WLD 271
Oxyacetylene Welding Projects

Welding Technology

Portland Community College

Index

This project was supported, in part,
by the
National Science Foundation
Opinions expressed are those of the authors
And not necessarily those of the Foundation

Portland Community College	**Welding Technology**
17705 NW Springville Road	**Lec/Lab Course Syllabus**
Portland, OR 97229	

Building Location

Welding lecture:	Bldg. 2, Rm. 132a/b	
Welding lab:	Bldg. 2, Rm. 131	Phone 614-7226

Time & Days

Morning Shift:	7am to 1pm	Monday through Thursday
Afternoon Shift	10:00 to 4:00pm	Monday through Thursday
Evening Shift:	4:00pm to 9:50pm	Monday through Thursday

Instructors

Connie Christopher	Office Bldg. 2 Rm. 232c	Phone 614-7502
Scott Judy	Office Bldg. 2 Rm. 232	Phone 614-7600
Matthew Scott	Office Bldg. 2 Rm. 233b	Phone 614-7601
Danny VanDyne	Office Bldg. 2 Rm. 232d,	Phone 614-7603

Introductory Statement

Practice hand coordination and controlling heat while welding steel with ox-acetylene equipment using all positions. Develops hand coordination when torch brazing steel and other types of materials.

This course utilizes a lecture/lab format, which includes classroom discussions and lab demonstrations. Topics covered will include safety, uses, nomenclature, equipment operation and set-up and shutdown procedures for oxyacetylene welding and brazing

This is an outcome-based course that will allow the student to work at his/her own pace. The student will be required to follow all safety regulations and complete common cutting and welding projects in accordance with industry standards. The student is expected to complete all the exercises within this training packet.

INTENDED OUTCOMES FOR THE COURSE

Function safely in the PCC Welding Shop

- Understand and practice personal safety by using proper protective gear.
- Understand and practice hand tool and power tool safety.
- Understand and practice equipment safety for welding and oxy fuel cutting systems.
- Understand and maintain a safe work area.
  Recognize and report dangerous electrical and air/gas hose connections.
  Understand and practice fire prevention.
- Access and explain the importance of the Material Safety Data Sheets (MSDS).

Demonstrate professional work ethics (Habits)

- Track training hours on time card.
- Perform projects in accordance to specifications and procedures.
- Follow oral and written directions in a positive manner.
- Manage time productively.
- Respects equipment and others.
- Demonstrate skill in problem solving and decision making.

Operate oxyacetylene portable welding units and manifold system

- Demonstrate correct setup and shutdown procedures for the portable welding tanks and manifold system.
- Perform oxyacetylene welding practice.

Interpret drawing and symbols to accurately layout, prepare and assemble weld joints

- Interpret lines, symbols and verbiage on project drawing.
- Layout material per drawing specifications.
- Assemble weld project per specification.
- Participate in shop cleanup.

Weld common joints with the with the Oxy-fuel welding process to code quality standards in the flat, horizontal, vertical, and overhead positions

- Develop a working knowledge of the vocabulary used in the welding industry.
- Use correct terminology.
- Define terms used in the Oxyacetylene process.
- Equipment identification, setup, shut down, and adjustment of equipment to settings called for in the Oxyacetylene welding process.
  Oxyacetylene hose connections, inspection, and proper use
  Filler rod identification and classification, characteristics, and use
- Describe essential variables of tip size to regulating Oxy-fuel settings on regulators
- Demonstrate how to adjust travel speed and amount of heat for thickness of material, and weld bead size.
- Demonstrate correct welding techniques with the Oxyacetylene welding process and torch brazing.
  Starting and stopping

Overlapping welds
Follow welding procedure

- Demonstrate correct welding techniques in the following joints:

Flat Position	**Horizontal Position**	**Vertical Position**	**Overhead Position**	**Braze Joints**
Bead Plate	Bead Plate	T- Joint	T- Joint	Bead Plate
T- Joint	T- Joint	Lap Joint	Lap Joint	Butt Joint
Lap Joint	Lap Joint	Butt Joint	Butt Joint	Lap Joint 1F
Outside Corner				Lap Joint 2F
Butt Joint				

- Demonstrate visual examination principles and practices

Attendance Policy

Students are expected to attend all class meetings for which they are scheduled. Repeated absence will affect the student's grade. Students are responsible to officially withdraw from a class when they stop attending. If a student has excessive absences and fails to withdraw, a grade of F will be assigned. If you do not attend or stop attending class(es) and fail to ***personally*** drop within the refund period, you will be responsible for all tuition and fees.

Full-time students (12 credits) are required to attend class daily for the entire class period.

Part-time students are required to schedule their days and hours of attendance with their instructor. Class dates are established at the beginning of the course. Absence from a scheduled class does not entitle a student to extend their course end date.
STUDENTS MAY ATTEND SCHEDULED HOURS ONLY, THERE ARE NO MAKE UP HOURS. YOUR INSTRUCTOR MUST APPROVE ANY CHANGE IN COURSE SCHEDULE.

Course Assignments

Video Training

Delmars Oxyacetylene Welding Video series

Welding Projects

Flat Position	**Horizontal Position**	**Vertical Position**	**Overhead Position**	**Braze Joints**
Bead Plate	Bead Plate	T- Joint	T- Joint	Bead Plate
T- Joint	T- Joint	Lap Joint	Lap Joint	Butt Joint
Lap Joint	Lap Joint	Butt Joint	Butt Joint	Lap Joint 1F
Outside Corner				Lap Joint 2F
Butt Joint				

Final Exam

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

Reference List

IPT's Metal Trades Handbook, Garby, Ronald and Ashton, Bruce.
Welding Principles and Applications, Jeffus, Larry.

Timeline:

Open-entry, open-exit instructional format allows the students to work 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.

Grading criteria:

The student's assessment will be based on the following criteria:
20% of grade is based on Safe work habits and shop practices
20% of grade is based on Completion of written and reading assignments
20% of grade is based on demonstrating professional work ethics
40% of grade is based on completion of welding exercises

Grading scale:

90 - 100% A – Superior

Honor grade indicating excellence. Earned as a result of a combination of some or all of the following as outlined in the course training packet. Superior examination scores, consistently accurate and prompt completion of assignments, ability of to deal resourcefully with abstract ideas, superior mastery of pertinent skills, and excellence attendance. Probable success in a field relating to the subject or probable continued success in sequential courses.

80 - 89% B - Above average

Honor grade indicating competence. Earned as a result of a combination of some or all of the following as outlined in the course training packet. High examination scores, accurate and prompt completion of assignments, ability to deal with abstract ideas, commendable mastery of pertinent skills and excellent attendance. Probable continued success in sequential courses.

70 - 79% C – Average

Standard college grade indicating successful performance earned as a result of a combination of some or all of the following as outlined in the course training packet. Satisfactory examination scores, generally accurate and prompt completion of assignments, ability to deal with abstract ideas, fair mastery of pertinent skills and regular attendance. Sufficient evidence of ability to warrant entering sequential courses.

60 - 69% D – Substandard

Substandard but receiving college credit. Substandard grade indicating that the student has met only minimum requirements as outlined in the course training packet. Earned as a result of some or all of the following: low examination scores, generally inaccurate, incomplete or late assignments, inadequate grasp of abstract ideas, barely acceptable mastery of pertinent skills, irregular attendance, insufficient evidence of ability to make advisable the enrollment in sequential courses. Does not satisfy requirements for entry into course where prerequisite are specified.

0 - 59% F – Failure

Non-passing grade indicating failure to meet minimum requirements as outlined in the course training packet. Earned as a result of some or all of the following: non-passing examination scores, inaccurate, incomplete or late assignments, failure to cope with abstract ideas, inadequate mastery of pertinent skills, repeated absences from class. Does not satisfy requirements for entry into course where prerequisites are specified.

Pass Acceptable performance.
A grade of “P” represents satisfactory achievement that would have been graded “C” or better on the grading scale, but is given instead of a letter grade. By the end of the eighth (8^{th}) week of class (or equivalent) students shall choose the graded or pass option. By the end of the eighth (8^{th}) week of class or equivalent), students may rescind an earlier request of the pass option.

No Pass No Pass:
Unacceptable performance or does not satisfy requirements for entry into courses where prerequisites are specified. This grade may be used in situations where an instructor considers the “F” grade to be inappropriate. The NP mark is disregarded in the computation of the grade point average.

CIPR Course In Progress Re-register
A mark used to only for designated classes. To receive credit, a student must reregister because of equipment usage is required. This may include course in modular or self-paced programs. This mark may also be used in skill-based course to indicate that the student has not attained the skills required to advance to the next level. If the course is not completed within a year, the “CIPR” changes to an “AUD” (Audit) on the transcript unless the course was repeated and a grade earned.

AUD Audit
Some courses may allow the students to attend a course without receiving a grade or credit for the course. Tuition must be paid, and instructor permission must be obtained during the first three weeks of class (or equivalent). Instructors are expected to state on their course handouts any specific audit requirements. Does not satisfy requirements for entry into courses where prerequisites are specified.

Repeated Courses

Courses with grades of “D,” “F,” “NP,” or “CIP,” and “CIPR,” may be repeated for a higher grade. All grades earned will appear on the transcript. The first earned grade of “C” or “P” or better will count in the accumulated credit total. The first grade of “C” or better will be used for the GPA calculation.

SPECIAL NOTE: If you have a special limitation or disability, which requires special assistance please notify your instructor.

IMPORTANT:

Grades will no longer be mailed to you automatically. You may request a copy by calling: **T.R.A.I.L**. at **977-5000** and select **Option 4.** Or you can access your grades on the World Wide Web at **https://banweb.pcc.edu/.**

Notice:

All projects must be completed in the PCC Welding Lab within your course time.

Oxyacetylene Welding Tip Selection

Welding tip sizes should be selected according to the thickness of the material to be welded and type of fuel gas to be used. Drill size listed with a tip indicates the size of the orifice when new so the correct size tip cleaner can be selected and the orifice can be properly checked for wear.

Caution:
Proper use of Tip Cleaners:
When using a tip cleaner on an orifice, select a cleaning probe slightly smaller than the orifice, and work your way up to the proper size, but never force and oversized probe into the orifice. The small diameter probe is easy to break off in the orifice, and that renders the tip useless. Do not move the probe in and out of the orifice more than necessary for this will elongate the orifice also rendering it useless.

Tip manufacturer's recommended regulator pressures for fuel gases should not exceed the minimum or maximum recommended for a specific size tip. Tip size and regulator pressures recommended by the manufacturer should be carefully followed. Gas consumption data on tip selection charts are for estimating purposes, and the actual consumption will vary with the material being welded and operator's skill. Gas pressure recommendations on tip data charts are usually based on a hose length of 25 feet, and longer lengths of hose should have about 3 PSI added per each additional 25 feet.

Rules of Thumb
For Rod and Torch Angles

1. The best practice for beginners is to hold both the rod and thee torch at 45deg. angles from the surface of the work piece to create a 90deg. angle between the two.
2. When the torch is held at a 45deg. angle, it not only reduces heat input directly under the tip, but spreads heat ahead of the weld for better control.
3. The flame should always be pointed along the direction of travel and not angled off to one side.
4. The straighter the flame angle the greater the heat input into the base metal.
5. As skill level is increased the more the vertical angle can be increased in some situations, a more vertical angle used usually will increase the chances of burning through the base metal.

Techniques for Controlling Flame and Rod Motions

Keep both the flame and the filler rod in almost constant motion with the flame moving slowly forward across the line of the weld in a back and forth motion as a the rod move s in and put out of the leading edge of the puddle.

Keep the motion of the rod opposite the motion of the flame so that the inner cone of the flame is pointed directly at the rod for only a part of each back and forth motion.

When the end of the rod is drawn away from the puddle, don't draw it away very far, but keep it in the outer cone of the flame.

WELDING NOZZLE FLOW DATA

Metal Thickness	**Tip Size**	**Drill Size**	**Oxygen Pressure (PSIG)**		**Acetylene Pressure (PSIG)**		**Acetylene Consumption (SCFH)**	
			Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Up to 1/32"	000	75 (.022)	3	5	3	5	1	2
1/16"-3/64"	00	70 (.022)	3	5	3	5	1 ½	3
1/32"-5/64"	0	65 (.035)	3	5	3	5	2	4
3/64"-3/32"	1	60 (.040)	3	5	3	5	3	6
1/16"-1/8"	2	56 (.046)	3	5	3	5	5	10
1/8"-3/16"	3	53 (.060)	4	7	3	6	8	18
3/16"-1/4"	4	49 (.073)	5	10	4	7	10	25
¼"-1/2"	5	43 (.089)	6	12	5	8	15	35
½"-3/4"	6	36 (.106)	7	14	6	9	25	45
¾"-1 ¼"	7	30 (.128)	8	16	8	10	30	60
1 ¼"-2"	8	29 (.136)	10	19	9	12	35	75
2 ½"-3"	10	27 (.144)	12	24	12	15	50	100
3 ½"-4"	12	25 (.149)	18	28	12	15	80	160

Math

on

Metal

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 math as it relates to industry requirements.

Construction with Angles/Bevels

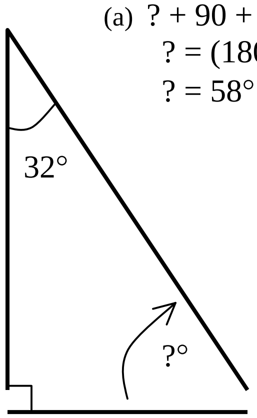
Welding involves a good deal of cutting on an angle in order to either create a beveled edge for a weld or to create edges for joining two pieces at an angle. It is useful to know a little about angles before working with them.

The following are some very useful facts to keep in mind when measuring angles:

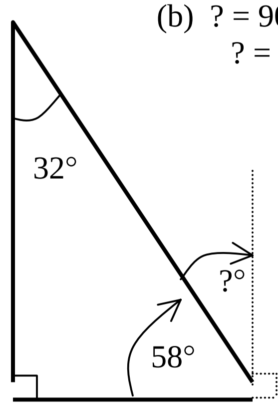
1. To go around in a complete circle is to go 360 degrees. 

2. In any triangle the three angles **ALWAYS** add up to 180 degrees. ***see** figure* (a)

(a) ? + 90 + 32 = 180
? = (180 - 90) - 32 = 90 - 32
? = 58°



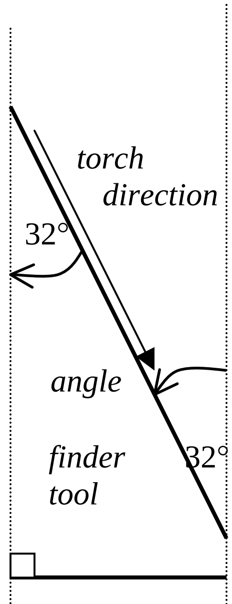
(b) ? = 90 - 58
? = 32



3. Two angles which together make a right angle must add up to 90 °. ***see** figure* (b)

4. Notice Figure b’s similarities with the following figure (c). Note that the two dotted lines are parallel to each other, and that the bold line intersects with them both. Then note the position of the two angles which are equal to each other. This will always be true with one line or surface intersecting two parallel lines or surfaces.

