WLD 221
Gas Tungsten Arc Welding
Mild Steel

INDEX

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By the
National Science Foundation
Opinions expressed are those of the authors
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Course Assignments

Reading

Welding Principles and Applications 7th edition By Larry Jeffus
Chapter 15, Gas Tungsten Arc Welding Equipment , Setup, Operation, and Filler Metals

Math

Practical Problems in Mathematics 6th edition by Robert Chasan
Chapter 38, Bends and Stretchouts of Angular Shapes
Chapter 39, Bends Stretchouts of Circular and Semicircular Shapes

Recommended assignments

Complete review question following each assigned chapter

Quizzes

Complete Interactive Quiz in CourseMate for each assigned chapter

Video Training

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

Welding Projects

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

Final Exam

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

Timeline

Open-entry, open-exit instructional format allows the students to work at their own pace. **It is the student's responsibility for completing 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 development of course outcomes. The methods of assessment may include one or more of the following: oral or written examinations, quizzes, written assignments, visual inspection techniques, welding tests, safe work habits, task performance and work relations.

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

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

For New Students

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

For Returning Students

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

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

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

Science

on

Steel

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

Contents of this Packet include

- Weld Cleanliness

- Electron Emission by Tungsten Electrode
- Use of Thoriated and Ceriated Electrodes
- Cleaning Action
- Surface Tension Driven Flow of Weld Metal affecting Penetration

Weld Cleanliness

Compared to SMAW, FCAW and GMAW, weld metal deposited by GTAW properly will be free of contamination of any kind. GTAW is a hydrogen-free process. The tungsten electrode and the molten metal pool are free of contamination because of the argon shielding gas used in welding. The only source of contamination is due to lack of good workmanship. Although GTAW is a very clean process, it can produce porous welds because of poor workmanship. For example, if the work-piece is covered with oil, grease or paint, the weld metal will contain porosity and be susceptible to hydrogen-assisted cracking.

Electron Emission by Tungsten Electrode

The temperature of the central core of the arc in GTAW can approach approximately 30,000ºC (54,000º F). The presence of metal vapors from the filler metal and even the tungsten electrode itself will reduce the arc temperature slightly. The actual temperature of the arc during welding is limited by several sources of heat loss, namely;

- Radiation
- Convection
- Conduction and
- Diffusion

Radiation from an arc varies from long wavelength infrared radiation to visible to short wavelength ultraviolet light. As intense as the gas tungsten arc is, the energy of the radiation is not high enough to produce x-rays, (which is abundantly generated in electron beam welding). The energy of radiation (E_{rad}) is a function of the wavelength (w), as shown below:

$$E_{rad} = h/w$$ where h is Plank's constant

The amount of arc radiation taking place during welding increases with arc temperature and atomic mass (of the media carrying the arc such as argon or helium). Using argon with GTAW, losses of up to 20% of the heat input are possible. Since the gas tungsten arc contains such intense ultraviolet energy, the problem to skin damage (similar to severe sunburns) takes place rapidly. Compared to GMAW, FCAW and SMAW, the GTAW process can cause the most severe skin burns if poor protective clothing is used.

<u>Use of Thoriated and Ceriated Electrodes</u>

In DC operation, pure tungsten electrodes are not used because the tip of the electrode melts and the cathode spot moves unstably all over the molten ball. The erratic arc motion makes precision welding very difficult. The simple addition of 2%ThO_2 (thoria) to the tungsten allows tungsten electrodes to operate at currents of 200 amps easily without the electrode melting. Furthermore, the 2% thoria electrodes nor only operate without melting, but also can achieve greater electron emission than pure tungsten.

Thoria is a very stable compound and has a melting point (over 3,000ºC or 5,500ºF) almost as high as tungsten (3,410ºC). The mechanism by which this happens depends on the high-temperature solid state reaction between tungsten (W) and ThO_2 to produce pure thorium (Th), as shown below:

$$W + ThO_2 \quad = \quad WO_2 + Th$$

At the very high temperatures experienced at the electrode tip during GTAW, the thorium diffuses to the outside surface of the electrode. During welding, the thorium-coated tungsten acts as if the electrode were entirely thorium. Thorium has a much lower work function than does tungsten. This means that the thorium-coated electrode can emit electrons with greater ease at lower temperatures than can tungsten. In fact, tungsten must be molten before it can achieve full thermionic emission of electrons. This is why AC welding of aluminum with pure tungsten electrodes requires that the tip of the tungsten be melted in the shape of a large ball. If pure tungsten does not have a melted ball at the electrode tip, the heat delivered by GTAW would be inadequate for welding because thermionic emission would not be achieved. The simple addition of 2%ThO_2 permits thermionic emission without having to melt the electrode using either DC or AC. The current density achieved by 2%ThO_2-W electrodes is about 10,000,000 A/m^2.

Since ThO_2 is mildly radioactive, research had been conducted over the years to find a substitute for ThO_2. Ceria or CeO_2, which is not radioactive, was found to be an excellent replacement of ThO_2 as shown in Table 1, below.

Table 1 Tungsten electrode characteristic using argon shielding gas (Approximate values).

	W	W – 2%ThO_2	W – 2%CeO_2
Electrode Temperature, ºC	3,450	3,300	2,800
Work function, eV	3.0	2.4	2.1
Emissivity	0.15	0.22	0.30

From Table 1, it can be seen that the electron work function is highest with pure tungsten and lowest with W-CeO_2. The emissivity is lowest at the highest temperature for thermionic emission with pure tungsten; while, the emissivity of W- CeO_2 is highest at the lowest temperature. This means that both W-ThO_2 and W-CeO_2 electrodes can operate below their melting points, while achieving full thermionic emission of electrons in the weld arc. These additions to tungsten have the beneficial effect of increasing arc stability.

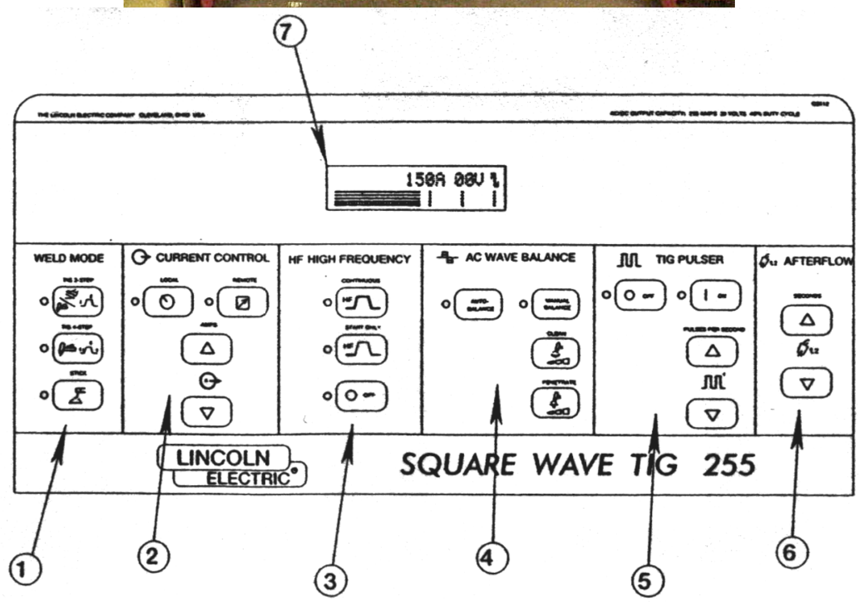
In automatic welding at high current continuously for long periods of time may cause excess evaporation of the thorium. If the surface thorium content is too low, the electrode may become unstable by acting like a pure tungsten electrode. The development of ceriated electrodes and lanthanated electrodes provide extended arc stability for automatic welding. These additions of CeO_2 and La_2O_3 diffuse much more slowly to the electrode surface because large tungstate and oxy-tungstate compounds form which are not very mobile at high temperatures. Thus, these ceriated and lanthanated electrodes have more long-term stability than thoriated electrodes.

Cleaning Action

For all practical purposes, there is no cleaning action when GTAW of steel. Thus, steel is rarely ever welded with DCEP or AC. The action of the cathode removing oxides does take place when GTAW steel and can be observed. However, the cleaning action effect is minor and not considered of any value in welding steel. In welding of aluminum and magnesium, this cleaning action is extremely important and beneficial. The reason why the oxide layer on steel does not "clean" nearly as well as that for aluminum is related to the chemical stability, oxide thickness, relative melting points between oxide and substrate, and dielectric or electrical insulating properties. The melting points of steel and iron oxide are not nearly as different as those for aluminum and aluminum oxide. Similarly, the difference in chemical stability between aluminum oxide and pure aluminum is very great; while the difference between steel and iron oxide is not as large. Thus, when welding with DCEP and the work piece is the cathode (negative pole), the electrons tend to build up charge to a much greater extent with the aluminum cathode than with the steel cathode. Eventually, the charge build-up becomes so great in the case of welding aluminum that the aluminum oxide layer is virtually exploded away from the surface or "cleaned". The same action takes place with steel except it is not strong enough to be beneficial. Thus, steel is almost always welded with DCEN.

Power Source Panel Identification Information

Lincoln, Square Wave 255



Controls and Settings for the Square Wave 255

1. Weld Mode Keys	2. Current Control Keys
3. High Frequency Keys	4. AC Wave Balance Keys
5. TIG Pulser Keys	6. After-flow Keys
7. Display	

Common Power Source Controls

1. **WELD MODE KEYS**: These keys select the Weld mode desired, as the graphic symbols indicate the TIG 2-Step mode is selected when using a Foot Amptrol (foot operated remote current control), the TIG 4-Step is selected when using a Hand Amptrol (hand operated remote current control, usually mounted on the torch). The third mode is selected when using the power source for Stick welding.

2. **CURRENT CONTROL**: This area contains the Local/Remote keys as well as the Amps Up/Amps Down keys. The up/down keys are used to adjust amperage from 5 to 315 amps. The “Local” current control allows the current to be adjusted only with the Amps up/Amps down keys. The “Remote” current control is automatically activated when using the TIG 2-Step and TIG 4-Step modes.

