WLD 151
SMAW Certification Practice: Unlimited Thickness Mild Steel

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

INTENDED OUTCOME (S) 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 groove joints with E7018 welding process to code quality standards in the vertical, and overhead positions

- Develop a working knowledge of the vocabulary used in the welding industry.
- Use correct terminology.
- Define terms used in the Shielded Metal Arc Welding process.
- Equipment identification, setup, shut down, and adjustment of equipment to settings called for.
    - Welding lead connections, inspection, and proper use
    - Filler rod identification and classification, characteristics, and use

- Demonstrate how to adjust travel speed and amount of heat for thickness of material, and weld bead size.
- Demonstrate correct welding techniques with the SMAW welding process.
  Starting and stopping
  Overlapping welds
  Follow welding procedure
- Demonstrate correct welding techniques in the following joints:
  Vertical Position:
    V-groove 3G
  Overhead Position:
    V-Groove 4G
- Demonstrate visual examination principles and practices
    Know Visual inspection Criteria

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

Reading

The Welding Principles and Applications: by Larry Jeffus.

Writing Work Sheets

Codes & Specifications
Welder Qualification Tests
Performance Qualification

Video Training

Miller Module - 10 AWS Bend Test

Cutting Projects

Complete Bill of Materials

Welding Projects

6" Vertical Groove
6" Overhead Groove
Bend Tests Procedures

Final Exam

Closed Book Exam

Required Texts

The Welding Principles and Applications: By Larry Jeffus

Reference List

Welding Principles and Applications: by Larry Jeffus
Standard Welding Terms and Definitions: ANSI/AWS A3.0-94
AWS D1.1 Structural Steel Welding Code

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.

Contents of this Packet

Importance of Code Qualification

In all industries, there are applicable codes and standards to assure the quality, reproducibility, and adequacy of welded joints. Depending upon the application, a welded joint may need certain mechanical properties; for example, welds on bridges must pass tests for strength, tensile ductility, bend ductility, and Charpy impact toughness. These codes are based on many years of experience. Changes to codes are ongoing to reflect the dynamic changes that taking place in the industry. There are many welding codes to ensure quality welding. For example, the following is a list of only a few typical industries and governing codes for welding quality.

Pressure Vessels	ASME Boiler and Pressure Vessel Code (Vol. IX – Welding Qualifications)
Pipe and Pipelines	API Standard 1104; Standard for Welding Pipelines and Related Facilities
Pressure Piping	ASME Code for Pressure Piping B31
All Steel Structures	AWS D1.1 Structural Welding Code – Steel
Buildings	AISC Specification for Structural steel Buildings
Bridges	AASHTO/AWS D1.5; Bridge Welding Code
Ships	ABS Rules for Building and Classing Steel Vessels
Sheet Metal	AWS D9.1; Sheet Metal Welding Code
Automotive Frames	ANSI/AWS D8.8; Specification for Automotive Frame Weld Quality
Aircraft	MIL-STD-1595A; Qualification of Aircraft, Missile and Aerospace Fusion Welders

Why Mechanical Properties Testing?

In all codes for welded structures and pipe, various degrees of mechanical testing are performed to assure the quality and integrity of the structure. This includes both procedure qualification and welder qualification. For example, the procedure qualification for steel structures in accordance with the AWS D1.5 Bridge Welding Code–Steel requires that certain welds undergo all-weld-metal tensile testing, transverse-to-weld tensile testing, side bend testing, Charpy v-notch (CVN) impact testing as well as non-destructive testing. Mechanical testing is very important because it ensures that the welding procedure, welder qualification, consumables, and the resulting metallurgy of the weld and heat-affected zone are all acceptable.

AWS D1.1 Structural Steel Welding Code

When a structure is going to be built, the owner and contractor agree on the appropriate welding code, which will be needed to govern the acceptability or rejection of structural welds being fabricated. AWS D1.1 Structural Welding Code – Steel is devised to provide welded joints with acceptable strength, ductility, and CVN impact toughness for the intended application, such as a building, general construction, motorized vehicle, etc. Not only are procedure qualification requirements but also welder qualification and certification. The qualification and certification tests for welders are specially designed to determine the welder's ability to produce sound welds routinely. To achieve these quality standards, the welder qualification and certification provide the means to ensure acceptable welds.

Significance of Bend Testing

Of all the tests prescribed by different welding codes, the bend test provides the best and most reliable measure of ductility of the entire weld joint, including the weld metal, heat-affected zone, and unaffected base metal. Welder qualification tests in AWS D1.1 always specify bend testing of welded joints. This is because the bend test is extremely sensitive to all types of metallurgical problems associated with welding. For example, weld joints which have inadequate ductility and fail the bend test may be have been affected by: (a) hydrogen assisted cracking, (b) micro fissuring due internal solidification cracking, (c) excessive slag inclusions, (d) excessive porosity, (e) wrong filler metal, causing embrittlement, (e) wrong welding parameters, causing embrittlement, and (f) other metallurgical factors affecting the ductility of the weld joint.

There are three types of bend tests, (1) side bend, (2) face bend, and (3) root bend. Side bend tests are generally required for welds that are greater than 3/8-inch thick for AWS D1.1 and over ½-inch thick for API-1104. For example, a 2-inch thick butt joint deposited by single-pass electroslag welding could not be tested by face or root bend testing, because the thickness is too great for practical testing. However, a 2-inch thick butt joint can be machined to several 3/8-inch thick side bend specimens and tested easily.

So, face and root bending are used to test the ductility of butt joints that are thinner than 3/8-inch. Whether face bends, root bends, or both face and root bends specimens are required depends upon the code used. In AWS D1.1 Structural Welding Code, both face and root bends are required in most cases. The root bend test determines the adequacy of the root preparation and soundness of the root portion of the weld joint. This is particularly important in open root welding applications. Similarly, the face bend test determines the adequacy of the weld metal deposited on the face of the joint. These specimens must be able to withstand bending strains that are produced when a plunger forces a 3/8-inch thick welded specimen into a guided bend fixture. The plunger, having a specified bend radius, forces the welded bend specimen into a die in order to endure a specified amount of bending (or plastic deformation), that is required by the code for structural applications. From Table 1, the plunger radius and plunger thickness increase with increasing yield strength of the base metal being tested. Bending becomes more difficult with increasing yield strength, because ductility decreases as the strength of the steel increases. Thus, AWS D1.1 permits the bend radius required for welder qualification to increase with increasing yield strength, as shown in Table 1.

Table 1 Specified Bending Parameters for Guided Bend Test for Steel Welds in accordance with AWS D1.1 Structural Welding Code - Steel

Yield Strength Of Base Metal	Plunger Thickness	Plunger Radius	Interior Die Opening	Die Radius
50,000psi and less	1 ½”	¾”	2 3/8”	1 3/16”
Over 50,000psi to 90,000psi	2”	1”	2 7/8”	1 7/16”
90,000psi and greater	2 ½”	1 ¼”	3 3/8”	1 11/16”

Bend Testing of Welds deposited with E7018 and other Low Hydrogen electrodes

The bend test for steel welds is very sensitive to the presence of diffusible hydrogen in the weld. Typically, these welds will fail in the heat-affected zone of high strength steels. Even if non-destructive testing shows a welded steel to be crack-free, the bend test can activate the hydrogen cracking mechanism in steel weld metal and the heat affected zone. If either the weld metal or heat-affected zone is susceptible to hydrogen cracking, the welded specimen will not pass the guided bend test. The use of E7018 and E7018M electrodes are low hydrogen and should prevent the occurrence of hydrogen assisted cracking in the heat-affected zone of steel welds. In addition to hydrogen assisted cracking, there are many other metallurgical causes for lack of adequate ductility in a welded structure, and the bend test is best suited to separate the “good” welds from the “bad” welds.

Guided Bend vs. Free Bend Testing

The most widely used bend test, which is required by most welding codes, is the guided bend test. The benefit of the guided bend test, like that required by the AWS/AASHTO D1.5 Bridge Welding Code and AWS D1.1 Structural Welding Code is that the weld metal, heat affected zone and the unaffected base metal are subject to bending equally. This test requires expensive fixturing and a hydraulic ram to perform the guided bend test.

There is another test called the free bend test. The free bend testing apparatus is less expensive build and is hand-operated. The disadvantage of this test is that all of the zones of the weld joint (weld metal, heat affected zone and unaffected zone) are not bent equally. In free bend testing, the zone(s) having the lowest tensile strength will bend the most, while the zone(s) having the highest strength will bend the least. This effect may hide potential problems in the weld joint. This is why most codes insist on the guided bend test and not the free bend test.

Tensile Testing and Charpy V-Notch Impact Testing

For welder qualification and certification in accordance with AWS D1.1, tensile testing and Charpy v-notch (CVN) testing of the test weld are not required. However, in other codes, these tests are also used for welder qualification (in addition to bend testing).

