WLD 223
Gas Tungsten Arc Welding
Stainless Steel

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Course Assignments

Information Sheets: Reading

Welding Principles and Applications 7th edition By Larry Jeffus
Chapter 17, Gas Tungsten Arc Welding of Pipe

Math

Practical Problems in Mathematics 6th edition by Robert Chasan
Chapter 40, Economical Layouts of Rectangular Plates
Chapter 41Economical Layout of Odd-Shaped Pieces; Take offs

Recommended assignments

Complete review question following each assigned chapter

Quizzes

Complete Interactive Quiz in CourseMate for each assigned chapter

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

Video Training:

"*Gas Tungsten Arc Welding"* by Miller
GTAW 1,2,and 3 of the Miller Modular series
Bergwall GTAW video series (4 videos)

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)

Timeline

Open-entry, open-exit instructional format allows the students to work their own pace. **It is the student's responsibility to complete all assignments in a timely manner**. See your instructor for assistance.

Outcome Assessment Policy:

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

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

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

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

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

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

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

Weldability and Welding Procedures

Austenitic Stainless Steels
This group is considered to be 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 considered to be 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 jigs and 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.

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 effect 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.

Classification System for Stainless Steel

Series Designation	Metallurgical Group	Principle Elements	Hardenable By Heat Treatment	Magnetic
2xx	Austenitic	Chromium-nickel-manganese	Non-hardenable**	Nonmagnetic
3xx	Austenitic	Chromium-nickel steels	Non-hardenable	Nonmagnetic
4xx	Martensitic	Chromium steels	Hardenable	Magnetic
4xx	Ferritic	Chromium steels	Non-Hardenable	Magnetic
5xx*	Martensitic	Chromium-molybdenum steels	Martensitic	Magnetic
*Not stainless		Groups of stainless steels.		
**Will work harden.				
AISI stainless steel classification system (Courtesy, The American Iron and Steel Institutes).				

Chemical Analyses of Stainless Steels in Percent by Weight

AISI No.	Carbon	Manganese	Silicon	Chromium	Nickel	Other Elements
Chromium-Nickel-Magnesium-Austenistic-Non-Hardenable						
201	0.15 Max.	5.5/7.5	1.0	16.0/18.0	3.5/5.5	N20.25
202	0.15 Max.	7.5/10.	1.0	17.0/19.0	4.0/6.0	N20.25
Chromium-Nickel-Austenitic-Non-Hardenable						
301	0.15 Max.	2.0	1.0	16.0/18.0	6.0/8.0	-
302	0.15 Max.	2.0	1.0	17.0/19.0	8.0/10.0	-
302B	0.15 Max.	2.0	2.0/3.0	17.0/19.0	8.0/10.0	-
303	0.15 Max.	2.0	1.0	17.0/19.0	8.0/10.0	S 0.15 Min.
303Se	0.15 Max.	2.0	1.0	17.0/19.0	8.0/10.0	Se 0.15 Min.
304	0.08 Max.	2.0	1.0	18.0/20.0	8.0/12.0	-
304L	0.03 Max.	2.0	1.0	18.0/20.0	8.0/12.0	-
305	0.12 Max.	2.0	1.0	17.0/19.0	10.0/13.0	-
308	0.08 Max.	2.0	1.0	19.0/21.0	10.0/12.0	-
309	0.20 Max.	2.0	1.0	22.0/24.0	12.0/15.0	-
309S	0.08 Max.	2.0	1.0	22.0/24.0	12.0/15.0	-
310	0.25 Max.	2.0	1.50	24.0/26.0	19.0/22.0	-
310S	0.08 Max.	2.0	1.50	24.0/26.0	19.0/22.0	-
314	0.25 Max.	2.0	1.5/3.0	23.0/26.0	19.0/22.0	-
316	0.08 Max.	2.0	1.0	16.0/18.0	10.0/14.0	Mo 2.0/3.0
316L	0.03 Max.	2.0	1.0	16.0/18.0	10.0/14.0	Mo 2.0/3.0
317	0.08 Max.	2.0	1.0	18.0/20.0	11.0/15.0	Mo 3.0/4.0
321	0.08 Max.	2.0	1.0	17.0/19.0	9.0/12.0	Ti 5 X C Min.
347	0.08 Max.	2.0	1.0	17.0/19.0	9.0/13.0	Cb+Ta10xC Min.
348	0.08 Max.	2.0	1.0	17.0/19.0	9.0/13.0	Ta 0.10 Max.

AISI No.	Carbon	Manganese	Silicon	Chromium	Nickel	Other Elements
Chromium-Martensitic-Hardenable						
403	0.15 Max.	1.0	0.5	11.5/13.0	-	-
410	0.15 Max.	1.0	1.0	11.5/13.5	-	-
414	0.15 Max.	1.0	1.0	11.5/13.5	1.25/2.5	-
416	0.15 Max.	1.25	1.0	12.0/14.0	-	S 0.15 Min.
416Se	0.15 Max.	1.25	1.0	12.0/14.0	-	Se 0.15 Min.
420	Over 0.15	1.0	1.0	12.0/14.0	-	-
431	0.20 Max.	1.0	1.0	15.0/17.0	1.25/2.5	-
440A	0.60/0.75	1.0	1.0	16.0/18.0	-	Mo 0.75 Max.
440B	0.75/0.95	1.0	1.0	16.0/18.0	-	Mo 0.75 Max.
440C	0.95/1.2	1.0	1.0	16.0/18.0	-	Mo 0.75 Max.
Chromium-Ferritic-Non Hardenable						
405	0.08 Max	1.0	1.0	11.5/14.5	-	Al 1.1/0.3
430	0. 12 Max	1.0	1.0	14.0/18.0	-	-
430F	0.12 Max	1.25	1.0	14.0/18.0	-	S 0.15 Min.
430FSe	0.12 Max	1.25	1.0	14.0/18.0	-	S 0.15 Min.
446	0.20 Max.	1.50	1.0	23.0/27.0	-	N 0.25 Max.
Martensitic						
501	Over 0.10	1.0	1.0	4.0/6.0	-	Mo 0.40/0.65
502	0.10 Max.	1.0	1.0	4.0/6.0	-	Mo 0.40/0.65

Filler Metal Composition

AWS Class	C	Cr	Ni	Mo	Mn	Si	Others
			Typical Composition %				
E308	0.08	19.5	10.5	-	2.5	0.90	-
E308L	0.04	19.5	10.5	-	2.5	0.90	-
E309	0.15	23.5	13.5	-	2.5	0.90	-
E309Cb	0.12	23.5	13.5	-	2.5	0.90	Cb+Ti-0.85
E309Mo	0.12	23.5	13.5	2.5	2.5	0.90	-
E310	0.20	26.5	21.5	-	2.5	0.75	-
E310Cb	0.12	26.5	21.5	-	2.5	0.75	Cb+Ti-0.85
E310Mo	0.12	26.5	21.5	2.5	2.5	0.75	-
E312	0.15	30.0	9.0	-	2.5	0.90	-
E316	0.08	18.5	12.5	2.5	2.5	0.90	-
E316L	0.04	18.5	12.5	2.5	2.5	0.90	-
E317	0.08	19.5	13.0	3.5	2.5	0.90	-
E318	0.08	18.5	12.5	2.5	2.5	0.90	-
E320	0.07	20.0	34.0	2.5	2.5	0.60	-
E330	0.25	15.5	35.0	-	2.5	0.90	-
E347	0.08	19.5	10.0	-	2.5	0.90	-
E410	0.12	12.5	0.60	-	1.0	0.90	-
E430	0.10	16.5	0.60	-	1.0	0.90	-

Recommended Filler Metal

	AISI No.	Recommended Filler Metal 1st Choice	2nd Choice	Popular Name	Remarks
Cr-Ni-Mn	201	308	308L		Substitute for 301
	202	308	308L		Substitute for 302
	301	308	308L		
	302	308	308L		
	302B	308	309		High Silicon
	303	-	-		Free machining-welding not recommended-312
	303Se	-	-		Free machining-welding not recommended-312
Cr-Ni-Austenitic	304	308	308L	1818	
	304L	308L	347	1818 Elc	Extra low carbon
	305	308	-		
	308	308	-	19/9	
	309	309	-	25/12	
	309S	309	-		Low Carbon
	310	310	-	25/20	
	310S	310	-		Low Carbon
	314	310	-		
	316	316	309Cb	18/12Mo	
	316L	316L	309Cb	18/12 Elc	Extra low carbon
	317	317	309Cb	19/14Mo	
	321	347	308L		
	347	347	308L	19/9 Cb	Difficult to weld in heavy sections.
	348	347	-	19/9CbLTa	
Cr-Martensitic	403	410	-		
	410	410	430	12Cr	
	414	410	-		
	416	410	-		Use 410-15
	416Se	-	-		Free machining welding not recommended.
	420	410	-	12 Cr Hc	High Carbon
	431	430	-		
	440A	-	-		High carbon-welding not recommended
	440B	-	-		High carbon-welding not recommended

Recommended Filler Metal Continued

		Recommended Filler Metal 1st Choice	2nd Choice	Popular Name	Remarks	
Cr-Ferritic	405	410	405Cb			
	430	430	309	16Cr		
	430F	-	-		Free machining-welding not recommended	
	430FSe	-	-		Free machining-welding not recommended	
	446	309	310			
	501	502	-	5Cr-1/2Mo	Chrome-moly steel	
	502	502	-	5Cr-1/2Mo	Chrome-moly steel	

Science

on

Stainless

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

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. Use of the WRC-1992 Diagram to Prevent Solidification Cracking
G. 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 of 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 shells 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.

Use of the WRC-1992 Diagram to Prevent Solidification Cracking

When welding stainless steel with austenitic fillers, the welder can predict whether he/she will have crack-free weld or one that contains solidification cracks. For example, consider the welding of 404 stainless steel with 308L filler metal. The compositions of the 304 plate and 308L filler metal are known from their mill certifications.

Table 1- Calculation of Weld Metal Admixture for Use with WRC-1992

	Filler Metal: 308L austenitic stainless steel	Base Plate: 304 austenitic stainless steel	Weld Metal Admixture
C	0.02	0.08	0.05
Mn	1.8	1.8	1.8
Si	0.8	0.8	0.8
Cr	20	19	19.5
Ni	10	9	9.5
Mo	-	-	-
S	0.010	0.012	0.011
P	0.010	0.030	0.020
Ti	-	-	-
Nb	-	-	-
N	0.04	0.04	0.04

The first step is to calculate the chromium equivalent (CrEq) and nickel equivalent (NiEq) for 304 base metal and 308L filler metal.

304 Base Metal

WRC-1992:

CrEq = %Cr + %Mo + 10.7*%Mo = 19.0 + 0 + 0 = 19

NiEq = %Ni + 35 x %C + 20 x %N = 9 + 35 x 0.08 + 20 x 0.04 = 12.6

308L Filler Metal

WRC-1992:

CrEq = %Cr + %Mo + 10.7*%Mo = 20 + 0 + 0 = 20

NiEq = %Ni + 35 x %C + 20 x %N = 10 + 35 x 0.02 + 20 x %N = 11.5

Weld Metal Admixture

WRC-1992:

CrEq = %Cr + %Mo + 10.7*%Mo = 19.5 + 0 + 0 = 19.5

NiEq = %Ni + 35 x %C + 20 x %N = 9.5 + 35 x 0.05 + 20 x 0.04 = 12.1

Finding Ferrite Number from WRC-1992

To determine the amount ferrite in the weld metal admixture, simply plot CrEq = 19.5 on the x-axis and NiEq = 12.1 on the y-axis of Figure 1. The point of intersection occurs at Ferrite Number (FN) = 6 in the FA region. This means that welding will be crack-free because the ferrite content is between 3 and 12FN.

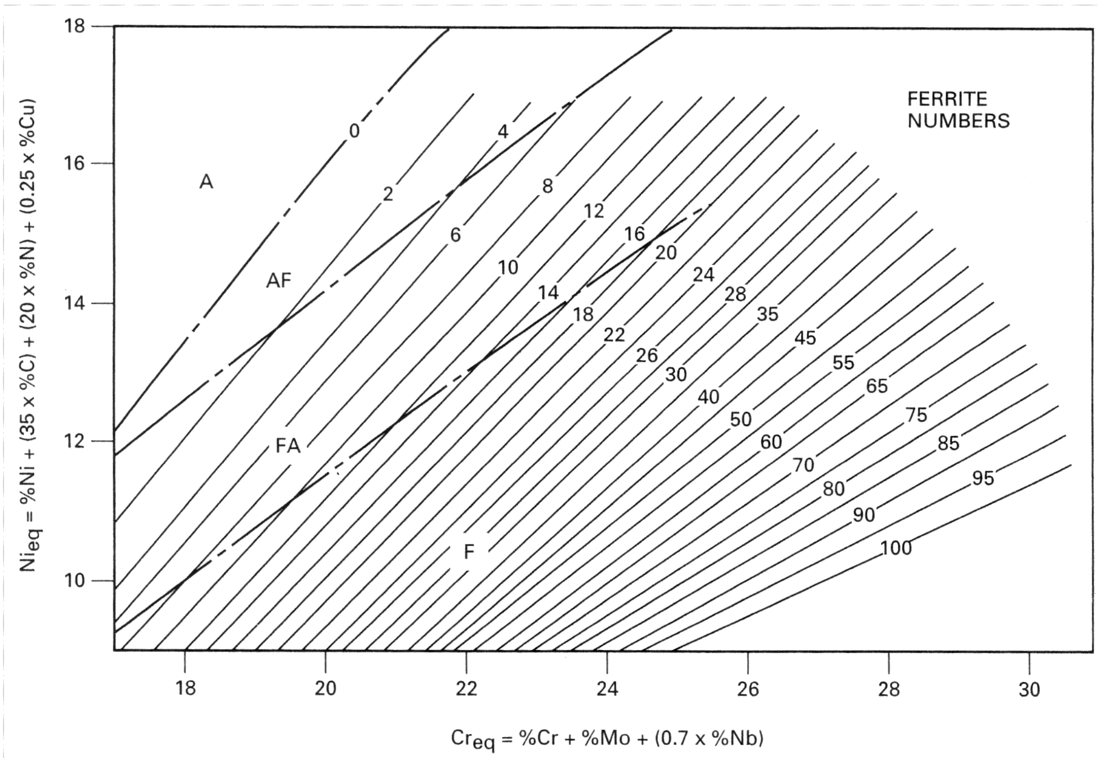


Figure 1- WRC-1992 Diagram to predict ferrite and austenite content in stainless steel weld metal.

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.

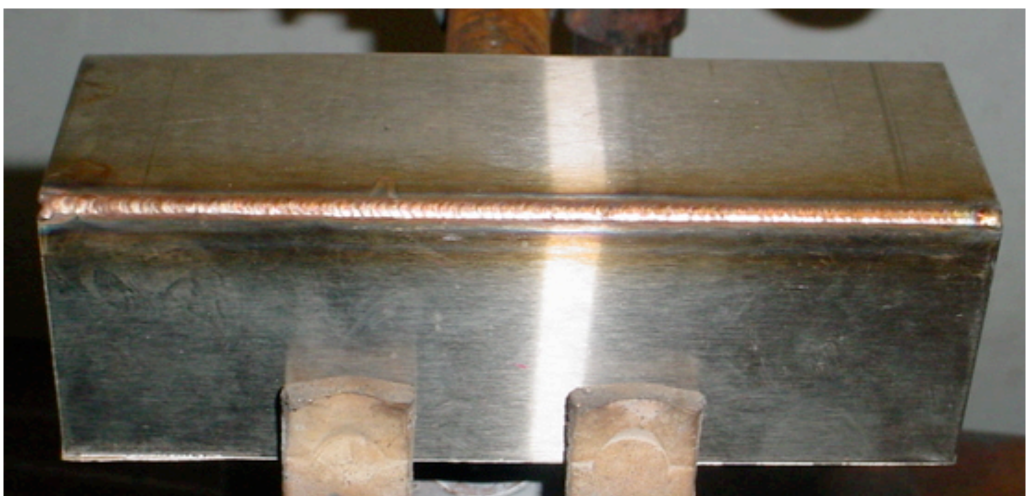
Craftsmanship Expectations for Welding Projects

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 AWS D1.1

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

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

Objectives of this welding exercise are:

- To learn how to set up and adjust the equipment.
- To develop your ability to control travel speed and arc length.
- Your goal is to fuse the edge surfaces resulting in a smooth rounded contour on all sides of the joint. Note that when "fuse" welding no filler material is added.

Cause and Effect Factors

Amperage

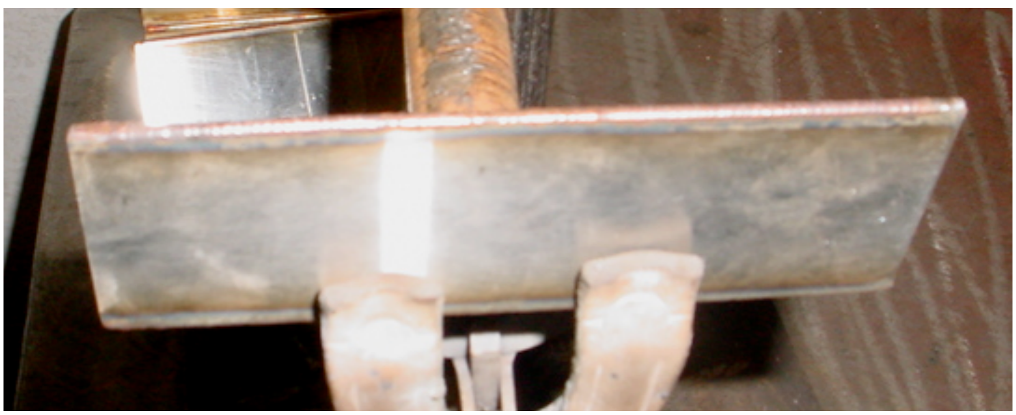
Too high = undercutting
Too low = lack of fusion on the edges of the joint

Travel Speed

Too slow = excessive heat, irregular shape, burning away of the edge
Too fast = weld does not wrap the edges of the plates leaving them sharp and jagged.

Arc length

Too short = touching the tungsten to the work, contaminating the tungsten and the work.
Too long = undercutting, and can result in loss of gas coverage creating porosity.



VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

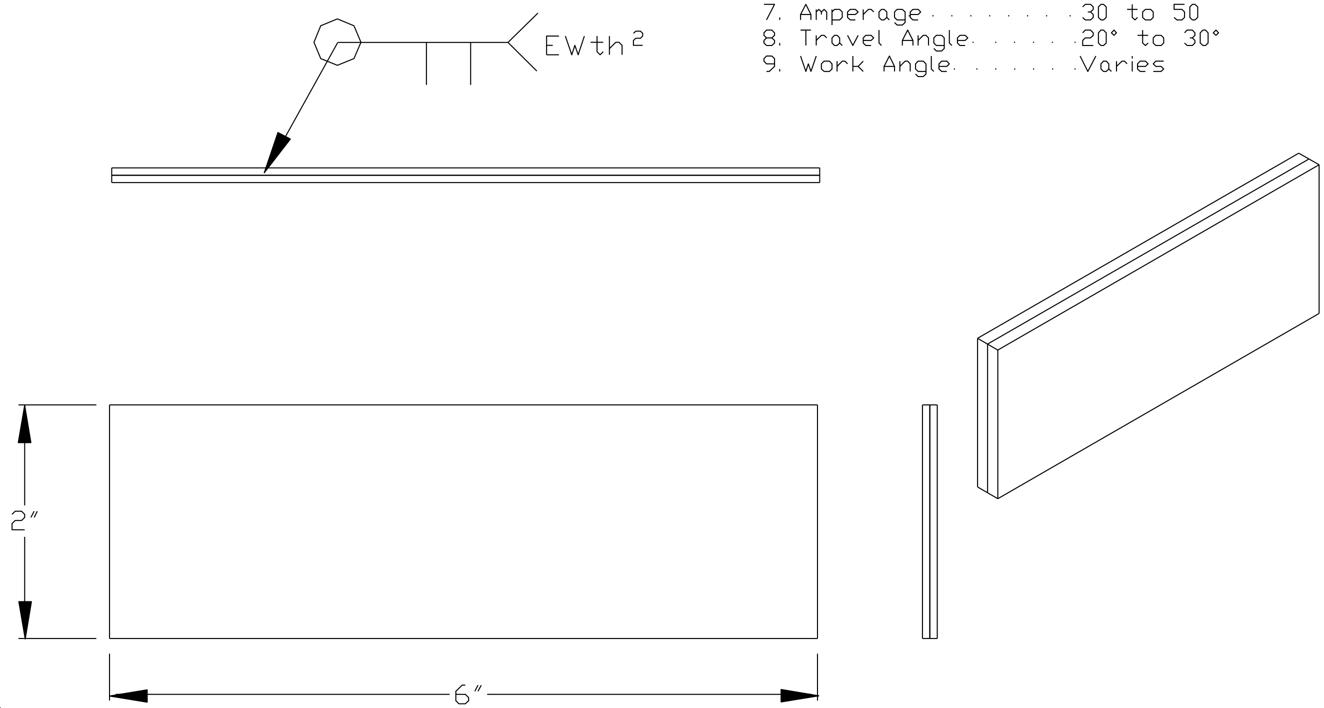
WLD 223

Fuse Weld

Flat Edge Joint (1G)

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 . . . . none
7. Amperage . . . . 30 to 50
8. Travel Angle . . . . . 20° to 30°
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 223-01			
Drawn By: John Deering	Size:		Qc No.	Rev.
Chk By: TANNER SCOTT Date: 8/21/08	Approve	Date		Sheet

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

Objectives of this welding exercise are:

- To practice set up and adjustment of the equipment.
- To develop consistency in control of travel speed and arc length.
- Your goal is to fuse the edge surfaces resulting in a smooth rounded contour on all sides of the joint. Note that when "fuse" welding no filler material is added.

Cause and Effect Factors

Amperage

Too high = undercutting, or melting holes through the work
Too low = lack of fusion on the edges of the joint

Travel Speed

Too slow = excessive heat, irregular shape, burning holes
Too fast = weld does not wrap the edges of the plates leaving them sharp and jagged.

Arc length

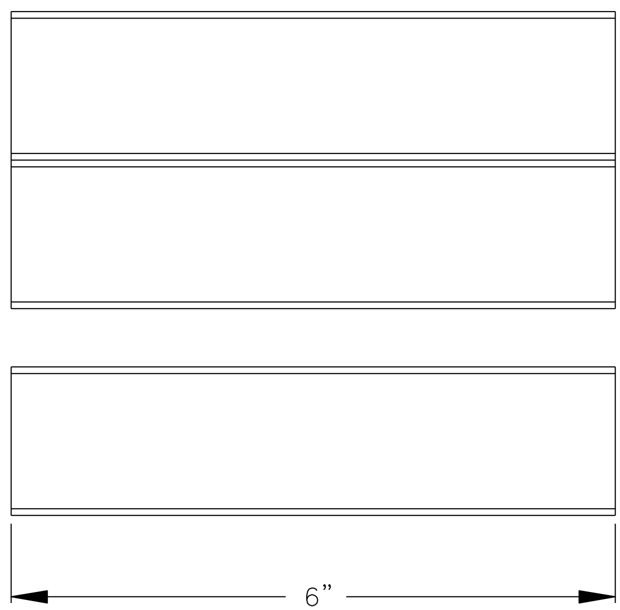
Too short = touching the tungsten to the work, contaminating the tungsten and the work.
Too long = undercutting, and can result in loss of gas coverage creating porosity.

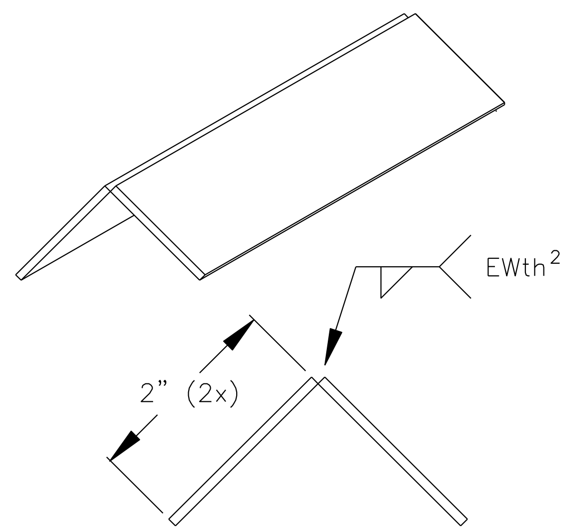
VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

WLD 223
Fuse Weld
Outside Corner (1F)

Welding Procedure

1. Electrode —— EWth 2
2. Electrode Diameter —— 1/16"
3. Current —— DCSP
4. Gas —— Argon 15 cfh
5. Material —— Stainless Steel, 16 gage
6. Amperage —— 30 to 50
7. Travel Angle —— 20° TO 30° LEAD
8. 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 223-02

Drawn By: John Deering

Size: | Qc No. | Rev.

Chk By: TANNER SCOTT Date: 8/21/08

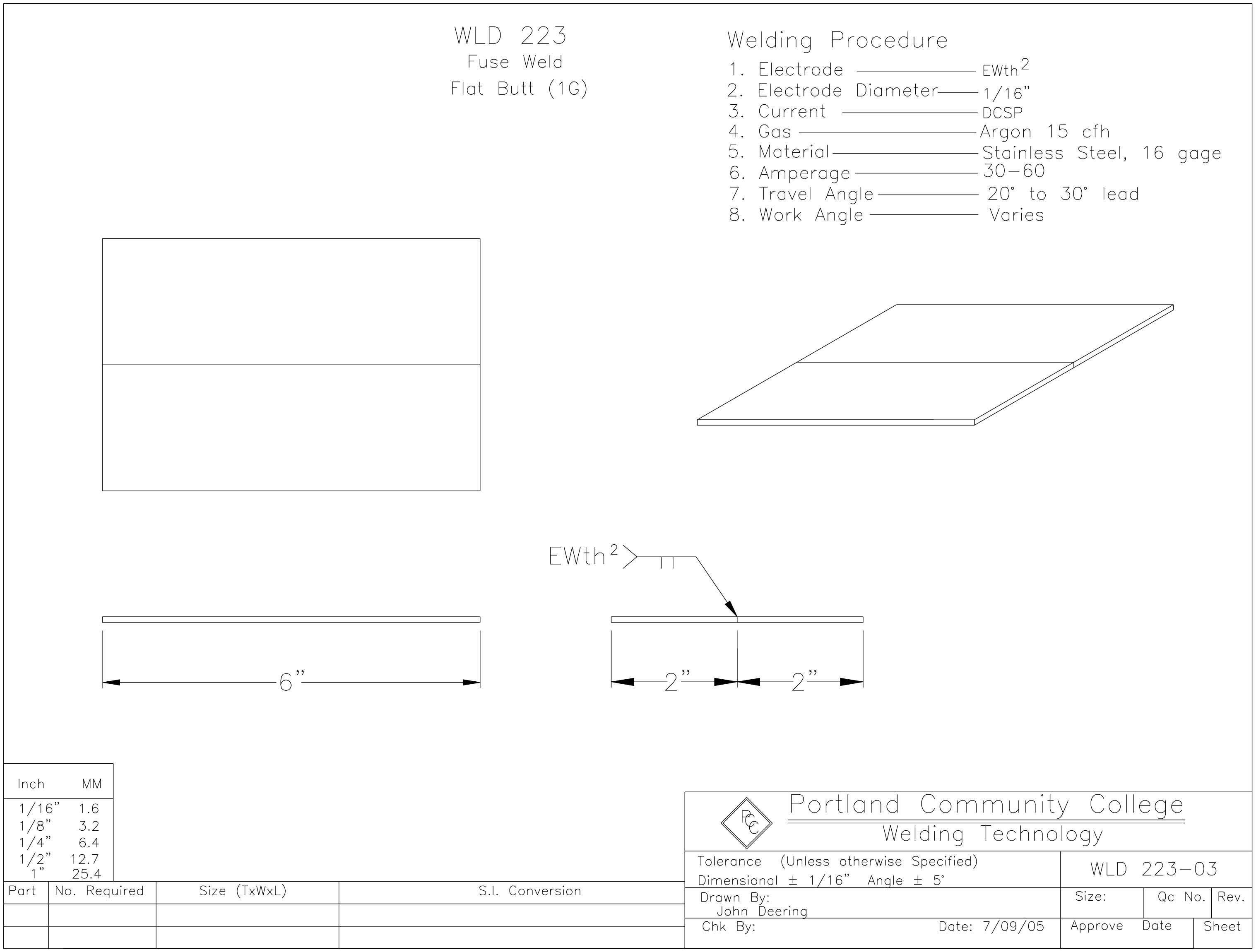
Approve | Date | Sheet

GTAW Flat Position Butt Joint Project #3

Objectives of this welding exercise are:

- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.

VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE


WLD 223
Fuse Weld
Flat Butt (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
EWth2
6"
2"
2"
Inch MM
1/16" 1.6
1/8" 3.2
1/4" 6.4
1/2" 12.7
1" 25.4
Part
No. Required
Size (TxWxL)
S.I. Conversion
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
WLD 223-03
Drawn By:
John Deering
Size:
Qc No.
Rev.
Chk By:
Date: 7/09/05
Approve
Date
Sheet

GTAW Flat T Joint — Project #4

Objectives of this welding exercise are:

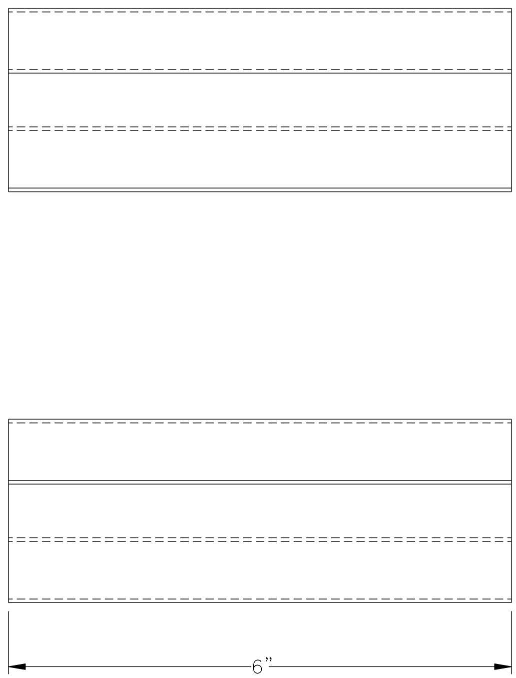
- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.

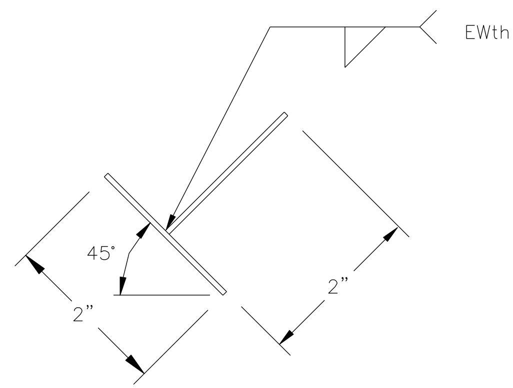
VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

WLD 223
T–Joint
Flat Position (1F)

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





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

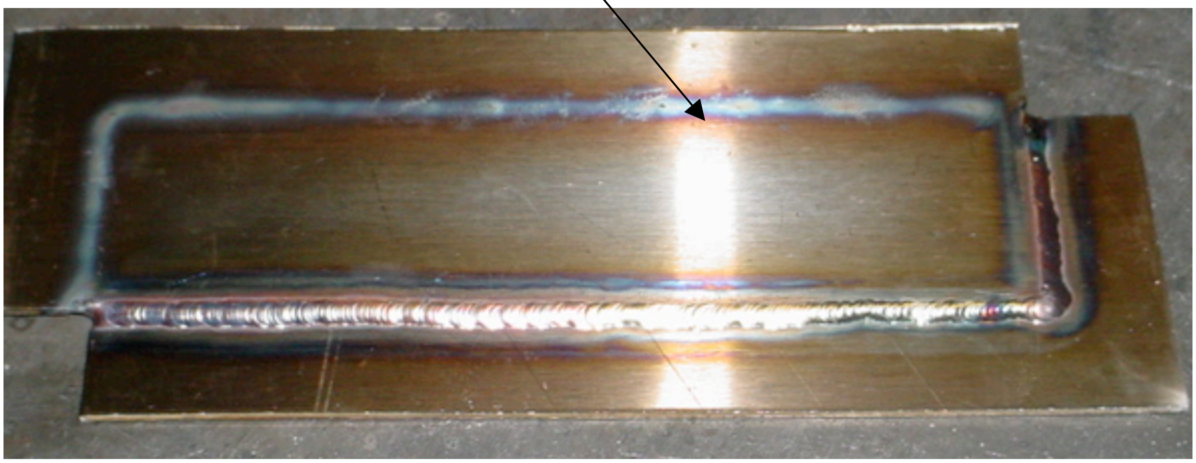
Tolerance (Unless otherwise Specified) Diensional ± 1/16" Angle ± 5°	WLD 223–04		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: TANNER SCOTT Date: 8/21/08	Approve	Date	Sheet

GTAW Horizontal Lap Joint Project #5

Objectives of this welding exercise are:

- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.

Note: There is no burn throguh (sugar) on the back side



VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

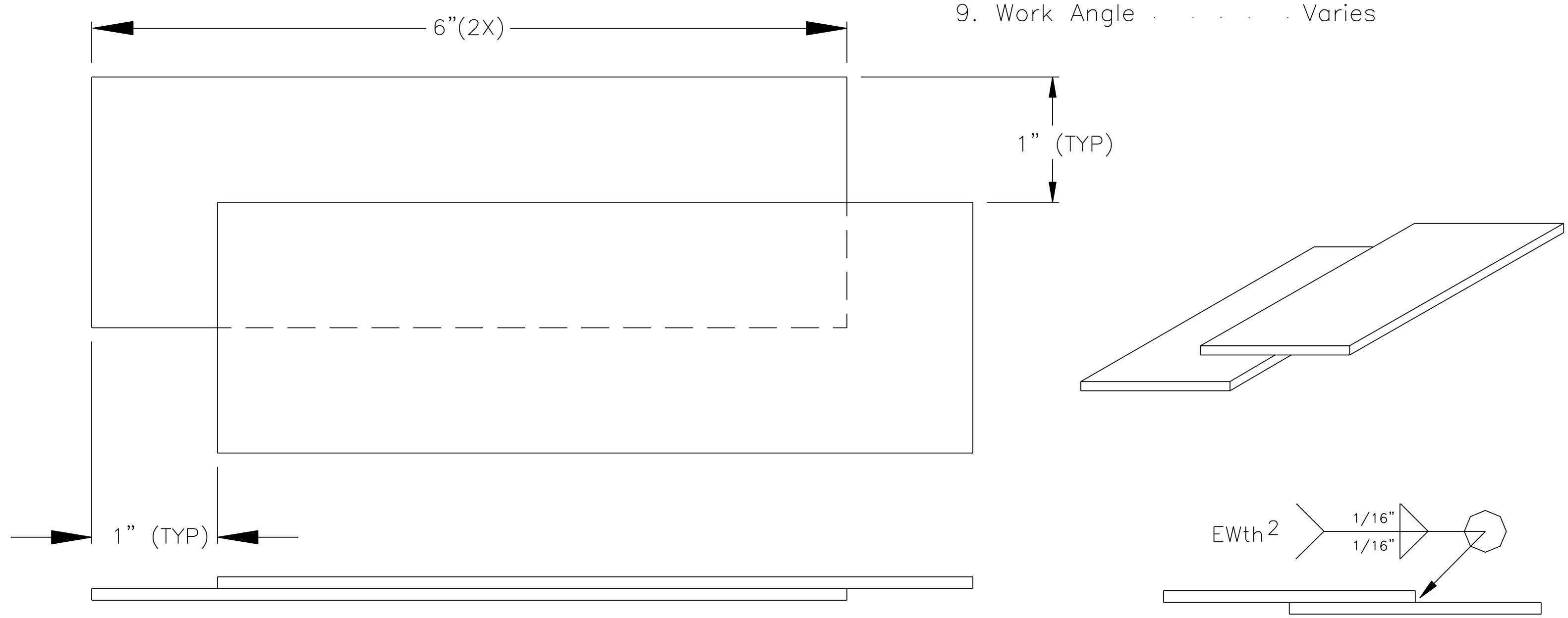
WLD 223

Lap Joint

Horizontal Position (2F)

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 40–80
8. Travel Angle . . . . . 20° to 30°
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

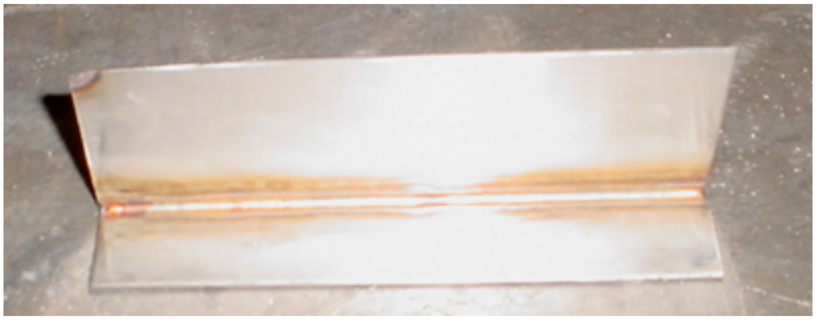
Welding Technology

Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle ± 5°		WLD 223-05		
Drawn By: John Deering		Size:	Qc No.	Rev.
Chk By: TANNER SCOTT	Date: 8/21/08	Approve	Date	Sheet

GTAW Horizontal T Joint Project #6

Objectives of this welding exercise are:

- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.



VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

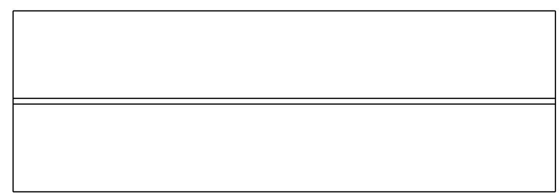
WLD 223

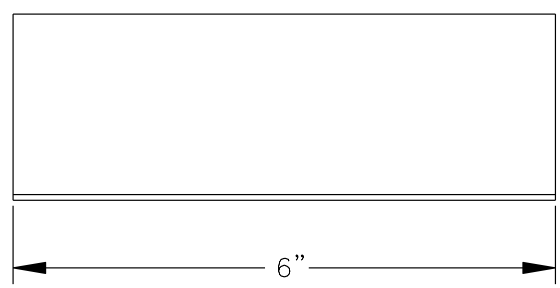
T–Joint

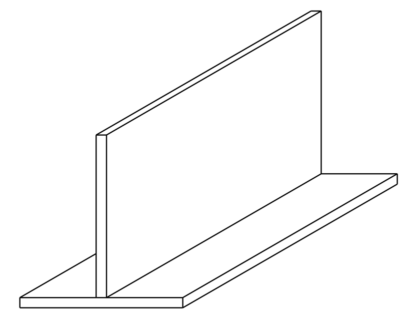
Horizontal Position (2F)

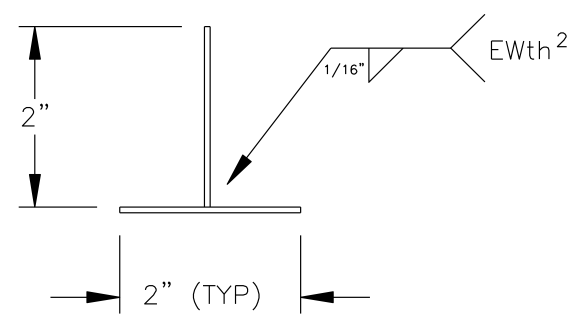
Welding Procedure

1. Electrode —— $EWth^2$
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 —— 40–80
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

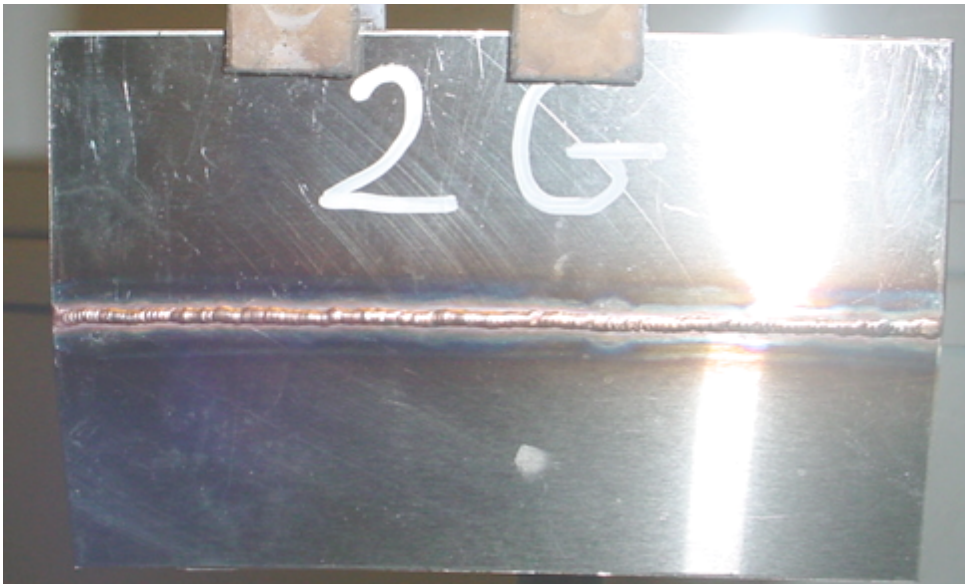
Welding Technology

Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle± 5°	WLD 223–06		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: TANNER SCOTT Date: 8/21/08	Approve	Date	Sheet

GTAW Horizontal Butt Joint Project #7

Objectives of this welding exercise are:

- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.



VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	**GRADE**

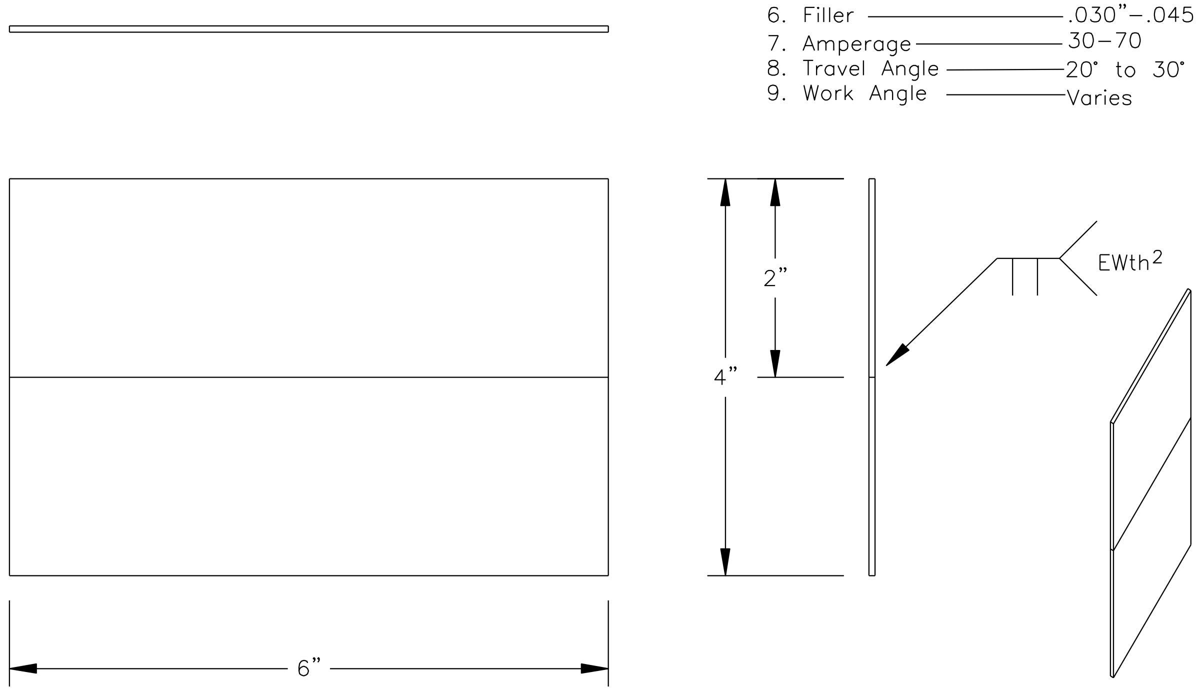
WLD 223

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



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 223-07

Drawn By: John Deering

Size: | Qc No. | Rev.

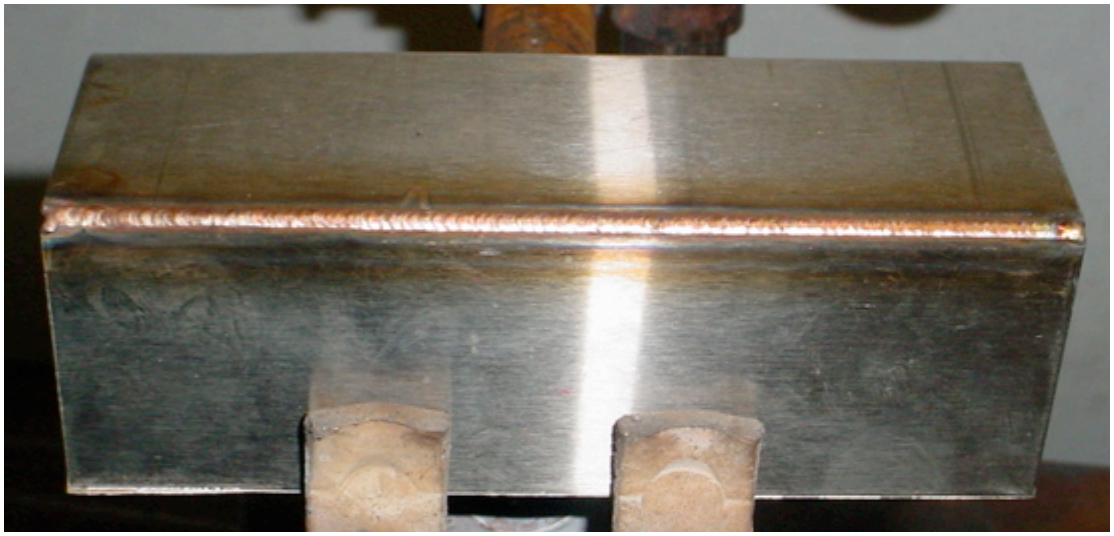
Chk By: TANNER SCOTT Date: 8/21/08

Approve | Date | Sheet

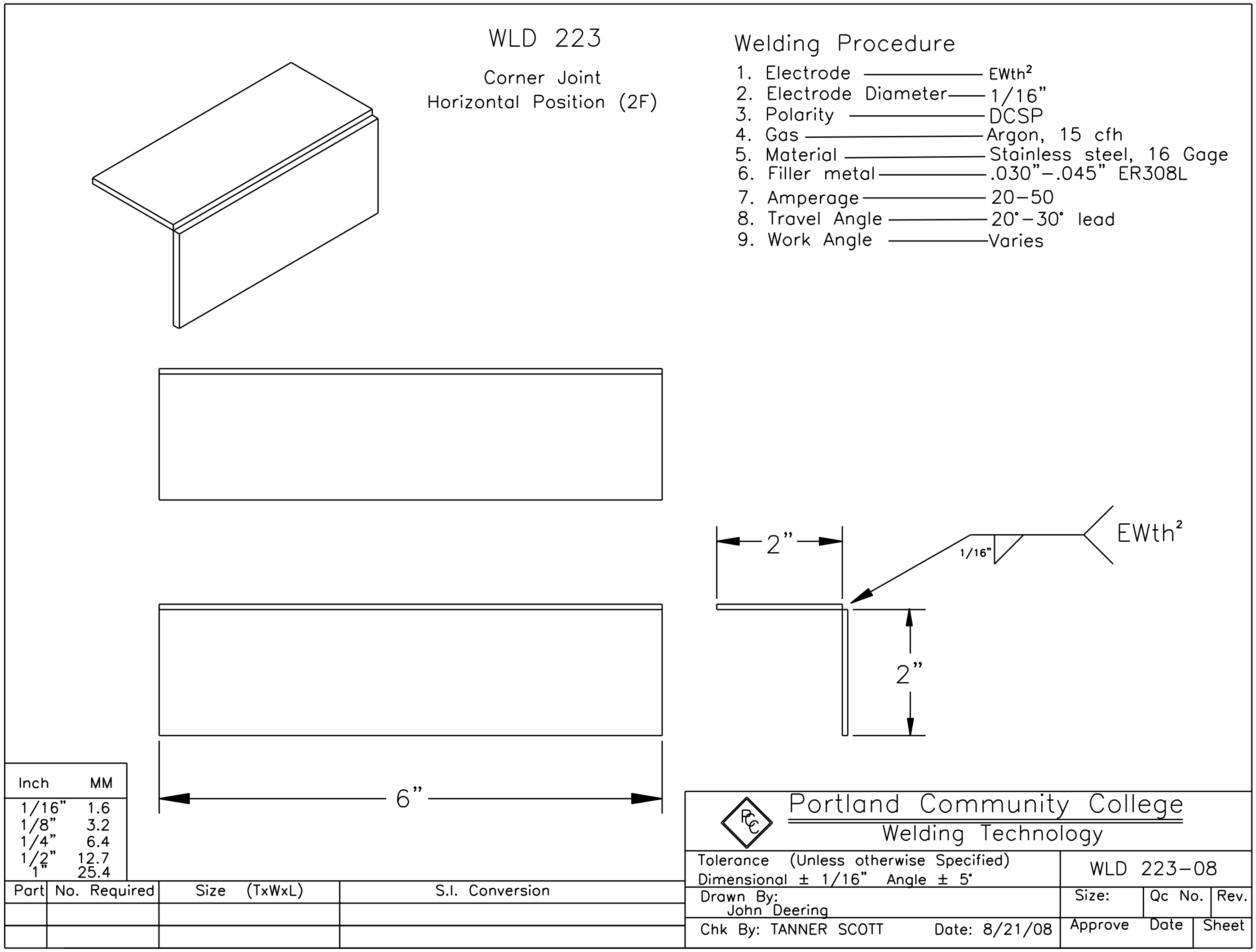
GTAW Horizontal Corner Joint Project #8

Objectives of this welding exercise are:

- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.



VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE


WLD 223
Corner Joint
Horizontal Position (2F)
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 — .030"-.045" ER308L
7. Amperage — 20-50
8. Travel Angle — 20°-30° lead
9. Work Angle — Varies
2"
2"
6"
1/16"
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°
WLD 223-08
Drawn By:
John Deering
Chk By: TANNER SCOTT
Date: 8/21/08
Size:
Qc No.
Rev.
Approve
Date
Sheet

GTAW Vertical Lap Joint — Project #9

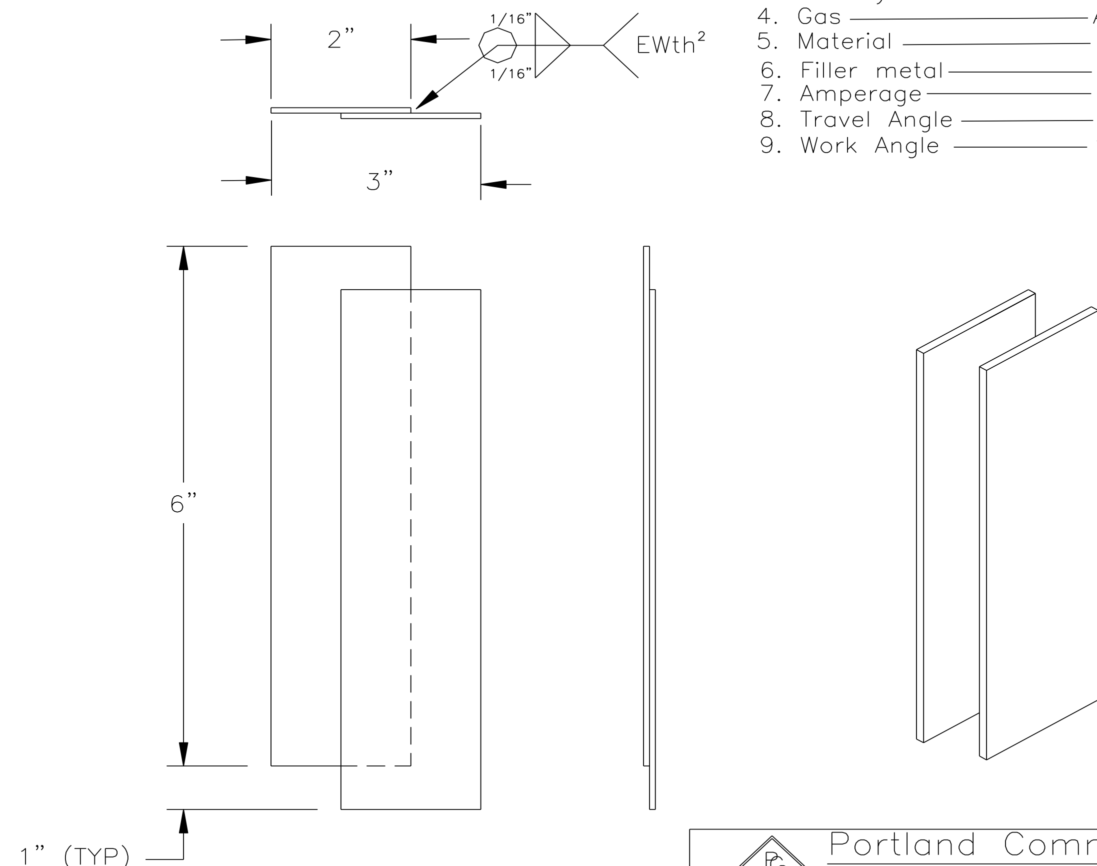
Objectives of this welding exercise are:

- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.

VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

WLD 223

Lap Joint
Vertical Position (3F)



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

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 223-9

Drawn By: John Deering

Size: | Qc No. | Rev.

Chk By: TANNER SCOTT Date: 8/21/08

Approve | Date | Sheet

GTAW Vertical T Joint Project #10

Objectives of this welding exercise are:

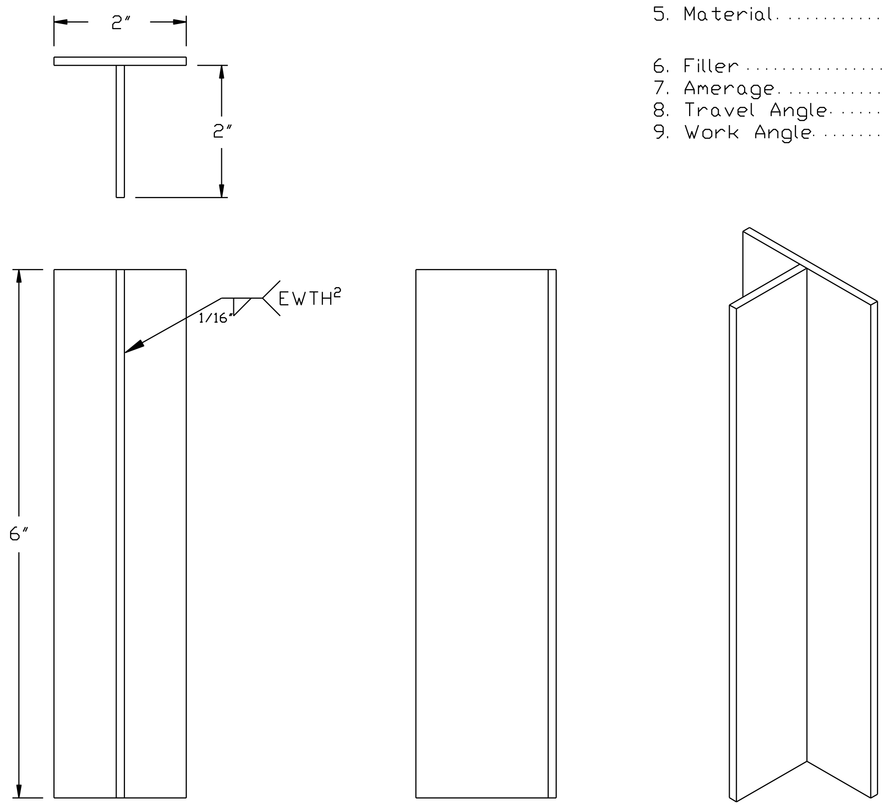
- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.

VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

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

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 223-10

Drawn By: John Deering

Chk By: TANNER SCOTT Date: 8/21/08

Size:	Qc No.	Rev.
Approve	Date	Sheet

GTAW Vertical Position Butt Joint — Project #11

Objectives of this welding exercise are:

- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.

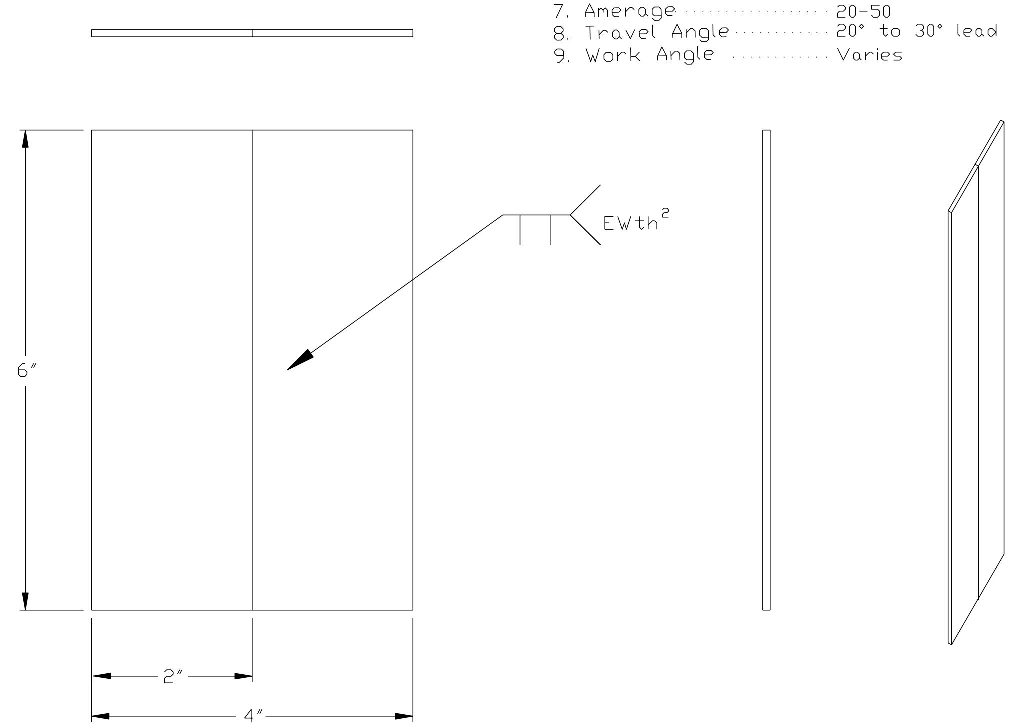
VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	**GRADE**

WLD 223

Vertical Position (3G)
Butt Joint

Welding Procedure

1. Electrode .... EWth²
2. Electrode Diameter ... 1/16″
3. Polarity .... DCSP
4. Gas .... Argon, 15cfh
5. Material .... Stainless Steel, 16 Gage or lighter material
6. Filler .... .030″-.045″ ER308L
7. Amerage 20-50
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 223-11		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: TANNER SCOTT Date: 8/21/08	Approve	Date	Sheet

GTAW Vertical Position Corner Joint Project #12

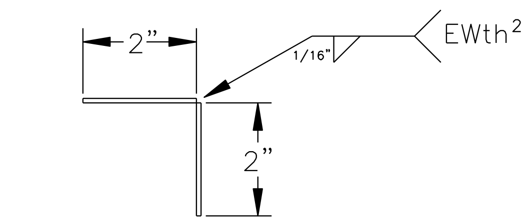
Objectives of this welding exercise are:

- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.

VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

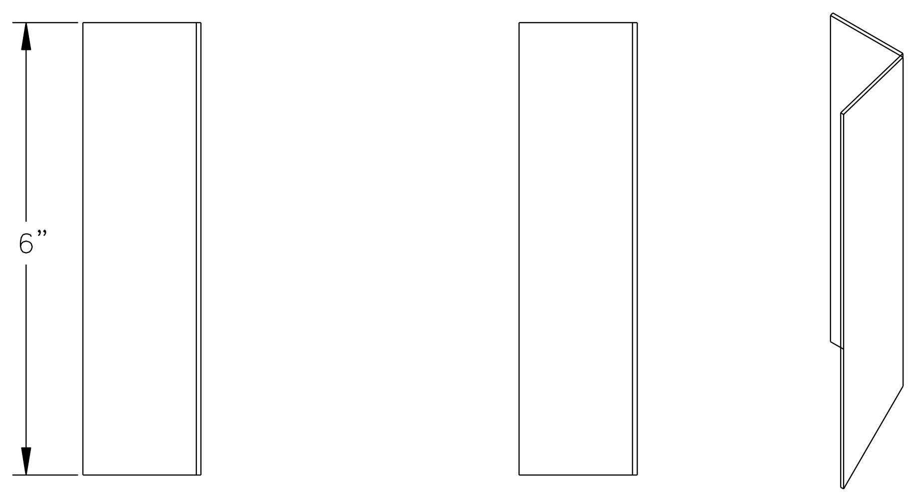
WLD 223

Corner Joint
Vertical Position (3F)



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



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

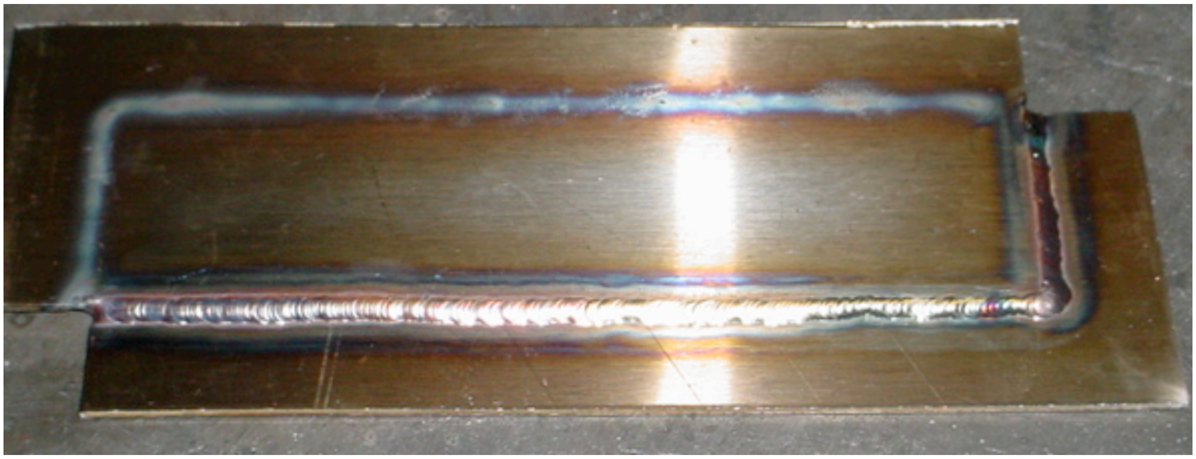
Part	No. Required	Size (TxWxL)	S.I. Conversion

Portland Community College Welding Technology	
Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle ± 5°	WLD 223-12
Drawn By: John Deering	Size: / Qc No. / Rev.
Chk By: TANNER SCOTT Date: 8/21/08	Approve / Date / Sheet

GTAW Overhead Position Lap Joint Project #13

Objectives of this welding exercise are:

- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.



VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	Grade

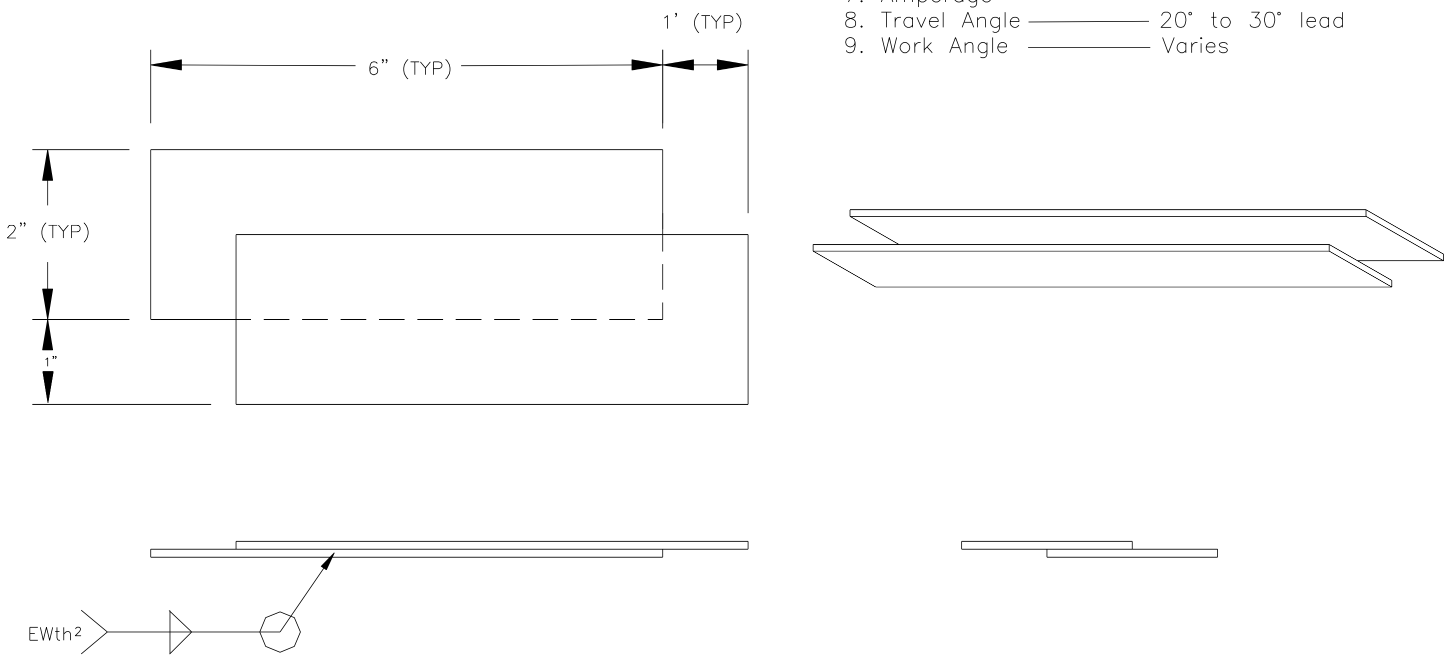
WLD 223

Lap Joint

Overhead Position (4F)

Welding Procedure

1. Electrode — EWth²
2. Electrod Diametere — 1/16"
3. Polarity — DCSP
4. Gas — Argon, 15 cfh
5. Material — Stainless Steel, 16 Gage
6. Filler — .045"-1/16" E308L
7. Amperage — 50 - 70
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

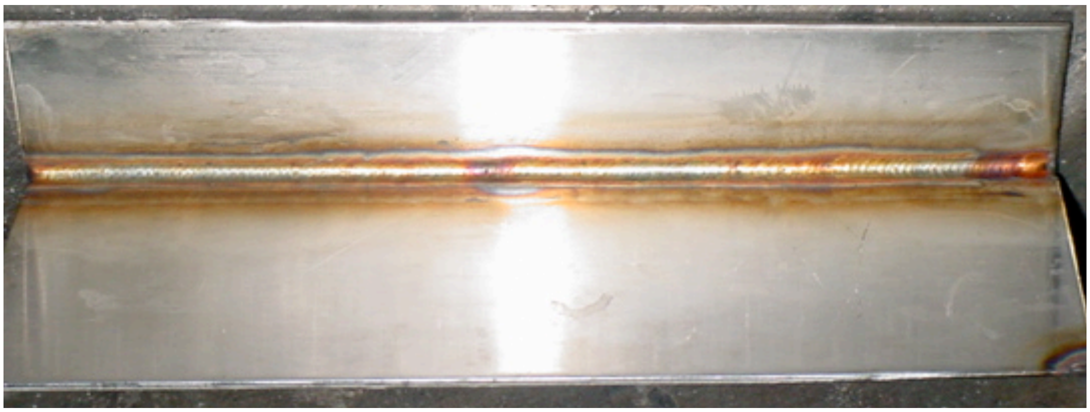
Part	No. Required	Size (TxWxL)	S.I. Conversion

Portland Community College Welding Technology				
Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle ± 5°	WLD 223-13			
Drawn By: John Deering	Size:		Qc No.	Rev.
Chk By: TANNER SCOTT Date: 8/21/08	Approve	Date		Sheet

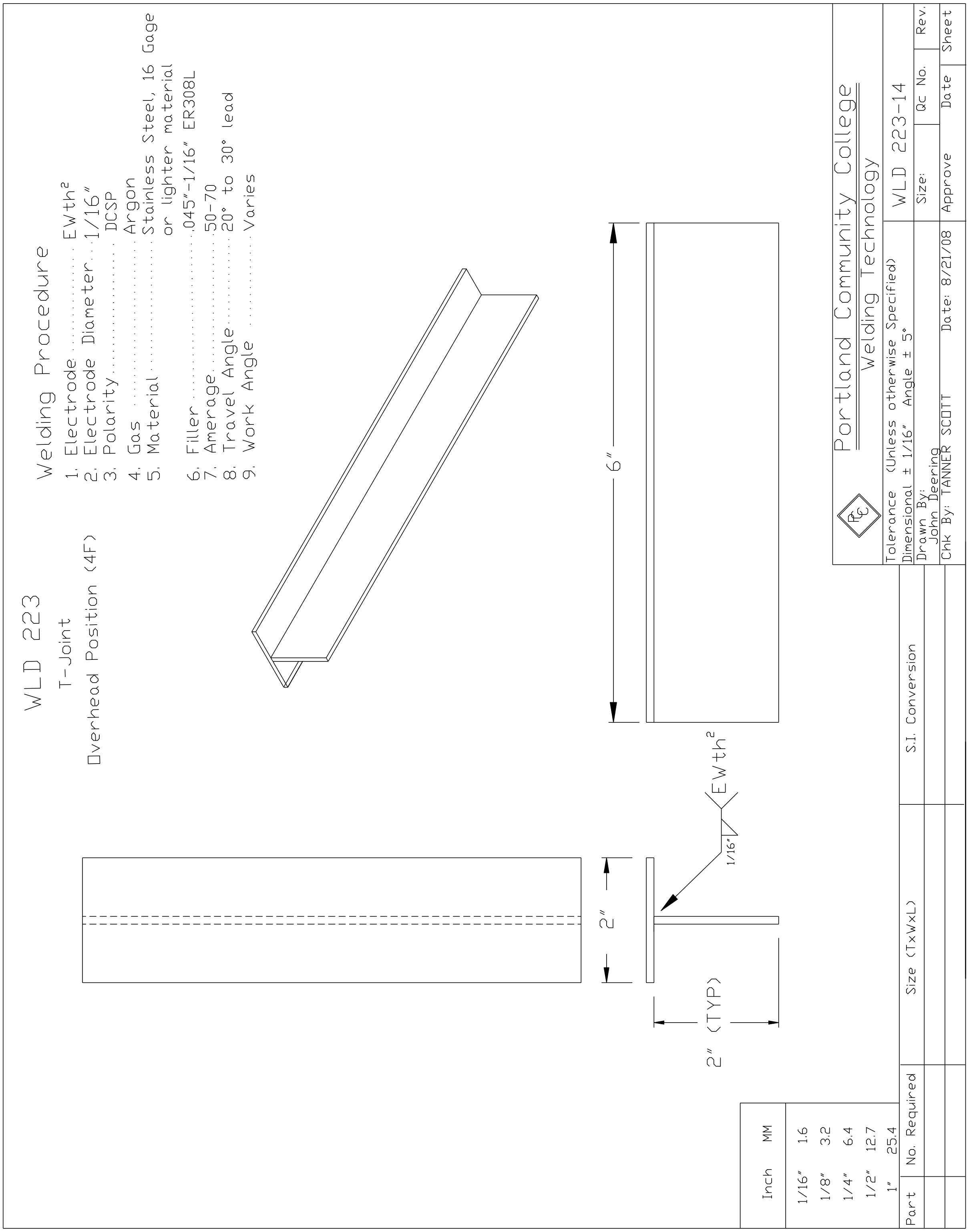
GTAW Overhead Position T Joint — Project #14

Objectives of this welding exercise are:

- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.



VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

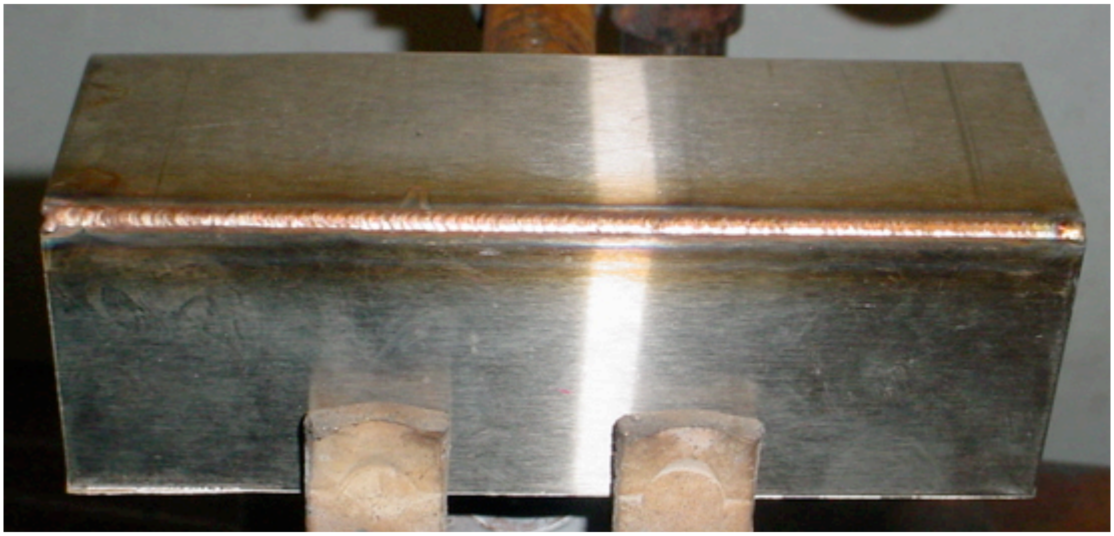


WLD 223
T-Joint
Overhead Position (4F)
Welding Procedure
1. Electrode EWth2
2. Electrode Diameter .. 1/16"
3. Polarity .... DCSP
4. Gas .... Argon
5. Material .... Stainless Steel, 16 Gage or lighter material
6. Filler .... .045"-1/16" ER308L
7. Amerage 50-70
8. Travel Angle .... 20° to 30° lead
9. Work Angle .... Varies
6"
2"
2" (TYP)
1/16"
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
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Chk By: TANNER SCOTT
Date: 8/21/08
Portland Community College
Welding Technology
WLD 223-14
Size:
Qc No.
Rev.
Approve
Date
Sheet

GTAW Overhead Corner Joint Project #15

Objectives of this welding exercise are:

- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.



VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

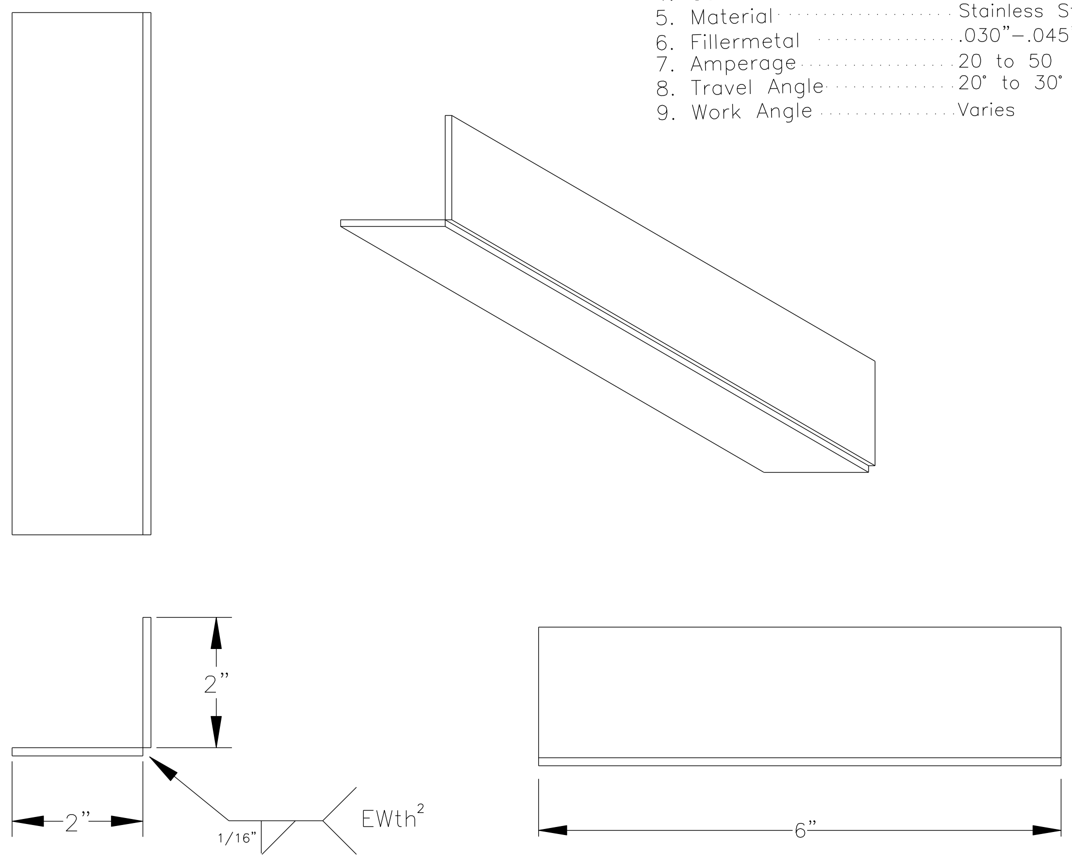
WLD 223

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



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 223-15		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: TANNER SCOTT Date: 8/21/08	Approve	Date	Sheet

Final Exam

Part One

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

Study Guide

Safety

- GTAW safety
- Hand Tool Safety

GTAW Processes

- Power source specifics
  - Polarity
  - Current out put
  - High Frequency
  - Shielding gases
- AWS electrode classification

Material Specs.

- Know types of Stainless Steels (memorize classification numbers and type)
- Carbide precipitation

Welding Symbols and Blueprints

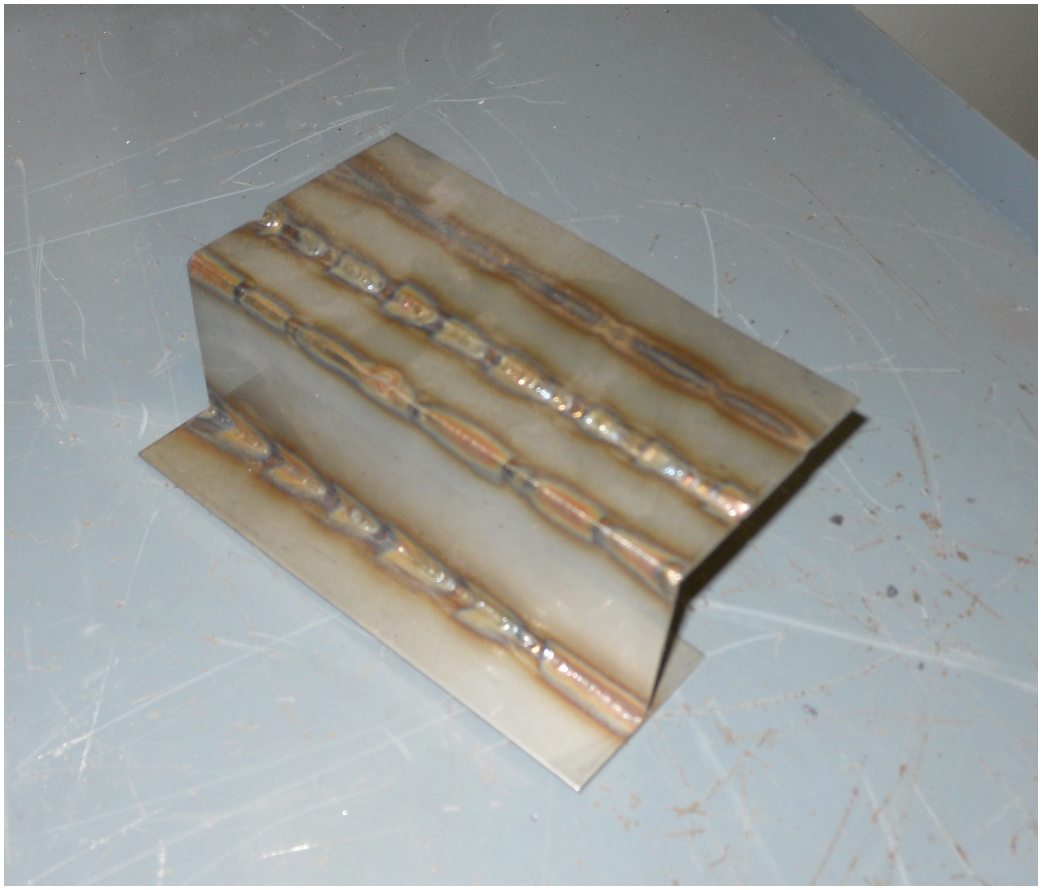
- Orthographic views
- Isometric views
- Welding symbol
  - Weld symbols
  - Reference line
  - Tail

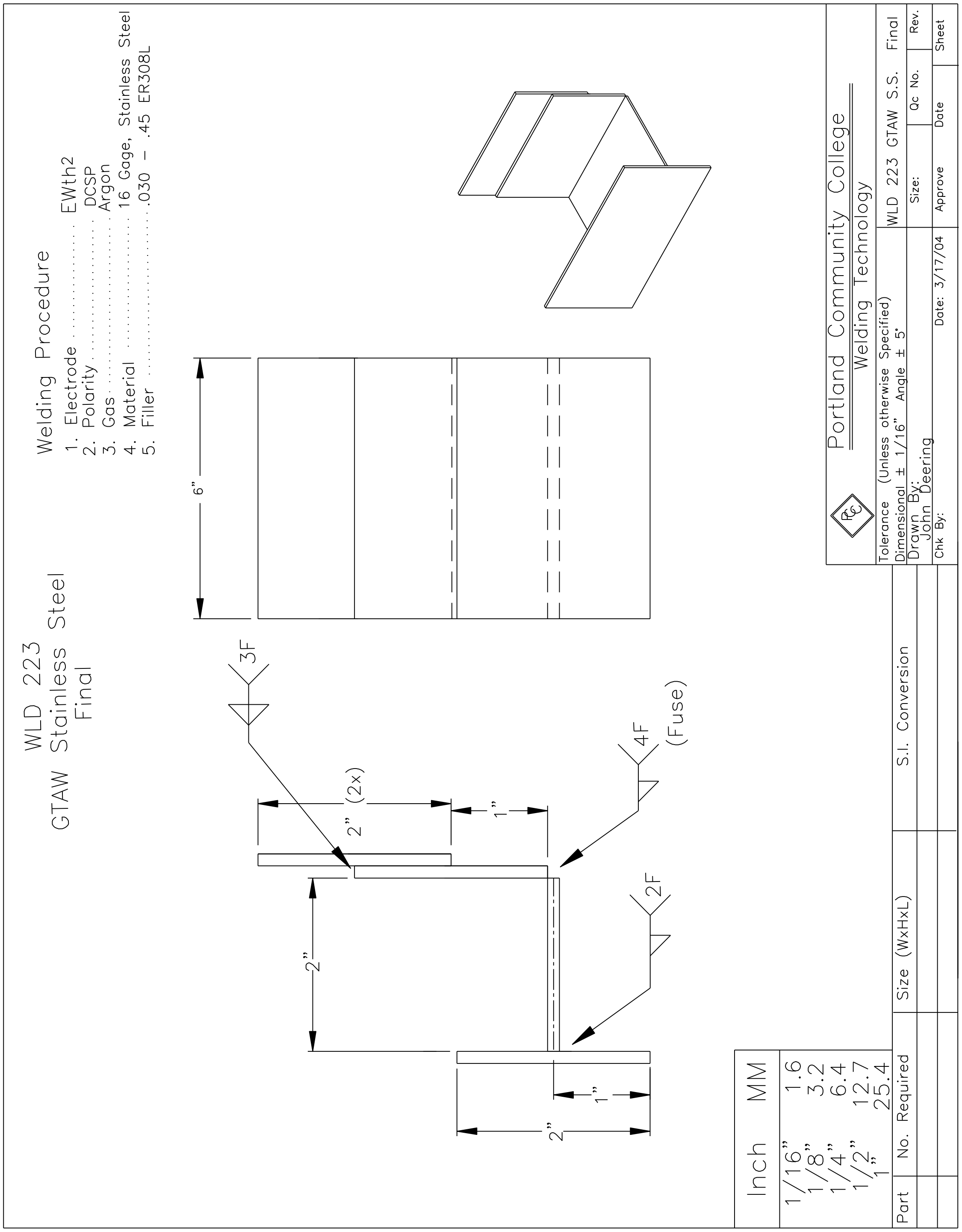
Math and Math conversions

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

Part Two

This portion of the exam is a practical test where you will fabricate and weld a weldment from a "blue print." The evaluation of this portion of the exam will be based on the rubric. You will have two class periods to build the project.




WLD 223
GTAW Stainless Steel
Final
Welding Procedure
1. Electrode EWth2
2. Polarity .... DCSP
3. Gas .... Argon
4. Material .... 16 Gage, Stainless Steel
5. Filler .... .030 - .45 ER308L
6"
3F
4F
(Fuse)
2F
2" (2x)
1"
2"
1"
2"
Inch MM
1/16" 1.6
1/8" 3.2
1/4" 6.4
1/2" 12.7
1" 25.4
Part
No. Required
Size (WxHxL)
S.I. Conversion
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By:
John Deering
Date: 3/17/04
Chk By:
WLD 223 GTAW S.S. Final
Size:
Qc No.
Rev.
Approve
Date
Sheet

Grading Rubric for the WLD 223 Practical Exam

Name:_________________________________ Date______________________

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

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

Final Grades - WLD 223

Name: __________________ Instructor: ____________________ Date: ___________________

Welding Projects = 40%

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

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

Quizzes = 20%

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

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

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

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

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

Final Exams 30%

Written Exam	Out of
Practical Exam	Out of

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

Add Lines A + B + C + D + E. This will give you your Final Grade TOTAL % __________

FINAL GRADE__________