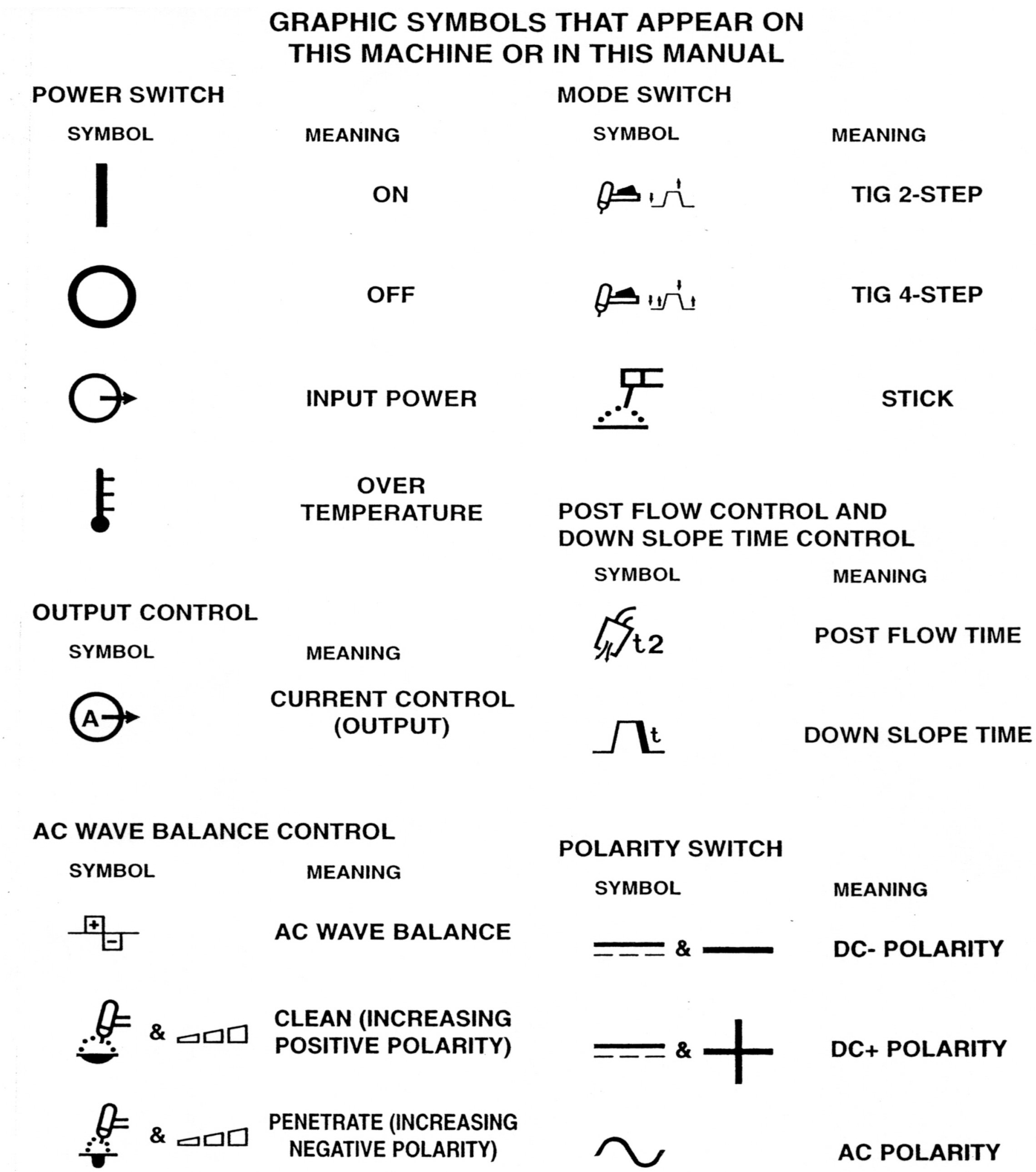
3. **HIGH FREQUENCY:** These keys are active in the TIG mode only. Select “Start Only” when using Direct Current straight polarity. Select “Continuous” when welding with Alternating Current. “Off” will automatically be selected when welding in the Stick mode.

4. **AC WAVE BALANCE**: These keys are active in the AC TIG mode only. They are used to set the amount of cleaning and/or penetration. Auto Balance automatically sets the AC Wave balance according to the welding current.

5. **TIG PULSER**: These keys are active in the TIG mode only. The On/Off keys turn the pulse option on and off. The Pulses Per Second keys adjust the pulsing frequency up and down, from 0.5 to 10 pulses per second. The background current (the welding current at the low point of the pulse cycle) is automatically adjusted from 40% to 60% of the peak current (the welding current selected). The ratio between the time spent at peak current verses, the time spent at the background current is fixed at 50%.

6. **AFTERFLOW**: These keys are active in the TIG mode only. These keys adjust the length of time the gas flows after the arc is extinguished.

Common Graphic Symbols



GRAPHIC SYMBOLS THAT APPEAR ON THIS MACHINE OR IN THIS MANUAL

POWER SWITCH

SYMBOL	MEANING
	ON
	OFF
	INPUT POWER
	OVER TEMPERATURE

OUTPUT CONTROL

SYMBOL	MEANING
	CURRENT CONTROL (OUTPUT)

AC WAVE BALANCE CONTROL

SYMBOL	MEANING
	AC WAVE BALANCE
&	CLEAN (INCREASING POSITIVE POLARITY)
&	PENETRATE (INCREASING NEGATIVE POLARITY)

MODE SWITCH

SYMBOL	MEANING
	TIG 2-STEP
	TIG 4-STEP
	STICK

POST FLOW CONTROL AND DOWN SLOPE TIME CONTROL

SYMBOL	MEANING
	POST FLOW TIME
	DOWN SLOPE TIME

POLARITY SWITCH

SYMBOL	MEANING
&	DC- POLARITY
&	DC+ POLARITY
	AC POLARITY

GRAPHIC SYMBOLS THAT APPEAR ON THIS MACHINE OR IN THIS MANUAL

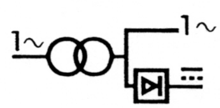
OPTIONAL WATER SOLENOID CONNECTIONS

SYMBOL	MEANING
	WATER (COOLANT) INPUT
	WATER (COOLANT) OUTPUT

OUTPUT CONNECTIONS

SYMBOL	MEANING
	WORK CONNECTION
	ELECTRODE CONNECTION

ADDITIONAL SYMBOLS

SYMBOL	MEANING
	REMOTE CONTROL
	DO NOT SWITCH WHILE WELDING
	WARNING
	PROTECTIVE GROUND
	TIG (GTAW)
1 ∼	SINGLE PHASE
	SINGLE PHASE TRANSFORMER AC & DC RECTIFIER POWER SOURCE

Craftsmanship Expectations for Welding Projects

Steps in completing welding projects:

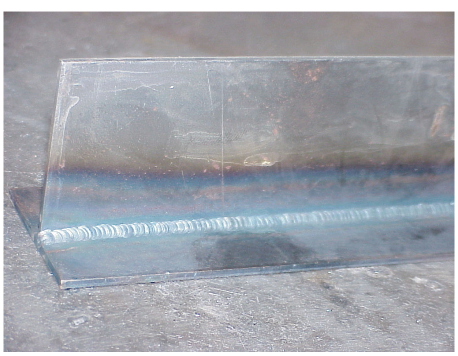
1. Thoroughly read each drawing.
2. Utilize scrap material to adjust machine.
3. Assemble the welding projects per drawing specifications.
4. Review the Welding Procedure portion of the prints to review welding parameter information.
5. Complete welding project. Practice as needed to meet acceptance 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.

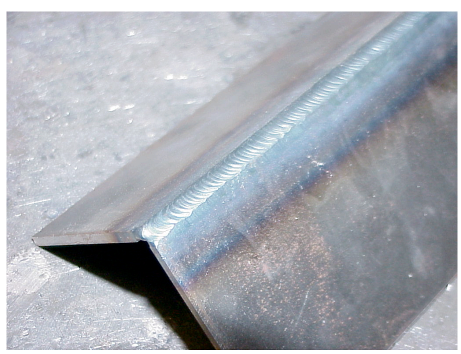
Factors for grading welding projects are based on the following criteria

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

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





Example of a High Quality Weld

GTAW Flat Position Edge Joint (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.

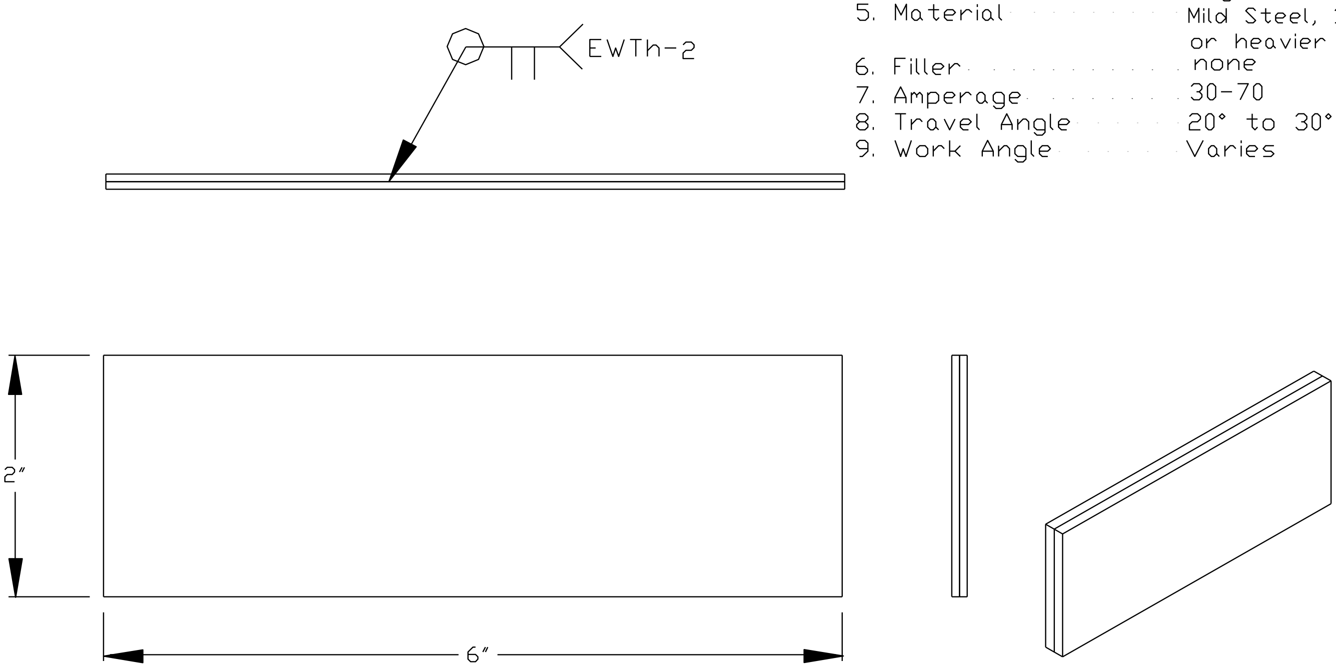
Too long = undercutting, and can result in loss of gas coverage creating porosity.

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

WLD 221
Fuse Weld
Flat Edge Joint

Welding Procedure

1. Electrode — EWTh-2
2. Electrode Diameter — 1/16"
3. Polarity — DCSP
4. Gas — Argon 15 cfh
5. Material — Mild Steel, 16 gage or heavier
6. Filler — none
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 (WxHxL)	S.I. Conversion

Portland Community College
Welding Technology

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

WLD 221-01

Drawn By:
John Deering

Size: | Qc No. | Rev.