Figure (c)



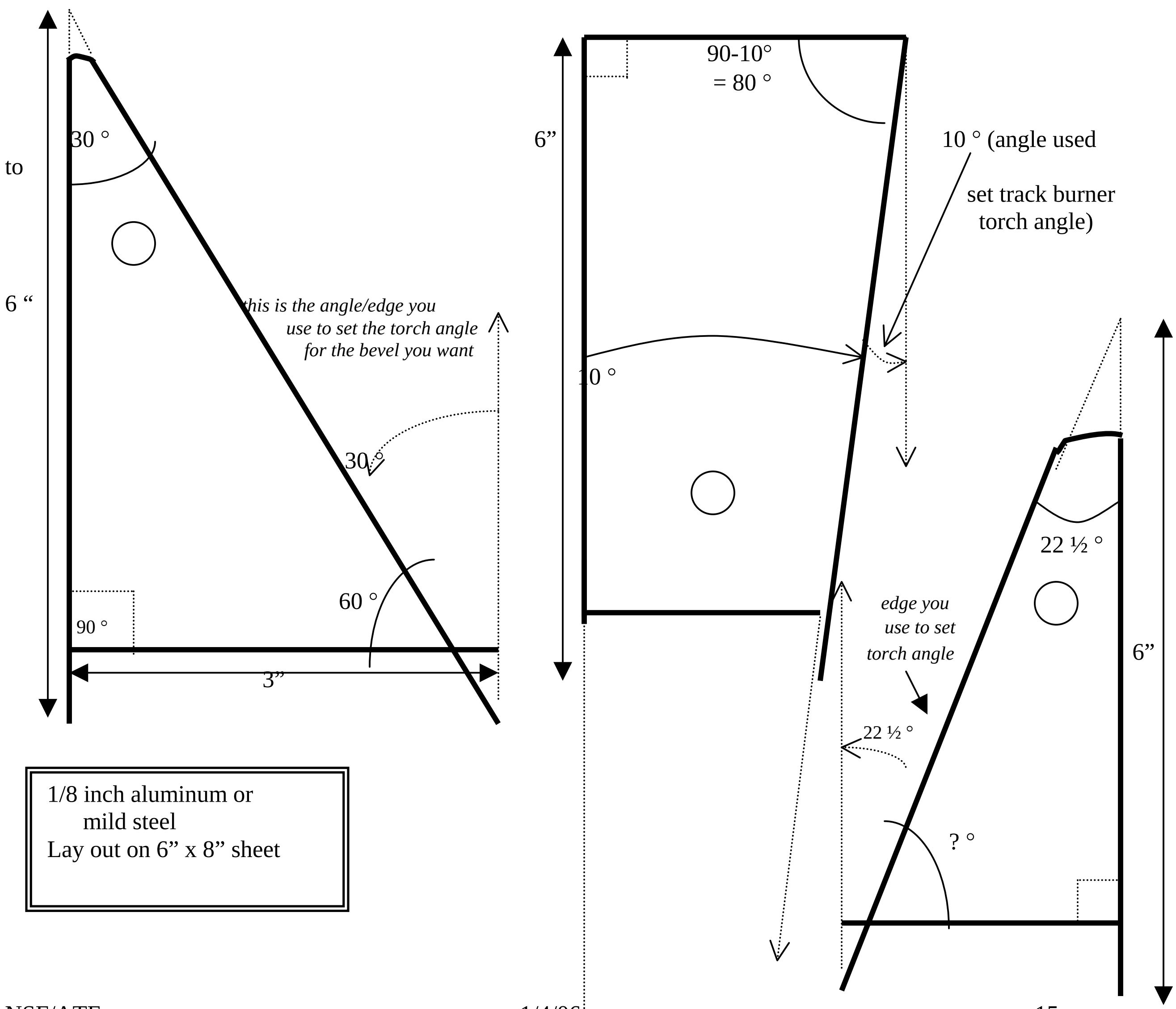
Next time you use your angle finder tool to set your torch angle at the track burner, notice the arrow indicates how you position your torch, with it pointing toward the angle of adjustment from vertical. And this angle is equal to the opposite and internal angle of your angle finder tool.

Remember that you often measure ½ the bevel, which is why you use a 22 ½ ° angle finder for a 45° bevel track burner surface.

Practical No. 2
Construction of Bevel (Angle) Finders

The purpose of this practical exercise is to get experience in measuring, laying out and cutting various standard angles and to construct some useful tools in the process. It is very important that you read the previous page in order to understand why these bevel finders are constructed the way they are.

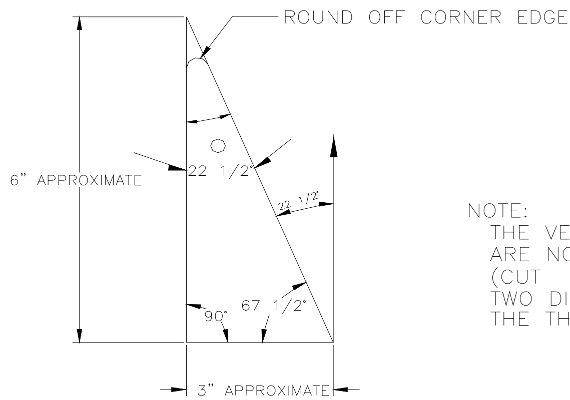
Use the measurements below to construct three bevel finders: one each for 10 °, 22 ½ °, and 30 °. Please be sure to measure these with accurate measuring tools such as a protractor before cutting. Do NOT use the sketches below or the templates from the tool room as patterns. Remember: You are making tools for yourself and want them to be as accurate as possible. Use the punch to make the ¼” DIA hole in one corner of each. This hole should indicate which corner is the specified angle, and it can also be used for hanging on a peg or on a ring to keep them together.



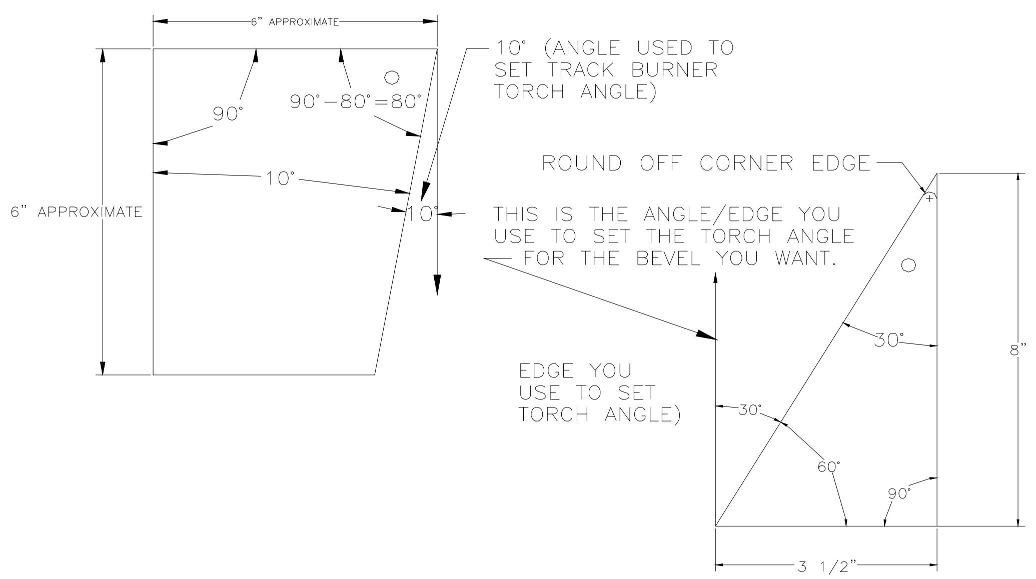
PRACTICAL N0. 2
Construction of Bevel (Angle) Finders

The purpose of this practical exercise is to get experience in measuring. laying out and cutting various standard angles and to construct some useful tools in the process. It is very important that you read the previous page in order to under stand why these bevel finders are constructed the way they are.

Use the measurements below to construct three bevel finders: one each for 10°, 22°, and 30°. Plese be sure to measure these with accurate measuring tools such as a protractor before cutting. DO NOT use the sketchess below or templates from the tool room as patterns. Remember: You are making tools for yourself and want them to be as accurate as possible. Use the punch to make the 1/4" DIA. hole in one corner of each. This hole should indicate which corner is the specified angle, and it can also be used for hanging on a peg or on a ring to keep them togeather.



NOTE:
THE VERTICAL AND HORIZONTAL DIMENTSION ARE NOT AS CRITICAL AS THE ANGLES (CUT THE 90° ANGLE, MEASURE OUT THE TWO DIMENTIONS APPROXMATELY. THEN CUT THE THREE ANGLES AS ACCURETLY AS YOU CAN.)



Portland Community College
Welding Technology

WLD SHEET MTH #7

Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Chk By:
Date: 10/30/02
Size: | Qc No. | Rev.
Approve | Date | Sheet

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

- Source of Heat for Oxy-Acetylene Welding
- Comparing Acetylene with Other Fuels
- Reasons for Oxidizing, Carburizing, and Neutral Flames
- Welding Structural Steel
- Benefits of Oxy-Acetylene
- Limitations of Oxy-Acetylene
- Fluxes for Oxy-Acetylene Welding

Source of Heat for Oxy-Acetylene Welding

The oxidation (or burning) of acetylene, which has a chemical composition of C_2H_2, is a highly exothermic reaction. That is, a great amount of heat is generated when acetylene combines with oxygen. This reaction takes place in two important parts. Upon ignition, the first acetylene reaction with pure oxygen from the gas cylinder causes the acetylene to dissociate as follows:

1st Reaction: $C_2H_2 + O_2 = 2CO + H_2 + \text{Heat}$ Eq. 1

The amount of heat liberated by this first reaction is 18,600 kJ/m^3 (500BTU/ft^3). In this reaction, oxygen from the gas cylinder causes acetylene to dissociate and form carbon monoxide (CO) and hydrogen (H). Additional heating is provided by the second reaction with oxygen from the air, as follows:

2nd Reaction: $2CO + H_2 + 1.5O_2 = 2CO_2 + H_2O$ (vapor) + Heat Eq. 2

In this 2nd reaction, hot carbon monoxide and hydrogen combine with oxygen in the air to provide an additional 33,800 kJ/m^3 (907BTU/ft^3). When a neutral flame is achieved, the reaction products generated by the oxy-acetylene reaction is a harmless mixture of water vapor and carbon dioxide, as shown in equation 2. As a result, the total heat produced by burning acetylene with oxygen is 52,400 kJ/m^3 (1407BTU/ft^3) of acetylene.

Comparing Acetylene with Other Fuels

Acetylene provides the highest flame temperature and combustion intensity of all the commercial fuels used in the welding and cutting industry, as shown Table 1. Although acetylene has the highest flame temperature, its high combustion intensity provides most “melting power”. This is because flame temperature alone can only be transferred by radiation and forced convection. Radiation of heat is proportional to the temperature difference between the hot gas and the work raised to the 4th power. Thus, it might be expected that flame temperature is the most important property of a fuel gas. In fact, only 15% of the heat transferred to the work-piece is by radiation.

More important is the combustion intensity of the fuel, which takes into account both its heating power (h) and burning velocity (V). The combustion intensity (C) has units of J/s·m^2 (Btu/s·ft^2), and is defined as:

$$C = h\ V$$

Where: "h" is the heating power in units of J/m^3 (Btu/ft^3)
"V" is the combustion velocity of the flame in units of m/s (ft/s)

From Table 1, oxy-acetylene provides both the highest flame temperature and combustion intensity. As a result, oxy-acetylene is best suited for welding applications because it can focus its energy in the root pass as well as subsequent passes. Due to its high flame temperature and combustion intensity, oxy-acetylene process can produce faster and more economical welds than those deposited with propane, hydrogen, propylene, and methylacetylene-propadiene.

For comparison, the use of methylacetylene-propadiene is basis of proprietary gas mixtures, which are provided by many companies and are designed to reduce the explosive danger of acetylene. Proprietary names for various mixtures of methylacetylene-propadiene, propane, butane, and propylene include: Mapp, Chem-O-Lean, Apachigas, FG-2, Gulf HP, Flamex, Hy Temp, and over 20 others.

Although methylacetylene-propadiene can produce more heat in the outer cone (secondary flame in Equation 2) than acetylene, methylacetylene-propadiene has a slower burn rate. As a result, methylacetylene-propadiene provides a poorly concentrated flame, which is unsatisfactory for welding, because it will tend to melt the sides of the joint instead of the root. Because methylacetylene-propadiene has such a diffuse heat pattern, distortion of the weld joint is much more of a problem than with oxy-acetylene. However, methylacetylene-propadiene is excellent for cutting, preheating, brazing and metallizing. Because of its slow burn rate, additional oxygen (beyond neutral) is needed to achieve higher combustion velocity causing the flame to be oxidizing. As a result, filler metals used with methylacetylene-propadiene must contain deoxidizers. Methylacetylene-propadiene can be used for welding, but oxy-acetylene is superior because of its focused heating pattern and higher combustion intensity.

Table 1 Flame temperatures and Approximate Combustion Intensities of Oxy-fuel Gases

Gas	Chemical Formula	Neutral Flame Temperature	Combustion Intensity, J/s·m^2 (Btu/s·ft^2)
Acetylene	C_2H_2	3100º C (5600ºF)	11 (12,700)
Methylacetylene-propadiene	C_3H_4	2600º C (5100ºF)	9.6 (11,000)
Propylene	C_3H_6	2500º C (4900ºF)	7.0 (8,000)
Hydrogen	H_2	2390º C (4800ºF)	6.6 (7,500)
Propane	C_3H_8	2450º C (4500ºF)	4.8 (5,500)

Reasons for Oxidizing, Carburizing, and Neutral Flames

A neutral flame occurs with the oxy-acetylene process only when the exact stoichiometry of the total chemical reaction is achieved. Stoichiometry means that exactly the correct amount of 2 parts acetylene and 5 parts oxygen are reacted to produce exactly 4 parts carbon dioxide and 2 parts water vapor, as shown below:

Total Reaction: $2C_2H_2 + 5O_2 = 4CO_2 + 2H_2O$ (vapor) Eq. 3

Equation 3 is the summation of equations 1 and 2. When the perfect stoichiometry shown in equation 3 is achieved, a neutral flame is produced because equation 3 is perfectly balanced. There are neither excess nor deficient ingredients in the reaction. For most welding applications like welding mild steel, a neutral flame is used.

An oxidizing flame can be produced intentionally by simply increasing the flow of oxygen into the oxy-acetylene torch. With an oxidizing flame, the excess oxygen is carried through the flame and into the weld pool. The unreacted excess oxygen is free to react with the molten weld metal to produce an oxide. For example, copper alloys containing zinc like many brass alloys are commonly welded with oxidizing flame. The zinc in the brass is preferentially oxidized as ZnO and is floated as a thin layer on top of the weld pool. The metallurgical reason for the zinc oxide layer is to protect the zinc from volatilizing out of the molten weld pool. This is because most brasses are composed of copper and from about 5% to 40% zinc. Because zinc has a low melting point of only 420ºC (787ºF) while copper has a high melting point of 1083ºC (1981ºF), zinc in the molten weld pool tends to boil and vaporize. This vaporization is greatly reduced by the presence of the beneficial ZnO blanket provided by an oxidizing flame.

A reducing or carburizing flame can be obtained by decreasing the amount of oxygen in equation 3, so that there is an excess of acetylene. A small feather becomes visible in the flame when there is an excess of acetylene and deficiency of oxygen. A reducing flame produces free carbon, which is incandescent in the flame. The hot unburned carbon is free to combine with iron in the weld pool to increase the carbon content of steel weld metal. For example, a slightly reducing flame is used for welding medium and high carbon steel to ensure that the carbon content of the weld metal does not decrease or decarburize. When welding these carbon steels, an oxidizing flame can seriously decarburize or reduce the carbon content of the weld, because carbon reacts with oxygen to form carbon dioxide gas as shown below:

$$C + 2O = CO_2$$

In order to ensure that no decarburization takes place, medium and high carbon steels are welded with either a neutral or a slightly reducing or carburizing flame to prevent oxidation of carbon.

