WLD 224
Gas Tungsten Arc Welding
(Mild Steel) Pipe I

Index

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Portland Community College
17705 NW Springville Road
Portland, OR 97229

Welding Technology
Lec/Lab Course Syllabus

Building Location

Welding lecture:	Bldg 2, Rm 132a/b	
Welding lab:	Bldg 2, Rm 132	Phone (503) 614-7226

Time & Days

Morning Shift	7am to 12:50pm	Monday through Thursday
Afternoon Shift	10 am to 3:50pm	Monday through Thursday
Evening Shift	4pm to 9:50pm	Monday through Thursday

Instructors

Connie Christopher	Office Bldg. 2 Rm. 232c,	Phone (503) 614-7502
Scott Judy	Office Bldg. 2 Rm. 232,	Phone (503) 614-7600
Matthew Scott	Office Bldg. 2 Rm. 233b,	Phone (503) 614-7601
Danny Merrick	Office Bldg. 2 Rm. 232d,	Phone (503) 614-7603

Introductory Statement

WLD 224, Gas Tungsten Arc Welding: (Mild Steel) Pipe I, course develops knowledge and manipulative skills required to weld mild steel plate and pipe in all positions using the GTAW and SMAW processes.

The goal of this course is to develop the skills needed to successfully utilize the GTAW process to apply the root pass and second pass in an open root joint and the fill and cap passes with the E7018 electrode. When the student has demonstrated this skill level through successful completion of plate welds, the student will then progress to pipe practice in the horizontal position (2G).

This course utilizes a lecture/lab format that includes classroom discussions and lab demonstrations. Topics covered will include safety, uses, nomenclature, equipment operation and set-up and shutdown procedures for oxyacetylene cutting, gas tungsten arc welding for the first two layers and shielded metal arc for the fill and cover passes using the E7018 electrode.

This is an outcome-based course that will allow the student to work at his/her own pace. It is important to note that 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 Lab.

- Students will understand and practice personal safety by using proper protective gear.
- Students will understand and practice hand and power tool safety.
- Students will understand and practice equipment safety.
- Students will understand and maintain a safe work area.
- Maintain a clean and clutter-free floor
- Recognize and report dangerous electrical and air/gas hose connections
- Understand and practice fire prevention
- Access and explain the importance of Material Safety Data Sheets (MSDS)

Demonstrate professional work ethics (habits).

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

Interpret drawings and symbols to accurately layout , prepare and assemble weld joints.

- Interpret lines, symbols and verbiage on project drawings
- Prepare and layout material per specification
- Assemble weld project per specification.
- Discuss agencies governing pipe
- Discuss the general acceptance criteria of welded pipe
- Recognize pipe sizes and schedules
- Identify pipe welding positions
- Discuss advantages of GTAW of pipe
- Prepare 6 inch diameter pipe using the oxy-acetylene pipe beveler

Operate oxyfuel portable and track cutting systems in accordance with industry standards

- Demonstrate correct setup and shutdown procedures for the Watts pipe beveling system.
- Perform oxyfuel cutting with guided practice.

Weld open root groove joints in the horizontal, vertical and over head plate positions using 6 inch schedule 40 or 80 pipe in the horizontal position using the GTAW and SMAW processes.

- Use correct terminology.
  - Define terms used in the GTAW and SMAW processes.
- Equipment identification, setup, shut down, and principles of operation for GTAW and SMAW.
  - Power source identification and adjustment.
  - Welding lead, connections, inspection, and use.
  - Electrode identification, characteristics, and use.
- Demonstrate correct welding techniques with the GTAW and SMAW.
  - Describe variables and their causes and effects to achieve desired results:
    - Welding current
    - Travel speed
    - Electrode angle
    - Arc length
    - Oscillation Techniques
- Demonstrate correct welding techniques per the welding procedure specifications:
  - Horizontal Butt Joint, single v-groove plate weld (2G).
  - Vertical Butt Joint, single v-groove plate weld (3G).
  - Overhead Butt Joint, single v-groove plate weld (4G).
  - Pipe axis vertical Butt Joint, single v-groove pipe weld (2G).
- Demonstrate visual examination principles and practices in accordance with ASME Section IX and AWS D1.1.
  - Develop knowledge of A.S.M.E. Section IX pipe welding code requirements in qualification procedures.
  - Use Welding Procedure Specification to set-up and weld qualification coupons.
  - Develop knowledge and skills of the welder qualification procedures on schedule 40 or 80 pipe using GTAW and SMAW processes.
  - Utilize welding code to reference weld profile inspection.

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 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

Reading
Welding Principles and Applications, By: Larry Jeffus
Chapter 17, Gas Tungsten Arc Welding of Pipe

Writing Work Sheets
Welding Steel Pipe
Welding Vocabulary

Video Training
Pipe Welding Made Easy GTAW/SMAW 2G

Welding Projects
2G Butt - Single Vee Grove Weld - Open Root (plate)
3G Butt - Single Vee Grove Weld - Open Root (plate)
4G Butt - Single Vee Groove Weld - Open Root (plate)
2G Butt - Single Vee Grove Weld - Open Root (pipe)

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

Required Texts
Welding Principles and Applications, By: Larry Jeffus

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

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.

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 mathematics as it relates to industry requirements.

Calculating Joint Preparation Tolerances and Determining if Your Weld is Within Tolerance

Joint Preparation
Your packet states that a joint shall be acceptable by visual inspection if:

1. The root opening does not exceed the specified dimension by ±1/16".

2. The included angle does not exceed the specified dimension by ± 5°

For this lab look at the drawing numbered WLD 224-01 Butt Joint Horizontal (2G)'

Given the above tolerances:

1. Calculate the range of the root opening in both fractional and decimal inches. Enter your calculations below.
2. Calculate the acceptable range of the included angle. Enter your calculations below.
3. Inspect and measure each joint after it has been prepared.
4. Record the actual dimensions of your joint in the space provided.
5. Determine if the actual dimensions are within tolerance.

Note: If you have forgotten how to calculate ranges and tolerances see the math reference packet.

WLD 224-01 Butt Joint Horizontal (2G)

Root opening range (in **fractional inches**) _____to_____
What is the actual measurement of the root opening? _____Is your weld within tolerance? Y/N

Root opening range (in **decimal inches**) _____to_____
What is the actual measurement of the root opening? _____Is your weld within tolerance? Y/N

Included angle range _____to_____
What is the actual measurement of the included angle? _____Is your weld within tolerance? Y/N

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:

- Benefits of Low-Hydrogen Practice for Welding of Steel Pipe
- Root Pass Capability with GTAW and SMAW (E7018)
- Composition of the ER70S-6 Filler Metal for GTAW
- Characteristics of E7018 Low-Hydrogen Electrodes
- Welding the Root Pass with GTAW and the Fill Passes with SMAW using E7018
- Shielding Gas Protection for GTAW
- Iron Powder in E7018 Electrode
- Baking of E7018 Electrodes
- Premium Pipe Weld Quality

Benefits of Low-Hydrogen Practice for Welding of Steel Pipe

In order to weld high strength steel line pipe, such as API-5L grade X60 or X70, some line pipe welding codes allow high-hydrogen cellulosic electrodes, like E6010 or E8010, for the root pass provided adequately high preheat temperatures are rigidly enforced. Without the use of preheating, these high strength line pipes would surely crack due to hydrogen-assisted cracking (HIC).

Because of its high integrity, GTAW of pipe products is required in many industries including oil, gas, nuclear, chemical and others. In addition, many structural codes for welding pipe (used for structural applications and not to carry oil, natural gas, or water) forbid the use of cellulosic electrodes (like E6010) and require only the use of low-hydrogen electrodes (such as E7018) and low-hydrogen processes, such as GTAW, GMAW and SMAW with low-hydrogen electrodes. Two excellent examples of low-hydrogen processes include:

- GTAW with solid wire filler metal such as ER70S-3 or ER70S-6 and
- SMAW with E7018 electrodes.

The GTAW process is a hydrogen-free process. The only source of hydrogen contamination in welding with GTAW comes from the drawing lubricant residue on the filler wire and workmanship issues. Also, SMAW with low-hydrogen electrodes such E7018 can provide low-hydrogen deposits for structural applications. The use of low-hydrogen procedures provides two important benefits:

- Substantial reduction of preheat temperature, or in some cases, the elimination of preheat;
- Insurance against hydrogen-assisted cracking in high strength steel pipe.

In practice, the combination of GTAW root pass(es) and E7018 fill passes is ideal of welding high strength steel pipe. The GTA root pass provides hydrogen-free high-integrity root, while the E7018 low hydrogen electrode provides economy in fill passes because it is also iron powder electrode.

Root Pass Capability with GTAW and SMAW (E7018)

Most pipe welding codes require 100% root penetration. Also, root reinforcement may also be required. Since small diameter pipe can only be welded from the outside, both root penetration and root reinforcement must be accomplished from the outside only. GTAW is an ideal process to provide excellent root pass penetration and integrity. Although GTAW is a very slow and time consuming process, it has several outstanding benefits:

1. GTAW is a hydrogen-free process, as mentioned above,
2. GTAW is an excellent process for depositing the root pass of pipe, and
3. GTAW produces weld metal which is free of any contamination (assuming excellent workmanship).

The reason why GTAW is so controllable for root pass welding is the clear view and control of the "keyhole" during welding. Although a keyhole exists for welding the root pass with E7018 electrode, the thick slag layer tends to partially obscure the view of the weld pool. On the other hand, the molten pool deposited by GTAW contains no slag and the keyhole is not obscured at all.