Chk By: Date: 3/10/04

Approve | Date | Sheet

GTAW Flat Position Corner Joint (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

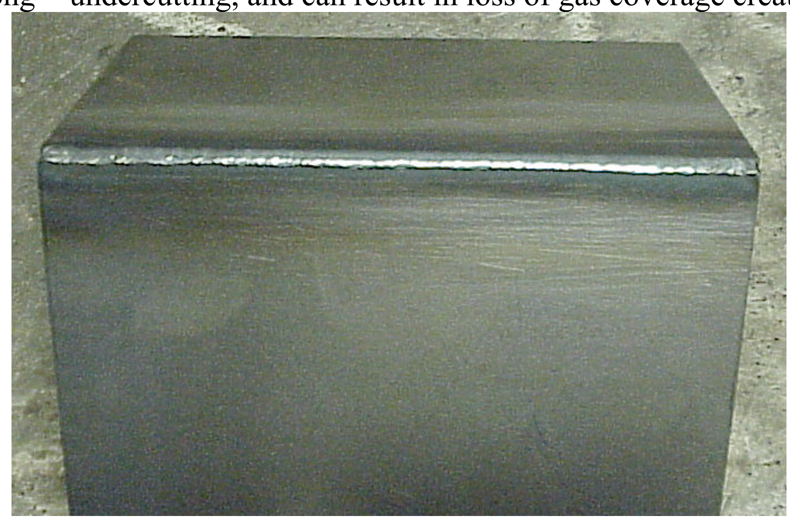
Too high = undercutting, or melting holes through the work
Too low = lack of fusion on the edges of the joint

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.

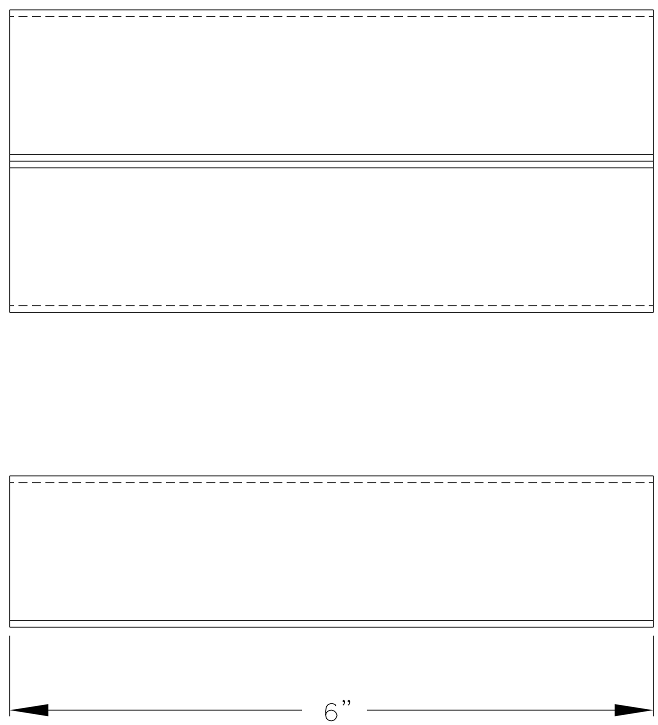
Arc length

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.



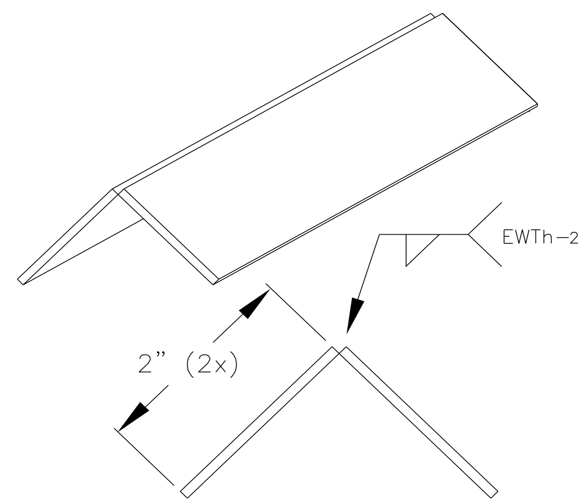
VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

WLD 221
Fuse Weld (1F)
Outside Corner



Welding Procedure

1. Electrode EWTh-2
2. Electrode Diameter ..... 1/16"
3. Current .... DCSP
4. Gas .... Argon 15 cfh
5. Material .... Mild Steel, 16 Gage or heavier material.
6. Filler .... none
6. Amperage 30-70
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 (WxDxL)	S.I. Conversion

Portland Community College
Welding Technology

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

WLD 221-02

Drawn By: John Deering

Size: | Qc No. | Rev.

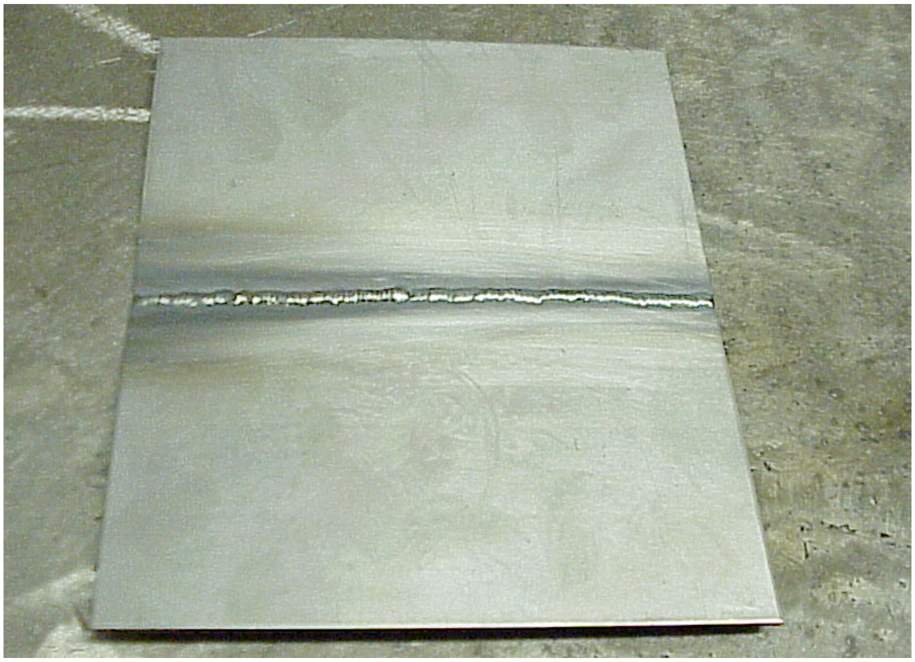
Chk By: Date: 03/01/04

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**

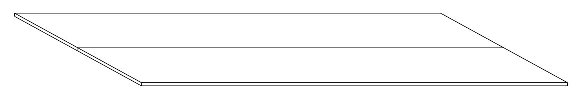
WLD 221

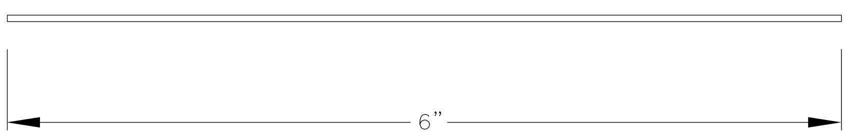
Fuse Weld (1G)

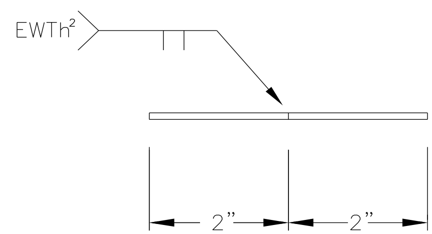
Flat Butt Joint

Welding Procedure

1. Electrode —— $EWTh^2$
2. Electrode Diameter —— 1/16"
3. Polarity —— DCSP
4. Gas —— Argon 15 cfh
5. Material —— Mild steel, 16 Gage or heavier material
6. Filler —— none
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

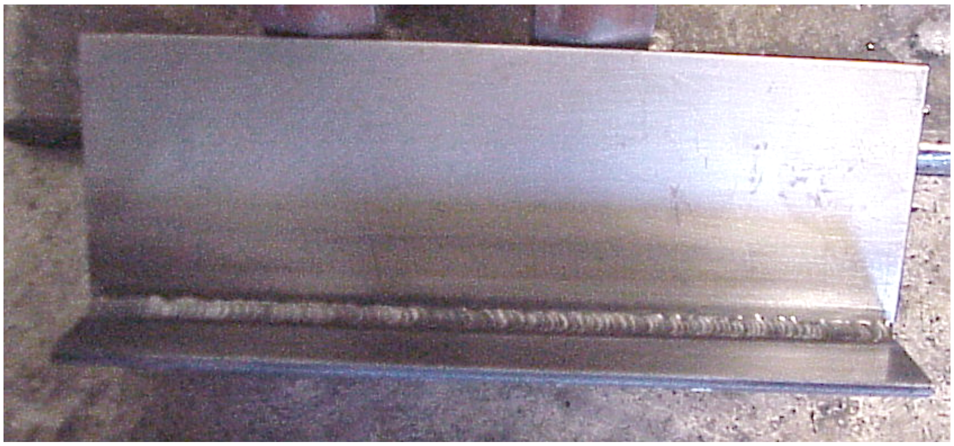
Welding Technology

Tolerance (Unless otherwise Specified) Demensional ± 1/16" Angle± 5°	WLD 221–03		
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.

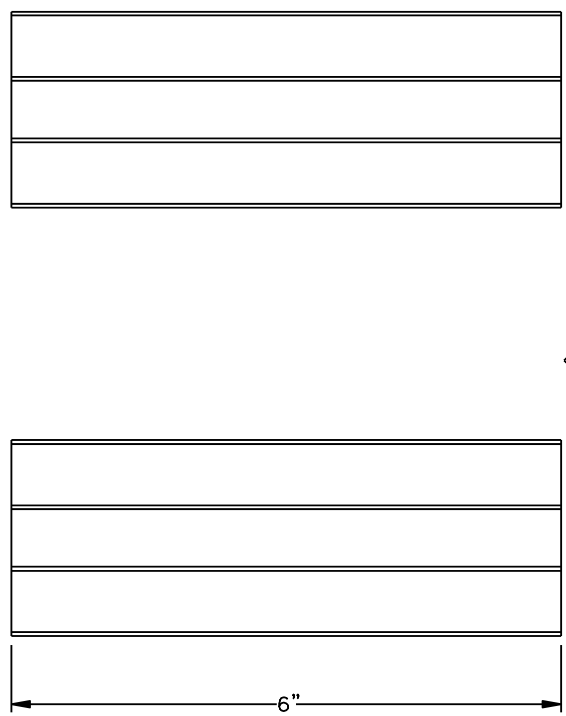


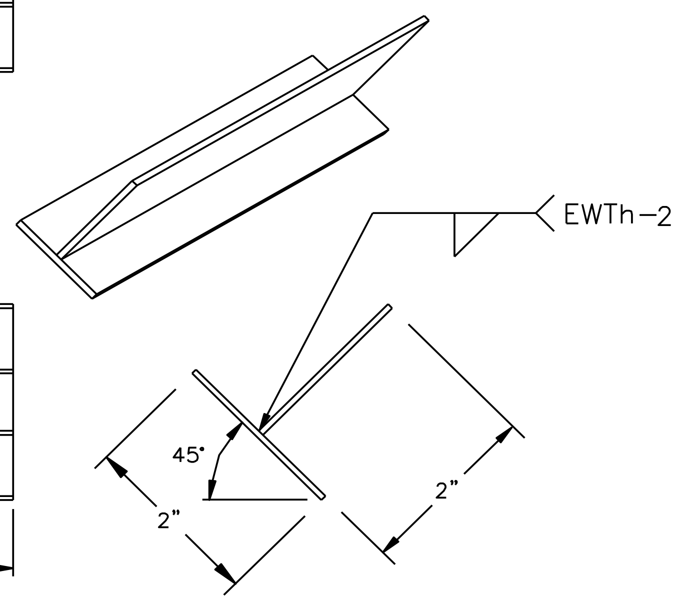
VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	**GRADE**