Welding Structural Steel

When a low carbon structural steel is welded by oxy-acetylene process, a neutral flame is recommended. If a carburizing or reducing flame is used (as is done for medium and high carbon steels), the carbon content of the weld pool increases causing the melting temperature of the steel to decrease. So, as the surface layers pick up carbon from the reducing flame, the low-melting carbon-rich layers melt and fuse easily while the lower parts of the weld joint may show lack of fusion. The preferred neutral flame does not change the melting temperature of the steel and should be used for low carbon structural steels. As mentioned in the previous section, a reducing or carburizing flame can be beneficial only when it is desirable to add carbon to the molten weld pool. In the case of medium and high carbon steels, a slightly reducing flame is used for insurance against oxidation and decarburization of the weld metal.

Benefits of Oxy-Acetylene

Acetylene, like other fuel gases, requires the presence of pure oxygen to support combustion suitable for welding metals like steel, cast iron, stainless steel, aluminum, nickel alloys, copper alloys, lead, and others. Since oxy-acetylene provides the highest flame temperature and combustion intensity, acetylene is the preferred fuel gas for welding applications. Other gases such as, methylacetylene-propadiene, propylene, hydrogen, and propane are used primarily for cutting, preheating, brazing and soldering.

Oxy-acetylene is ideal for welding steel sheet metal, thin walled tubes, small pipe, and assemblies with poor fit-up. This is because oxy-acetylene has a low energy density flame (compared to arc welding). The welder, who uses oxy-acetylene, can control heat input, avoid melt-through, use a neutral, reducing or oxidizing flame, and provide a clear view of the weld pool. Small diameter steel pipe up to about 3 inches and wall thickness up to 3/16 inch can be welded in a single pass.

Limitations of Oxy-Acetylene

Acetylene is capable of melting nearly all metals. Certain metals can not be suitably welded by oxy-acetylene or any other oxy-fuel process. These metals include: refractory metals like tungsten, niobium, tantalum, and molybdenum; as well as highly reactive metals like titanium and zirconium. Refractory metals possess melting temperatures that are too high for joining by oxy-acetylene.

For example, the melting temperature of pure tungsten is 3410ºC (6170ºF) while the neutral flame temperature for oxy-acetylene is only 3100ºC (5600ºF). Similarly, highly reactive metals like titanium require inert gas shielding because titanium will react with oxy-acetylene gas reactants. For example, from Equation 1, above, the reaction products of the oxy-acetylene flame are:

$$2CO + H_2$$

At welding temperatures, molten titanium will react with both CO and H to form detrimental compounds of TiC, TiO, and TiH. Thus, oxy-acetylene is not recommended for welding titanium.

Compared to other arc welding processes like GTAW, the heat intensity of oxy-acetylene is very low. As a result, oxy-acetylene is virtually never used when an arc welding process can do the same job more economically, faster, and more efficiently.

The mechanical properties of weld metal deposited by oxy-acetylene are very poor compared to similar welds deposited by GTAW, FCAW or GMAW. Although there are several reasons for the poor mechanical properties in oxy-acetylene welds, the most important is due to the very slow cooling rate. Because the heat intensity for oxy-acetylene is so low (compared to arc welding), it takes a long time to heat the part to welding temperatures which in turn causes very slow weld cooling rates. Slow heating and cooling rates cause very large grain size and poor microstructure in both the weld metal and the heat-affected zone. In steels, the Charpy impact toughness values for weld metal deposited by oxy-acetylene are poor compared to the excellent toughness obtained by GTAW, FCAW and GMAW.

As all students of welding are aware, acetylene is an explosive gas and has to handled with extreme care as outlined in the safety manual.

Fluxes for Oxy-Acetylene Welding

Generally, fluxes for oxy-acetylene welding are not needed. In welding steel, the gas flame provides enough protection to eliminate the use of fluxes. However, the slightly reactive metals do require the use of fluxes to protect the molten pool from the gaseous atmosphere. For example, oxy-fuel welding of most non-ferrous metals, cast irons, and stainless steels require fluxes. The function of fluxes is to provide protection from the atmosphere as well as the gas products in the flame such as those shown in Equation 1, namely, CO and H_2. The flux coats the molten pool by floating a thin protective liquid layer on the pool surface. In addition, the more active fluxes, such as fluoride fluxes, react with the contaminants to form a very thin slag, which floats above the weld.

Oxyacetylene Welding Beat Plate (1F) (Autogenous) Project #1

Welding Sequence

Hold the torch on the plate until a puddle is formed and move the torch in a circular or side-to-side, or half moon oscillation pattern with proper torch angles across the plate. If the size of the molten weld pool changes speed up or slow down to keep it the same size all the way down the sheet.

Tips:

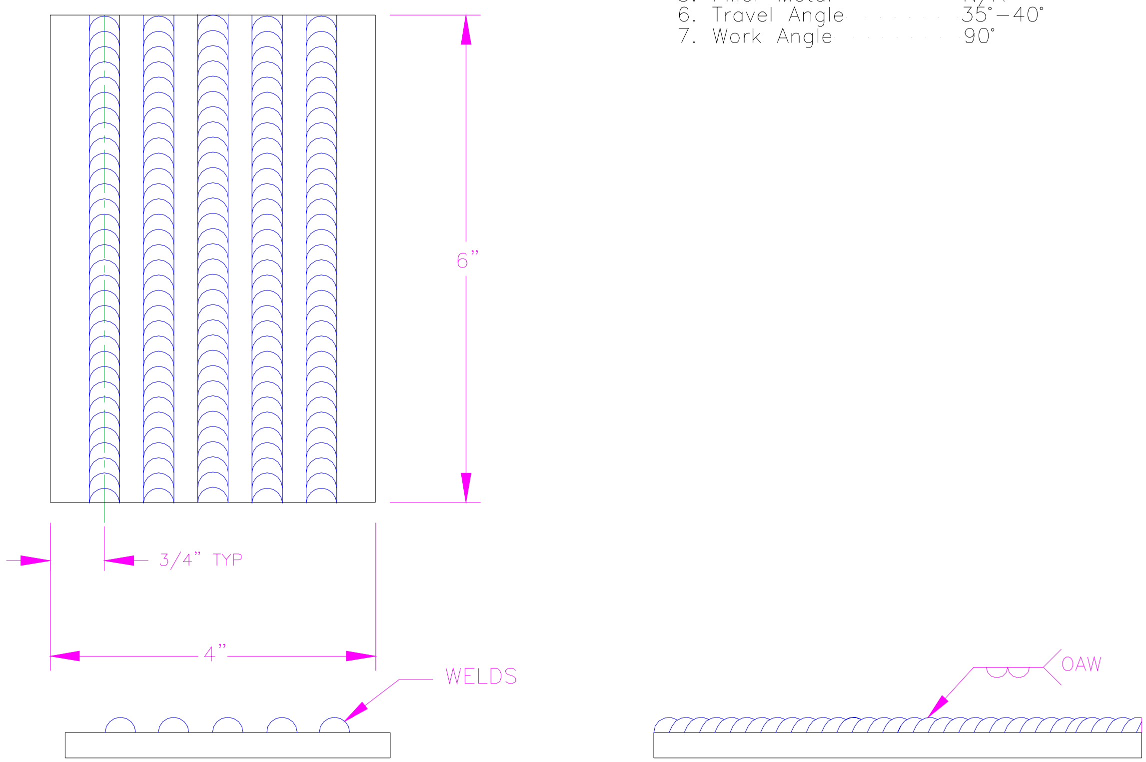
Repeat this until you can keep the width of the molten weld pool uniform and the direction of travel in a straight line. The distance between the inner cone and the metal ideally should be 1/8"inch to ¼"inch. Finished weld bead should be flat and 3/8" wide. This is referred to as coupling distance or stand off.

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

OAW
Flat Position
Autogenous Weld

Welding Procedure

1. Material . . . . . . 12 Gauge – 4"X6"
2. Gas Pressure . . . . C2H2 3–5 pig
   O2 3–5 psig
3. Flame . . . . Neutral
4. Tip Size 0
5. Filler Metal . . . . . N/A
6. Travel Angle . . . . . 35°–40°
7. Work Angle . . . . . . 90°



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 271–01

Drawn By:
John Deering

Size:	Qc No.	Rev.
Approve	Date	Sheet

Chk By: Date: 10/01/03

OAW Bead Plate W/Filler (1F) Project #2

Technique

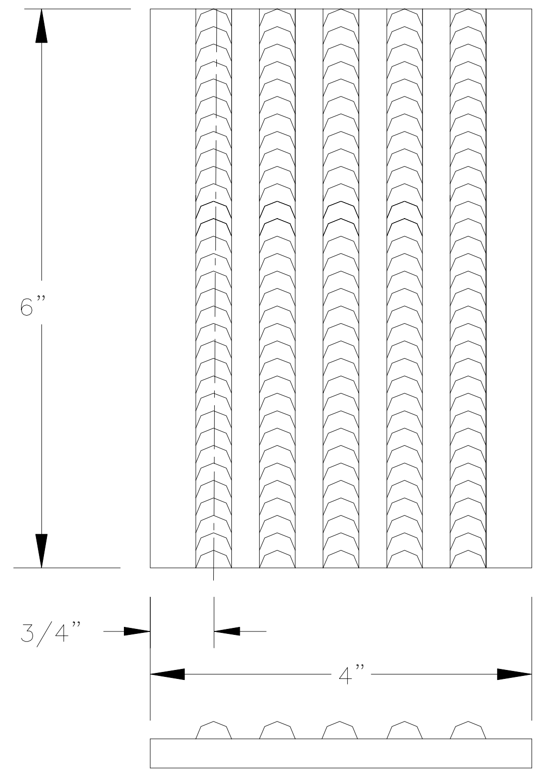
Torch manipulation can be circular, side-to-side, or half moon. The filler metal should be added directly into the molten weld pool or puddle. (This will allow for heat control).

Tips:

Travel to produce a 3/8"in. weld bead width and a slightly convex face.

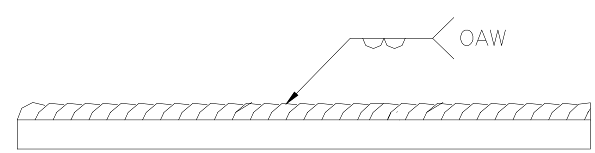
VT Criteria	Student Assessment	Instructor Assessment
Reinforcement (0" –1/8")		
Undercut (1/32")		
Weld Bead Contour (Smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade Date

OAW
Flat Position
Bead Plate with Filler



Welding Procedure

1.	Material	12 Gauge – 4”X6”
2.	Gas Pressure	C2H2 3–5 psig
		O_2 3–5 psig
3.	Flame	Neutral
4.	Tip Size	0
5.	Filler Metal	RG 45 (3/32” diameter)
6.	Travel Angle	35°–40°
7.	Work Angle	90°
8.	Welding Position	Flat



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 271–02

Drawn By: John Deering

Size: Qc No. Rev.

Chk By: Date: 10/01/03

Approve Date Sheet

OAW Outside Corner 1F(Autogenous) Project #3

Technique

Use a very slight side-to-side oscillation motion. The welder should see the shoulder of the joint break down approximately 1/16”. This will insure complete penetration. A smooth weld bead with 100% penetration will be achieved.

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

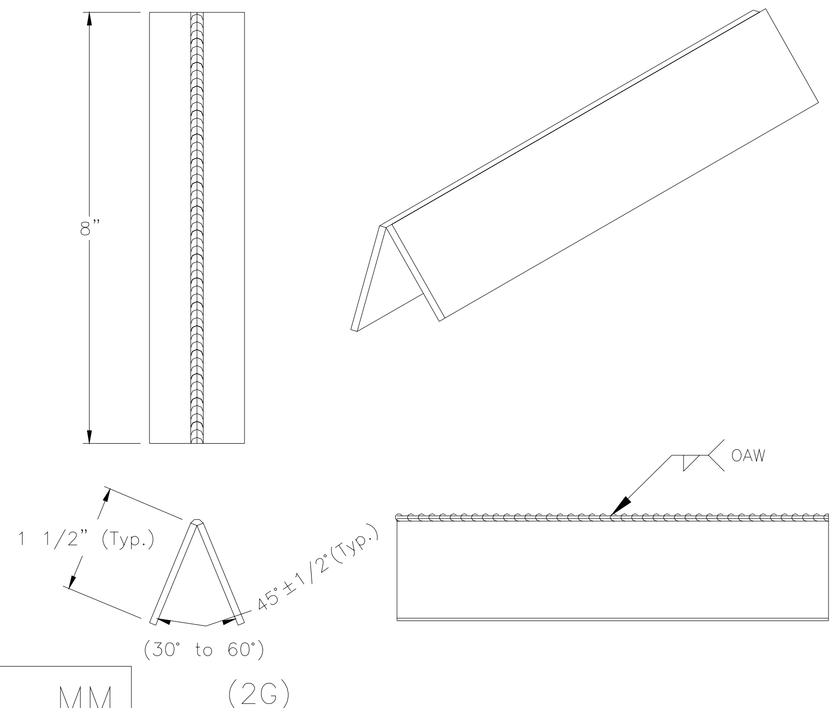
OAW

Flat Position

Mild Steel Corner Joint

Welding Procedure

1. Material — 12 Gauge-1 1/2" x 6"
2. Gas Pressure — C2H2 3-5 psig; O2 3-5 psig
3. Flame — Neutral
4. Tip Size — 0 or 1
5. Filler Metal — Flux coated brazing rod
6. Travel Angle — 35°-40°
7. Work Angle — 30°



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 271-03

Drawn By: John Deering

Chk By: Date: 10/01/03

Size:	Qc No.	Rev.
Approve	Date	Sheet

OAW Lap Joint 1F Project #4

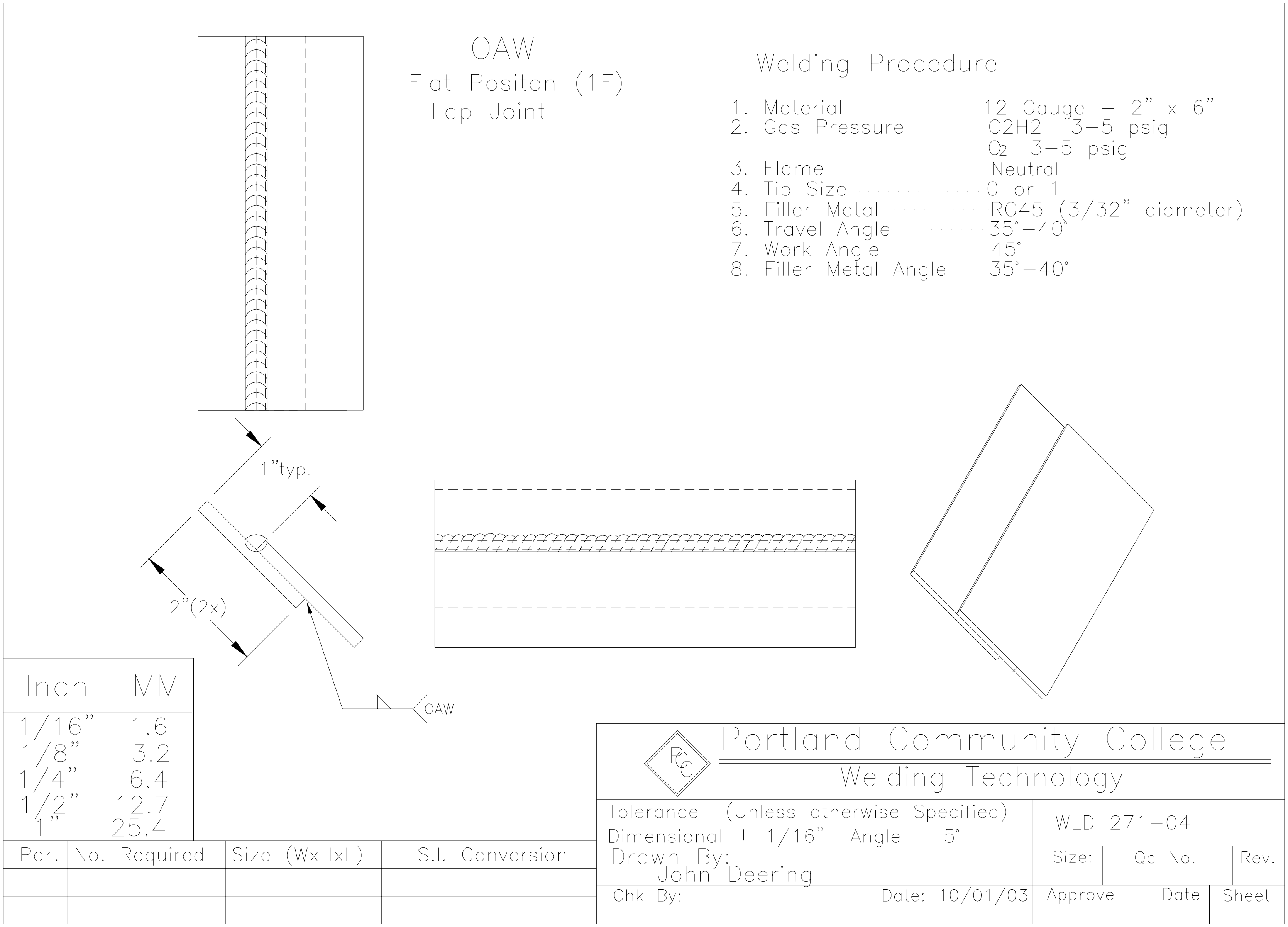
Technique

A side-to-side oscillation should be used. This technique will help control the heat in the plate with the edge exposed. The filler metal shall be added directly into the puddle.