Composition of the ER70S-6 Filler Metal for GTAW

ER70S-6 filler metal is designed for welding steels with rust and scale, while the standard ER70S-3 general purpose wire is designed for multi-pass welding steel with little of light rust. The reason why ER70S-6 has so much tolerance for rust and scale is the presence of high levels of manganese (Mn) and silicon (Si) deoxidizers (in the wire) as shown in Table 1. Mn and Si react with iron oxide or rust in a manner shown below:

$$2FeO + Si = 2Fe + SiO_2$$

$$FeO + Mn = Fe + MnO$$

Table 1- Typical Compositions of Undiluted Weld Metal Deposited by GTAW

Element	ER70S-3 (Standard)	ER70S-6 (High Mn and Si)
C	0.09	0.08
Mn	0.90	1.3
Si	0.4	0.8
P	0.013	0.012
S	0.009	0.011

Furthermore, the presence of high levels of Mn and Si in the ER70S-6 wire provides greater fluidity and wetting characteristics than with standard ER70S-3. Because of the higher levels of Mn and Si, the strength of weld metal deposited with ER70S-6 is greater than standard ER70S-3 as shown in Table 2.

Table 2- Typical Tensile Properties for Steel Weld Metal Deposited by GTAW

	ER70S-3 (Standard)	ER70S-6 (High Mn and Si)
Yield Strength, psi	60,000	74,000
Tensile Strength, psi	75,000	88,000
% Elongation	34	25

Both Mn and Si are strengtheners in steel weld metal as well as deoxidizers. This is why the ER70S-6 produces stronger but less ductile weld metal than does the ER70S-3 electrode. Even though these two electrodes produce different strength levels of weld metal, they are both classified as "ER70xx", which means that the tensile strength can not exceed 90,000psi.

Characteristics of E7018 Low-Hydrogen Electrodes

Although an all-position electrode, the E7018 electrode provides moderate penetration and build-up. The slag layer is heavy and protective, but easily removed. The iron powder in the flux coating provides about double the deposition rate compared to E6010 electrodes. The molten weld metal is protected from the surrounding air primarily by the molten slag layer and not by the rapidly expanding gases, which is the primary shielding for E6010 cellulosic electrodes. Since E7018 provides only limited gaseous protection and less penetration compared to cellulosic electrodes (for example: E7010), E7018 is not suited for open root passes. Without substantial gaseous protection the open root is susceptible to both hydrogen contamination and porosity because of air and moisture contamination from the back-side of the root. In addition, the weld starting location of an E7018 weld deposit is very susceptible to porosity because of the time-lag associated with the build-up of the thick slag shielding. A short starting tab is recommended when using E7018.

Because of the poor open root welding capability of E7018 electrode, other welding electrodes are needed to achieve an excellent open root pass. Two welding processes are commonly used: (1) SMAW with cellulosic electrode, and (2) GTAW. SMAW with E6010 cellulosic electrode is commonly used for open root welding only when high hydrogen processes are allowed by code. However, many codes require low-hydrogen processes for all passes including the root pass. To achieve low-hydrogen conditions in the root pass, the GTAW process can be used. GTAW is not only a low hydrogen procedure but also a hydrogen-free process, which is often required by code for the root pass.

Welding the Root Pass with GTAW and the Fill Passes with SMAW using E7018

The most common application of low-hydrogen welding of pipe is:

- Root pass with GTAW and ER70S-6
- Subsequent passes with E7018 low-hydrogen, iron-powder electrodes

The root pass is welded with GTAW using ER70S-6 in order to deposit a root pass with reinforcement and low hydrogen. The high levels of Mn and Si in the ER70S-6 electrode provides not only deoxidation of the open root pass, but also increased fluidity and wetting for excellent bead shape particularly on the back side of the root. The back-side of the open root pass is usually contaminated with air and moisture. So, the presence of extra Mn and Si deoxidizers helps prevent porosity and reduced mechanical properties when the back-side of the root pass is contaminated by the atmosphere. Surface tension of the molten weld pool provides the means to produce a smooth build-up of reinforcement on the backside of the root pass.

Once the critical root pass is completed, filler passes can be applied by using the more cost-effective E7018 low-hydrogen and iron powder electrode. The presence of iron powder provides substantially increased deposition rate. In addition, E7018 maintains low hydrogen conditions and fulfills the requirement for all-position welding capability.

Shielding Gas Protection for GTAW

GTAW of steel requires an envelop of the inert gas, argon (Ar), to cover the molten pool and to protect the pool from atmospheric contamination. Unfortunately, the shielding gas can be "blown" away by wind. Most codes state that welding with GTAW must be performed either indoors or in a protected environment where windy conditions are eliminated. If the argon shield is disturbed, the weld metal properties will suffer. In addition, breaking the argon shielding by windy conditions will also allow moisture from the air to contaminate the weld. Moisture contains water which dissociates into hydrogen and oxygen under the welding arc. This hydrogen can cause hydrogen-assisted cracking.

Iron Powder in E7018 Electrode

The use of from 25 to 40% iron powder in E7018 has two very beneficial effects. First, deposition rate of E7018 is nearly doubled compare to all-position electrodes without iron powder, such as E7010. The second beneficial effect is the improved arc behavior and reduced spatter with iron powder additions. The reason why iron powder affects the performance of the E7018 electrode is because the iron powder in the covering causes the covering to become electrically conductive near the arc. As a result, the arc tends to spread out radially and deposits over a wider area. The diffuse arc area provides many conductive paths (to the weld pool), thereby limiting current surges when molten metal globules short circuit between the electrode wire and the weld so that spatter is greatly reduced.

Baking of E7018 Electrodes

Unlike E6010 cellulosic electrodes, the E7018 low-hydrogen must be kept dry for maximum resistance to weld metal cracking. The electrodes are dried at the manufacturing plant and then immediately packed in hermetically sealed steel cans to preserve the low moisture (low hydrogen) properties. However, as soon as the hermetically sealed can is opened and E7018 electrodes are redrawn for use, humidity in the air slowly deposits moisture in the coating. This is why AWS D1.1 Structural Welding Code allows E7018 electrodes to be exposed to the atmosphere for only 4 hours. After 4 hours, the unused electrodes must be returned to the baking oven for the required re-drying cycle. There is no limit to the number of times that the E7018 electrodes can be taken out for 4 hours and returned back to the drying oven.

Premium Pipe Weld Quality

By combining the GTAW root pass with subsequent fill passes with SMAW using E7018, the welder can produce very high quality line pipe. This welding procedure is both efficient and low-hydrogen. When codes prohibit the use of cellulosic and other high-hydrogen electrodes (such as SMAW with E6010) for welding the root pass, then a combination of GTAW and SMAW with E7018 can be used.

Plate Preparation & Welding Information Sheet

Prepare 3/8” plate to be welded utilizing the GTAW process for the first two passes and the E7018 electrode for the fill and cap passes.

Use the Track burner to cut a 37-½ degree bevel angle on the 3/8” plate. Triangle protractors are available in the Tool Room.

Use a grinder to prepare the groove face, topside and bottom side of the welding joint. Follow up with a sanding disk on a grinder to smooth the surfaces. A smooth surface is important to allow the GTAW cup to pivot when walking the cup.

With Gas Tungsten Arc Welding the root pass and second pass, it is incredibly important to ensure the surfaces to be joined are thoroughly cleaned. Pictured below is an example of how the surfaces should be cleaned.

The groove face and backside of the root area are cleaned to shiny metal (free of rust and mill scale). This is an important step to prevent undercut.

Fit the 3/8" thick plates together with a knife-edge and a 1/8” root opening.

An 1/8” piece of filler metal is used as a spacer

The plates are aligned on one plane. This prevents one plate being higher than the other. This condition is known as “Hi–Low” and 1/16” is the maximum tolerance by code.

Equipment Set-up

When using the GTAW process to apply the root pass, it is common to use a "standard" Shielded Metal Arc Welding machine with an air-cooled GTAW torch. Pictured below is a common shielded metal arc welder used for gas tungsten arc welding.

For the GTAW process the following set-up procedures should be used:

- Direct Current Electrode Negative (DCEN of DCSP)
- Argon shielding gas set at 20-25 cubic feet per hour (cfh)
- 1/8" 2% Thoriated Tungsten
  - Grind the tungsten electrode to a 22-degree angle with the grinding marks going length wise with the length of the electrode. This is an incredible important step in making a high quality weld.
- Cup size will vary based on which pass is being applied ad operator preference.
  - Root Pass cup size = #5
  - Second Pass cup size = #7

  Note that gas cups are sized by a numbering system. Each number equates to 1/16 of an inch for its inside diameter dimension. Therefore a number five cup would have an inside diameter of 5/16 of an inch.

Correct torch assembly is pictured below

Collet, Collet Body, Gas Cup, Tungsten (1/8 inch diameter 2% Thoriated), and Back Cap

Cup Selection and Tungsten extension

Use a number five-cup for the root pass. Extend the tungsten out to where it will almost touch the root of the joint. This extension will vary slightly among welders, however it is critical that the tungsten is extended enough so that the welder can hold a tight arc length while welding the root pass.

Ensure the gas is turned on at the cylinder and the torch prior to striking the arc with the GTAW torch. Otherwise the tungsten will be contaminated and the tungsten will need to be ground clean prior to being used again.

Tack weld ends of plate ensuring to maintain the correct root opening. Tacks should average 1/2" to 3/4" in length. The first tack should be approximately 1/4" long, however, to control distortion and shrinkage. Feather backs the end of the tack with a hand grinder (notching wheel) to provide access for 100% penetration.