WLD 221
T-Joint (1F)
Flat Position

Welding Procedure

1. Electrode —— EWTh-2
2. Electrode Diameter —— 1/16"
3. Polarity —— DCSP
4. Gas —— Argon 15 cfh
5. Material —— Mild steel, 16 Gage or heavier
6. Filler —— 1/16" ER70S2
7. Amperage —— 30-70
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"	25.7

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

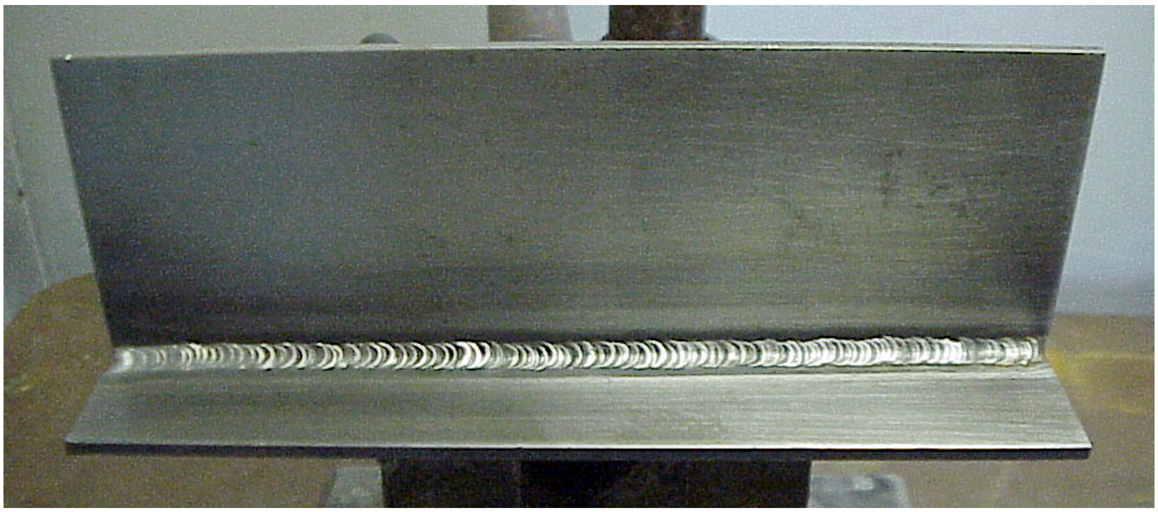
Portland Community College
Welding Technology

Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle ± 5°	WLD 221-05		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Date: 03/01/04	Approve	Date	Sheet

GTAW Horizontal T 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.

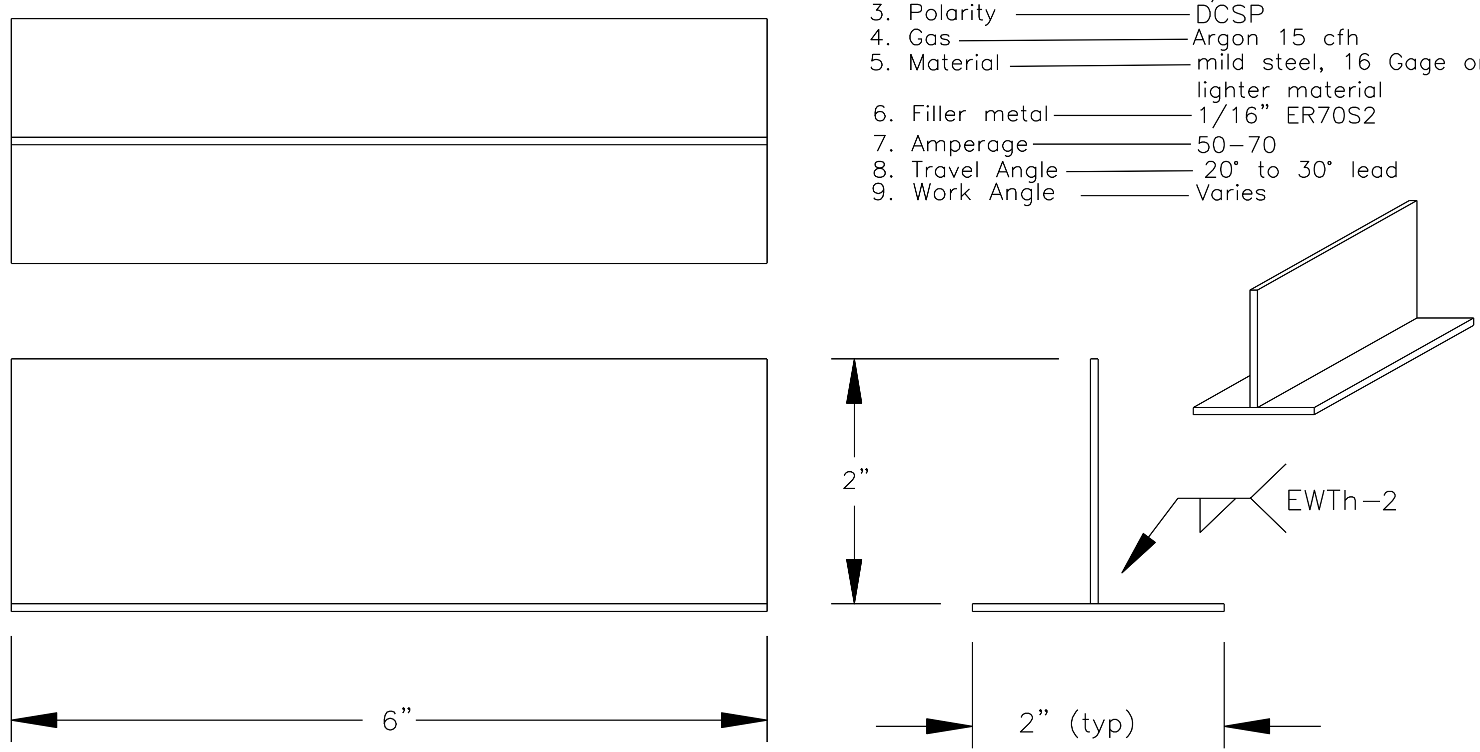


VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

WLD 221
Mild Steel T–Joint (2F)
Horizontal Position

Welding Procedure

1. Electrode — EWTh–2
2. Electrode Diameter — 1/16"
3. Polarity — DCSP
4. Gas — Argon 15 cfh
5. Material — mild steel, 16 Gage or lighter material
6. Filler metal — 1/16" ER70S2
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 (WxHxL)	S.I. Conversion

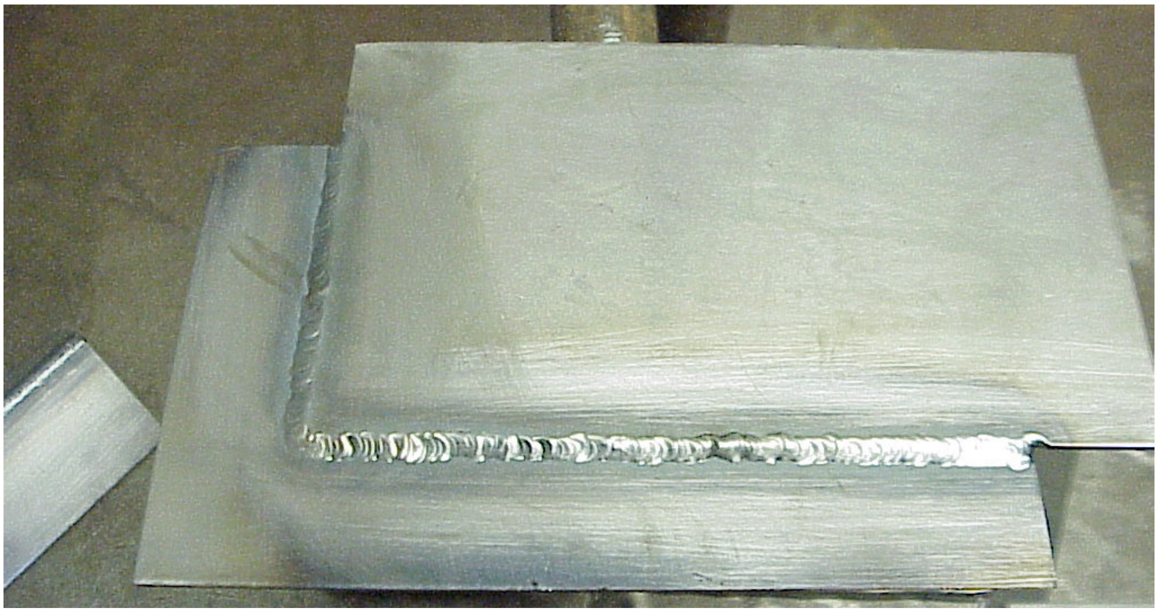
Portland Community College
Welding Technology

Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle± 5°	WLD 221 –07		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Date: 01/01/04	Approve	Date	Sheet

GTAW Horizontal Lap 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.

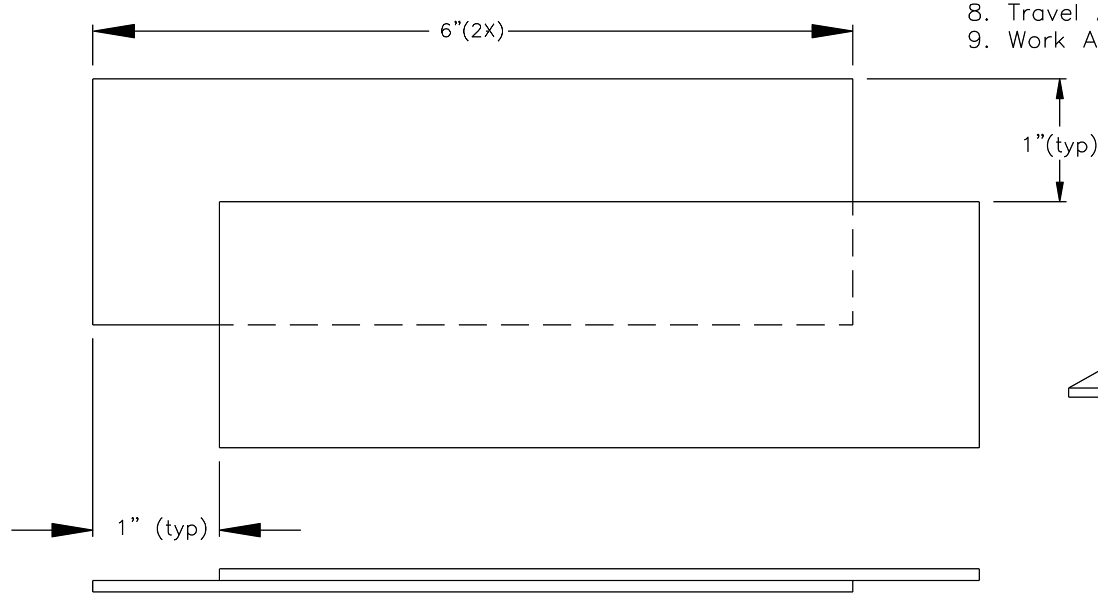


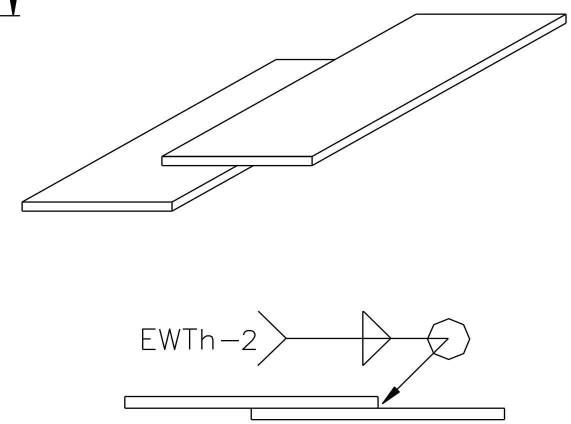
VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