Tips:

When heating the two plates ensure that both plates start melting at the same time. Note that the heat is not distributed uniformly in the lap joint. This is because the difference in heating rate, the flame must be directed on the bottom plate and away from the metal top plate. The finished weld bead face should be 3/8" wide, even rippled, and fuse into both plates.

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


OAW
Flat Positon (1F)
Lap Joint
Welding Procedure
1. Material 12 Gauge – 2" x 6"
2. Gas Pressure C2H2 3–5 psig
O2 3–5 psig
3. Flame Neutral
4. Tip Size 0 or 1
5. Filler Metal RG45 (3/32" diameter)
6. Travel Angle 35°–40°
7. Work Angle 45°
8. Filler Metal Angle 35°–40°
1"typ.
2"(2x)
OAW
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 271–04
Drawn By:
John Deering
Size: Qc No. Rev.
Chk By: Date: 10/01/03
Approve Date Sheet

OAW T-Joint 1F Project #5

Technique

A half moon oscillation should be used to put heat in both pieces of metal. The filler metal should be added to the middle of the puddle. Too much heat, traveling to fast, or torch angle to low will cause undercutting. Travel at a speed to produce a 3/8"beadwidth, with ¼" equal legs.

Tips:

The T-Joint has the same problem with uneven heating as the lap joint does. It is important to hold the flame so that both plates melt at the same time. Another problem that is unique to the tee joint is that a large percentage of the welding heat is reflected back on the torch. This reflected heat can cause even a properly cleaned and adjust torch to backfire or pop. To help avoid drop your torch angle more towards the direction of travel.

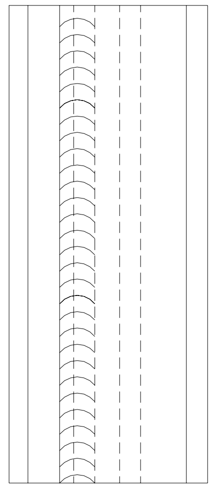
VT Criteria	Student Assessment	Instructor Assessment
Reinforcement (0" –1/8")		
Undercut (1/32")		
Weld Bead Contour (Smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade Date

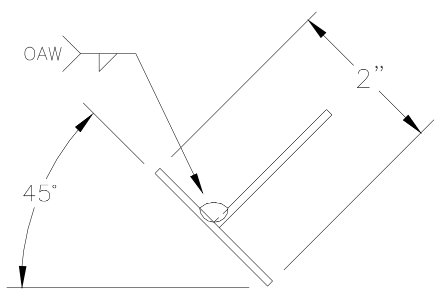
OAW

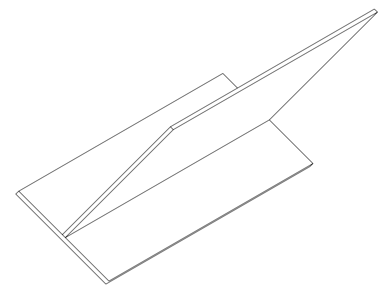
Flat Position (1F)
T–Joint

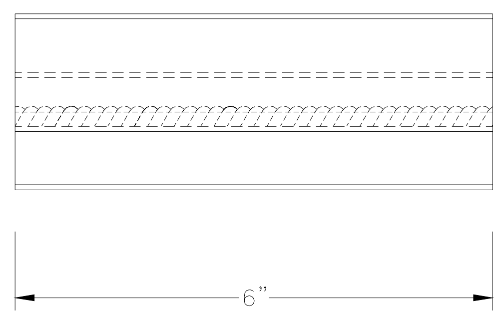
Welding Procedure

1. Material .... 12 Gauge 2"x6"
2. Gas Pressure .... C2H2 3–5 psig
   O2 3–5 psig
3. Flame .... Neutral
4. Tip Size .... 0 or 1
5. Filler Metal .... RG 45 (3/32" diameter)
6. Travel Angle .... 35°–40°
7. Work Angle .... 45°
8. Filler Metal Angle .... 35°–40°









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 271–05

Drawn By:
John Deering

Size: | Qc No. | Rev.

Chk By: Date: 10/01/03

Approve | Date | Sheet

OAW Open Root Butt Joint 1G Project #6

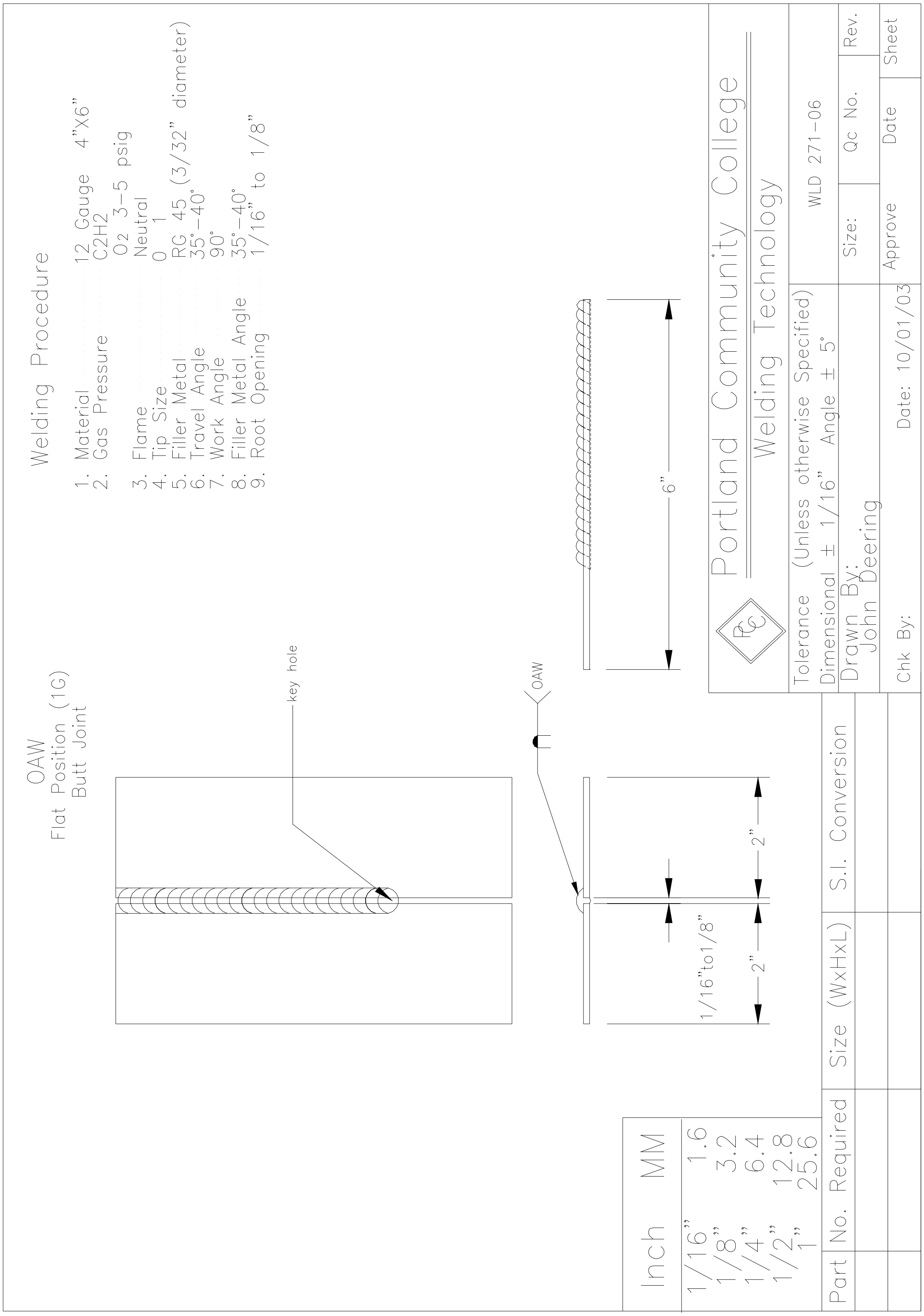
Technique:

Both plates should be preheated to form a keyhole. Move torch side-to-side and add filler directly into the puddle. A slight keyhole should be maintained to ensure complete penetration. The weld should completely fuse into side of joint and completely penetrate to form a root reinforcement of 1/16". Bead width on face should be ¼".

Tips:

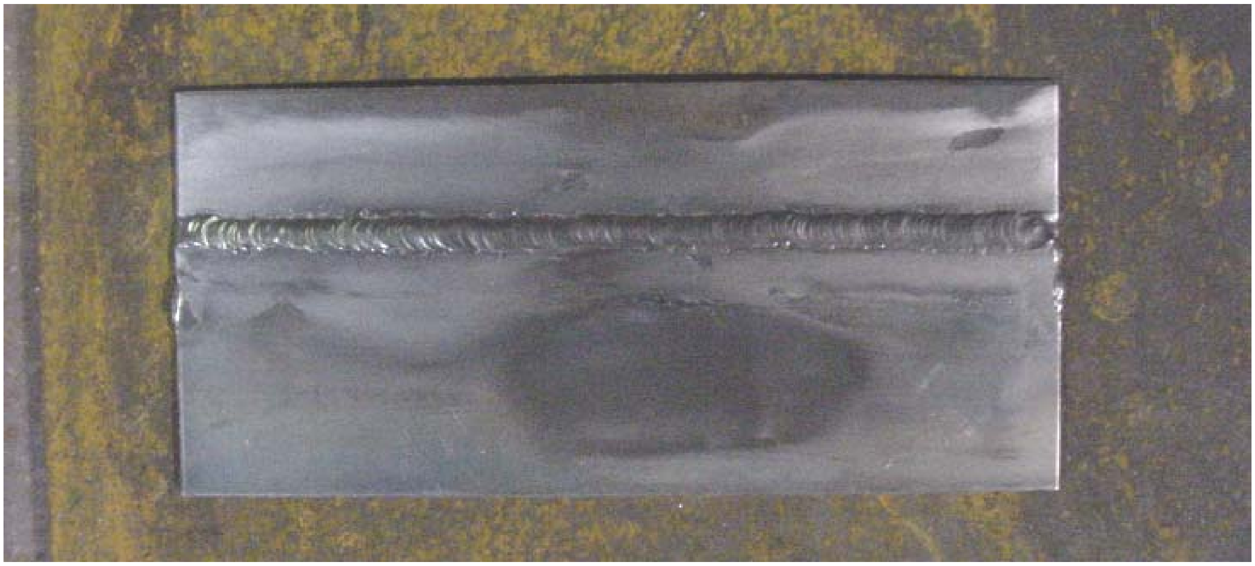
Tack plates together at both ends, place one or more tacks in middle to hold spacing and to prevent warping during welding.

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

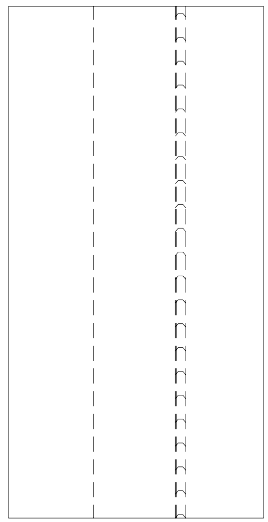

OAW
Flat Position (1G)
Butt Joint
key hole
OAW
1/16"to1/8"
2"
2"
6"
Welding Procedure
1. Material 12 Gauge 4"X6"
2. Gas Pressure C2H2
O2 3-5 psig
3. Flame Neutral
4. Tip Size 0 1
5. Filler Metal RG 45 (3/32" diameter)
6. Travel Angle 35°-40°
7. Work Angle 90°
8. Filler Metal Angle 35°-40°
9. Root Opening 1/16" to 1/8"
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By:
John Deering
Chk By:
Date: 10/01/03
WLD 271-06
Size:
Qc No.
Rev.
Approve
Date
Sheet
Inch MM
1/16" 1.6
1/8" 3.2
1/4" 6.4
1/2" 12.8
1" 25.6
Part No. Required Size (WxHxL) S.I. Conversion

OAW Lap Joint 2F Project #7

Technique:
A side-to-side oscillation should be used. This technique will help control the heat in the plate with the edge exposed. The filler should also be added to the top side of the puddle.
Tips:
Heat is conducted away more quickly in the bottom plate, resulting in the top plate's melting more quickly. Flame heat should be directed at the bottom plate to compensate for this situation. The finished weld bead face should be 3/8" wide, even rippled, and penetrate into both plates.



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

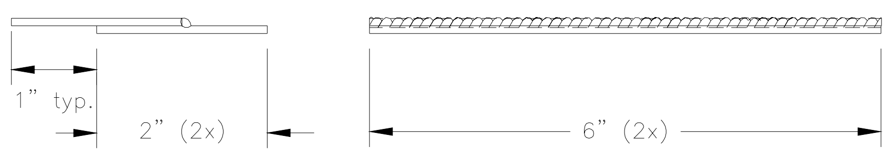


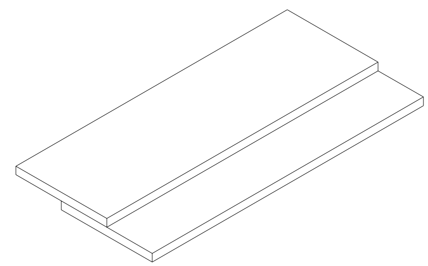
OAW

Horizontal Position (2F)
Lap Joint

Welding Procedure

1. Material .... 12 Gauge–2"x6"
2. Gas Pressure ...... C2H2 3–5 psig
   O_2 3–5 psig
3. Flame .... Neutral
4. Tip Size .... 0 or 1
5. Filler Metal .... RG 45 (3/32" diameter)
6. Travel Angle .... 35°–40°
7. Work Angle .... 45°
8. Filler Metal Angle . 35°–40°





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

Chk By: Date: 10/01/03

WLD 271–07

Size:	Qc No.	Rev.
Approve	Date	Sheet

OAW T-Joint 2F Project #8

Technique:
A side-to-side oscillation should be used to put heat into both pieces of metal. The filler metal should be added to the to toe of the puddle. **Too much heat, traveling too fast, or torch angle too low will cause undercutting.