The tack weld is lightly feathered at both ends to ensure complete penetration when transitioning on or off a tack weld. Excessive grinding can lead to excessive burn through.

Striking the arc with a "scratch start" GTAW torch.

Technique
Rest the cup near the area you want to begin welding at. Hold the torch with an arc length of approximately 1/16" to 1/8".

Use the filler metal to quickly sweep across the tungsten electrode as though you were lighting a match.

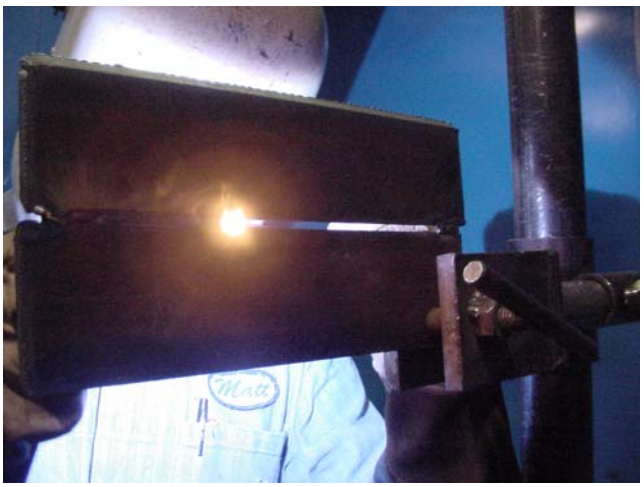
This scratching motion will initiate the arc with out contaminating the tungsten.

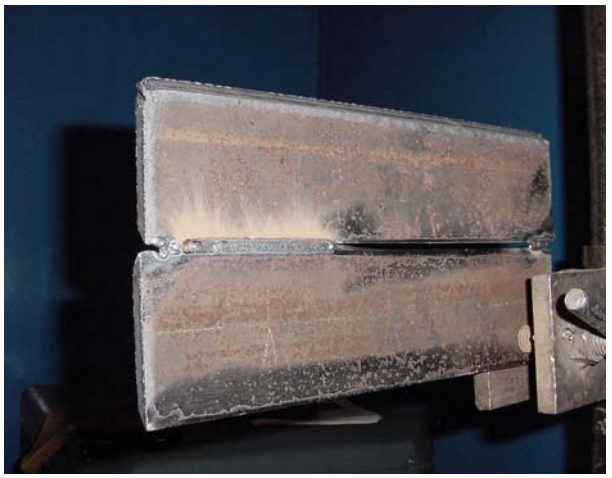
An Alternate way to initiate the arc:
Rest the cup near the area you want to begin welding at. Rock the tungsten into the base metal and quickly rock the torch back. This technique should initiate the arc with minimal tungsten contamination.

Advance the torch forward by walking the cup and consuming the filler metal once the arc is initiated. This technique requires the filler to be submerged into the puddle while the arc oscillates over it fusing it into the edges of the root.

Note how the filler metal is slightly necking down. There is just enough amperage to metal the filler metal and fuse the base melt.

The welder has to ensure the filler metal is centered at the bottom of the root and is being fused to the root surface while keeping a tight arc length. An indicator that 100% penetration is being obtained is a line that develops in the center of the root bead while welding is taking place. If the welder can view this during welding, he/she will know 100% penetration is being obtained.





Note that the filler metal protrudes slightly through the root opening. This is an example of a correctly fit up plate.

There are six variables to control when running the open root pass with the GTAW process:

- Addition of filler metal
- Root opening
- Amperage
- Arc length
- Travel speed
- Root face vs. knife edge

Suggestions for the root pass are:

- Center the filler metal in the bottom of the joint and add a slight amount of downward pressure on the filler. Be careful not to add too much pressure because the filler metal may push through without fusing into the root.
- Keep the torch moving so the root bead keeps advancing.
- Vary filler metal size for differences in root opening. Use 3/32" diameter filler metal for tight areas and 1/8" filler metal for wide areas.

An example of a high quality root pass.

Regardless of what pass the welder is applying, feeding the filler metal into the puddle and being able to advance the filler metal in your hand with out breaking the arc is an essential function of GTA welding. Pictured to the right is one technique where the filler metal is "clamped" with three fingers and advanced with the thumb and the index finger.

Stopping techniques for the GTAW process.

Porosity has a tendency to develop in the crater when terminating a weld with an air-cooled torch, without the aid of high frequency. Use one of the following techniques to avoid this.

Technique #1 ***Chilling the Weld***
This is where the welder will extend the arc length slowly until the arc is terminated. Using this technique, the puddle will freeze and porosity will be avoided. This is an excellent technique for carbon steel applications.

Technique #2 ***Walking up the Filler Metal***
This is where the welder quickly walks the torch up the groove face and the filler metal. This increase in travel speed will reduce the puddle size and puddle will solidify without developing porosity.

Either technique will take practice to ensure high quality welds.

Root Pass Inspection

A quality root pass

- The root pass must have 100% penetration free of undercut and suck back.
- The root pass must be inspected for complete penetration, undercut and excessive penetration. See Craftsmanship Expectations for inspection criteria.

Applying the Second Pass (the *Cold Pass*)

- Applying the second pass, which is known in SMAW pipe welding as the "hot pass", is critical for a sound root pass. It is important to not over heat the gas tungsten arc root pass thus destroying its internal contour. Therefore, the second pass will be referred to as the cold pass in this training packet. This emphasizes the need to closely control the heat input into the second pass.
- Clean the face of the root bead using a hand grinder with a wire brush prior to applying the cold pass. Cleanliness is very important in the GTAW process. Ensure that the wire brush used is stainless steel and is not contaminated.
- Increase amperage approximately 5 to 10 amps above root bead setting. This will allow for increased travel speed.
- Change out the gas nozzle to a larger size than used on the root pass (number 7 cup). Use the "cup walking" technique to apply the second pass. Remember to keep the filler metal in the middle of the root pass while maintaining a consistent arc length and emphasize the side walls when welding. Keep a steady travel speed forward is important so the root pass is not over heated and the internal contour is destroyed.

- Using the "Cup Walking" technique, place the filler metal in the middle of the root bead while welding regardless of the plate/pipe's position. Walk the cup forward consuming the filler metal. This is know as "running the filler." It is important, keep the filler metal submerged into the puddle. While welding, do not pause the tungsten in the center of the joint. This will over heat the root bead causing suck back thus destroying the internal root bead contour. Emphasize the side walls with out slowing down across the middle of the weld while applying the second pass.

Purpose for the second pass is to provide extra thickness to the root bead so the first SMAW E7018 layer does not burn through the root pass.

Low Hydrogen Fill and Cover Pass Technique

Equipment Set-up

- Turn the welder off and switch out the GTAW torch for the SMAW electrode holder ("stinger").
- Change the polarity to Direct Current Electrode Positive (DCEP or DCRP)
- Obtain scrap material to set the amperage for the E7018 electrode.

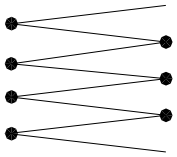
Special Note:

Remember that a "tight arc length" is essential when welding with E7018. The puddle relies on the vaporization of the flux and the molten slag for added shielding. Keep the electrode in the puddle at all times, *No Whipping Out of the Puddle*, to produce a sound weld.

Failure to follow these techniques may result in porosity, undercut, slag inclusions, or lower impact strength.

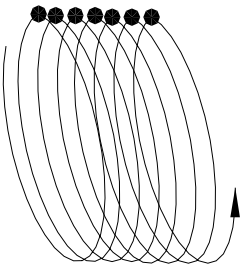
Oscillation Techniques for the E7018

* Use a straight side–to–side weave for the flat, vertical and overhead positions.



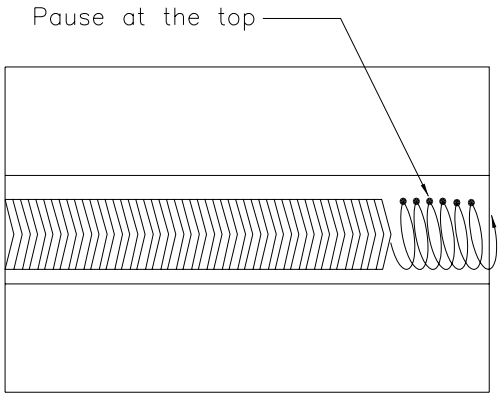
Pause slightly at the sides

* Use a slant loop technique for the horizontal welding positions.



Pause slightly at the top of the rotation Note: For a horizontal weld, the maximum bead width should be no more than 1/2" wide. Excessively wide beads will lead to an over lap condion.

The Slant Loop technique is also an excellent choice for fill pass.



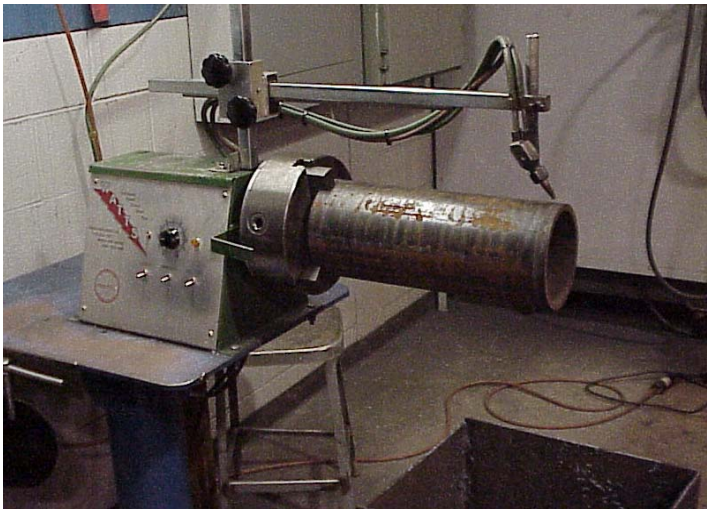
Welding Sequence for the horizontal position (2G).