WLD 221
Lap joint (2F)
Horizontal Position

Welding Procedure

1. Electrode	EWTh-2
2. Electrode Diameter	1/16"
3. Polarity	DCSP
4. Gas	Argon 15 cfh
5. Material	Mild steel, 16 Gage or heavier material
6. Filler metal	1/16 ER70S2
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 (WxHxL)	S.I. Conversion

Portland Community College
Welding Technology

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

WLD 221-06

Drawn By:
John Deering

Size:	Qc No.	Rev.

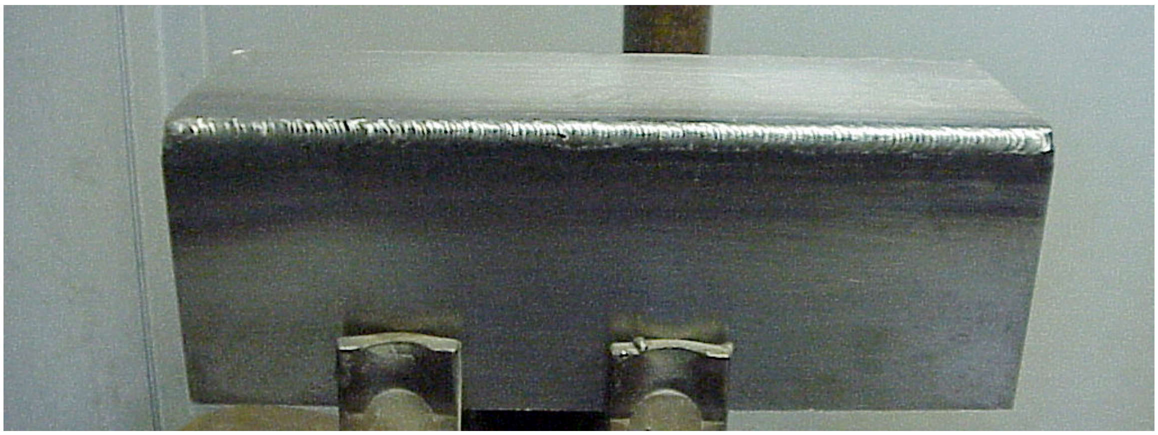
Chk By: Date: 01/01/04

Approve	Date	Sheet

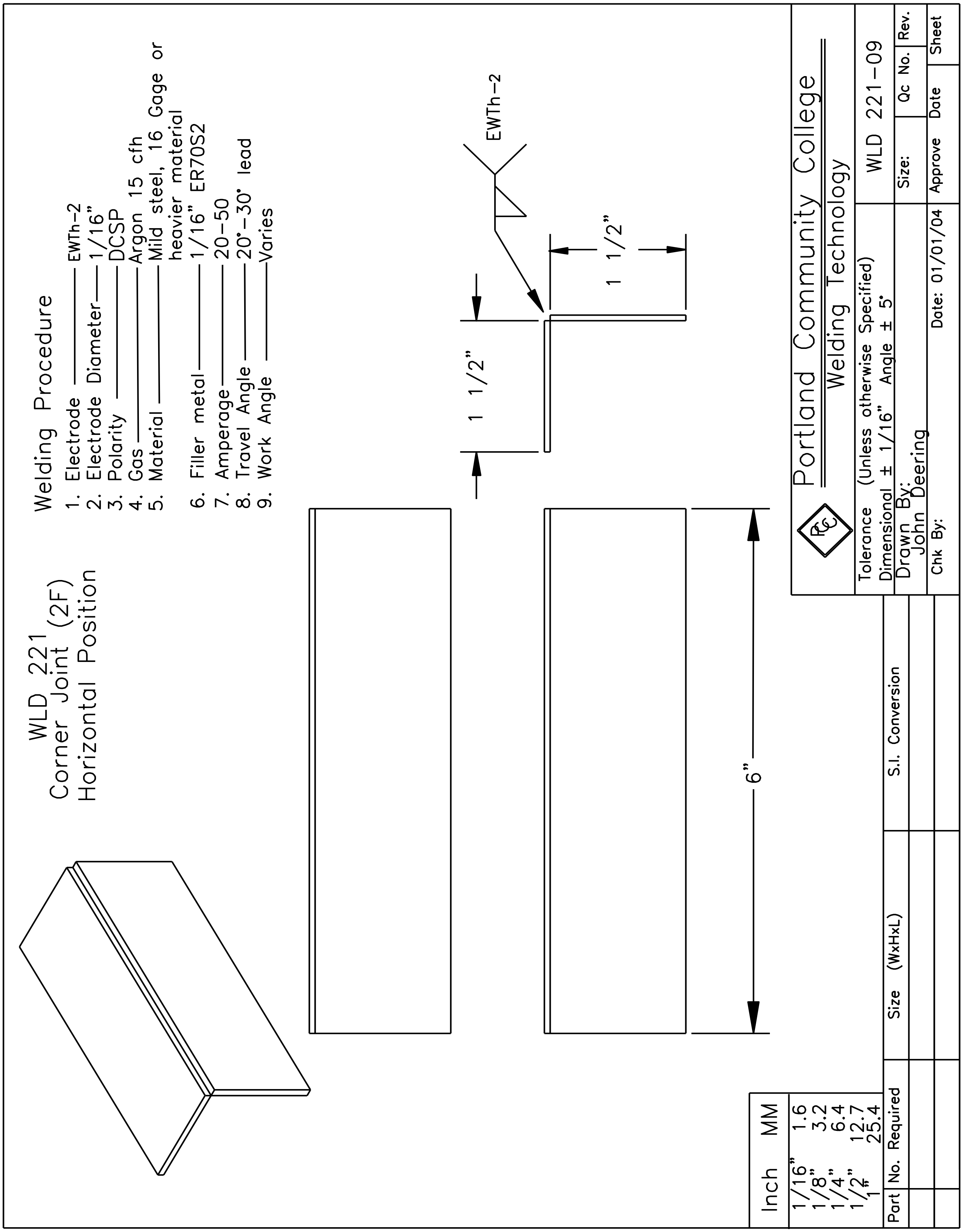
GTAW Horizontal Corner Joint Project #7

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.



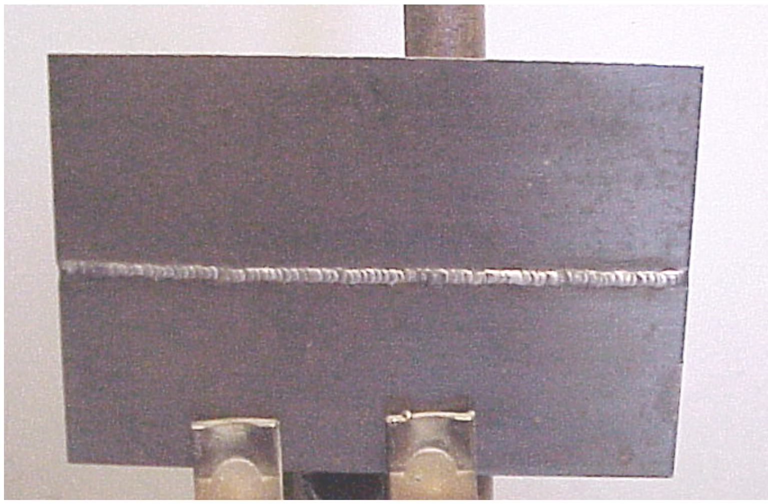
VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE


WLD 221
Corner Joint (2F)
Horizontal Position
Welding Procedure
1. Electrode — EWTh-2
2. Electrode Diameter — 1/16"
3. Polarity — DCSP
4. Gas — Argon 15 cfh
5. Material — Mild steel, 16 Gage or heavier material
6. Filler metal — 1/16" ER70S2
7. Amperage — 20-50
8. Travel Angle — 20°-30° lead
9. Work Angle — Varies
EWTh-2
1 1/2"
1 1/2"
6"
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
PCC
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Chk By:
Date: 01/01/04
WLD 221-09
Size:
Qc No.
Rev.
Approve
Date
Sheet

GTAW Horizontal Butt 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

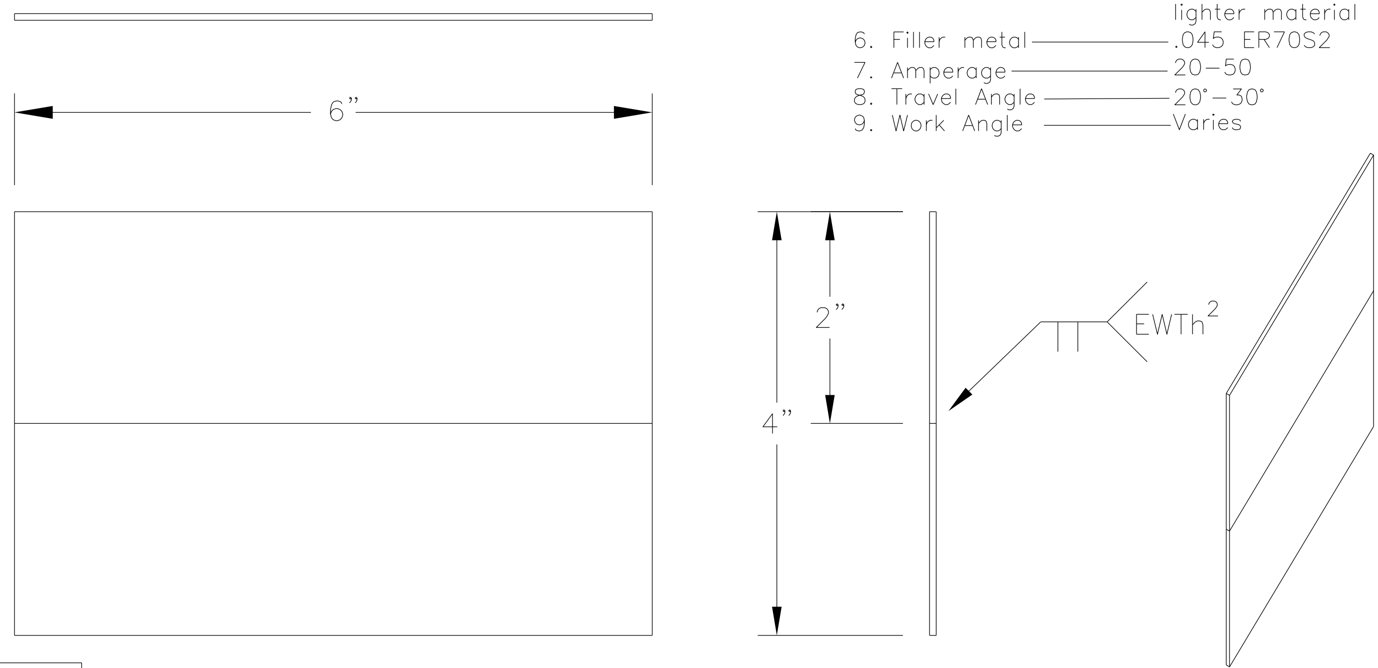
WLD 221

Butt Joint (2G)

