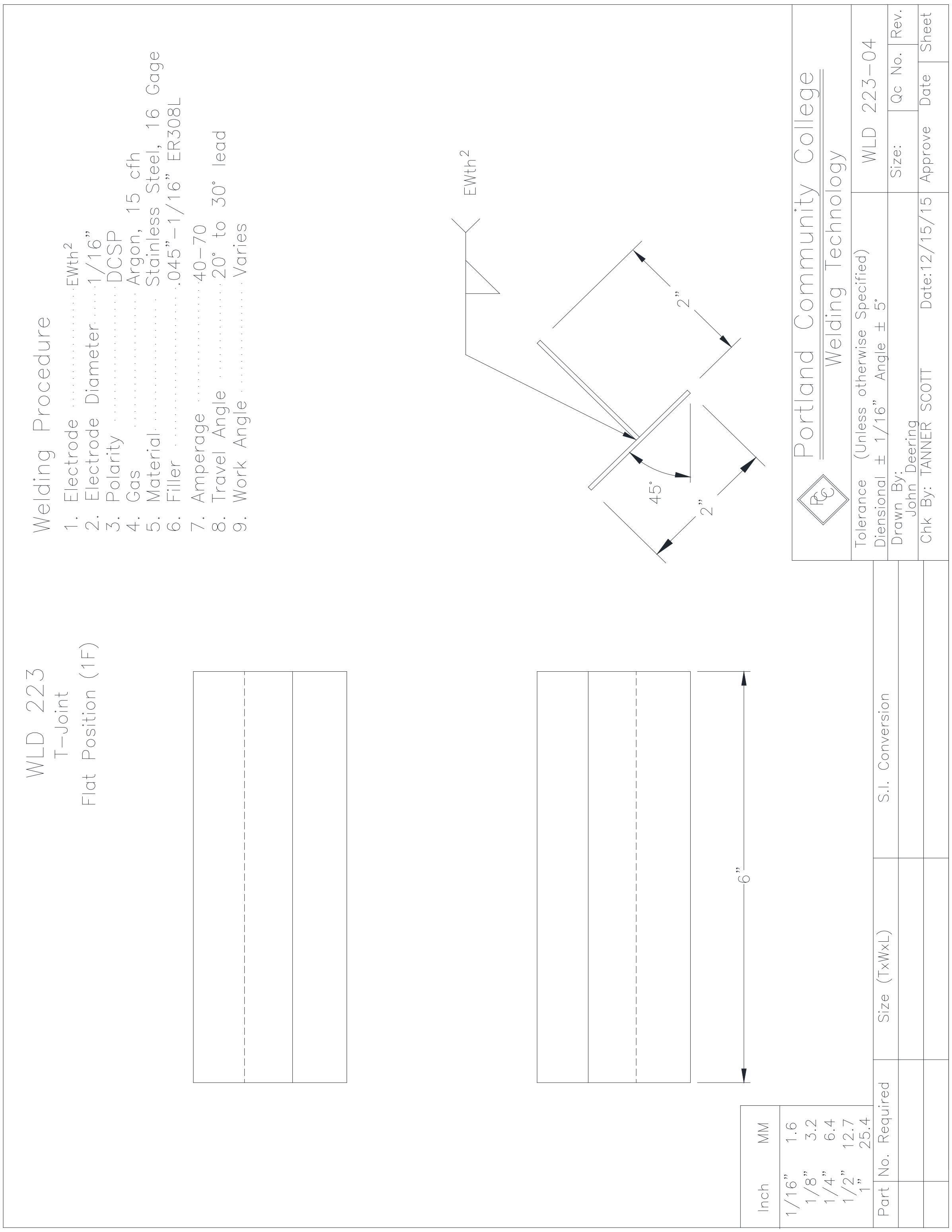
GTAW Flat Position Edge Joint (Autogenous/Fuse Weld) Project #1



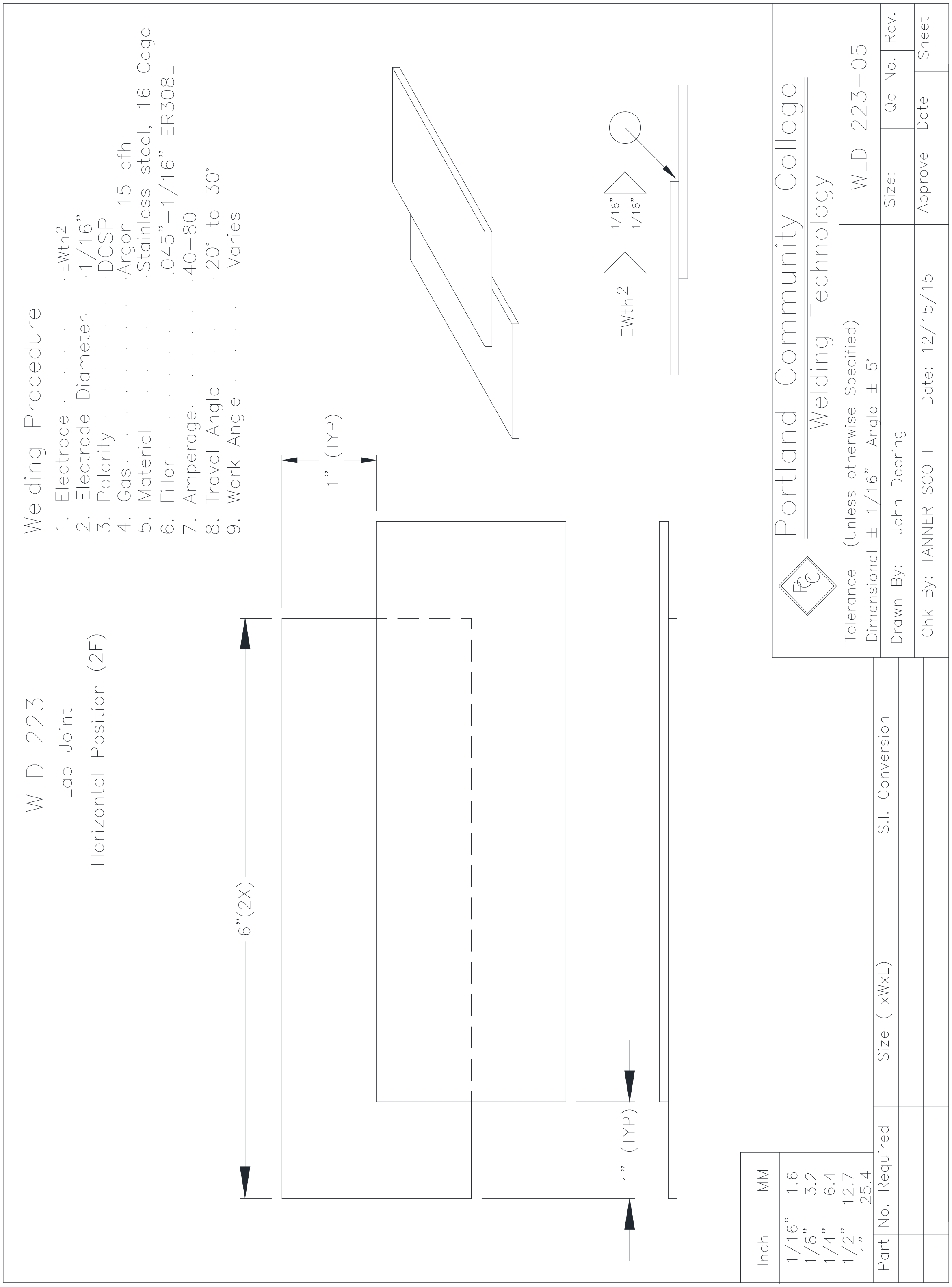
GTAW Flat Position Corner Joint (Autogenous/Fuse Weld) Project #2