Helpful Hints

Groove Welding Techniques

To make a quality weld when welding a groove joint is important because that weld will most likely be inspected by X-ray or Ultrasonic welding inspection techniques because it is a complete joint penetration (CJP) weld. Hence, here are a few techniques to make a successful weld.

First

Adjust the travel speed to control the amount of weld metal deposition. Travel speed controls bead width and penetration. Varying the travel speed so that a consistent width weld will be the outcome. The reason for varying the travel speed is due to the heat build up while welding.

When the arc if first struck a plate is at a lower temperature as compared to when the weld is stopped approximately six inches later. This temperature difference can be approximately 400 degrees Fahrenheit, Hence, it is important to vary the travel speed to maintain a uniform amount of fill because as the plate gets hotter more weld metal will be deposited.

Second

Maintaining an even filling of the groove is also essential. When welding, the heat input into the plate will cause a heavier deposition near the end of the weld as compare to the beginning of the weld. This can be corrected by not only adjusting your travel speed but also by adjusting your ***work angle***. With this "side angle" adjustment you can deposit more or less metal on the groove face. This is important because when welding out a groove, it is critical to reference the top shoulder on the groove face to keep an even fill for the length of the weld. This will technique will provide for a smoother more even foundation for the cover passes (finish beads).

Review the effects of:

- Travel speed
- Electrode angle (both work and travel)
- Bead placement and Planning
- Inter-pass cleaning
- Heat input control.

Visual Inspection Criteria

This section will familiarize the student with inspection criteria that will be applied to the evaluation of their projects. PCC Welding Department utilizes the visual inspection requirements set forth in AWS D1.1. The following criteria are gathered from this source.

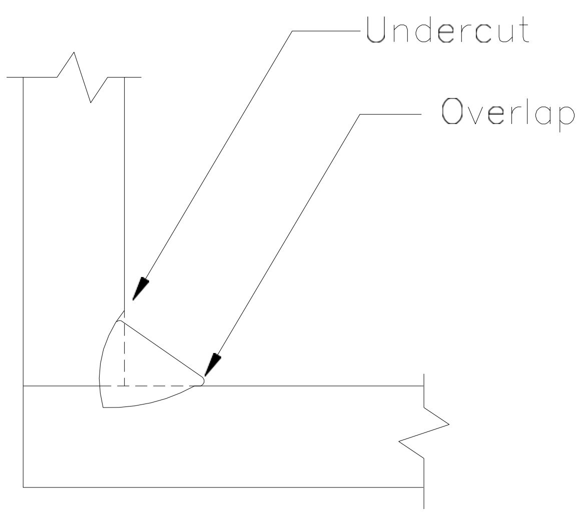
Undercut

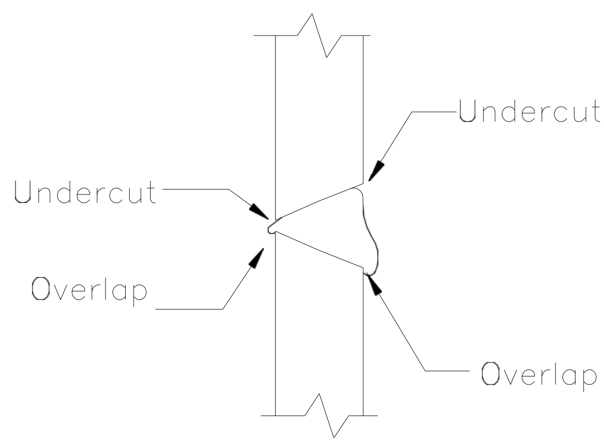
Is a condition where the base metal has been melted away during the welding operation and there is insufficient filler metal deposited to adequately fill the resulting depression. These grooves vary in depth and length. Undercut can be present at a weld-to-weld junction or a weld to base metal junction (toe of weld). Undercut causes a stress concentration point (stress riser) that is a potential starting point for weld cracking.

Causes:

Improper welding technique
Arc length too long
Oscillation too abrupt, not spending enough time on the sides of the puddle.
Amperage too high
Base material too hot
Travel speed too fast

Maximum undercut allowed is 1/32" in depth for welder qualification requirements.



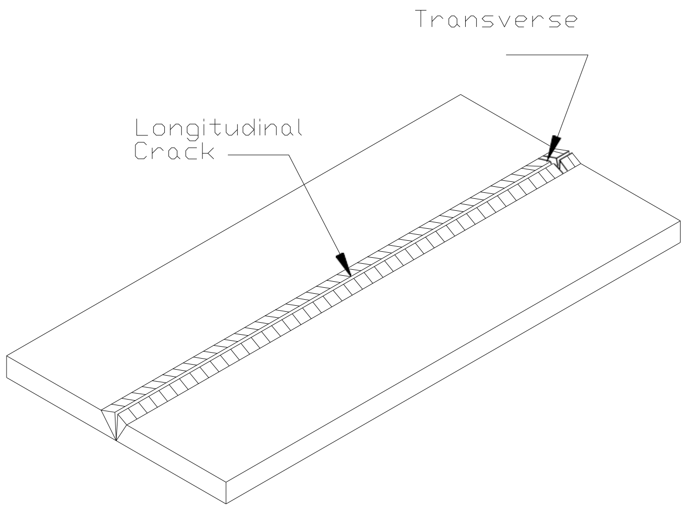


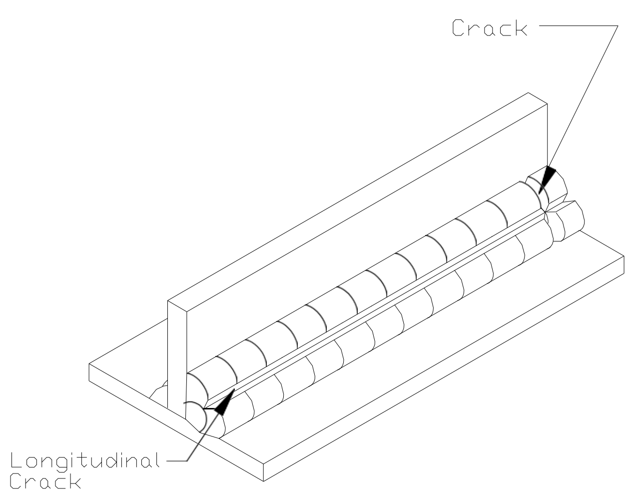
Cracks

Cracks are caused by stresses in the immediate area that exceed the strength of weld metal or base metal (tensile strength).

Cracks are a major concern because of their ends, which are generally sharp and jagged. With increased stress, the crack can then propagate (travel) in the weld or base metal causing catastrophic (total) failure.

Maximum Cracks Allowed: None





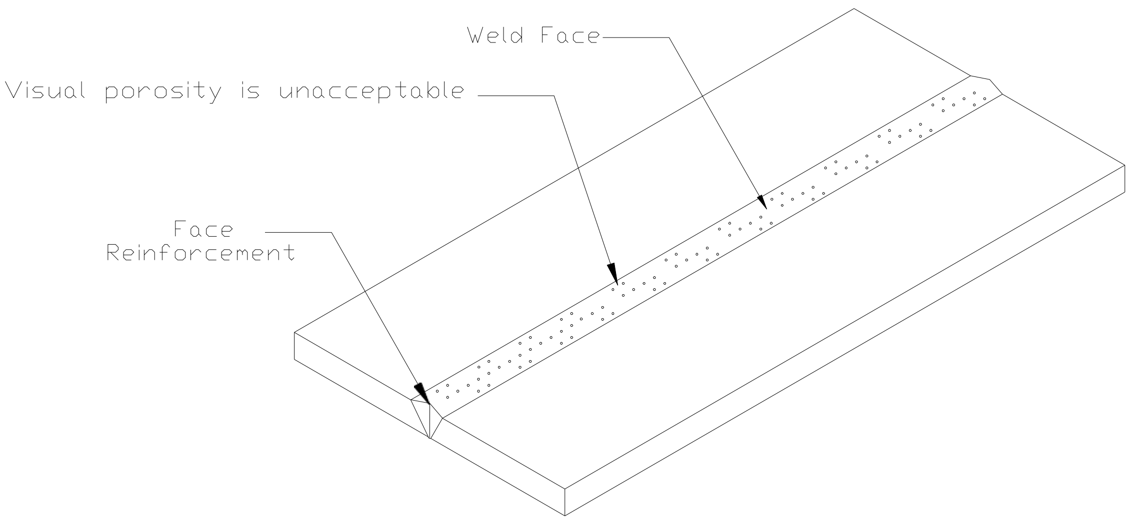
Porosity

Cavity type discontinuities caused by gas trapped during weld solidification. Due to its spherical shape, porosity is considered the least detrimental discontinuity.

Causes:

Loss of shielding gas
Base metal contamination (oils, grease, water)
Too long of an arc.