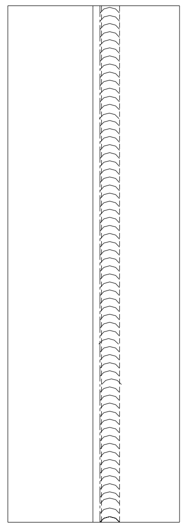
VT Criteria	Student Assessment	Instructor Assessment
Reinforcement (0" –1/8")		
Undercut (1/32")		
Weld Bead Contour (Smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade Date

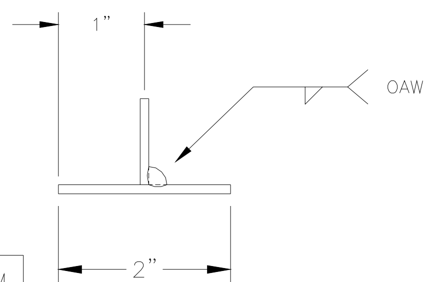
OAW

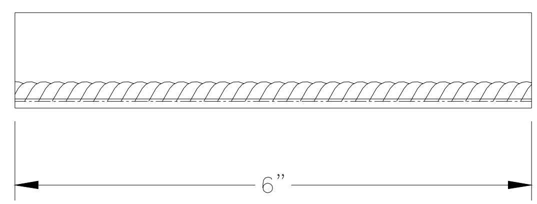
Horizontal Position (2F)
T–Joint

Welding Procedure

1. Material .... 12 Gauge–2"x6"
2. Gas Pressure .... C2H2 3–5 psig
   O 3–5 psig
3. Flame .... Neutral
4. Tip Size .... 0 or 1
5. Filler Metal .... RG 45 (3/32" diameter)
6. Travel Angle .... 35°–40°
7. Work Angle .... 35°–45°
8. Filler Metal Angle .... 35°–40°







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
Chk By: Date: 10/01/03

WLD 271–08
Size: Qc No. Rev.
Approve Date Sheet

OAW Lap Joint 3F Project #9

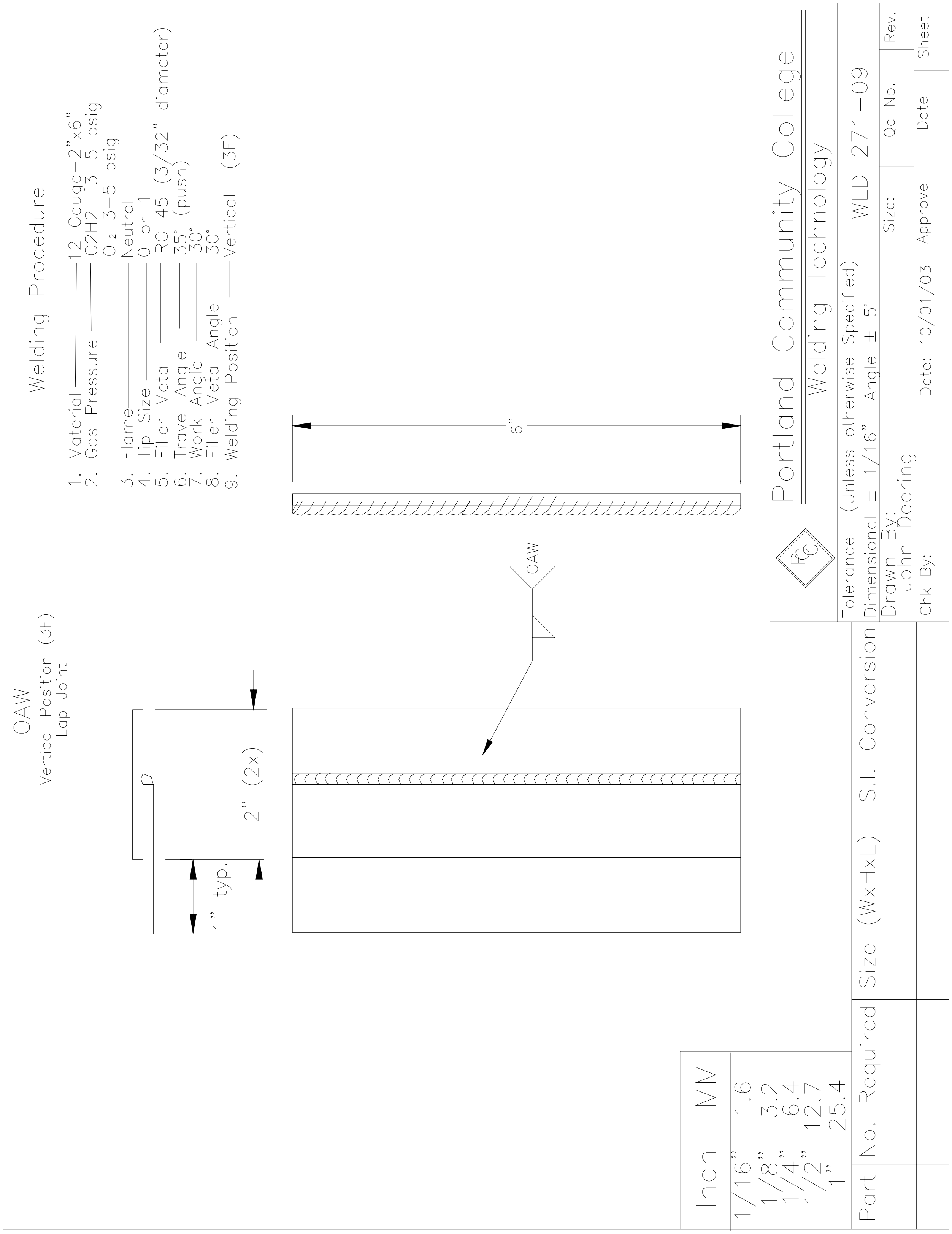
Technique:

A slight side-to-side technique should be used. Heat input is critical: if too hot, the bead will sag, if too much of the top plate is melted the puddle width will become too large. Thus the center of the puddle will be too cold to form a good bead. The finished weld bead face should be flat to slightly convex and 3/8" wide.

Tips:

A vertical weld is the most common out-of-position weld that a welder is required to perform. When making a vertical weld, it is important to control the size of the molten weld pool. If the molten weld pool size increases beyond that which the shelf will support the molten weld pool it will overflow and drip down the weld. These drops, when cooled, look like the drips of wax on a candle. To prevent the molten weld pool from dripping, the trailing edge of the molten weld pool must be watched. The trailing edge will constantly be solidifying, forming a new shelf to support the molten weld pool as the weld progresses.

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


OAW
Vertical Position (3F)
Lap Joint
Welding Procedure
1. Material — 12 Gauge-2"x6"
2. Gas Pressure — C2H2 3-5 psig
O₂ 3-5 psig
3. Flame — Neutral
4. Tip Size — 0 or 1
5. Filler Metal — RG 45 (3/32" diameter)
6. Travel Angle — 35° (push)
7. Work Angle — 30°
8. Filler Metal Angle — 30°
9. Welding Position — Vertical (3F)
1" typ.
2" (2x)
6"
OAW
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 271-09
Drawn By:
John Deering
Size: Qc No. Rev.
Chk By: Date: 10/01/03
Approve Date Sheet

OAW T- Joint 3F — Project #10

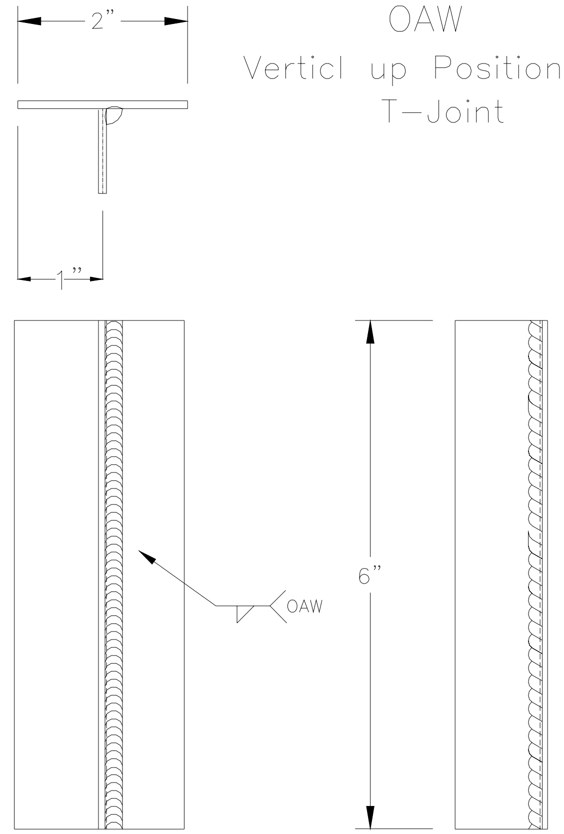
Technique:
A side-to-side technique should be used to put heat into both plates. The filler metal should be added to the top third of the puddle to ensure complete penetration. The finished weld bead face should be evenly rippled and flat. Fillet should have ¼" equal legs.

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

OAW

Verticl up Position (3F)

T—Joint



Welding Procedure

1. Material — 12 Gauge—2”x6”
2. Gas Pressure — C2H2 3—5 psig
   O_2 3—5 psig
3. Flame — Neutral
4. Tip Size — 0 or 1
5. Filler Metal — RG 45 (3/32” diameter)
6. Travel Angle — 20° (push)
7. Work Angle — 45°
8. Filler Metal Angle — 20°

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 271—10		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Date: 10/01/03	Approve	Date	Sheet

OAW Lap Joint 4F Project #11

Technique:

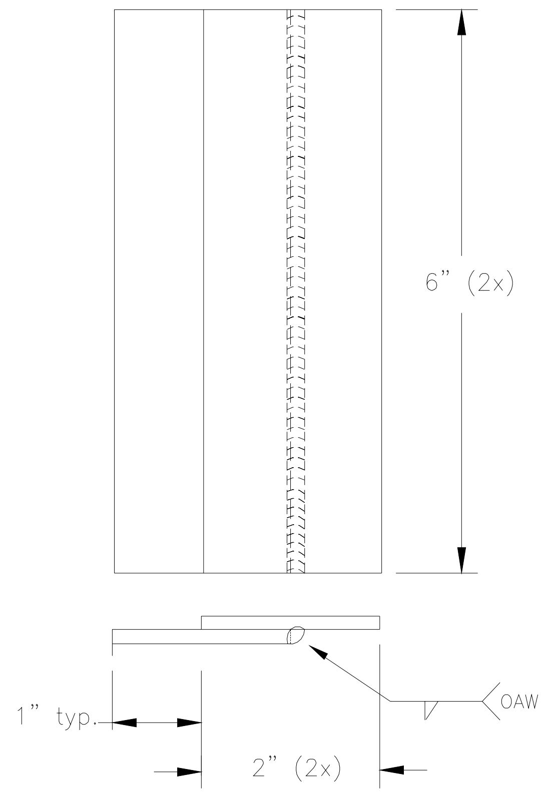
A side-to-side oscillation should be used. This technique will help control the heat in the plate with the edge exposed. The filler metal should be add to the top toe because gravity will cause it to drop to the lower toe. The finished weld bead face should be 3/8” width evenly rippled, and penetrated into both plates.

Tips:

When welding in the overhead position it is important to wear proper protection including leather gloves, leather sleeves or jacket, a leather apron, and a cap. The possibility of being burned increases greatly when welding in the overhead position. However, with the proper protective clothing you should avoid being burned. With the overhead weld, the molten weld pool is held to the plate by surface tension in the same manner that a drop of water is held to the bottom of a glass plate. With the torch off, your face shield down, and a rod in your hand, try to progress across the plate in a straight line. Use several directions until you find the direction that suits you.

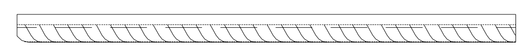
VT Criteria	Student Assessment	Instructor Assessment
Reinforcement (0” –1/8”)		
Undercut (1/32”)		
Weld Bead Contour (Smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade Date

OAW
Overhead Position (4F)
Lap Joint



Welding Procedure

1. Material .... 12 Gauge–2"x6"
2. Gas Pressure .... C2H2 3–5 psig
   O_2 3–5 psig
3. Flame .... Neutral
4. Tip Size .... 0 or 1
5. Filler Metal .... RG 45 (3/32" diameter)
6. Travel Angle .... 30°
7. Work Angle .... 30° – 40°
8. Filler Metal Angle .... 30°



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

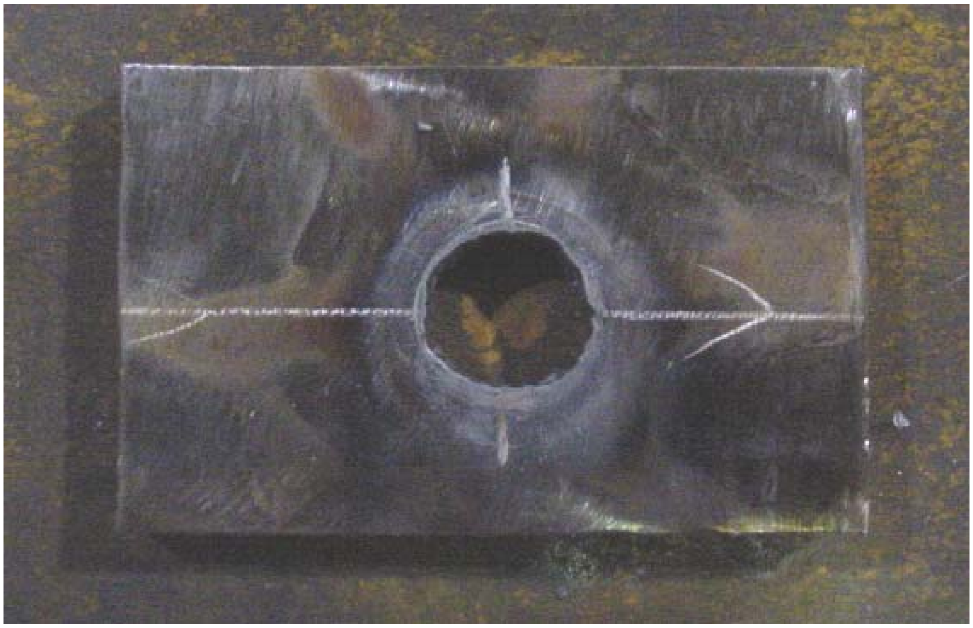
Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle ± 5°	WLD 271–11		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Date: 10/01/03	Approve	Date	Sheet

Oxy-Acetylene Cutting and Piercing   Project #12

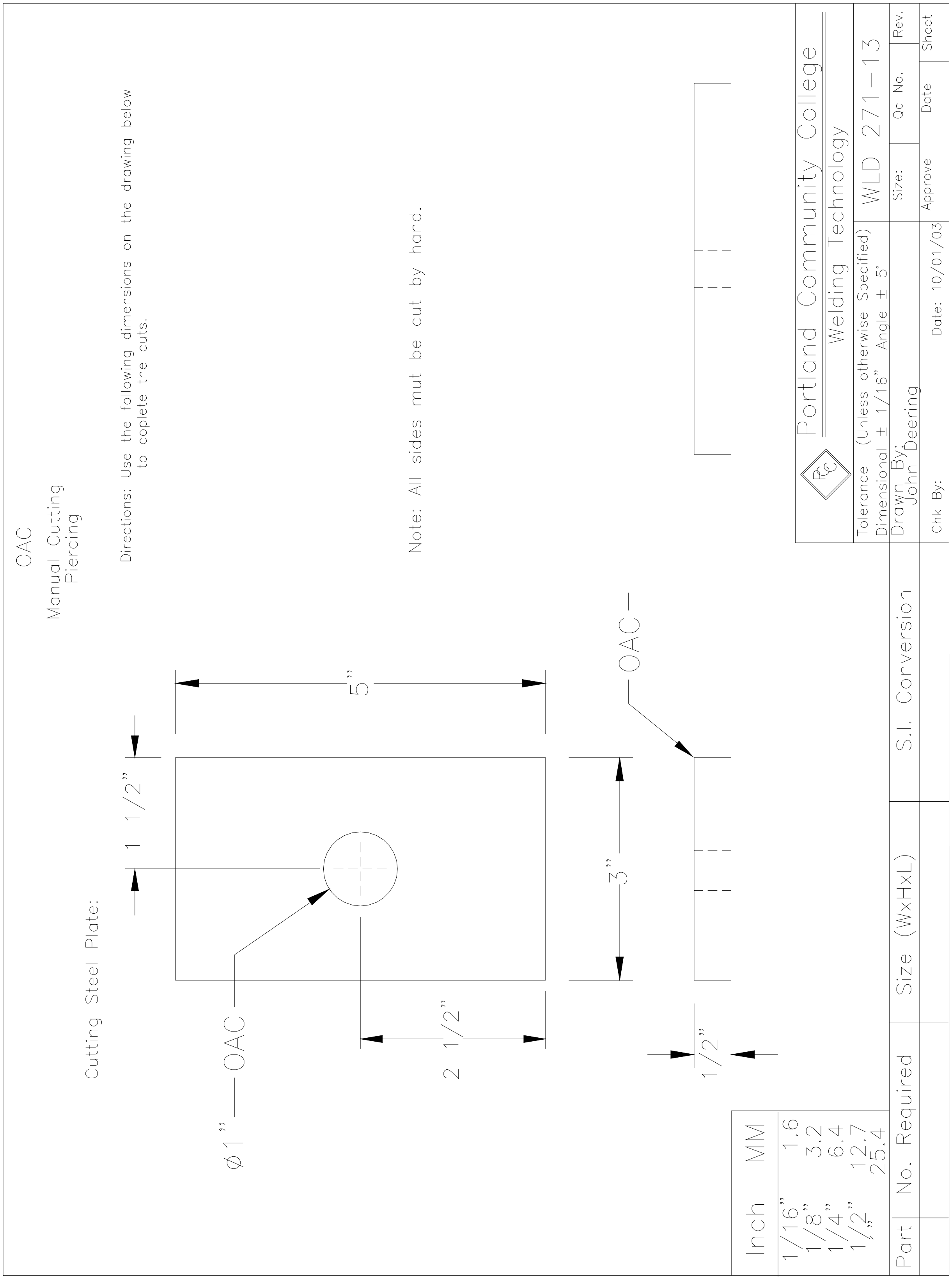
Using a portable hand torch set, cut plate to dimensions given on blue print. Lay out center hole and pierce.

Layout hole using tape measure, tri-square, soapstone, and center punch.

Pierce hole using Oxy-Fuel cutting torch cut to dimension given on print.



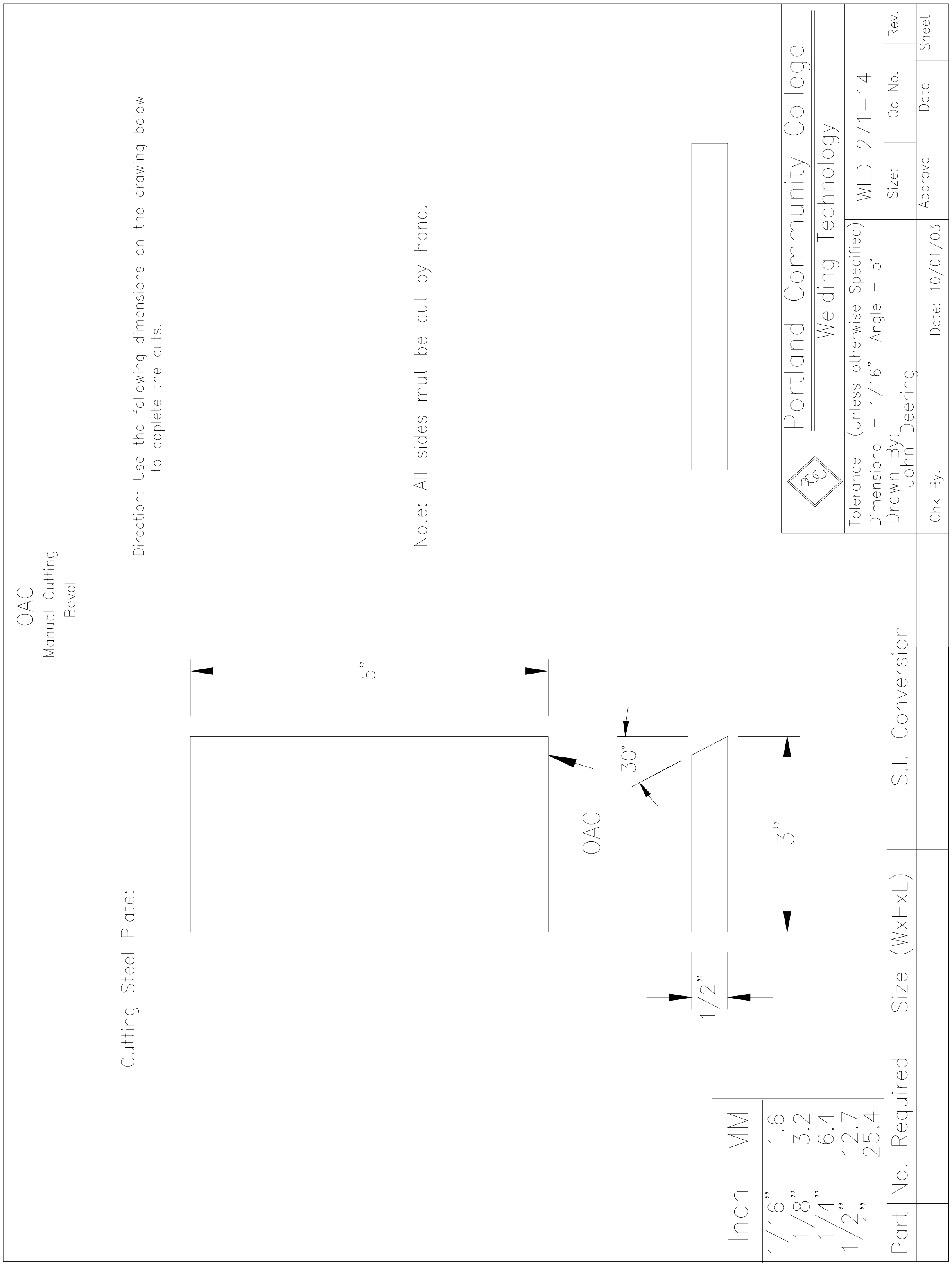
VT Criteria	Student Assessment	Instructor Assessment
Plus or minus 1/8		
Squared within + or - 1/8		
Part clean of all Slag		
Layout of hole within + or – 1/8		
Hole size + or – 1/8		
Bevel cuts are to be smooth		
Layout of overall part + or – 1/8		
		Grade Date


OAC
Manual Cutting
Piercing
Directions: Use the following dimensions on the drawing below
to coplete the cuts.
Note: All sides mut be cut by hand.
Cutting Steel Plate:
Ø1" — OAC
5"
1 1/2"
3"
2 1/2"
1/2"
OAC
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 271-13
Drawn By:
John Deering
Date: 10/01/03
Chk By:
Size:
Qc No.
Rev.
Approve
Date
Sheet

Oxy-Acetylene Manual Cut Beveling Project #13

Using a 30 degree bevel template layout material, setup torch and bevel all four sides of material. Make sure you have a properly cleaned tip and flame setting on torch to ensure a smooth and clean cut.

VT Criteria	***Student Assessment***	***Instructor Assessment***
Plus or minus 1/8		
Squared within + or - 1/8		
Part clean of all Slag		
Bevel cuts are to be smooth		
Layout of overall part + or – 1/8		
		Grade ***Date***


Cutting Steel Plate:
OAC
Manual Cutting
Bevel
Direction: Use the following dimensions on the drawing below
to coplete the cuts.
Note: All sides mut be cut by hand.
5"
OAC
30°
3"
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
Chk By:
Date: 10/01/03
WLD 271-14
Size:
Qc No.
Rev.
Approve
Date
Sheet

Braze Welding

Braze Welding does not need capillary action to pull filler metal into the joint. Brazing and Soldering are both classified by the American Welding Society a Liquid-solid phase bonding processes. Liquid means that the filler metal is melted: solid means that the base material or materials are not melted. The phase is the temperature at which bonding takes place between the solid base material and the liquid filler metal. The bond between the base material and filler metal is a metallurgical bond because no melting or alloying of the base metal occurs. If don correctly, this bond results in a joint having four or five times the tensile strength of that of the filler metal itself.

Soldering and brazing differ only in that soldering takes place at a temperature below 840degrees F (450dgC) and brazing occurs at a temperature above 840degrees F (450dgC). Because only the temperature separates the two processes, it is possible to do both soldering and brazing using different mixtures of the same metals, depending upon the alloys used and their melting temperatures.

Brazing is divided into two major categories, brazing and braze welding. In brazing, the parts being joined must be fitted so that the joint spacing is very small, approximately .025l in. (.6mm) to .002 in. (0.6 mm). This small spacing allows capillary action to draw the filler metal into the joint when the parts reach the proper phase temperature.

Capillary action is the force that pulls water up into a paper towel, or pulls a liquid into a very fine straw, Braze welding does not need capillary action to pull filler metal into the joint. Depending on joint design.

Some advantages of soldering and brazing as compared to other methods of joining include:

- Low temperature- since the base metal does not have to melt, a low-temperature heat source can be used.
- May be permanently or temporarily joined--Since the base metal is not damaged, parts may be disassembled at a later time b simply reapplying heat. The parts then can be reused. However the joint is solid enough to be permanent.
- Dissimilar materials can be joined—It is easy to join dissimilar metals, such as copper to steel, aluminum to brass, and cast iron to stainless steel. It is also possible to join nonmetals to each other or nonmetals to metals. Ceramics are easily brazed to each other or to metals.
- Speed of Joining
    A. Parts can be pre-assembled and dipped or furnace soldered or brazed in large quantities.

    B. A lower temperature means less time in heating.

- Less chance of damaging parts—A heat source can be used that has a maximum temperature below the temperature that may cause damage to the parts. With the controlled temperature sufficiently low, even damage from unskilled or semiskilled workers can be eliminated.

- Slow rate of heating and cooling—because it is not necessary to heat a small area to its melting temperature and then allow it to cool quickly to a solid, the internal stresses caused by rapid temperature changes can be reduced.
- Parts of varying thickness can be joined—Very thin parts or thin part and a thick part can be joined without burning or overheating them.
- Easy realignment—Parts can easily be realigned by reheating the joint and then repositioning the part.

Physical Properties of the Joint

Tensile Strength

The tensile strength of a joint is its ability to withstand being pulled apart. A brazed joint can be made that has a tensile strength four to five times higher than the filler metal itself.

Shear Strength

The shear strength of a joint is its ability to withstand a force parallel to the joint. For a solder or braze join, the shear strength depends upon the amount of overlapping are of the base parts. The greater the area that is overlapped, the greater the strength.

Ductility

Ductility of a joint is its ability to bend without failing. Most soldering and brazing alloys are ductile metals, so the joint made with these alloys is also ductile.

Fatigue Resistance

The fatigue resistance of a metal is its ability to be bent repeatedly without exceeding its elastic limit and without failure. For most soldered or brazed joints, fatigue resistance is usually fairly low.

Fluxes

General

- They must remove any oxides that form as a result of heating the parts.
- They must promote wetting.
- They should aid in capillary action.

The flux, when heated to its reacting temperature, must be thin and flow through the gap provided at the joint. As it flows through the joint, the flux absorbs and dissolves oxides, allowing the molten filler metal to be pulled in behind it. After the joint is complete, the flux residue should be easily removable.

Brazing Methods

General

Soldering and brazing methods are grouped according to the method with which heat is applied: Torch, furnace, induction, dip, or resistance.
It is preferable to use on of the fuel gases having a higher heat level in the secondary flame this is where acetylene brazing comes in. The oxyacetylene flame has a higher temperature near the inner cone, but it has little heat in the outer flame. This often results in the parts being overheated in a localized area.

Some advantages of using a torch include the following:

- Versatility—Using a torch is the most versatile method. Both small and large parts in a wide variety of materials can be joined with the same torch.
- Portability—A torch is very portable. Anyplace a set of cylinders can be taken or any where the hoses can be pulled into can be soldered or brazed with a torch.
- Speed – The flame of the torch is one of the quickest ways of heating the material to be joined, especially on thicker sections.

Some disadvantages of using a torch include the following

- Overheating—When using a torch, it is easy to overheat or burn the parts, flux, or filler metal.
- Skill—A high level of skill with a torch is required to produce consistently good joints.
- Fires—It is easy to start a fire if a torch is used around combustible materials.

JOINT DESIGN

General

The spacing between the parts being joined greatly affects the tensile strength of the finished part. As the parts are heated, the initial space may increase or decrease, depending upon the joint design and fixtures. The changes due to expansion can be calculated, but trial and error also works.

The strongest joints are obtained when the parts use lap or scarf joints where the joining area is equal to three times the thickness of the thinnest joint member. The strength of a butt joint can be increased if they are being joined can be increased. Parts that ¼" in.(6mm) thick should not be considered for brazing or soldering if another process will work successfully.
Joint preparation is equally as important to successfully be brazed.

Braze Welding Information Sheet

When brazing apply flame to the joint area, heating both edges or surfaces to a dull red color. Do not over heat the base metal. If the base metal becomes to hot, the zinc in a brass filler rod will burn off and this may produce toxic fumes. Too much heat is indicated when the joint area turns copper in color. Some brazing flux compounds are specially formulated so they melt when proper brazing temperature is reached.

While heating the metal, keep the end of the brazing rod in or near the torch flame to preheat the rod. This helps the rod melt more easily when touched to the hot material that you are going to apply filler to. Then the base metal has been heated to a dull red color bring the brazing rod into contact with the dull red area. Maintain uniform heating in the base metal by using a smooth, uniform torch motion. The brazing rod will quickly melt and flow over or between the joint surfaces.

The width of braze welding bead is determined by the width of the portion of the base metal that is heated enough to melt the filler metal. The filler metal will only flow on and adhere to the base metal surface that is free of oxides and is at the correct temperature. Move the torch flame in a particular direction causes the filler metal to follow in the same direction. As a guideline, the width of the braze weld bead should be just a little wider than a normal fusion weld on the same thickness of metal.

When braze welding, move the weld bead along the joint at a uniform rate of travel, as you would the molten puddle when gas welding, increase travel speed slightly. Do not hold the flame as close in weld brazing as you would in gas welding. Holding the flame to close will cause the base material to become to hot and will increase the width of the weld bead. Flashing the torch away from the weld puddle the metal cools and the bead will narrow. You may move and change the work distance as necessary to obtain the desired bead width. The finished welded joint should have the appearance of adequate adhesion to the base metal. The filler metal should seep all through the brazed joint and appear underneath. On braze welded joints, the filler metal should completely fill the joint area and have a smooth appearance.

A white deposit of (like white soot) along the toe of the brazed joint indicates an overheated joint. Discoloration of the braze filler metal in the joint also indicates overheating. A good welded joint should show the color of the filler metal itself.

Fluxes

Various metals require different types of fluxes. Most fluxes fall into one of several chemical groupings, which include borates, boric acid, alkalis, fluorides, and chlorides. Manufacturers have their own trade names for fluxes to be used with different metals. For the best results follow the manufacturer's recommendations for selection and application. Fluxes are available in many forms, such as solids, powders, pastes, liquids, sheets, rings and washer. They are also available mixed with the filler metal, inside the filler metal, or on the outside of the filler metal.

Purposes of Fluxes:

- Flux chemically cleans the base metal.
- Flux prevents oxidation of the filler metal.
- Flux floats and removes the oxides already present.
- Flux increases the flow of the filler metal.
- Flux increases the ability of the filler metal to adhere to the base metal.
- Flux brings the filler metal into immediate contact with the metals being joined.
- Flux permits the filler metal to penetrate the pores of the base metal.

Braze Filler Rods

Characteristics of filler rods for braze welding:

A. Filler rods consist of copper alloys containing about 60 percent copper and 40 percent zinc, which:
    1. Produce a high tensile strength.
    2. Increase ductility.

B. Filler rods contain small quantities of tin, iron, manganese, and silicon, which help to:
    1. Deoxidize the weld metal.
    2. Decrease the tendency to fume.
    3. Increase the free-flowing action of the molten metal.
    4. Increase the hardness of the deposited metal for greater wear resistance.

C. Filler rods should be cleaned with emery cloth before use, ones without flux already on.

TROUBLESHOOTING TIPS FOR BRAZING

IF BRAZING ALLOY DOESN'T WET SURFACES, BUT·"BALLS UP" INSTEAD OF RUNNING INTO THE JOINT, TRY:

1. Increased amount of flux.
2. Roughened surfaces produced by shot blasting, pickling, etc.
3. Removing surfaces of cold-drawn and cold-rolled bar stock by machining or grinding.
4. Pickling parts to remove surface oxides.
5. Placing the assembly in a different posit/on, such as on an incline. to encourage brazing alloy to run into joints.

Look for:

6. Impurities in the acid used for pickling, grit from shot blasting, lubricant from various machining operations, etc.

IF BRAZING ALLOY DOESN'T CREEP THROUGH THE JOINT, EVEN THOUGH IT MELTS AND FORMS A FILLET, TRY:

1. More time for heating.
2. Higher temperature.
3. A looser fit, or a tighter one.
4. Flux applied to both alloy and parent metals within and around joint.
5. More thorough cleaning of parts before assembly.

Look for:

1. Interruption of capillarity within the joint, such as by a gap.
2. Line contact within the joint instead of a uniform fit.
3. Freezing of brazing alloy caused by excessive pick-up of the parent metal.
4. Flux breakdown due to too much heat.
5. Improper or insufficient cleaning.

IF JOINT OPENS DURING BRAZING, ALTHOUGH IT WAS TIGHT WHEN ASSEMBLED, LOOK FOR:

1. Excessively tight press fit, which stretches outer member beyond its elastic limit.
2. High coefficient of expansion.
3. Unequal expansion of parts due to unlike metals or sections.
4. Release of residual stresses (stresses from cold-working) in certain parts.
5. An unsupported section which might sag at high temperatures.
6. Porosity in parent metals caused by burning through it when tack welding parts together.

IF BRAZING ALLOY MELTS, BUT RETAINS ITS ORIGINAL FORM WITHOUT FLOWING, TRY

1. Coating the brazing alloy with flux before using and applying flux generously to parent metals within and around the joint.
2. Mechanically or chemically cleaning the brazing alloy, if noticeably oxidized before using.

IF BRAZING ALLOY FLOWS AWAY FROM, INSTEAD OF INTO, THE JOINT, TRY:

1. Providing a reservoir at the joint into which brazing alloy can flow.
2. Placing the assembly in a different position, such as on an incline, to encourage brazing alloy to run into joints.
3. Placing brazing alloy in strategic position above the joint if axis is vertical, or against the shoulder if axis is horizontal, so it will creep into the joint.
4. A light copper plating on surfaces.

Look for:

5. Burrs at edges of punched holes, or other obstacles over which the brazing alloy might not creep.

(Information courtesy of United Wire & Supply Corp.)

TB Bead Plate (Braze Welding) Project #14

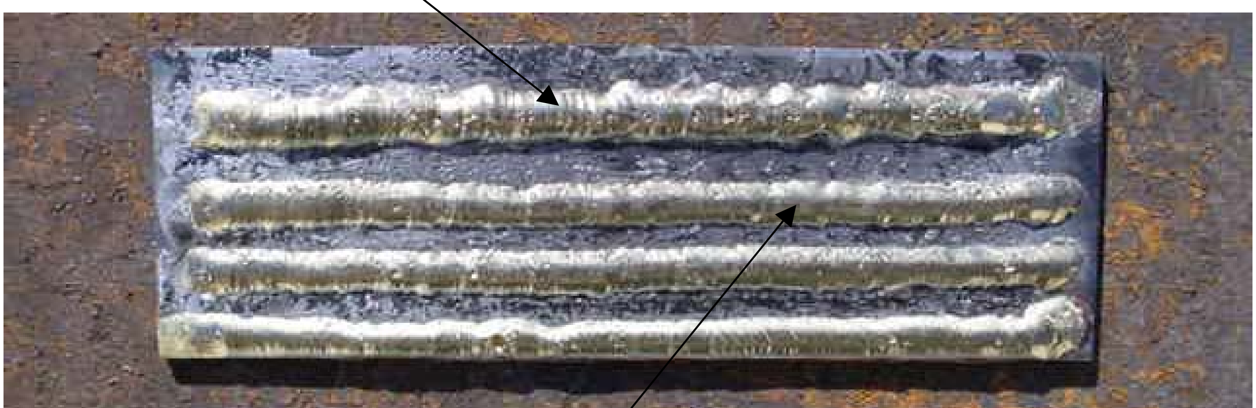
Technique:

Heat the base metal to a dull red color the width of weld bead is determined by the amount of heat applied to base metal. Add a drop of filler to start a weld bead in the dull red area start travel in a smooth but particular direction causes the filler metal to follow in that same direction.

Tips:

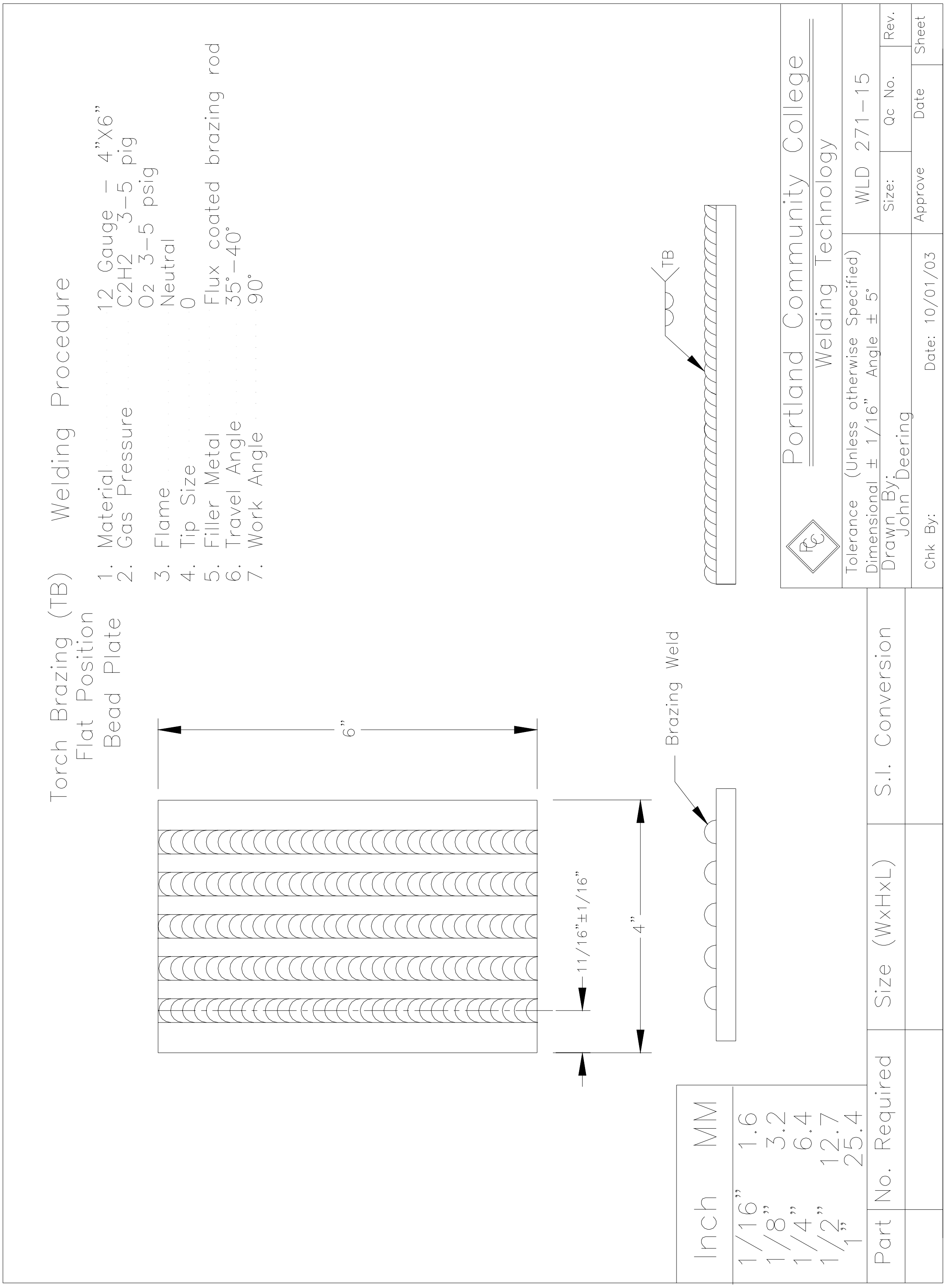
Control heat input on base metal. Flashing torch away from weld puddle will aid in controlling heat input. Add filler in middle of puddle. Flashing and adding filler will help control size of weld bead. Weld bead should not be larger than 3/8"in. in width.

First bead too high of a flame allows gases in molten puddle causing pin holes to form.



By using a lower flame slightly oxidizing makes an easier flowing puddle smoother bead no porosity making it easier to control puddle.

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


Torch Brazing (TB)
Flat Position
Bead Plate
Welding Procedure
1. Material 12 Gauge - 4"X6"
2. Gas Pressure C2H2 3-5 pig
O2 3-5 psig
3. Flame Neutral
4. Tip Size 0
5. Filler Metal Flux coated brazing rod
6. Travel Angle 35°-40°
7. Work Angle 90°
6"
4"
11/16"±1/16"
Brazing Weld
TB
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By:
John Deering
Chk By:
Date: 10/01/03
WLD 271-15
Size:
Qc No.
Rev.
Approve
Date
Sheet
Inch MM
1/16" 1.6
1/8" 3.2
1/4" 6.4
1/2" 12.7
1" 25.4
Part No. Required
Size (WxHxL)
S.I. Conversion

TB Butt Joint 1F (Braze Welding) Project #15

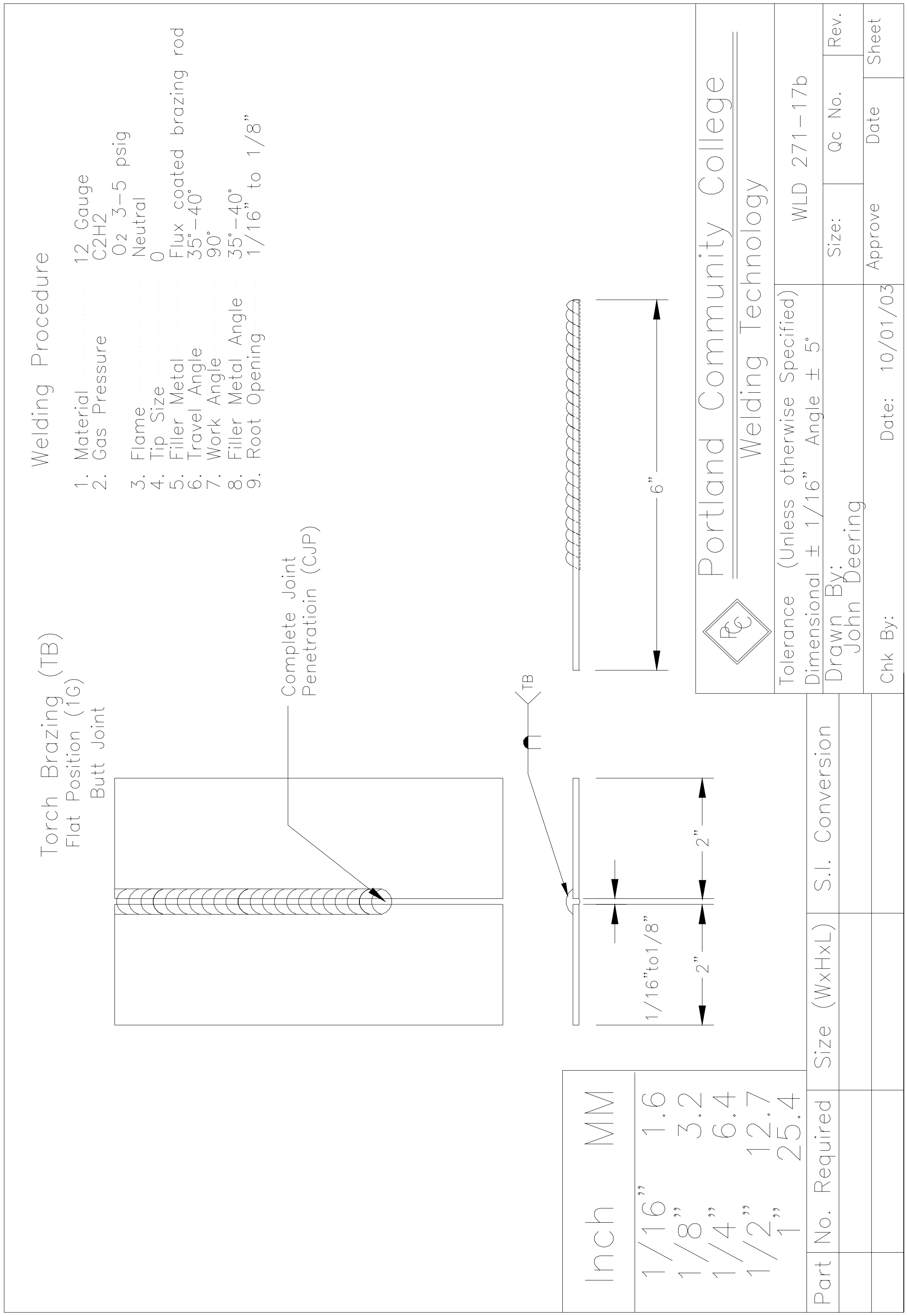
Technique:

Heat both edges of base metal evenly apply filler when metal has reached a dull red color. Add a drop of molten braze filler to form the beginning of the bead. Remove the filler just back of the flame and forward of the direction of travel. Check periodically to make sure there is plenty of flux on filler rod. Use a slight circular or half moon motion in the direction of travel. Move the filler metal along the joint at a uniform rate. Increase rate of travel speed if width becomes too wide.

Tips:

Control heat input on plate. Flashing torch will aid in controlling heat input. Add filler in middle of puddle. Flashing and adding filler will help control size of weld bead. Weld bead should not be larger than 3/8”in. in width.

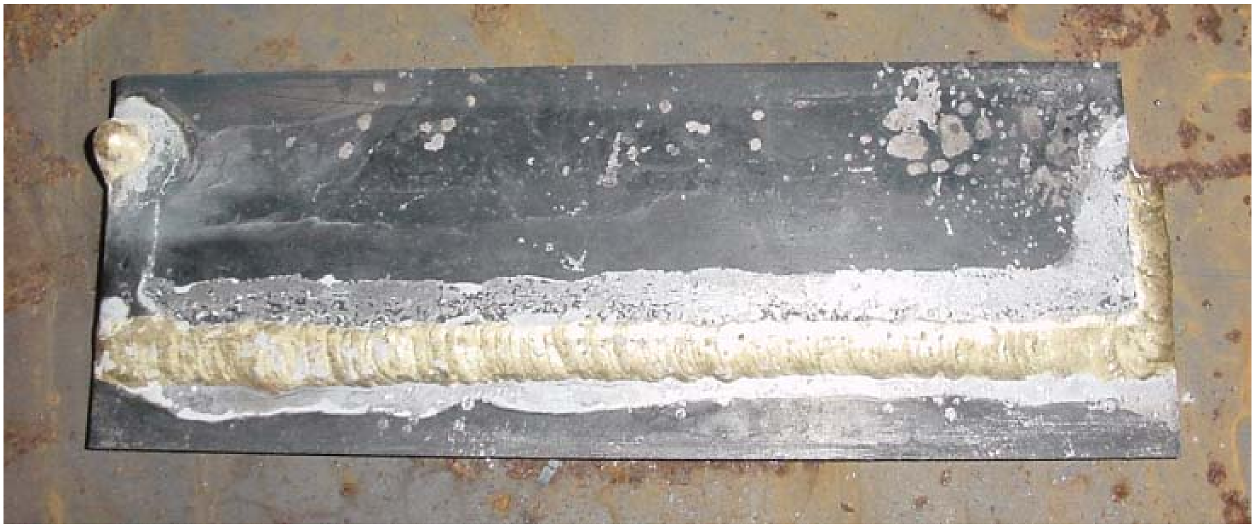
VT Criteria	*Student Assessment*	*Instructor Assessment*
Reinforcement (0” –1/8”)		
Undercut (1/32”)		
Weld Bead Contour (Smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade ***Date***


Torch Brazing (TB)
Flat Position (1G)
Butt Joint
Complete Joint
Penetratioin (CJP)
TB
1/16"to1/8"
2"
2"
6"
Welding Procedure
1. Material 12 Gauge
2. Gas Pressure C2H2
O2 3-5 psig
3. Flame Neutral
4. Tip Size 0
5. Filler Metal Flux coated brazing rod
6. Travel Angle 35°-40°
7. Work Angle 90°
8. Filler Metal Angle 35°-40°
9. Root Opening 1/16" to 1/8"
Inch MM
1/16" 1.6
1/8" 3.2
1/4" 6.4
1/2" 12.7
1" 25.4
S.I. Conversion
Part No. Required
Size (WxHxL)
Portland Community College
Welding Technology
PCC
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Date: 10/01/03
Chk By:
WLD 271-17b
Size:
Qc No.
Rev.
Approve
Date
Sheet

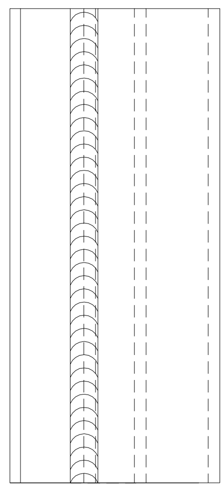
TB Lap-Joint 1F (Braze Welding) Project #16

Technique:
Heat area to be welded to a dull red, concentrate on lower base metal then with a slightly circular motion, move the flame up and heat the upper plate when both pieces have reached a dull red. Position the flame in the center of joint, then insert filler rod add a molten drop of bronze to joint pulling filler rod just slightly out of the flame and in the direction of travel. Repeat as necessary until weld bead and joint has been completely welded.

Tips;
Control heat input on plate. Flashing torch will aid in controlling heat input. Add filler in middle of puddle. Flashing and adding filler will help control size of weld bead. Weld bead should not be larger than 3/8"in. in width.



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



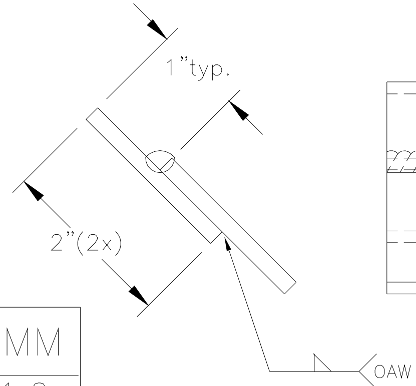
Torch Brazing (TB)

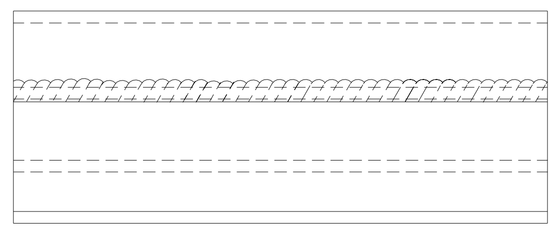
Flat Positon (1F)

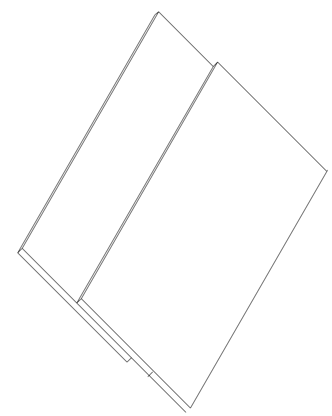
Lap Joint

Welding Procedure

1. Material .... 12 Gauge – 2" x 6"
2. Gas Pressure .... C2H2 3–5 psig
   O_2 3–5 psig
3. Flame .... Neutral
4. Tip Size .... 0 or 1
5. Filler Metal .... Flux coated brazing rod
6. Travel Angle .... 35°–40°
7. Work Angle .... 45°
8. Filler Metal Angle .... 35°–40°







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 271–TB Lap		
Drawn By: John Deering		Size:	Qc No.	Rev.
Chk By:	Date: 10/01/03	Approve	Date	Sheet

TB Lap-Joint 2F (Braze Welding) Project #17

Technique:
Hold the torch at approximately 45deg. work angle and a 45deg. travel angle and move down until flame is about 1/8 of an inch from surface at the very corner of joint. Concentrate heat on lower plate and then move to the upper plate in a circular motion until both plates have reached a dull red. Insert filler rod into flame drop a portion of filler into dull red area, start circular motion of flame move torch in direction of travel adding additional filler as needed.
Tips;
Control heat input on plate. Flashing torch will aid in controlling heat input. Add filler in middle of puddle. Flashing and adding filler will help control size of weld bead. Weld bead should not be larger than 3/8"in. in width.

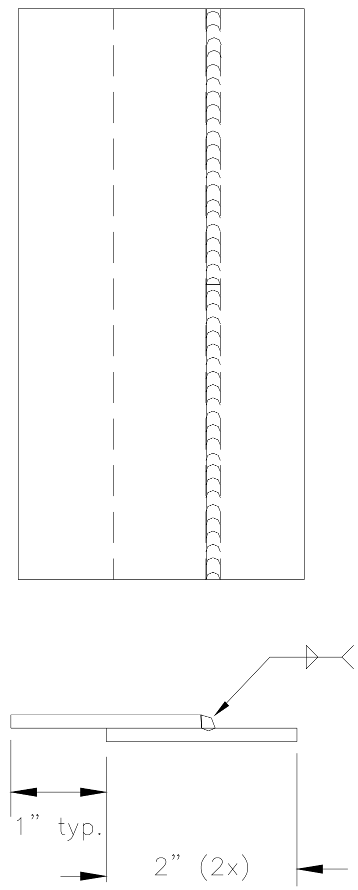
VT Criteria	*Student Assessment*	*Instructor Assessment*
Reinforcement (0" –1/8")		
Undercut (1/32")		
Weld Bead Contour (Smooth)		
Penetration		
Cracks (none)		
Arc Strikes (none)		
Fusion (complete)		
Porosity (none)		
		Grade ***Date***

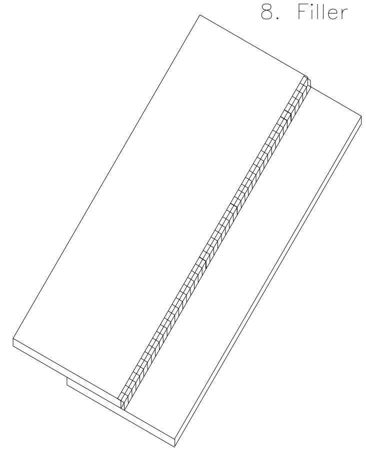
Torch Brazing (TB)

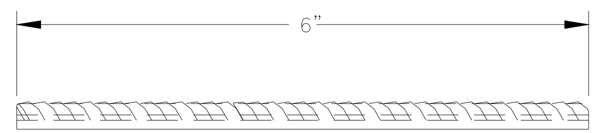
Horizontal Position (2F)
Lap Joint

Welding Procedure

1. Material	12 Gauge – 2” x 6”
2. Gas Pressure	C2H2 3–5 psig
	O_2 3–5 psig
3. Flame	Neutral
4. Tip Size	0 or 1
5. Filler Metal	Flux coated brazing rod
6. Travel Angle	35° (push)
7. Work Angle	30°
8. Filler Metal Angle	30°







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 271–17a

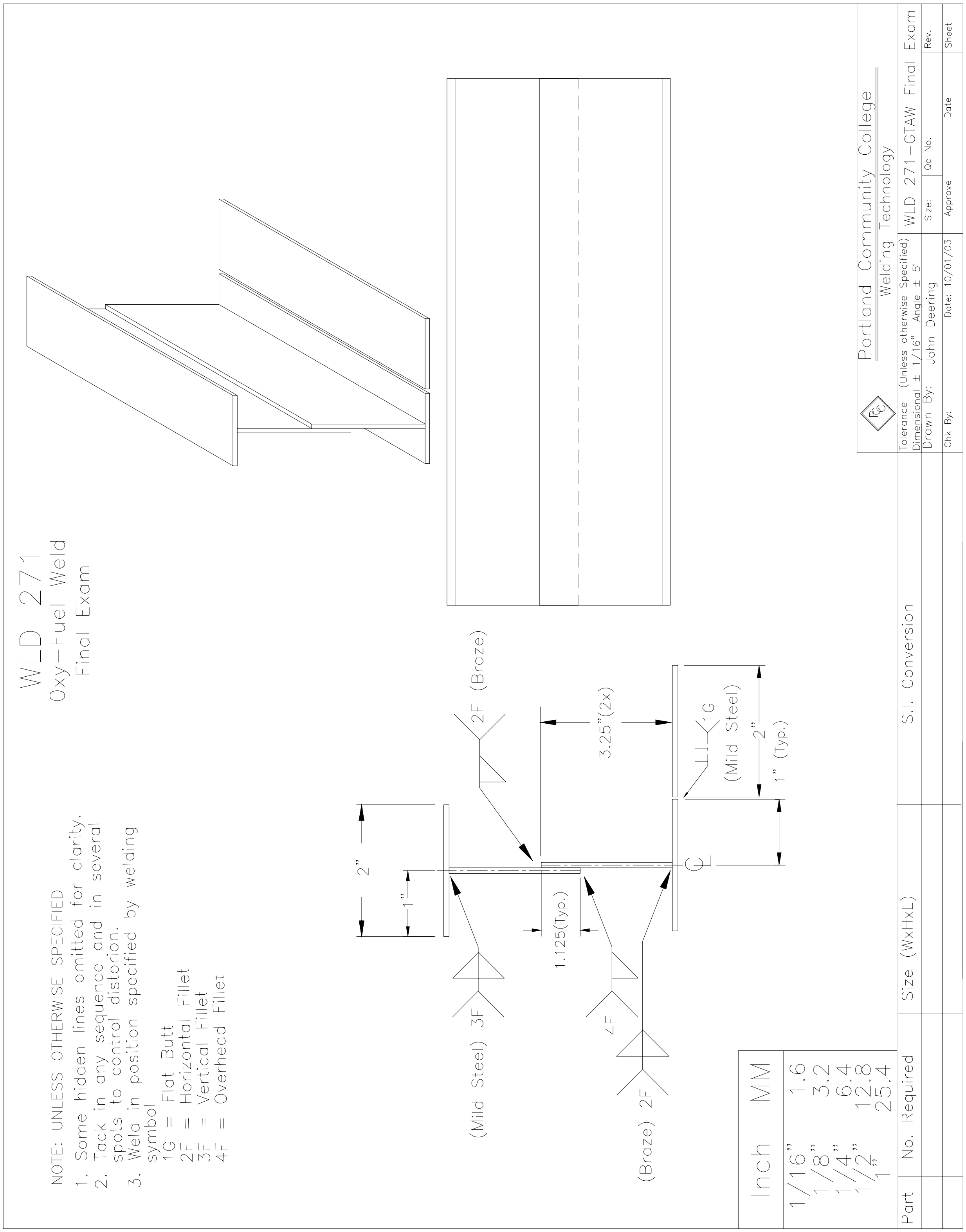
Drawn By: John Deering
Chk By: Date: 10/01/03

Size:	Qc No.	Rev.
Approve	Date	Sheet

Final Exam

Part One
This portion of the final exam is a closed book test. 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. Complete the exam and write all answers on the answer sheet. Once completed, return exam to your instructor.

Part Two
This portion of the exam is a practical test where you will fabricate and weld a weldment form a "blue print". The evaluation of this portion of the exam will be based of the Rubric. You will have two class periods to construct and weld the project. When completed return the print with the weldment to the instructor.


WLD 271
Oxy-Fuel Weld
Final Exam
NOTE: UNLESS OTHERWISE SPECIFIED
1. Some hidden lines omitted for clarity.
2. Tack in any sequence and in several spots to control distorion.
3. Weld in position specified by welding symbol
1G = Flat Butt
2F = Horizontal Fillet
3F = Vertical Fillet
4F = Overhead Fillet
2"
1"
1.125(Typ.)
3.25"(2x)
2"
1" (Typ.)
2F (Braze)
1G
(Mild Steel)
(Mild Steel) 3F
4F
(Braze) 2F
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 (WxHxL)
S.I. Conversion
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
Drawn By: John Deering
Chk By:
Date: 10/01/03
WLD 271-GTAW Final Exam
Size:
Qc No.
Approve
Date
Rev.
Sheet

Grading Rubric for the Practical Exam

Hold Points

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

Points	*Hold Point*	*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.	_________
28 points	*Minimum points acceptable. This equates to the minimum AWS D1.1 Code requirements.*	

Total Points ______