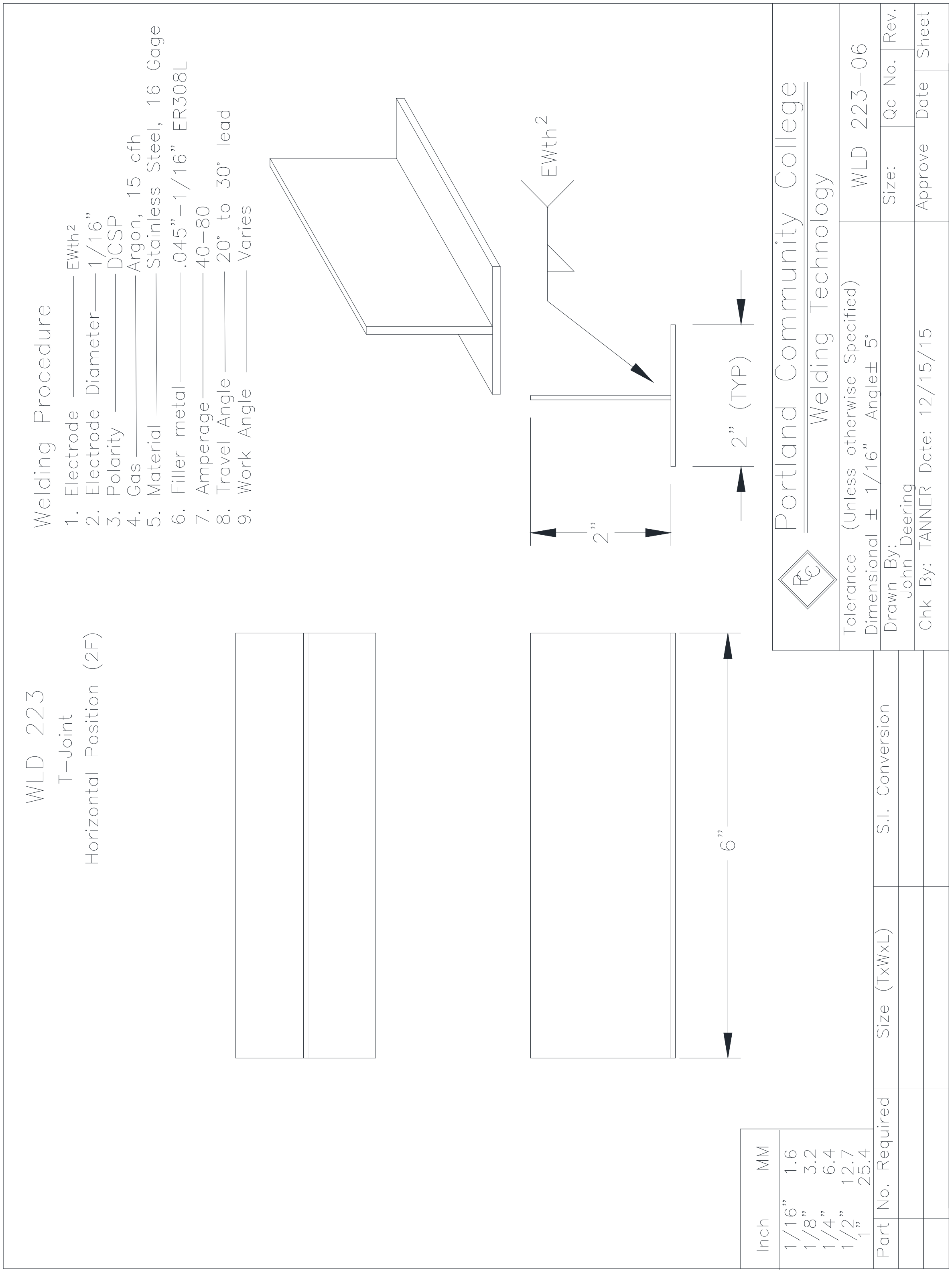

WLD 223
Butt Weld
Flat Position (1G)
Welding Procedure
1. Electrode — EWth2
2. Electrode Diameter — 1/16"
3. Current — DCSP
4. Gas — Argon 15 cfh
5. Material — Stainless Steel, 16 gage
6. Amperage — 30-60
7. Travel Angle — 20° to 30° lead
8. Work Angle — Varies
9. Filler Metal ER308L .045"
EWth2
2"
2"
6"
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
WLD 223-03
Drawn By: John Deering
Chk By:
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