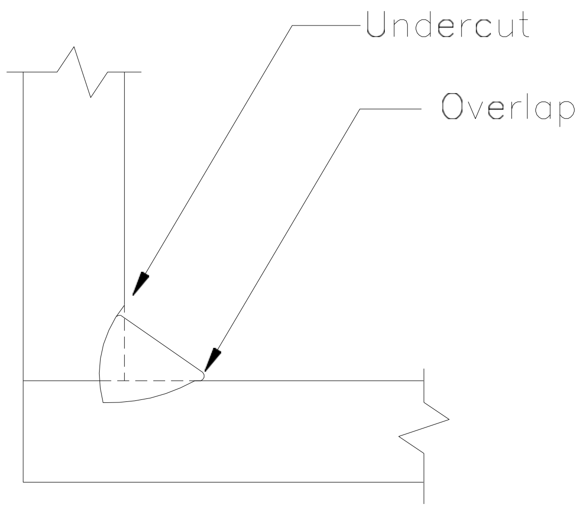
***Visual porosity is unacceptable for welder qualification requirements*.**

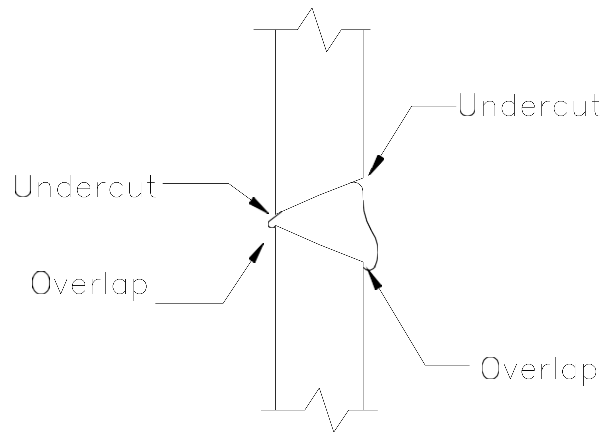


Overlap (Also known as: Cold Lap, Roll Over or Cold Roll)

Is the protrusion of weld metal beyond the weld toe or root. Due to its linearity and relatively sharp end condition, over lap represents a significant weld discontinuity.

None Allowed



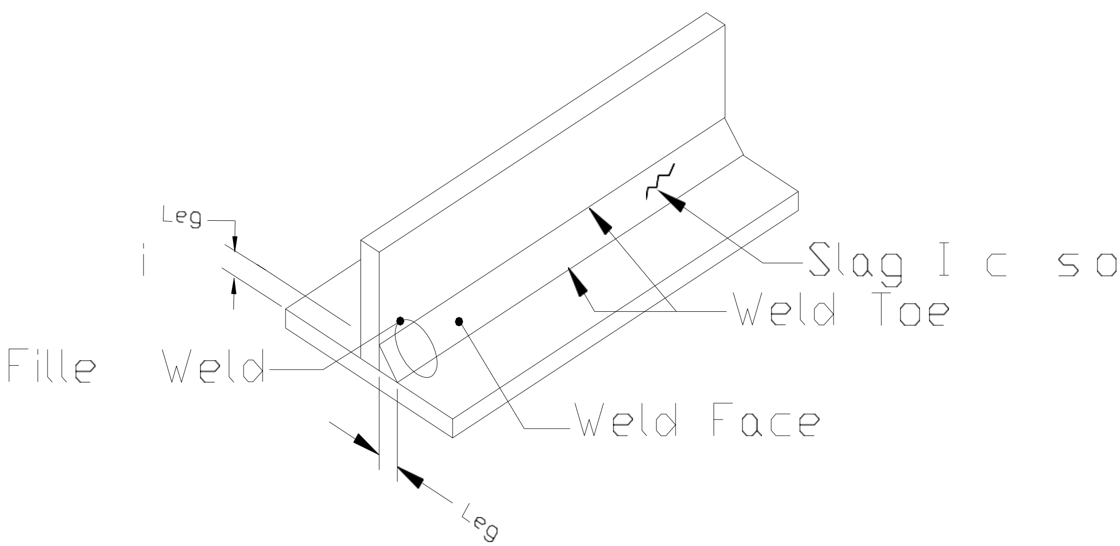


Slag Inclusions

Slag is a nonmetallic by product of the welding process. If slag is not cleaned out thoroughly prior to depositing the next pass it can be trapped. Or, if the previous weld(s) have poor weld profile slag can become trapped in the crevices when welded over.

Slag inclusions are most often caused by improper cleaning, improper electrode manipulation and or poor bead placement.

Slag Inclusion



Weld Profile

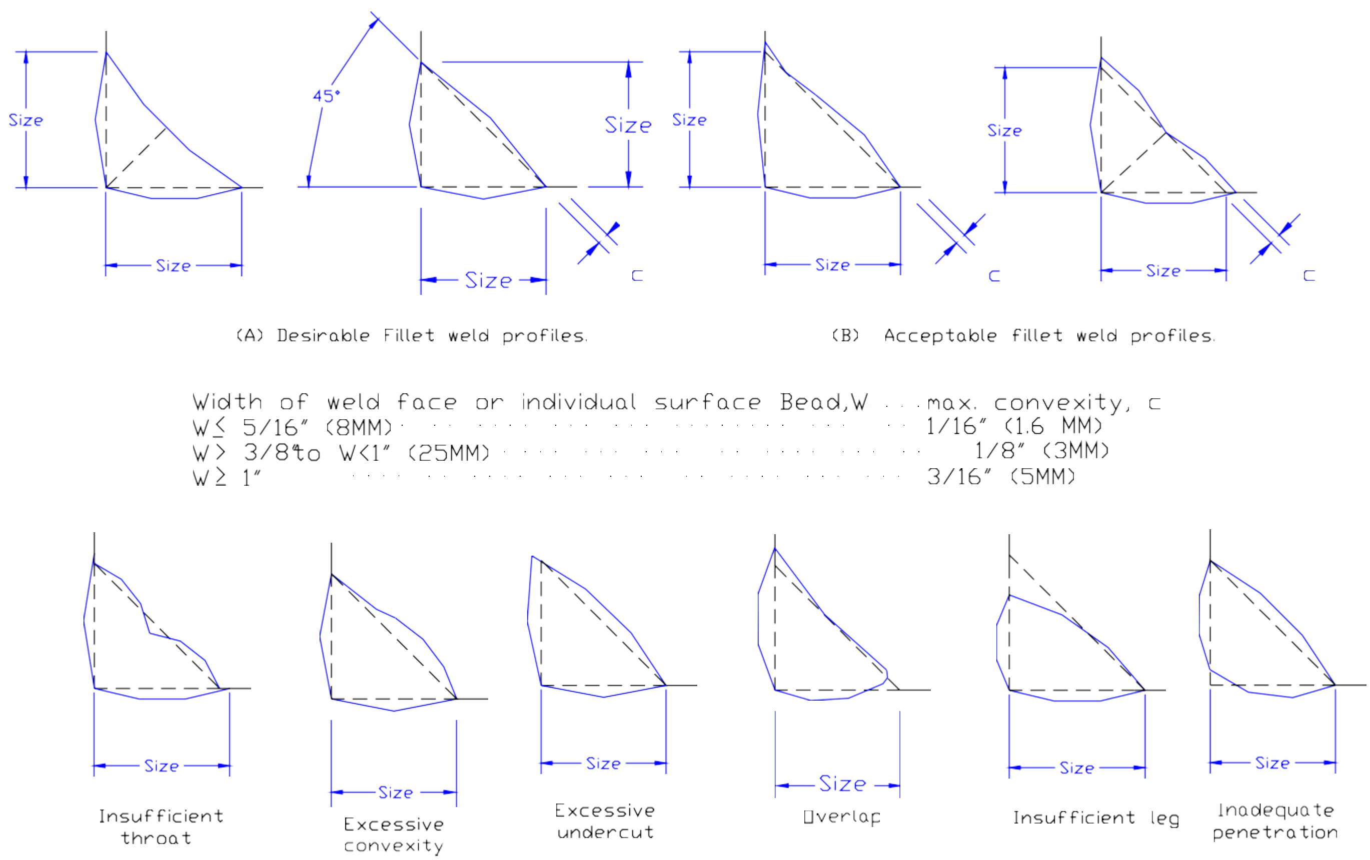
Weld profiles are important aspect of welding because they have a high tendency to cause most of the weld failures. The weld profile is also a good indicator of the internal weld quality. A good profile will usually mean a good internal weld too.

Reinforcement

Minimum: Flush with base metal
Maximum: 1/8" high

Bead Contour

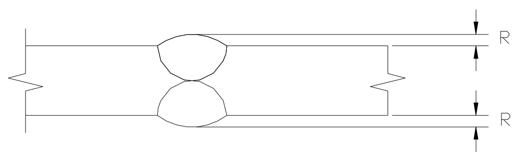
Smooth transition from bead to bead and weld metal to base metal.