Horizontal Position

Welding Procedure

1. Electrode — EWTh2
2. Electrode Diameter — 1/16”
3. Polarity — DCSP
4. Gas — Argon 15 cfh
5. Material — Mild steel, 16 Gage or lighter material
6. Filler metal — .045 ER70S2
7. Amperage — 20–50
8. Travel Angle — 20°–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

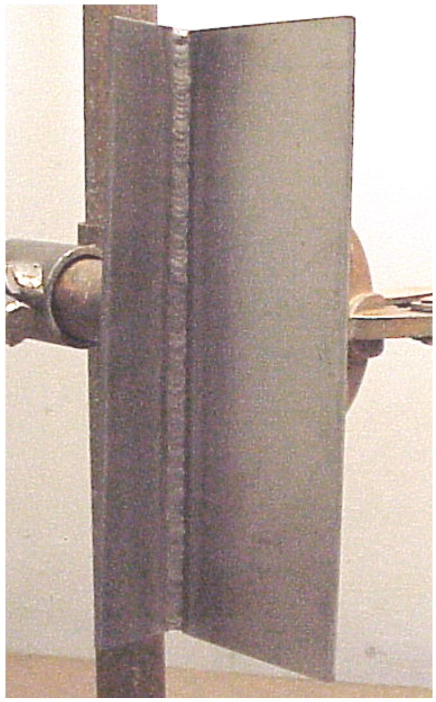
Welding Technology

Tolerance (Unless otherwise Specified) Dimensional ± 1/16” Angle ± 5°	WLD 221–08		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Date: 7/09/05	Approve Date		Sheet

GTAW Vertical T 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.

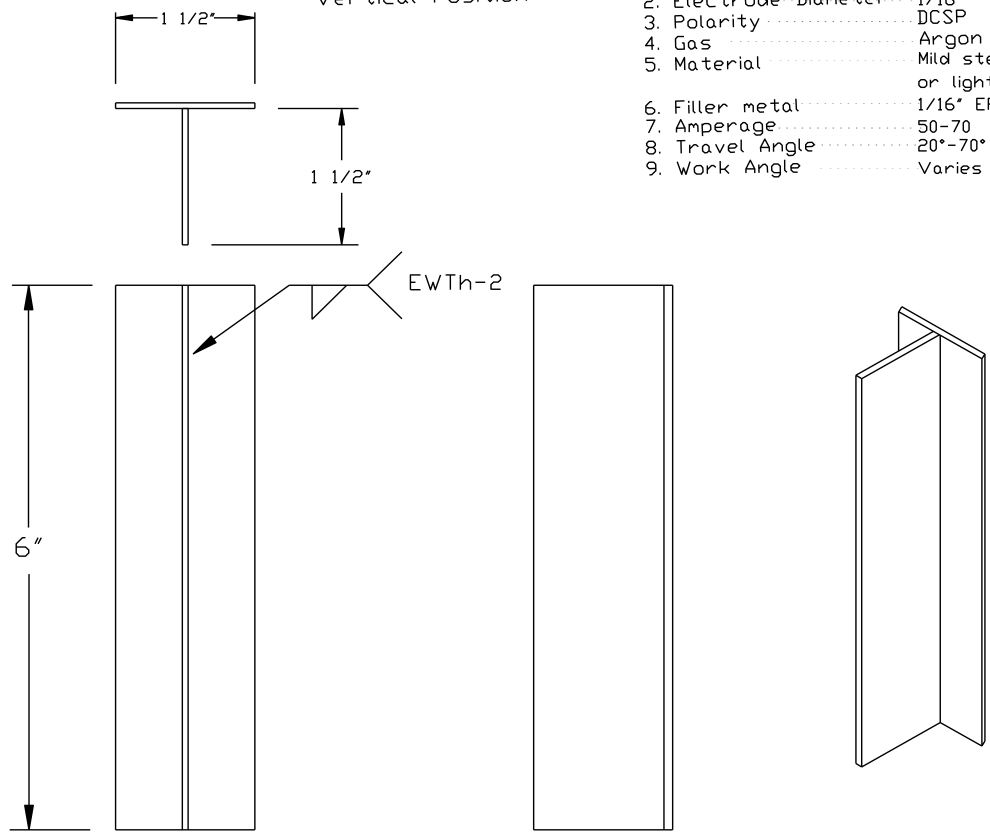


VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

WLD 221
T-Joint (3F)
Vertical Position

Welding Procedure

1. Electrode EWTh-2
2. Electrode Diameter .... 1/16"
3. Polarity .... DCSP
4. Gas .... Argon 15 cfh
5. Material .... Mild steel, 16 Gage or lighter material
6. Filler metal .... 1/16" ER70S2
7. Amperage 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 (WxHxL)	S.I. Conversion

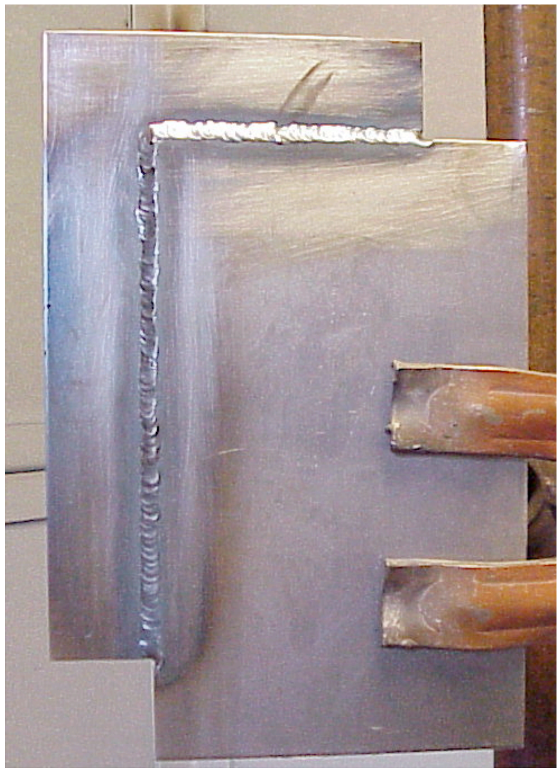
Portland Community College
Welding Technology

Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle ± 5°	WLD 221-11		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Date: 01/01/04	Approve Date		Sheet

GTAW Vertical Lap Joint Project #10

Objectives of this welding exercise are:

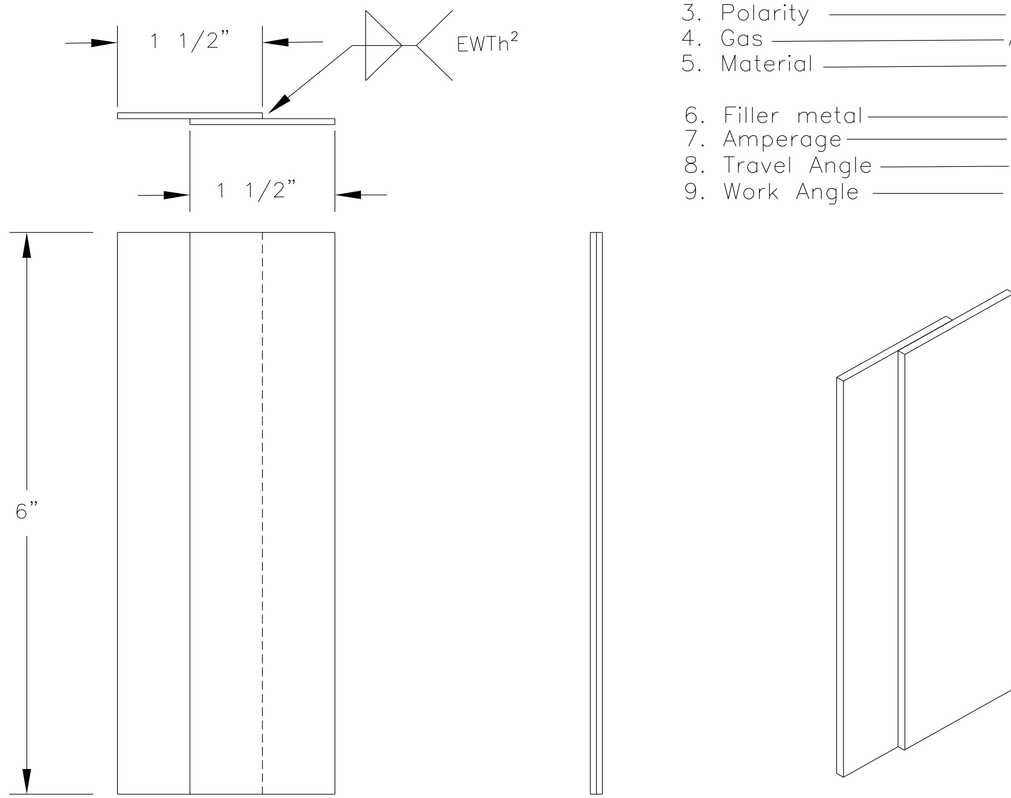
- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.



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

WLD 221
Lap Joint (3F)
Vertical Position

Welding Procedure
1. Electrode — EWTh2
2. Electrode Diameter — 1/16"
3. Polarity — DCSP
4. Gas — Argon 15 cfh
5. Material — Mild steel, 16 Gage or heavier material
6. Filler metal — 1/16 ER70S2
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"	12.8
1"	25.4

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

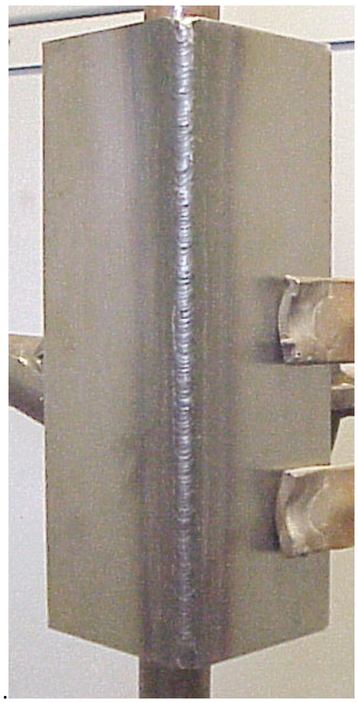
Portland Community College
Welding Technology

Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle ± 5°	WLD 221–10		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Date: 7/09/05	Approve	Date	Sheet

GTAW Vertical Position Corner 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.

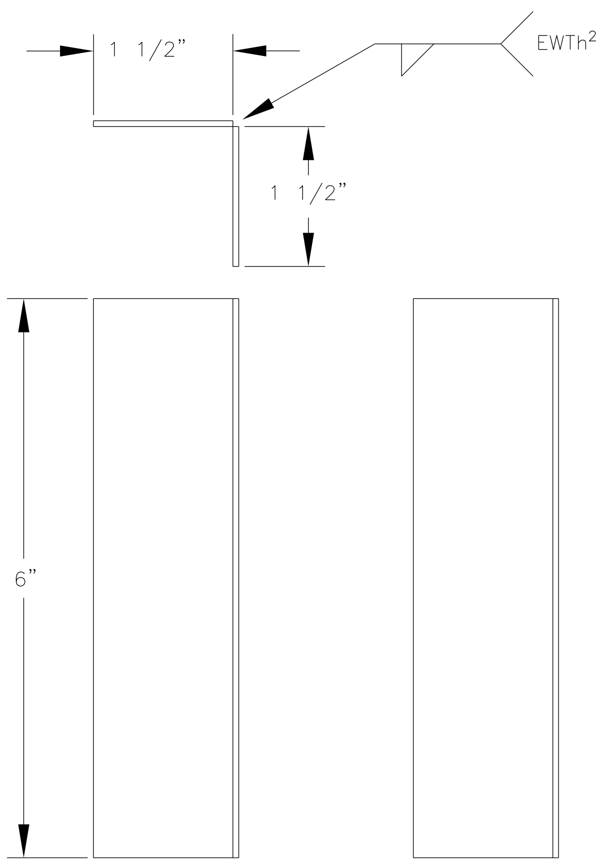


VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

WLD 221

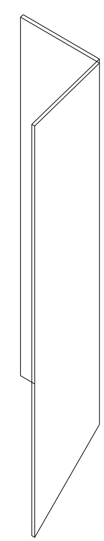
Corner Joint (3F)

Vertical Position



Welding Procedure

1. Electrode — EWTh2
2. Electrode Diameter — 1/16"
3. Polarity — DCSP
4. Gas — Argon, 15 cfh
5. Material — Mild Steel, 16 Gage or heavier material
6. Filler metal — .045 ER70S2
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 221-11		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Date 7/09/05	Approve Date		Sheet

GTAW Vertical Position Butt Joint Project #12

Objectives of this welding exercise are:

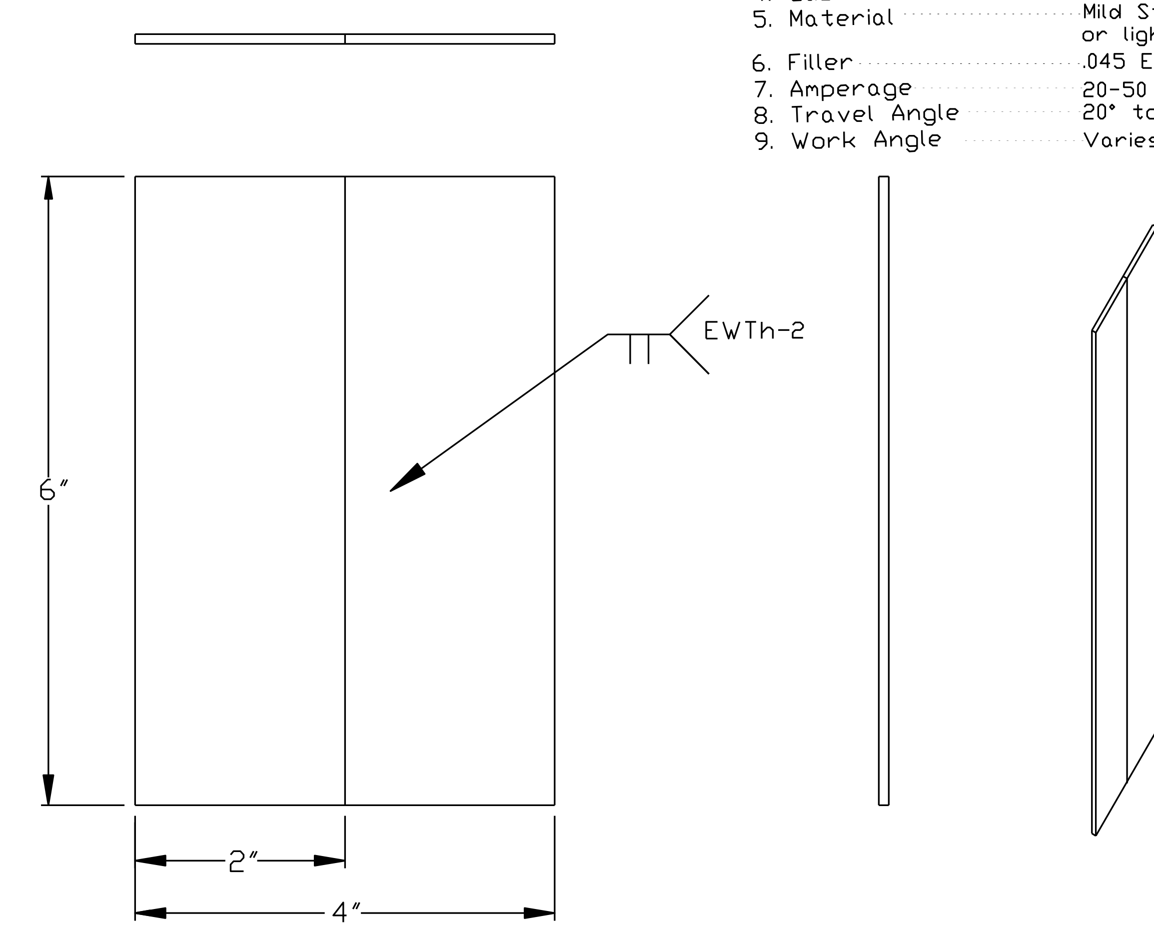
- To practice set up and adjust of the equipment for a different application.
- To develop consistency in your ability to control travel speed and arc length.
- To develop the ability to add filler material to the weld pool.

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

WLD 221
Butt Joint (3G)
Vertical Position

Welding Procedure

1. Electrode EWTh-2
2. Electrode Diameter .... 1/16"
3. Polarity .... DCSP
4. Gas .... Argon, 15 cfh
5. Material .... Mild Steel, 16 Gage or lighter material
6. Filler .... .045 ER70S-6
7. Amperage 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 (WxHxL)	S.I. Conversion

Portland Community College
Welding Technology

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

WLD 221-12

Drawn By: John Deering

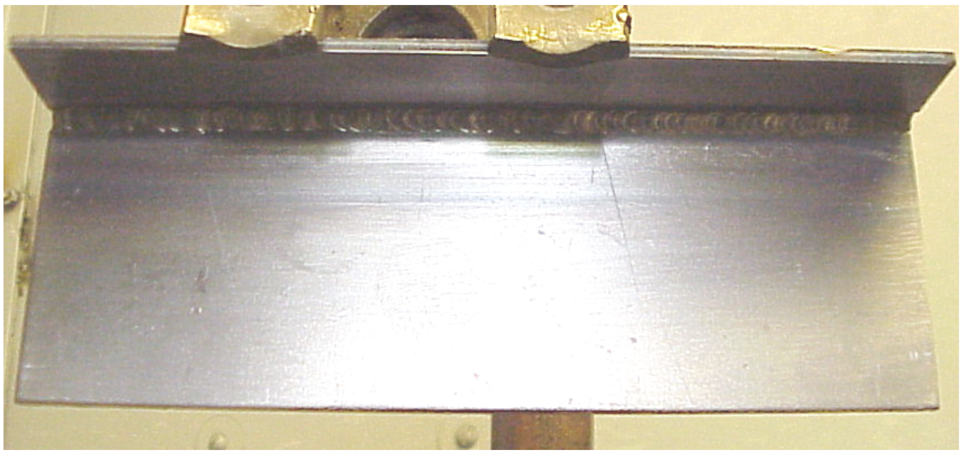
Size: | Qc No. | Rev.

Chk By: | Date: 03/01/04 | Approve Date | Sheet

GTAW Overhead Position T 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.

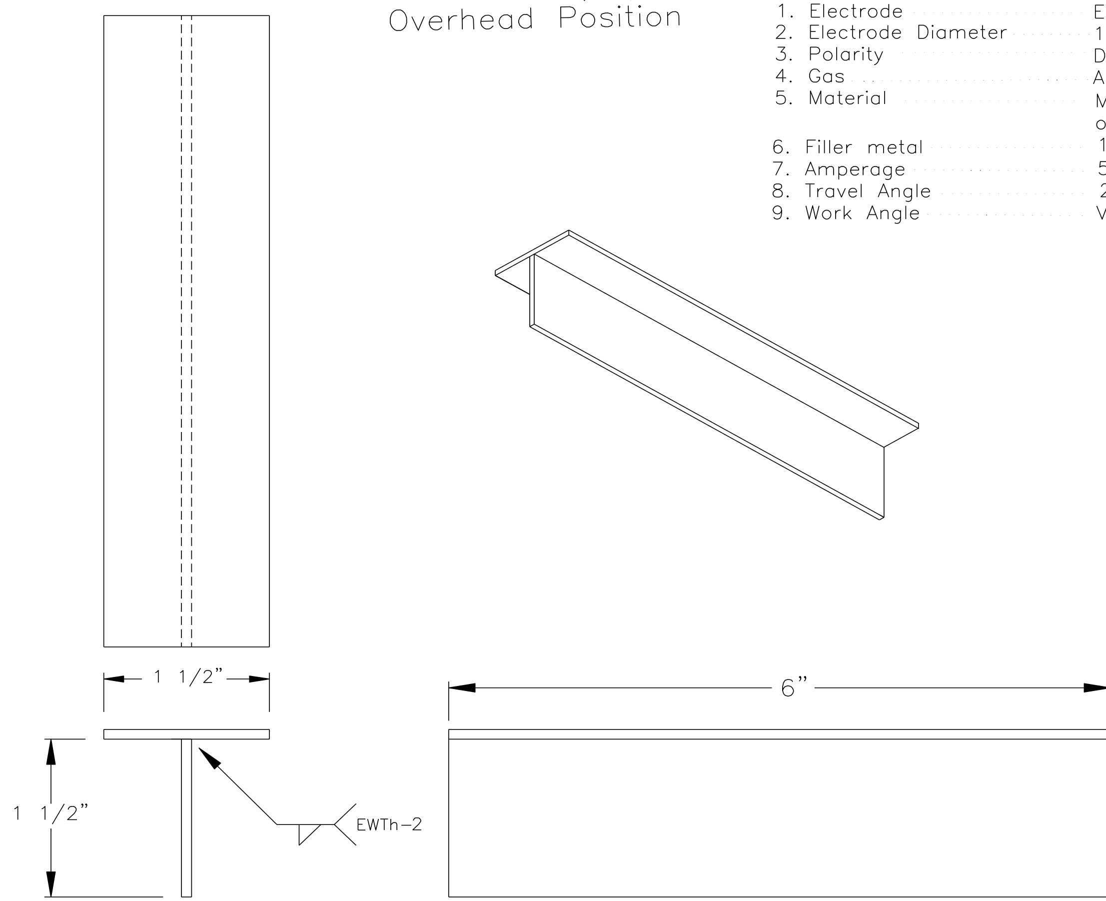


VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	GRADE

WLD 121
T–Joint (4F)
Overhead Position

Welding Procedure

1. Electrode	EWTh–2
2. Electrode Diameter	1/16”
3. Polarity	DCSP
4. Gas	Argon
5. Material	Mild Steel, 16 Gage or, lighter material
6. Filler metal	1/16” ER70S2
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 (WxHxL)	S.I. Conversion