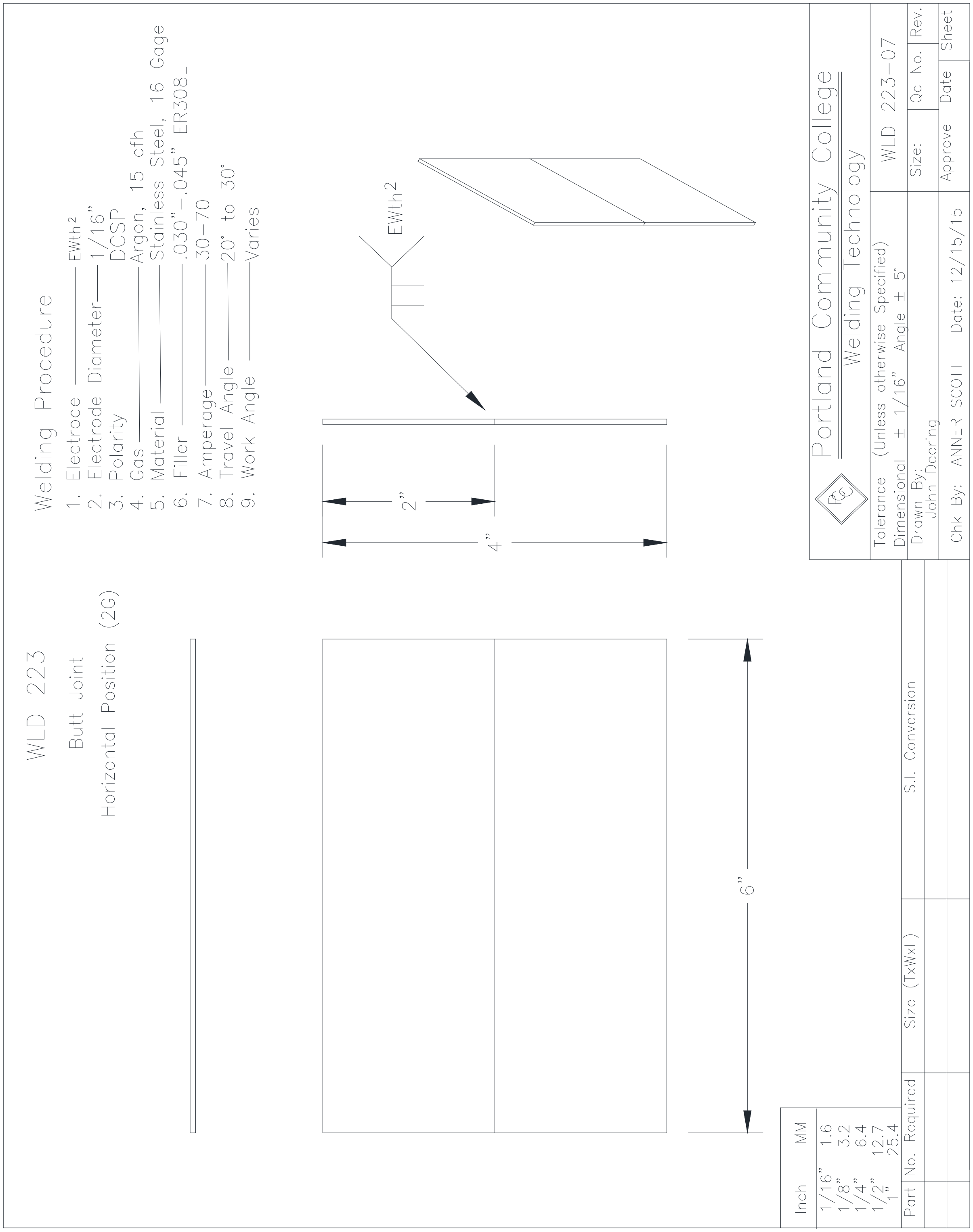

Welding Procedure
1. Electrode EWth2
2. Electrode Diameter 1/16"
3. Polarity DCSP
4. Gas Argon, 15 cfh
5. Material Stainless Steel, 16 Gage
6. Filler .045" - 1/16" ER308L
7. Amperage 40-70
8. Travel Angle 20° to 30° lead
9. Work Angle Varies
EWth2
2"
2"
45°
6"
WLD 223
T-Joint
Flat Position (1F)
Portland Community College
Welding Technology
WLD 223-04
Tolerance (Unless otherwise Specified)
Diensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Chk By: TANNER SCOTT
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 Horizontal Lap Joint Project #5