The first cover pass is shown in the picture to the right.

Note that there is enough room for the electrode to fit into the crevice for the second pass.

Pictured to the right is a completed horizontal weld. Note that the post weld clean-up has not been completed.

Watts Pipe Cutter Information Sheet



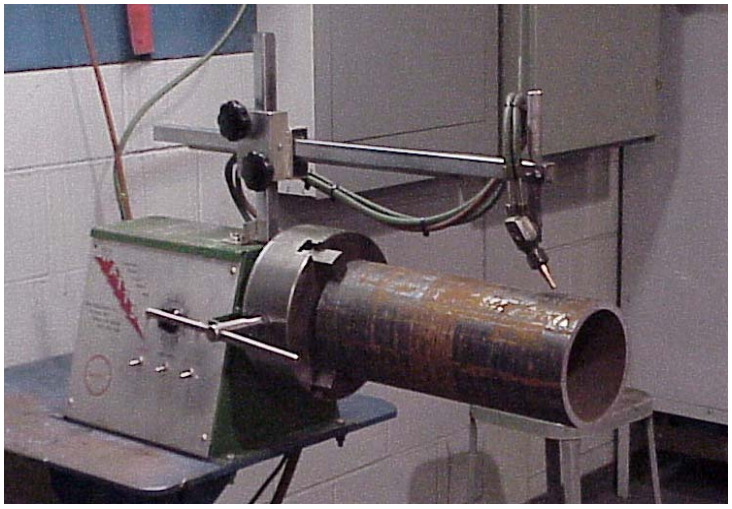
- The Watts pipe beveler uses oxygen and acetylene gas to flame cut pipe bevels. All safety procedures that apply to the track burners and hand torches will apply with this pipe beveler.

- Place pipe in jaws and snug jaws down with T-bar wrench.

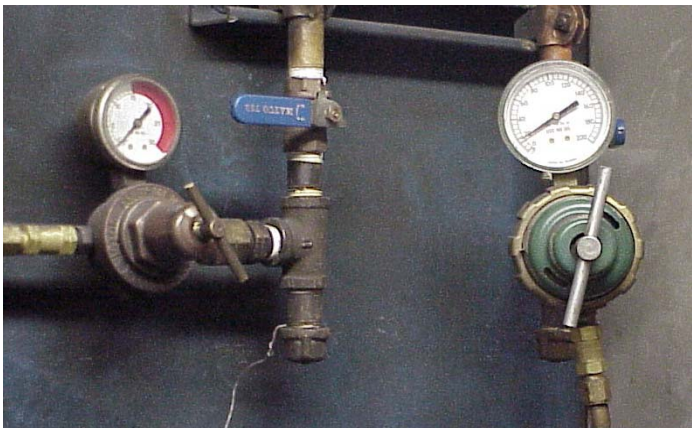
- Swivel cutting head over pipe ensuring there is approximately ¾" clearance between the cutting tip and pipe.

- Slowly hand rotate the pipe referencing the cutting tip to pipe wall distance. For a quality cut this variation should not exceed 1/16". Make adjustments when necessary.

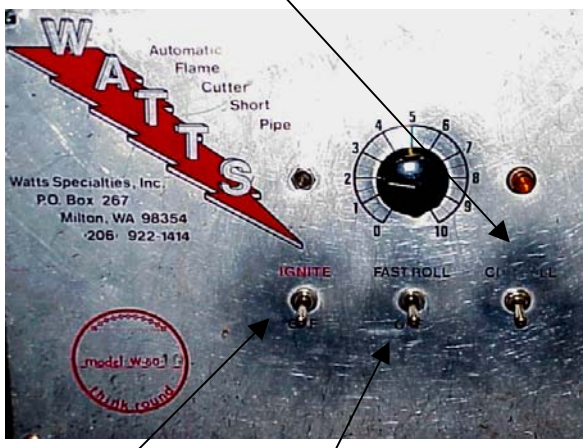
- Tighten jaws after alignment is completed.

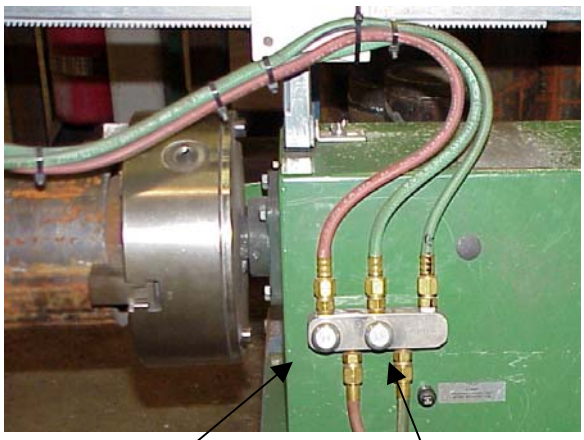


- Turn on manifold and adjust cutting pressures. A good starting point is 5 psi for Acetylene and 40 psi for Oxygen.



- Turn the *Ignite toggle switch* ON and open the acetylene needle valve on the back side of the unit. Light the torch and adjust the acetylene flame so the heavy soot disappears.

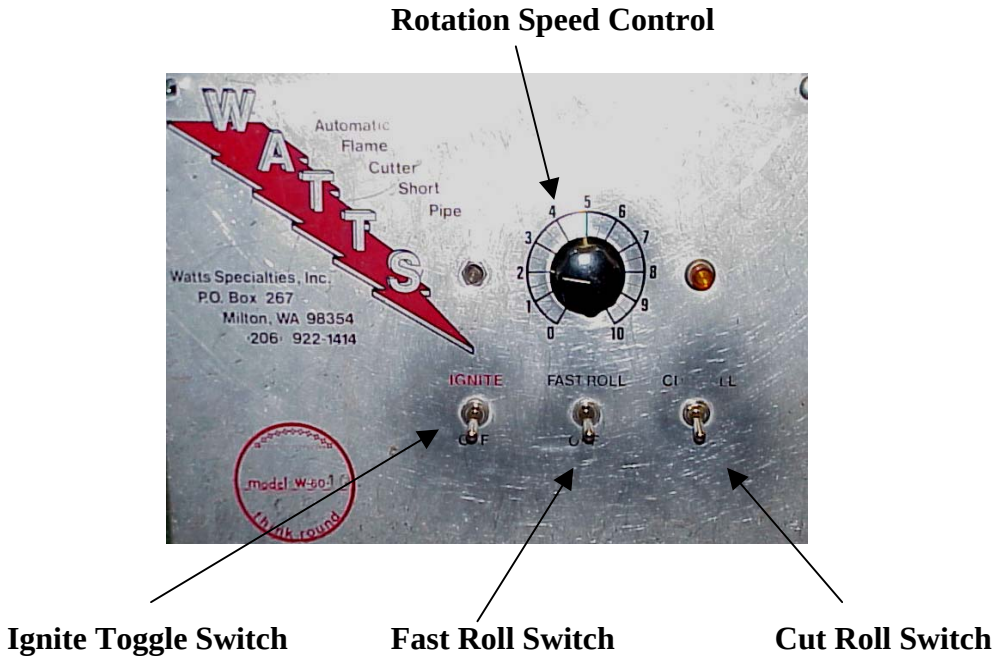




- Add oxygen, and adjust to a neutral flame.

- Turn the *Cut and Roll toggle switch* ON and adjust to a neutral flame. When adding the cutting oxygen, the fuel gas to oxygen ratio changes, thus requiring the need to readjust to a neutral flame.

- Once flame is adjusted, the manual needle valves do not need to be turned off each time. Use the *Ignite toggle switch* to turn ON and OFF the torch.



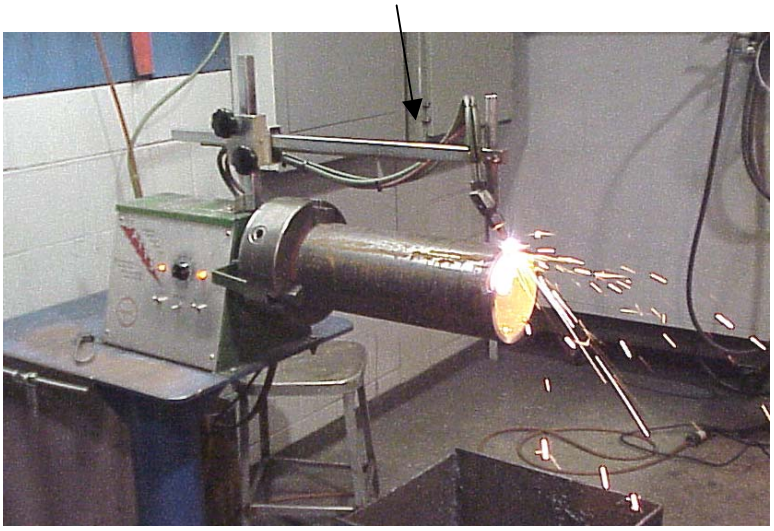
- Light torch and align head over the pipe. Use the *Fast Roll toggle* switch and preheat the pipe by having it rotate 360 degrees. Once pipe is preheated let the torch set idle over one area to heat the kindling temperature (cherry red).