Unacceptable fillet weld profiles

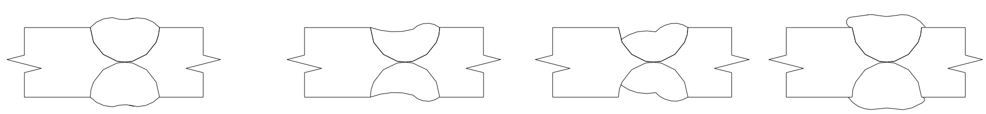
Reference AWS D1.1

Groove Weld Information Sheet



Acceptable butt weld profile.

NOTE: Reinforcement (R) shall not exceed 1/8".



Excessive Reinforcement | Insufficient Weld Size | Excessive Undercut | Overlap

WLD Infor. Sheet 2

Helpful Hints

1. Be prepared to feel confident during your test. You need to have demonstrated consistency during your practice tests. Repeat the practice tests as many times as necessary to ensure confidence and consistent performance.

2. **Be comfortable!!!** Plan your test on a day that you know you will be at your best, well rested and able to concentrate. Check your clothing, to be certain you are protected from any stray sparks. Nothing breaks your concentration faster than getting burned or catching on fire!

3. Check the condition of your cover lenses**; make sure that you can see clearly.**

4. Bring a flashlight so you may thoroughly inspect your inter-pass cleaning. Clean the weld thoroughly. Make sure your slag hammer and wire brush are in good condition.

5. Plan the weld carefully to avoid having to patch up low spots. Decide before you strike the arc the size and location of the bead you are about to run. **If the weld fill becomes uneven, fix it immediately by filling in the low areas, don't wait until the flush layer or cover layer.**

6. Notify your fellow students in your area that you are testing; ask their cooperation in avoiding any banging or movement of the booth area while you are welding.

7. **Above all don't panic!** Relax and take your time. Don't hold your breath! If at any time you become uncomfortable stop and reposition.

8. If you cannot see **STOP**. If you feel you have lost or are loosing control of the puddle **STOP**.

9. Do not over heat the plates. Allow the plates **to air cool to 200 degrees** before you attempt to weld the cover passes.

10. See **your instructor** at anytime if you have a concern. Take a break as needed.

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 assemblies of metal at a time. This will save a great amount of time.
3. Assemble the welding projects per drawing specifications.
4. Review the Welding Procedure portion of the prints to review welding parameter information.
5. See the instructor for the evaluation.

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

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

Example of a High Quality Weld

Weld Quality per AWS D1.1

VT Criteria	Cover Pass
Reinforcement (groove welds)	Flush to 1/8"
Fillet Weld Size	See specification on drawing
Undercut	1/32" deep
Weld Contour	Smooth Transition
Penetration	N/A
Cracks	None Allowed
Arc Strikes	None Allowed
Fusion	Complete Fusion Required
Porosity	None Allowed
Overlap	None Allowed

E7018 Butt Joint- Single V (3G) Project #1+2

Welding Sequence

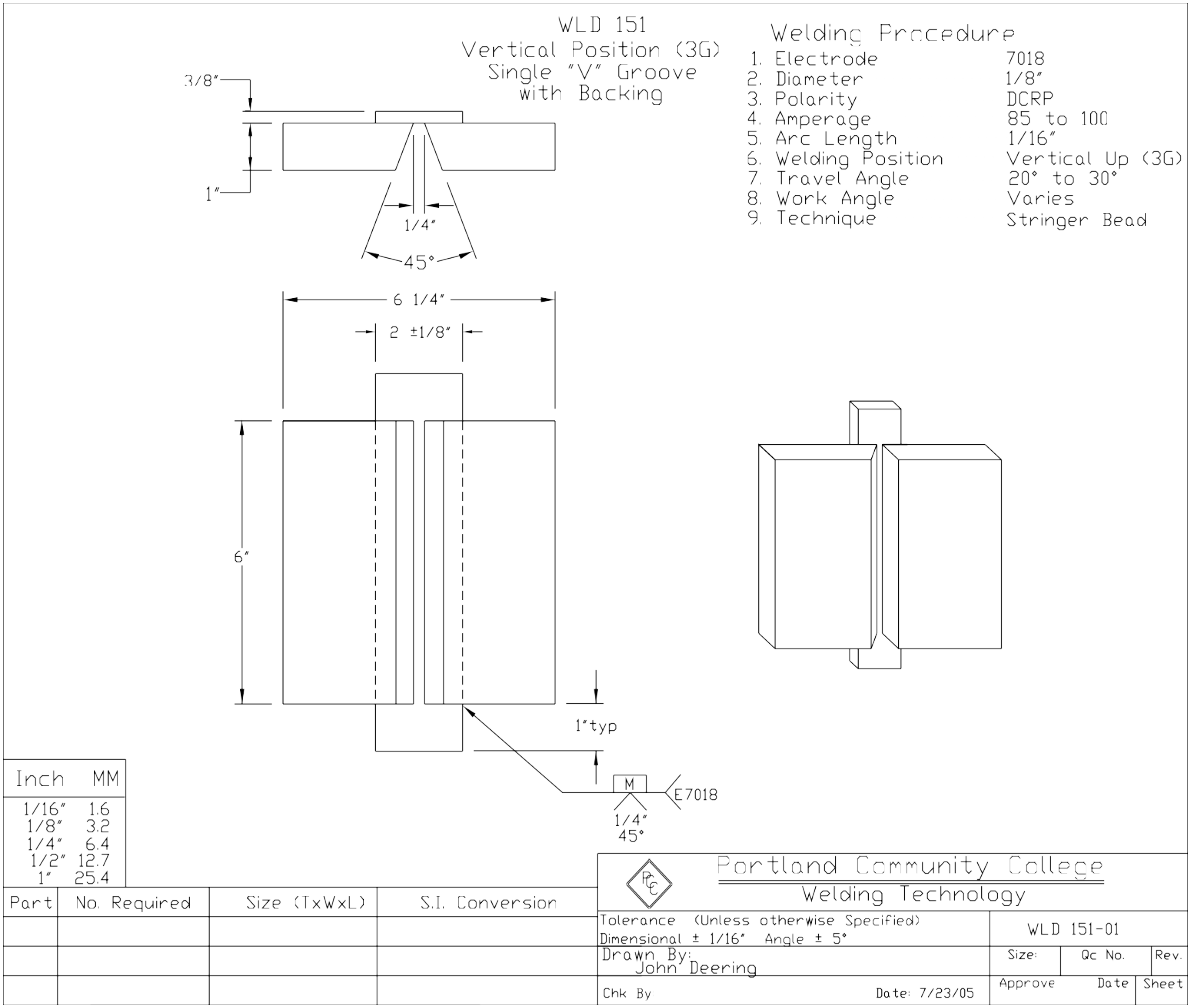
E7018-- Root Pass	Single pass technique with slight weave to ensure the weld metal is fusing into all three pieces of metal.
E7018—Fill	Use the split bead technique with stringer beads ensuring even fill.
E7018—Finish Beads	Use stringer bead technique keeping the electrode in the puddle at all times.

Bead Placement

High Quality Cover Passes

Successful completion of this project will require the student to complete **TWO** welds that meet both visual testing requirements and bend test requirements set forth in AWS D1.1 Structural Steel Welding Code.

Vertical V-Groove	Root	Cover	Bends	Instructor Signature/Date
Project 1				
Project 2				


WLD 151
Vertical Position (3G)
Single "V" Groove
with Backing
Welding Procedure
1. Electrode 7018
2. Diameter 1/8"
3. Polarity DCRP
4. Amperage 85 to 100
5. Arc Length 1/16"
6. Welding Position Vertical Up (3G)
7. Travel Angle 20° to 30°
8. Work Angle Varies
9. Technique Stringer Bead
3/8"
1"
1/4"
45°
6 1/4"
2 ±1/8"
6"
1"typ
M
E7018
1/4"
45°
Inch MM
1/16" 1.6
1/8" 3.2
1/4" 6.4
1/2" 12.7
1" 25.4
Part
No. Required
Size (TxWxL)
S.I. Conversion
Portland Community College
Welding Technology
Tolerance (Unless otherwise Specified)
Dimensional ± 1/16" Angle ± 5°
WLD 151-01
Drawn By:
John Deering
Size:
Qc No.
Rev.
Chk By
Date: 7/23/05
Approve
Date
Sheet