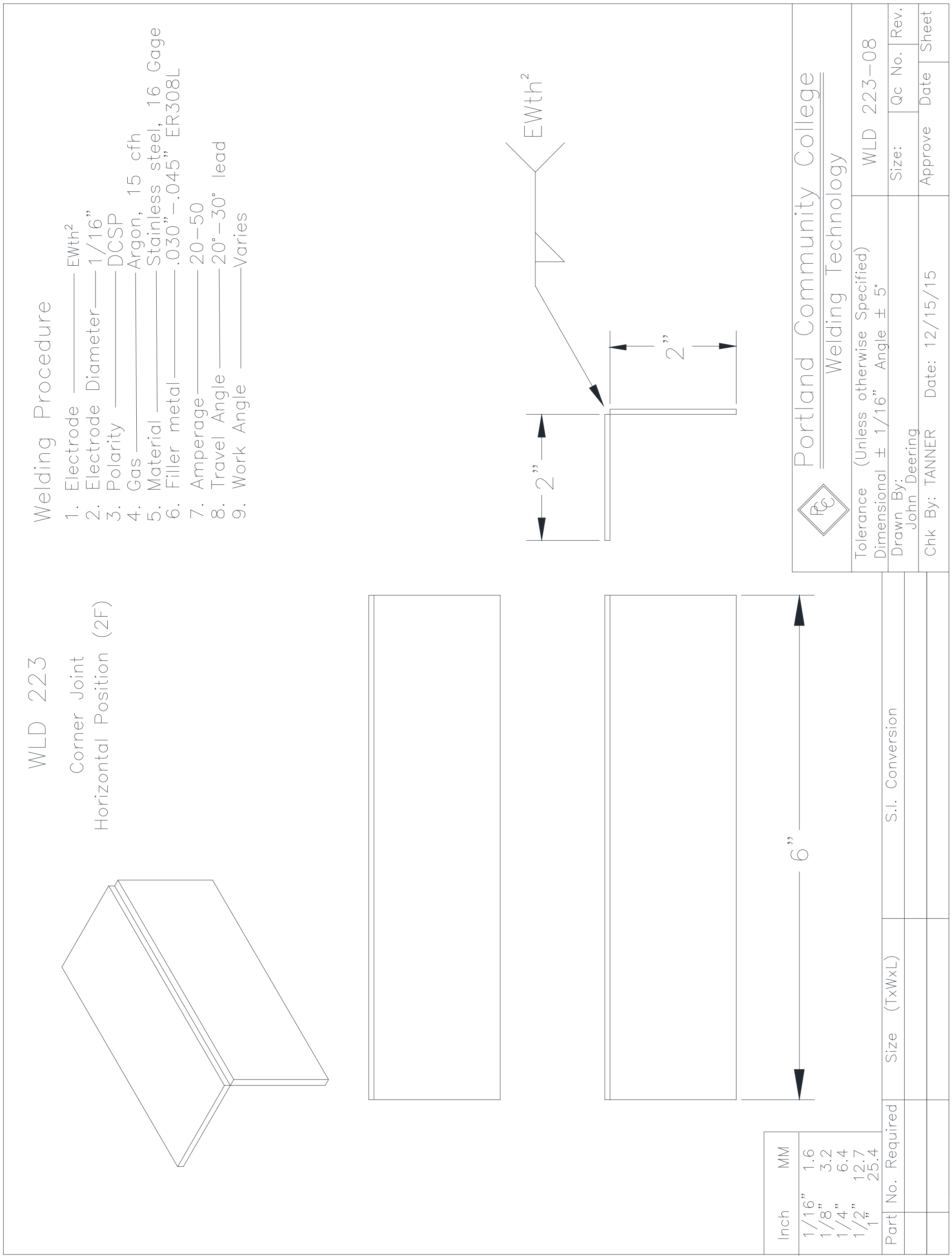


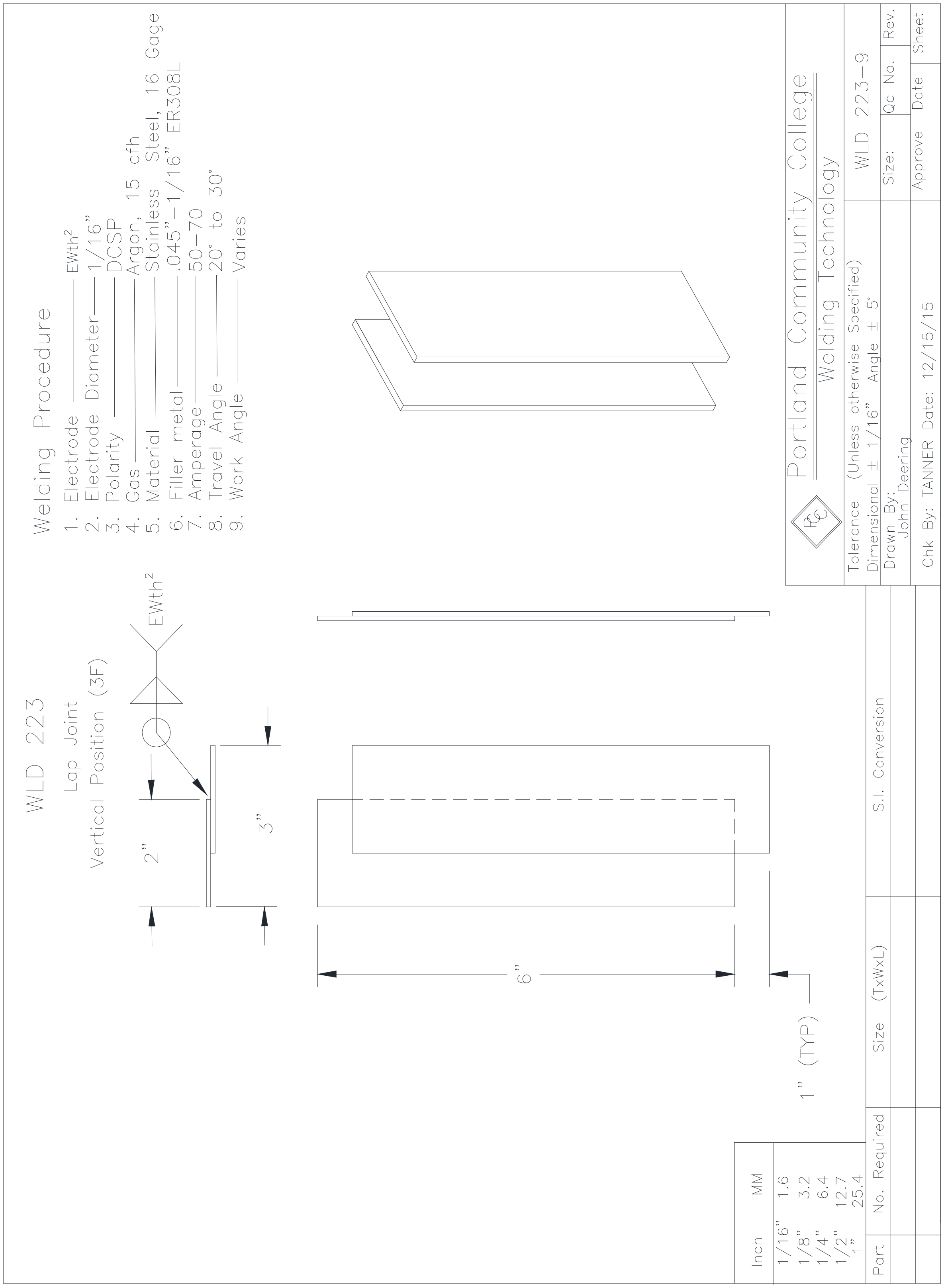
GTAW Horizontal T Joint Project #6



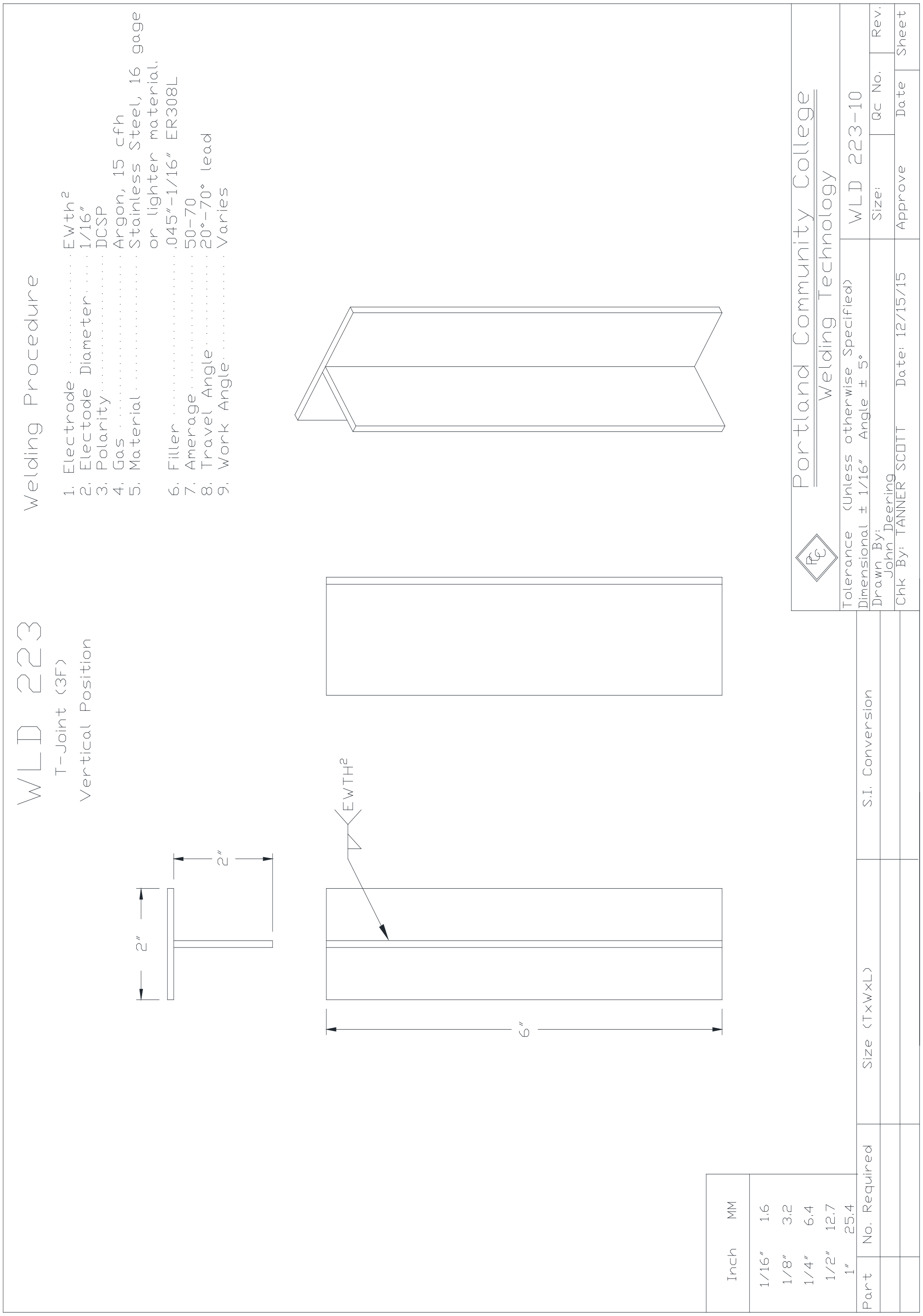

WLD 223
Butt Joint
Horizontal Position (2G)
Welding Procedure
1. Electrode — EWth2
2. Electrode Diameter — 1/16"
3. Polarity — DCSP
4. Gas — Argon, 15 cfh
5. Material — Stainless Steel, 16 Gage
6. Filler — .030"-.045" ER308L
7. Amperage — 30-70
8. Travel Angle — 20° to 30°
9. Work Angle — Varies
EWth2
2"
4"
6"
Portland Community College
Welding Technology
WLD 223-07
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Chk By: TANNER SCOTT 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 Horizontal Corner Joint Project #8