  Helpful Hint: Clamp vice grips at the cutting start point. This is a good visual reference for when the pipe cut will be completed as well as a tool to catch the pipe coupon.

- Once pipe is cherry red, turn the *Cut and Roll toggle switch* on and the cut will begin.

  Helpful Hint: Once flame pierces through the pipe, adjust the torch back slightly to remove the starting flaw.

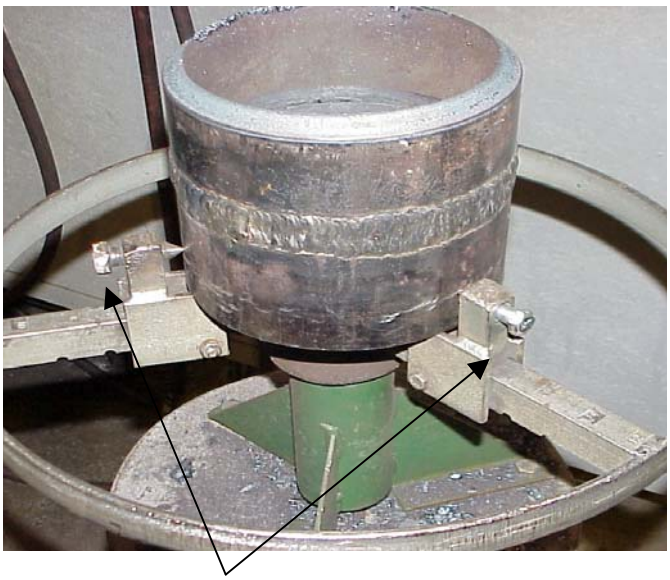
Torch Extension Arm



- Once pipe cut is completed, adjust torch extension arm back to make additional cuts or remove pipe coupon and replace with next coupon and complete the cutting process.

Watt's Pipe Grinding Station Information Sheet

- Ensure pipe is cool enough to touch before handling it.
- Mount pipe in the rotating fixture ensuring that it is mounted concentrically.
- Tighten the thumbscrew ensuring that the pipe is secure.



Thumb Screws

- Hand start the pipe fixture rotation and then begin grinding the groove face.

- Ensure grinder has enough clearance, so it does not hit or catch on the rotating fixture.

- Do not let the fixture rotate too fast. Slow it down frequently so that the pipe is not thrown from the fixture.

- Ensure the grinder is placed in such a manor that the sparks are shooting downward.

- Ensure screens are in place so no by standers are showered with sparks.

- Grind the groove face to a mirror image. Also polish the internal and external surfaces to prevent contamination pick up. Remember to grind the groove face to a "knife edge." In general, no root face is needed for the GTAW root pass application unless the welder prefers. The root face may be 0" to 1/8".

- Once the grinding and polishing operation is completed, remove pipe coupon and replace with next coupon and complete the preparation process again.

Fitting up the Pipe

"Dry" fit pipe together by rotating top pipe on the bottom one to determine best fit-up to eliminate high-low condition and excessive root opening. Once the best fit up is determined, draw a soap stone line to indicate placement of pipe coupons once the spacer is put into place.

High Low

A ***high-low*** condition refers to the pipe material being offset at the root area. This is due to each pipe coupon not being a perfect circle. The ASME Code only allows 1/16" for high low.

Use Filler metal as a spacer wire between the pipes for the proper root opening and place the pipe coupons back together as previously determined.

Make the first tack weld ¼” to ½” long between the open ends of the filler metal spacer. The first tack should be a maximum of ½” long to help control distortion. The remaining three tacks should be ¾” long for 6 inch diameter pipe.

Remove the spacer wire and reposition it as shown and weld the second tack opposite of the first tack (this is referred to as *diametrically opposed* to the first tack).

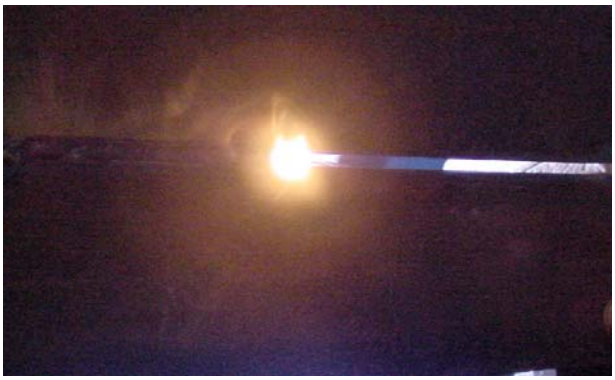
Tack weld the two remaining sides starting with the wider of he two sides. At this point the pipe should have one tack weld at 12, 3, 6 and 9 o’clock positions.

Use a hand grinder with a 1/8" thick notching wheel to feather (ramp) the tacks. Too much grinding on the ends of the tack will potentially cause burn through when welding the root pass.

Minimal grinding is all that is needed for each end of the tack.

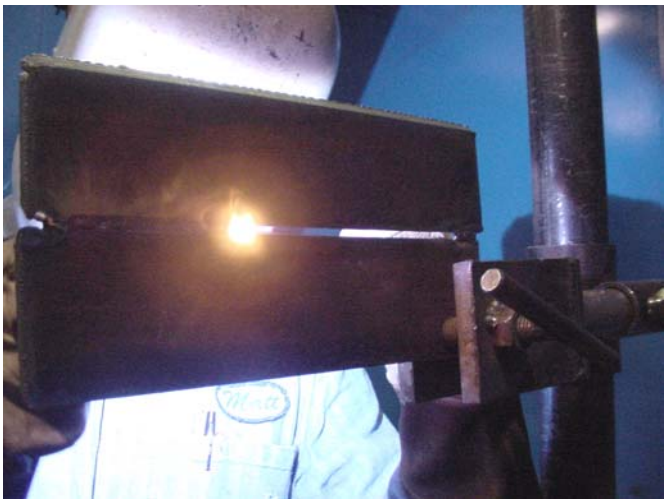
Place the pipe in the fixture in the horizontal position to be welded.

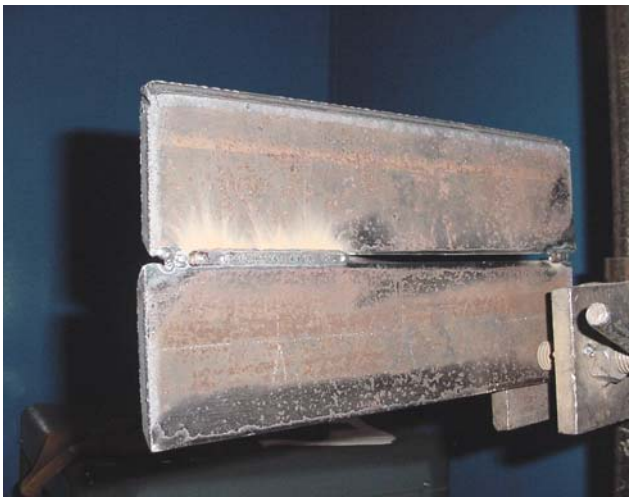
Place the filler metal at the end of the tack weld and strike the arc over the tack weld. Start "walking the cup" to advance the torch forward. Once the tungsten melts the end of the tack weld push the filler metal into the tack weld slightly to ensure complete penetration. Using a slight rotating pushing technique will assist in adding the filler metal to achieve complete penetration at this junction. Be careful to not add too much filler metal at this point because this will lead to excessive penetration.



Advance the torch forward by wiggling/walking the cup and consuming the filler metal. This technique requires the filler metal to be submerged into the puddle while the arc oscillates over it fusing it into the knife edges of the root.

There is ***no distinctive sound*** as an indicator of 100% penetration while applying the root pass with the GTAW process. The welder has to ensure the filler metal is centered in the bottom of the root and is being fused to the root surface. An indicator that 100% penetration is being obtained is a line that develops in the center of the root bead while welding is taking place. If the welder can view this during welding, s/he will know 100% penetration is being obtained.



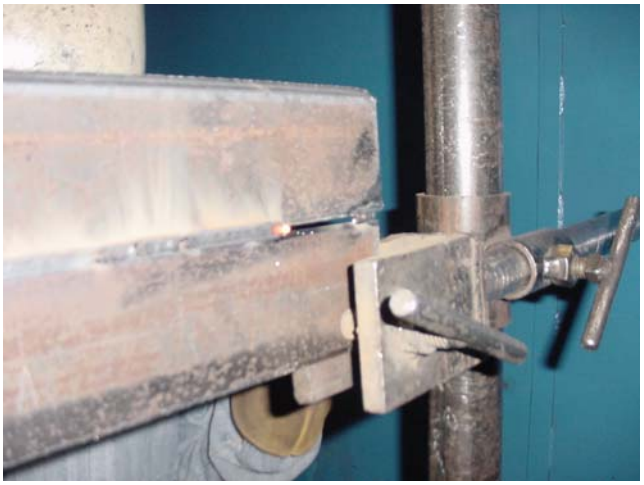


There are six variables to control when running the open root pass with the GTAW process:

- Addition of filler metal
- Root opening
- Amperage
- Arc length
- Travel speed
- Root face vs. knife edge

Suggestions for the root pass are:

- Center the filler metal in the bottom of the joint and add a slight amount of pressure to it. Be careful not to add too much pressure because the filler metal may push through without fusing into the root. Thus, leaving a portion of unconsumed filler metal protruding through the backside of the root. This would deem the weld rejectable.
- Keep the torch moving to keep the bead advancing.
- Vary filler metal size for differences in root opening. Use 3/32" diameter filler metal for tight areas and 1/8" filler metal for wide areas. For excessively wide root openings the 1/8" filler metal can be hammered flat. This will flatten the filler metal so it will catch the edges of the root opening so the filler metal will rest in the joint and not fall through the root opening.