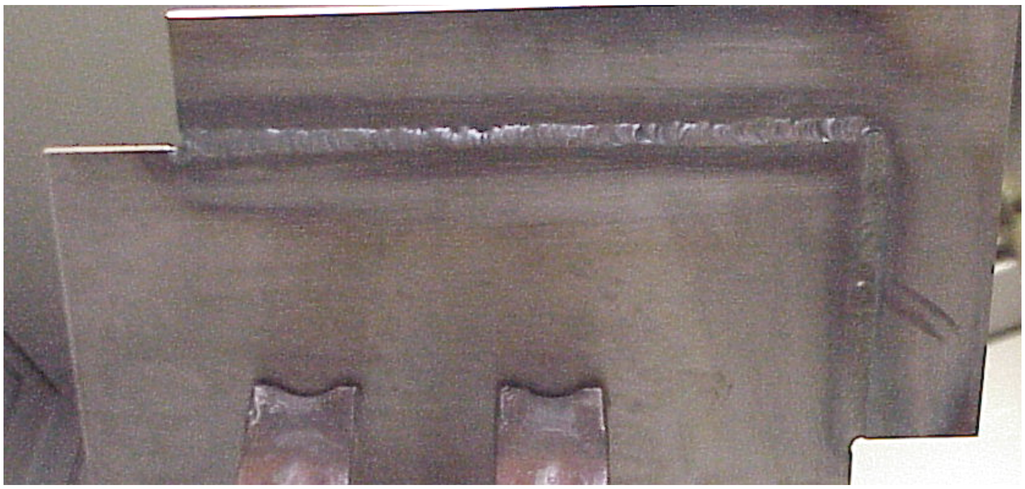
Portland Community College
Welding Technology

Tolerance (Unless otherwise Specified) Dimensional ± 1/16” Angle ± 5°	WLD 121–15		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Date: 10/01/03	Approve	Date	Sheet

GTAW Overhead Position Lap 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.

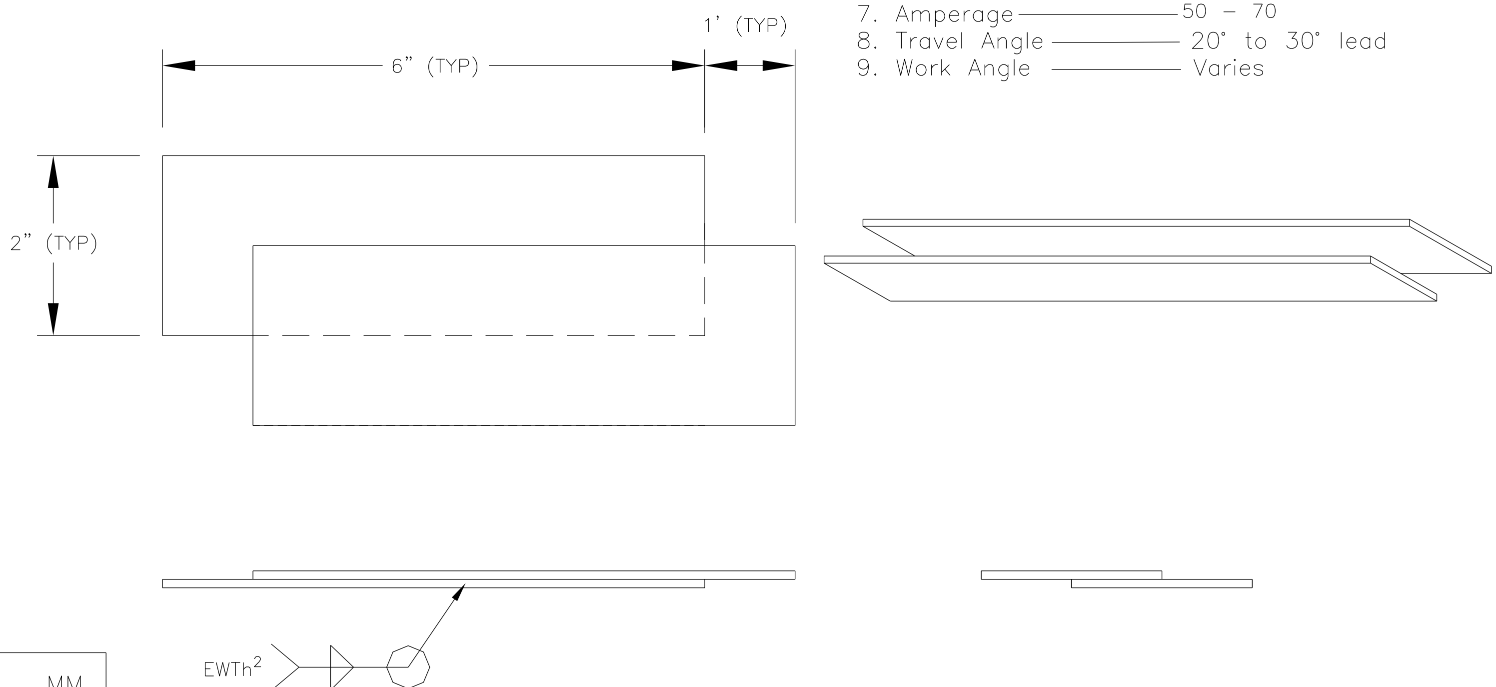


VT Criteria	Student Assessment	Instructor Assessment
Weld Size		
Undercut		
Weld Contour		
Penetration		
Cracks		
Arc Strikes		
Fusion		
Porosity		
Overlap		
	Completed	Grade

WLD 221
Lap Joint (4F)
Overhead Position

Welding Procedure

1. Electrode — $EWTh^2$
2. Electrode Diameter — 1/16"
3. Polarity — DCSP
4. Gas — Argon, 15 cfh
5. Material — Mild steel, 16 Gage or heavier material
6. Filler metal — 1/16" ER70S2
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 221-14

Drawn By:
John Deering

Chk By: Date: 7/09/05

Size:	Qc No.	Rev.
Approve	Date	Sheet

Final Exam

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

Study Guide

Safety

- GTAW safety
- Hand Tool Safety

GTAW Processes

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

Welding Symbols and Blueprints

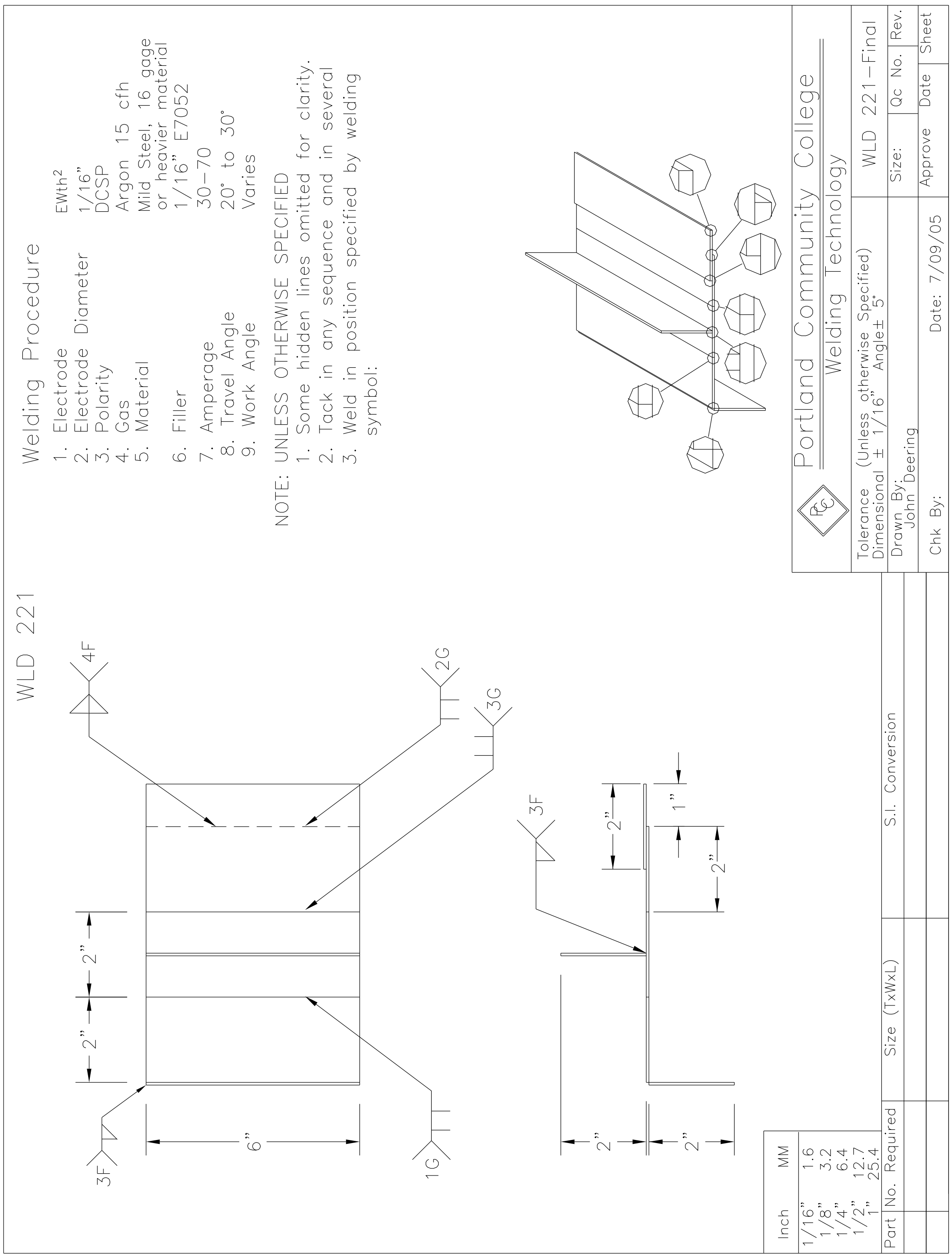
- Orthographic views
- Isometric views
- Welding symbol
  - Weld symbols
  - Reference line
  - Tail

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 ***Traveler.*** You will have two class periods to build the project.



Grading Traveler for the WLD 221 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 221

Name: __________________ Instructor: ____________________ Date: ___________________

Welding Projects = 40%

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

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

Quizzes = 20%

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

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

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

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 _________