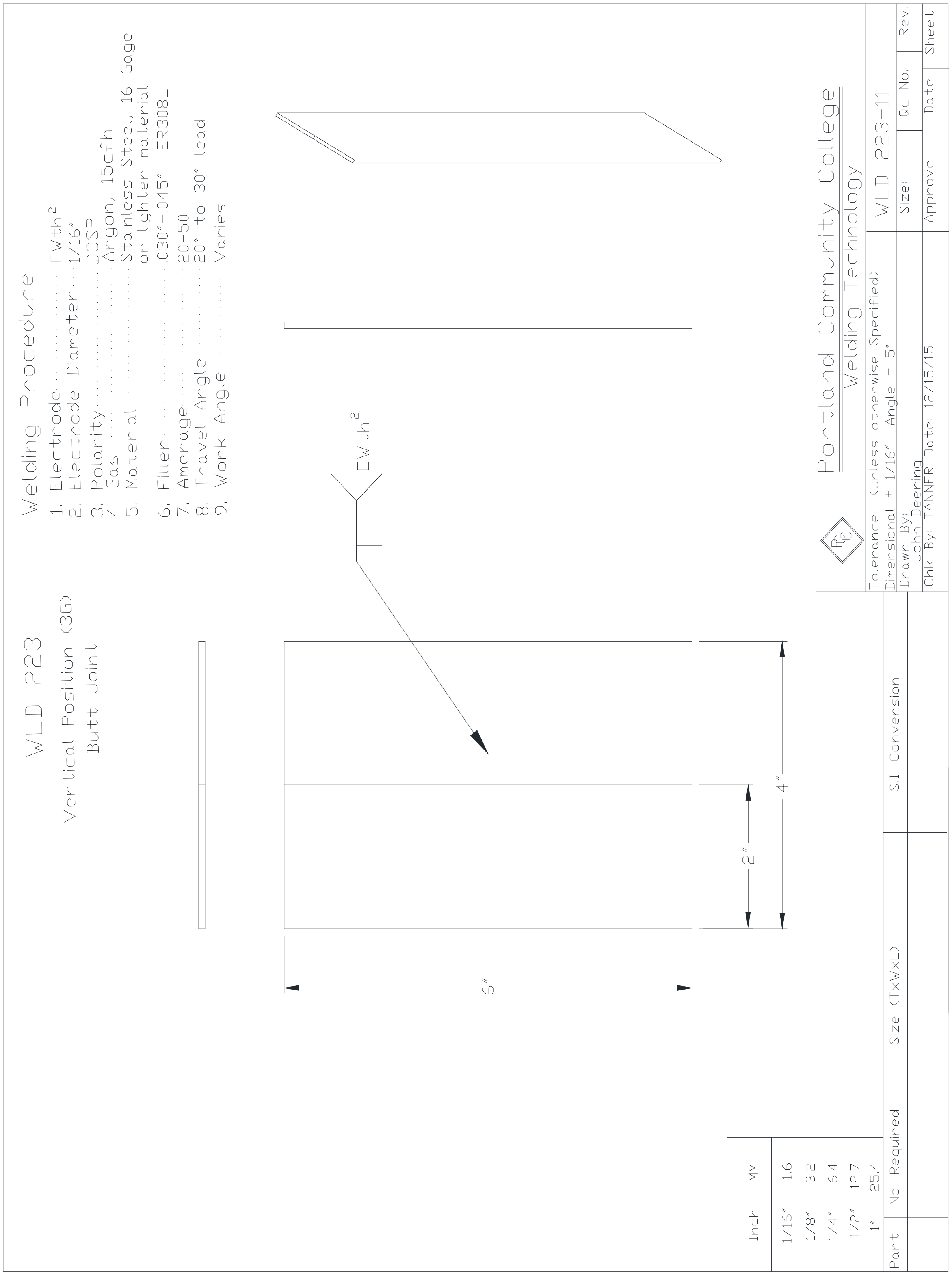


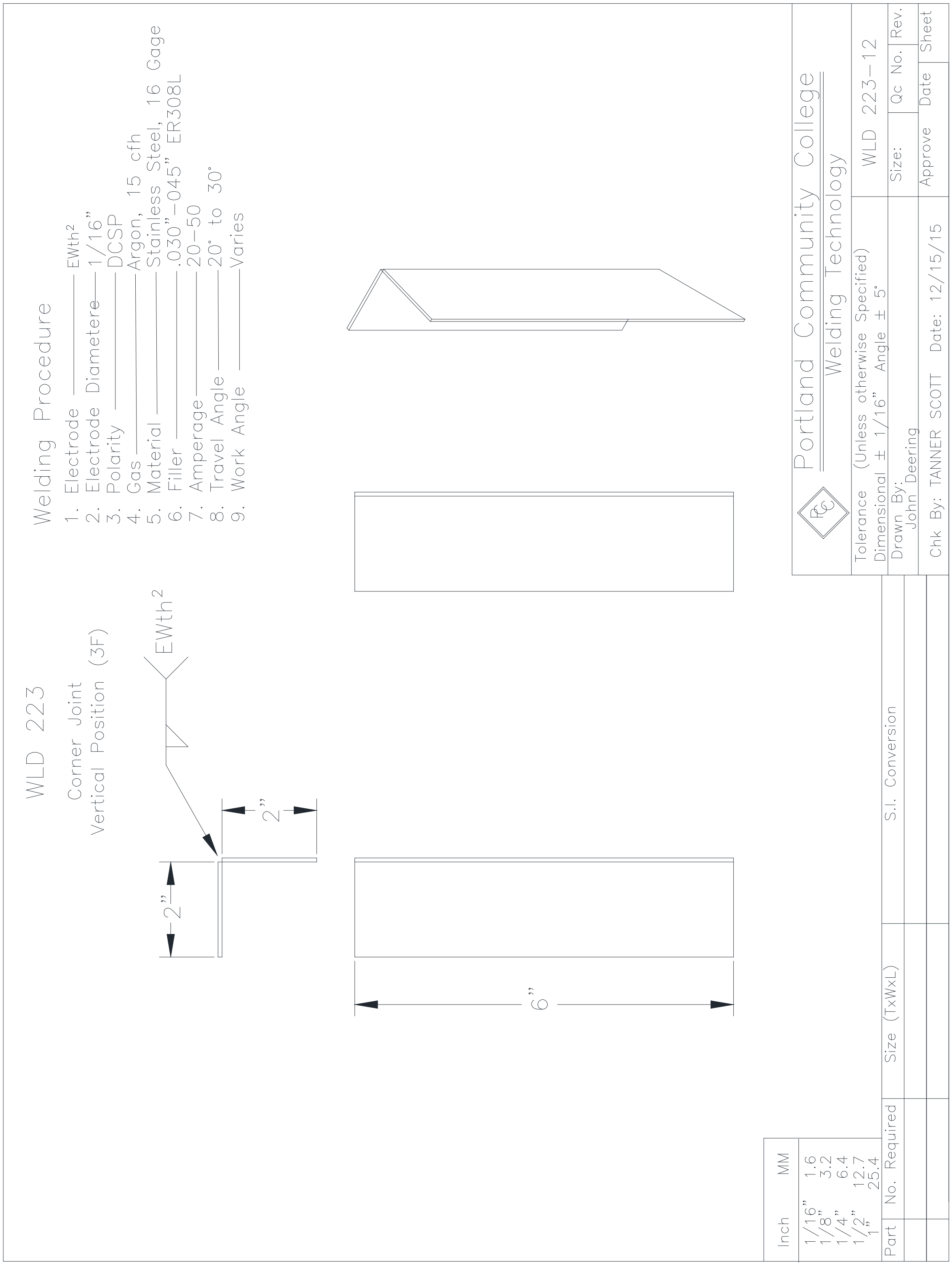


WLD 223
Lap Joint
Vertical Position (3F)
EWth²
2"
3"
6"
1" (TYP)
Welding Procedure
1. Electrode — EWth²
2. Electrode Diameter — 1/16"
3. Polarity — DCSP
4. Gas — Argon, 15 cfh
5. Material — Stainless Steel, 16 Gage
6. Filler metal — .045"-1/16" ER308L
7. Amperage — 50-70
8. Travel Angle — 20° to 30°
9. Work Angle — Varies
Portland Community College
Welding Technology
WLD 223-9
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

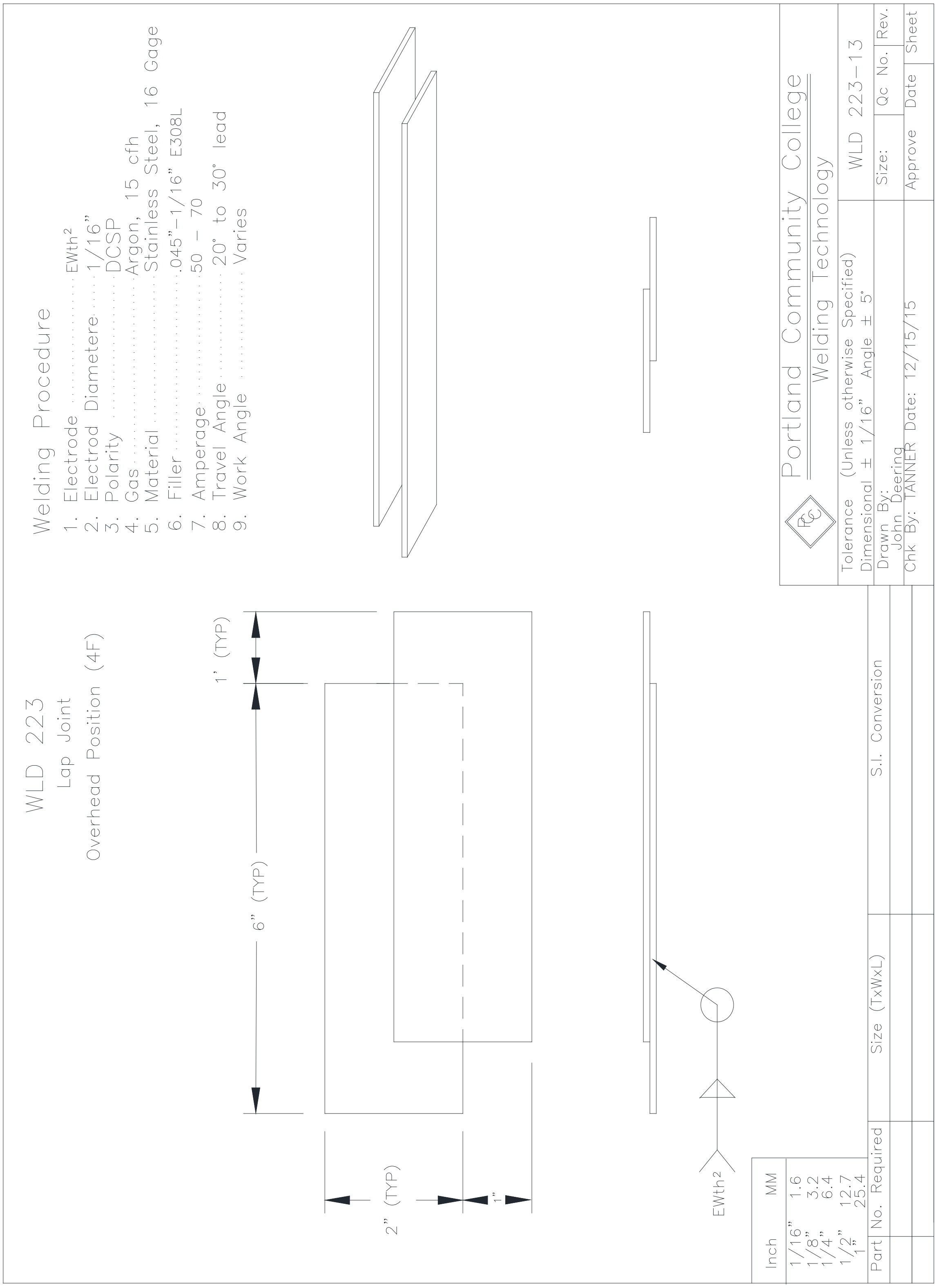

WLD 223
T-Joint (3F)
Vertical Position
Welding Procedure
1. Electrode .... EWth²
2. Electode Diameter .... 1/16″
3. Polarity .... DCSP
4. Gas .... Argon, 15 cfh
5. Material .... Stainless Steel, 16 gage or lighter material.
6. Filler .... .045″-1/16″ ER308L
7. Amerage 50-70
8. Travel Angle .... 20°-70° lead
9. Work Angle .... Varies
2″
2″
6″
EWTH²
Inch MM
1/16″ 1.6
1/8″ 3.2
1/4″ 6.4
1/2″ 12.7
1″ 25.4
Part
No. Required
Size (TxWxL)
S.I. Conversion
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16″ Angle ± 5°
Drawn By:
John Deering
Chk By: TANNER SCOTT
Date: 12/15/15
WLD 223-10
Size:
Qc No.
Rev.
Approve
Date
Sheet