Regardless of what pass the welder is applying, feeding the filler metal into the puddle and being able to advance the filler metal in your hand without breaking the arc is an essential function of GTA welding. Pictured to the right is one technique where the filler metal is "clamped" with three fingers and advanced with the thumb and the index finger.

Stopping techniques for the GTAW process.

Porosity has a tendency to develop in the crater when terminating a weld with an air-cooled torch, without the aid of high frequency. Use one of the following techniques to avoid this.

Technique #1 ***Chilling the Weld***
This is where the welder will extend the arc length slowly until the arc is terminated. Using this technique, the puddle will freeze and porosity will be avoided. This is an excellent technique for carbon steel applications.

Technique #2 ***Walking up the Filler Metal***
This is where the welder quickly walks the torch up the groove face and the filler metal. This increase in travel speed will reduce the puddle size and puddle will solidify without developing porosity.

Either technique will take practice to ensure high quality welds.

Root Pass inspection

A quality root pass.

Note that the filler metal is slightly protruding through the root opening. This is an indication of a correctly fit up pipe.

- Essentially there will be no slag on the GTAW root pass side. However, the root pass will still need to be inspected for complete penetration, undercut and excessive penetration. See Craftsmanship Expectations for inspection criteria.

Applying the Second Pass (the *Cold Pass*)

- The second pass, which is known in SMAW pipe welding as the "hot pass", is critical for a sound root pass. The hot pass purposes include - "burning out slag", recontour the pass, and annealed the root. With Tig welding the welder essentially puts in a "super" clean root pass that does not need the attributes of applying a hot pass. Hence a "cold" pass. It is important to not over heat the root pass thus destroying its internal contour. Therefore, the second pass will be referred to as the cold pass in this training packet.
- Clean the face of the root bead with a hand grinder using a wire brush prior to applying the cold pass. Cleanliness is very important in the GTAW process! Ensure that the wire brush is stainless steel and is not contaminated with other metals.
- Increase amperage approximately 5 to 10 amps above root bead setting. This will allow for increased travel speed.
- Change out gas nozzle to a larger size than the root pass (number 7 cup). Use the "wiggling" cup walking technique to apply the second pass. Keep the filler metal in the middle of the root pass while maintaining a consistent arc length across the puddle and emphasize the side walls when welding. Keeping a steady forward travel speed is important so the root pass is not over heated and the internal contour is destroyed.
- Using the "Cup Walking" technique, place the filler metal in the middle of the root bead while welding regardless of the plate/pipe's position. Walk the cup forward consuming the filler metal. It is important to keep the filler metal submerged into the puddle. This is called "running the wire." While welding, do not pause the tungsten electrode in the center of the joint. This will over heat the root bead thus destroying the internal root bead contour. It is important to emphasize the side walls with out slowing down across the middle of the weld while applying the second pass.

The purpose of the second pass is to provide additional thickness to the root bead so the first SMAW E7018 layer does not burn through the root pass.

Low Hydrogen Fill and Cover Pass Technique

Equipment Set-up

- Turn the welder off and switch out the GTAW torch for the SMAW electrode holder ("stinger").
- Change the polarity to Direct Current Electrode Positive (DCEP or DCRP)
- Obtain scrap material to set the amperage for the E7018 electrode.

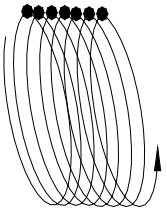
Special Note:

Remember, a tight arc length is essential when welding with the E7018. The puddle relies on the vaporization of the flux and the molten slag for added shielding. Keep electrode in the puddle at all times, *No Whipping Out of the Puddle*, to produce a sound weld.

Failure to follow these techniques will result in porosity, undercut, slag inclusions, or lower impact strength.

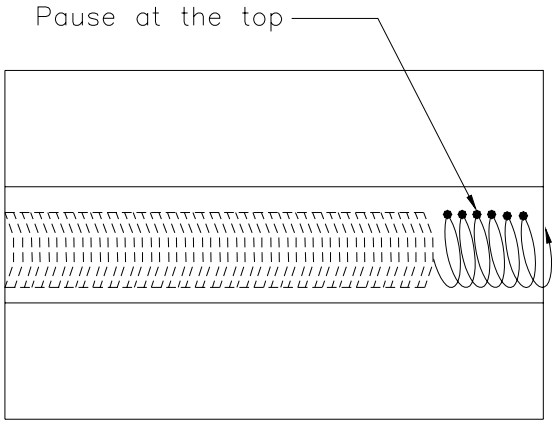
Oscillation Techniques for the E7018

- Use a slant loop technique for the horizontal welding positions.



Pause slightly at the top of the rotation Note: For a horizontal weld, the maximum bead width should be no more than ½" wide. Excessively wide beads will lead to an over lap condition.

The *Slant Loop* technique is also an excellent choice for fill pass.



Welding Sequence for the horizontal position (2G).

The first cover pass is shown in the picture to the right.

Note that there is enough room for the electrode to fit into the valley for the second pass.

Pictured to the right is a completed horizontal weld. Note that the post weld clean-up has not been completed.

Welding Vocabulary

Name:_____ Date: _____

Directions:
Define the following terms. Use the textbooks in the Welding Resource Room (Bldg 2/132a) if these terms are not in the Welding Principals and Applications.

1. High-Low

2. Suck Back

3. ER70S-6

4. Feathering tacks

5. Burn Through

6. Bevel Angle

7. Defect

8. Knife Edge (Root Face)

9. Root Penetration

10. Root Opening

11. DCEN

12. DCEP

13. Arc Length

14. Over Lap

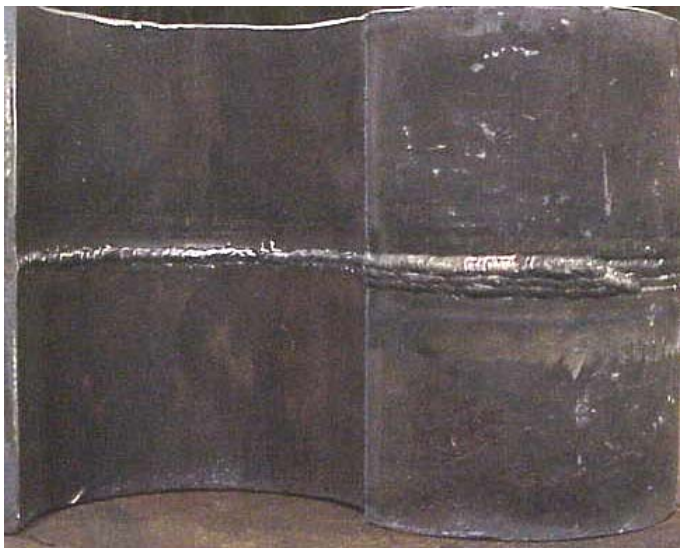
Craftsmanship Expectations for Welding Projects

The student should complete the following tasks prior to welding.

1. Thoroughly read each drawing.
2. Make a cutting list for each project. Cut at least two project's assemblies at a time. This will save a great amount of time.
3. Assemble the welding projects per drawing specifications.
4. Review Welding Procedure portion of the prints to review welding parameter information.
6. See the instructor for the evaluation and assistance.

Factors for grading welding projects are based on the following criteria:

Metal Preparation	**Project Layout**	**Post Weld Clean-up**
Oxyfuel Cut quality	Accurate (+/- 1/16”)	Remove Slag/Spatter
Grind all cut surfaces clean	Limit waste	Remove sharp edges



Weld Quality per ASME Section IX and AWS D1.1

VT Criteria	**Root Pass**	**Cover Pass**
Reinforcement	Flush to 1/16”	Flush to 1/8”
Undercut	1/32 “ deep	1/32” deep
Bead Contour	Smooth Transition	Smooth Transition
Penetration	Complete Joint Penetration	N/A
Cracks	None Allowed	None Allowed
Arc Strikes	None Allowed	None Allowed
Fusion	Complete Fusion Required	Complete Fusion Required
Porosity	None Allowed	None Allowed

GTAW/SMAW Butt Joint- Single Vee (2G) Project #1

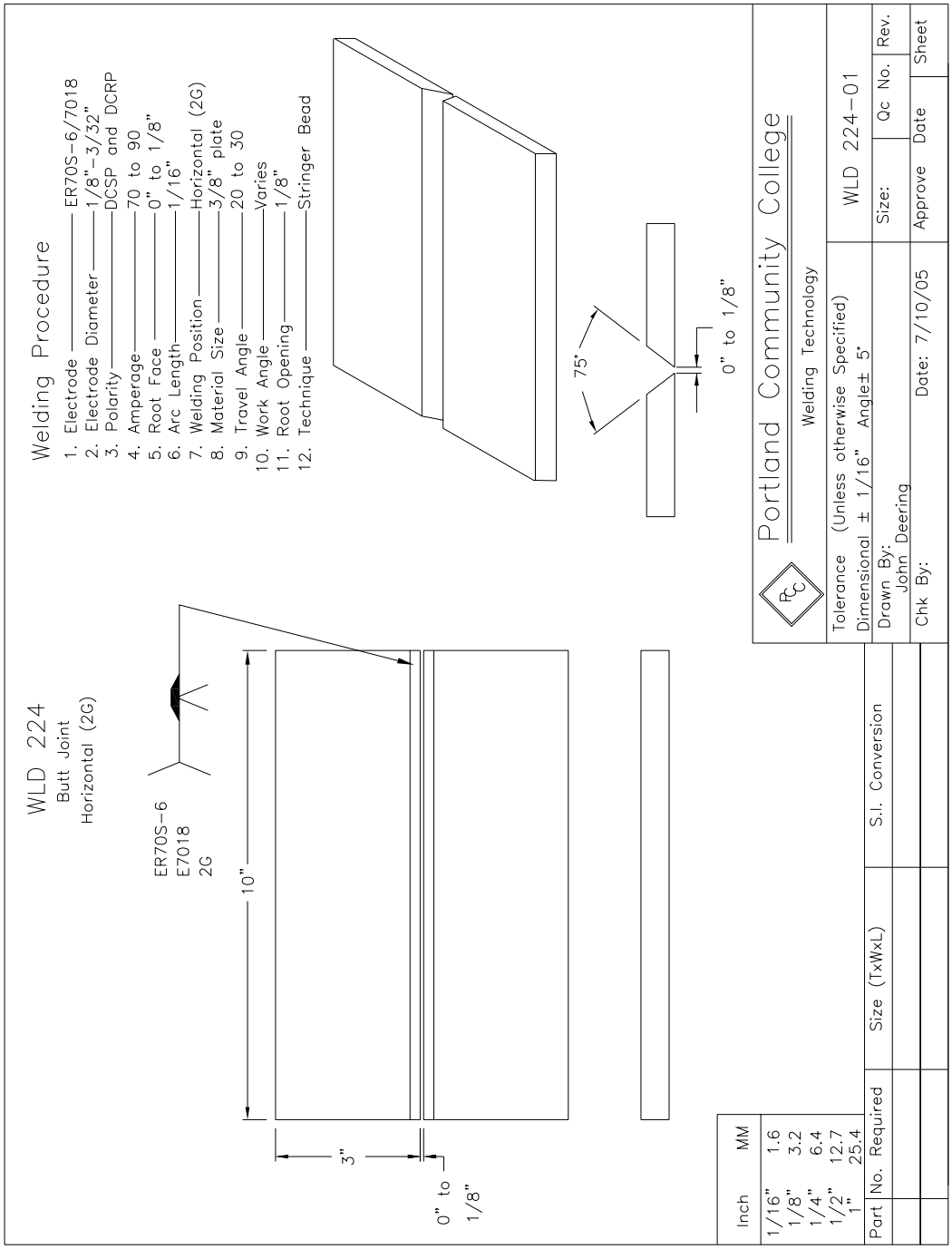
Welding Sequence

GTAW --Root Pass	Utilize the cup walking technique to apply the root.
GTAW --Cold Pass	Increase amperage approximately 10 amps above the root bead setting.
SMAW E7018--Fill and Cap	A tight arc is essential with the E7018, keep the electrode in the puddle-No Whipping. Use a stringer bead technique for the horizontal position.

Front view of the horizontal groove weld

Weld Quality per ASME Section IX and AWS D1.1

VT Criteria	Root Pass	Cover Pass
Reinforcement		
Undercut		
Bead Contour		
Penetration		**N/A**
Cracks		
Arc Strikes		
Fusion		
Porosity		
Grade and Date		


WLD 224
Butt Joint
Horizontal (2G)
Welding Procedure
1. Electrode — ER70S-6/7018
2. Electrode Diameter — 1/8"-3/32"
3. Polarity — DCSP and DCRP
4. Amperage — 70 to 90
5. Root Face — 0" to 1/8"
6. Arc Length — 1/16"
7. Welding Position — Horizontal (2G)
8. Material Size — 3/8" plate
9. Travel Angle — 20 to 30
10. Work Angle — Varies
11. Root Opening — 1/8"
12. Technique — Stringer Bead
ER70S-6
E7018
2G
10"
3"
0" to 1/8"
75°
0" to 1/8"
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle± 5°
Drawn By: John Deering
Chk By:
Date: 7/10/05
WLD 224-01
Size:
Qc No.
Rev.
Approve
Date
Sheet
Inch MM
1/16" 1.6
1/8" 3.2
1/4" 6.4
1/2" 12.7
1" 25.4
Part No. Required
Size (TxWxL)
S.I. Conversion

GTAW/SMAW Butt Joint- Single Vee (3G) Project #2

Welding Sequence

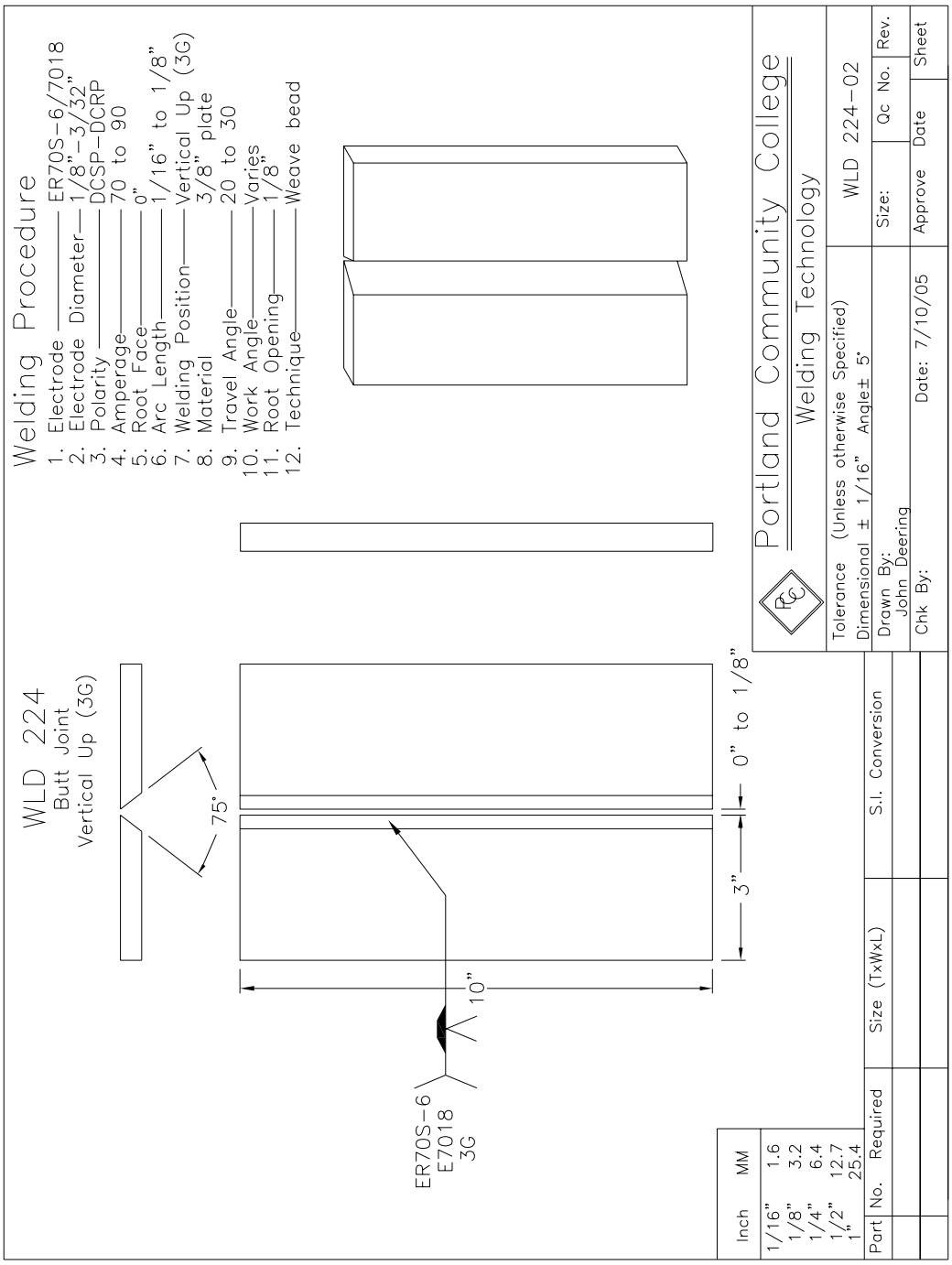
GTAW --Root Pass	Utilize the cup walking technique to apply the root.
GTAW --Cold Pass	Increase amperage approximately 10 amps above the root bead setting.
SMAW E7018--Fill and Cap	A tight arc is essential with the E7018, keep the electrode in the puddle-No Whipping. Use a stringer bead technique for the horizontal position.

Root Pass View

Cover Pass View

Weld Quality per ASME Section IX and AWS D1.1

VT Criteria	Root Pass	Cover Pass
Reinforcement		
Undercut		
Bead Contour		
Penetration		**N/A**
Cracks		
Arc Strikes		
Fusion		
Porosity		
Grade and Date		


Welding Procedure
1. Electrode ER70S-6/7018
2. Electrode Diameter 1/8"-3/32"
3. Polarity DCSP-DCRP
4. Amperage 70 to 90
5. Root Face 0"
6. Arc Length 1/16" to 1/8"
7. Welding Position Vertical Up (3G)
8. Material 3/8" plate
9. Travel Angle 20 to 30
10. Work Angle Varies
11. Root Opening 1/8"
12. Technique Weave bead
WLD 224
Butt Joint
Vertical Up (3G)
75°
ER70S-6
E7018
3G
10"
3"
0" to 1/8"
Inch MM
1/16" 1.6
1/8" 3.2
1/4" 6.4
1/2" 12.7
1" 25.4
Part No. Required
Size (TxWxL)
S.I. Conversion
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle± 5°
Drawn By:
John Deering
Chk By:
Date: 7/10/05
WLD 224-02
Size:
Qc No.
Rev.
Approve
Date
Sheet

GTAW/SMAW Butt Joint- Single Vee (4G) Project #3

Welding Sequence

GTAW --Root Pass	Utilize the cup walking technique to apply the root.
GTAW --Cold Pass	Increase amperage approximately 10 amps above the root bead setting.
SMAW E7018--Fill and Cap	A tight arc is essential with the E7018, keep the electrode in the puddle-No Whipping. Use a stringer bead technique for the horizontal position.

Root Pass View

Cover Pass View

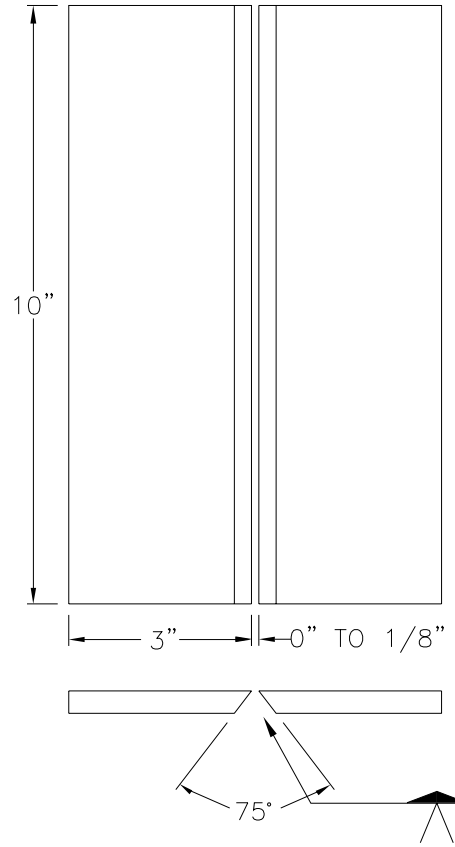
Weld Quality per ASME Section IX and AWS D1.1

VT Criteria	Root Pass	Cover Pass
Reinforcement		
Undercut		
Bead Contour		
Penetration		**N/A**
Cracks		
Arc Strikes		
Fusion		
Porosity		
Grade and Date		

WLD 224

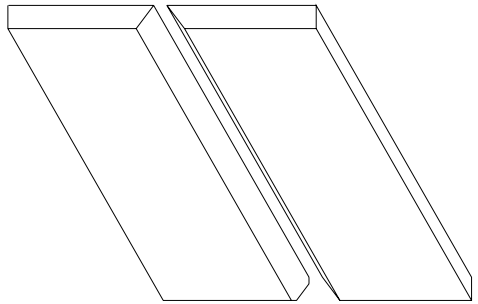
Butt Joint

Overhead Joint (4G)



Welding Procedure

1. Electrode——ER70S-6/7018
2. Electrode Diameter—1/8"-3/32"
3. Polarity——DCSP-DCRP
4. Amperage——70 to 90
5. Root Face——0"
6. Arc Length——1/16" to 1/8"
7. Material Size——3/8" plate
8. Welding Position——Overhead (4G)
9. Travel Angle——20 to 30
10. Work Angle——20 to 70
11. Root Opening——1/8"
12. Technique——Weave bead



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)
Dimentional ± 1/16" Angle± 5°

WLD 224-03

Drawn By: John Deering

Size: | Qc No. | Rev.

Chk By: Date: 7/10/05

Approve Date | Sheet

GTAW/SMAW Butt Joint- Single Vee Pipe (2G) Project #4

Welding Sequence

GTAW --Root Pass	Utilize the cup walking technique to apply the root.
GTAW --Cold Pass	Increase amperage approximately 10 amps above the root bead setting.
SMAW E7018--Fill and Cap	A tight arc is essential with the E7018, keep the electrode in the puddle-No Whipping. Use a stringer bead technique for the horizontal position.

Weld Quality per ASME Section IX and AWS D1.1

VT Criteria	Root Pass	Cover Pass
Reinforcement		
Undercut		
Bead Contour		
Penetration		**N/A**
Cracks		
Arc Strikes		
Fusion		
Porosity		
Grade and Date		

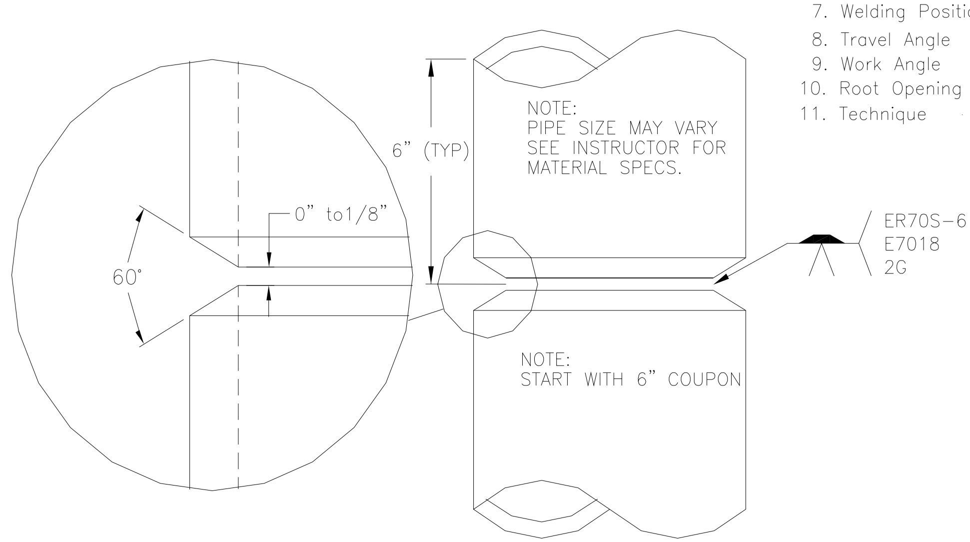
WLD 224

GTAW Pipe, Butt Joint

Single V-Groove (2G)

Welding Procedure

1. Electrode ER70S-6/7018
2. Electrode Diameter . . . 1/8"-3/32"
3. Polarity . . . . DCSP/DCRP
4. Amperage . . . . 70 to 90
5. Root Face . . . . 0"
6. Arc Length . . . . 1/16" to 1/8"
7. Welding Position . . . . Vertical Pipe (2G)
8. Travel Angle . . . . 20 to 30
9. Work Angle . . . . Varies
10. Root Opening . . . . . . 1/8"
11. Technique . . . . Stringer bead



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 (WxHxT)	S.I. Conversion

Portland Community College

Welding Technology

Tolerance (Unless otherwise Specified) Dimensional ± 1/16" Angle± 5°	WLD 224-04		
Drawn By: John Deering	Size:	Qc No.	Rev.
Chk By: Date: 06/25/05	Approve	Date	Sheet

Final Exam

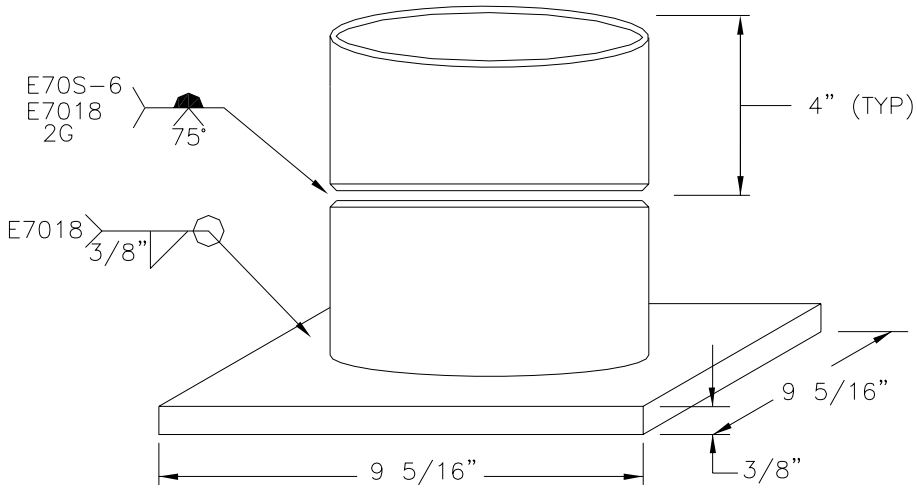
Part One
This portion of the final exam is a closed book test. Consult with your instructor to determine items that you may need to review. Complete the exam and write all answers on the answer sheet provided. Once completed, return the exam and answer sheet to your instructor.

Part Two
This portion of the exam is a practical test where you will fabricate and weld a weldment from the drawing attached to the final exam. The evaluation of this portion of the exam will be based on the grading rubric attached.

WLD 224

Final Exam

1. Use the GTAW process to weld the root & second pass.
2. Use the SMAW process to weld the fill & CAP passes.
3. Use WPS for weld fit up requirments, root & second pass.



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) Fraction ± 1/16" Angle± 5°		WLD 224–Final Exam
Drawn By: John Deering	Size:	Qc No. / Rev.
Chk By: Date: 7/10/05	Approve Date	Sheet

***Name*_____**

WLD 224 Grading Rubric for the Practical Exam

Hold Points

Hold Points are mandatory points in the fabrication process that 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 ASME and AWS D1.1 Code requirements.*	
	Total Points	_____