E7018 Butt Joint- Single V (4G) Project #3+4

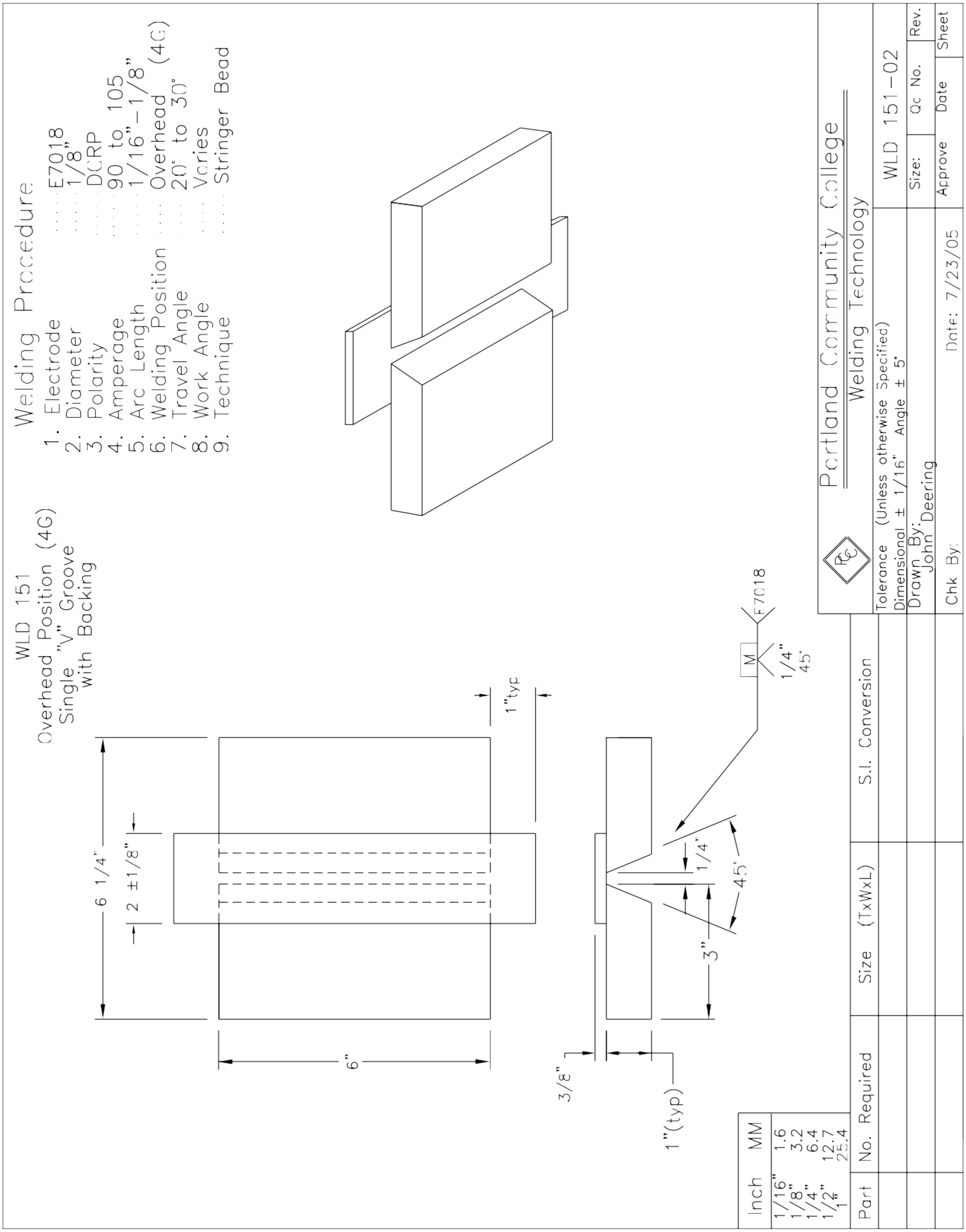
Welding Sequence

E7018-- Root Pass	Single pass technique with slight weave to ensure the weld metal is fusing into all three pieces.
E7018—Fill	Use the split bead technique with stringer beads ensuring even fill.
E7018—Finish Beads	Use stringer bead technique keeping the electrode in the puddle at all times.

Bead Placement ***High Quality Cover Passes***

Successful completion of this project will require the student to complete **TWO** welds that meet both visual testing requirements and bend test requirements set forth in AWS D1.1 Structural Steel Welding Code.

Overhead V-Groove	Root	Cover	Bends	Instructor Signature/Date
Project 3				
Project 4				


WLD 151
Overhead Position (4G)
Single "V" Groove
with Backing
Welding Procedure
1. Electrode E7018
2. Diameter ..... 1/8"
3. Polarity ..... DCRP
4. Amperage ..... 90 to 105
5. Arc Length ..... 1/16"-1/8"
6. Welding Position ..... Overhead (4G)
7. Travel Angle ..... 20° to 30°
8. Work Angle ..... Varies
9. Technique ..... Stringer Bead
6 1/4"
2 ±1/8"
1"typ
6"
3"
3/8"
1"(typ)
1/4"
45°
E7018
M
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: 7/23/05
WLD 151-02
Size: Qc No. Rev.
Approve Date Sheet

Shop Pre-Test Bend Procedure
for 1" Test Plate

Bend tests are used to determine the ductility and soundness of a weld joint. The test will determine if fusion was obtained in the weld joint. Use the following procedure in preparing and bending your coupons.

1. Reference the AWS D1.1 Structural Welding Code to determine the dimensional layout of the bend coupons (use this diagram for all positions).

2. Flush back up strip off of the plate. **Note: flushing of the backing strip maybe removed by flushing provided that at least 1/8 inch of its thickness is left to be removed by grinding.**

3. Layout four 3/8" thick coupons and cut using the track burner**. Do Not Bend coupons greater than 3/8" thick. This will damage the machine.**

4. Allow coupon to air cool. **Do Not Quench!**

5. Grind coupon's smooth, ensuring grinding marks are going with the length of the coupon's and all edges are rounded.

6. Request permission from your instructor to use the bend test machine.

7. CAUTION: ***Keep hands and fingers clear when operating equipment.***

8. Ensure guard is in the correct position. The coupons sometimes eject out the end of the machine rapidly.

9. Place coupon in the machine taking care to not position your hands/fingers in the way. Locate weld in the center of the die. Position coupons for side bends only.

10. Actuate the machine by the lever on top of the machine and stand clear of end where the coupon will exit.

11. Inspect the coupon for fusion type defects. **Reference AWS D1.1 Structural Welding Code, for acceptance criteria**.

Inspection by instructor:	**Instructors signature:** ______________________________
Date:__________________	**Student signature:** ______________________________

Bend Test Procedure
For 1" Test Plate

Bend tests are used to determine the ductility and soundness of a weld joint. The test will allow the welder to determine if she or he has obtained fusion in the weld joint. Use the following procedure in preparing and bending your coupons.

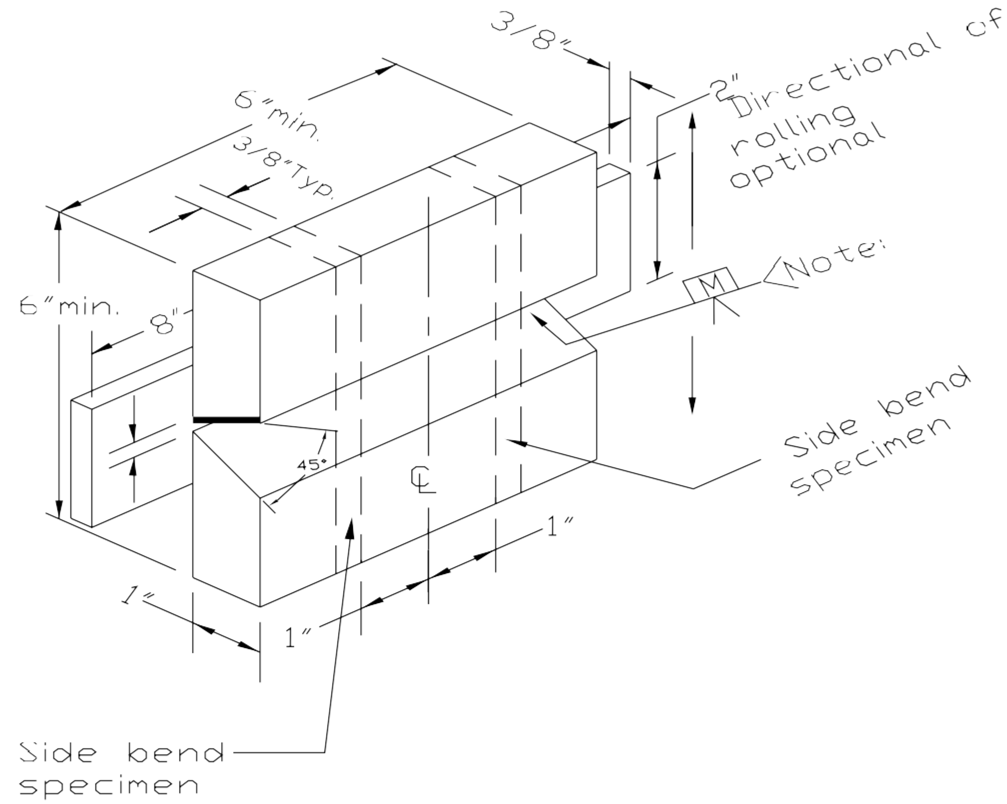
1. Flush back up strip off of the plate at the flushing station.

2. Layout four 3/8" coupons and cut using the track burner. **Do Not Bend** coupons greater than 3/8 " thick it will damage the dies in the bending machine!

Final Exame Bend Test Preperation

SHOP TEST

1" Bend Test



Note:

1. When radiography is used for testing, no tack welds shall be in test area.
2. The backing thickness shall be 1/4" min to 3/8" max; backing width shall be 3" min when not removed for radiography, otherwise 1" min.

Inch	MM
1/4"	6
3/8"	10
1"	25
5"	125
6"	150

Note: Back Strap Dimensions
T x W x L
3/8"x 2 x 8

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

Portland Community College
Welding Technology

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

WLD Fillet Weld 1 inch Bend Test

Drawn By: John Deering

Size: | Qc No. | Rev.

Approve | Date | Sheet

Chk By: | Date: 01/12/02

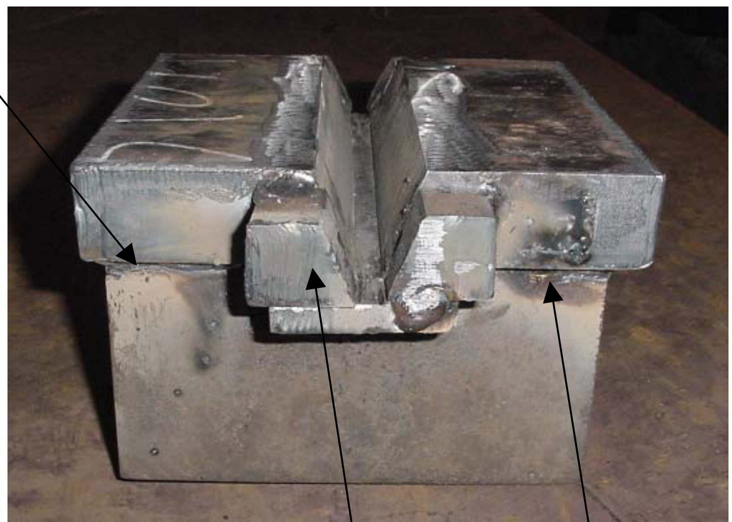
STEP 2: Assemble Groove Joint and Strong Backs

Strong Backs

- Root Opening = ¼"

- Use Clamps or fixturing device to ensure a "tight" fit-up.

- Adjust plate position as needed to ensure proper root opening.
- Ensure that there is **NO** gap between the beveled plates and the back strap surface.
- Tack the assembly together with 1" tack welds at the ends where the plates meet the back up strip.
- Do not tack weld on the backside of the test plate.
- Strong backs are used to control distortion of the plates during welding.
- Position strong backs on the backside of the groove assembly 3/16" in from the ends of the plates.
- Tack the strong backs across the ends of the plates. **Weld only on the outside edge of the strong back.**

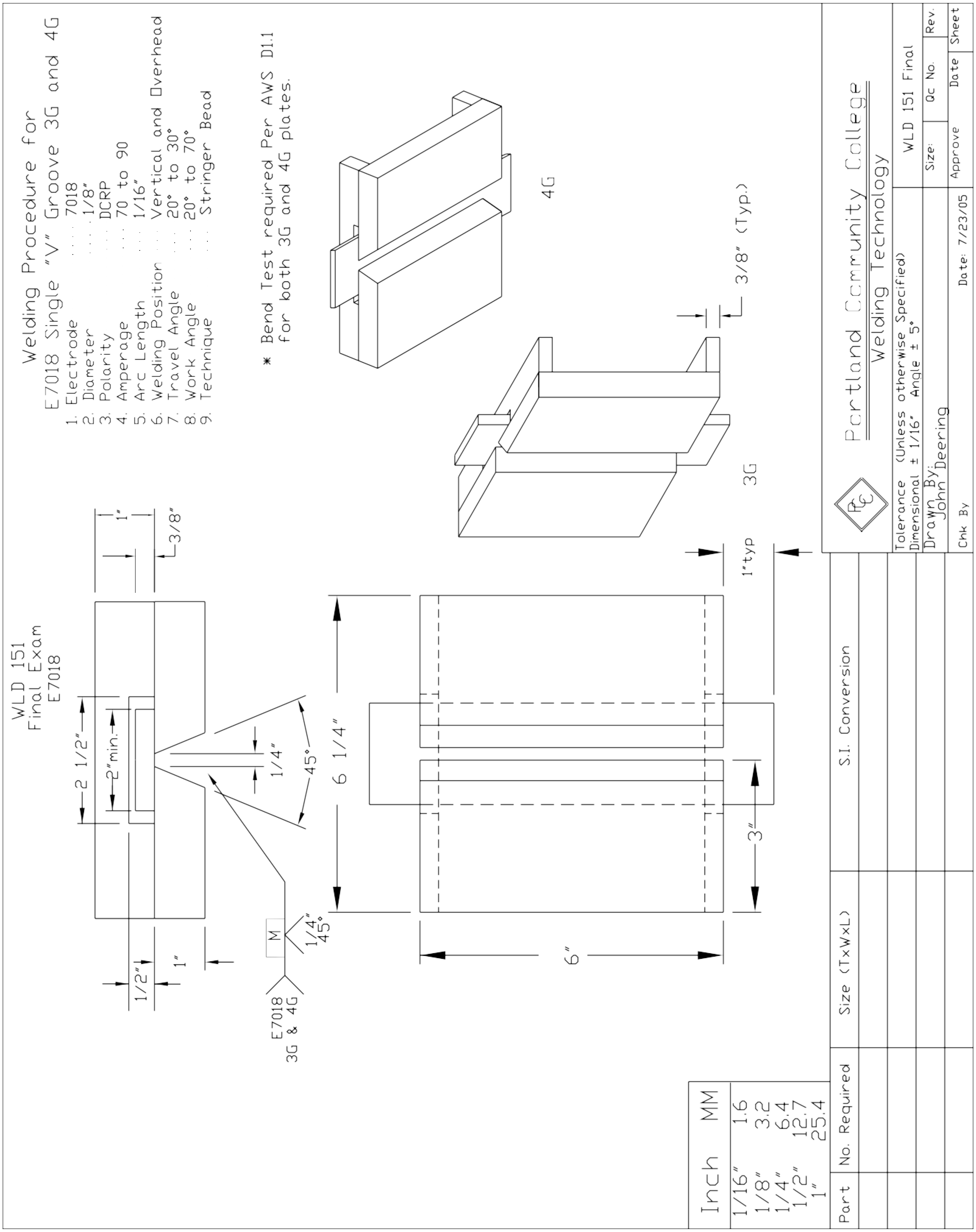


V-groove run off tabs

Weld only on outside edge of the strong back.

- **DO NOT** weld on the plate side (inside) of the strong backs.

Inspection by instructor:	**Instructors signature:** ______________________
Date: ____________	**Student signature:** ______________________


Welding Procedure for
E7018 Single "V" Groove 3G and 4G
1. Electrode 7018
2. Diameter .... 1/8"
3. Polarity .... DCRP
4. Amperage .... 70 to 90
5. Arc Length .... 1/16"
6. Welding Position .... Vertical and Overhead
7. Travel Angle .... 20° to 30°
8. Work Angle .... 20° to 70°
9. Technique .... Stringer Bead
* Bend Test required Per AWS D1.1
for both 3G and 4G plates.
4G
3G
3/8" (Typ.)
WLD 151
Final Exam
E7018
2 1/2"
2" min.
1/4"
45°
6 1/4"
1"
3/8"
1/2"
1"
M
1/4"
45°
E7018
3G & 4G
6"
3"
1"typ
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: 7/23/05
WLD 151 Final
Size:
Qc No.
Rev.
Approve
Date
Sheet

SUMMARY OF VISUAL INSPECTION CRITERIA

A. The test must be complete. The full length (6") of the test plate will be visually inspected. Use your run off tabs throughout the test to insure quality results at the start and finish at both ends of the plates. All craters shall be filled to the full cross section of the weld.

B. Reinforcement layer (**cover pass**) height shall be **Flush** to **1/8" (3 mm)** above the plate.

C. A reinforcement layer higher that **1/8" (3 mm)** will not be accepted.

D. Weld width cannot exceed ¼" wider than original groove opening.

E. Weld shall merge smoothly with the base metal.

F. Weld must be free of porosity, slag inclusions, and/or cold lap.

G. Undercut shall not exceed **1/32 in. (1 mm).**

H. Arc strikes outside of the weld area are **NOT** acceptable.

Proceed to Bend Test Procedure

Final Exam Part 1 Written

Part One

The final exam is a closed book test. Consult your instructor to determine items that you may need to review. Once you determine that you are ready for final written exam see your instructor. Complete the exam and write all answers on the answer sheet. Once completed, return the exam to your instructor.

Part Two

Using the Welding procedure in the packet, complete the practical test.

Multiplying Fractions

(this page for those who want to know how to do it by hand, not just by calculator)

for fractions, no mixed numbers . . .

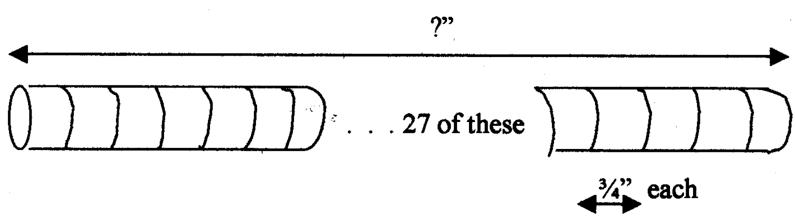
Rule #1: *Convert any whole numbers to fractions by putting a "1" underneath them*
Rule #2: *Multiply the top numbers (numerators) together*
Rule #3: *Multiply the bottom numbers (denominators) together*
Rule #4: *Reduce the resulting fraction to lowest terms*

Example 1: $\frac{1}{4} \times \frac{3}{4} = \frac{1x3}{4x4} = \frac{3}{16}$

Example 2: $\frac{3}{16} \times 4 = \frac{3}{16} x \frac{4}{1} = \frac{3x4}{16x1} = \frac{12}{16} = \frac{3}{4}$

Try these:

1. $\frac{1}{2}$ x $\frac{5}{8}$ = ________
2. $\frac{3}{8}$ x $\frac{7}{8}$ = ________
3. $\frac{29}{16}$ x $\frac{1}{4}$ = ________
4. $\frac{5}{32}$ x 6 = ________ (note: 6 = 6/1 and *Reduce!*)
5. You need to cut 27 small pieces of steel tubing. Each piece is ¾ " long. How long a length of tubing must you buy? *Note: 27 = 27/1*



for mixed numbers . . .

Convert all mixed numbers to improper fractions and do as above.
If answer is improper fraction, convert to mixed number for ease in measurement.

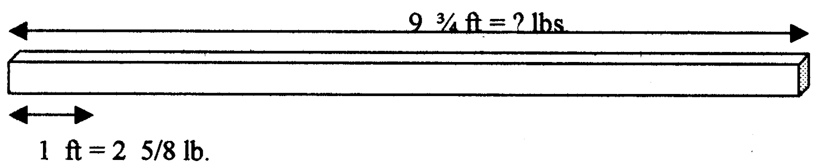
Example 1: $3\frac{1}{2} \times \frac{3}{4} = \frac{7}{2} \times \frac{3}{4} = \frac{21}{8}$

$= 2\frac{5}{8}$

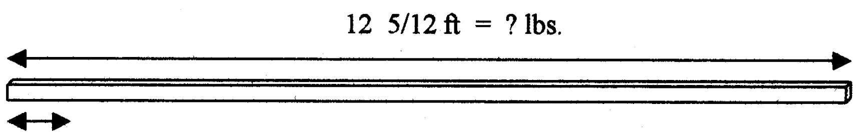
This kind of multiplication comes into play when you are trying to figure out total weight of a piece of metal, given the length of it and its weight per foot in pounds.

For the following exercises, you may use your fraction key on your calculator. But remember to do the calculation twice to see if you get the same answer each time. It is very easy to push the wrong buttons or push too hard or too gently.

1. A 9 ¾ foot long piece of quarter inch steel weighs 2 5/8 lb/ft. Find the total weight of the piece.

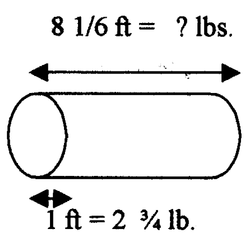


2.



Find the total weight of this length of steel.

3.



Find the total weight of this length of pipe.

Dividing Fractions

(this page for those who want to know how to do it by hand, not just by calculator)

Rule #1: *Convert any whole numbers to fractions by putting a "1" underneath them*
Rule #2: *Convert any mixed numbers to improper fractions*
Rule #3: *Keeping the first fraction exactly like it is, flip the second fraction, so that the top is now on the bottom, and the bottom number is now on top: numerator now on bottom, denominator now on top.*
Rule #4: *Multiply fractions like you always do. (across the top, across the bottom)*
Rule #5: *Reduce the resulting fraction to lowest terms*

Example 1: $\frac{1}{4} \div \frac{1}{8} = \frac{1x8}{4x1} = \frac{8}{4} = 2$

Example 2: $1\frac{3}{4} \div 2 = \frac{7}{4} \div \frac{2}{1} = \frac{7}{4} x \frac{1}{2} = \frac{7x1}{4x2} = \frac{7}{8}$

Try these: (Remember to reduce when you can!)

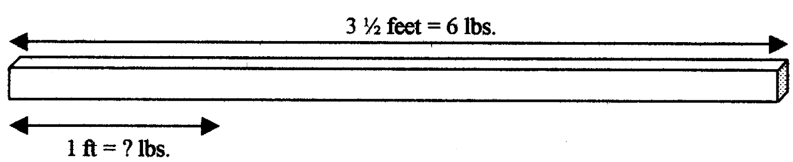
1. $5 \div \frac{5}{8} =$ _________

2. $\frac{3}{16} \div \frac{1}{4} =$ _________

3. $7\frac{7}{8} \div \frac{1}{4} =$ _________ *Convert answer to mixed number.*

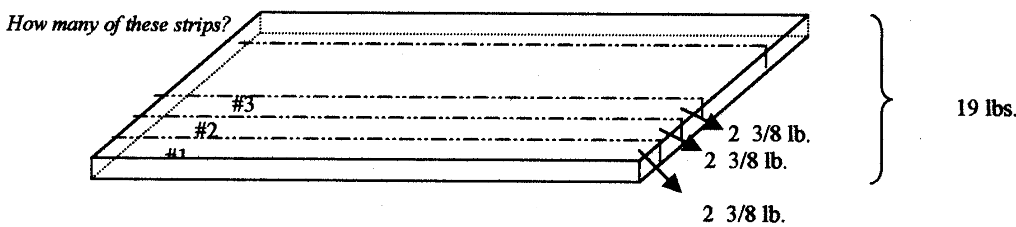
4. $2\frac{1}{2} \div 8 =$ _________ (note: 8 = 8/1)

5. You have a 6 lb pc of steel that is 3 ½ feet long. How much does it weight per ft.?

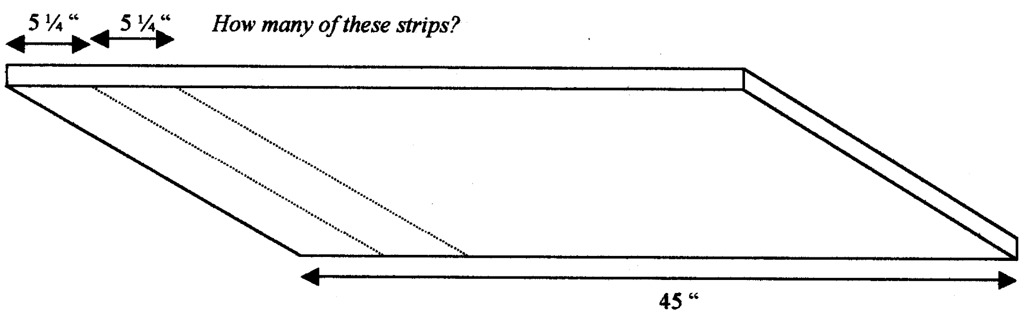


Required for all students: *Try doing the following problems, either by hand or using your calculator:*

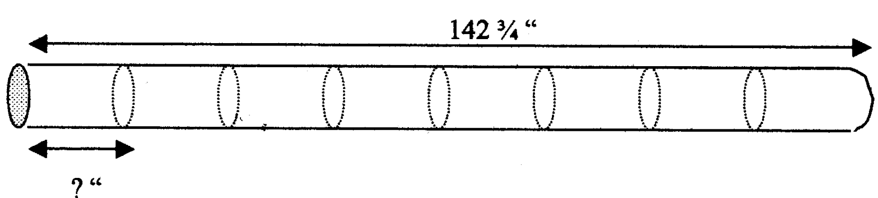
1. A sheet of metal weights 19 lbs. In a shearing operation, the sheet is cut into strips weighing 2 3/8 lb. each. ***How many*** strips of metal are produced?



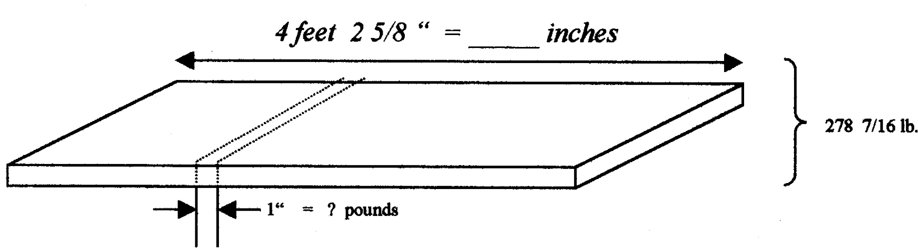
2. How many 5 ¼ inch strips can be sheared from a thin piece of sheet metal 45 inches long? If there is any left over after your cuts, see if you can figure out exactly what length will be left over.



3. A piece of 6 7/8" diameter tubing 142 ¾ inches long is being cut into 8 pieces of equal length. How long is each piece?

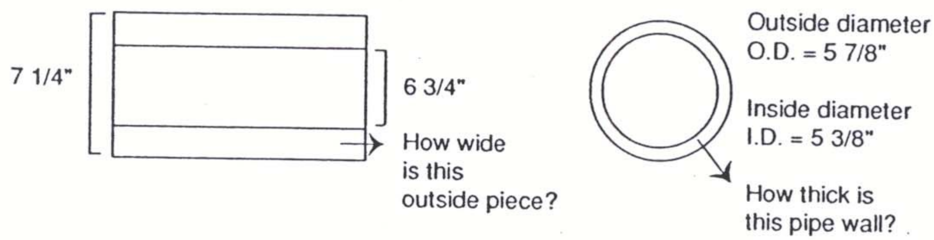


4. How much does one inch length of steel plate weigh, if the 4 ft 2 5/8" plate weighs a total of 278 7/16 lbs? *Note that 9/16 = 9 ounces out of the 16 ounces that make up one pound.*



Dividing Fractions and Mixed Numbers in Half

Sometimes you have a piece like this (below) where one part of it is centered and you know how wide it is; you also know how wide the entire piece is. For instance, in a pipe, you may know the inside diameter and you may know the outside diameter, but what you want to know is how thick the pipe walls are.



First you subtract the inside diameter from the outside diameter, and you get 1/2". But this has to be split in half in order to find out how thick the wall is at any given point. If it was one inch, it would be simple: 1/2". But often, the difference between the diameters is a fraction or a mixed number (that is, a whole number with a fraction).

So how do we divide fractions and mixed numbers in half?!

Let's take fractions first. They are the easiest. Remember that dividing something in two is the same as taking one half of it. That "of" means multiplication. So dividing a number in two is the same as multiplying by one-half. And when we studied multiplying fractions, we learned to just multiply the top numbers of the fractions (numerators) together and the same with the bottom numbers (denominators).

For example:

$$\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$$

We can see that 1/2 of 1/2 = 1/4. Notice how the denominator (bottom number) doubled. Does that always happen? Let's try a few other examples:

$$\frac{5}{8} \times \frac{1}{2} = \frac{5}{16} \qquad \frac{3}{4} \times \frac{1}{2} = \frac{3}{8} \qquad \frac{1}{4} \times \frac{1}{2} = \frac{1}{8}$$

Now we know that when we halve a fraction, all we have to do is divide the denominator. That way we have the same number of pieces (on top), but they are twice as small (1/4 is half the size of 1/2, just as 1/8 is half the size of 1/4), so we actually have half as much.

Divide these fractions in half:

1. $\frac{7}{8}$ **2.** $\frac{9}{8}$ **3.** $\frac{15}{16}$

Not so bad, right?

Now we need to discuss how to divide mixed numbers. If we have an even whole number and a fraction, then it's easy, just divide the whole number in half and then double the denominator of the fraction.

For example: $\frac{1}{2}$ x (*think one half of*) $4\ \frac{3}{8} = 2\ \frac{3}{16}$

But what if the whole number is odd? For example, 5 3/4? There are probably many ways you could divide this number in half.

1. One way is to change it to an improper fraction by multiplying 5 by 4 and adding 3 and getting 23/4. Then half of it would be 23/8. Change this back to a mixed number, which is 23 divided by 8 = 2 and 7 remaining: 2 7/8.

2. Another way would be to divide 5 in half and get 2 1/2 2 4/8), divide 3/4 in half and get 3/8 and then add them together to get 2 7/8.

3. Another way would be to borrow one from the five and make that 4/4. Add it to 3/4 to get 7/4. Divide 7/4 in half to get 7/8. Finally divide the remaining 4 (whole number) in 2 to get 2 and add it to the 7/8. Your answer is 2 7/8.

Probably the easiest way to remember, depending on the number you are dividing in half, is the first method. It uses methods you already know and is very straightforward, especially if you have a calculator to multiply and divide any big numbers you come across.

Try dividing these numbers in half:

a. 10 7/8 inches

b. 7 1/4 feet

c. 3 1/2

Codes and Standards

Name: ______________________________ Date: ____________________

Directions

Reference Chapter 19 and the index in your **Welding Principles and Applications** text and utilize that information to complete the questions on this work sheet. Answer the questions using ***complete sentences***, and do not hesitate to reference other sections in the text to find an answer.

1. What are codes and standards?

2. Why is it important to select the correct welding code or standard?

3. What is the difference between welding codes or standards and welding specifications?

4. What does the following abbreviations stand for:

5. What might influence the selection of a particular code or specification for welding?

6. What information should be included in a WPS?

.

7. What is the purpose of the PQR?

8. Who should witness the test welding being performed for a tentative WPS.

9. Ideally, a WPS should be written with enough information to allow a good welder to________________.

10. List examples of fixed and variable costs that must be considered when estimating a job?

11. List examples of overhead costs that a welding shop might have.

.

12. What effect on the weld cost does increasing the groove angle have?

13. What potential problems can be caused by having too small or too large a weld bead?

Testing an Inspection of Welds

Name:______________________________ Date: _______________________

Directions:

Read chapter 20 in the **Welding Principles and Welding Applications** text and utilize that information to complete the questions on this work sheet. Answer the questions using *complete sentences,* and do not hesitate to reference other sections in the text to find an answer.

1. Why are all welds not inspected to the same level or standard?

2. Why is the strength of all production parts not known if a sample number of parts are mechanically tested?

   .

3. Why is it possible to do more than on nondestructive test on a weldment?

4. What is a discontinuity?

5. What is a defect?

6. What is a tolerance?

7. What are the 12 most common discontinuities?

8. How can porosity form in a weld and not be seen by the welder?

9. What welding process can cause porosity to form?

10. How is piping porosity formed?

11. What are inclusions, and how are they caused?

12. When does inadequate joint penetration usually become defective?

13. How can a notch cause incomplete fusion?

14. How can an arc strike appear on a guided bend test?

15. What is overlap?

16. What is undercut?

17. What causes crater cracks?

18. What is under fill?

19. What is the difference between a lamination and a delamination?

20. How can stress be reduced through a plate's thickness to reduce lamellar tearing?

21. What would be the tensile strength in pounds per square inch of a specimen measuring 0.375 in. thick and 1.0 in. wide if it failed at 27,000 pounds?

22. What would be the elongation for a specimen for which the original gauge length was 2 in. and final gauge length was 2.5 in.?

23. How are the results of a stress test reported?

24. How are the specimens bent for a guided bend root, face, and side bend test?

25. What part of a fillet weld break test is examined?

26. Which nondestructive test is the most commonly used test?

Welder Certification

Name: ______________________________ Date: _____________________

Directions

Reference chapter 21 and the index in the **Welding Principles and Applications** text and utilize that information to complete the questions on this work sheet. List the section where your answers were obtained in the code. Answer the questions using *complete sentences,* and do not hesitate to reference other sections in the code to find an answer.

1. How does applying for a welding job differ from most other types of jobs?

2. What is the major difference between a qualified welder and a certified welder?

3. What process can a welder be certified for?

4. List the variables that, if changed, would require that a new certification test be given.

5. What is required to become an AWS Certified Welder?

Final Grading Rubric for practical exam
Class Name: WLD

Name:________________________________ Date: ______________________

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

Points Possible	***Hold Points***	***Instructor's Evaluation***
5 points	**Blueprint Interpretation and Material Cut List** 5 points = 0 errors, all parts labeled and sized correctly 3 points = 1 error in part sizing and/or identification 2 points = 2 errors 1 point = 3 errors 0 points = 4 or more errors	
10 points	**Material Layout and Cutting (Tolerances +/- 1/16")** 10 points Layout and cutting to +/-1/16" Smoothness of cut edge to 1/32" 7 points Layout and cutting to +/- 1/8" Smoothness of cut edge to 1/16 **REWORK REQUIRED IF OUT OF TOLERANCE BY MORE THAN 1/8 INCH**	
10 points	**Fit-up and Tack weld (Tolerances +/- 1/16")** 10 points Tolerances +/- 1/16" Straight and square to +/-1/16" 7 Points Tolerances +/- 1/8" Straight and square to +/-1/8" **REWORK REQUIRED IF OUT OF TOLERANCE BY MORE THAN 1/8 INCH**	
15 points	**Weld Quality** Subtract 1 point for each weld discontinuity, incorrect weld size and incorrect spacing sequence.	
28 points	***Minimum points acceptable. This equates to the minimum AWS D1.1 Code requirements.***	
	Total Points	**/40**

WLD 151: 7018 Certification Practice
Student Name:________ _______Date__________

Vertical V-Groove	Root	Cover	Bends	Instructor Signature/Date
Project 1				
Project 2				

Overhead V-Groove	Root	Cover	Bends	Instructor Signature/Date
Project 3				
Project 4				

	Assessment	Instructor Signature/Date
Packet questions		
Final Practical		