GTAW Vertical Position Butt Joint — Project #11

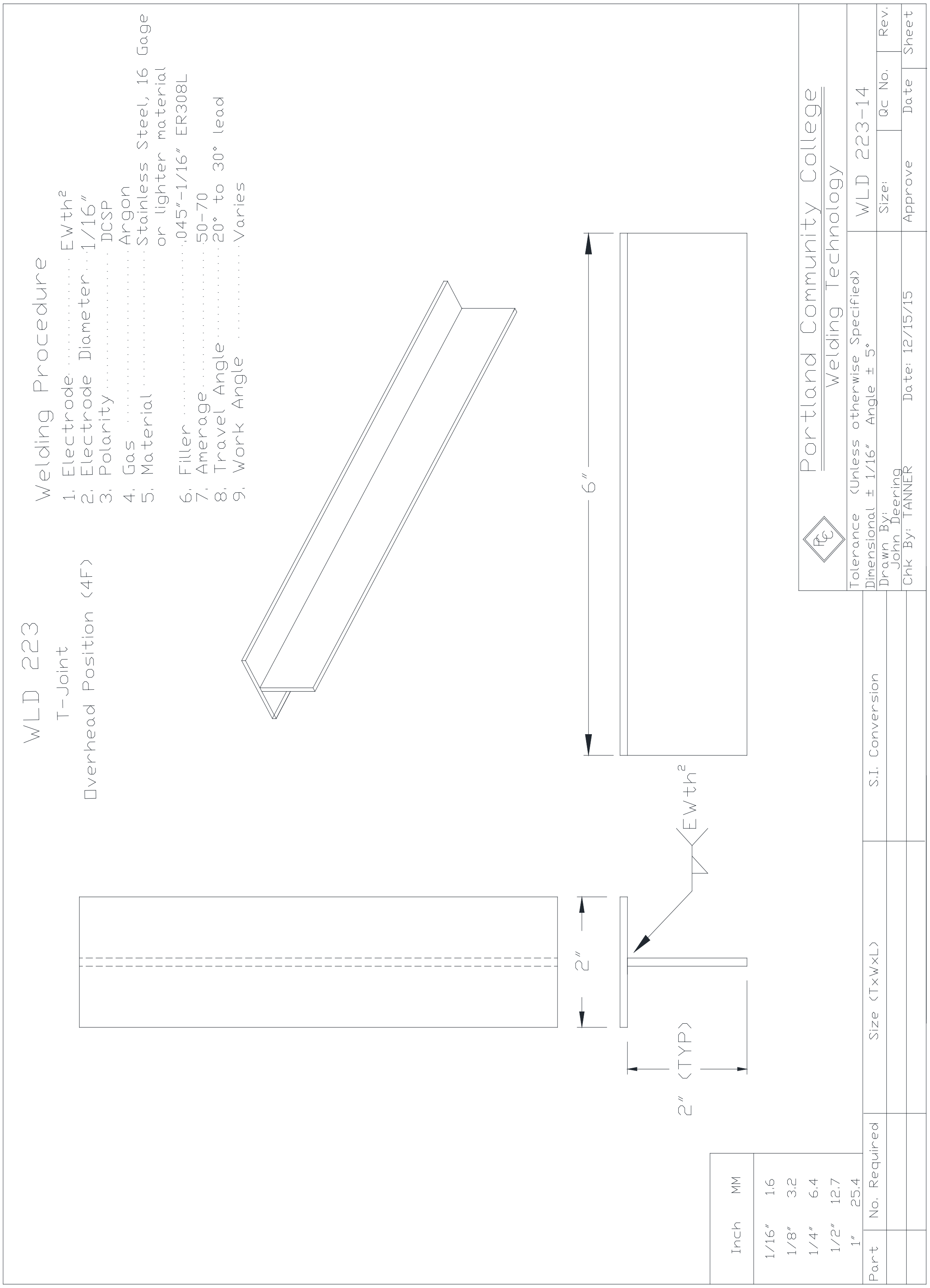


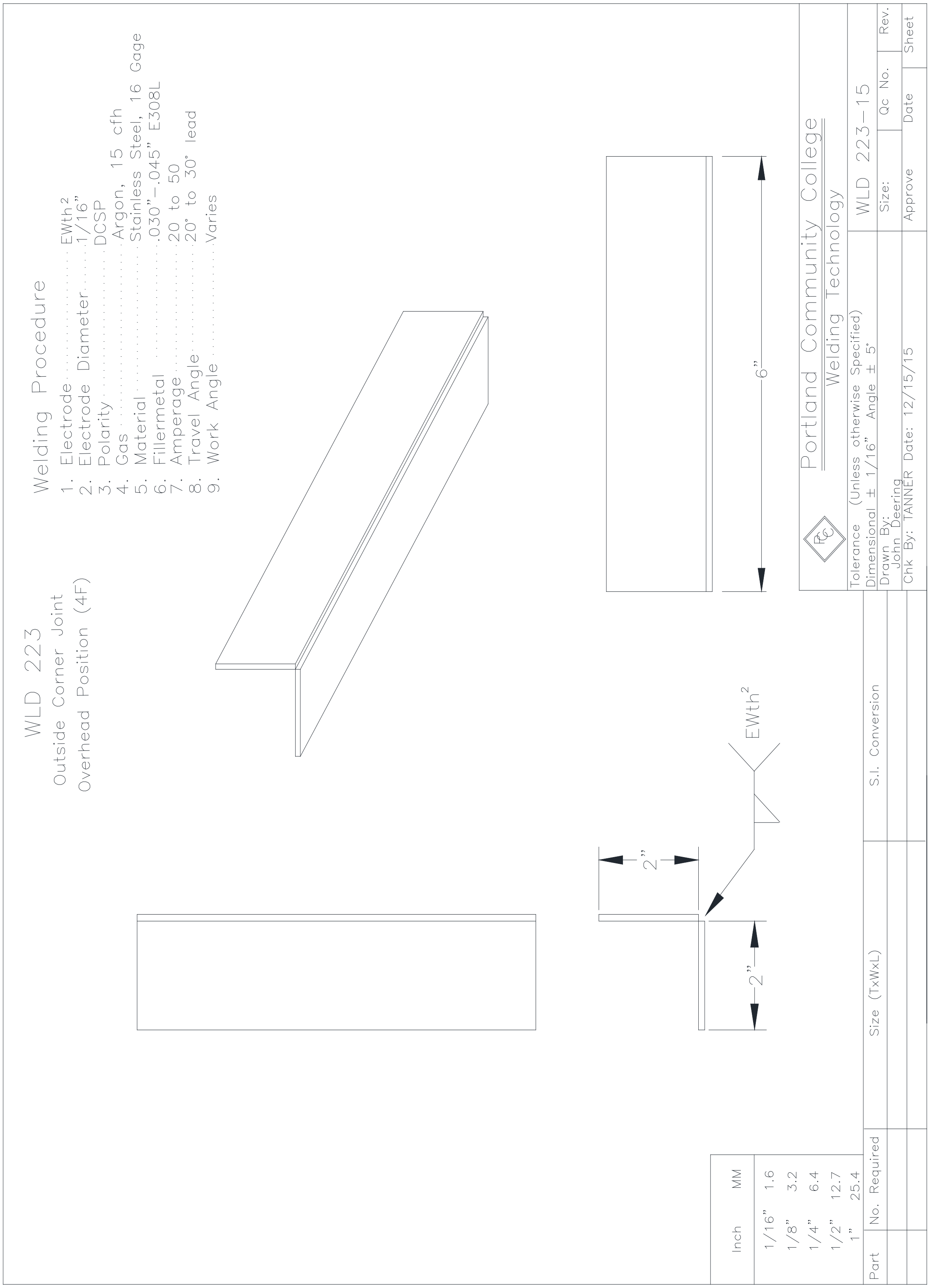

WLD 223
Corner Joint
Vertical Position (3F)
EWth2
2"
2"
6"
Welding Procedure
1. Electrode — EWth2
2. Electrode Diametere — 1/16"
3. Polarity — DCSP
4. Gas — Argon, 15 cfh
5. Material — Stainless Steel, 16 Gage
6. Filler — .030"-045" ER308L
7. Amperage — 20-50
8. Travel Angle — 20° to 30°
9. Work Angle — Varies
Portland Community College
Welding Technology
WLD 223-12
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Size:
Qc No.
Rev.
Chk By: TANNER SCOTT 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 Overhead Position Lap Joint Project #13



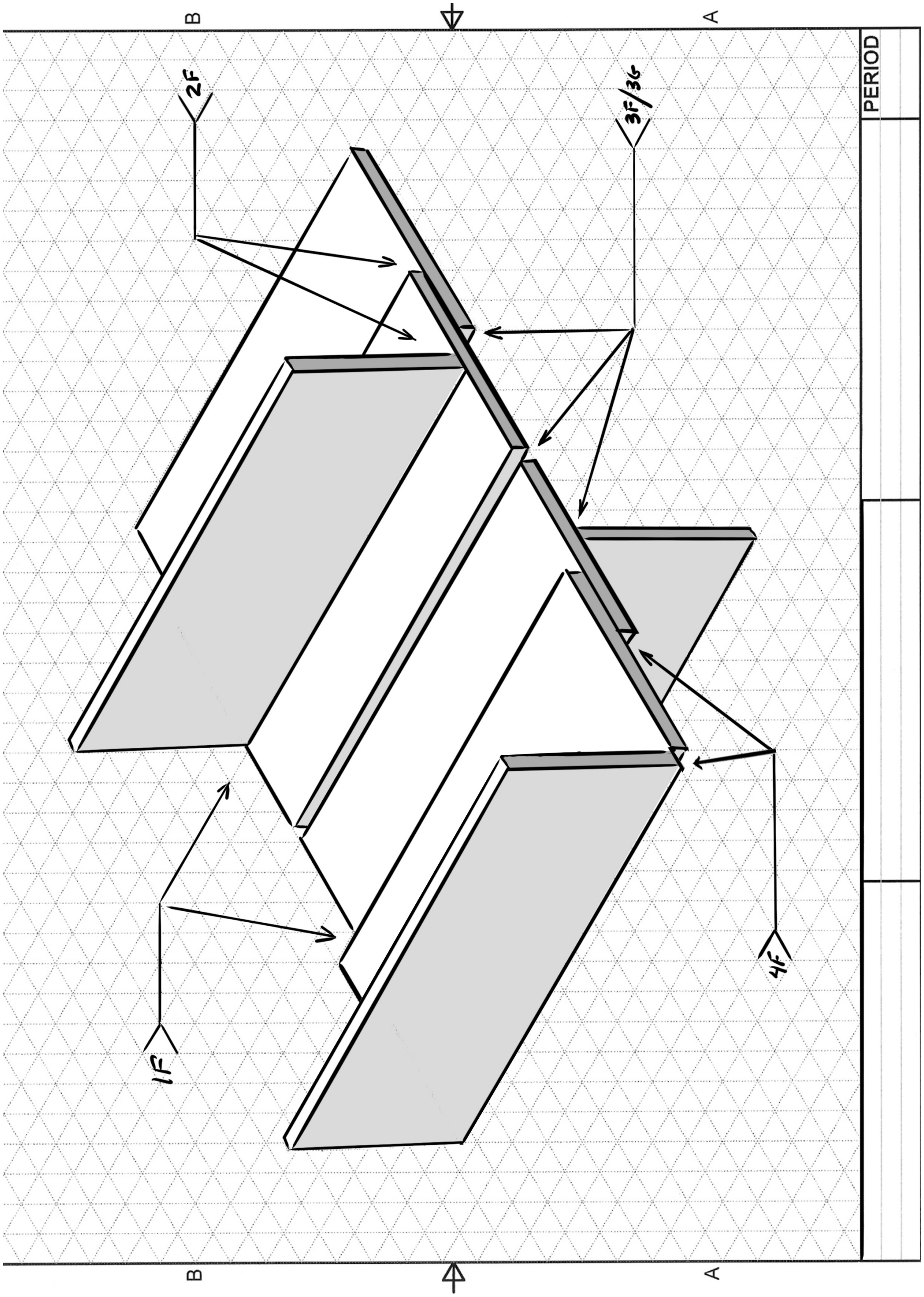
GTAW Overhead Position T Joint   Project #14




WLD 223
Outside Corner Joint
Overhead Position (4F)
Welding Procedure
1. Electrode EWth2
2. Electrode Diameter ...... 1/16"
3. Polarity .... DCSP
4. Gas .... Argon, 15 cfh
5. Material .... Stainless Steel, 16 Gage
6. Fillermetal .... .030"-.045" E308L
7. Amperage .... 20 to 50
8. Travel Angle .... 20° to 30° lead
9. Work Angle .... Varies
6"
2"
2"
EWth2
Portland Community College
Welding Technology
WLD 223-15
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

Practical Exam

This portion of the exam is a practical test that will be graded byu the standard rubric.



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

Name: ______________________________________Date: ___________

SKIP to Stainless section if you have these questions completed for either 221 or 222

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?

STAINLESS STEEL – Larry Jeffus Textbook

1. What is the most common sign that there is a problem with a stainless-steel weld bead?

2. What color should we keep our welds no darker than?

3. List the temperatures at which various colored oxide layers form.

   Light Straw_______

   Tan_____________

   Brown___________

   Purple___________

   Dark Blue________

   Black____________

4. What welding technique can help minimize the risk of carbide precipitation?

5. What is carbide precipitation?

6. What are black crusty spots on a stainless weld bead caused by?

WELDING PACKET

7. What is the most weldable of the stainless-steel groups?

8. List three ways to help control distortion while welding stainless steel.

9. What alloying element makes stainless steel stainless?

10. What can be the benefits of Pulsed GTAW welding?

11. What are the two most common wrought stainless alloys?

12. What is 309L commonly used for?

Final Grading Rubric for practical exam
Class Name: WLD 223

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 223 GTAW Stainless Steel: 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: