AG. 240 AGRICULTURAL FABRICATION

COURSE DESCRIPTION: A course to develop skills in metal equipment assembly and joining processes.

UNITS OF INSTRUCTION	MINUTES OF INSTRUCTION
Safety	94
Metal Technology Skills	940
Cost Effective Construction Techniques	3,196
TOTAL MINUTES	4,230

AG. 240 AGRICULTURAL FABRICATION

UNITS OF INSTRUCTION AND OBJECTIVES

A. Safety

1. Determine the importance of Agricultural Metal Fabrication Technology
2. Reinforce basic technical skills
3. Identify safety practices
4. Identify laboratory management procedures

B. Metal Technology Skills

1. Determine uses of metal
2. Identify types of metal
3. Recognize properties of metal
4. Use appropriate bench metal techniques
5. Properly select and use oxy-fuel equipment
6. Properly select and use shielded metal arc welding equipment
7. Properly select and use gas metal arc welding equipment
8. Properly select and use gas tungsten arc welding equipment
9. Properly select and use plasma arc cutting and welding equipment
10. Properly apply specialty welding and cutting techniques

C. Cost Effective Construction Techniques

1. Utilize computer assisted design techniques
2. Prepare construction plans and working drawings
3. Determine recommended and required design features
4. Read and interpret plans and working drawings
5. Prepare bill of materials
6. Fabricate and maintain agricultural equipment

Considerations Before Fabrication

AG 240-A

Unit objective

After completion of this unit, students will understand basic steps involved in planning a fabrication project. Students will learn to consider the scope and sequence of fabrication projects. This knowledge will be demonstrated by completion of assignment sheets.

Specific Objectives and Competencies

After completion of this unit, the student should be able to:

1. Determine the scope of a project.
2. Identify steps involved in a project.
3. Arrange the steps in a sequence necessary to complete the project.
4. Determine a sequence in which the project will be completed.
5. Develop a timeline to include completion dates of each step.
6. Identify equipment and materials that are best suited for the project.
7. Complete a project proposal.
8. Maintain weekly progress reports.
9. Record expenses.
10. List three purposes for keeping records.
11. Document amendments to original plans.
12. Determine savings of purchasing project versus fabricating.

A. Introduction:

Prior to beginning any project the following items should be considered. Students should have a definite understanding of the amount of time and money involved in a fabrication project before they begin. They should consider all possible alternatives. For example, would steel or wood be best suited and most economical for the project? Can the project be purchased for less money than what it will cost to fabricate it?

B. Purpose:

This section is intended to point out steps to follow when planning a project. It includes some difficulties that may arise if a project is not carefully planned. It definitely does not answer all questions that should be considered prior to beginning a project. It does, however, point out many common problems or questions that could occur with a number of projects. Many projects are unique and different problems may be encountered.

Careful consideration prior to fabrication will eliminate numerous problems that may arise as the project progresses. Projects are often incomplete because students run out of time and/or money to complete the project. Incomplete projects are not only inconvenient for the instructor, but also instill poor work ethics and lack of pride in students. Supporters of the program will also lose appreciation if projects are not completed.

Students should be presented with a detailed awareness of options and possible problems that will be associated with their project before they begin. Students should consider the scope and sequence of their project before beginning. Once a student has thoroughly considered the project he/she can (cooperatively with the instructor) decide to continue with the project.

C. Prints:

Some form of prints should be developed prior to beginning on a project. Whether it is professional prints or a sketch on a napkin, even the most skilled fabricators rarely begin a project without a drawing. Good prints will be a set of plans containing all necessary information to complete the project.

Students often see something and think “that would be easy to build” but as the project progresses they realize that the project is much more work than what it originally appeared to be. By having students prepare prints they will gain insight on the size of the project.

Preparing prints begins a mindset, which will eliminate errors later in the project. While preparing prints students will recognize certain elements of the project that may present difficulties as the project progresses. Prints should include specifications, which are supplemental information to the prints as well as a cutting list. For more information on prints refer to section **240D**.

D. Materials Considerations:

There are numerous materials that may be used for projects. Cost, strength, durability, and application will be the basis for making decisions for materials which will be used to fabricate a project. The following is a list of examples that may be considered when selecting materials for a project:

Pipe vs. Square Tubing:

Pipe is often less expensive than square tubing, however it is much more difficult and time consuming to fit pipe joints together than it is for joining square tubing. Durability and strength are relatively similar.

Plywood vs. 2 x’s:

Plywood is about one half the expense as 2 x’s, however 2 x’s will obviously be much stronger and more durable. Plywood, in most cases will be less time consuming to install and tends to make a structure more rigid.

Self-Tapping Screws vs. Bolts:

Self-tapping screws are less expensive and timelier to install. However, bolts are stronger, more durable, and easier to replace when broken.

Materials that may be on hand from a previous project could reduce costs even if they are not the best suited materials for the project.

For more information on strength of materials see **240E**
For more information on common dimensions see **240B**

E. Tools and Equipment Considerations:

Available tools and equipment should also be considered when ordering materials. Materials may be limited due to lack of equipment or a lack of capacity on certain equipment.

All metal cutting and bending equipment has a maximum width or thickness that can be used. Wide materials may have to be cut with a torch or plasma cutter rather than with a saw. This requires more joint preparation time and could possibly be eliminated if it is considered prior to ordering materials. Alternative materials may have to be used to stay within the capacities of the equipment. For example if 12" channel iron is too big for the available saw, heavier web thickness 8" or 10" channel iron could be substituted. Or instead of using channel iron, narrower I-beam should be considered.

On the other hand, if a shop has a pipe notcher, pipe may be a good choice of materials since it is less expensive.

Instructors should always consider shop space. With larger projects there may not be enough room for other student projects.

F. Developing a Progress Schedule:

Fabrication projects almost always seem to take more time than estimated. Developing a timeline or progress schedule for a project is crucial for fabrication students. Not only does it help reduce the number of incomplete projects at the end of the school year, but it also is a part of preparing students for the workforce. In the workforce bonuses and penalties are often paid based on project completion dates.

Schedules can be in any form such as: weekly, monthly, or established completion dates. If a student establishes a schedule it can be not only be used to help keep them on task but it may also be used as a grading system with bonus points for early completion of a step or penalty points for late completion.

When establishing schedules it is important to remember that approximately only 80 to 85% of class time will be spent actually working on the project. The remainder of the time may be used in a number of ways such as:

Time in the classroom.
Clean up time (clean shops are crucial to timely progress)
Looking for tools or materials
Waiting for tools being used by other students

Schedules may include steps such as:

Identifying a project
Researching the project (taking measurements from similar projects)
Writing a proposal to do the project
Planning the project

Drawing prints
Considering material options
Cost Estimation (bill of materials)
Ordering Materials
Cutting materials
Layout
Assembly (broken down into steps specific to the project)

A sample schedule is included at the end of this section.

G. Cost Estimation:

Prior to ordering materials students should complete a cost estimation otherwise know as a bill of materials. Upon completion of the estimation a student may decide that he/she will not be able to afford to complete the project.

Materials may be purchased from a number of suppliers. Once students have recognized what materials will be necessary for a project they should begin researching suppliers. Students should identify materials that are in stock and those that may have to be special ordered. Materials that have to be special ordered could cause lost work time while waiting. On the same note students should determine steps of the project that can be completed at any time and put those steps off until such time arises.

If there are multiple material dealers in the area the student should obtain bids from each dealer to obtain the lowest cost materials. Costs can often be greatly reduced by obtaining bids, even for small orders. When a dealer is called for a bid they will generally cut prices since they know that their competitors will also be bidding.

H. Cutting Materials:

Most shops have limited cutting tools as well as limited material storage. The instructor should plan cutting of materials. Depending on progress of different projects a student may have to cut all materials before assembly or maybe just cut enough materials to complete the first step. This will allow other students to continue working without time lost while waiting for cutting tools. Another option to save time would be to set up the saw for angle cuts and allow other students to cut materials before changing the angle.

I. Written Proposals:

In the workforce there are very few projects that are started without some type of written documentation whether it is a bid, call for bid, proposal for completion, or a contract. This is an excellent opportunity for instructors to incorporate writing in a fabrication class. Proposals can be in cooperation with English classes.

Students can write a proposal prior to beginning their project. Variation in projects may call for variation of formats; therefore the instructor should identify proposal formats. Proposals may address all of the points brought up in this section and more, but they should at least address the following:

What will the project be?
Who will it be for?
How much will it cost?
How will it be funded?
What tools/equipment will be necessary?
What materials will be necessary?
When will it be started?
When will it be completed?

Proposals may also be used as a contract between the student, instructor, and the party for whom the project is being completed. Such contracts can be motivation for students to complete the project in a timely manner as well as an agreement to fund the project.

J. Records

1. Reasons for keeping records-Record keeping is time consuming, however, it can be very beneficial.

   a. To document labor expenses.

      -If an outside party is paying for the project; records of how the project progressed and problems that were encountered can be useful to justify additional labor that was required.

   b. To document material expenses

   c. To be able to reproduce the project at a later time.

      -Record a copy of the plans, bill of materials, cutting list, etc.
      -Record the suppliers that materials and parts were ordered from, especially for hard to find parts.
      -document short cuts or changes that would be made if the project is to be reproduced in progress reports.

   d. To document parts and material suppliers

-Keeping names and contact information of the salesperson that parts or materials were ordered from can be useful in a number of ways:

To purchase replacement parts
To quickly exchange incorrect items
To order addition materials that need to match the specifications of materials already received.
To be able to order the same materials if the project is reproduced later.

e. Records of welding qualifications may be useful later if a liability issue raised. (See 240H for liability and welding qualifications)

f. Fabrication shops must keep accurate records for taxes.

g. Records of shop projects should be kept as the project progresses in order to have a detailed and accurate set of records to submit to the Lincoln Arc Welding Contest

B. Organization of Records

1. A portfolio or record book should include the following:

a. A cover page that gives the name(s) of those working on the project, starting date, completion date, and project name.

b. Records of welding qualifications. (see 240H)

c. A written proposal as described in this section.

d. Prints or working drawings and documentation of any changes that may have been made from the print. (see 240D)

e. Bill of materials (see 240B)

f. Parts and material bids with names and contact information of each bidding agency.

g. Records of expendable material expenses

h. Cutting list (see 240D)

i. Pictures of similar projects that were used in the design, and pictures that document progress from start to finish.

j. Written documentation of progress and problems encountered. (see 240A-10)

k. Documentation of any changes or short cuts that should be made if the project is reproduced.

B. Methods of recording expenses

1. Expenses may be recorded in a spreadsheet.

2. Expenses may be recorded in a financial program.

   a. Some financial programs (Quick Books) have an option to do estimates so project expenses can be calculated prior to beginning.

3. Expenses may be recorded in rows and columns on accounting paper.

Name____________________

Project: 4 place Snowmobile Trailer Total Estimated Hours: 68

Step to be Completed	Estimated Hours	Actual Hours	Reason for Difference Between Estimated Hours and Actual Hours
Research-Locate & measure other trailers	3		
Prints	2		
Bill of Materials	2		
Write Proposal	2		
Order Materials	2		
Cutting all material before layout & assembly	6		
Layout sub frame	1		
Assemble sub frame	2		
Layout square frame	1.5		
Assemble square frame	5		
Position square frame on sub frame	1		
Secure square frame to sub frame	2		
Locate axle placement	.5		
Position axle(s) on frame	1		
Secure axle(s) to frame axle(s)	2		
Attach fenders	1.5		
*Layout ramps (4)	2		
*Assemble ramps (4)	3		
Attach brackets for rear ramps (2)	2		
Build hinges and latches for front ramps (2)	2		
Attach front ramps	2		
Attach hitch coupler	.5		
Attach jack	1		
*Build ski fasteners (4)	3		
Attach ski fasteners (4)	1.5		
Paint preparation	4		
Paint	3		
Cut decking	2		
Secure decking	4		
Wiring	4		

Note: Steps are listed in order in which project will be completed. ***** indicates steps that may be completed out of sequence. Theses steps can be completed while waiting on materials or equipment.

Name____________________

List steps in order to be completed. Identify steps that may be completed out of sequence.

Project: Total Estimated Hours:

Step to be Completed	Estimated Hours	Actual Hours	Reason for Difference Between Estimated Hours and Actual Hours

Name__________________

Consider the following questions as they apply to your project. Write your answers on a separate sheet of paper.

1. List all the materials that you will need to complete your project (leave space for #2 answers).

2. Estimate the quantities of the above materials that you will need.

3. List alternative materials that may be used in place of the materials listed above.

4. Consider the tools in the shop, are there any materials listed above that will be difficult to use with the tools available? What other tools may be needed?

5. List three metal suppliers and their phone numbers.

6. List three hardware suppliers and their phone numbers.

7. Will your project require any special materials that may not be available at a hardware store or metal supplier? If so list a possible supplier of the part(s) and their phone number.

8. Call at least one supplier and obtain standard lengths and prices for the materials you listed above.

9. Identify three sources of information. If you have questions about your project, who would be able to direct you?

10. Locate a product that is for sale and similar to the project you are considering. Determine whether it will be feasible to continue with your project, be sure to consider your labor and consumable materials?

Ordering Materials

AG 240-B

Unit objective

After completion of this unit, students will understand units of measure by which various materials are sold. Students will learn to select and order necessary materials for a fabrication project. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

Specific Objectives and Competencies

After completion of this unit, the student should be able to:

1. Match terms used to describe metals with the correct shape.
2. Identify the units of measure by which materials may be purchased.
3. Prepare a bill of materials.
4. Obtain bids for materials.
5. Calculate cost comparisons to evaluate bids.
6. Order necessary materials.

Suggested Activities:

Obtain sample sets of materials and have students measure and identify each sample.

Have students complete the cost conversion worksheet in this section.

Put students into groups of 3 or 4. Provide each group with a list of materials and assign each student to obtain a bid from different suppliers. Assign students to convert prices from the bids to a standard unit and identify the lowest bid.

Unit References:

Steel Handbook, Pacific Steel Service Centers

Stock List, Joseph T. Ryerson & Son Inc., 1995

Introduction:

Ordering materials is often simplified if the order is placed by the instructor. However, a number of valuable skills can be learned by the student if he/she orders the materials.

By ordering materials students will gain the following:

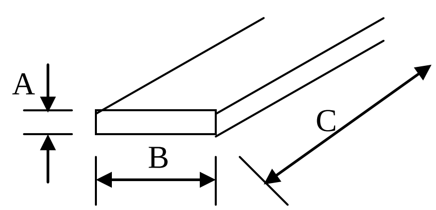
Communication Skills
Phone Skills
Technical Jargon

A. Metal Shapes-The following is a list of common metal shapes (available in various types of steel, aluminum, or stainless steel) and common sizes in which they are available. The available sizes listed may not be available through all dealers.

1. Flat iron, bar stock, or strips – Thickness (A) is given first, then width (B), followed by length (C).

   Common sizes:

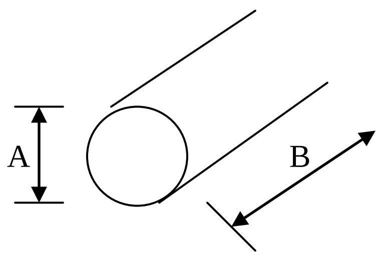
   Thickness (A) from .065" to 2"
   Width (B) from ½" to 12"
   Length (C) 20' hot rolled or 12' cold rolled



2. Round stock – Diameter (A) given first followed by length (B)

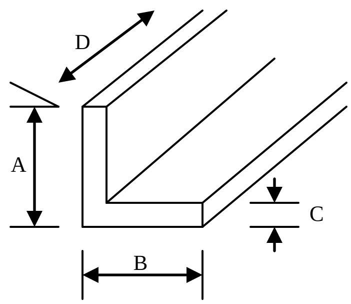
   Common Sizes:

   Diameter (A) form 1/8" to 12"
   Length (B) 20' hot rolled or 12' cold rolled



3. Angles – Longest leg length (A) given first followed by leg length (B) followed by thickness (C) and finally length (D)

   Common Sizes:
   Legs A and/or B from ½" to 8"
   Thickness (C) from 1/8" to 1"
   Length (D) 20', 40', and 60'



4. Channels –Channels are grouped into 4 different groups. The groups are classified as: standard or C-channel, bar channel, junior channel, and ship and car channel. Each group has a slightly different shape.

   Standard or C-channel is most often used for fabrication.

   Web depth (A) given first then the weight (lbs. Per foot) followed by the length (D).

   Different weights will slightly vary the web thickness (B) and Flange width (C).

   Common Sizes:
   Web depth (A) from 3" to 10" by increments of 1" then 12" & 15"
   Length (D) 20', 40', and 60'

   Bar channel has a much thicker web and narrower flange than C-channel. Bar channel is only available in smaller sizes.

   Web depth (A) given first, followed by flange width (C), and then web thickness (B).

   Common Sizes:
   ¾" x 3/8" x 1/8" to 21/2" x 5/8" x 3/16"
   Length (D) 20'

Ship and car channel has a thicker web and a wider flange than C-channel.

Web depth (A) given first then the weight (lbs. Per foot) followed by the length (D).

Different weights will slightly vary the web thickness (B) and Flange width (C).

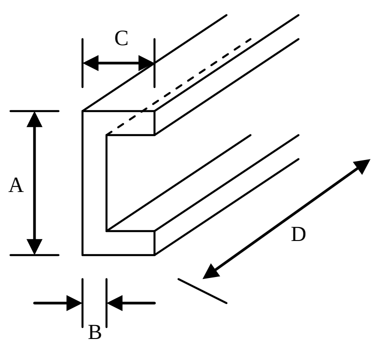
Common Sizes:
Web depth (A) from 3" to 10" by increments of 1" then 12", 13", & 15"
Length (D) 20', 40', and 60'

Junior channel has a wider flange than bar or c-channel. Junior channel has the thinnest web available. It is a light-weight channel that is mainly used for stair stringers. Junior channels are often press brake formed to specification.

Web depth (A) given first then the weight (lbs. Per foot) followed by the length (D).

Different weights will slightly vary the web thickness (B) and Flange width (C).

Common Sizes:
Web depth (A) from 8" to 12" by increments of 2"
Length (D) to 40'



5. Beams-Similar to channels; beams are grouped into 3 different groups. The groups are classified as: S-beams (standard), W-beams (wide flange), and M-beams (JR. or light). Each group has a slightly different shape

S-beams are most commonly used for fabrication.

Web depth (A) given first then the weight (lbs. Per foot) followed by the length (D).

Different weights will slightly vary the web thickness (B) and Flange width (C).

Common Sizes:
Web depth (A) from 3" to 10" by increments of 1" then 12", 15", 18", 20", and 24"
Length (D) 20', 40', and 60'

W-beams have a wider flange (C) and a wider web (B) than S-beams.

Web depth (A) given first then the weight (lbs. Per foot) followed by the length (D).

Different weights will slightly vary the web thickness (B) and Flange width (C).

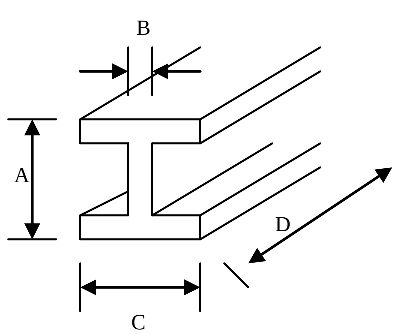
Common Sizes:
Web depth (A) from 4" to 30"
Length (D) 20', 40', and 60'

M-beams are about half as heavy as W-beams or S-beams. Web thickness (B) and flange width (C) are less.

Web depth (A) given first then the weight (lbs. Per foot) followed by the length (D).

Different weights will slightly vary the web thickness (B) and Flange width (C).

Common Sizes:
Web depth (A) from 6" to 10"
Length (D) 20', 40', and 60'

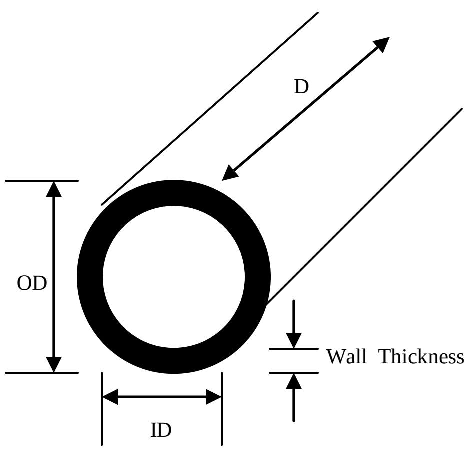


6. Pipe-Pipe sizes are a nominal measurement. Nominal means that they do not actually measure the exact size that they are called. Sizes are determined by referring to a chart after measuring the outside diameter (OD). Wall thickness is also determined from a chart. Schedules are used as a nominal measurement of wall thickness. A sample chart is given below. Steel suppliers will furnish a complete chart with the sizes stocked.

Nominal diameter is given first, followed by schedule (wall thickness), and then length (D).

Common Sizes: Nominal diameters from 1/8" to 42"
Schedules: 5, 10, 20, 30, 40, 60, 80, 100, 120, 140, & 160
Length: 21'

Nominal Size (in.)	OD (in.)	Schedule 10 Thickness	Schedule 40 Thickness	Schedule 80 Thickness	Schedule 100 Thickness
1	1.315	.1090	.1330	.1790	x
1 ½	1.900	.1090	.1450	.2000	.4000
4	4.500	.1200	.2370	.3370	x
8	8.625	.1480	.3220	.5000	.5940



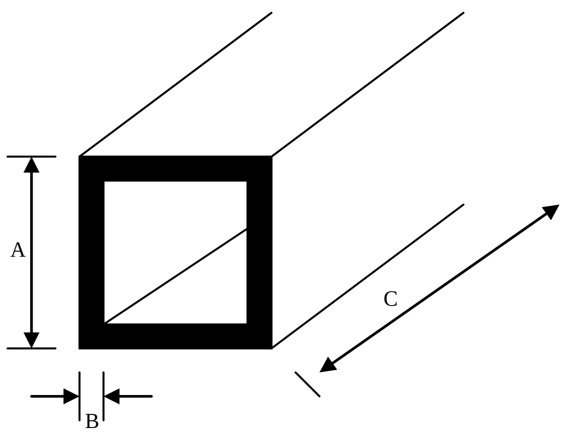
7. Round Mechanical Tubing-Outside diameter (OD) given first, followed by wall thickness (decimal inches, fractional inches, or wire gauge #), then length (D). See above illustration.

   Common Sizes:
   OD from 1/8" to16"
   Wall thickness from 0.022" to 2 ½"
   Lengths from 8' to 24'

8. Square Tubing-Outside dimension (A) given first, followed by wall thickness (B), then length (C).

Common Sizes:

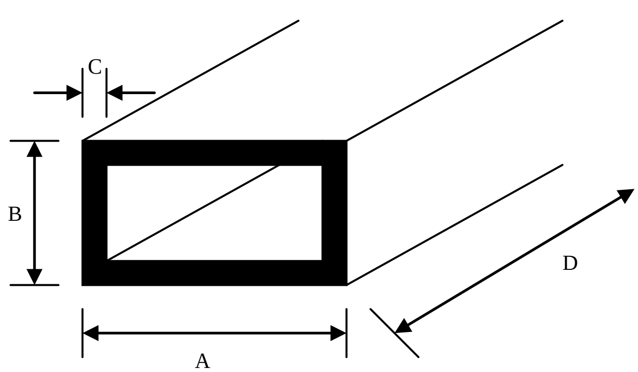
Outside dimension (A) from 3/8" to 16"
Wall thickness (B) from 0.035" to 5/8"
Lengths (C) 20' and 40'



9. Rectangular Tubing-Longest outside dimension (A) given first, followed by shortest outside dimension (B), then wall thickness (C), finally length (D)

Common Sizes:

Outside dimensions (A x B) from 1" x ½" to 16" x 8"
Wall thickness (C) from 0.049" to ½"
Lengths (D) from 7' to 40'



The following tables give dimensions that may be useful for ordering materials that will telescope inside one another. It is important to remember that these dimensions are calculated. Therefore, they should theoretically fit as listed. However steel may have variations such as the seam, round or square corners if tubing, or roundness of pipe that are not accounted for in the calculations.

Indicates the diameter of round stock that will telescope inside the schedule 40 pipe diameter given in the column on the left with less than 3/32" clearance.

Schedule 40 Nominal	Round Stock Diameters in Inches								
Pipe Size in Inches	1/4	5/16	7/16	9/16	13/16	1	1 5/16	1 9/16	2
1/8	0.019								
1/4		0.052							
3/8			0.0555						
1/2				0.0595					
3/4					0.0115				
1						0.049			
1 1/4							0.0675		
1 1/2								0.0475	
2									0.067

Indicates the outside diameter of pipe that will telescope inside the pipe diameter and schedule given in the column on the left with less than 3/32" clearance.

Nominal Pipe Size	Nominal Pipe Sizes in Inches						
in Inches	1/8	1/4	1	1 1/2	3	3 1/2	4
3/8 sch. 80	0.018						
1/2 sch. 80		0.006					
1/2 sch. 40		0.082					
3/4 sch. 80							
1 1/4 sch. 40			0.065				
2 sch. 80				0.039			
3 1/2 sch. 40					0.048		
4 sch.40						0.026	
5 sch. 120							0.063

Indicates the outside dimension of square tubing that will telescope inside the square tubing listed in the column on the left with less than 3/32" clearance.

Square Tubing	Square Tubing Size in Inches								
Size in Inches	1/2	3/4	1	9/16	13/16	1	1 5/16	1 9/16	2
3/4 x .095	0.06								
1 x .095		0.06							
1 1/4 x .109			0.032						
1/2				0.0595					
3/4					0.0115				
1						0.049			
1 1/4							0.0675		
1 1/2								0.0475	
2									0.067

Indicates the calculated inside dimension of square tubing.

SQUARE TUBING Wall Thickness

Size	0.049	0.065	0.072	0.083	0.095	0.109	0.12	0.134	0.148	0.188	0.203	0.25
1/2	0.402	0.37										
3/4	0.652	0.62	0.606	0.584	0.56	0.532	0.51					
1	0.902	0.87	0.856	0.834	0.81	0.782	0.76					
1 1/4	1.152	1.12	1.106	1.084	1.06	1.032	1.01	0.982	0.954	0.874		
1 1/2	1.402	1.37	1.356	1.334	1.31	1.282	1.26	1.232	1.204	1.124	1.094	1
1 3/4		1.62	1.606	1.584	1.56	1.532	1.51					
2	1.902	1.87	1.856	1.834	1.81	1.782	1.76	1.732	1.704	1.624	1.594	1.5
2 1/4		2.12				2.032						1.75
2 1/2		2.37	2.356	2.334	2.31	2.282	2.26	2.232		2.124	2.094	2
3				2.834		2.782	2.76	2.732	2.704	2.624	2.594	2.5
3 1/2							3.26	3.232	3.204	3.124	3.094	3
4				3.834	3.81	3.782	3.76	3.732	3.704	3.624	3.594	3.5
4 1/2										4.124	4.094	4
5							4.76			4.624	4.594	4.5
6										5.624	5.594	5.5

B. Bidding Materials-Costs can often be greatly reduced by obtaining bids. Dealers will often reduce prices when a bid is requested because they know that their competitors will also be bidding. When bidding materials be sure to ask what lengths the materials are available in. Bids can be written or verbal. Bids can also include cut prices. Dealers will cut any desired length of material, however, the cut price may be as much or more as ordering a full stick.

1. A bill of materials sheet can be used as a bid sheet. Materials can be listed and their costs filled in as the bid price. (for more information look at Curriculum Section 240D)

    a. A bill of materials is a list of all the materials needed for a project with the total cost calculated.

    b. This tabular form includes the number of pieces, the dimensions, a description of the items, the cost per unit, and the total cost.

    c. It is preferable to order standard stock sizes that will provide the desired materials with the least possible waste.

    d. List similar materials together and in the order they will be used.

1. Verbal Bids-Verbal bids are usually obtained by calling the supplier and asking for prices on certain materials. When calling for a verbal bid be sure to get the name of the sales person and write it down so you can speak to the same person if you call back later.

a. Advantages of verbal bids:
    Simple
    Timely
    Prices are current

b. Disadvantages of verbal bids:
    Prices, dimensions, or quantities may be confused in communications
    No documentation to bind quoted prices

2. Written Bids-Written bids can be obtained by providing a list of necessary materials, dimensions, and quantities to the supplier. The supplier will list the prices and return them. Written bids may be mailed, faxed, hand delivered, or e-mailed. Be sure a name and phone number are listed on the bid so suppliers can contact you if they have questions. The bill of materials form on 240B-13 can be used to obtain written bids.

    a. Advantages of written bids:
        Prices are typically binding up to an expiration date
        Less chance of miscommunication between parties

    b. Disadvantages of written bids:
        Usually takes a few days for suppliers to respond
        More time required for suppliers to contact you and determine if one product would be able to substitute for another.

C. Comparing Bids-Suppliers may quote prices in a number of ways. Prices can be quoted in $ per stick, $ per foot, or $ per pound. Prices that are given per pound or per foot may also be given per 100 pounds (cw) or per 100 feet (cf). Once bids have been received they should be re-calculated to a common unit before comparison.

1. Converting prices:

    a. Converting $ per stick to $ per foot
        $ per stick / length of stick = $ per foot

    b. Converting $ per stick to $ per pound
        $ per stick / (length of stick * pounds per foot) = $ per pound
        Supplier catalogs should list pounds per foot

    c. Converting $ per foot to $ per stick
        $ per foot * length of stick = $ per stick

    d. Converting $ per foot to $ per pound

$ per foot * pounds per foot = $ per pound
Supplier catalogs should list pounds per foot

e. Converting $ per pound to $ per stick
$ per pound * length of stick * pounds per foot = $ per stick
Supplier catalogs should list pounds per foot

f. Converting $ per pound to $ per foot
$ per pound * pounds per foot = $ per foot
Supplier catalogs should list pounds per foot

2. Comparing prices-Once the prices have all been converted to the same unit it should be easy to compare them and determine which supplier offers the best prices. However, the length of material available should also be considered when comparing bids. If one supplier offers 20 feet lengths and another offers 24 feet lengths at a higher price per pound or per foot price it may still be less expensive to purchase the more expensive 24 feet lengths depending on the project. For example:

You need 3 pieces of 1" tubing 8' long. Supplier A has the tubing in 20' lengths for $0.40 per pound and supplier B has 24' lengths for $0.45 per pound.

From supplier A you will have to purchase 2 sticks to get the material you need.
$0.40 per pound * 1.169 lbs per foot * 20 ft * 2 sticks = $18.70
Waste- 1 piece 4' and one piece 12'

From supplier B you will only have to purchase 1 stick.
$0.45 per pound * 1.169 lbs per foot * 24 ft = $12.63
No wasted material

BILL OF MATERIALS
STEEL

Sold To________________________________ Date__________________

Project or Job____

STEEL COMPANY
1111 West First Street, Anytown 555-1212

TERMS: CASH CHARGE ACCT.

No Pieces	Size & Description	Length	Quantity (lbs)	Price per Pound	Total price
Cost from other sheet (if needed)					
Welding Fee					
Sub total					
Taxes					
Total Cost					
Received by________________________________					

130I-10

No Pieces	Size & Description	Length	Quantity (lbs)	Price per Pound	Total price
Total cost					

Cost Conversion Worksheet

Name___________________

1. ¼" x 1 ¼" flat stock is priced at $0.26 per pound. What is the total price for one 20' stick if it weighs 1.063 pounds per foot?

2. What is the price per foot of the flat stock in the previous problem?

3. 3/8" x 21' schedule 40 pipe is $8.42 per stick. What is the price per foot?

4. 3/8" x 21' schedule 40 pipe is $8.42 per stick. How much is it per pound if it weighs 0.2447 pounds per foot?

5. 7/16" x 20' round stock is $0.21 per foot. What is the price per stick?

6. What is the price per pound for the round stock in the previous problem if it weighs 0.511 pounds per foot?

7. 3/8" round stock is $41.27 per cwt (100 lbs). How much would it be for a 20' stick if it weighs 0.376 pounds per foot?

8. What is the price per foot of the 3/8" round stock in the previous problem?

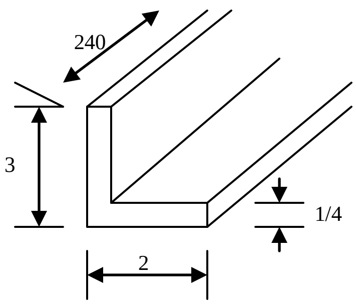
9. 6" x 10.5 lb channel is $95.89 for a 20' stick. What is the per pound price?

10. A sheet of 16 ga. 48" x 120" sheet metal is priced at $29.89 per cwt. What is the price per sheet if it weighs 2.5 pounds per square foot?

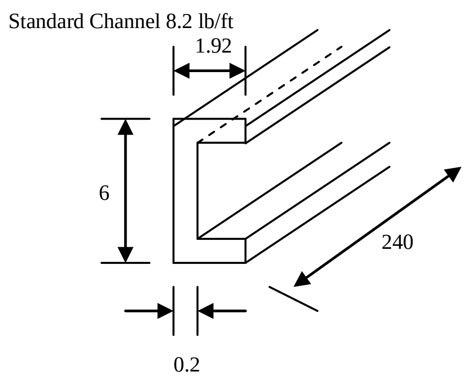
ORDERING MATERIALS
UNIT TEST

Name_________________

For questions 1-5 write a description for each diagram in the correct order as if you were ordering the materials over the phone. All dimensions are in inches.

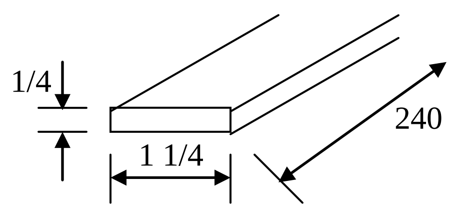


1. ________________________________

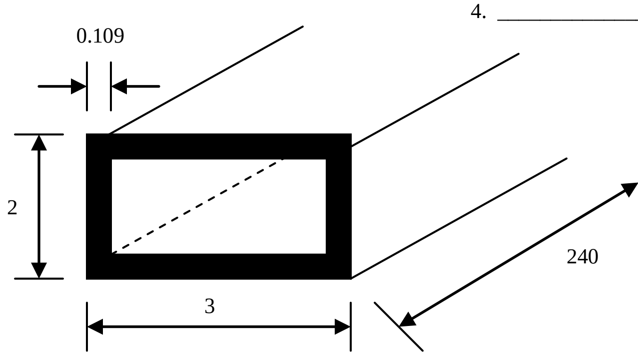


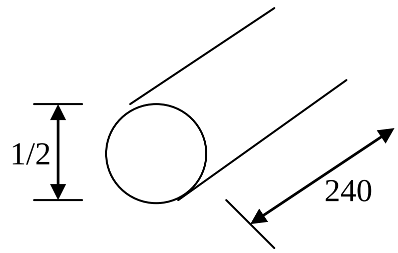
2. ________________________________

3. ________________________________



4. ________________________________





5. ________________________________

6. List one reason for bidding materials.

7. List one advantage to obtaining bids over the phone.

8. List one advantage to obtaining written bids.

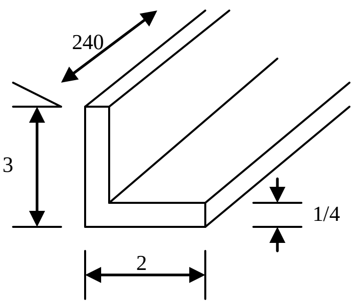
9. A 20' stick of flat stock is $5.45. What is the price per pound if it weighs 1.063 pounds per foot?

10. You need 4 pieces of 1 ½" square tubing that are 6' long for your project. Steel Sisters quoted 24' sticks at $0.50 per pound. Iron Brothers quoted 20' sticks at $0.45 per pound. Given the tubing weighs 1.6 lbs per foot which bid makes your project the cheapest?

ORDERING MATERIALS
UNIT TEST

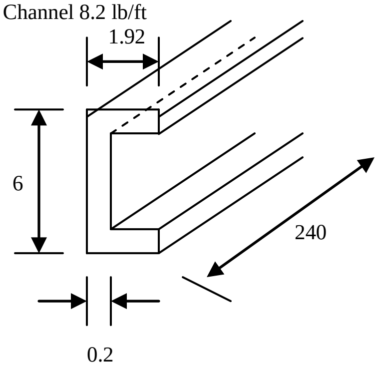
Name__Key____________

For questions 1-5 write a description for each diagram in the correct order as if you were ordering the materials over the phone. All dimensions are in inches.



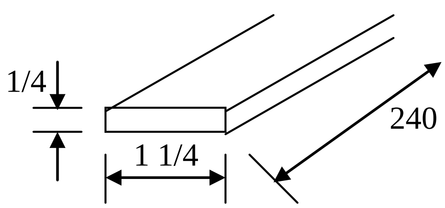
1. 3 x 2 x ¼ x 20' Angle

Standard Channel 8.2 lb/ft

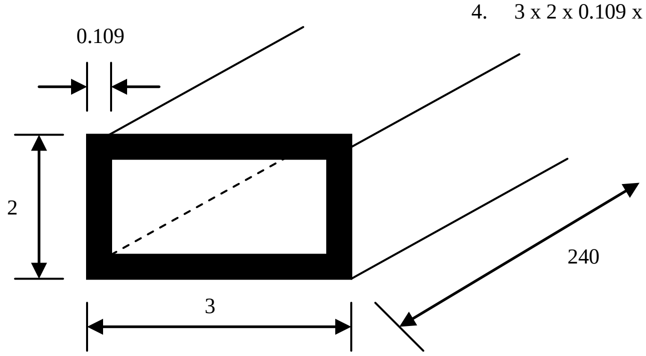


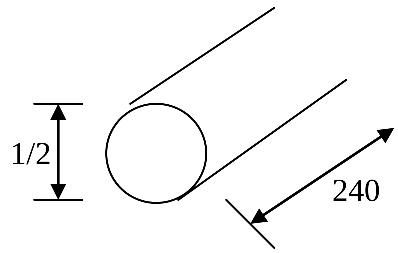
2. 6 x 8.2 lb x 20' standard channel

3. ¼ x 1 ¼ x 20' flat stock



4. 3 x 2 x 0.109 x 20' rectangular tubing





5. ½ x 20' Round stock

6. List one reason for bidding materials.

Bidding Materials-Costs can often be greatly reduced by obtaining bids. Dealers will often reduce prices when a bid is requested because they know that their competitors will also be bidding.

7. List one advantage to obtaining bids over the phone.

Simple
Timely
Prices are current

8. List one advantage to obtaining written bids.

Prices are typically binding up to an expiration date
Less chance of miscommunication between parties

9. A 20' stick of flat stock is $5.45. What is the price per pound if it weighs 1.063 pounds per foot?

$5.45 per stick / (20' * 1.063 lbs. per ft.) = $0.256 per pound

10. You need 4 pieces of 1 ½" square tubing that are 6' long for your project. Steel Sisters quoted 24' sticks at $0.50 per pound. Iron Brothers quoted 20' sticks at $0.45 per pound. Given the tubing weighs 1.6 lbs per foot which bid makes your project the cheapest?

24' * 1.6 lb. per ft. * $0.50 = $19.20 Steel Sisters is cheapest

20' * 2 sticks *1.6 lb. per ft. * $0.45 = $28.80 Iron Brothers

Joint Design and Project Lay Out

AG 240-C

Unit objective

After completion of this unit, students will understand basic steps involved in laying out a fabrication project. Students will learn to prepare materials, equipment, and facilities for assembly. This knowledge will be demonstrated by completion of a unit test with a minimum of 85 percent accuracy.

Specific Objectives and Competencies

After completion of this unit, the student should be able to:

1. Select proper welding joints.
2. Determine most efficient method for cutting materials.
3. Mark stock for cutting operations.
4. Arrange the cut materials into desired positions for assembly using basic geometry.
5. Prepare necessary jigs or fixtures.

Unit References:

Lincoln Electric Company, *The Procedure Handbook of Arc Welding*, 1973

Gosse, F. Jonathan & Proctor, E. Thomas (1992) *Pritn Reading for Welders*, American Technical Publishers Inc. Homewood, IL

A. Basic welding joints

1. Butt joint
2. Lap joint
3. T joint
4. Edge joint
5. Corner Joint

B. Considerations when selecting weld joints to maximize strength and minimize labor and materials.

1. Minimize edge preparation
    a. Minimal edge preparation reduces cutting and machining time and expenses
2. Minimize filler metal-For equivalent strength longer fillet welds with smaller legs are less costly than short intermittent fillet welds with larger legs.
    a. Minimizing filler metal reduces cost and time
    b. Minimizing filler metal deposited reduces welding heat.
3. Reduce excess heat
    a. Reducing heat controls distortion.
    b. Reducing heat minimizes changes in the molecular structure of the metal in the heat affected zone.
    c. Use of low-hydrogen electrodes reduces or eliminates preheating requirements.
4. Minimize number of welds
    a. Minimal number of welds reduces welding heat, distortion, time, and filler metal.
    b. Stiffeners and gussets do not need much welding. Reduce the number, length, or leg size if possible.
5. Size the weld for the thinnest joint member

a. The strength of a structure is limited be the weakest member, therefore, weld sizes should not exceed the strength of the weakest weld member.

b. On joints where a thicker piece is being welded to a thinner piece position the thicker joint so the thicker piece can be used as backing.

6. Welding positions

   a. The four welding positions are flat, horizontal, vertical, and overhead.

   b. In the horizontal, vertical, and overhead positions gravity reduces penetration and filler metal control.

   c. If feasible joints should be turned to be welded in the flat postion

7. Weld joint access

   a. When laying out projects, be sure that weld joints can be accessed with weld equipment and may be fully viewed the welder.

8. Joint fit-up

   a. Poor fit-up can caused welds to fail and is costly.

   b. Avoid excessive pre-stressing members by forcing alignment.

C. Material considerations for joint design

1. Over designing is a waste of money and materials.

2. Good appearance has value but only in areas that can be easily viewed

3. Deep and symmetrical sections resist bending efficiently (channels, beams, rectangular tubing).

4. Closed tubular materials are better than open materials.

5. Use of stiffeners and gussets will provide rigidity with minimal weight.

6. Use standard sizes because of availability and economy.

D. Alignment of joints

1. Proper end to end or edge to edge alignment assures that the members are true.

2. Proper fit-up of joints ensures quality welds with good penetration.

D. Metal Grain

1. Metal has a grain that runs lengthwise through the metal similar to wood.

    a. Welds that are perpendicular to the grain should be avoided.

        -Welds that are perpendicular to the grain will fail before welds that are the length of the grain.

        -If such welds cannot be avoided a gusset or fish plate should be installed to reinforce the joint

    b. To avoid welds that are perpendicular to the grain joints should be cut at 45°.

E. Cutting methods

1. Chop (hot) saw

    a. Chop saws are one of the quickest methods of cutting metal.

    b. Chop saws have smaller capacities than band saws.

    c. Chop saws do not always cut straight or accurate.

    d. Chop saws leave a burr on the edge of the metal that can interfere with joint fit-up

    e. Chop saw has a wider kerf than a band saw but less than a torch or plasma cutter.

2. Band saws (horizontal or vertical)

    a. Band saws cut slower than a chop saw or shear but faster and with greatest precision of any cutting tool.

    b. Band saws typically have a greater capacity than chop saws

3. Hydraulic shears

a. Shears only cut certain materials. Pipe or tubing cannot be cut with a shear.

b. Shears may leave the edge of the metal curved or rounded, which may interfere with joint fit-up.

c. Shears can only cut limited thickness

4. Cutting torch or Plasma cutter

a. Unlimited thickness, cutting with a torch or plasma cutter should only be done when the cut cannot be made with a saw or shear.

b. Torches and plasma cutters leave slag and rough edges which require a lot of time grinding to allow proper joint fit-up.

c. The heat from a torch or plasma cutter may cause distortion or changes in the metals physical or mechanical properties. (see 240E)

d. Plasma cutters and torches have the widest kerf of any cutting method.

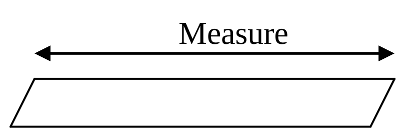
F. Cut layout

1. Lay out cuts to minimize scraps

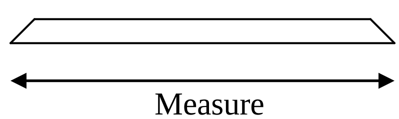
a. Lay out cuts in such a manner that scraps can be used as stiffeners, gussets or other parts.

2. Angle cuts

a. Parallel cuts have the angle on both ends of the material in the same direction. Parallel cuts are measured along one side from the long end of one angle to the short end of the other angle.



b. Opposing cuts have the angle on both ends of the material in opposite directions. Opposing cuts are measured along one edge between the longest points.



-Anytime a square frame is to be assembled 45° opposing cuts should be made on each end of the material. The combination of two 45° cuts makes a 90° corner.

-This type of joint allows a greater surface to be welded and avoids making welds that are perpendicular to the grain for stronger joints.

-To cut opposing angles the cutting stock must be rotated 180° or turned end over end 180° or the blade of the saw must be changed to 45° in the opposite direction between each cut.

3. Making multiple cuts

a. Multiple cuts of the same specifications.

-Saw stop may be set up to indicate that the material is the proper length from the blade. This saves the time of measuring and marking individual pieces.

b. Multiple cuts of various lengths on the same stick of material.

-Most accurate way to cut multiple cuts from the same stick is to mark and make one cut at a time. However, this is time consuming.

-Lay out cutting lines on the material. After the first length is marked add the kerf width to the preceding measurements to be cut. On each cut make sure that the blade is on the outside of each line. The blade should be on the side of the line opposite the end where the measuring began.

G. Project lay out

1. Study the working drawing to understand which parts must be assembled first and in what sequence.

2. Construct jigs to speed up the assembly of duplicate parts.

3. Plan the lay out to minimize the number of pieces to reduce assembly time.

4. Weld larger joints that may have the greatest contraction upon cooling first.

a. Joints can be pre-set or pre-bent to allow for distortion (see 240E).

5. Determine a sequence in which the project will be assembled. (see 240A).

   a. Larger pieces are typically assembled first and then smaller pieces are added. Welding longer more flexible sections first allows for more straightening or movement that may be required before final assembly. For example on a trailer:

      -The outside of the frame is built first
      -Then the sub frame
      -Then cross members, gussets and other support members are added

5. Draw actual sized diagrams on the floor for parts that are not 90° corners. For example on a trailer; the A-frame can be assembled before it is put on the trailer frame. (see figure on next page)

   1. If an A-Frame hitch coupler is to be attached to the A-Frame. Lay the coupler on the floor and trace the 55° angle from the coupler. Mark the center of the ball on the floor. With reference to the 55° lines.

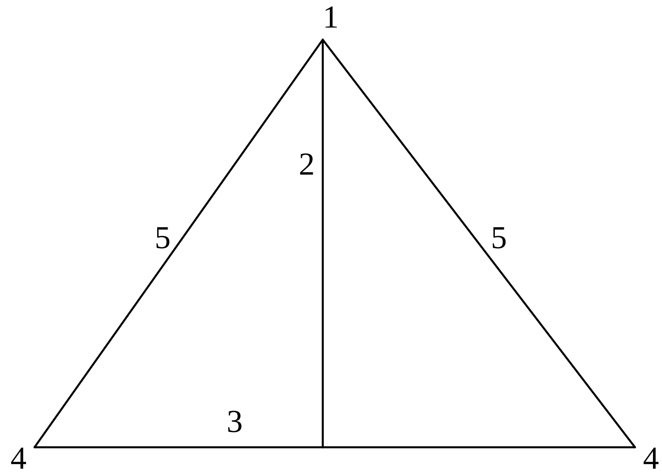
   2. Draw a line from the center of the ball back the distance that the A-Frame is to be.

   3. Draw another line perpendicular to that line at the end of it.

   4. Measure the distance from the center of the trailer to the outside points where the A-Frame will attach to the trailer and mark this distance on the line from step 3.

   5. Connect those marks with the marks traced from the hitch coupler in step 1.

   6. The A-Frame can be fabricated using these lines as a reference


1
2
5
5
3
4
4

240C- 10

JOINT DESIGN AND PROJECT LAYOUT

Unit Exam

Name_______________

1. List the 5 basic welding joints.

2. List three factors to consider when selecting weld joints for a project.

3. Which welding position is most often preferred?

4. List two methods for cutting materials and give and advantage and disadvantage for each method.

5. Explain why 90° joints should be cut at two 45° angles rather than welding two 90° pieces together in a T.

6. Sketch a piece of flat stock cut at opposing angles.

7. List or diagram the steps for laying out an A-frame for a trailer.

240C- 11

JOINT DESIGN AND PROJECT LAYOUT

Unit Exam

Name Key_________

1. Butt joint, Lap joint, T joint, Edge joint, Corner Joint

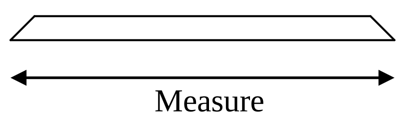
2. Minimize edge preparation, Minimize filler metal, Reduce excess heat, Minimize number of welds, Size the weld for the thinnest joint member, Welding positions, Weld joint access.

3. Flat

4. Chop saw, Advantage – Quick, Disadvantage-inaccurate
   Band saw, Advantage-Accurate, Disadvantage-Slow
   Shear, Advantage-Quick, Disadvantage-rounds edges
   Torch or plasma cutter, Advantage-no limits on thickness, Disadvantage-requires grinding

5. Cutting pieces at 45° gives more surface to weld and prevents welding perpendicular to the grain.

6.



7. 1) If an A-Frame hitch coupler is to be attached to the A-Frame. Lay the coupler on the floor and trace the 55° angle from the coupler. Mark the center of the ball on the floor. With reference to the 55° lines.

2) Draw a line from the center of the ball back the distance that the A-Frame is to be.

3) Draw another line perpendicular to that line at the end of it.

4) Measure the distance from the center of the trailer to the outside points where the A-Frame will attach to the trailer and mark this distance on the line from step 3.

5) Connect those marks with the marks traced from the hitch coupler in step 1.

PRINTS

AG 240-D

UNIT OBJECTIVE

After completion of this unit, students will understand basic lines and symbols used on prints. Students will learn to read and draft plans for fabrication projects. Students will be able to understand and use AWS welding symbols properly. Students will be able to draw the proper symbols and make the proper welds from reading AWS print symbols. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Identify the different types of lines used in a drawing or layout.
2. Identify the three types of drawings (orthographic, isometric, and oblique).
3. Identify the different weld symbols used by AWS and their meaning.
4. Identify the different joint symbols used by AWS and their meaning.
5. Know the importance of the placement of each symbol.
6. Draw the different symbols and lines used by AWS.
7. Make the proper welds in the proper locations using an AWS blueprint or diagram.
8. Make fabrication plans using the AWS symbols.
9. Match various lines with correct functions.
10. Calculate actual measurements from scaled drawings.
11. Interpret prints
12. Prepare prints.

Unit References:

Burke, Stanley R., & Wakeman, T. J. (1990). MODERN AGRICULTURAL MECHANICS (2nd ed.). Danville, IL: Interstate Publishers.

Cooper, Elmer L. (1987). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS. Albany, NY: Delmar Publishers.

Gosse, F. Jonathan & Proctor, E. Thomas (1992) PRINTREADING FOR WELDERS, American Technical Publishers Inc. Homewood, IL

Griffin, Ivan H., Roden, Edward M., Briggs, Charles W. (1984) BASIC TIG & MIG WELDING, THIRD EDITION, Albany, NY: Delmar Publishers

Jones, M. M. (1955). SHOPWORK ON THE FARM (2nd ed.). New York: McGraw-Hill.

Spencer, H. C., & Dygdon, J. T. (1980). BASIC TECHNICAL DRAWING. New York: Macmillan.

Miller, R. T., (1997) WELDING SKILLS, Second Edition, Homewood, Illinois., American Technical Publishers, Inc.

Resources:

Bear, W. F., Hamilton, W. H., & Mann, A. (1974). PLANNING PROJECT CONSTRUCTION. Available from Hobar Publications, 1234 Tiller Lane, St. Paul, MN 55112, (612) 633-3170

INTRODUCTION

A. Working Drawings

1. A working drawing is a set of plans with all necessary information to complete a job.

    a. Specifications or “specs” are supplemental information for working drawings. Specifications are commonly written instructions.

B. Prints

1. Prints are reproductions of working drawings

2. Prints were once referred to as blueprints

    a. The term blueprint originated because of the process used to develop them. Blueprints were actually printed on blue paper with white lines.

    b. Blueprints have been replaced with technology of computers and copiers.

PREPARING A WORKING DRAWING

A. Sketches and Working Drawings

1. Sketches are freehand drawings of an object for a project done in order to get the idea down on paper.

   a. Sketches are not usually drawn to scale.
   b. Neatly drawn sketches with fairly accurate dimensions are usually sufficient for simple projects.
   c. Sketches of larger and more complicated projects can serve as the basis for accurate working drawings.

2. Working drawings are complete drawings done in universal graphic language so that the object depicted can be constructed from the drawing alone without additional information.

   a. Dimensions - Working drawings use lines scaled to the dimensions of the actual objects.
   b. Views - Working drawings show specific views of an object with enough detail to enable project construction.

      1) Most working drawings show three separate sides of an object from three flat, head-on views.
      2) Pictorial drawings show three sides of an object together in one view.

B. Types of Working Drawings

1. Orthographic Drawings

   a. They show a flat, head-on view of every side that differs in size and shape.
   b. They may illustrate six views of the object: top, bottom, front, back, right side, and left side (the ends).
   c. They usually use only three views: top, front, and end.

2. Pictorial Drawings

   a. Isometric Drawings

      1) Isometric drawings are based on three lines or axes: one vertical axis with two others at 60 degrees to the vertical.

2) Such drawings can show the true dimensions of an object's top, side, and end views.

3) The line angles of isometric drawings are not accurate, but are nevertheless used to give the object a three dimensional effect.

b. Oblique Drawings

1) Oblique drawings are based on three lines or axes similar to isometric drawings, except that one axis is horizontal, one vertical, and the third is at a convenient angle (typically 30 degrees to 45 degrees) to the horizontal.
2) Like isometric drawings, oblique drawings can depict the true dimensions of an object's top, side, and end.
3) The front of an oblique drawing always shows the true shape of that side of the object from a head-on view.
4) If the object being drawn has a side with curved or irregular lines, this side is used for the front.

SAFETY IN SKETCHING, DRAWING, AND PLAN READING

Some pieces of drawing equipment have sharp points; therefore, when using these drawing instruments, you should exercise care to prevent injury to yourself and/or others.

Safety Practices:

1. Keep sharp-pointed drawing instruments stored in their case to prevent injury to yourself and/or others.
2. When using drawing instruments, lay them in a safe place to prevent them from falling.
3. To prevent drawing instruments from falling, fasten the drawing tabletop securely before you start to draw.
4. Never play with sharp-pointed drawing instruments.

C. Constructing Working Drawings

1. Drawing to Scale

a. Scale drawing permits the size of the object to be reduced proportionally in order for it to be drawn on the size of paper chosen.

b. Common scales of a drawing may be 1/8," 1/4," 3/4," 1," and 3," to represent one foot. For example, 1/8 inch = 1 foot.
c. An architect's scale is the most common type of scale used for drawing agricultural projects.

1) Its main divisions at the end of the scale, which are in inches or fractions of an inch, represent one foot.
2) The divisions are subdivided even smaller to represent inches and fractions of an inch.
3) An architect's triangular scale has six faces with a different scale on each end of each face.

d. Use of engineer's paper (graph paper) permits drawing to scale without an architect's scale. It is cross-ruled paper with 4, 8, or 12 divisions to the inch. Simply count the number of divisions in order to draw a line to scale.

2. Sheet Layout (Example, on page 240D-16)

a. Attach a sheet of paper to the drawing board with tape.

1) If a T square and triangles will be used as drawing aids, use the T square to align the paper with the left edge of the drawing board.
2) If a T square is not available, tracing paper or vellum may be attached with engineer's paper under it to serve as a drawing aid.

b. Draw border lines 1/2 inch from the paper's edge, 3/4 inch from the bottom.
c. Make a title block at the bottom of the paper which includes the following information about the drawing:

1) The name of the person doing the drawing.
2) The date of the drawing.
3) The title of the drawing.
4) The scale of the drawing.

3. Types of Lines Used in Drawings (Page 240E-15)

a. Border line: a heavy, solid line drawn parallel to the edge of the drawing paper.
b. Object line: a solid line representing the visible edges and form of an object.
c. Hidden line: a series of dashes which indicate the presence of hidden edges.

d. Extension line: a solid line indicating the exact area specified by a dimension.
e. Dimension line: a solid line with arrowheads at both ends to indicate the length, width, or height of an object.
f. Center line: a long-short-long line used to depict the center of a round object.
g. Leader line: a solid line with an arrow pointing from an explanatory note to a specific feature of an object.
h. Break line: a solid, zigzag line which indicates that part of the object being drawn is not fully illustrated or has been left out.

4. Developing the Views

a. Choose an appropriate scale which will allow all views to fit within the border lines.
b. Locate and mark off the spaces for the various views.
c. Establish the main lines of the drawing, then add the minor ones.
d. Develop all the views together. In a three-view, orthographic drawing, project from the front view to the top and end views with the T square and triangles.

1) Use the T-square against only the left edge of the board for drawing horizontal lines, since the board may not be perfectly square.
2) Use a right-angle triangle with the T-square to draw vertical lines.

e. Finally, add the dimension lines and notes.

ACTIVITY:

1. Make a freehand sketch of a simple shop project. Engineer's paper can be used.
2. Develop an orthographic (3-D) drawing from the sketch of the project.

PROJECT PLANNING & CONSTRUCTION

A. Project Planning Considerations

1. Will the project be subject to loads or weights such that strength considerations must be taken into account?

a. Strength is important when planning a ladder or ramp, but it is not as critical a factor when planning a decorative lamp stand.

2. Are suitable materials, tools, and fasteners readily available?

a. If building a project that needs to be arc welded, is the appropriate type (AC, DC, MIG, TIG) and size of welder available along with the correct size and type of welding rod?

3. Is there a similar part or item commercially available which would eliminate the need to "reinvent the wheel."

a. For example, if planning to build an engine stand, check commercially available models to get ideas regarding design, size, and types of materials used, as well as joint types.

4. Use standard size, commercially available parts and components to hold down expense and excessive fabrication time and costs.

a. It will cost more and require more fabrication time to specify 1/8" X 1-1/16" strip steel (NOT commercially available) rather than 1/8" X 1" strip steel which is commercially available.

5. Consider set-up and jigging techniques to eliminate "impossible" or extremely difficult fabrication and assembly.

a. When sketching or laying out plans, consider what the sequence of procedures should be in order to complete all the steps in the simplest and most efficient way.

6. When appearance is not a consideration, use less expensive materials.

a. Use hot rolled steel in place of cold rolled steel because the cost of hot rolled steel is less and the strength is the same even though the appearance is slightly less shiny.
b. Use economical grades of lumber for general utility and construction projects.

B. Interpreting Working Plans

1. Cutting List

a. A cutting list itemizes the various dimensions of materials (wood, metal, etc.) that must be cut before being assembled.
b. This tabular form includes the name of the project part, the number of pieces, the dimensions, and the type of material.

c. This list serves as a checklist of project parts required for assembly and speeds up the construction process by alerting the builder to set up cutting jigs for project parts having the same dimensions.

d. If a plan has no dimensions specified, but is drawn to scale, use an architect's scale to determine the dimensions required.

2. Bill of Materials (for more information see section 240B)

a. A bill of materials is a list of all the materials needed for a project with the total cost calculated.

b. This tabular form includes the number of pieces, the dimensions, a description of the items, the cost per unit, and the total cost.

c. It is preferable to order standard stock sizes that will provide the desired materials with the least possible waste.

d. List similar materials together and in the order they will be used.

ACTIVITY:

1. Have student draw the jack stand project in 240K
2. Calculate the construction cost of a project by making a bill of materials from a working drawing. A bill of materials form may be obtained from 240B.
3. Complete a cutting list from a working drawing of a project.
4. Use the drawing provided in 240K to construct jack stands.
5. Lay out and assemble the project.

Special Material and Equipment:

A working drawing for the project to be constructed and the tools and materials required. Architect's scale or ruler, pencils, paper, drawing board, T square, 45 degree triangle (8" long sides), 30 degree X 60 degree triangle (10" side), cross-ruled paper, tracing vellum.

AWS WELDING SYMBOLS

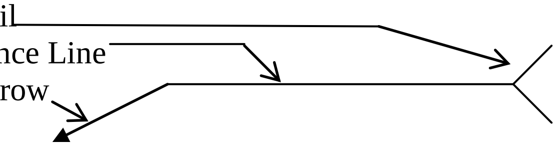
A. Introduction to AWS Welding Symbols

1. The welding symbols used today are considered shorthand for the welder. Developing a clear means of communication between the designing engineer and the welder building the project. The American Welding Society (AWS) has developed a standard set of symbols to be used for this purpose. Both the designing engineer and the welder use these symbols without need for further communication.

B. The Welding Symbol

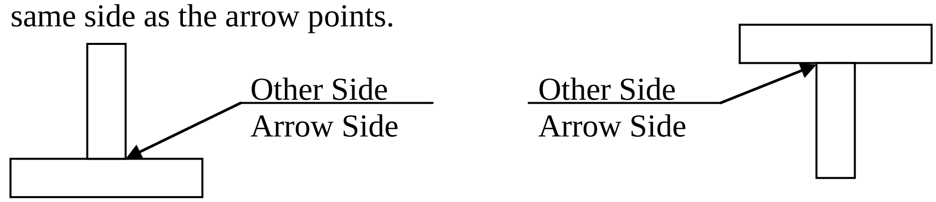
1. The welding symbol is made up of three parts.

   a. The Tail
   b. Reference Line
   c. The Arrow

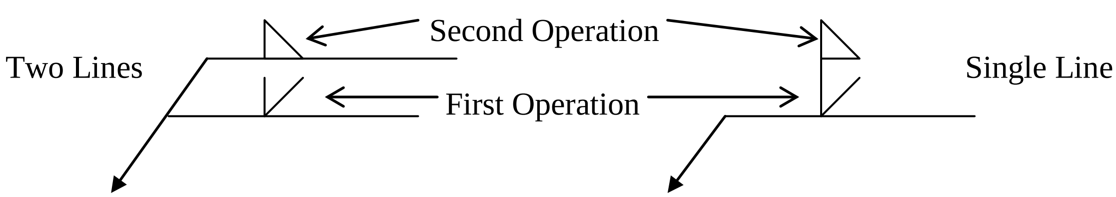


2. The Reference Line

   a. The reference line is the main foundation for welding symbols used in blueprints.
   b. Anything written above the reference line itself indicates a weld on the other side of where the arrow points.
   c. Anything written below the reference line itself indicates a weld on the same side as the arrow points.



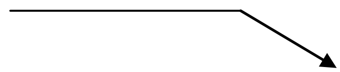
   d. Additional reference lines are used to present a sequence of welds or operations to be preformed. Sometimes it is necessary to prepare the joint before welding, this will be defined in the welding symbol. Additional references can be made in two ways, fist drawing another reference line or stacking symbols.



3. The Arrow

   a. The arrow runs from the reference line and designates the joint that needs to be welded.
   b. A straight arrow is used for weld locations.
   c. A broken-arrow line is used for joint preparation and breaks toward the piece that is to be beveled.

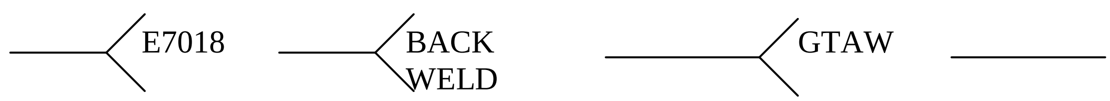
Straight Arrow Line



Broken-Arrow Line

4. The Tail

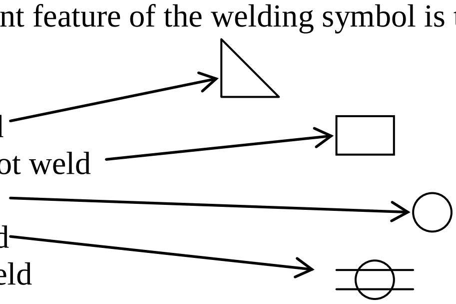
   a. Inside the tail will be further information about the weld. Usually, the method of welding or type of welding rod to be used.
   b. Specification or other references will be placed here.
   c. The tail might not appear on the reference line if it is not being used.



C. The Weld Symbol

1. The most important feature of the welding symbol is the type of weld to be used on the joint.

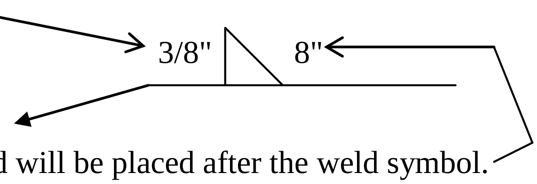
   a. Fillet weld
   b. Plug or Slot weld
   c. Spot weld
   d. Seam weld
   e. Groove weld



      1) Square Groove
      2) V-Groove
      3) Bevel–Groove
      4) U-Groove
      5) J-Groove
      6) Flare-V
      7) Flare-Bevel
      (see chart, 240E-27)

D. Size of Welds

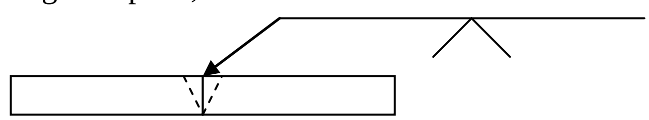
1. The size of the weld will be indicated on the weld symbol.
2. The size will be expressed in decimals, fractions, or metric unit (mm).
3. The size will be located in front of the weld symbol on the reference line.



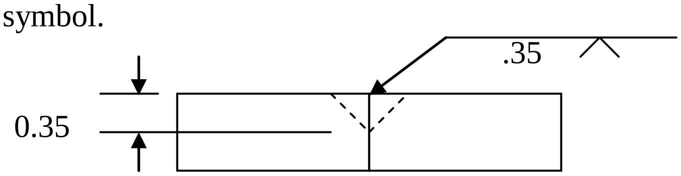
4. The length of the weld will be placed after the weld symbol.
5. If the length of the legs on a fillet weld are meant to be unequal they will be labeled with two dimensions.
6. If a note gives the size of the welds, no dimensions will appear on the symbol. (See Chart 240E-28)

E. Sizes, Gaps, and Angle of Grooves

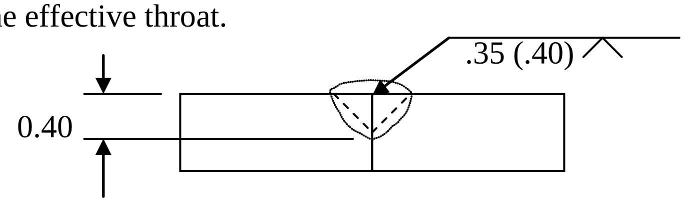
1. If the groove goes through the plate, a measurement of distance is not needed.



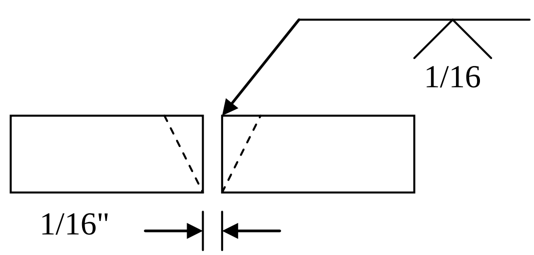
2. If the groove only goes a certain depth through the metal, a measurement will be given before the weld symbol.



3. If a number appear in parentheses (.40) before the weld symbol, it will determine the depth of the effective throat.



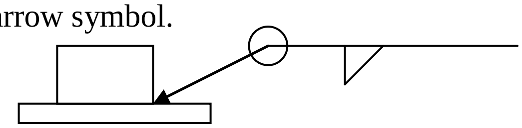
4. If a gap between the two pieces of metal is needed, it will be indicated on the weld symbol.

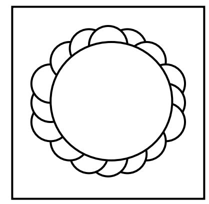


F. Other Symbols

1. All Around, Symbol – When a bead is to be welded all the way around a plate or pipe the circle symbol will appear on the reference line's connection with the arrow symbol.

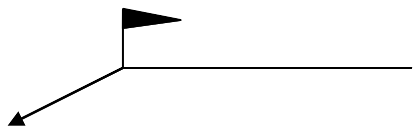
Side View



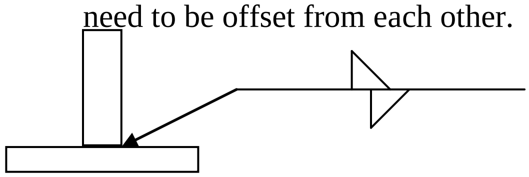


Top View

2. Field Weld, Symbol – When a weld is to be made or inspected out in the field a flag will appear on the reference line's connection with the arrow symbol.

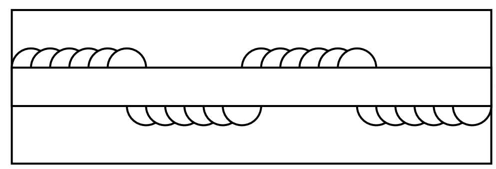


3. Offset Symbols – If the welds symbols are off set from each other, the beads need to be offset from each other.



End View

Top View



4. Contour and Finish Symbols

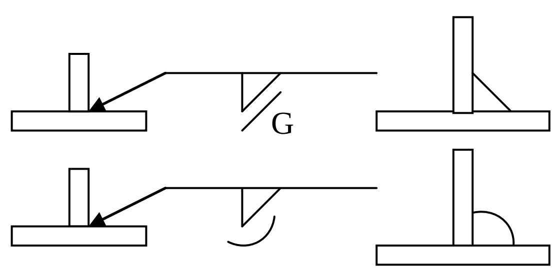
   a. Flush – The flush symbol will be used when the finished surface needs to be flush.

   b. Convex – The convex symbol will be used when the finished surface needs to be convex.

   c. Concave – The concave symbol will be used when the finished surface needs to concave, this is very seldom used but it has its' purpose.

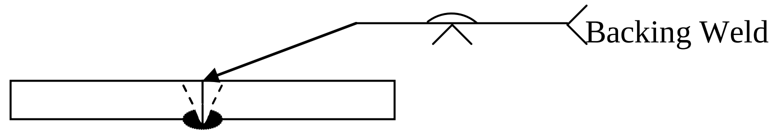
   d. Finish Method – Most of the time the welding process will determine the finished surface. If a mechanical means of surfacing are needed it will be indicated by a letter, otherwise a letter will not appear.

      1) C – Chipping
      2) M – Machining
      3) G – Grinding
      5) R – Rolling
      6) H – Hammering
      7) U – Unspecified

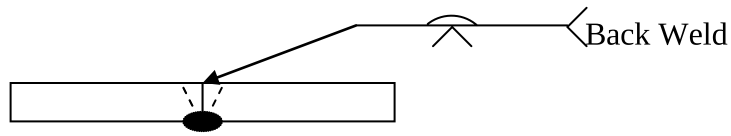


5. Back and Backing Welds

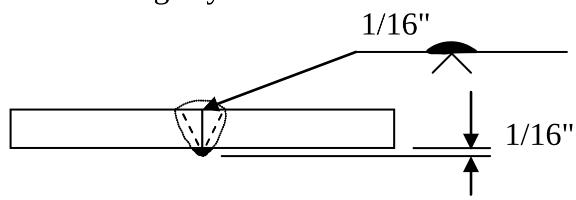
a. A Backing weld will be made on the opposite side of a groove before the groove weld is made and will also appear on the opposite side of the reference line. It will also be noted in the tail as to be a Back or Backing weld.



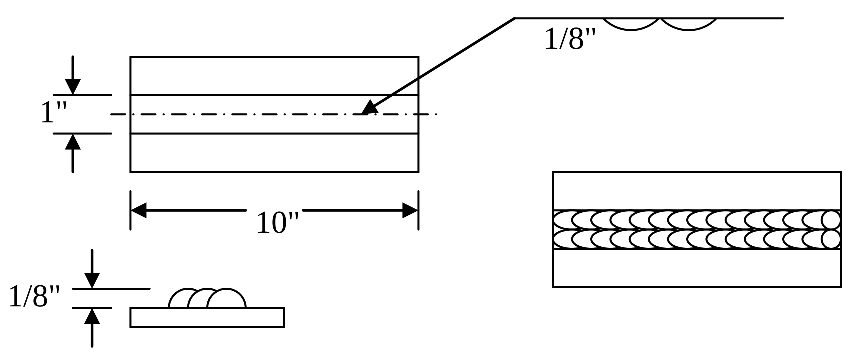
b. A Back weld will be made on the opposite side of a groove weld after the groove weld and will also appear on the opposite side of the reference line. It will also be noted in the tail as to be a Back or Backing weld.



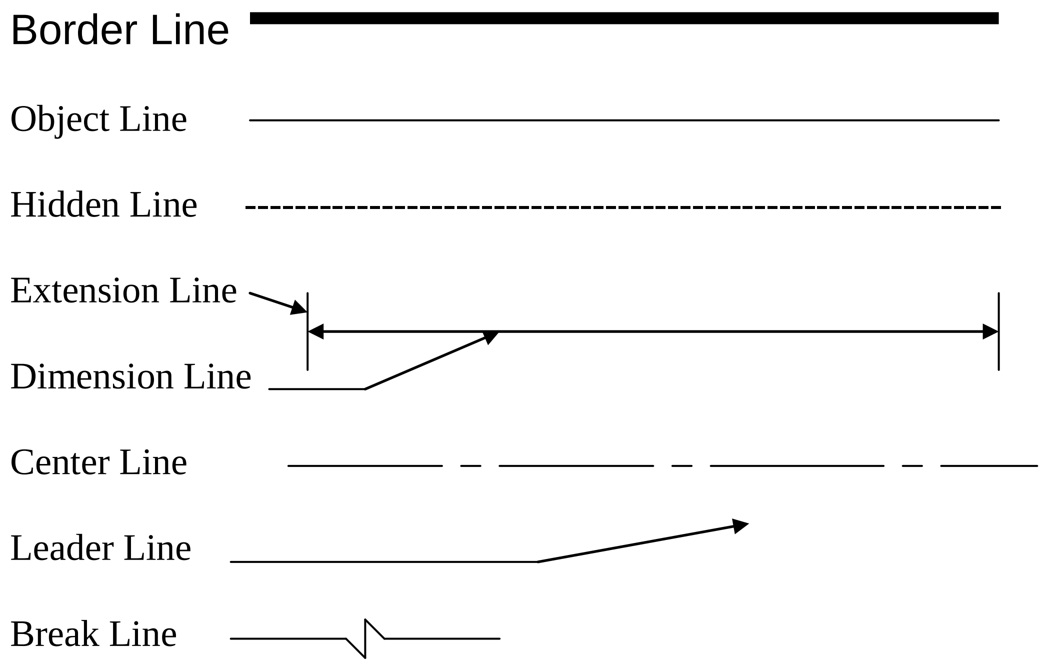
6. Melt-Through Welds – Welds that are required to melt through to the other side of the metal will be indicated by the melt-through symbol, which will appear opposite of the weld symbol. The height of the melt through will be indicated left of the melt-through symbol.



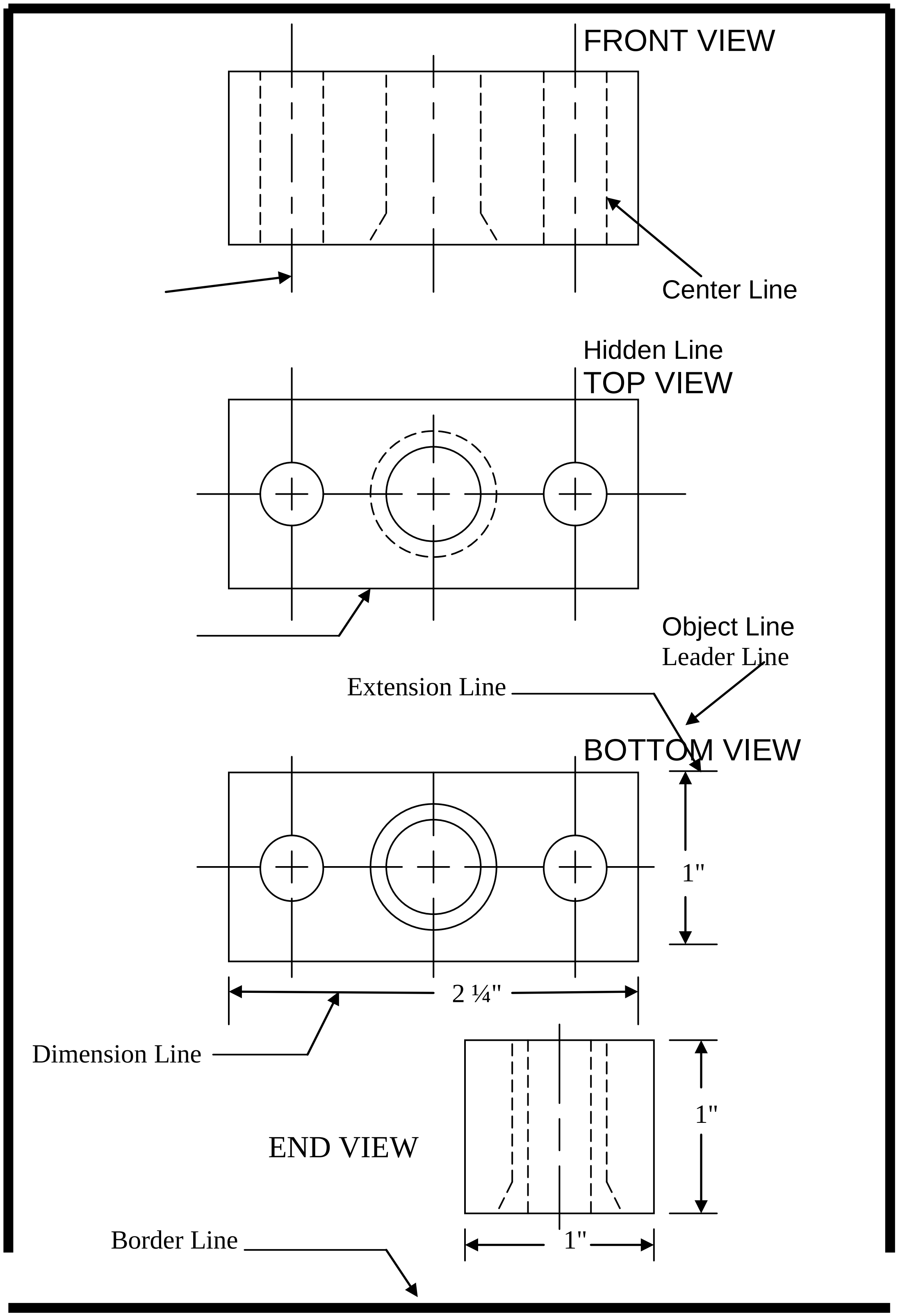
7. Surfacing and Hardfacing Welds – Welds that are applied to areas that need to be built up or need hardfacing to prevent wear. The height of the weld will be indicated to the left of the weld symbol.



BASIC LINES USED IN DRAWING AND SKETCHING



FLYWHEEL PULLER

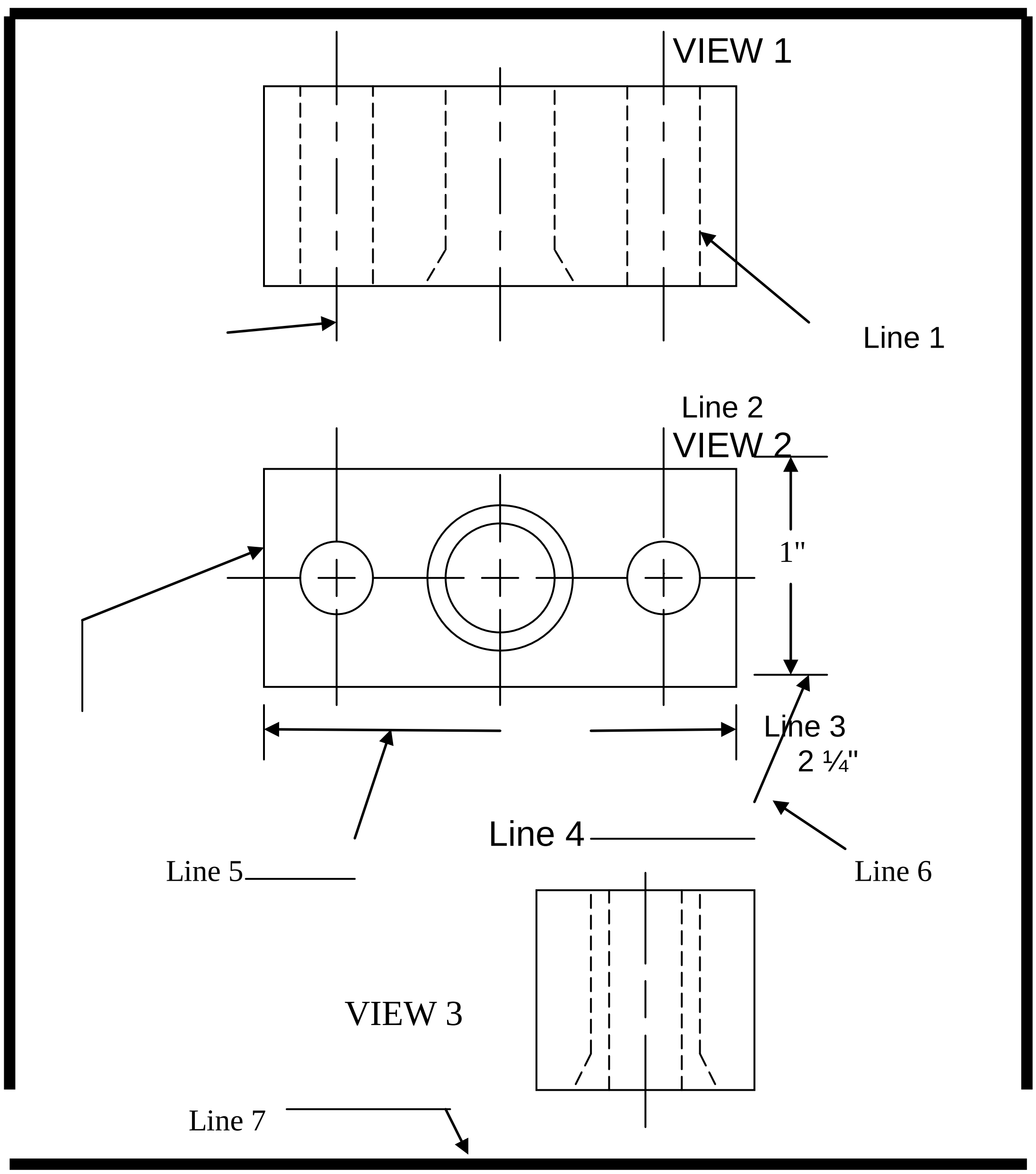


Name____________________ Date_____________________

DRAFTING WORKSHEET

Identify and name the following Views and Lines

1. View 1 ___________ View 2 ___________ View 3 ___________
2. Line 1 _________________________
3. Line 2 _________________________
4. Line 3 _________________________
5. Line 4 _________________________
6. Line 5 _________________________
7. Line 6 _________________________
8. Line 7 _________________________



Name___________________

Date____________________

DRAFTING, EXAM

Answer the following questions 1 – 5, matching.

1. Border Line _____ A.

2. Leader Line _____ B.

3. Center Line _____ C.

4. Hidden Line_____ D.

5. Object Line _____ E.

Fill in the Blanks and Short Answer

6. Name the three views on orthographic drawings.

________, ________, _________.

7. What is a sketch?

8. What is a working drawing?

9. Name one safety practice used in making a drawing.

10.What does the Broken Line indicate?

11.Name three items you will find in a title block.

_____________, ____________________, ____________________.

12.Name two things to consider when planning a project.

______________, ___________________.

13.What tool is used to measure lines?

14.What drawing instrument is used to make horizontal lines.

15. What drawing instruments are used to make vertical lines?

Exam, Answer Sheet

1. D
2. A
3. E
4. B
5. C

6. Front, Side, End
7. Sketches are freehand drawings of an object for a project done in order to get an idea down on paper.
8. Working drawing are complete drawings done in universal graphic language so that the object depicted can be constructed from the drawing alone with out additional information.
9. Name one of the four. 1, Store sharp-pointed drawing instruments stored in their case. 2, Place drawing instruments in a safe place to prevent falling. 3, Fasten the drawing tabletop securely before you start to draw. 4, No playing with sharp-pointed drawing instruments.
10. Indicates that part of the object being drawn is not fully illustrated or has been left out.
11. Name of the person who doing the drawing, the date, and title of the drawing.
12. Name two of the five. Strength, Suitable Materials, Don't reinvent the wheel, Use standard sizes, Sequence of procedures.
13. Ruler or architects scale
14. T-square
15. T-square and a 90* triangle

Worksheet, answers

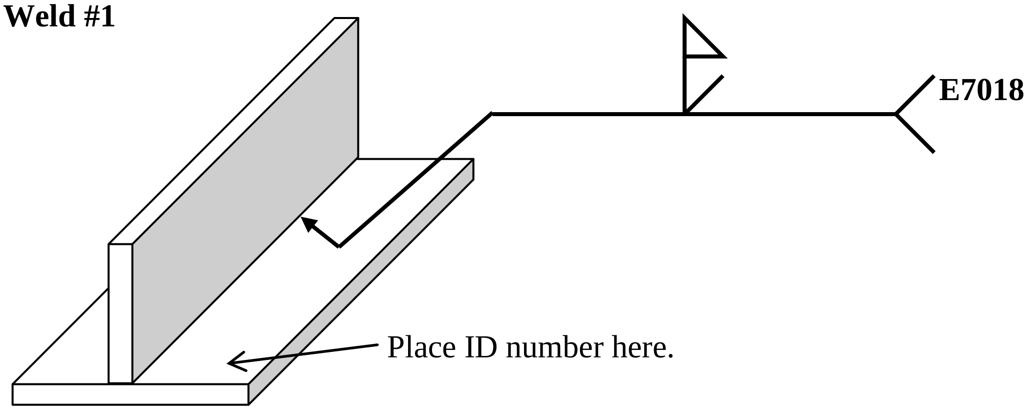
1. 1, Side View 2, Bottom View 3,End View
2. Line 1 – Center Line
3. Line 2 – Hidden Line
4. Line 3 – Object Line
5. Line 4 – Extension Line
6. Line 5 – Dimension Line
7. Line 6 – Leader Line
8. Line 7 – Border Line

ACTIVITY:

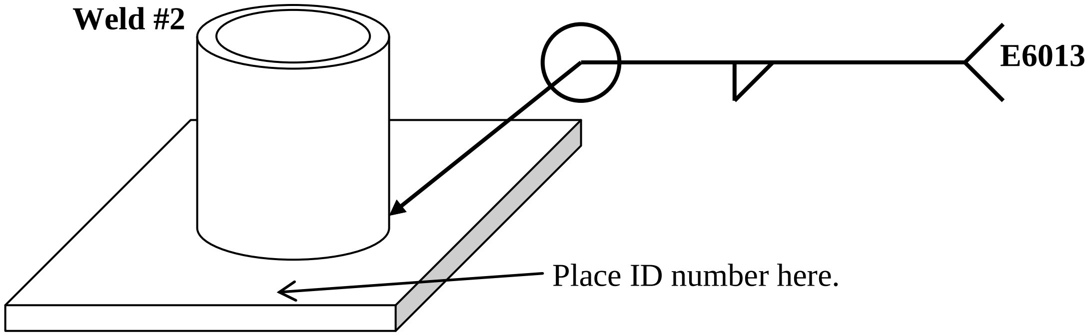
1. Have students perform one, two, or all three welds on this page.

Welding Assignments

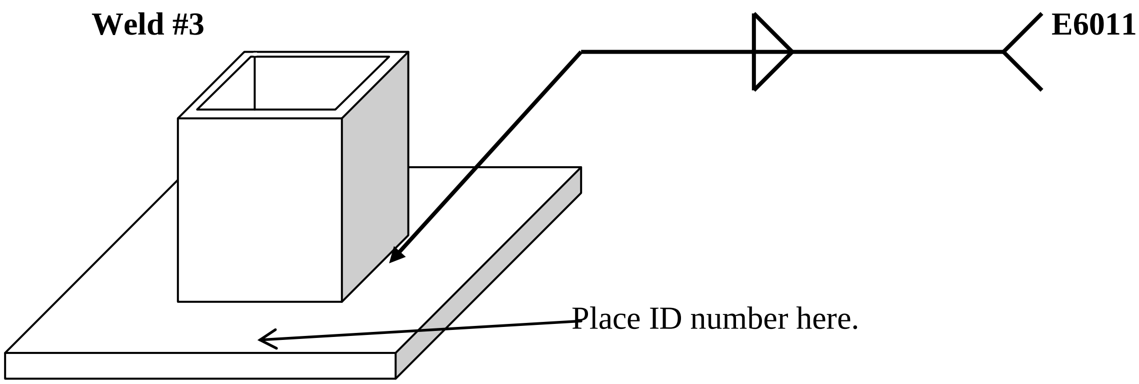
Weld #1



Weld #2



Weld #3

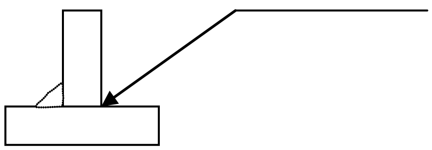


Quiz

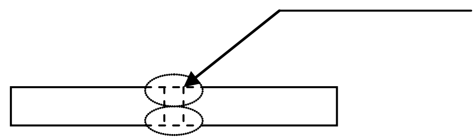
Name____________________
Date_____________________
Score____________________

Draw in the proper weld symbol in the proper location on the reference line.
1 – 5, 10 pts each

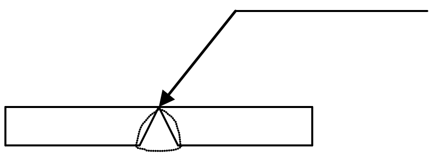
1.



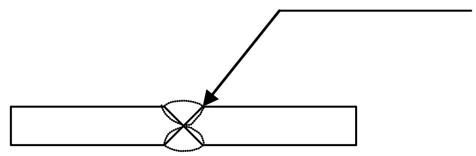
2.



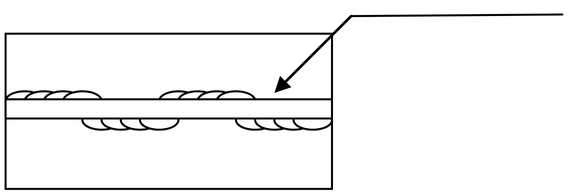
3.



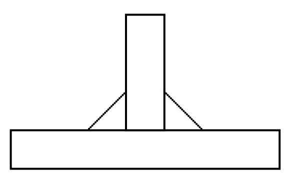
4.



5. (Top View)



(End View)



6. Fill in the blanks, identify the parts of the Welding Symbol. (50 pts.)

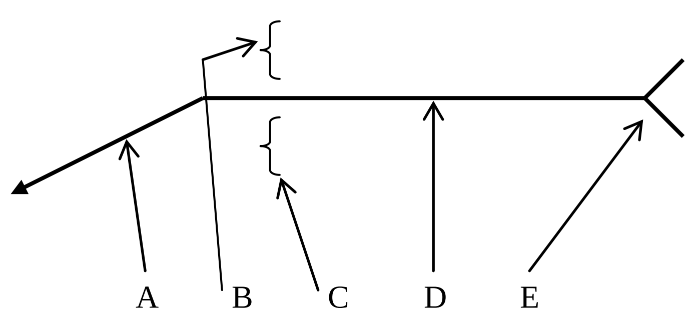
A.____________________

B.____________________

C.____________________

D.____________________

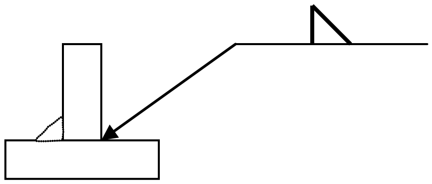
E.____________________



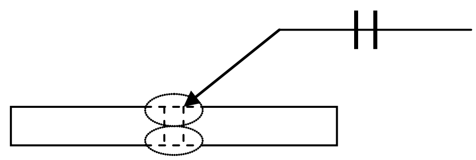
Name________KEY_____
Date___________________
Score___________________

Draw in the proper weld symbol in the proper location on the reference line.
1 – 5, 10 pts each

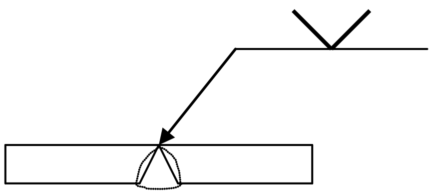
1.



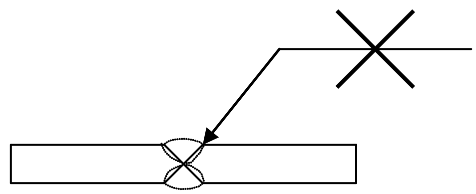
2.



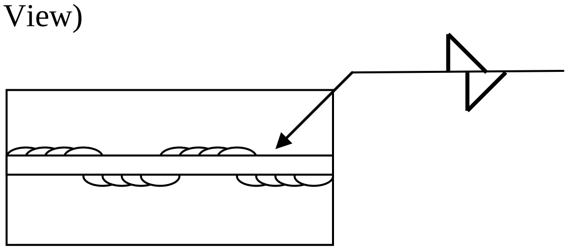
3.



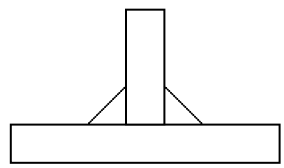
4.



5. (Top View)



(End View)



6. Fill in the blanks, identify the parts of the Welding Symbol. (50 pts.)

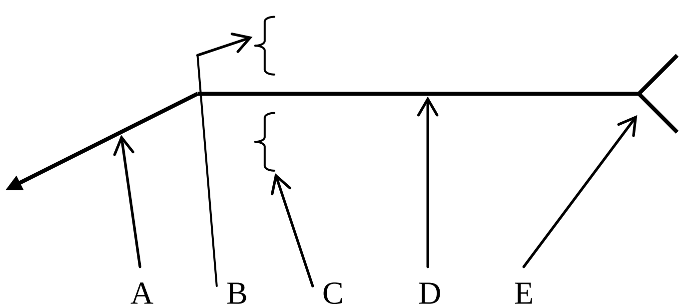
A.______Arrow______

B.______Other Side___

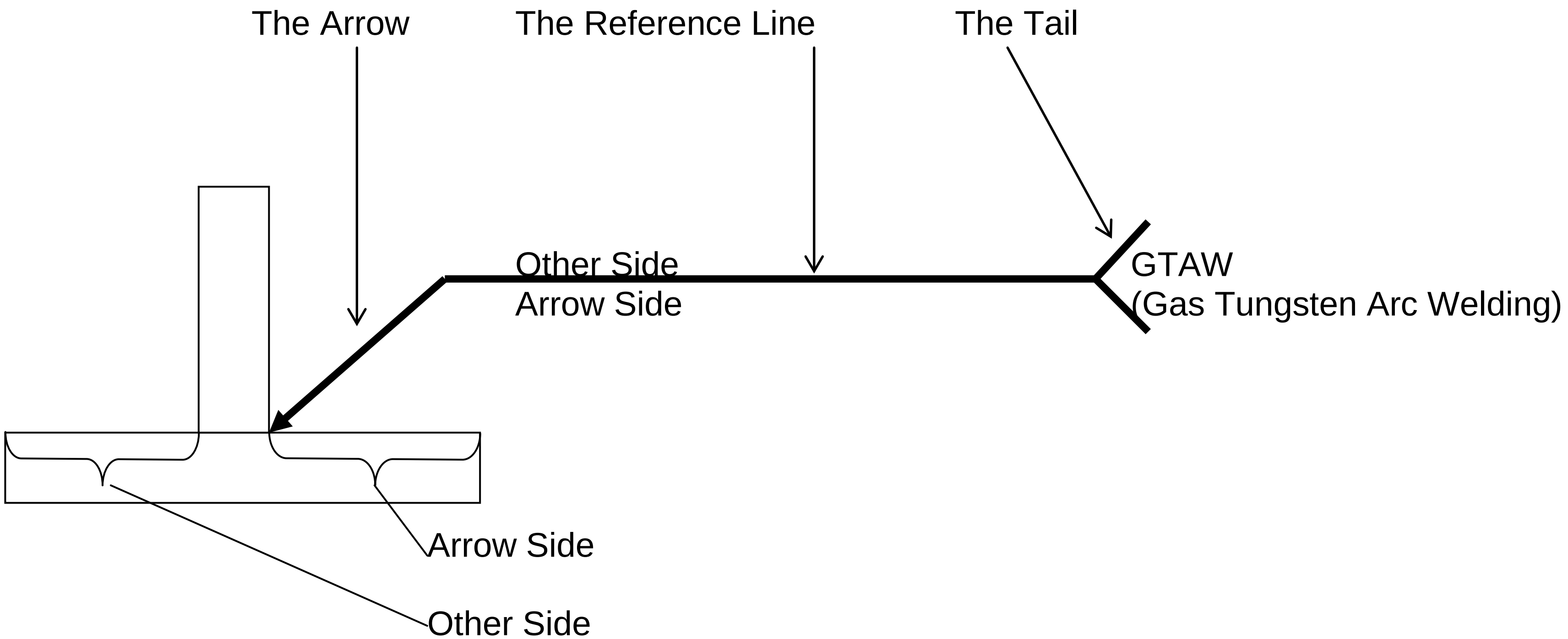
C.______Arrow Side__

D.______Reference Line

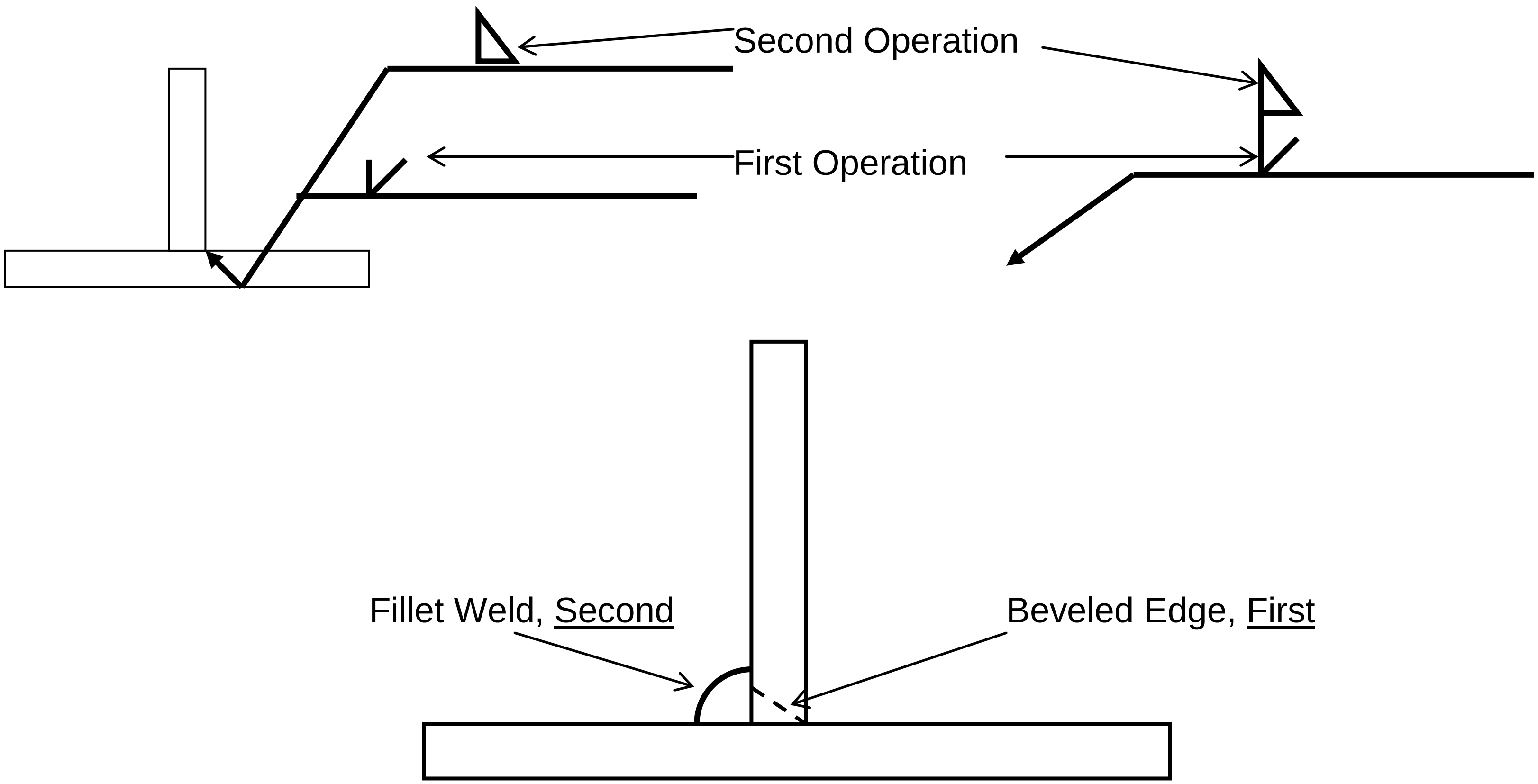
E.______Tail_________



THE WELDING SYMBOL



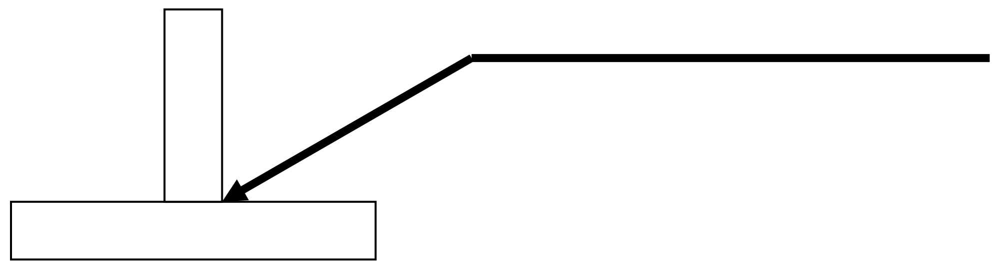
Additional Reference Lines



ARROW LINES

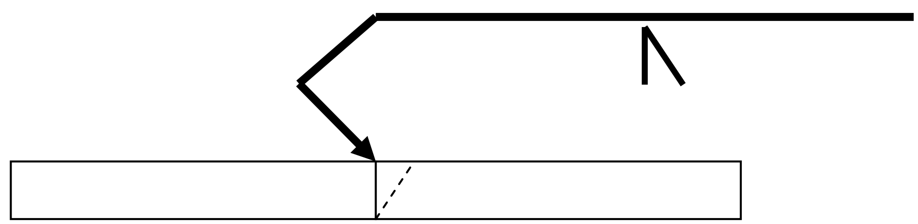
Straight Arrow Line

Arrow points to the joint that needs to be welded.



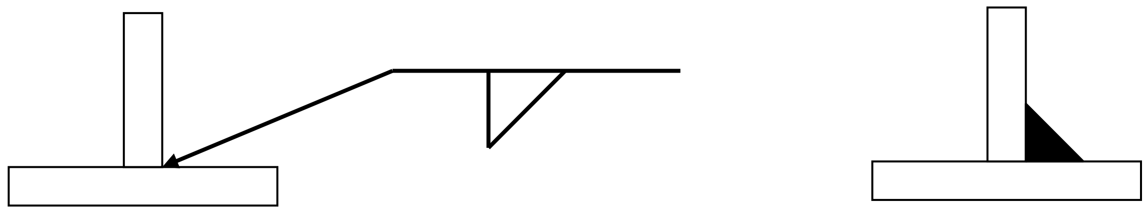
Broken-Arrow Line

Arrow points to the side that needs to be beveled

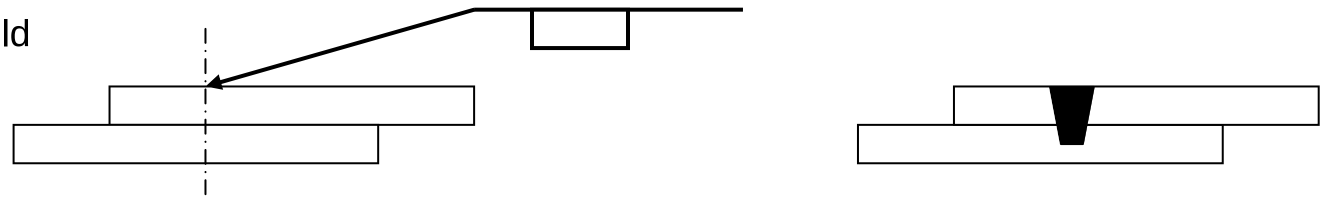


TYPE OF WELDS

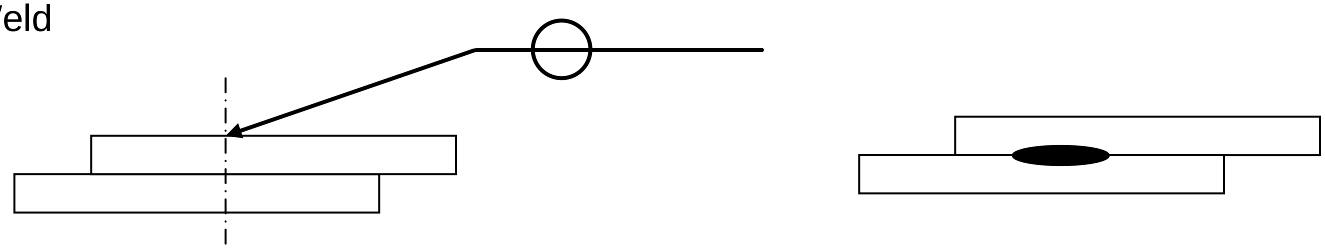
Fillet Weld



Plug Weld

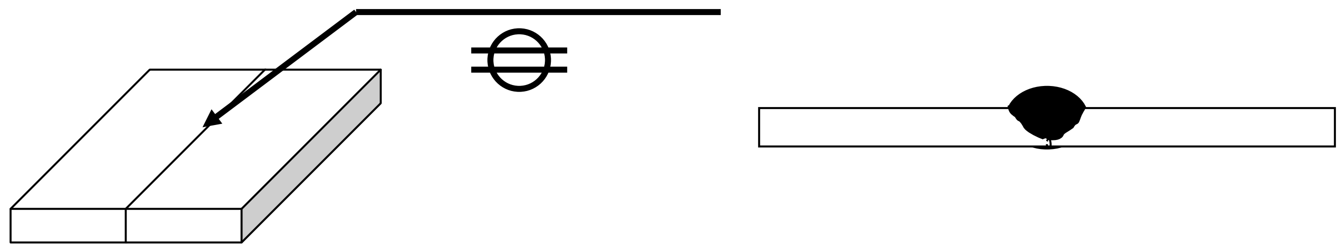


Spot Weld



TYPE OF WELDS

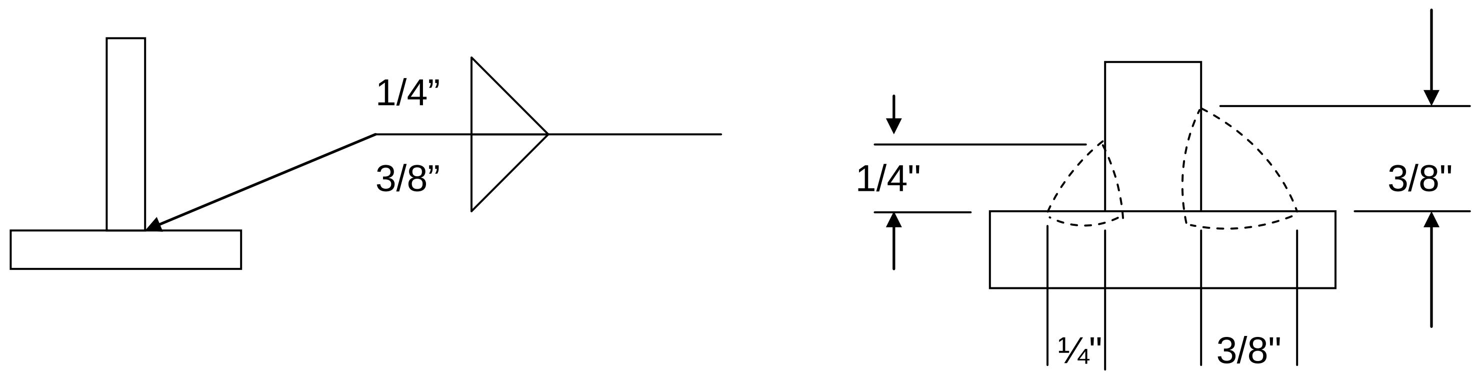
Seam Weld



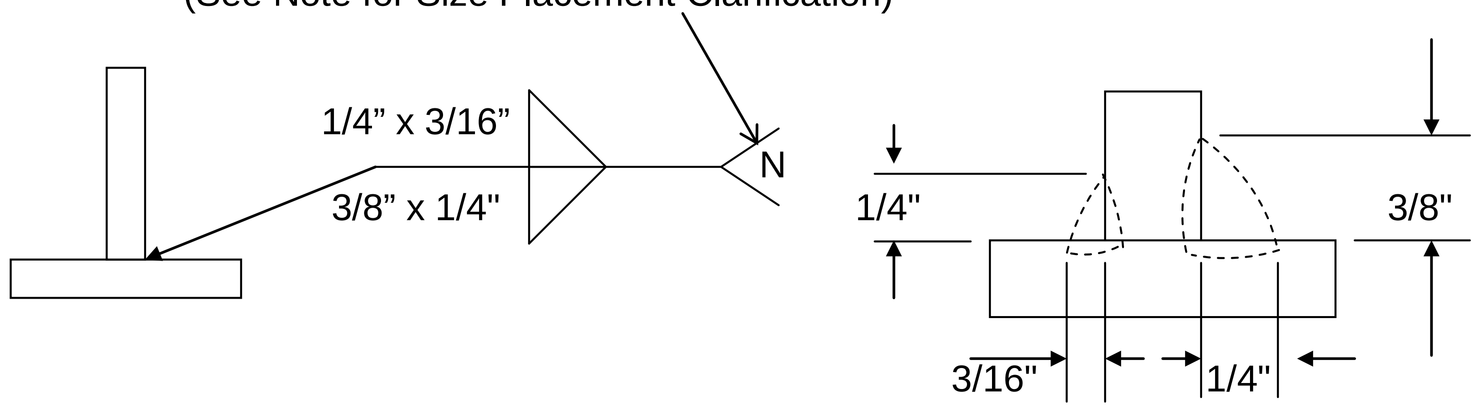
Groove Welds

Square	V	Bevel	U	J	Flare-V	Flare-Bevel

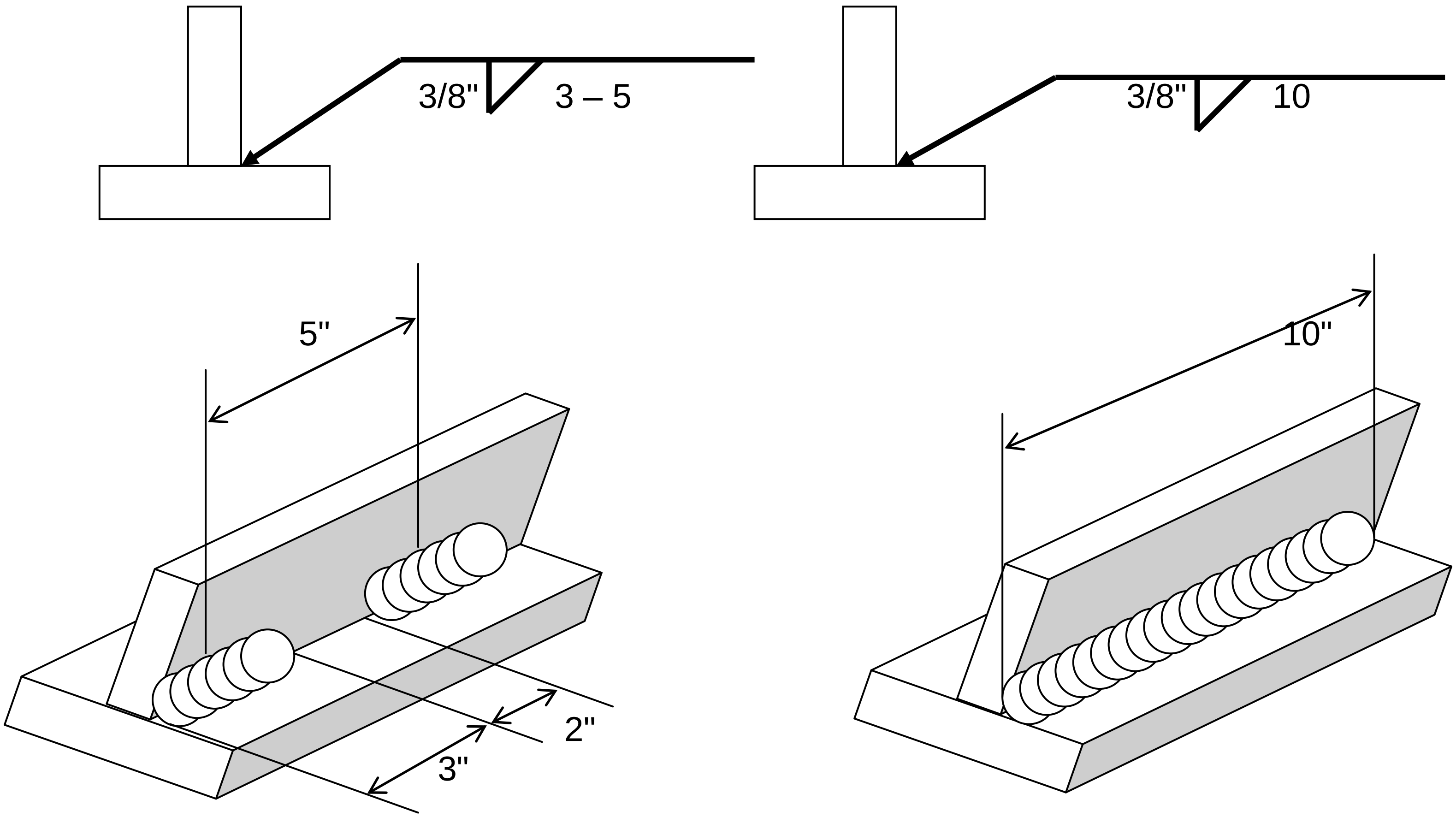
Sizes of Welds



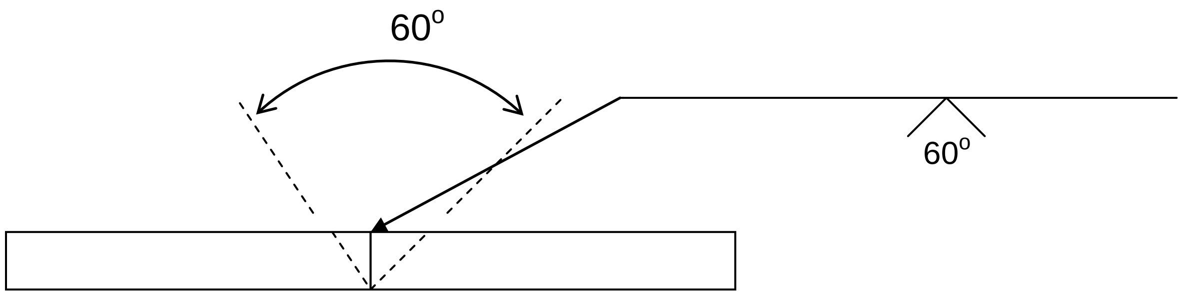
(See Note for Size Placement Clarification)



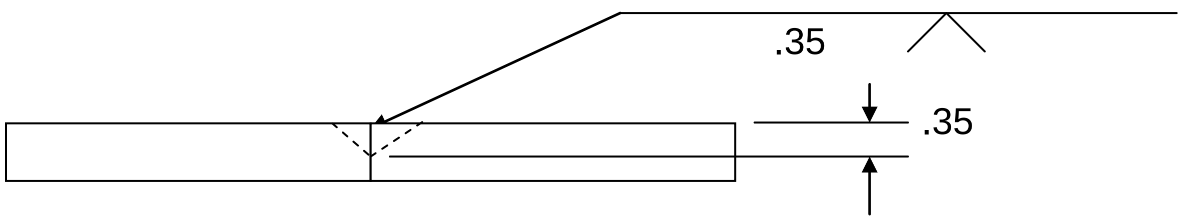
Length of Welds



Sizes, Gaps, and Angle of Grooves

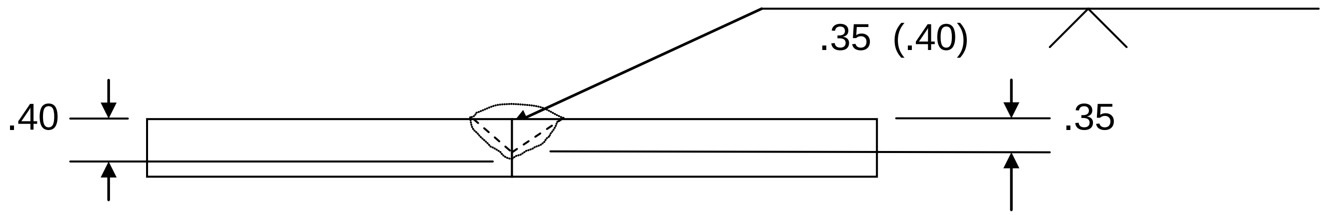


No measurement on depth, the Bevel goes all the way to the other side.

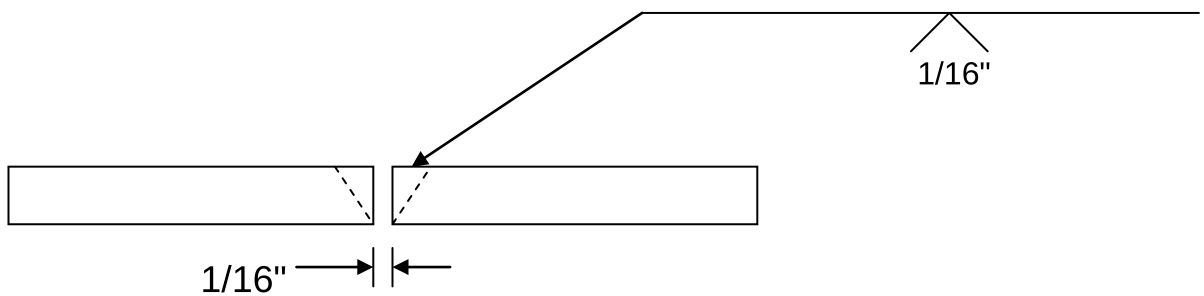


Measurements left of the weld symbol will indicate the depth of the grove.

Sizes, Gaps, and Angle of Grooves

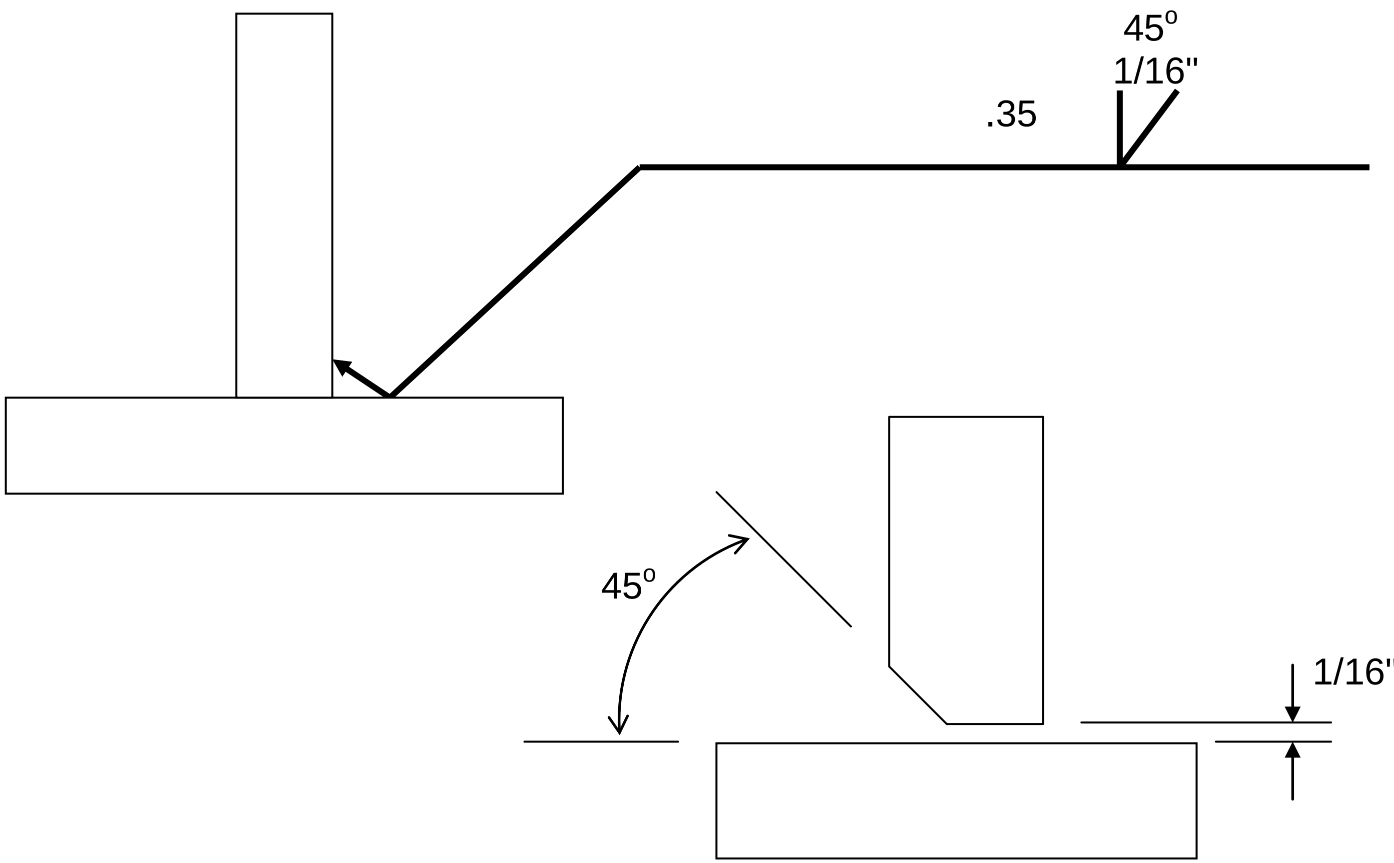


The effective throat measurement will be given in parentheses, left of the weld symbol.



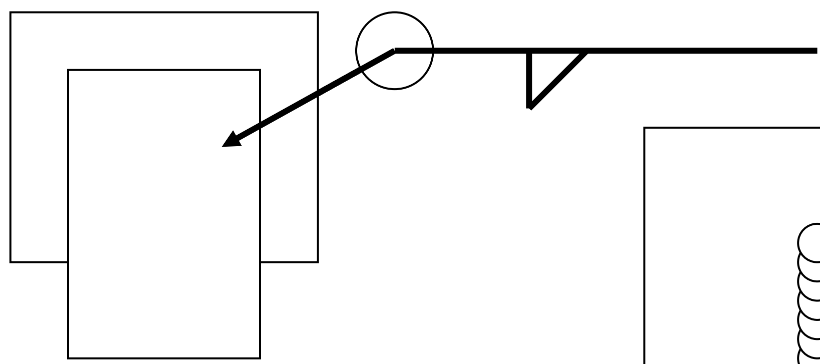
Gaps between the metal will be indicated on the weld symbol.

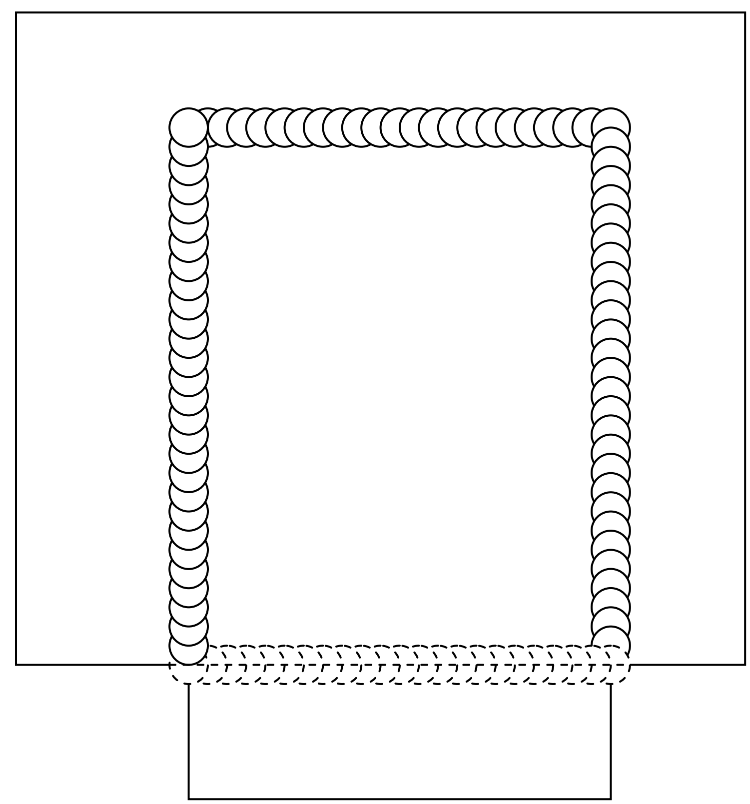
Sizes, Gaps, and Angle of Grooves



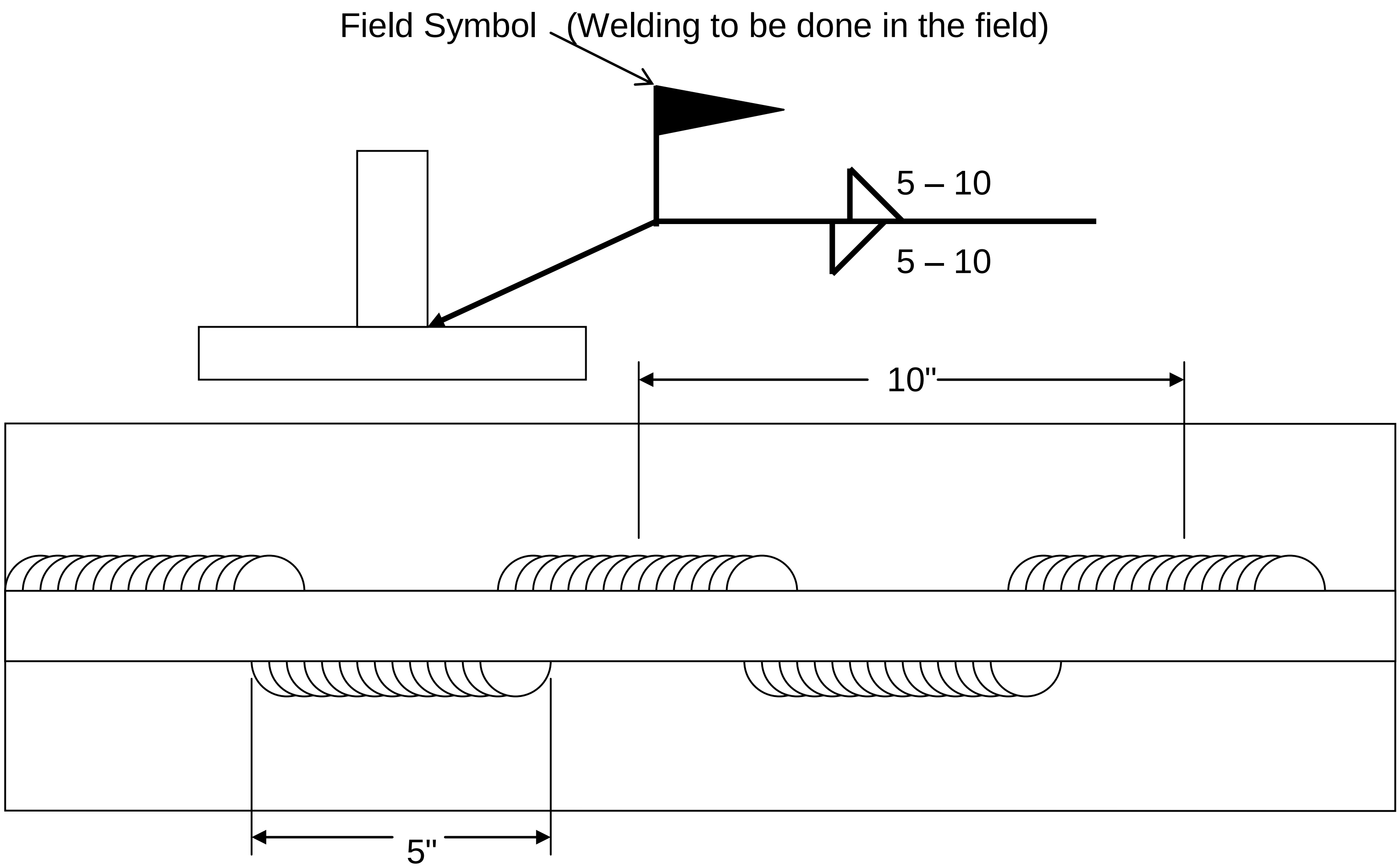
OTHER SYMBOLS

Welding All the way around

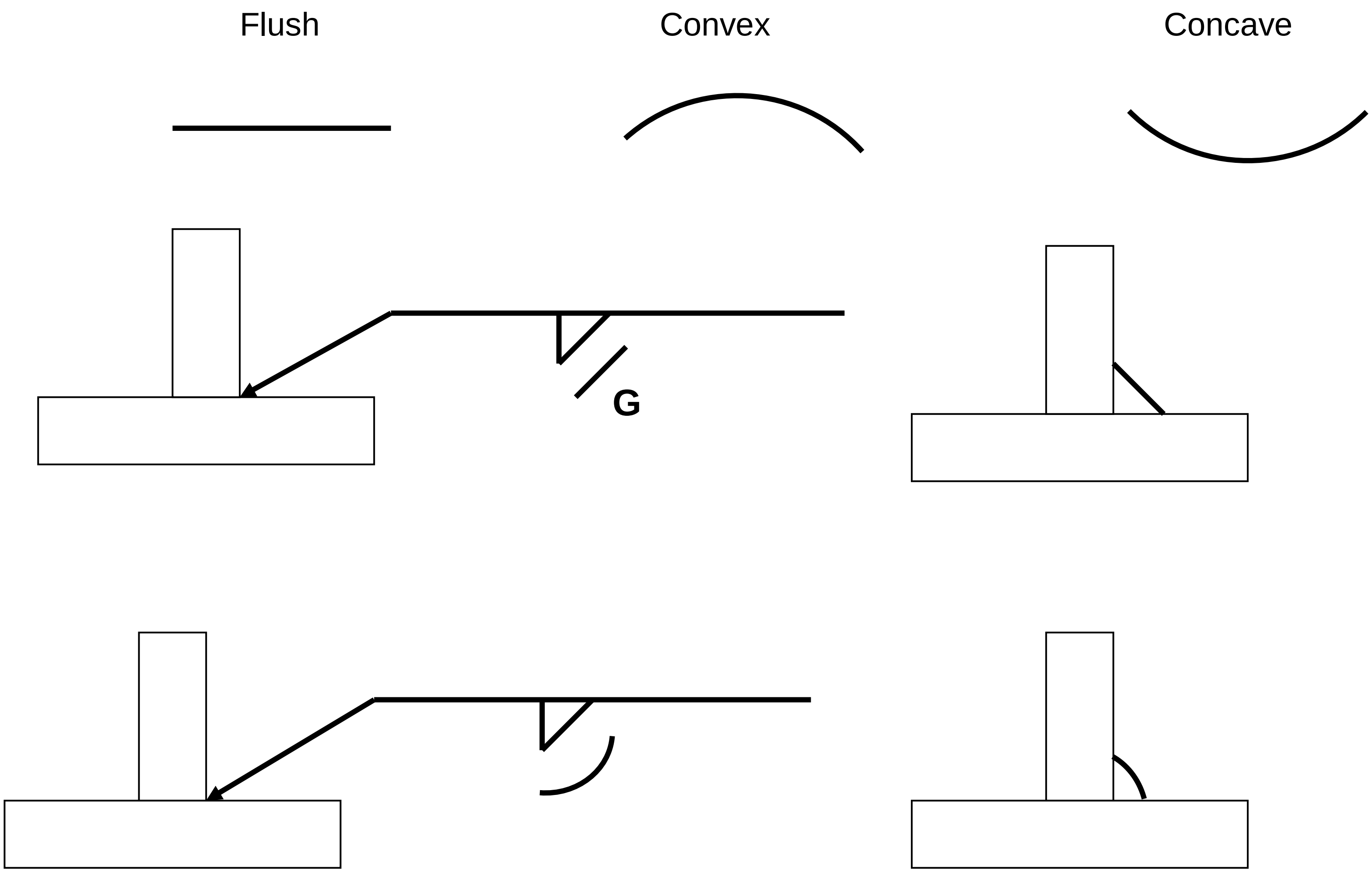




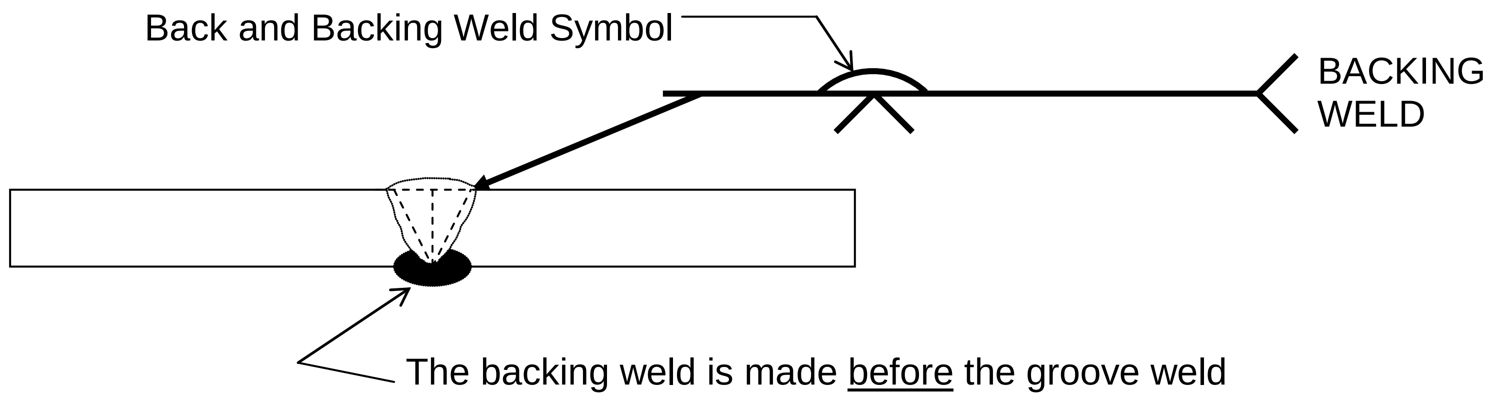
OFFSET WELDING and FIELD WELDING

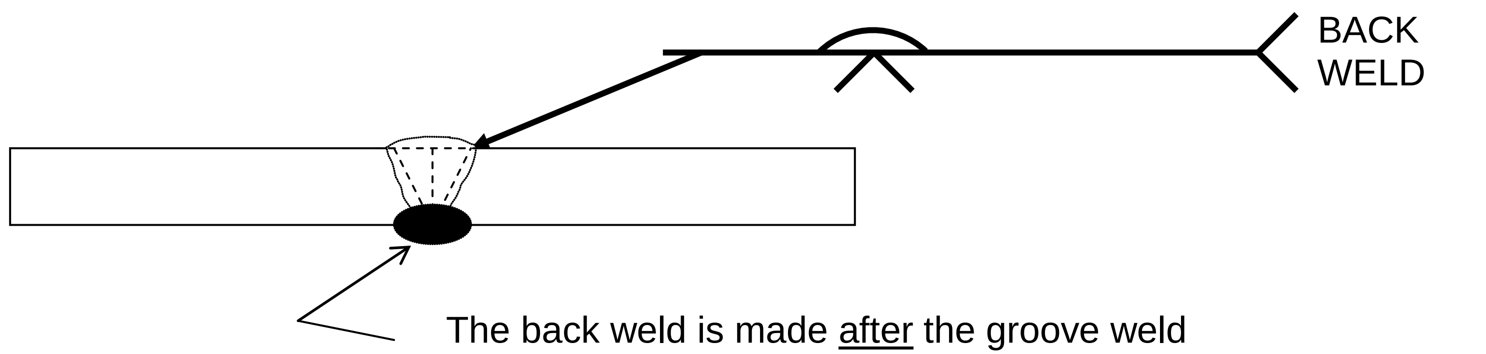


CONTOUR and FINISH SYMBOLS

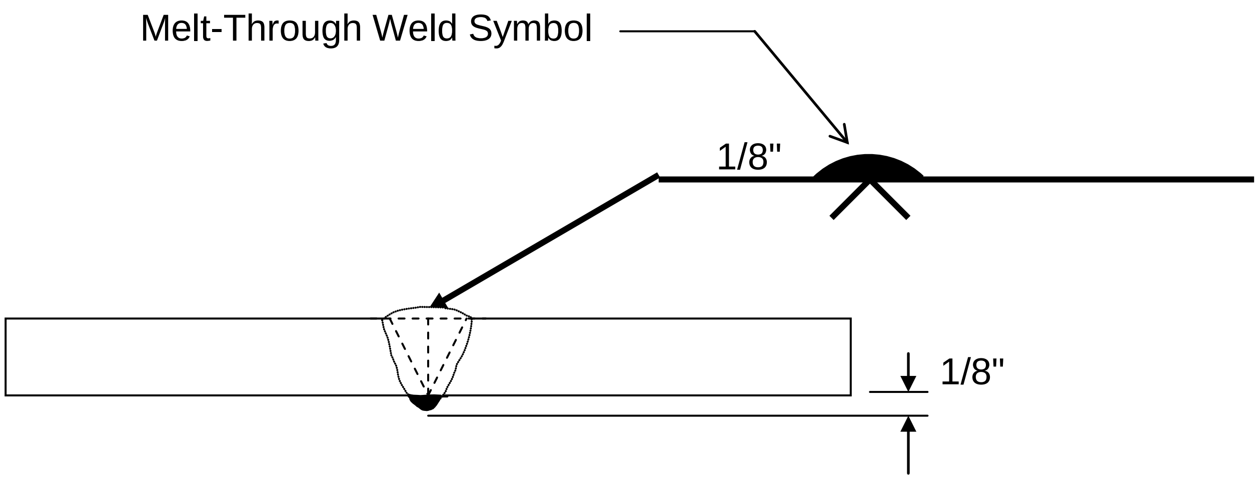


BACK and BACKING WELDS

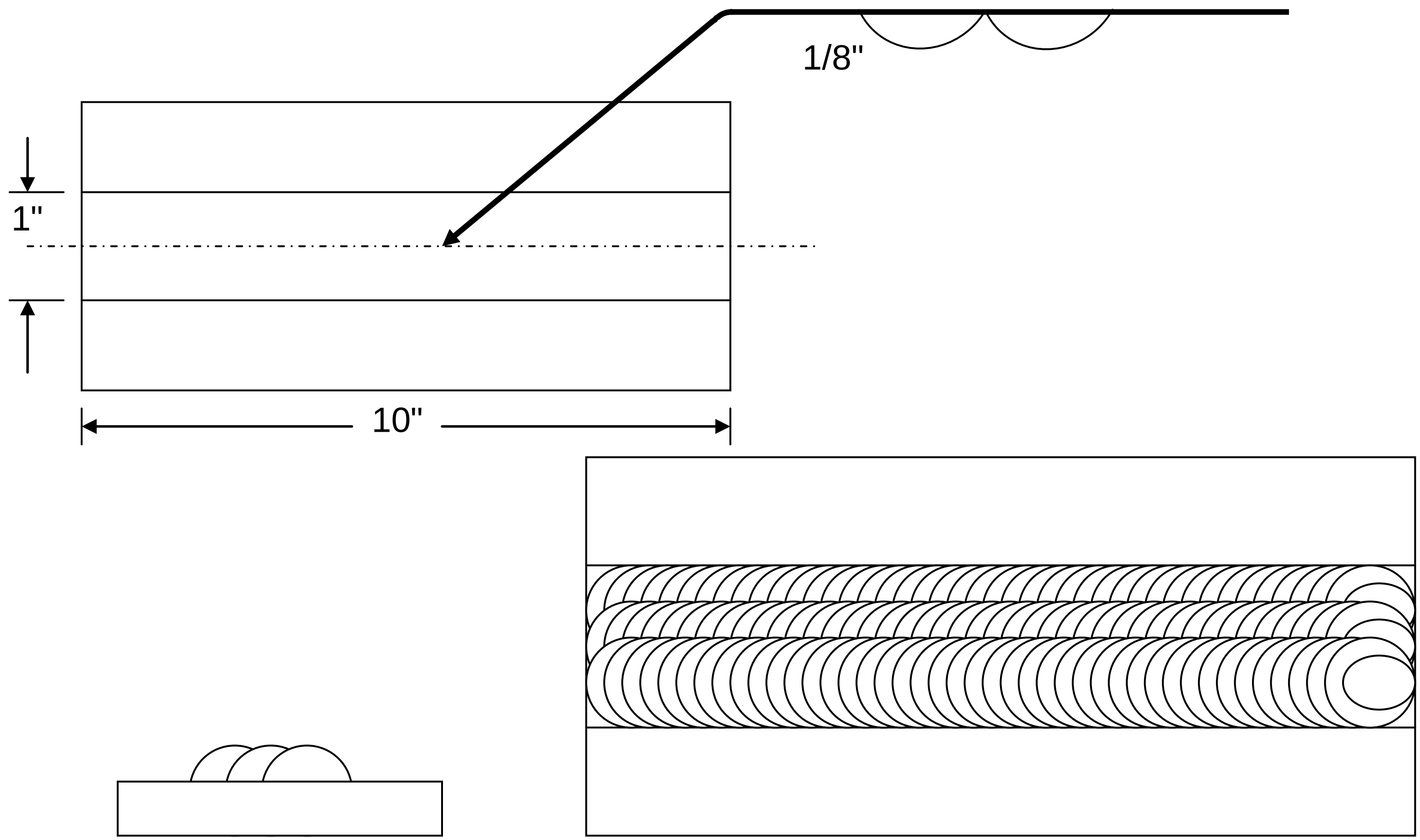




MELT-THROUGH WELDS



SURFACING and HARDFACING WELDS



Welding Metallurgy

AG 240-E

Unit objective

After completion of this unit, students will understand numbering systems used to identify various metals. Students will learn to identify various metals from various testing methods and identify correct welding procedures for each metal. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

Specific Objectives and Competencies

After completion of this unit, the student should be able to:

1. Identify metals from spark patterns.

2. Identify metals by using a file or chisel to determine hardness.

3. Match metal sample to correct metal type.

4. Identify metal properties from metal classifications.

5. Select metals for a project based on properties and classifications.

6. Identify various strains that metal may be subject to.

7. Calculate strength of materials for various forces.

8. Select metals for a project based on strength of material.

9. Describe the effects of heating and cooling when applied to metals.

Suggested Activities:

Obtain sample sets of metals and have students identify each metal on the worksheet provided in this unit.

Assign each student a specific metal to bring to class to complete a metal collection.

Show *Controlling Distortion* video by Lincoln Electric Company.

Provide students with welding coupons for a horizontal fillet. Instruct them to observe the distortion forces while tacking the pieces perpendicular to one another.

Cut two pieces of 1/8" flat stock 6" in length. Align the pieces so they are parallel with about 1/8" gap between them. Begin welding at one end. Weld about two inches and observe the distortion forces.

Provide students with welding coupons for a butt weld. Instruct them to observe the distortion forces from welding the two pieces together.

Have students forge a cold chisel from a potato digger link. Then harden and temper the chisel so it is a useable tool.

Place a crankshaft (malleable cast) in a vise and hit it with a hammer. It should bend without breaking. Harden a crankshaft by heating it beyond the critical temperature and quenching it in water (white cast). Place the crankshaft in a vice and break it with a hammer. Use caution, the hardened crankshaft may shatter into several pieces.

Demonstrate hardness testing with a file.

Demonstrate malleability testing with a hammer and chisel.

Unit References:

Modern Welding Technology, fourth edition, Prentice Hall, Upper Saddle River, New Jersey, 1998

Procedure Handbook of Welding, Lincoln Electric Company, Cleveland, Ohio, 1973

Welding Skills, second edition, American Technical Publishers, Homewood, Illinois, 1997

ASM 202 Class Notes, University of Idaho

Tempil Basic Guide to Ferrous Metallurgy, Tempil Big Three Industries Inc., 2901

Welding Metallurgy

A. Introduction

This unit contains a broad spectrum if information that should be considered for most fabrication projects. Heating and cooling of metal has many effects on various metals. Metals expand and contract when heated or cooled respectively. This often this creates severe stresses, which results in distortions.

Various metals require different welding procedures. A weld is prone to failure if the proper procedure is not used for specific metals. For example, welding high-carbon steel with the same procedure as low-carbon steel will produce a brittle weld.

This unit also covers forces that metals may be subject to and calculations for strength of materials.

B. Properties of Metals

1. Chemical Properties

   Chemical properties include a metal's ability or inability to resist corrosion, oxidation, and reduction. Corrosion is a wasting or loss of metal due to atmospheric conditions. Oxidation occurs when oxygen combines with metal forming metal oxides. Flame cutting ferrous metal is achieved by oxidation. Reduction is the removal of oxygen from the molten puddle to reduce the effects of atmospheric contamination.

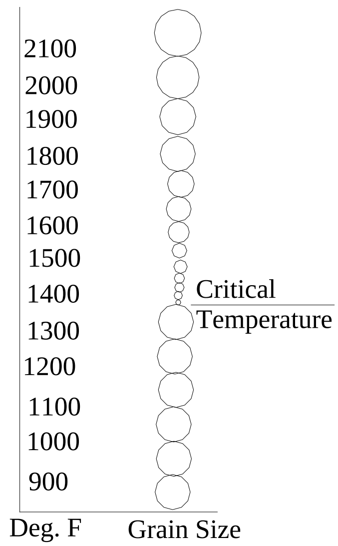
2. Physical Properties

   Physical properties are the properties that affect metal when subject to heat. The physical properties of metal include melting point, thermal conductivity, and grain size. Solid metals change into liquid at different temperatures. In carbon steels the melting point decreases as the carbon content increases. The grain size of carbon steels changes as the temperature changes. Thermal conductivity refers to the ability of metal to transfer heat.

   a. Grain Size

      As temperature increases the grain size remains the same size until the carbon steel reaches the critical temperature (transformation temperature). Once the critical temperature is achieved the grain size immediately gets significantly smaller. Heating beyond the critical temperature will gradually increase the grain size as temperature is increased toward the melting point.

When carbon steel is quenched after it has reached the critical temperature or above grain size is essentially frozen. The grain size that was achieved from heating will be maintained upon quenching. If carbon steel is quenched at the critical temperature it will be hardened with minimum brittleness. If carbon steel is heated beyond the critical temperature and quenched it will be more brittle because of the larger grain size.



b. Thermal Conductivity

Thermal conductivity is the ability of metal to transmit heat. Thermal conductivity of metal should be considered prior to welding. Carbon steels that are greater than 3/8" in thickness require preheating and/or post heating when welding. The mass of cold metal around the welded area will rapidly quench the weld and make it brittle.

3. Mechanical Properties

Mechanical properties determine the behavior of metal under applied loads. Such properties include but are not limited to, tensile strength, bending strength, shear strength, ductility, hardness, malleability, and brittleness. Welding can alter mechanical properties.

a. Ductility

Ductility is the ability of metal to stretch, bend, or twist without breaking or cracking. A metal with high ductility such as annealed carbon steel will break gradually as the load is increased. Whereas, a metal with low ductility such as hardened carbon steel will fail suddenly by cracking under heavy loads.

b. Hardness

Hardness is the property which resists indentation or penetration. Hardness is expressed as the area of indentation made by a special ball under a standard load. Hardness and tensile strength are directly proportional. The harder the metal the greater its tensile strength.

c. Brittleness

Brittleness is a condition in which metal will easily fracture under low stress. Brittleness is a lack of ductility. Brittleness is a result of improper welding or hardening techniques.

d. Malleability

Malleability is the ability of a metal to be deformed by rolling, pressing or forging without developing defects.

Other mechanical properties are discussed later in this section under strength of materials.

C. Effects of Welding

With any arc welding process the metal reaches a superheated temperature above melting. Weld metal is deposited in the molten state and immediately begins to freeze or solidify. When a weld is made several changes take place. Obviously the temperature of the metal changes, along with the temperature change the grain structure and size may change, and the dimensions may change due to expansion and contraction. The rate of cooling or quench is detrimental to the changes that occur. The rate of cooling is affected by the type of welding process, the procedure, the metal, and the mass of the metal.

1. Welding Process

   Any process that leaves slag over the weld has the slowest cooling rate. Gas shielded welds cool much faster. Faster cooling rates increase hardness and brittleness.

2. Welding Procedure

   The welding procedure influences the heat energy used to complete the weld. The greater the heat the slower the cooling rate. Heat input is a combination of amperage, voltage, and travel speed. To increase the heat input the amperage may be increased or the travel speed decreased. Changes in voltage only slightly alter heat input. Preheating can also be used to reduce the cooling rate.

3. Metal

The effect welding heat will have on metal is relative to the carbon content and physical properties of the metal prior to welding. Such changes can occur anywhere within the heat-affected zone (HAZ). The heat-affected zone is the area beyond the weld in which enough heat was extended to cause phase changes in the metal.

When welding on hardenable steel (at least .5% carbon) the heat-affected zone can increase in hardness to an undesirable level, causing a weld to fail. On the other hand, welding on hardened steel can essentially anneal the metal, causing the heat-affected zone to become soft. Once a weld has cooled the hardness of the weld metal and base metal in the heat-affected zone will be relatively uniform.

Another complication is with the composition of various metals. As weld metal is deposited some of the base metal is melted and mixed with the weld metal, which can produce a dilution of weld metal. Unless the composition of the weld metal and base metal are identical there will always be a dilution of the weld metal which may alter the tensile strength. Construction steels can be grouped into five general categories depending on whether or not they are hardenable and their nature once hardened. Those categories are:

a. Non hardenable low-carbon mild steel
b. Low hardenable with low susceptibility to cracking when hardened, or low-alloy steels with a carbon content less than 0.2%.
c. Low hardenable with high susceptibility of cracking when hardened, less than .25% carbon and no more than 1% manganese.
d. High hardenable steels with low susceptibility of cracking when hardened, this includes most low-carbon low-alloy high strength steels with carbon less than 0.15%, manganese and nickel up to 1.5%, chromium and molybdenum up to 0.25%, and vanadium up to 0.2%.
e. High hardenable steel with high susceptibility of cracking when hardened, alloy steels with carbon not exceeding 0.25% but with other alloys.

There are several precautions that should be taken when welding on the above categories of metals. They are respectively:

a. No special precautions
b. Use low-hydrogen processes and filler, preheat or increase heat input for thicker material.
c. Low-hydrogen processes are recommended, use high heat input, and preheat thicker material to 480-600°F.
d. Low-hydrogen processes are required, preheat and high heat input are recommended. Increase preheat as metal thickness increases.
e. Low-hydrogen processes are required, preheat and post heat.

4. Mass

Thicker materials rapidly transfer heat away from the weld area into the cold surrounding metal causing a quenching effect. The quenching effect results in a brittle weld. Uniform preheating of carbon steel allows the weld to cool at a normal rate. Uniform post heating may also be used to relieve stresses from welding. Preheating should be done on metal that is more than 3/8" thick.

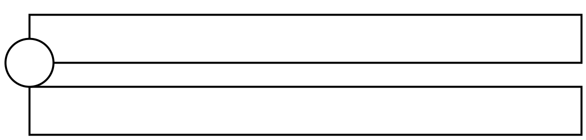
D. Controlling Distortion

1. Reactions to Expansion and Contraction

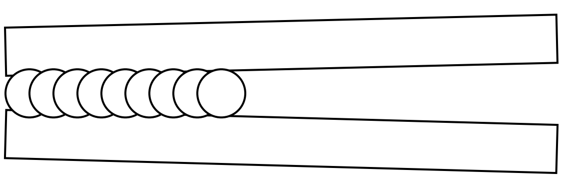
Metal that is unrestricted will expand in all directions when heated uniformly. As it cools it will contract in all directions back to the original shape. If expansion is restricted by an outside force the shape of the metal will be altered.

Cold metal that surrounds a welded area is restrictive to expansion therefore causing distortion. Refer to welding textbooks for a more thorough description of distortion.

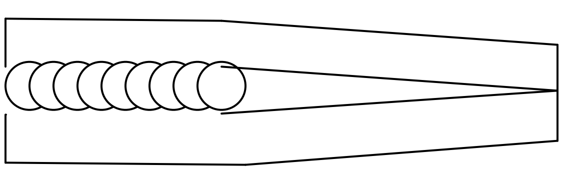
Numerous techniques such as back stepping, skip welding, preheating, post heating, peening, and jigs are described in welding textbooks to control distortion. However, with a basic understanding of distortion it can be minimized by joint design. The diagram below shows how distortion effects joints. Every weld pulls metal closer together at the point at which the weld was finished.



1. Tack two pieces of 1/8" flat stock about 6" in length with 1/8” gap as shown.

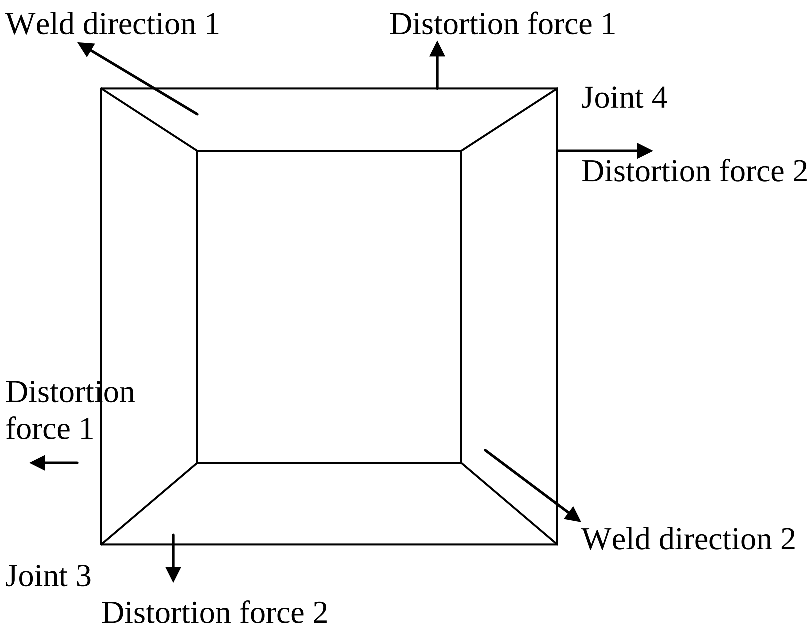


2. A 2" weld is made. As the weld progresses heat is transferred to the metal causing expansion forces which results in the pieces spreading apart.

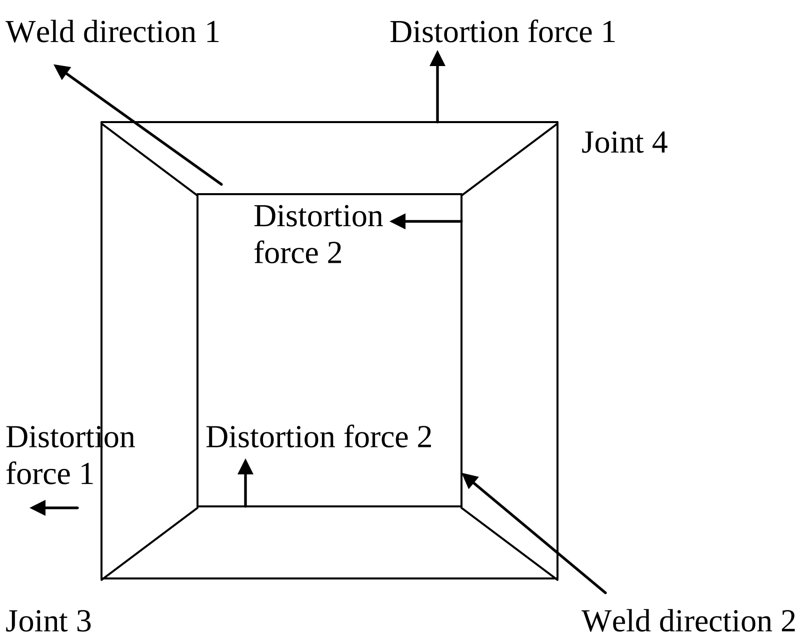


3. When the weld is stopped the deposited weld metal cools and contraction forces pull the two pieces of metal together, closing the gap.

Another important issue to control distortion is welding sequence. Welding sequences will vary with each application. With a basic understanding of distortion it is simple to determine a welding sequence. The following diagram describes distortion forces. The pieces in the diagram are 2 ½" x ¼" flat stock assembled like a picture frame.



All joints should be welded as numbered in the previous diagram. A welding sequence to prevent distortion is similar to the sequence used to torque head bolts or wheel lugs. In this manner distortion forces oppose one another to reduce distortion, rather than working together. When joint 1 is welded in the direction shown, (from inside corner to outside corner) the start of the weld acts as a pivot point while the remainder of the weld cools and begins to contract pulling the members in the directions indicated (distortion forces 1). If joint two is welded next in the same direction (from inside corner to outside corner) then the distortion forces from joint 2 counteract the forces from joint 1 and the members remain square. If the same welds are done in opposite directions as shown below the distortion forces work together to pull the members out of square.



D. Heat Treating Metals

Heat treatment is used to soften metal, harden metal, and temper metal. An understanding of these processes is important prior to welding because welding can often effect the structure of the metal being welded.

1. Critical Temperature

Critical temperature was previously mentioned in the physical properties section regarding grain size. The grain size of metal immediately changes once the critical temperature is reached. The critical temperature varies between carbon steels. As the carbon content increases the critical temperature decreases. In general the critical temperature is somewhere between 1350 and 1700° F. The key to knowing that the critical temperature has been obtained is that the magnetism of ferrous metal is lost at the critical temperature. Ferrous metal will stick to a magnet at any temperature below the critical temperature. Once the critical temperature has been reached it will no longer stick to a magnet.
Note: Metal must contain at least 0.5% carbon to be heat treatable.

For the following heat-treating processes it is important that the metal is exactly at the critical temperature. Heating beyond the critical temperature increases the grain size, which increases brittleness.

2. Annealing

Annealing is a softening process which relieves stresses following welding and allows hardened metal to be machined or bent. Annealing is achieved by uniformly heating metal to the critical temperature. The metal is then submerged in some type of insulating material (dry ash, dry sand, or lime) and allowed to cool over a period of several hours.

3. Hardening

Hardening increases tensile strength. It is important to remember that hardening will also increase brittleness of carbon steels. For example a file is hardened, the file is resistant to machining but, will easily break if struck with a hammer. Hardening is achieved by uniformly heating carbon steel to the critical temperature and rapidly quenching it. The rate of quenching will affect the hardness of the steel. Oil, water, salt water, and salted ice water are commonly used for quenching. Salted ice water will result in the fastest quench, whereas oil will be the slowest. Hardness and brittleness are both increased as the quenching rate increases. High-carbon steels require a slower quench, low-carbon steels require a more rapid quench. Each steel alloy requires a different recipe for hardening. Steel manufacturers can supply information such as critical temperature and quenching solution request.

4. Normalizing

Normalizing can be either a hardening or a softening process. Normalizing returns carbon steel to its original state. If a piece of carbon steel has been annealed and then normalized then the normalizing process hardened the steel. On the other hand, if a piece of carbon steel is hardened and then normalized the process softened the metal. Normalizing is achieved by heating carbon steel to the critical temperature and allowing it to cool in still air.

5. Tempering

Tempering is a slight softening that should be done after hardening to relieve stresses and reduce brittleness. Tempering is achieved by heating metal to about 500° F (polished steel will be a purple color at this temperature) and then quenching it in water.

Tempering can be done at the same time as hardening. When hardening, the quench can be located in the area of the red color and cooled until oil will stick to the metal. There should be enough heat left in the remainder of the steel to reach the 500° F needed for tempering. The cold chisel project in the back of this section is a good example of this.

E. Metal Descriptions

1. Ferrous Metals

Wrought Iron is soft and ductile. When a bar is fractured, it shows a fibrous wood-like structure. It can be bent in many shapes at room temperature and is one of the easiest metals to weld. Wrought iron contains iron silicate, a type of glass-like slag, distributed through the iron base metal in the form of threads or fibers. The slag is responsible for the good corrosion resistance of wrought iron. Wrought iron melts at 2900°F.

Mild Steel (low carbon) is used more than any other steel since it can be easily forged and welded. It melts at 2700°F. Most all bridges, buildings, ships, and all types of farm machinery are made of this material. It contains between .05% to .30% carbon.

Machineable Steel (medium carbon) is made much the same as mild steel with the addition of carbon, which increases the **Hardness**, increases the **Tensile Strength**, and **Lowers the Melting Point.** This steel can be machined more readily than low carbon steel and is used for many parts of machinery as shafts, gears, etc. It can be case hardened to stand abrasion and has tensile strength of 70,000 to 80,000 pounds per square inch (psi). Machineable steel melts at 2600°F. It contains between .3% to .6% carbon.

<u>Hot Rolled Steel</u> - Large chunks of hot machineable steel known as **Billets** are heated and rolled into various shapes. Hot rolled steel usually has a rough scaly surface resulting from oxidation, it is soft and easily worked. It is not too suitable for close fitting tolerances.

<u>Cold Rolled Steel</u> is produced by de-scaling hot rolled steel and then passing it through rollers and dies while cold. It has a smooth surface, is hard and is suitable for use in close fitting tolerances.

<u>**Tool Steel (high carbon)**</u> - This steel is usually made in an electric furnace and refined and carefully tested for the correct carbon content which is .60% to 2.05. Steel of this type is used for making such tools as screwdrivers, hammers, taps and dies, twist drills, and cutlery. It can be heat treated (hardened and tempered) and has a tensile strength of approximately 120 to 125 thousand pounds per square inch. Its melting point is 2500^{o}F.

<u>**High Speed Steel**</u> is manufactured with the addition of one of three of the following elements: cobalt, molybdenum, or tungsten. All high-speed steel also contains about 4% chromium. High-speed steel is used in the production of cutting tools such as drill bits, taps and dies. The letters "**HS**" will appear on tools made with high-speed steel.

<u>**Cast Steel**</u> - Cast steel implement parts are formed by pouring molten steel into molds similar to those used in making gray castings. The exterior surface resembles gray cast iron, but steel castings as compared to gray cast iron are **More Ductile** and have a brighter fine grain structure. Carbon in cast steel generally is around 0.3%. The gates of a steel casting are larger than the gates from a cast-iron casting.

<u>**Stainless Steels**</u> are so named because of their ability to resist corrosion. They are divided into four groups.

<u>**Group 1 (austenitic)**</u>: Chrome-nickel steels contain 0.25% or less carbon, 16-25% chromium and 6-22% nickel. A typical number of this type steel would be 18-8, meaning 18% chromium and 8% nickel. Heat treatment does not add to the strength of austenitic stainless, but it may be work hardened.

<u>**Group 2 (martensitic)**</u>: Hardenable chromium steels contain 12-18% chromium with carbon ranging from 0.15% to 1.20%. These steels can be hardened by heat treatment and are used in the manufacture of cutlery.

<u>**Group 3 (ferritic)**</u>: Non-hardenable steels contain from 12% to 27% chromium and 0.08 to 0.20% carbon. They are used for equipment that is subjected to high pressures and high heats.

Group 4: ELC stainless steels (precipitation hardening): have the same analyses as the regular austenitic alloys of the corresponding type numbers except for an Extra Low Carbon (ELC) content. The corrosion resistance of austenitic stainless steels depends on a uniform distribution of chrome throughout the metal. This uniform distribution of chrome is upset by welding and the metal must be annealed to restore the distribution. The ELC stainless steels resist this tendency toward carbide precipitation because there is less carbon to unite with the chromium.

There are approximately 40 types of stainless steels, which fall into the previous groups. Melting points of stainless steels varies from 2500 to 2800^{o}F depending on the type. Most stainless steels are non-magnetic. Some stainless steels, which are magnetic, are type 410, 430 and 446.

Clad Steels - are steels, which have been protected on one or both sides with a dense layer of pure nickel, stainless steel, or silver. This layer provides corrosion resistance at a cheaper cost than if the entire plate were corrosion resistant material. Clad steels are usually used for pressure vessels.

Gray Cast Iron - Contains above 1.7% carbon, is very brittle, and is made by re-melting pig iron with scrap steel and scrap cast iron in a furnace called a Cupola. This molten metal is then poured into **Flasks** containing sand molds and cooled slowly. Cast iron is not ductile, has a tensile strength of 12 to 15 thousand psi, wears well, can be machined and requires no lubricant when drilling holes in it. Castings must be large to gain the strength required. Melting point is 2300^{o}F.

Malleable Iron Castings are made from white cast iron of special composition. They are given a heat treatment, which completely changes the physical properties. The castings are packed in oxide scale in a metal container for about 60 hours at a temperature of 1700^{o}F and cooled slowly. This process is called **Annealing.** This process increases the tensile strength to 53,000 psi. Malleable iron will bend before it breaks. Malleable cast iron is used to produce mower guards, ledger plates, chains and crankshafts. Melting point is 2300^{o}F.

Note: When malleable iron is heated above 1382^{o}F, the metal reverts to one having some of the characteristics of white cast.

Ductile Cast Iron is the newest type of cast iron and is also the most expensive. The graphite in ductile cast iron is present in the form of rounded high tensile strength, good casting qualities, and has excellent corrosion resistance. Melting point is 2300^{o}F.

2. NON-FERROUS METALS:

With the exception of nickel, titanium and tungsten, non-ferrous metals cannot be identified by the spark test because no sparks are produced while grinding.

Aluminum is a silver metal which is 1/3 the weight of steel but is 80% as strong as steel. More use is being made of aluminum each year because of its lightness. Aluminum is available in many grades for different applications. Melting point of aluminum is 1215^{o}F. The melting point of aluminum oxide is 2016^{o}F. It is very important to remove this aluminum oxide or "skin" from the surface of aluminum before welding or soldering.

Brass is a light yellow colored alloy of copper and zinc with copper forming 60 to 90% of the alloy. It is used for radiators, pipes, welding rods and pipe fittings. There are three principal types of brass: yellow brass, aluminum brass, and naval brass which has tin added. Melting point of brass is 1650^{o}F.

Bronze is a dark yellow colored alloy of copper and tin with 5 to 20% tin. It is used for bushings, springs, fittings, valves and pistons. There are eight principle types of bronze depending on the additional metals used for the alloy. Melting point of bronze is 1600^{o}F.

Copper is a reddish-brown metal and is the most common non-ferrous material available. Copper enters freely into alloy with at least 30 elements of which 17 are used in making commercial copper alloys. Pure copper is used mainly as electrical conductors. There are about six types of copper. Melting point of copper is 2000^{o}F.

Lead is bluish-white in color and has a high luster. It is soft, highly malleable and ductile and is a poor electrical conductor. Lead is classed as a heavy metal and is readily attacked by acetic acid. Melting point of lead is 620^{o}F.

1. Antimonial lead, which contains about 6% antimony, is used in the manufacture of storage batteries.
2. Corroding lead is used in the manufacture of paint pigments.
3 Common lead is lower in purity and is used for cable coverings and roofing.
4. Chemical led contains .04 to .08% copper and is used in the chemical industry.

Magnesium is a silvery white metal which has a density about 2/3 that of aluminum, making it the lightest of the commercial metals. Magnesium alloys are used in the manufacture of chain saw cases, lawnmower bodies, and other tools where light weight is important. Magnesium is about 50% stronger than aluminum. Much care must be taken while welding magnesium since it will burn violently when heated to its kindling temperature. Magnesium can be distinguished from aluminum by applying a drop of 0.5% solution of silver nitrate to the surface. Magnesium will turn black while aluminum will not. Another test involves the use of vinegar. Magnesium will cause vinegar to fizz while aluminum will give no reaction. Melting point of magnesium is 1200^{o}F.

Nickel is a tough silvery metal, which has excellent resistance to corrosion and oxidation even at high temperatures. Nickel is used extensively as an alloy with steel or copper. It is somewhat magnetic. The most important nickel-copper alloy is Monel, which is 67% nickel, 28% copper and 5% manganese. It is used where parts are subjected to wear and corrosion. Inconel is a nickel-chromium alloy. It has high corrosion resistance to acids and alkalis. Melting point of nickel is 2640^{o}F.

Tin does not corrode in moist air and adheres tenaciously to iron. It has a low melting point of 450^{o}F and is used in solder, brass, bronze and pewter. So called tin cans are made of sheet iron coated with tin.

Tungsten is very hard and very resistant to heat. Its alloys are used for high speed cutting bits and electrodes for TIG welding. It is also used for filaments in light bulbs. Tungsten is classed as a very heavy metal and has a melting point of 6098^{o}F.

Zinc is a bluish-white metal that is used for galvanizing in alloys such as zinc die cast and it is used as an alloy with copper in the production of brass. It has excellent corrosion resistance and is low in cost. Melting point of zinc is 786^{o}F.

Titanium is a silvery-gray metal that weighs about one-half as much as steel. It is used primarily in aircraft construction. Some of its alloys reach tensile strengths of 200,000 psi. Melting point of most alloys is around 3000^{o}F.

F. Methods of Identifying Metals

1. Use

PERCENT CARBON	**APPLICATIONS**
0.05-0.10	Stamping, sheets, wire, rivets, welding stock, cold-drawn parts.
0.10-0.30	Rolled structural shapes, formed structural parts, control levers and rods, shafts, machine and carriage bolts, screws, welded tubing, parts to be carburized, such as gears, sprockets, and small forgings.
0.60-0.80	Plow beams, cultivator tool bars, springs (coil or flat), drop-forging dies, hammers, wrenches, band saws, set screws, lock washers.
0.80-1.00	Plow shears, moldboards, harrow and plow disks, cultivator sweeps and shovels, hay-rake teeth, cutting and blanking punches and dies, springs.
1.20-1.40	files, reamers, razors, saws, and metal-cutting tools.

2. SURFACE APPEARANCE

A. Metals cast in sand molds have a rough surface appearance due to the imprint made by the sand. Also, there is a ridge left along the edge of the casting where the two halves of the mold come together.

B. Castings have one or more enlarged areas along the side called gates. On the surface gates appear as if they were broken or fractured. These "gates" are formed by openings left in the castings for the metal to flow into the castings. Cast steel usually has a large gate while gray cast iron has a small gate.

C. Pieces made by the drop-forged process have a rough, scaly surface appearance. Part numbers, which are stamped on, appear sharp and distinct.

D. Color of the metal such as copper or brass can be an aid in identification.

3. IDENTIFYING BY SOUND

A. The ring of the metal when tapped with a hammer will often tell the type of metal used in manufacturing the part. Steel gives a higher pitch than that given off by cast iron.

4. LOOK AT FRACTURES

A. Observe such items as the nature of the break, the type of grain, and the color of grain.

1. Gray cast iron is dark gray and will rub off black on the fingers.
2. White cast iron has a very bright shiny appearance.
3. Malleable cast iron parts usually bend before breaking.
4. The fractured surface of steel provides a definite grain pattern. Low carbon is a bright gray while high carbon is very light gray.
5. Cast steel will break abruptly with little or no bending.
6. Wrought iron is soft and ductile and shows a fibrous wood like structure.

6. CHIP TEST WITH COLD CHISEL
7.
Malleability-Ability of metal to be deformed without defects by rolling, pressing, or forging.

A. Steel - a chip can be raised quite easily on low carbon steel. This chip will bend 180^o without breaking. As the carbon content increases the chip will be harder to raise and will break at 60^o to 90^o.
B. Both gray and white cast irons are very brittle and chip cannot be raised without breaking.
C. A chip very similar to that of low carbon steel can be raised on malleable cast iron, however, the texture of malleable cast iron will identify it.

6. THE SPARK TEST

A. The spark test, when conducted by an experienced observer, is a quick and effective method for the classification of steels according to their chemical composition. The test is to be considered neither as a substitute for a chemical analysis nor as an unequivocal method for identifying unknown steels. However, for definite-type steels, <u>a skillful operator</u> can classify carbon steels to within 0.20% carbon content and can identify alloyed steels with regard to chromium, vanadium, tungsten, etc., within approximately 1%. The test consists essentially of holding the steel in contact with a high-speed abrasive wheel and visually noting the characteristics of the spark stream that is thrown off.

B. Principles

Incandescent steel particles containing carbon as their principal alloying ingredient, produce yellow or yellow-white streams which appear to broaden, light up, and then burst as they are hurled through the air. When the incandescent particle of carbon steel comes in contact with oxygen in the air, the carbon present in the particle is burned to form carbon dioxide. The transition from solid carbon to gaseous carbon dioxide is accompanied by an increase in volume. Although the particles of steel are hot enough to be plastic, they offer resistance to this volume increase, thus building up an internal pressure that is relieved only by explosion of the particles. Examination of the grinder dust from carbon steel reveals numerous hollow spheres in the residue, each with one end completely blown away. The relation of carbon content to the frequency and size or complexity of bursts also indicates that carbon is the element responsible for the forking of spark stream carrier lines.

1. Carbon Steels

a. 10% carbon steel exhibits few bursts. Each burst is simple in outline, as if the particle were ruptured into only 2 or 3 pieces, each piece forming its own short trajectory path.

b. 20% carbon steel exhibits a slightly larger number or concentration of bursts and each burst is usually more complex, as if each particle were blown into more pieces.

c. 30% or higher carbon steel will swell noticeably and then burst with explosive force or intensity. The numerous secondary bursts add to the complexity of the configuration since each particle leaving the primary burst seems to burst again. This is particularly true for tool steels with carbon levels of .60% or more.

d. An exception to this pattern of carbon bursts occurs when certain additional elements are alloyed into the steel. Elements such as silicon, chromium, nickel and tungsten tend to suppress the carbon bursts. In other words, their presence seems to prevent the bursting of the particle, even though large amounts of carbon are present. It is important to note that whenever alloying elements are present in sufficient quantities to suppress the carbon bursts, they also change the color of the trajectory from yellow-white to orange or red in color.

2. Gray Cast Iron

a. Cast iron gives off a very small volume of fine red shafts that change to yellow or straw color as the carbon oxidizes causing a typical but more refined carbon burst.

b. Cast iron grinds away with such ease that the individual particles are heated only up to a red heat when they are torn loose. The trajectory is relatively short, since the particles do not attain sufficient velocity to travel as far as steel particles.

3. Malleable Iron

a. Malleable iron is chemically identical to gray cast iron but differs in the form of the iron and carbon. The result is a metal possessing greater ductility, strength and toughness.

b. When malleable iron is spark tested, particles are heated to a straw-yellow color before they are torn free and they carry further to form a longer trajectory than do the red particles of gray cast iron.

c. The spark patter or configuration is otherwise identical to that of gray cast iron.

4. High Speed Steel

a. There are three general types of high-speed steels, cobalt, molybdenum and tungsten. All three contain about 4% chromium which suppress the carbon (.70%-.80%) burst completely.

b. The spark patterns vary from relatively long, sparse, but slightly zigzag red shafts with no bursts or sprigs, to more numerous but short orange-red color shafts, without bursts, swelling before ending to form orange or orange-red sprigs and arrows.

5. Nickel

a. Pure nickel electrodes are used for welding cast iron and malleable iron. Nickel is very soft metal that produces a short orange-red wavy stream. Since it is so soft that metal seems to "fill" the grinder creating a peculiar rough action. The burr formed on the piece being ground is also indicative of soft nickel.

6. Titanium displays a very bright white spark.

7. MAGNETISM

A. All ferrous metals except most types of stainless steels are magnetic.
B. Most non-ferrous metals except nickel are non-magnetic.

8. MELTING AND BURNING

A. Stainless steels and cast irons are very difficult to cut with the oxy-acetylene torch since they are resistant to oxidation.
B. Filings of magnesium tend to burn brightly in the flame of a propane torch.

9. HARDNESS-Property of metal that resists indentation.

A. A file can be used to test differences in hardness of steels and cast irons. White cast iron is very hard and can barely be cut.
B. Lead is so soft that it can be cut with a pocketknife.

10. DUCTILITY-Ability of metal to stretch, twist, or bend without breaking.

A. Low and medium carbon steels and malleable cast iron will bend.
B. Gray and white cast iron will break before bending.
C. Ductility is a good indicator of hardness. Lead is a very soft metal therefore, it bends very easily and is therefore very ductile.

11. WEIGHT

A. To get a reasonable idea of weight, a known volume of metal should be weighed with very accurate scale. Sometimes it is very misleading to simply try to determine weight by handling the sample.
B. Tungsten is the heaviest metal we are studying and magnesium is the lightest according to the chart of weights and specific gravities on the next page:

Substance	Avg. Wt. Lb./Cu. Ft.	Avg. Specific Gravity
Aluminum, pure, rolled	167.1	2.68
Brass 67% Cu 33% Zn	519	8.31
Bronze 90% Cu 10% Zn	541	8.67
Chromium	428	6.86
Cobalt	546	8.75
Copper plate & sheet	557	8.92
Iron, cast grey	442	7.08
Lead, sheet	712	11.41
Magnesium	109	1.75
Molybdenum	636	10.19
Nickel, rolled	541	8.67
Steel	489	7.84
Tin, cast, 7.2 to 7.5	459	7.35
Titanium, pure	281	4.5
Tungsten	1224	19.6
Zinc, rolled	449	7.19

G. S.A.E. STEEL NUMBERING SYSTEM

A numeral index system is used to identify the compositions of the S.A.E. steels making it possible to use numerals on shop drawings and blueprints that are partially descriptive of the composition of material covering such numbers. The first digit indicates the type to which the steel belongs: thus 1 - indicates a carbon steel; 2 - a nickel steel; and 3 - a nickel chromium steel. In the case of the simple alloy steels, the second digit generally indicates the approximate percentages of the predominant alloying element. Usually the last two or three digits indicate the average carbon content in "points," or hundredths of 1 percent (for example 2340 steel would have approximately 3% nickel and .40% carbon). **NOTE:** In some instances this procedure for numbering has been deviated from, these instances are indicated by "*" preceding the steel. This is true in several of the corrosion and heat resisting alloys as well as the triple alloy steels.

The basic numerals for the various types of S.A.E. steel are:

TYPE OF STEEL & DIGITS	NUMERAL
Carbon Steels	
Plain Carbon	10xx
Free Cutting (screw stock)	11xx
Manganese Steel	
Mn 1.75	13xx
Nickel Steels	
Ni 3.50	23xx
Ni 5.00	25xx
Nickel Chromium Steels	
Ni 1.25; Cr. 0.65 or 0.80	31xx
Ni 3.50; Cr 1.55	33xx
Corrosion and Heat-Resisting	303xx
Molybdenum Steels	
Mo 0.	40xx
Chromium-Molybdenum	
*Cr 0.50 and 0.95; Mo 0.25 and 0.20	41xx
Nickel-Chromium-Molybdenum Steels	
*Ni 1.80; Cr 0.50 and 0.80; Mo 0.25	43xx
Nickel-Molybdenum Steels	
*Ni 1.55 and 1.80; Mo 0.20 and 0.25	46xx
*Ni 3.50' Mo 0.25	48xx
Chromium Steels	
Low Cr - Cr 0.27 and 0.65	51xx
Medium Cr (bearing) - 1.00	52xx
Corrosion and Heat-Resisting	514xx and 515xx
Chrome-Vanadium Steels	6xxx
Tungsten Steels	7xxx
Silicon-Manganese Steels	9xxx

H. Wrought Aluminum Code Classification System

Aluminum is classified into three different groups: commercially pure aluminum, wrought alloys, and casting alloys. Commercially pure aluminum has low tensile strength due to the lack of alloys, however it has high ductility. Commercially pure aluminum is used for products that are pressed or formed. Casting alloys are poured into castings or molds. Many casting alloys are weldable. Wrought alloys contain at least one alloy element, which increases tensile strength. The major alloying elements are: copper, manganese, magnesium, silicon, chromium, zinc, and nickel. Some wrought alloys are heat treatable and some are not. Wrought alloys are commonly used for fabrication. A four-digit classification code is used to classify wrought alloys. The first digit indicates the major alloying element.

Major Alloy	**Number**	**Heat Treatable**	**Uses**
At least 99% Aluminum	1xxx	Not Heat Treatable	Chemical storage tanks
Copper	2xxx	Heat Treatable	Aerospace structures, pistons
Manganese	3xxx	Not Heat Treatable	Heat exchangers
Silicon	4xxx	Heat Treatable and Not Heat Treatable	Welding alloy,
Magnesium	5xxx	Not Heat Treatable	Wheels, boats, bicycles, trucks, trains, tankers, containers
Magnesium and Silicon	6xxx	Heat Treatable	Auto, Snowmobiles, Boats, Trailers, bicycles
Zinc	7xxx	Heat Treatable	Support structures, baseball bats, bicycles
Other	8xxx		

1. 1xxx Series Aluminum

The second digit in this series indicates modifications and impurity limits. The combination of the last two digits indicates the decimal percentage of purity. For example, 1188 is 99.88% pure aluminum with control on one impurity, 1075 is 99.75% pure aluminum with no special control on impurity.

2. 2xxx through 7xxx Series Aluminum

The final two digits are essentially an arbitrary number that assigns an alloy number within the series. For example 2024 is alloy number 24 of the 2xxx series. The second digit indicates the number of revisions to the alloy number. For example 5356 the number 56 alloy has been revised 3 times.

3. Temper Designations

All aluminum alloys can be strengthened by strain hardening and some of them can also be strengthened by thermal hardening. Temper designations follow the alloy classification. Temper designations consist of letters and subdivisions of tempers are indicated by numbers. A dash separates the alloy classification from the temper designation. The basic temper designations are:

F = as fabricated, no attempt to control or mechanical properties
O = fully annealed

H = strength improved by strain hardening (cold worked), numbers that follow H indicate the manner and extent to which strain hardening was achieved.

Subdivisions of H temper

The first digit indicates the specific operation:

H1 = strain hardened only
H2 = strain hardened and partially annealed
H3 = strain hardened and stabilized

The second digit indicates the degree of strain hardening. These numbers range from 1 through 8, with 8 having the highest tensile strength.

W = solution heat treated and then aged at room temperature
T = thermally treated to produce stable tempers, T is always followed by one or more numbers.

Subdivisions of T temper

Heat treated alloys are designated by temper numbers 1 through 10 as follows:

T1 = Strength is increased by room temperature aging
T2 = Annealed to improve ductility and dimensional stability, cast products only
T3 = Solution heat treated and then cold worked
T4 = Solution heat treated and naturally aged to a stable condition
T5 = Artificially aged
T6 = Solution heat treated and then artificially aged
T7 = Solution heat treated and then stabilized
T8 = Solution heat treated, cold worked, and then artificially aged
T9 = solution heat treated, artificially aged, and then cold worked
T10 = Artificially aged and then cold worked

I. Cast Alloy Aluminum Code Classification

The first digit represents the alloy group as follows:

Major Alloy	Number
At least 99% Aluminum	1xx.x
Copper	2xx.x
Silicon, with copper and or magnesium	3xx.x
Silicon	4xx.x
Magnesium	5xx.x
Zinc	6xx.x
Tin	7xx.x
Other	8xx.x

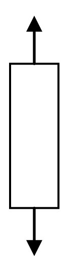
The second two digits identify the alloy number or indicate the aluminum purity. The digit after the decimal point indicates the product form. A zero indicates a casting, and a 1 or 2 indicates an ingot.

J. Forces on Structures

1. There are six different types of forces that may act on machinery as shown below. The formula for calculating stress is given with each diagram. The stress calculation can be used to calculate a safe load and determine the strength of material necessary for a given load.

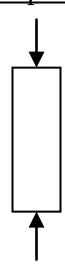
S=Stress   P=Pounds   A=Area (square inches)   K=1000
M=Moment   Z=Section Modulus   T=Torque

Tension



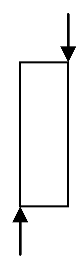
S=P/A

Compression



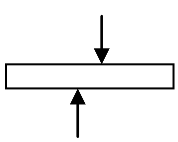
S=P/A

Column Action



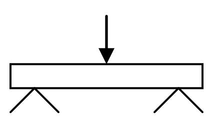
S=P/KA

Shear



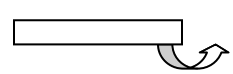
S=60% of tension S

Bending



S=M/Z

Torsion

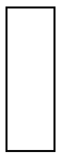


S=T/Z

Tension- Machine steel is designed to have 63,000 psi tensile strength. That is it would require 63,000 pounds to pull a piece of steel that has a 1 square inch cross sectional area into two pieces. However steel will permanently deform with a pull of 35,000 psi. Therefore, a safety factor must be used. Safety factors range from 2 to 10 with 10 being used for extreme stress such as for roller chain.

Tensile strength divided by the safety factor = safe pull

For example: 63,000/3=21,000 psi safe load for steel.



What is the safe load for 1" x 1/4" mild steel?

S=P/A

A=.25 x 1=.25 sq. in.

21,000 psi (safe load)=P/.25 sq. in.

P=21,000 psi x .25 sq. in.

P=5000 lb. Safe load

The required area to carry a given load can be found from the same relationship.

A=F/S where F=SA

Compression- The same formulas apply for compression as tension except for long compression members which are known as columns. If buckling occurs, then failure is by column action instead of compression.

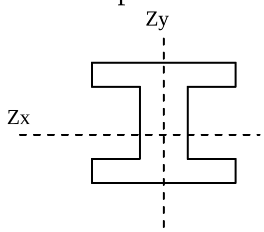
Column Action- Column action occurs when the column is trying to bend away from opposing forces.

Bending- When a member is bent, a compressive stress and a tensile stress are produced in the member. The maximum stress is at the outer portion or surface of the material at a point where the bending moment is greatest. If the cross-section of the member is symmetrical then the tensile stress is equal to the compressive stress.

> To calculate safe loads for bending the value Z (section modulus-may also be S value in recent publications) must be looked up in a steel specification table. Some of the Z values are included in this section in tables copied from the American Institute of Steel Construction Handbook.

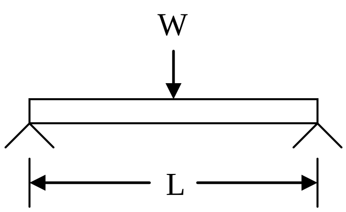
There are normally two Z values for each shape of metal. The is a Z value for the x axis and a Z value for the y axis. The Zx value is typically greater than the Zy value.

For example: I-Beam



The bending moment must be calculated to determine safe load. There are two basic types of beams used to calculate bending moment. These are a simple beam (a beam supported on both ends) and a cantilever beam (a beam only supported on one end).

There is also two different load distributions to consider when calculating bending moments. These are point load in which all of the load is centered over one point or distributed load where the load may be distributed over the entire beam.

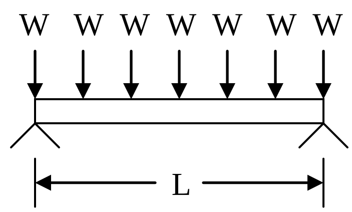


Simple Beam with Point Load

$M=(WL)/4$

M=weight*length divided by 4

L=inches W=pounds

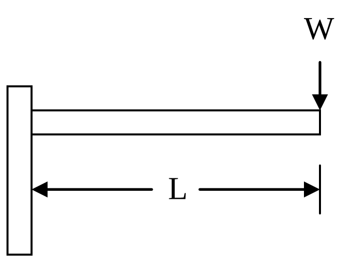


Simple Beam with Distributed Load

$M=((WL)(WL))/8$

M=weight*length squared divided by 8

L=inches W=pounds per foot

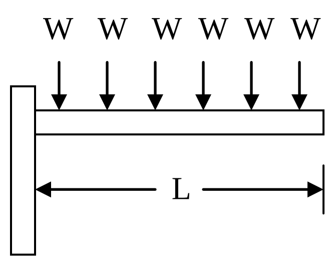


Cantilever Beam with Point Load

$M=WL$

M=weight*length

L=inches W=pounds



Cantilever Beam with Distributed Load

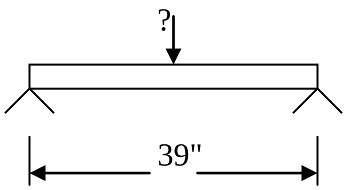
$M=((WL)(WL))/2$

M=weight*length squared divided by 2

L=inches W=pounds per foot

Sample Problems:

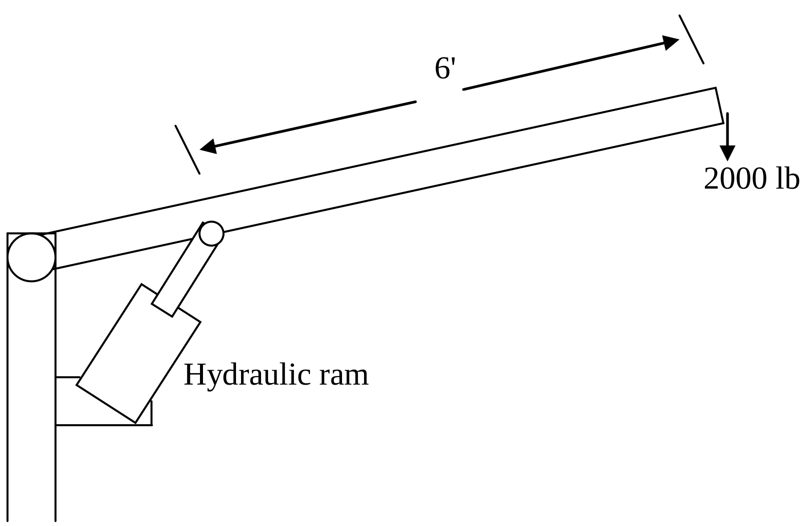
What is the safe load for a 2 ½" schedule 40 pipe as shown below?



1. Find M using safe load value (21,000 lbs) for stress.
   S=M/Z
   21,000 lb=M/1.06 (from table cubic inches)
   M=21,000*1.06
   M=22,260 in lb

2. Solve M=(WL)/4 for W to get safe load.
   22,260=39W/4
   (22.260*4)/39=W
   W=2283 lbs safe bending load

What size of tubing would be required for the following lever as used in an engine hoist (cherry picker).



1. This is a cantilever beam with a point load. The shortest end of the beam is ignored because: It is shorter than the other end and it is a simple beam so it will have a lower moment than the other end. Therefore, if the long end is built to withstand the load the short end will have no problem withstanding the load.

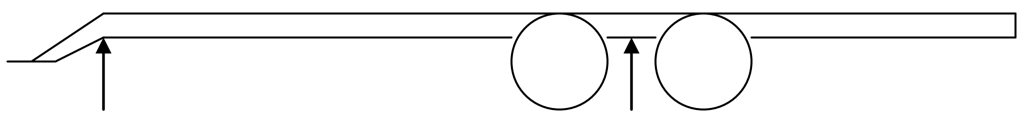
2. Find M
   M=W*L
   M=2000*72
   M=144,000 in lb

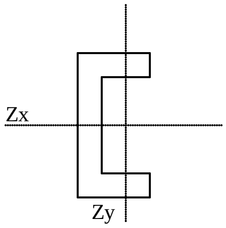
4. Find Z using safe load value
   S=M/Z
   Z=M/S
   Z=144,000/21,000
   Z=6.86

5. Refer to the tables and select tubing with a Z value of at least 6.86.
   5" x 5/16" square tubing has a Z value of 7.81
   6" x 3/16" square tubing has a Z value of 7.83
   6" x 3" x 3/8" tubing has a Z value of 7.56

With simple reasoning these formulas can be applied to any structure.

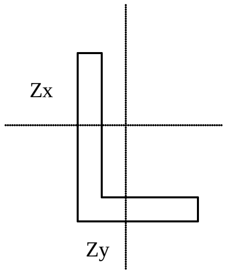
For example the side frame rails of a trailer: The front half is a simple beam supported by the axles on one end and the hitch on the other end. The rear half is a cantilever beam supported only by the axles. For the most part the decking of the trailer will create a distributed load.





Channels (American Standard)

Web Depth (in)	Weight lb/ft	Zx (cubic in)	Zy (cubic in)
15	50	53.8	3.78
15	40	46.5	3.36
15	33.9	42	3.11
12	30	27	2.06
12	25	24.1	1.88
12	20.7	21.5	1.73
10	30	20.7	1.65
10	25	18.2	1.48
10	20	15.8	1.32
10	15.3	13.5	1.16
9	20	13.5	1.17
9	15	11.3	1.01
9	13.4	10.6	0.962
8	18.75	11	1.01
8	13.75	9.03	0.853
8	11.5	8.14	0.781
7	14.75	7.78	0.779
7	12.25	6.93	0.702
7	9.8	6.08	0.625
6	13	5.8	0.642
6	10.5	5.06	0.564
6	8.2	4.38	0.492
5	9	3.56	0.449
5	6.7	3	0.378
4	7.25	2.29	0.343
4	5.4	1.93	0.283
3	6	1.38	0.268
3	5	1.24	0.233
3	4.1	1.1	0.202

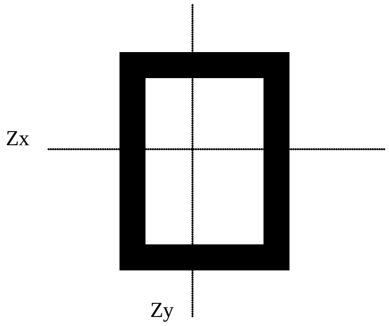


Angles			
Leg (in)	Thickness (in)	Zxy (cubic in)	
8	1.1250	17.5	
8	1.0000	15.8	
8	0.8750	14	
8	0.7500	12.2	
8	0.6250	10.3	
8	0.5625	9.34	
8	0.5000	8.36	
6	1.0000	8.57	
6	0.8750	7.63	
6	0.7500	6.66	
6	0.8750	5.66	
6	0.5625	5.14	
6	0.5000	4.61	
6	0.4375	4.08	
6	0.3750	3.53	
6	0.3125	2.97	
5	0.8750	5.17	
5	0.7500	4.53	
5	0.6250	3.86	
5	0.5000	3.16	
5	0.4375	2.79	
5	0.3750	2.42	
5	0.3125	2.04	
4	0.7500	2.81	
4	0.6250	2.4	
4	0.5000	1.97	
4	0.4375	1.75	
4	0.3750	1.52	
4	0.3125	1.29	
4	0.2500	1.05	
3.5	0.5000	1.49	
3.5	0.4375	1.32	
3.5	0.3750	1.15	
3.5	0.3125	0.976	
3.5	0.2500	0.794	
3	0.5000	1.07	
3	0.4375	0.954	
3	0.3750	0.833	
3	0.3125	0.707	
3	0.2500	0.577	
3	0.1875	0.441	

2.5	0.5000	0.724		
2.5	0.3750	0.566		
2.5	0.3125	0.482		
2.5	0.2500	0.394		
2.5	0.1875	0.303		
2	0.3750	0.351		
2	0.3125	0.3		
2	0.2500	0.247		
2	0.1875	0.19		
2	0.1250	0.131		
1.75	0.2500	0.186		
1.75	0.1875	0.144		
1.75	0.1250	0.099		
1.5	0.2500	0.134		
1.5	0.1875	0.104		
1.5	0.1563	0.088		
1.5	0.1250	0.072		
1.25	0.2500	0.091		
1.25	0.1875	0.071		
1.25	0.1250	0.049		
1	0.2500	0.056		
1	0.1875	0.044		
1	0.1250	0.031		
Pipe				
Nominal Dia. (in)	**OD (in)**	**ID (in)**	**Wall Thickness (in)**	**Z (cubic in)**
0.50	0.84	0.622	0.109	0.041
0.75	1.05	0.824	0.113	0.071
1.00	1.315	1.049	0.133	0.133
1.25	1.66	1.38	0.14	0.235
1.50	1.9	1.61	0.145	0.326
2.00	2.375	2.067	0.154	0.561
2.50	2.875	2.469	0.203	1.06
3.00	3.5	3.068	0.216	1.72
3.50	4	3.548	0.226	2.39
4.00	4.5	4.026	0.237	3.21
5.00	5.563	5.047	0.258	5.45
6.00	6.625	6.065	0.28	8.5
8.00	8.625	7.981	0.322	16.8
10.00	10.75	10.02	0.365	29.9
12.00	12.75	12	0.375	43.8
0.50	0.84	0.546	0.147	0.048
0.75	1.05	0.742	0.154	0.085
1.00	1.315	0.957	0.179	0.161
1.25	1.66	1.278	0.191	0.291
1.50	1.9	1.5	0.2	0.412
2.00	2.375	1.939	0.218	0.731
2.50	2.875	2.323	0.276	1.34

3.00	3.5	2.9	0.3	2.23
3.50	4	3.364	0.318	3.14
4.00	4.5	3.826	0.337	4.27
5.00	5.563	4.813	0.375	7.43
6.00	6.625	5.761	0.432	12.2
8.00	8.625	7.625	0.5	24.5
10.00	10.75	9.75	0.5	39.4
12.00	12.75	11.75	0.5	56.7
2.00	2.375	1.503	0.436	1.1
2.50	2.875	1.771	0.552	2
3.00	3.5	2.3	0.6	3.42
3.50				
4.00	4.5	3.152	0.674	6.79
5.00	5.563	4.063	0.75	12.1
6.00	6.625	4.897	0.864	20
8.00	8.625	6.875	0.875	37.6
Square Tubing				
Size (in)	**Thickness (in)**	**Z (cubic in)**		
10	0.625	60.7		
10	0.5	52		
10	0.375	41.7		
10	0.3125	35.8		
10	0.25	29.6		
10	0.1875	22.9		
8	0.625	35.5		
8	0.5	31.1		
8	0.375	25.4		
8	0.3125	22		
8	0.25	18.4		
8	0.1875	14.3		
7	0.5	22.6		
7	0.375	18.8		
7	0.3125	16.4		
7	0.25	13.7		
7	0.1875	10.8		
6	0.5	16.2		
6	0.375	13.5		
6	0.3125	11.8		
6	0.25	9.95		
6	0.1875	7.83		
5	0.5	10.3		
5	0.375	8.8		
5	0.3125	7.81		
5	0.25	6.64		
5	0.1875	5.28		
4	0.5	5.7		

4	0.375	5.1		
4	0.3125	4.61		
4	0.25	4		
4	0.1875	3.24		
3.5	0.25	3.02		
3.5	0.1875	2.45		
3	0.25	2.1		
3	0.1875	1.73		
2	0.25	7.66		
2	0.1875	0.668		



Rectangular Tubing				
Y Wall (in)	**X Wall (in)**	**Thickness (in)**	**Zx (cubic in)**	**Zy (cubic in)**
12	8	0.5	56.2	45.2
12	8	0.375	45	36.3
12	8	0.3125	38.7	31.3
12	8	0.25	32	25.9
12	8	0.1875	24.7	20
12	6	0.5	45.2	30.7
12	6	0.375	36.6	25
12	6	0.3125	31.6	21.7
12	6	0.25	26.2	18.1
12	6	0.1875	20.4	14.1
12	4	0.5	34.2	17.6
12	4	0.375	28.1	14.7
12	4	0.3125	24.5	13
12	4	0.25	20.5	10.9
12	4	0.1875	16	8.63
12	2	0.375	19.7	5.62
12	2	0.3125	17.4	5.14
12	2	0.25	14.7	4.51
12	2	0.1875	11.6	3.7
10	8	0.5	43	38.1
10	8	0.375	34.7	30.8
10	8	0.3125	30	26.7
10	8	0.25	24.8	22.1
10	8	0.1875	19.3	17.2
10	6	0.5	34	25.6
10	6	0.375	27.8	21
10	6	0.3125	24.1	18.3
10	6	0.25	20.1	15.3
10	6	0.1875	15.7	12
10	4	0.5	24.9	14.5
10	4	0.375	20.8	12.3
10	4	0.3125	18.2	10.8
10	4	0.25	15.3	9.17
10	4	0.1875	12	7.26
10	2	0.375	14.5	4.74
10	2	0.3125	12.8	4.33
10	2	0.25	10.8	3.8
10	2	0.1875	8.58	3.11
8	6	0.5	24.1	20.6
8	6	0.375	19.9	17.1

8	6	0.3125	17.4	14.9
8	6	0.25	14.6	12.5
8	6	0.1875	11.4	9.85
8	4	0.5	17.9	11.9
8	4	0.375	15	10
8	4	0.3125	13.1	8.87
8	4	0.25	11.1	7.52
8	4	0.1875	8.71	5.96
8	3	0.5	14.4	7.74
8	3	0.375	12.3	6.74
8	3	0.3125	10.8	6.04
8	3	0.25	9.18	5.18
8	3	0.1875	7.28	4.16
8	2	0.375	9.52	3.73
8	2	0.3125	8.52	3.43
8	2	0.25	7.31	3.03
8	2	0.1875	5.85	2.49
7	5	0.5	17.4	14.3
7	5	0.375	14.5	12
7	5	0.3125	12.7	10.6
7	5	0.25	10.7	8.9
7	5	0.1875	8.4	7.02
6	4	0.5	11.1	8.79
6	4	0.375	9.54	7.58
6	4	0.3125	8.46	6.74
6	4	0.25	7.19	5.76
6	4	0.1875	5.72	4.6
6	3	0.5	8.6	5.63
6	3	0.375	7.56	5.01
6	3	0.3125	6.77	4.52
6	3	0.25	5.82	3.92
6	3	0.1875	4.66	3.17
6	2	0.375	5.57	2.72
6	2	0.3125	5.08	2.53
6	2	0.25	4.44	2.25
6	2	0.1875	3.61	1.87
5	3	0.5	6.21	4.57
5	3	0.375	5.58	4.14
5	3	0.3125	5.06	3.77
5	3	0.25	4.38	3.29
5	3	0.1875	3.55	2.68
5	2	0.25	3.39	1.92
5	2	0.1875	2.75	1.6
4	3	0.25	3.23	2.74
4	3	0.1875	2.62	2.23
4	2	0.25	2.35	1.54
4	2	0.1875	1.93	1.29
3	2	0.25	1.47	1.15
3	2	0.1875	1.24	0.977

Ferrous Metal ID Worksheet

Name____________________

Match the metals on the left to the correct properties on the right.

1.________	Cast Steel	A. Non-magnetic, smooth shiny appearance.
2.________	Cold Rolled Machine Steel	B. 0.6% to 2% carbon content, melting point of 2500 F°, used for making tools.
3.________	Malleable Cast	C. 0.3 to 0.6% carbon, melts at 2600 F°, rough scaly surface, soft and easily worked, used for structures and machinery.
4.________	Wrought Iron	D. Contains Cobalt, Molybdenum, or Tungsten and 4% Chromium, used for making cutting tools.
5.________	Mild Steel	E. 0.3 to 0.6% carbon, melts at 2600 F°, smooth shiny surface, soft and easily worked, used for structures and machinery.
6.________	High Speed Steel	F. Very resistant to abrasion, impossible to machine, melts at 2300 F°, not ductile, very brittle.
7.________	Tool Steel	G. Soft and ductile, can be bent at room temperature, melts at 2900 F°, fractured appearance is a fibrous wood-like structure.
8.________	White Cast Iron	H. 0.05 to 0.3% carbon, melts at 2700 F°, used more than any other steel, easily worked, used for structures and machinery.
9.________	Stainless Steel	I. At least 1.7% carbon, very brittle, not ductile, can be machined, melts at 2300 F°.
10.________	Hot Rolled Steel	J. 0.3% carbon, soft, ductile, machineable, used for making chains and implement parts.
11.________	Gray Cast Iron	K. Annealed white cast iron, very ductile, melts at 2300 F°, used for crankshafts

Non-Ferrous Metal ID Worksheet
Name____________________

Match the metals on the left to the correct properties on the right.

1._______ Titanium	A. Silver color, 1/3 the weight of steel but 80% as strong, melts at 1215 F°.
2._______ Tin	B. Light yellow colored alloy of copper and zinc, used for radiators, pipe, welding rod, melts at 1650 F°.
3._______ Aluminum	C. Dark yellow colored alloy of copper and tin, used for bushings, fittings, valves, pistons, and springs, melts at 1600 F°.
4._______ Zinc	D. Reddish-brown color, commonly available, used mainly as an alloy with other metals or as an electrical conductor when pure, melts at 2000 F°.
5._______ Brass	E. Bluish-white color, high luster, soft, very malleable and ductile, poor electrical conductor, very high specific gravity, melts at 620 F°.
6._______ Nickel	F. Silvery-white color, lightest of all commercial metals, used for chain saw cases, and lawn mower bodies, reacts with silver nitrate and vinegar, melts at 1200 F°.
7._______ Bronze	G. Silver colored, excellent corrosion and oxidation resistance, used only as an alloy with steel or copper, somewhat magnetic, melts at 2640 F°.
8._______ Lead	H. Does not corrode in moist air, used in solder, brass, bronze, and pewter, melts at 450 F°.
9._______ Copper	I. Very hard, very resistant to heat, alloys are used for high speed steel and TIG welding electrodes, also used for light bulb filaments, melts at 6098 F°.
10._______Magnesium	J. Bluish-white color, used for galvanizing, used as an alloy with copper to produce brass, excellent corrosion resistance, melts at 786 F°.
11._______Tungesten	K. Silvery-gray color, weighs about one half as much as steel, used in aircraft construction, most alloys melt around 3000 F°.

METAL IDENTIFICATION

Name____________________

FERROUS METAL

__________________ Wrought Iron

__________________ Mild Steel (Low Carbon)

__________________ Hot Rolled Machine Steel (Med. Carbon)

__________________ Cold Rolled Machine Steel (Med. Carbon)

__________________ Tool Steel (High Carbon)

__________________ High Speed Steel

__________________ Cast Steel

__________________ Stainless Steel

__________________ Gray Cast Iron

__________________ White Cast Iron

__________________ Malleable Cast Iron

NON-FERROUS METAL

__________________ Aluminum

__________________ Brass or Bronze

__________________ Copper

__________________ Lead

__________________ Magnesium

__________________ Nickel

__________________ Titanium

__________________ Tungsten

__________________ Zinc Die Cast

Welding Metallurgy
Unit Test

Name____________________

Matching: Match the terms to the correct definition.

Ductility	Shear Strength	Hardness	Malleability
Tensile Strength	Brittleness	Aluminum	Bending Strength
Mild Steel	Tool Steel	Grey Cast	Brass
White Cast	Tungsten	Magnesium	Stainless Steel
Cold Rolled Steel	Malleable Cast	Zinc	High Speed Steel

1.______________ Ferrous, Non-magnetic, smooth shiny appearance.

2.______________ Property of metal that resists indentation.

3.______________ Non-ferrous, bluish-white color, used for galvanizing.

4.______________ Ferrous, contains Cobalt, Molybdenum, or Tungsten and 4% Chromium, used for making cutting tools.

5.______________ Property in which metal will easily break under low stress.

6.______________ Light yellow colored alloy of copper and zinc, used for radiators, pipe, and welding rod.

7.______________ Ability of metal to withstand two equal forces acting in opposite directions.

8.______________ Non-ferrous, very hard, very resistant to heat, alloys are used for high speed steel and TIG welding electrodes.

9.______________ Ferrous, 0.6% to 2% carbon content, melting point of 2500 F°, used for making tools.

10.______________ Ability of metal to resist deflection in the direction of a force.

11.______________ Ferrous, at least 1.7% carbon, very brittle, not ductile, can be machined, melts at 2300 F°.

12.______________ Ability of metal to be deformed without defects by rolling, pressing, or forging.

13.______________ Non-ferrous, silvery-white color, lightest of all commercial metals.

14.______________ Ability of metal to stretch, twist, or bend without breaking.

15.______________ Ability of metal to resist forces pulling it apart.

Welding Metallurgy
Unit Test

Name____________________

Multiple Choice: Choose the best answer

1. The critical temperature of carbon steels is approximately:
   A. 2300 to 2700 F°
   B. 1800 to 2200 F°
   C. 1300 to 1700 F°
   D. 800 to 1200 F°

2. At what thickness should carbon steel be preheated before welding?
   A. 1/8"
   B. 1/4"
   C. 3/8"
   D. 1/2"

3. Which of the following factors **cannot** affect the cooling rate of a weld.
   A. Welding process
   B. Length of the weld
   C. Type of metal
   D. Mass of the metal

4. Which of the following is not a mechanical property of metal?
   A. Ductility
   B. Malleability
   C. Hardness
   D. Melting point

5. Ferrous metal:
   A. Expands when heated, and hardens when quenched
   B. Expands when cooled and hardens when quenched
   C. Expands when heated and softens when quenched
   D. Expands when cooled and softens when quenched

6. Which of the following is not a physical property of metal?
   A. Thermal Conductivity
   B. Grain Size
   C. Ductility
   D. Melting point

7. Which of the following is a non-ferrous metal?
   A. Stainless Steel
   B. Nickel
   C. Mild Steel
   D. White Cast Iron

Welding Metallurgy
Unit Test

Name____________________

True Or False:

1.________ The grain size of carbon steel increases once the critical temperature is reached.

2.________ Hardening metal will also increase ductility.

3.________ Annealing will soften metal

4.________ As the carbon content of metal increases the melting point and critical temperature will decrease.

5.________ Welding on hardened steel will anneal the heat affected zone.

6.________ The rate at which metal cools can alter the physical properties of the metal.

7.________ Electroslag welds cool slower than gas shielded welds.

8.________ Once ferrous metals reach the critical temperature they are no longer magnetic.

9.________ Annealing will also increase brittleness.

10.________ To harden carbon steel it should be heated to the critical temperature and quenched.

11.________ Mild steel contains enough carbon to be heat treated.

12.________ Normalizing can be a softening or a hardening process.

13.________ Tempering relieves residual stresses from hardening.

14.________ Bronze and brass are two terms that refer to the same metal alloy.

15.________ Nickel is a ferrous metal because it is magnetic.

Welding Metallurgy
Unit Test

Name KEY

Matching: Match the terms to the correct definition.

Ductility	Shear Strength	Hardness	Malleability
Tensile Strength	Brittleness	Aluminum	Bending Strength
Mild Steel	Tool Steel	Grey Cast	Brass
White Cast	Tungsten	Magnesium	Stainless Steel
Cold Rolled Steel	Malleable Cast	Zinc	High Speed Steel

1. Stainless Steel Ferrous, Non-magnetic, smooth shiny appearance.

2. Hardness Property of metal that resists indentation.

3. Zinc Non-ferrous, bluish-white color, used for galvanizing.

4. High speed steel Ferrous, contains Cobalt, Molybdenum, or Tungsten and 4% Chromium, used for making cutting tools.

5. Brittleness Property in which metal will easily break under low stress.

6. Brass Light yellow colored alloy of copper and zinc, used for radiators, pipe, and welding rod.

7. Shear Strength Ability of metal to withstand two equal forces acting in opposite directions.

8. Tungsten Non-ferrous, very hard, very resistant to heat, alloys are used for high speed steel and TIG welding electrodes.

9. Tool Steel Ferrous, 0.6% to 2% carbon content, melting point of 2500 F°, used for making tools.

10. Bending strength Ability of metal to resist deflection in the direction of a force.

11. Grey Cast Ferrous, at least 1.7% carbon, very brittle, not ductile, can be machined, melts at 2300 F°.

12. Malleability Ability of metal to be deformed without defects by rolling, pressing, or forging.

13. Magnesium Non-ferrous, silvery-white color, lightest of all commercial metals.

14. Ductility Ability of metal to stretch, twist, or bend without breaking.

15. Tensile strength Ability of metal to resist forces pulling it apart.

Welding Metallurgy
Unit Test

Name KEY

Multiple Choice: Choose the best answer

1. The critical temperature of carbon steels is approximately:
   A. 2300 to 2700 F°
   B. 1800 to 2200 F°
   C. 1300 to 1700 F°
   D. 800 to 1200 F°

2. At what thickness should carbon steel be preheated before welding?
   A. 1/8"
   B. 1/4"
   C. 3/8"
   D. 1/2"

3. Which of the following factors **cannot** affect the cooling rate of a weld.
   A. Welding process
   B. Length of the weld
   C. Type of metal
   D. Mass of the metal

4. Which of the following is not a mechanical property of metal?
   A. Ductility
   B. Malleability
   C. Hardness
   D. Melting point

5. Ferrous metal:
   A. Expands when heated, and hardens when quenched
   B. Expands when cooled and hardens when quenched
   C. Expands when heated and softens when quenched
   D. Expands when cooled and softens when quenched

6. Which of the following is not a physical property of metal?
   A. Thermal Conductivity
   B. Grain Size
   C. Ductility
   D. Melting point

7. Which of the following is a non-ferrous metal?
   A. Stainless Steel
   B. Nickel
   C. Mild Steel
   D. White Cast Iron

Welding Metallurgy
Unit Test

Name Key

True Or False:

1. F________ The grain size of carbon steel increases once the critical temperature is reached.

2. F________ Hardening metal will also increase ductility.

3. T_______ Annealing will soften metal

4. T________ As the carbon content of metal increases the melting point and critical temperature will decrease.

5. T________ Welding on hardened steel will anneal the heat affected zone.

6. T________ The rate at which metal cools can alter the physical properties of the metal.

7. T________ Electroslag welds cool slower than gas shielded welds.

8. T________ Once ferrous metals reach the critical temperature they are no longer magnetic.

9. F________ Annealing will also increase brittleness.

10. T________ To harden carbon steel it should be heated to the critical temperature and quenched.

11. F________ Mild steel contains enough carbon to be heat treated.

12. T________ Normalizing can be a softening or a hardening process.

13. T________ Tempering relieves residual stresses from hardening.

14. F________ Bronze and brass are two terms that refer to the same metal alloy.

15. F________ Nickel is a ferrous metal because it is magnetic.

Math and Measuring

AG 240-F

Unit objective

After completion of this unit, students will understand measuring, squaring, and basic math used to solve fabrication related problems. Students will learn to measure and/or calculate angles, dimensions, and conversions. Students will also be able to identify the standard measurements using a tape measure, ruler, yardstick, and micrometer. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

Specific Objectives and Competencies

After completion of this unit, the student should be able to:

1. Measure objects with a ruler, tape, or square within one sixteenth of an inch.
2. Read and measure with a micrometer within 1/1000.
3. Identify the significance of math as it applies to fabrication projects.
4. Convert between fractional measurements and decimal measurements.
5. Convert between metric and standard measurements.
6. Convert between feet and inches.
7. Complete addition, subtraction, multiplication, and division procedures for architectural measurements.
8. Calculate area, circumference, perimeter, and volume of basic geometric shapes.
9. Calculate quantities and costs of necessary materials.
10. Calculate distances between centers.
11. Arrange cuts to minimize waste.
12. Calculate diagonal measurements to assure two sides are square.
13. Calculate unknown angles.

Unit References:

Cooper, E. L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Hokanson, C. M. (1984). APPLIED PROBLEMS IN MATHEMATICS FOR AGRICULTURE. Danville, IL:

THE STARRETT BOOK FOR STUDENT MACHINISTS,(1998) The L. S. Starrett Company, Athol, Massachusetts 01331

Special Material and Equipment:

Ruler or Yardstick, Tape Measure, Framing Square, Calipers, Micrometer, Calculators (optional), 25' measuring tape, objects and land to measure

MEASURING

A. Measuring is essential to the design and fabrication of quality projects.. Measuring is used to:

1. Create drawings, plans or models of projects to be built.
2. Measure and cut materials to size.
3. Place materials properly in construction.
4. Select proper size replacement parts for tools and equipment.
5. Determine quantity of materials needed for projects.
6. Calculate area and volume.

B. Common measuring tools and their uses:

1. Ruler or Yardstick - rigid measuring devices. Specialized rules or scales are made for drawing or drafting.
2. Tape Measure - flexible measuring device typically used in fabrication and construction.
3. Framing Square - L shaped measuring device used in fabrication and construction. Useful for drawing right angles on materials to be cut.
4. Calipers - pincher like measuring devices used to measure the diameter of objects.
5. Micrometers - exceptionally accurate calipers for making very small measurements. Often used in machinery repair and in fabrication of precision tools.
6. Surveyors rod - used with a sight level or transit to measure vertical height. Important for leveling building sites, preparing forms for concrete, grading roads and ditches, laying pipe.

C. Units of measurement:

1. English Fractional Rule - Inches are divided into 8, 16, 32 or 64 equal segments.
2. English Decimal rule - Inches are divided into 10 or 100 equal segments.
3. Metric Rule - Basic unit of length is the meter. Each meter is divided into 100 centimeters. Each centimeter is divided into 10 millimeters.
4. See Tables 1-3 for a comprehensive listing of units of linear, square and cubic measurements for the English (Table 1) and Metric (Table 2) systems. Table 3 lists equivalencies of Metric and English units useful for converting measurements between systems.

D. Understanding Metric Measurements

1. The metric system has the advantage of being a completely decimal system.
2. The units of measure in the metric system relate to one another by multiples of ten. This makes the metric system mathematically logical and easy to use.
3. Instead of working with complicated division and multiplication to change from one measurement unit to another, the decimal point is merely moved.

    a. To change sizes of metric units, multiply or divide by 10, 100, 1,000 or 1,000,000, which is as simple as moving a decimal point.
    b. For example, to change 357 centimeters to meters, divide by 100. The answer is obvious without figuring--3.57 meters. Metric measures make calibration of instruments and equipment much easier.

4. Below is a table of metric prefixes whose meaning indicates whether to multiply or divide when changing measurement:

    a. Mega- = 1,000,000 times the basic unit (meter, liter, grams).
    b. Kilo- = 1,000 times the basic unit.
    c. Hecto- = 100 times the basic unit.
    d. Deca- = 10 times the basic unit.
    e. Deci- = 1/10 times the basic unit.
    f. Centi- = 1/100 times the basic unit.
    g. Milli- = 1/1000 times the basic unit.
    h. Micro- = 1/1,000,000 times the basic unit.

ACTIVITY:

1. Add and subtract both English and metric units of measure; then discuss the use of common fractions in English unit manipulation and the use of decimals in metric unit manipulation.
2. Perform English-to-metric and metric-to-English conversions.
3. Compare U.S. standard measure and metric measure tools and identify engines and machinery which require metric measure tools.

Table 1. English Units of Measure

Linear Units (Length)

12 inches (in. or ")	=	1 foot (ft or ')
3 feet	=	1 yard (yd)
16 1/2 feet	=	1 rod (rd)
5 1/2 yards	=	1 rod
320 rods	=	1 mile (mi)
5,280 feet	=	1 mile
1,760 yards	=	1 mile
1 furlong (fur)	=	1/8 mile or 660 feet

Square Units (Area)

144 square inches (sq. in. or in.^{2})	=	1 square foot (sq. ft or ft^2)
9 square feet	=	1 square yard (sq. yd or yd^2)
30 1/4 square yards	=	1 square rod (sq. rd or rd^2)
160 square rods	=	1 acre (A)
43,560 square feet	=	1 acre
640 acre	=	1 square mile (sq. mi or mi^2)

Cubic Units (Volume)

1,728 cubic inches (cu in. or in.^{3})	=	1 cubic foot (cu ft or ft^3)
27 cubic feet	=	1 cubic yard (cu yd or yd^3)
128 cubic feet	=	1 cord (cd) - measure of fire wood

Table 2. Metric Units of Measure

Linear Units (Length)

1 kilometer (km)	=	1,000 meters
1 hectometer (hm)	=	100 meters
1 decameter (dkm)	=	10 meters

Square Units (Area)

1 square centimeter (cm^2)	=	100 square millimeters (mm^2)
1 square decimeter (dm^2)	=	100 square centimeters (cm^2)
1 square meter (m^2)	=	10,000 square centimeters (cm^2)
10,000 square meters	=	1 hectare

Cubic Units (Volume)

1 cubic centimeter (cm^3)	=	1,000 cubic millimeters (mm^3)
1 cubic meter (m^3)	=	1,000,000 cubic centimeters (cm^3)
1,000 cubic centimeters	=	1 cubic decimeter (dm^3)
1,000 cubic centimeters	=	1 liter (l)
1 cubic centimeter (cc)	=	1 milliliter (ml)

Table 3. English to Metric Conversions

Linear Units (Length)

1 in	=	25.4 mm	or	1 mm	=	0.03937 in
1 in	=	2.54 cm	or	1 cm	=	0.3937 in
1 ft	=	30.48 cm	or	1 m	=	39.37 in
1 ft	=	0.3048 m	or	1 m	=	3.281 ft
1 yd	=	0.9144 m	or	1 m	=	1.0936 yd
1 mi	=	1.6093 km	or	1 km	=	0.6214 mi

Square Units (Area)

1 in^2	=	6.452 cm^2	or	1 cm^2	=	0.1549 in^2
1 ft^2	=	0.0929 m	or	1 m^2	=	10.76 ft^2
1 yd^2	=	0.8361 m^2	or	1 m^2	=	1.196 yd^2
1 mi^2	=	259 ha				
1 mi^2	=	2.589 km^2				
1 acre	=	0.4047 ha		1 ha	=	2.471 acres

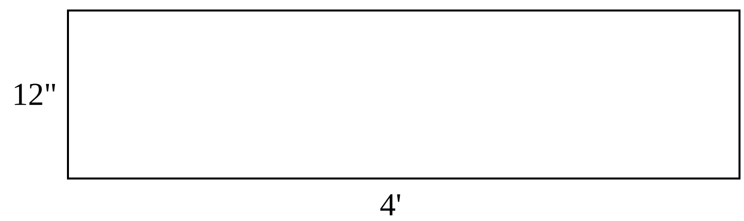
Cubic Units (Volume)

1 in^3	=	16.387 cm^3	or	1 cm^3	=	0.06102 in^3
1 ft^3	=	0.0283 m^3	or	1 m^3	=	35.32 ft^3
1 yd^3	=	0.7646 m^3	or	1 m^3	=	1.208 yd^3

To convert units, multiply unit on left by conversion factor on right.
(e.g. 10 in x 25.4 mm/in = 254 mm)

MATH WITH ENGLISH MEASUREMENTS

A. Always convert to similar units. For example, to find the area of the square below:



The area can be found in square inches by converting 4' to 48".

12" * 48" = 192 square inches

Or the area can be found in square feet by converting 12" to 1'.

1' * 4' = 4 square feet

B. Parts of a fraction-The number above the line (1) is called the numerator and the number below the line (2) is called the denominator. ½

C. Types of fractions:

1. **Proper fractions** have a numerator smaller than the denominator. For example: 15/32, 7/16, 3/8, 1/4, 1/2

2. **Improper fractions** have a numerator that is larger than the denominator. For example: 53/32, 19/16, 13/8, 5/4, 3/2

3. **Mixed numbers** are a combination of a whole number and a fraction. For example: 1 15/32, 5 7/16, 2 3/8, 1 1/4, 4 1/2

D. Lowest Common Denominator

1. Fractions can only be added together when they have the same (common) denominator. If fractions with different denominators are to be added then the lowest common denominator must be found. To find the lowest common denominator for: 1/16+1/8+1/4+1/2.

   a. In the English measuring system the lowest common denominator will always be divisible by 2, 4, 8, 16, 32, or 64.

   b. In the above example the lowest common denominator is 16.

2. Convert the fractions so they both have the same denominator (lowest common denominator.

   a. Multiply the denominator by a number that produces the lowest common denominator. Then multiply the numerator by the same number.

      In the above example:
      ½ is multiplied by 8 to get 8/16
      ¼ is multiplied by 4 to get 4/16
      1/8 is multiplied by 2 to get 2/16
      1/16 remains 1/16

E. Converting fractions to decimals.

1. Divide the numerator by the denominator. Example 3/8=0.375

F. Converting from decimals to fractions.

1. Look up the decimal on a fraction and decimal equivalent chart and find the corresponding fraction.

   a. Fraction and decimal equivalent charts can often be found:

      -on a framing square
      -on a rule
      -on a yard stick
      -in text books
      -in material catalogs
      -on tap and drill charts

ADDITION OF FRACTIONAL MEASUREMENTS

A. Find the lowest common denominator as previously described.

B. Add the fractions.

1. Add the numerators

   8+4+2+1=15

2. The lowest common denominator is then used for the denominator.

   $1/16+1/8+1/4+1/2 \longrightarrow 1/16+2/16+4/16+8/16= 15/16$

   a. If the sum of the fractions creates an improper fraction convert it to a mixed fraction as follows:

      -Divide the numerator by the denominator. The number of times that the denominator can be divided into the numerator is placed before the fraction as a whole number. The remainder is left in the numerator. For example:

      11/16+9/16=20/16
      16 divides into 20 1 time with a remainder of 4
      Write the fraction as 1 4/16
      4/16can still be reduced to 1/4

      11/16+9/16=1 ¼

C. Adding mixed fractions

1. Add the fractions as described previously.

2. Convert improper fractions to mixed fractions.

3. Add the whole numbers together including any whole numbers generated from converting improper fractions. For example:

   1 11/16+2 9/16
   $11/16+9/16=20/16 \longrightarrow 1\ 1/4$
   1+1+2=4

   1 11/16+2 9/16=4 ¼

SUBTRACTION OF FRACTIONAL MEASUREMENTS

A. Convert fractions to lowest common denominator as described on (240F-9)

B. Subtract the numerators

1. 9/16-3/16=6/16 → 3/8

2. If subtracting mixed numbers a whole number may have to be borrowed to make the numerator large enough to subtract from. For example: 3 5/8-2 7/8

   A whole unit must be borrowed from the 3 and add as a whole fraction (8/8) to 5/8.
   2 13/8 –2 7/8=6/8 → ¾

MULTIPLICATION OF FRACTIONAL MEASUREMENTS

A. Multiplying proper fractions. Example 3/8 * 5/8

1. Multiply the numerators the product is the numerator of the resulting fraction.

   3*5=15

2. Multiply the denominators the product is the denominator of the resulting fraction.

   8*8=64

   3/8 * 5/8 = 15/64

3. Reduce and convert to a mixed fraction if necessary.

B. Multiplying mixed fractions or whole numbers and fractions. Example 1/2 * 3

1. Convert the whole number to an improper fraction.

   3=6/2

2. Multiply improper fractions using the same method as multiplying proper fractions.

   a. Multiply the numerators the product is the numerator of the resulting fraction.

      1*6=6

   b. Multiply the denominators the product is the denominator of the resulting fraction.

      2*2=4
      1/2 * 3 = 6/4

   c. Reduce and convert to a mixed fraction if necessary.

      6/4 → 1 ½

DIVISION OF FRACTIONAL MEASUREMENTS

A. Dividing proper fractions. Example: 5/8 ÷ 1/4

1. Invert (turn upside down) the divisor (1/4) and multiply

   5/8 * 4/1

   a. Multiply the numerators of the inverted fraction and the dividend.

      5 * 4 = 20

   b. Multiply the denominators of the inverted fraction and the dividend.

      8 * 1 = 8

2. Reduce or convert to mixed fraction if necessary

   5/8 ÷ 1/4 = 20/8 → 2 4/8 → 2 ½

B. Dividing mixed fractions or whole numbers and fractions. Example: 3/4 ÷ 2

1. Convert the whole number or mixed fraction to an improper fraction.

   2 → 4/2

2. Invert (turn upside down) the divisor (4/2) and multiply

   3/4 * 2/4

   c. Multiply the numerators of the inverted fraction and the dividend.

      3 * 2 = 6

   d. Multiply the denominators of the inverted fraction and the dividend

      4 * 4 = 16

2. Reduce or convert to mixed fraction if necessary

   3/4 ÷ 2 = 6/16 → 3/8

CALCULATING AREA AND VOLUME

A. Calculating Area

1. Square measure is a system for measuring area. The area of an object is the amount of surface contained within defined limits. For example, use a square that covers four square inches.

   a. The perimeter of the square is the total length of its sides.

   perimeter = P = 2 x length + 2 x width

   = (2 x 2) + (2 x 2) = 8 in

   b. The area of a square or rectangle is equal to the length times the width.

   A (area) = length x width

   = 2 x 2 = 4 in^2

2. Finding the area of circles.

   a. The perimeter of a circle is equal to the diameter (D) of the circle times pi (π). π is the ratio of a circle's perimeter to its diameter. This ratio is 22/7 or approximately 3.14. Pi is constant for all circles. The perimeter of a circle is known as its circumference.

   Perimeter of a circle = π x D = 3.14 x D

   b. The area of a circle is equal to pi times the radius squared. The radius of a circle is half the diameter:

   Area of a circle = π x R^2

   c. For example, a circular grain silo has round floor 18 feet in diameter.

   The perimeter (circumference) of the floor is
   Perimeter = 3.14 x 18 = 56.52 feet

   The area of the floor is
   Area = 3.14 x (9 x 9) = 3.14 x 81 = 254.34 ft^2

3. Finding the area of the curved surface of a cylinder.

   a. The curved-surface area of a cylinder is equal to the circumference (π x D) of an end times the height (H).

      Area of a cylinder = A = (π x D) x H

   b. Example - If the silo in the example above is 50 feet tall:

      The area of the sides of the silo is:
      Area = (3.14 x 18) x 50 = 2826 ft^2

4.Finding the area of a triangle.

   a. The area of a triangle is equal to one half the base (B) times the height (H).

      Area = 1/2 x (base x height)

   b. Example - what is the area of the triangular wall of a storage shed with a base of 2 meters and a height of 3 meters

      The area of the wall is:
      Area = 1/2 x (2 x 3) = 3 m^2

ACTIVITY:

1. Take actual measurement of plots and fields around the school shop or farm and determine individual and total acreage.
2. Determine how much sheet metal was used in constructing a barrel, feed bin, etc. Calculate the amount of paint required to paint the inside and outside of the silo in the example above.

B. Calculating Volume

1. A cubic measure is a system of measurement of volume or capacity of an object expressed in cubic units. A cubic measure requires three dimensions:

   a. Linear measure adds only one dimension to find total distance.
   b. Square measure multiplies two dimensions to find area of a surface.
   c. Cubic measure multiplies three dimensions (length, width, and height) to find the volume of various types of structures and containers.
   d. When determining the volume of an object, all measurements must be expressed in the same units of measurement.

2. Finding the volume of rectangular solids and cubes.

a. The volume of a rectangular solid is equal to the length (L) times the width (W) times the height (H).

Volume of a rectangular solid = L x W x H

b. Example - Determine the volume of the rectangular crate

Volume = 6' x 4' x 4' = 96 ft^3

c. A cube is a special rectangular solid where length = width =height.

d. The volume of a triangular prism is equal to the area of the triangle times the length of the prism.

3. Finding the volume of cylinders and cones.

a. The volume of a cylinder is equal the area of the circular base (π x R 2) times the height (H) of the cylinder.

Volume of a cylinder = (π x R 2) x H

b. The volume of a cone is equal to 1/3 times the area of the circular base (π x R^2) times the height (H) of the cone.

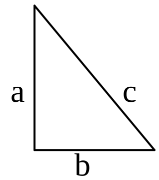
Volume of a cone = 1/3 x (π x R^2) x H

ACTIVITY:

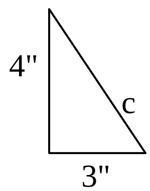
1. Measure various rectangular and cylindrical containers or buildings and determine their volumes.
2. Measure a paper-cone cup and calculate how much water it can hold.

CALCULATING THE UNKNOWN LENGTH OF ONE SIDE OF A TRIANGLE

A. a squared + b squared = c squared



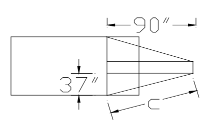
Example: Find length c



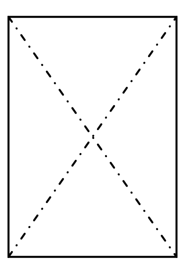
a*a+b*b=c*c
4*4+3*3=25
The square root of 25 is the length of c.
c=5"

B. Applications

1. Use to find unknown dimensions in prints. Example: prints for a trailer give the following dimensions you need to calculate how long C should be cut.



2. Use to find the diagonal measurement for squaring a frame.



a. A frame is square when the two diagonal measurements are equal.
b. Knowing what this length should be saves time of measuring in both directions.

RULES, YARDSTICKS, AND TAPE MEASURES

A. Ruler

1. Rules come in a variety of body lengths, most commonly 6 - 12 inches, sometimes 13 inches if metric measurements are on the other side.

    a. An inch is a unit of measurement used in the United States
    b. Usually divided into 8, 16, or 32 segments (Page 240F-21)

2. 12 inches equals 1 foot.
3. 3 feet equals 1 yard
4. Rules are mostly used for measuring and drawing straight lines in drafting and sketching.

B. Yardsticks

1. Yardsticks have a body length of 36 inches equaling 3 feet, sometimes 3 feet and 3 inches if metric measurements are on the other side equaling one meter
2. Yardsticks are mostly used in measuring the length of cloth products and the water level in open top water tanks.

C. Tape Measures

1. Tape measures are flexible measuring devices and come in a large variety of lengths

    a. 10 ft, 16 ft, 20 ft, 25 ft, 30 ft, 50 ft, 100 ft, etc.

2. Tape measures are mainly used in construction, framing, fabrication, landscape layouts, surveying, etc.
3. Marks on the tape measure

    a. Foot marks, every 12 inches along a tape measure there will be a marker to indicate the distance in feet. There will be a mark at 12 inches, 24 inches, 36 inches, etc.
    b. Spacing Studs, studs used in framing walls are on 16-inch centers. At 16-inch intervals on a tape measure there will be a mark to indicate the spacing of studs. There will be a mark at 16 inches, 32 inches, 48 inches, etc.
    c. Truss marks, every 19 $^{3/16}$ inches along a tape measure there will be a small black diamond. This indicates the center for trusses.

CALIPERS AND MICROMETERS

A. Calipers

1. Definitions

a. Calipers are instruments used to measure the diameter or thickness of an object

b. Both inside and outside calipers are used

1) Inside calipers measure inside distances such as the diameter of an engine cylinder

2) Outside calipers measure the outside of round objects such as crankshafts

2. Reading Calipers

a. Many economical calipers are not direct-reading measuring tools but require a separate rule or scale to measure their settings

1) Such calipers are used as measurement transfer tools similar to small-hole and telescoping gauges

2) They transfer the internal measurement of an engine part to a micrometer caliper for precision reading

b. More expensive calipers have their own dimension scales

c. A slide caliper (vernier caliper) is a direct-reading measuring instrument used to make fast, accurate measurements

B. Micrometers

1. Definitions and Parts Identification (Page 240F-23)

a. The micrometer is a direct-reading, precision measuring tool, which can measure to 0.001 inch (one thousands of an inch)

1) Micrometers come in various sizes for different size objects

2) They are very delicate and are ruined if dropped

b. To use a micrometer properly, the mechanic should be able to identify its' parts

2. Using and Reading a Micrometer

a. Zeroing out the micrometer

1) Screw the adjusting nut in until the zeros on the sleeve and thimble line up. Note the tightness of the adjusting nut, the same tightness will be used when taking measurements.
2) Micrometers 2 inch or larger will need a standard to be zeroed out

b. To measure with a micrometer, place the object to be measured between the anvil and the spindle

1) Screw the spindle until it touches the object

a) Adjust the micrometer to the same tightness as when the micrometer is zeroed out
b) Over tightening will ruin the micrometer and take inaccurate measurements

3. Reading the micrometer

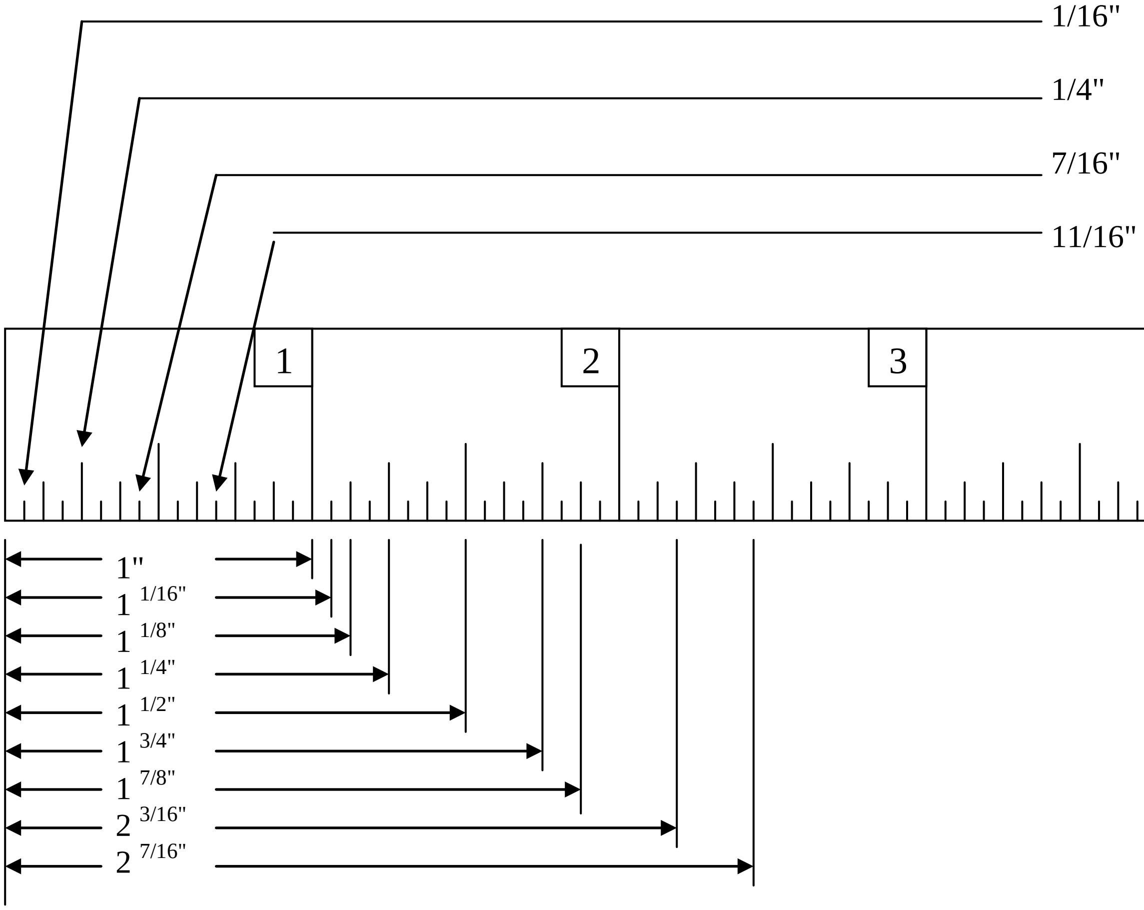
a) Identify the frame size of the micrometer being used and write down the smallest number of inches that can be read

1) If the micrometer has a 1-to-2 inch frame, write down 1.000 in.
2) One inch is already given since the anvil and the spindle can be no closer together than one inch

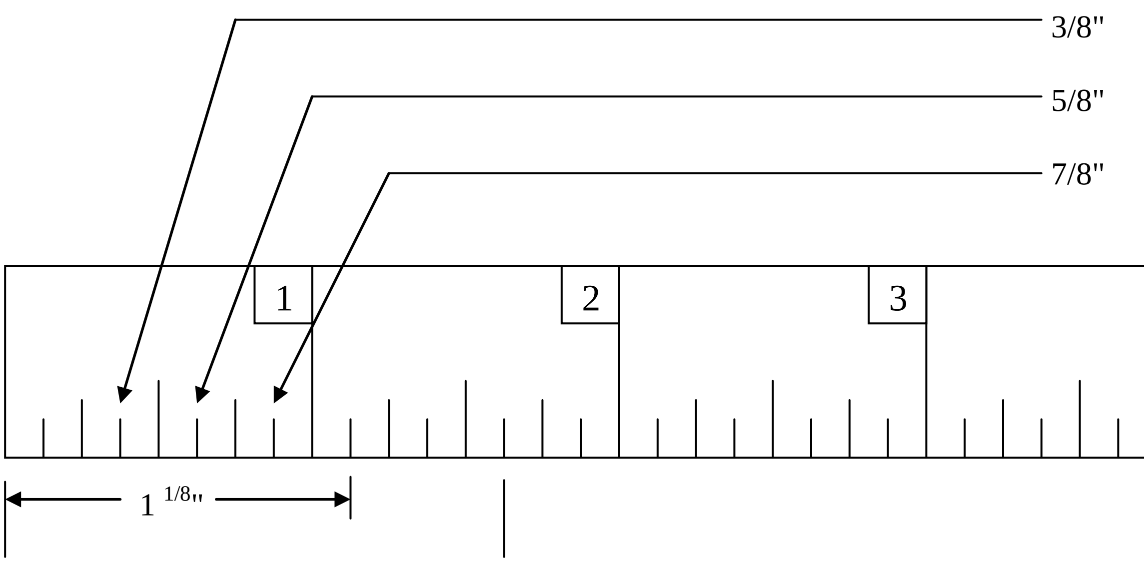
b) Every revolution of the thimble is equal to 0.025 in. (twenty-five thousandths of an inch)
c) List the number of tenths of an inch (hundred thousandths) indicated by the largest number visible between the sleeve
d) Count the number of lines easily visible between the last tenths marking and the thimble then multiply the number by 0.025
e) Locate the line of the thimble that matches the horizontal line on the sleeve and write its' number down in thousandths of an inch
f) Total the values

MEASURING WITH A RULER

1/16th INCH SCALE

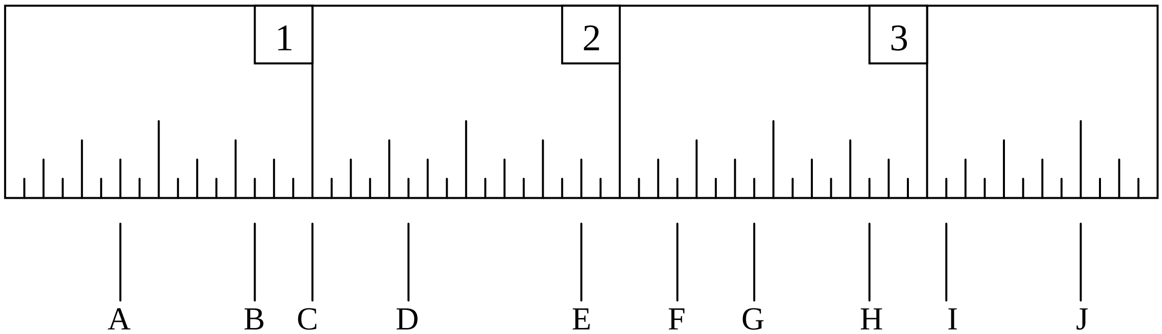


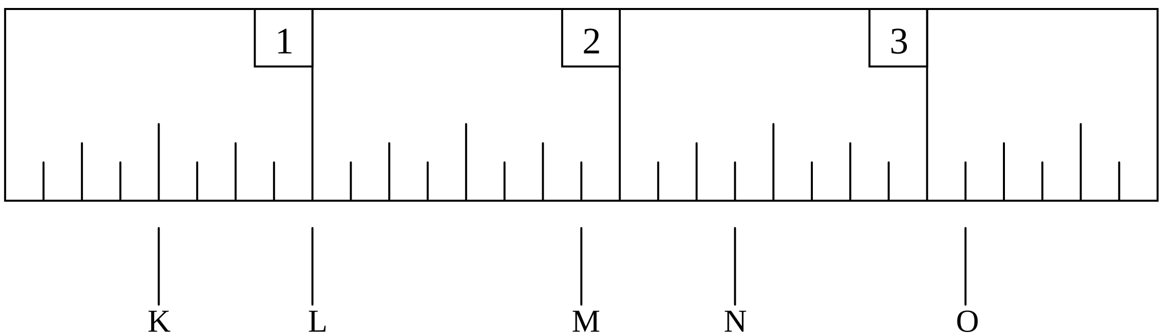
1/8th INCH SCALE



← 1 5/8" →

MEASURING WITH A RULER, WORKSHEET





Write down the measurements for the location at each letter.

1. A=_________	6. F=_________	11. K=_________
2. B=_________	7. G=_________	12. L=_________
3. C=_________	8. H=_________	13. M=_________
4. D=_________	9. I=_________	14. N=_________
5. E=_________	10. J=_________	15. O=_________

Measure lines 16 through 20 to the nearest 1/16th and record the results.

16. 16=_________

17. 17=_________

18. 18=_________

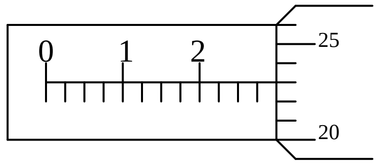
19. 19=_________

20. 20=_________

READING THE MICROMETER

Picture shows only the sleeve and part of the thimble
Measure to the nearest one thousandth.

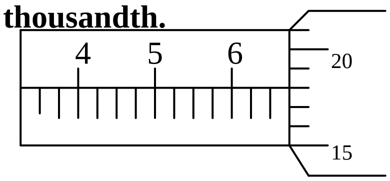
Example A
0 – 1 inch micrometer



Sleeve Reading:	0.200 inch
	0.025 inch
	0.025 inch
	0.025 inch
Thimble Reading:	<u>0.023 inch</u>
Total Reading:	0.497 inch

Measure to the nearest one thousandth.

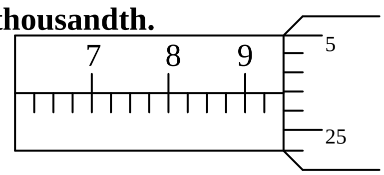
Example B
1 – 2 inch micrometer



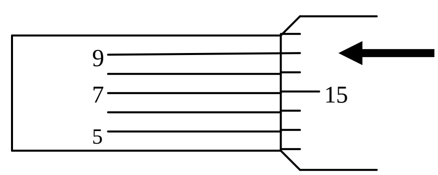
1 – 2 inch micrometer =	1.000 inch
Sleeve Reading:	0.600 inch
	0.025 inch
	0.025 inch
Thimble Reading:	<u>0.018 inch</u>
Total Reading:	1.668 inches

Measure to the nearest <u>ten</u> thousandth.

Example C
2 – 3 inch micrometer



Top View, Vernier Scale

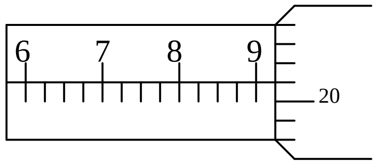


2 – 3 inch micrometer:	2.0000 inch
Sleeve Reading:	0.9000 inch
	0.0250 inch
	0.0250 inch
Thimble Reading:	0.0010 inch
Vernier scale:	<u>0.0009 inch</u>
Total Reading:	2.9519 inches

MICROMETER WORKSHEET

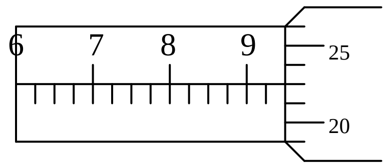
Fill in the correct measurement in the blank.
Measure to the nearest one thousandth.

0 – 1 inch



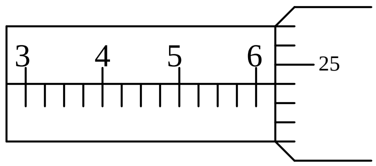
1. __________

0 – 1 inch



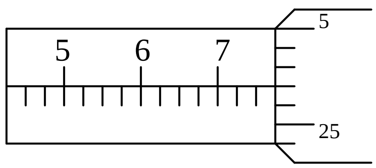
2. __________

1 – 2 inch



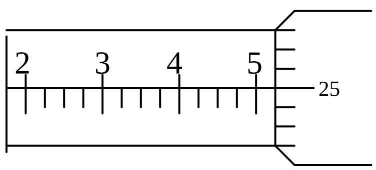
3. __________

1 – 2 inch



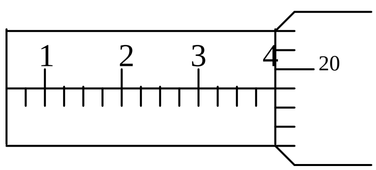
4. __________

0 – 1 inch



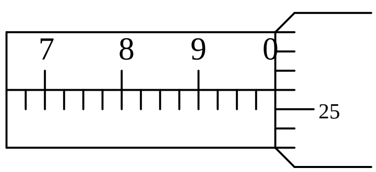
5. __________

2 – 3 inch



6. __________

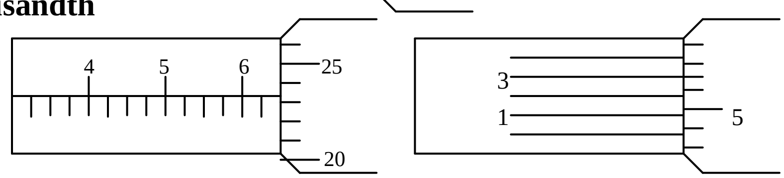
0 – 1 inch



7. __________

Ten Thousandth

2 – 3 inch



8. __________

WORKSHEET, VOLUMES AND AREAS

Calculate the area of squares, rectangles and triangles.

1. Calculate the perimeter and area of a 6" x 6" square.
   P = 2 ~~x~~ length + 2 ~~x~~ width
   A = length ~~x~~ width

2. Calculate the perimeter and area of a 3" x 8" rectangle.
   (use the formulas in the question above)

3. Calculate the area of a triangle, with a 4' base and 5' high.
   A = ½ ~~x~~ (base ~~x~~ height)

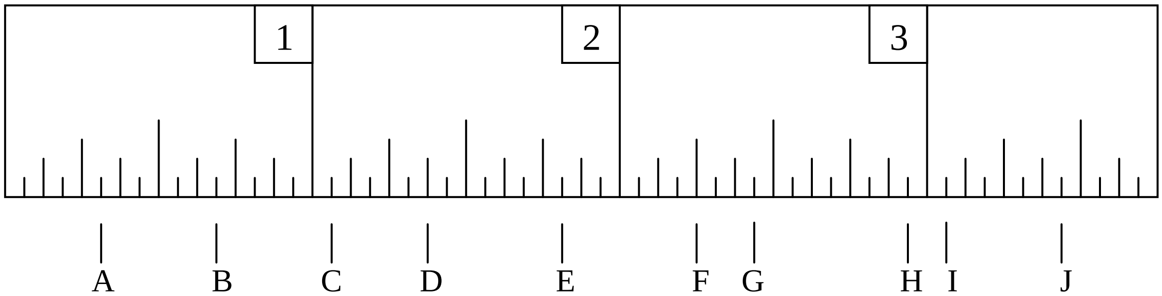
Calculate the area of a circle and cylinder.

4. Calculate the perimeter and area of a 12" diameter circle.
   Perimeter = π x D
   Area = π x R^2

5. Calculate the perimeter and area of a 3"circle.
   Perimeter = π x D
   Area = π x R^2

6. Calculate the area of a 4" diameter 7" deep cylinder
   Area of a circle = π x R^2
   Area of a cylinder = π x R^2 x height

MEASURING EXAM, RULES AND MICROMETERS

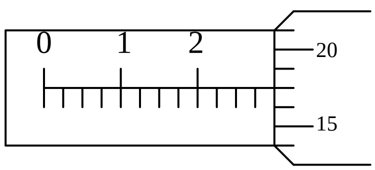


Write down the measurements for the location at each letter

1. A=_______
2. B=_______
3. C=_______
4. D=_______
5. E=_______
6. F=_______
7. G=_______
8. H=_______
9. I=_______
10. J=_______

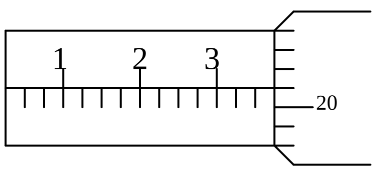
Write down the measurement to the nearest <u>one</u> thousandth.

11. 0 –1 inch



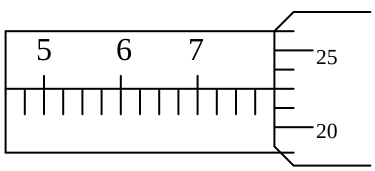
11.___________

12. 2 –3 inch



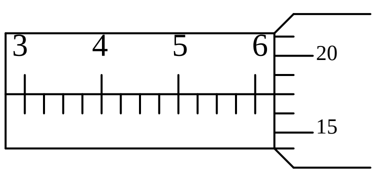
12.___________

13. 1 –2 inch



13.___________

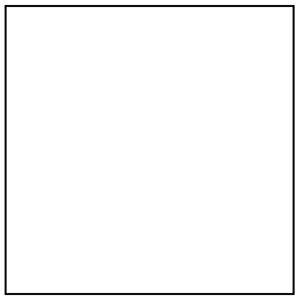
14. 1 –2 inch

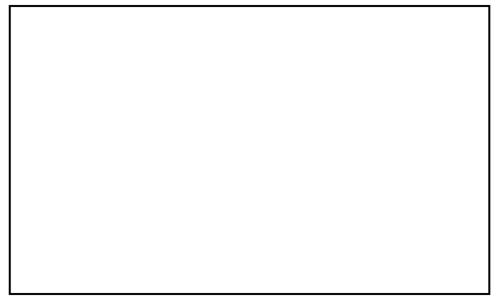


14.___________

VOLUME AND AREA

Using your ruler, measure the distance around these boxes and calculate the perimeter and area. P= 2 ~~x~~ length + 2 x width   A= length ~~x~~ width

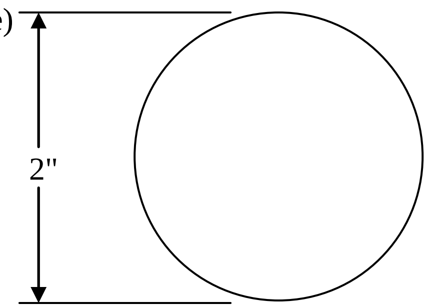
15. 

16. 

Perimeter = ________________   Perimeter = __________________

Area in Square inches = _____   Area in Square inches = _______

Calculate the area of a circle. (circle is not to scale)



17. Area in square inches. = ____________
    Formula: $\pi \cancel{x} R^2$

18. Calculate the area of a cylinder, 2 ½" diameter and 3" high.
    Formula: $\pi \cancel{x} R^2 \cancel{x}$ height

ANSWER SHEET

Worksheet, Ruler

1. 3/8"
2. 13/16"
3. 1"
4. 1, 5/16"
5. 1, 7/8"
6. 2, 3/16"
7. 2, 7/16"
8. 2, 13/16"
9. 3, 1/16"
10. 3, 1/2"
11. 1/2"
12. 1"
13. 1, 7/8"
14. 2, 3/8"
15. 3, 1/8"
16. 4, 1/8"
17. 1, 15/16"
18. 2, 5/8"
19. 1"
20. 3, 5/8"

Worksheet, Micrometer

1. 0.921
2. 0.948
3. 1. 624
4. 1.777
5. 0.525
6. 2.394
7. 1.001
8. 2.6483

Worksheet, Volume

1. 24" and 36in^2
2. 22" and 24in^2
3. 10ft^2
4. 37.7" and 113in^2
5. 9.42" and 28.3in^3
6. 351in^3

Measuring Exam

1. 5/16"
2. 11/16"
3. 1, 1/16"
4. 1, 3/8"
5. 1, 13/16"
6. 2, 1/4"
7. 2, 7/16"
8. 2, 15/16"
9. 3, 1/16"
10. 3, 7/16"
11. 0.287
12. 2.371
13. 1.797
14. 1.617
15. 6" and 2 1/2in^2
16. 8" and 3 3/4in^2
17. 3.14in^2
18. 14.71in^2

ADDING ENGLISH MEASUREMENTS WORKSHEET

Name_________________

1. 1/32+1/32=___________
2. 1/16+1/16=___________
3. 1/8+1/8=___________
4. 1/4+1/4=___________
5. 1/2+1/2=___________
6. 3/32+1/16=___________
7. 7/16+3/8=___________
8. 5/8+1/4=___________
9. 3/4+1/2=___________
10. 2 3/16+3 5/16=___________
11. 3 7/8+1 5/8=___________
12. 1 ½+1 1/8=___________
13. 2 ¼+3 1/16=___________
14. 3 1/8+2 1/16=___________
15. 2 3/8+1 1/8=___________

Word Problems:

16. If the following cuts are to be made from one stick of flat stock what will the overall length of the material need to be before cutting? (ignore kerf losses)

-25 ¼"
-14 1/8"
-3 9/16"

17. The inside diameter of a pipe is 4 3/32" the wall thickness is 5/32" what is the outside diameter of the pipe?

18. What length of material would be needed to make a rectangular frame that measures 18 ½" x 36 ¾"?

SUBTRACTING ENGLISH MEASUREMENTS WORKSHEET

Name________________

1. 3/32-1/32=__________

2. 5/16-1/16=__________

3. 3/8-1/8=__________

4. 3/4-1/4=__________

5. 3/4-1/2=__________

6. 5/32-1/16=__________

7. 9/16-1/8=__________

8. 7/8-1/4=__________

9. 1/2-1/4=__________

10. 2 3/32-5/16=__________

11. 5 1/16-2 1/8=__________

12. 3 5/8-2 1/4=__________

13. 3 3/4-1 1/2=__________

14. 3 1/2-1 1/2=__________

15. 3 7/8-1 15/16=__________

Word Problems:

16. If 18 7/8" are cut from a piece of pipe that was 24" long how much of the pipe is left? (Ignore kerf loss)

17. Assume that the saw used to cut the pipe in the above problem has a 1/16" kerf. What is the length of the pipe now.

18. How much clearance will there be between a piece of 1" square tubing that slides into a piece of 1 1/2" tubing that has 3/16" walls.

MULTIPLYING ENGLISH MEASUREMENTS WORKSHEET

Name________________

1. 1/32*2=__________

2. 1/16*2=__________

3. 1/8*2=__________

4. 1/4*2=__________

5. 1/2*2=__________

6. 1 1/32*2=__________

7. 1 1/16*2=__________

8. 1 1/8*2=__________

9. 1 1/4*2=__________

10. 1 1/2*2=__________

11. 1 5/8 *3=__________

12. 2 9/16*4=__________

13. 6 1/4*5=__________

14. 5 3/8*2=__________

15. 2 3/32*5=__________

Word problems:

16. How long would a piece of square tubing have to be to be able to cut three pieces that measured 18 ¾" each? (ignore kerf loss)

17. What is the area of a square frame that measures 16 3/8" on the inside?

18. If a piece of 1 ½" square tubing has 3/16" walls what is the inside dimension of the tubing?

DIVIDING ENGLISH MEASUREMENTS WORKSHEET

Name_________________

1. 1/2 ÷2=___________

2. 1/4÷2=___________

3. 1/8÷2=___________

4. 1/16÷2=___________

5. 1/32÷2=___________

6. 3/4÷3=___________

7. 3/4÷2=___________

8. 7/8÷2=___________

9. 9/16÷2=___________

10. 3/8÷2=___________

11. 12 3/4÷3=___________

12. 16 1/2÷2=___________

13. 24 9/16÷3=___________

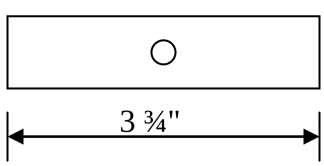
14. 25 1/2÷2=___________

15. 20 3/4÷4=___________

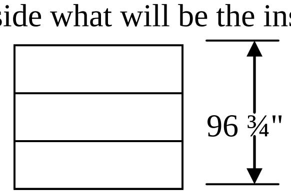
Word Problems

16. How many 5 1/4" pieces can be cut from a 30" long piece of angle iron?

17. A hole needs to be drilled in the center of a piece of channel iron that is 3 ¾" long. How far from the end of the piece should it be center punched for the hole?



18. Two cross members are to be welded into a square frame that measures 96 3/4" on the inside what will be the inside to inside distance between the cross members?



ADDING ENGLISH MEASUREMENTS WORKSHEET

Name KEY____________

1. 1/32+1/32=1/16______

2. 1/16+1/16=1/8_______

3. 1/8+1/8=1/4_______

4. 1/4+1/4=1/2_______

5. 1/2+1/2=1_________

6. 3/32+1/16=5/32______

7. 7/16+3/8=13/16_____

8. 5/8+1/4=7/8_______

9. 3/4+1/2=1 1/4_____

10. 2 3/16+3 5/16=5 1/2_____

11. 3 7/8+1 5/8=5 1/2_____

12. 1 ½+1 1/8=2 5/8____

13. 2 ¼+3 1/16=5 5/16____

14. 3 1/8+2 1/16=5 3/16____

15. 2 3/8+1 1/8=3 1/2_____

Word Problems:

16. If the following cuts are to be made from one stick of flat stock what will the overall length of the material need to be before cutting? (ignore kerf losses)

-25 ¼"
-14 1/8"   42 5/16"
-3 9/16"

17. The inside diameter of a pipe is 4 3/32" the wall thickness is 5/32" what is the outside diameter of the pipe?

4 13/32"

18. What length of material would be needed to make a rectangular frame that measures 18 ½" x 36 ¾"?

110 ½"

SUBTRACTING ENGLISH MEASUREMENTS WORKSHEET

Name KEY___________

1. 3/32-1/32=1/16______

2. 5/16-1/16=1/4_______

3. 3/8-1/8=1/4_______

4. 3/4-1/4=1/2_______

5. 3/4-1/2=1/4______

6. 5/32-1/16=3/32______

7. 9/16-1/8=7/16______

8. 7/8-1/4=5/8_______

9. 1/2-1/4=1/4_______

10. 2 3/32-5/16=1 25/32___

11. 5 1/16-2 1/8=2 15/16___

12. 3 5/8-2 1/4=1 3/8_____

13. 3 3/4-1 1/2=2 1/4_____

14. 3 1/2-1 1/2=2_________

15. 3 7/8-1 15/16=1 15/16___

Word Problems:

16. If 18 7/8" are cut from a piece of pipe that was 24" long how much of the pipe is left? (Ignore kerf loss)

5 1/8"

17. Assume that the saw used to cut the pipe in the above problem has a 1/16" kerf. What is the length of the pipe now.

5 1/16"

18. How much clearance will there be between a piece of 1" square tubing that slides into a piece of 1 1/2" tubing that has 3/16" walls.

1/8"

MULTIPLYING ENGLISH MEASUREMENTS WORKSHEET

Name KEY____________

1. 1/32*2=1/16______

2. 1/16*2=1/8_______

3. 1/8*2=1/4_______

4. 1/4*2=1/2_______

5. 1/2*2=1_________

6. 1 1/32*2=2 1/16____

7. 1 1/16*2=2 1/8_____

8. 1 1/8*2=2 1/4_____

9. 1 1/4*2=2 1/2_____

10. 1 1/2*2=3_________

11. 1 5/8 *3=4 1/4_____

12. 2 9/16*4=10 1/4____

13. 6 1/4*5=31 1/4____

14. 5 3/8*2=10 3/4____

15. 2 3/32*5=10 15/32__

Word problems:

16. How long would a piece of square tubing have to be to be able to cut three pieces that measured 18 ¾" each? (ignore kerf loss)

56 ¼"

17. What is the area of a square frame that measures 16 1/2" on the inside?

272 ¼ square inches

18. If a piece of 1 ½" square tubing has 3/16" walls what is the inside dimension of the tubing?

1 1/8"

DIVIDING ENGLISH MEASUREMENTS WORKSHEET

Name KEY______________

1. 1/2 ÷2=1/4_______

2. 1/4÷2=1/8_______

3. 1/8÷2=1/16______

4. 1/16÷2=1/32______

5. 1/32÷2=1/64______

6. 3/4÷3=1/4_______

7. 3/4÷2=3/8_______

8. 7/8÷2=7/16______

9. 9/16÷2=9/32______

10. 3/8÷2=3/16______

11. 12 3/4÷3=4 1/4_____

12. 16 1/2÷2=8 1/4_____

13. 24 9/16÷3=8 3/16____

14. 25 1/2÷2=12 3/4____

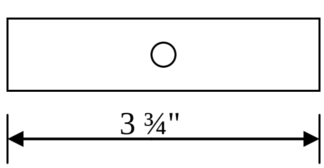
15. 20 3/4÷4=5 3/16____

Word Problems

16. How many 5 1/4" pieces can be cut from a 30" long piece of angle iron?

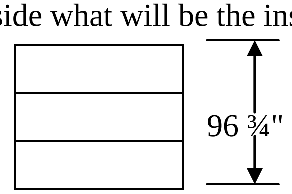
5 pieces

17. A hole needs to be drilled in the center of a piece of channel iron that is 3 ¾" long. How far from the end of the piece should it be center punched for the hole?



1 7/8"

18. Two cross members are to be welded into a square frame that measures 96 3/4" on the inside what will be the inside to inside distance between the cross members?



32 ¼"

SAFETY PRACTICES IN THE SHOP

240-G

UNIT OBJECTIVE

After completion of this unit, students will be able to identify the importance of safety in the scope the agricultural mechanics industry in the United States, Idaho, and the local community. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Recognize and report hazardous situations.
2. Develop a proper attitude toward use of safety glasses and coveralls.
3. Develop a proper attitude toward work and avoid unsafe practices.
4. Practice all shop and equipment safety regulations.
5. Use a fire extinguisher properly.
6. Make and keep a folder containing <u>Material Safety Data Sheets</u>.

SAFETY PRACTICES IN THE SHOP

A. Introduction:

The most frequent cause of injuries and accidents in agriculture comes from the use of tools and machinery. Forty-four percent of all agriculture-related injuries occur while using farm machinery. Most of these accidents and injuries can be prevented though the development of safe work habits. The school agricultural mechanics shop is a good place to develop these safe habits.

B. Setting Up a Safe Agricultural Mechanics Shop

1. Install all machinery according to the manufacturer's directions.
2. Provide proper storage for all tools, equipment, material, scraps, flammable liquids, chemicals, and waste materials.
3. Keep all tools and equipment fitted and adjusted properly.
4. Remove all damaged tools and equipment from the shop or to a place where they cannot be accidentally picked up and used.
5. Provide proper orientation and practice to anyone who is going to use a particular piece of equipment.
6. Keep all moving parts of machinery properly shielded.
7. Keep working areas free of clutter, grease, dirt, and un-needed tools.
8. Avoid placing or storing objects where they might fall. Mark any area where an object may fall.
9. Protect the eyes, face, hands, and body with protective clothing and gear.
10. List safety precautions for all equipment and tools. (See safety sheets on pages 240G-14 through 240G-35)

C. Color marking systems are used to help shop users be alert to danger or hazards, to help people locate certain objects, or to help people react quickly during an emergency.

1. Red is used to signify danger. Red tape or paint should be placed around all equipment or areas that are to be identified as items of danger or emergency.
2. Orange is used to mark off areas where machine hazards are likely. This color is designated to mark off a safe working distance or an area in the flight path of moving parts.
3. Yellow is the color used to designate caution. Yellow and black stripes are often used to mark stairs and other stationary objects where a hazard may occur.
4. Green indicates the presence of safety equipment, safety areas, or first aid kits.

5. Purple is used to signify radioactivity. This is not a problem in most agricultural mechanics shops, but some chemicals may be used where radioactive isotopes are present.
6. Gray is used to signify all work areas and usable machinery. Most shop floors are also painted gray because it is a restful color and it contrasts well with all other safety colors.
7. White, or white and black stripes are used to mark traffic pathways within the shop.
8. Blue is used as a background color if information is to be provided. Signs such as 'Out of Order' are written in white lettering on a blue background.

D. Protective clothing and gear can reduce the amount of injuries in the shop. Many accidents are caused by flying debris or contact with moving equipment. Thirty-six percent of all accidents in the shop occur to the arms and hands, ten percent occur to the head, and twenty-five percent of all injuries occur to the body. Proper use of protective clothing and gear can minimize or prevent these injuries.

1. Safety goggles or glasses should be worn in the shop at all times. They should be equipped with impact resistant lenses.

    a. Tinted eye protection must be worn when welding. Separate tints are required for arc and gas welding in order to prevent burns to the eyes.
    b. A face shield is required where flying debris is a problem. Grinders, planers, and power saws are examples of equipment that cause flying debris.

2. Headgear is used to restrain long hair and protect the head from falling objects. Woolen hats, headbands, and hairnets are acceptable to prevent long hair from coming in contact with moving parts, chemicals, or an open flame. Hard hats are required when falling objects may be a hazard.
3. Protective clothing is used to keep the body safe from injuries. Such clothing should fit properly and have no loose cuffs, strings, or ties that may get caught in machinery. The clothing should also be fire resistant and be tough enough to protect the body from scrapes and abrasions. Several types of protective clothing are available.

a. Coveralls are very popular because they cover the entire body as well as the legs and arms. Pockets are also an advantage of coveralls. Care should be taken to prevent any loose strings or cuffs on the coveralls. All buttons and zippers should have a protective flap and care should be taken to prevent ripped pockets from getting caught in moving machinery.
b. Aprons are often used to protect the body while welding. The leather apron prevents sparks from reaching the body. The disadvantage of aprons is that they require a string to tie them on, which is a hazard when working around moving parts. Aprons protect the body well, but do not provide protection to the arms and legs.
c. Shop coats are a good medium between coveralls and aprons. They protect both the body and arms and still have pockets to hold small tools. Zippers and buttons should have a protective flap to prevent electric shock or catching in moving parts. The shop coat is also the easiest body protection to put on and is often cheaper than coveralls.

4. Proper footwear is also important when working in the shop. Open toed footwear must NEVER be worn in the shop. Leather shoes with steel reinforced toes provide excellent protection. Leather is fire resistant and tough enough to resist the impact of many falling objects.

   a. Rubber boots are required when working in water or when using pesticides. These boots are also ideal when doing concrete work due to their resistance to water and the ease with which they can be cleaned.

5. Gloves can be both protective devices and safety hazards in the shop. Gloves are used to keep the hands warm and to protect them from abrasion, heat, and chemicals. Gloves are excellent protection when using tools that emit flying debris, such as grinders and chainsaws. Caution should be taken when wearing gloves around moving parts. Gloves can easily be pulled into the machines and serious injury can result. It is not advisable to wear gloves where the hands will come in close contact with the moving parts of a machine.
6. Ear plugs or earmuffs are ideal when working around noisy machinery. Some machines, such as planers, emit a very high pitched sound that can damage the inner ear if protection is not worn.
7. Masks and respirators should be worn when using machines that produce large amounts of dust. Application of chemicals also requires the use of a respirator.

E. Uncontrolled fires in an agricultural mechanics shop can spread very rapidly, causing death, serious injury, and the destruction of property and equipment.

Since all shops contain flammable materials, students should be informed of the causes of fires, methods of preventing fires, and the extinguishing of fires, as well as emergency procedures when a fire occurs.

1. Causes of Fires in the Shop

   a. Fire occurs only when three factors are combined. These are fuel, oxygen, and heat. The absence of any one of these factors will prevent a fire.

      1) Fuel consists of any combustible material. Any common material in the shop from old rags to grease and oil can act as the combustible. All combustible materials must be properly stored to prevent the dangers of fire.
      2) Heat is required to ignite the combustible. Heat can be provided from many sources in the shop including open flames, electric sparks, or high friction heat.
      3) Oxygen must be present in order for fuels to burn. The absence of oxygen will prevent a fire or put one out. Storing combustibles in airtight conditions will prevent fires. Care must be taken when using airtight combustible containers to avoid the buildup of high pressure. A puncture to the container with all three factors present can cause a serious explosion.

2. Preventing Fires in the Shop

   a. Familiarizing oneself with the factors involved in starting a fire can help lead to better prevention. The absence of any one of the factors described above will prevent a fire from starting, or put one out if it has already started. There are many safety precautions that can be taken in the shop to prevent the combination of fuel, heat, and oxygen.

      1) Store fuels only in approved containers. These containers should be made of metal and ideally equipped with doors that seal automatically in the presence of fire.
      2) Store fuels in a separate area from other flammable materials such as wood and paper.

      3) Keep the shop environment at a cool temperature with all areas being well below the combustion temperature of all materials. Most chemicals and liquid fuels will

have data which label the combustion temperature and safe storage temperature range.

4) Use fires only in areas that are designated safe for that purpose. (Forge, cutting torch, etc.)

3. Extinguishing Fires in the Shop

a. Fires are extinguished by removing any one of the three factors listed above. Different types of fires require different methods to extinguish them. Fires are categorized according to the type of fuel they burn. These classes of fires must be known in order to correctly extinguish all types of fires in the shop.

1) Class A fires are termed as ordinary combustibles. These fires burn fuels such as wood, paper, and trash; they do not involve any liquid fuel or electricity. Such fires can easily be contained by smothering them, using water to cool them, or by removing the unburned fuel and letting the fire burn itself out.
2) Class B fires are those that utilize flammable liquids for fuel. These fires are more difficult to extinguish and can be much more dangerous than class A fires.
3) Class C fires involve electrical equipment. This type of fire not only has the risk of burning and smoke inhalation, but also of electrocution.
4) Class D fires involve combustible metals. Very few metals will burn. Burning metals are very difficult to put out and require a Class D fire extinguisher in order to quench them.

b. The fire classifications are based on how cheaply and easily the fires can be extinguished. Class A fires can be extinguished safely using water. Water is the cheapest and easiest fire retardant to apply. In some situations, such as in electrical fires, water is not safe to use due to the chance of electrocution.

c. Fire extinguishers vary as do the types of fires. Each fire extinguisher is labeled with the types of fires it can put out. Symbols are used to indicate each type of fire extinguisher.

1) The green triangle is used to designate fire extinguishers that can put out ordinary combustible fires.
2) A red square is designates Class B fires which involve flammable liquids.

3) Electrical equipment fires can be extinguished with a fire extinguisher labeled with a C surrounded by a blue circle.
4) Combustible metal fires are extinguished by a fire extinguisher that has a yellow star symbol with a D in the center.

d. Fire extinguishers have a variety of different ingredients, depending on their capabilities.

1) Extinguishers containing water that are powered by pump or gas pressure can be used on Class A fires only.
2) Carbon dioxide gas extinguishers are useful on both Class B and Class C fires.
3) Dry chemical extinguishers can be used on Class A, B, and C fires.
4) Fire extinguishers that emit foam are to be used on Class A and Class B fires only.
5) Class D fire extinguishers contain special chemicals that can extinguish combustible metal fires.

e. Fire extinguishers should not be used on humans and animals unless absolutely necessary. A blanket is used to smother fires on humans and animals.
f. Using a fire extinguisher involves three easy steps.

1) Locate the fire extinguisher and remove it from its holder. Hold the fire extinguisher upright and pull the ring pin.
2) Start back ten feet from the flames and aim the nozzle at the BASE of the fire.
3) Squeeze the lever and sweep the nozzle in a side-to-side motion across the base of the fire.

g. Shop students should have a lesson on the types of fires, the capabilities of the fire extinguishers in the shop, the location of the fire extinguishers, and the methods of using them.
h. Each fire extinguisher should be checked at least once a month to assure that it will be usable in case of an emergency.

F. Regardless of the safety precautions taken by the instructor, accidents continue to occur in the shop. Most of these accidents can be prevented if each student develops safe working habits. Many simple shop rules can lead toward the development of a sense of the importance of safe shop procedures.

1. Discourage horseplay in the shop. Shop work requires the undivided attention of the worker if a task is to be performed safely for everyone in the shop. 'Playing around' distracts from this safe attention.
2. Have students report any hazard to the instructor immediately. Many accidents occur because students believe that the instructor already knows about a hazard.
3. Have each student read the safety signs on equipment before using it and warning labels on all chemicals or materials to be used.
4. Have a safety orientation with the students regarding the placement of safety equipment, the school's safety procedures and each student's responsibility in the event of an accident.
5. Enforce all shop safety regulations at all times. Leniency often leads to ignorance of the rules when it comes to shop safety.

G. Safety Signs

1. Post safety signs on each piece of equipment and at the storage area for portable tools. (Signs are provided in this chapter)
2. Students will understand all safety procedures on the signs before using the equipment.
3. Students will follow all the safety rules posted on the signs while using the equipment.

H. Material Safety Data Sheets (MSD)

1. Idaho schools with the Resource Conservation and Recovery Act, the Idaho Hazardous Waste Management Act, and other federal and state laws, rules and regulations which pertain to inventory, use and disposal of hazardous materials and hazardous waists.
2. In complying with this law, Ag Departments are required to keep a MSD sheet on any hazardous material including; used oil, paint thinner, etc.
3. Check with your local school district, each district might have a different policy.

ACTIVITY:

1. Conduct a shop safety tour with the class.
2. Use slides, videos, and films to illustrate the importance of shop safety.
3. Conduct practice emergency drills to assess student performance in case of an accident.

4. Have students sign written contracts wherein they agree to abide by all the safety procedures; posted or un-posted rules, in the shop. (Page 240G-13)
5. Photo copy and post safety signs (Pages 240G-14 through 240G-35) on shop equipment.

References:

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Phipps, Lloyd J., and Miller, Glen M.(1998) AGRISCIENCE MECHANICS. Danville, IL: Interstate Publishing

Burke, Stanley R., and Wakeman, T. J. (1990) MODERN AGRICULTURAL MECHANICS, 2ed EDITION. Danville, IL: Interstate Publishing

Resources:

UTAH SAFETY COUNCIL
5263 SOUTH 300 WEST, SUITE 201
SALT LAKE CITY, UTAH 84107
1-800-933-5943

University of Idaho, Environmental & Health Safety
1-888-884-3246 ext. 6524

Special Materials and Equipment:

Fire extinguisher; layout of the shop, including safety exits; videos and films on safety practices in the shop.

Name________________________
Date__________________________

1. What area of agriculture sees the greatest number of injuries and accidents?

2. What precautions can be taken to prevent accidents in the agricultural mechanics shop?

3. List and describe at least two building requirements that assure a safe agricultural mechanics shop.

4. Color coding is used in the shop to:

    a. make tools easier to find
    b. add color to an otherwise dull shop
    c. alert people to dangers and hazards
    d. all of the above

5. Which color is used to signify danger?

    a. Red
    b. Gray
    c. Blue
    d. Brown

6. Accidents among farmworkers most often involve:

    a. burns
    b. machinery
    c. drowning
    d. falls

7. Flammable liquids and dirty rags must be disposed of by:

    a. throwing them in the trash
    b. flushing them down the drain
    c. burning them in a safe area outside of the shop
    d. placing them in special metal containers that close in the presence of fire

8. Lumber and metal material should be stored:

   a. in a storage closet
   b. in vertical racks
   c. in any available corner of the shop
   d. in the overhead rafters

9. Tools are silhouetted in the tool cabinet in order to:

   a. make tools easier to locate
   b. easily identify missing tools
   c. allow the tool cabinet to be neatly organized every time the tools are returned
   d. all of the above

10. Which of the following can be used to extinguish a fire?

   a. Fuel
   b. Oxygen
   c. Water
   d. Heat

11. List and describe the four types of fires. What are the symbols and colors that designate each type?

12. Which of the following is classified as protective clothing?

   a. Coveralls
   b. Apron
   c. Lab coat
   d. All of the above

13. List the three steps involved in using a fire extinguisher.

14. What type of fire will a fire extinguisher containing water be useful on?

   a. Class A
   b. Class B
   c. Class C

d. All of the above

ANSWER SHEET

1. The use of tools and machinery.
2. Development of safe work habits.
3. Any thing listed in Section B of this unit.
4. C
5. A
6. B
7. D
8. B
9. D
10. C
11. Class A – Green triangle
    Class B – Red square
    Class C – C surrounded by a blue circle
    Class D – Yellow star with a D in the center
12. D
13. 1) Locate the fire extinguisher and remove it from its holder. Hold the fire extinguisher upright and pull the ring pin.
    2) Start back ten feet from the flames and aim the nozzle at the BASE of the fire.
    3) Squeeze the lever and sweep the nozzle in a side-to-side motion across the base of the fire.
14. Class A

SAFETY CONTRACT

1. I understand that eye protection needs to be worn correctly in the shop at all times without exception.

2. I will follow all safety procedures at all times without exception.

3. I understand that loose clothing, loose jewelry, including rings of any kind, long hair (not in a ponytail), and neckties (not protected by coveralls) can be dangerous in the shop and should not be worn.

4. I understand that Safety Signs are to be understood before using the equipment and the safety procedures are to be followed during its' use.

5. I understand that protective clothing is an important part of shop safety and that clean coveralls and leather boots should be worn at all times (especially in welding and agricultural fabrication).

6. I understand that horseplay in never allowed in the shop and can cause serious injury to myself and to other students around me.

7. I will report all accidents, no matter how minor.

8. I understand that cleaning the shop at the end of each class period is an important part of shop safety and I will participate at the end of every class or whenever it is needed.

9. I understand that running is never allowed in the shop at any time.

10. I understand that all tools and equipment, welding electrodes, steel, wood, and grease rags are to be stored properly.

Failure to comply with this safety contract can and will result in detentions, parent-teacher conferences, and/or expulsion from this class and any other shop class you are currently in and you will be kept out of any other shop classes in the future for safety and liability reasons.

Parent's Signature___________________ Student's Signature ______________________

Instructor's Signature ______________________

Date ______________________

ACETYLENE WELDER

Do not operate this machine until you have received instructions on its proper use and you understand all items on this sign.

1. Use proper shade lenses - shade 5 to 7

2. Assume that all metal is <u>Hot</u> in this area

3. Always chain cylinders to cart, bench, or walls

4. Keep oil and grease away from oxygen cylinders and equipment. Oil or grease burns violently in the presence of oxygen.

5. Test connection for leaks frequently with soap and water

6. Keep area clear of combustible materials

7. Stand on one side of gauges when opening cylinder values

8. Never use a match to light the torch

9. Do not walk with a lighted torch or lay down a lighted torch. An unattended lighted torch may cause burns.

10. Never open acetylene valve more than 1 to 1 ½ turns and leave the shut-off wrench in position at all times in case the tank must be turned off quickly

11. Welding or cutting galvanized metal will produce poisonous fumes

12. Before welding a container that may have held a flammable material, it should be steam cleaned and filled with water

ARC WELDER

Do not operate this machine until you have received instructions on its proper use and you understand all items on this sign.

1. Use proper shade lenses – shade 10 to 12

2. Wear protective clothing

3. Assume that all metal in the area is <u>Hot</u> until you have tested it

4. There is a possibility of being shocked if you are wet, standing on wet floors, or if the welder has loose connections

5. Make sure the welding area is free of combustible material

6. Make sure exhaust fan is running before starting to weld

7. Welding galvanized metal or surfaces painted with lead base paints produces poisonous fumes

8. Warn persons nearby before striking arc

10. Before welding containers which may have held combustible materials, steam clean them and fill with water

11. Wear eye protection while chipping

12. Do not throw electrode stubs on floor because of slipping hazard

STATIONARY BELT SANDER

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection

2. Use the lower half of the wheel

3. Do not use the machine if part of the belt is worn away. This will damage the rubber wheel.

4. Use pliers or vise grips for holding small stock

5. Do not use too much pressure. Pushing too hard on the wheel may cause you to lose your balance and fall toward the wheel.

6. Do not talk to anyone while operating this machine

PORTABLE CIRCULAR SAW

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection

2. Use only sharp blades

3. Always check location of power cord before starting the cut so cord is not in blade path

4. Make sure you have good footing and are well balanced

5. Use both hands on the saw

6. Clamp small pieces. Do not attempt to hold them with one hand and saw with the other.

7. Make sure guard is in proper place before laying the saw down after a cut

8. Make sure saw is unplugged before changing blades or making adjustments

9. Make sure blade guard is in good operating condition

10. Be sure ports are open to avoid overheating motor

11. Never try to support a piece of lumber with your leg or knee while sawing. Leg cuts are a common injury.

METAL CUT-OFF WHEEL

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection

2. Make sure stock is securely clamped in vise

3. Maintain enough pressure so as to cut rapidly, but not so much as to stop the machine

4. Keep hands away from wheel

5. Do not attempt to catch metal which is being cut off. The metal will be hot.

6. Do not attempt to cut more than one piece of metal at a time

7. Check disc of damage before each use

DRILL PRESS

Do not operate this machine until you have received instructions on its proper use and you understand all items on this sign.

1. Wear eye protection

2. Use sharp drill bits only

3. Clamp your work - loose metal can cause serious injury

4. Remove chuck key before drilling

5. Place work on wood to prevent damage to table

6. Use proper speed: Slow speeds for large drills
   Fast speeds for small drills

Drilling speeds for steel in revolutions per minute

Drill Diameter	**Carbon steel drill**	**High speed drill**
1/4	458	917
1/2	229	458
3/4	153	306

7. Place long end of piece being drilled to your left so that if it happens to slip, it will not strike operator

8. Do not wear gloves, loose fitting clothing or jewelry

9. Never grab metal spirals - they may cause serious cuts

10. Do not allow anyone around you while drilling

11. If you have long hair, wear a hat or tie the hair back
12. Use slower feed when breaking through material

FLOOR SHEAR

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Never get hands close to cutting edges
2. Be cautious about sharp edges on metal after it is sheared
3. Do not leave the handle of the shear in the down position. This will cause tripping.
4. Do not cut more than one thickness of metal at a time.
5. Do not cut metal which is too heavy for the shear. This shear is designed to cut metal no more than _________ inches thick.
6. Do not cut hardened steel such as car spring
7. Shear blades should make close contact with each other through the duration of the cut

FORGE

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection

2. When lighting the forge, turn on the gas first, then the air

3. When turning off the forge, shut off the gas first, then the air

4. When the forge is not in use, use a gate valve ahead of the electric valve to shut off the gas

5. Assume that all metal is <u>Hot</u> in this area until you have tested it

6. Make sure tongs fit the work piece securely

7. Be sure hammer handles are in good shape and securely fastened to hammer heads

8. Do not strike the face of an anvil with a hammer. This can cause serious injury from flying chips of metal from the hammer.

9. When using a hot cutter or hardie, make sure everyone in the area knows you are cutting metal and the metal may fly.

BENCH GRINDER

Do not operate this machine until you have received instructions on its proper use and you understand all items on this sign.

1. Wear eye protection

2. Tool rests should be as close as possible to grinding stones without touching them

3. After installing a new wheel, stand to one side and let the grinder run a full minute before using it

4. Do not grind on the side of the wheel. Side pressure may cause the wheel to break.

5. Keep fingers away from wheel. Use pliers for holding small pieces.

6. Keep stones dressed and trued. A shiny surface indicates a dull wheel. Vibration indicates out-of-roundness.

7. Do not use a stone that is worn down to ½ of its original diameter

HYDRAULIC JACK

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Make sure the jack is capable of lifting the load

2. Check lift points carefully to avoid damage to the item being lifted and to the jack

3. When working under lifted objects, support the objects with jack stands and lower the jack. Never work under anything which is supported only by the jack.

4. Never leave an object supported only by a jack

HYDRAULIC PRESS

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection

2. Make all adjustments before pressure is applied to work

3. Do not attempt to hand hold the work

4. Make sure everyone in the area knows you are using the press and that there is danger from flying metal

5. Stand behind the end of the press to avoid flying metal

6. Stop periodically to inspect the work to make sure everything is all right

7. Always remove pressure before leaving the area

8. Always use sufficient supports, clamps, or other devices to hold and support the work evenly

METAL LATHE

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection

2. Remove chuck key as soon as you finish loosening or tightening chuck. This habit will prevent the lathe from being turned on with the key still in the chuck.

3. Always revolve chuck by hand before turning on the power

4. Do not wear gloves, rings, or loose clothing

5. Always roll up sleeves

6. Keep cutting tool away from stock until machine is turned on

7. Always check automatic feed to determine its direction before starting a cut

8. Never reach over the rotating chuck

9. Do not touch revolving work or attempt to pull off cuttings

10. Do not attempt to change gears while lathe is running

11. Do not lean against machine

MIG WELDER

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear dry gloves and coveralls while operating this machine. More splatter or molten metal will be experienced than with ordinary arc welders.

2. Electrode should be touched to work very lightly before starting to weld. Excess pressure may cause electrode to coil inside of cable.

3. Do not touch electrode to bare skin. Since electrode is not coated, it may cause shock.

4. Be sure gas is turned on before starting to weld

5. Do not lay the torch on the welder

6. Periodically clean the torch nozzle. Excess pile up of splatter can stop the electrode feed and cause it to coil up inside the cable.

7. Keep the cable as straight as possible while welding to prevent binding the electrode

8. Keep eyes shielded after the weld is completed. Small pieces of slag explode from the weld as it cools.

PORTABLE DRILLS

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection

2. Use only sharp drills

3. Avoid wearing loose clothing

4. Remove chuck key before drilling

5. Keep a firm grip on the drill. Be alert to the possibility of the bit catching and throwing you off balance.

6. Do not lock the switch in the “ON” position while the brill is being held with the hands

7. Use less pressure when breaking through the stock

8. Do not use bits larger than specified by the chuck size. This will cause overloading of the drill motor.

9. Be sure that stock being drilled is securely fastened before drilling

10. Use a center punch before starting to drill

11. Do not let drill bit spin in hole without cutting

PORTABLE DISC GRINDER

Do not operate this machine until you have received instructions on its proper use and you understand all items on this sign.

1. Wear eye protection

2. See that other workers are out of range or are wearing eye protection

3. Do not lay the grinder down until it comes to a complete stop

4. Make sure you are balanced and have good footing

5. Hold the grinder firmly with both hands at all times

6. Check the location of the power cord at all times to avoid cutting it

7. Check for cracked or glazed grinding wheels frequently

8. Use the left-hand portion of the disc so the particles will fly away from you

RADIAL ARM SAW

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection

2. Use only sharp blades

3. Keep the table clean

4. Do not wear gloves, rings, or loose clothing

5. Always use anti-kickback fingers while ripping

6. Do not stand with your face directly in line with the blade

7. Check rotation of blade before ripping. The board should be pushed in against the rotation of the blade.

8. For cross cutting, the blade rotates down from the operator and the saw is pulled forward slowly. Cutting too fast may cause the saw to climb the board or stall.

9. Adjust blade so that it will be about 1/16" below the surface of the table

STEAM CLEANER

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Make sure water is flowing through the cleaner before lighting the burner

2. Check electrical connections so that they will not get wet and cause shocks while the steam cleaner is being used

3. Hold the hose by the insulated handgrip and wear gloves to prevent burns

4. Make sure everyone in the area is aware that hot water and steam are being used

5. Be sure the safety blow-out plug is pointed toward the floor

6. Be sure to keep a constant supply of water flowing into the steam cleaner

7. Do not operate the cleaner unless water droplets are emitted with the steam

8. When shutting down, turn off the burner and leave water flowing until it is cool, then turn off water. Do not leave until it is completely shut down.

TABLE-TYPE BAND SAW

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Make sure stock is securely clamped in vise

2. If saw teeth wear off unusually fast, reduce the speed

3. Keep moving parts lubricated

4. Keep hands away from blade while cut is being made

5. Keep adjustable blade guides as close as possible to the stock

6. Keep proper tension on blade

7. Place metal in saw in the proper position. When sawing angle iron, place both legs down, when sawing rectangular stock, place the widest side toward the saw blade.

8. When cutting short metal, place another piece of metal of equal width in the opposite end of the vise jaws. This will provide good grip on the metal being cut.

9. Gently lower the blade when starting the cut

10. Do not press down on the saw while it is cutting

11. Do not leave saw unattended while it is running

TABLE SAW

Do not operate this machine until you have received instructions on its proper use and you understand all items on this sign.

1. Wear eye protection

2. Use only sharp blades

3. Keep table clean

4. Do not wear gloves, rings, or loose clothing

5. Always use the guard for cross cutting and ripping

6. Use the rip fence for ripping and the miter gauge for cross cutting. <u>Never</u> attempt to use the rip fence and the miter gauge at the same time.

7. The blade should be adjusted so that it protrudes no more than 1/4" above work

8. Never allow your fingers too close to the saw blade. Use a push stick.

9. Do not attempt to clear the table of scraps while the saw is running
10. Do not stand with your face directly in line with the saw blade
11. Make sure saw is disconnected from the power source while changing blades and making adjustments

TIG WELDER

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear dry gloves and coveralls while operating this machine

2. Touching the electrode to bare skin may cause shock

3. Be sure gas is turned on before starting to weld

4. On water cooled torches, keep a constant watch for leaks in the line. Wet cables or floors lead to shocks.

5. A 2% solution of silver nitrate will turn magnesium black and will not affect aluminum. Magnesium will burn if overheated. If a magnesium fire is experienced, discontinue the arc, but keep the inert gas directed on the flame until the fire is extinguished.

6. Do not turn off welder until the time delay switch has shut off the flow of gas

7. Do not lay the torch on the welder

8. Touching the electrode on the work piece, using too small a nozzle or insufficient gas pressure, or using too long an arc will cause black welds

9. Clean metal with a grinder or wire brush that is used for aluminum only

UPRIGHT BAND SAW

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Use only sharp blades

2. Do not wear gloves, rings, or loose clothing

3. Keep both hands on the same side of the blade while pushing work through the saw. This will prevent binding.

4. Do not allow fingers any closer than 2 inches from the blade. Keep hands to one side of the blade. Use a push stick.

5. Do not reach around and attempt to pull stock through the saw

6. Saw guide should be no more than ½" above stock being cut

7. Use vise grips to hold round stock. Round stock tends to twist and may break the blade or cause it to fly off.

POWER WIRE BRUSH

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection - wires from the wheel could lodge in your eye

2. Do not wear gloves, rings or loose-fitting clothing

3. Hold work at or below the center of the wheel. Any object caught by the wheel will then be thrown down.

4. Use pliers to hold small objects to be brushed

5. Do not use excessive pressure

Liability

AG 240-H

Unit objective

This unit is intended to be used by the instructor as a reference for liability issues that may be raised with fabrication projects.

Unit References:

Godfrey, Lex, Burley High School, Burley, ID

Lincoln Electric Company, *The Procedure Handbook of Arc Welding*, 1973

A. Who is liable if a project or weld fails.

1. Liability can be affected by a number of factors.

   a. If the project was sold for a profit the party receiving the profit would be the first to assume liability. Projects can be sold to cover all expenses including:

      1) Parts and materials expenses
      2) Expendable material expenses (welding rod, gas, etc.)
      3) Depreciation of equipment. Projects can be marked up beyond parts and materials to purchase new equipment.

2. If the project is not sold for a profit, the school, teacher, and student can still be liable. However, the liability is less than if the project were sold for a profit.

B. Reducing liability

1. Welding qualifications

   a. Prior to welding on a project students should be certified for the same welding processes and positions that will be used on the project.

   b. Certifications can be done by the teacher in the shop. You do not have to be a certified welding inspector to be able to qualify students for welding processes.

   c. By qualifying students you are saying that at the time the project was built the student was able to produce structurally sound welds.

   d. Liability is greatly reduced by qualifying students for welding processes.

2. Inspecting welds

   a. If the teacher inspects and passes the welds before the project leaves the shop, then the teacher is assuming all liability.

   b. If the welds have been inspected and passed with good knowledge and judgment then there is obviously very little chance that the project will fail.

   c. If the teacher does not inspect the welds he/she can still be held responsible for negligence.

2. Sell projects as is

    a. Have the buyer sign a form stating that he/she understands that there is no warranty on the project because it was purchased from a school shop at a substantially reduced price.

    b. It is the buyers responsibility to inspect the project.

    c. If it is written that the project is sold as is the buyer assumes all liability.

C. Welder Qualifications

1. Qualification for welding on material less than ¾" thick.

    a. A 60 ° V-groove weld must be done on two coupons that measure a minimum of 6 1/8" long (the length of the weld) x 5" wide and 3/8" thick

    b. The root opening must be ¼".

    c. A backing strip that measures at least 3/8" x 1" x length of weld must be used.

    d. When the weld cools the backing strip must be removed flush with the surface of the coupons. Grind the face of the weld flush with the welding coupons

        -Always grind lengthwise
        -Leave no indentations or irregular spots

    e. Cut (perpendicular to the weld) and discard one strip from each end leaving 3" in the center of the weld.

    f. From the remaining 3" cut two 1 ½" strips that are perpendicular to the weld.

    g. Round the edges of the strips to a 1/16" radius. This insures against failure caused by cracks starting at the sharp corner.

    h. Perform a root bend on each strip. The bend must be 180°.

    i. Inspect for cracks. The weld passes if any crack or other opening does not exceed 1/8". Cracks at corners are not considered.

2. Electrode and process specifications

a. The electrode used for the qualification procedure should be the same as will be used on the project.

b. Some electrodes will qualify welders to use other electrodes. American welding society codes give those specifications.

c. Qualification with a low-hydrogen (E7018) electrode qualifies a welder to use any electrode.

3. Position specifications

a. Welding position qualifications are as follows:

Test Position	Qualifications
Flat 1G	1G
Horizontal 2G	1G, 2G
Vertical 3G	1G, 2G, 3G
Overhead 4G	1G, 4G

If student qualify with a in the vertical position they are qualified to weld in all positions except overhead. They have to qualify separately for the overhead position. For welders to be qualified for all positions they must qualify in the vertical and overhead positions.

4. Metal specifications

a. The metal used for the qualification procedure should be of the same yield strength that will be used on the project. Qualification on some metals will qualify welders for other metals. Check American Welding Society codes for more information.

5. Welding certificate

a. Once a student has qualified a welding certificate should be filled out and filed. (see example and blank form in this section)

School Name
Address

Welding Certification (Sample)

The underlined information is to be filled in be the teacher.

Welder's Name Super Welder Soc. Sec. No. 111-11-1111
Welding Process SMAW Type Manual
In accordance with Welding Procedure Specification: Shop # that describes weld
Backing BAR Material Specification Metal # from metal book
Test plate thickness 3/8"
Thickness range to ¾" Diameter Range NA
Filler metal specification No. A5.1 # From rod box Class No. E7018
Other
Position 3G Vertical
Gas % Composition
Electrical Characteristics-Current DC Polarity Reverse
Weld Progression Uphand
Other

For Information Only

Filler Material Diameter and Trade Name 1/8" Lincoln
Gas Metal Arc Welding Shield Gas Trade Name

Guided Bend Test

Type	Figure No.	Results
Side	4.13	
Face	4.12	
Root	4.12	Satisfactory

Test conducted at High School Welding Shop
Laboratory test date

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of **ANSI/AWS D1.1-96**

Date:____
School Instructor

Note: This Performance Qualification Record is not to be used in lieu of an employers Performance Qualification Test. It is a formal statement of the ability of this individual on this date in a training situation only.

School Name
Address

Welding Certification

Welder's Name Soc. Sec. No.
Welding Process Type
In accordance with Welding Procedure Specification:
Backing Material Specification
Test plate thickness
Thickness range Diameter Range
Filler metal specification No. Class No.
Other
Position
Gas % Composition
Electrical Characteristics-Current Polarity
Weld Progression
Other

For Information Only
Filler Material Diameter and Trade Name
Gas Metal Arc Welding Shield Gas Trade Name

Guided Bend Test

Type	Figure No.	Results
Side	4.13	
Face	4.12	
Root	4.12	

Test conducted at
Laboratory test date

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of **ANSI/AWS D1.1-96**

Date:____
School Instructor

Note: This Performance Qualification Record is not to be used in lieu of an employers Performance Qualification Test. It is a formal statement of the ability of this individual on this date in a training situation only.

Tricks and Tips

AG 240-I

A. Finding the center of a circle.

1. Use dividers or a compass and spread them to approximately the same length as the radius of the circle.

2. Draw three arcs from different points around the circumference of the circle.

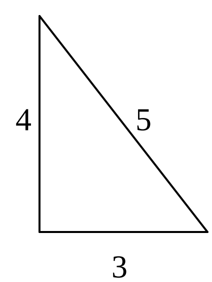
3. The point where the three arc intersect is the center of the circle.

B. Squaring with a 3, 4, 5, triangle.

1. A triangle that measures 3 x 4 x 5 is a right triangle.

2. These numbers can be in any unit inches, feet, yards, etc. Or they can all be multiplied by any number and used in the same way.

3. Measure from one corner and make a mark at 3 units. Measure the other direction and make a mark at 4 units. Then measure diagonally between the marks. When this measures 5 units the members are at 90°.



C. Transferring and Splitting angles

1. Use a sliding T bevel to obtain the necessary angle.

2. Draw a straight line on a piece of plywood or cardboard about ½" from one edge parallel with that edge.

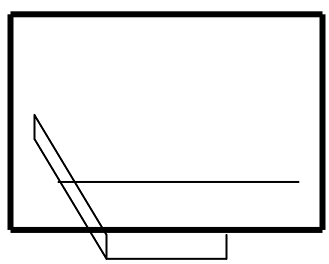
3. Transfer the angle from the sliding T bevel to the board. The angle should intersect the line drawn in step 2.

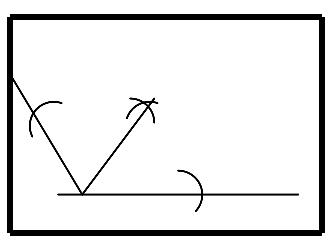
4. Spread a compass about 3" or 4" and place the point where the two lines of the original angle intersect. Place an arc on each line an equal distance from that point.

5. Spread the compass approximately another ½". Make an arc in the center of the angle with the point of the compass on each arc created in step 4.

6. Draw a line from the intersection of the arcs in step 5 to the intersection of the two lines in step 3.

7. The angle between this line and the line from step 2 can now be transferred to the sliding T bevel and used to cut to pieces of material to combine and obtain the original angle.





D. To assure proper joint alignment of joints

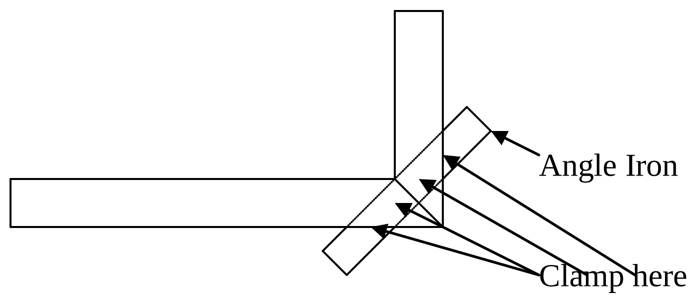
1. Use a short 1' or 2' piece of angle iron and 4 clamps

2. Clamp the outside (flat side) of the angle iron to one member of the joints with two clamps.

3. Align the other member of the joint and clamp it to the angle iron with two clamps.

4. If the joint is at an angle the angle iron will be place diagonally between the two members of the joint. If it is a straight joint the angle iron will be parallel to the members of the joint.

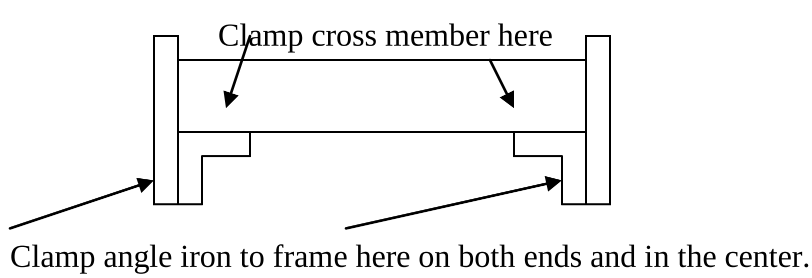
5. The angle iron assures that one side of the joint is flat, therefore, the remaining sides of the joint should be aligned.



E. Aligning cross members.

1. Clamp a piece of angle iron to the inside of frame rails on both sides the entire length of the frame. The angle iron should be positioned so the top of the angle iron is flush with where the bottom of the cross members should be on both ends.

2. Clamp the cross members to the angle iron.



End View

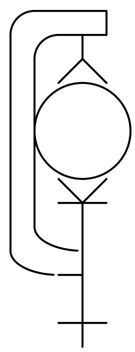
F. To align pipe or shaft to be welded in a straight line.

1. Cut two pieces of angle iron that are about 8" long. The size of the angle iron will depend on the diameter of the pipe or shaft. The angle iron should be able to lay on the pipe or shaft with the legs against the pipe or shaft and the angle toward the outside.

2. Tack the center of the two pieces of angle iron to each side of a C-Clamp.

3. Use the C-Clamp to clamp the pipe or shaft together.

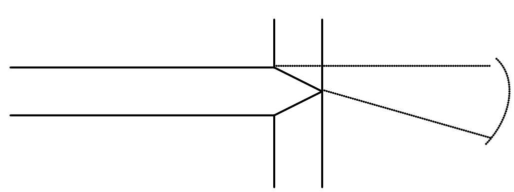
4. This should insure that the joint is straight.



End View

G. To make a T-Joint from pipe

a. Cut two sides of the pipe off at 33° from the center of the diameter so it will fit around another pipe to make a T.



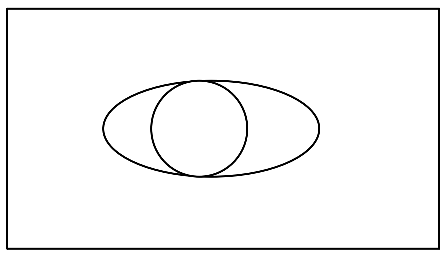
33°

H. Welding around other pieces where filler metal is not necessary. For example building up gears or filling in a hole that is out of round.

   a. Apply carbon to areas where filler metal is not desired. Carbon paste may be purchased from a welding supply company.

   b. To fill in around a hole that is out of round.

      i. Apply carbon past to the proper diameter pipe, bolt, shaft, etc. and place it in the hole.
      ii. Begin welding around the hole until it is filled.



Trailer Fabrication

AG 240-J

Unit objective

This unit is intended to be used by the instructor as a reference for fabricating trailers. Students will be exposed to various fabrication components after fabricating a trailer. Students will learn to apply welding, math, measuring, and other skills previously learned to complete a trailer. This knowledge will be demonstrated by completion of a trailer project.

Specific Objectives and Competencies

After completion of a trailer, students should be able to:

1. Estimate costs and completion date of a project.
2. Draft or sketch a drawing of a project.
3. Calculate tongue weight and axle placement.
4. Apply strength of material analysis.
5. Order materials.
6. Interpret wiring diagrams, mechanical drawings, and or blueprints.
7. Layout a project.
8. Measure and cut materials with accuracy.
9. Weld joints with minimum distortion.
10. Understand proper work ethic.

Unit References:

Bott, Steve, Minico High School, Rupert, ID

Godfrey, Lex, Burley High School, Burley, ID

Hyatt, Keith, Payette High School, Payette, ID

Johnson, Val, Madison High School, Rexburg, ID

Miller, Zebbie, Shelley High School, Shelley, ID

Redneck Trailer Supplies Parts Catalog, Redneck Inc., Springfield, MO, 2001

Trailer Parts Suppliers:

Henderson Wheel & Supply
112 West 34th St.
Boise, ID
Phone: 208-344-6525
Toll Free: 800-248-3444

Pacific Steel
1900 20th St.
Nampa, ID 83653
Phone: 208-467-2113
Toll Free: 800-727-9901

Pacific Steel
Highland Avenue
Twin Falls, ID 83303
Phone: 208-734-7440
Toll Free: 800-388-3878

Pacific Steel
604 12th St.
Lewiston, ID 83501
Phone: 208-743-2181
Toll Free: 888-455-3598

Pacific Steel
1000 Triangle
Sandpoint, ID 83864
Phone: 208-263-2584
Toll Free: 800-256-8303

Pacific Steel
320 W. Main
Burley, ID 83318
Phone: 208-678-2321
Toll Free: 800-292-2321

Pacific Steel
257 E. Anderson
Idaho Falls, ID 83402
Phone: 208-523-3225
Toll Free: 800-225-8783

Pacific Steel
2206 N. Main
Pocatello, ID 83204
Phone: 208-232-2355
Toll Free: 800-654-3323

Redneck Trailer Supplies
15778 Hwy 20/26
Caldwell, ID 83605
Phone: 208-459-7956
Fax: 208-459-8375
www.redneck-trailer.com

Six Robblees' Inc.
3710 E. Trent
Spokane, WA 99202
Phone: 509-535-8862

Trailer plans can be ordered from:

Master Plans & Design, Inc.
1509 Shelton Dr.
Nacogdoches, Texas 75961
Phone: 936-560-4879
Toll Free: 800-520-0694
Fax: 1-936-560-3031
www.trailerplans.com

Introduction

Planning a trailer-A multitude of factors must be considered when planning to build a trailer. Such factors include but are not limited to:

Gross Weight
Weight distribution
Axle Selection
Tire/wheel size
Wheel lug pattern
Axle placement
Tire displacement-clearance of fenders
Hitch coupler selection
Trailer brake selection
Lighting

A. Gross Vehicle Weight-Prior to building a trailer an estimated weight of what will be on the trailer must be known. The combination of this weight and the weight of the trailer itself is the gross vehicle weight (GVW). This weight should be stamped on the trailer to release the school, teacher, and students from any liability in the event of an accident due to overloading.

   This weight estimate will be very important in later steps. It will be necessary to select axle(s), wheels, tires, hitch coupler, and steel. It may also be useful in determining axle placement and tongue weight.

   1. Estimating cargo weight.

      a. The individual that will be using the trailer should be able to give an estimate of the weight they intend to haul.

      b. Most snowmobiles weigh less than 600 pounds.

      c. Most four wheelers weigh less than 800 pounds.

      d. Average size horses weigh about 1200 pounds.

      e. A backhoe weighs 15,000 to 20,000 pounds.

   2. Estimating the weight of the trailer.

      a. Once the cargo weight has been determined the weight of the trailer can be calculated using weights provided from the steel supplier and the trailer parts supplier.

B. Axle Selection-There are two types of axles; spring axles and rubber torsion axles.

1. Spring axles are less expensive. Spring axles require more labor to install.

2. Torsion axles are more expensive, offer a smoother ride, and require less labor to install.

3. Number of axles

   a. Single Axle-Single axle trailers are often used for light loads such as a two-place snowmobile or motorcycle trailer.

   b. Tandem Axle (2)-Most trailers are tandem (2) axle. Tandem axle trailers are safer on the road than single axle trailers. If a tire blows on a tandem axle trailer the second tire will hold the weight and prevent the trailer from swerving.

   c. Triple Axle-Triple axle trailers are commonly used for heavy loads such as equipment. However, triple axle trailers tend to excessively wear the center tire because it acts as a pivot point when turning. Tandem axle trailers can be built heavy enough to be equivalent to a triple axle trailer.

4. Capacity of axles

   a. Single Axle-The axle should have a rated capacity of at least 20% more than the GVW. So a trailer with a GVW of 1600 lbs. should have a 2000 lb. axle.

   b. Tandem Axle-The axles should have a rated capacity of at least 20% more than one half of the GVW. So a trailer with a GVW of 10,000 lbs. should have two 6000 pound axles.

   c. Triple Axle-The axles should have a rated capacity of at least 20% more than one third of the GVW. So a trailer with a GVW of 20,000 lbs. should have three 8000 pound axles.

5. Brakes-Determine if brakes are necessary and if so how many axles need brakes. Most states require that at least one axle has brakes. Some states require that all axles have brakes. Contact the local DMV to find out what is required in by state law. Idaho code requires trailers over 1500 lb GVW to have brakes adequate to stop and hold the vehicle. Idaho code also requires trailers to have a breakaway device that will automatically apply trailer brakes if the trailer breaks away from the tow vehicle.

a. Electric Brakes-Electric brakes are most common on light trailers. They are low maintenance however; they do not operate as well as hydraulic brakes. Installation requires a brake wire connection between the tow vehicle and the trailer.

b. Hydraulic Brakes-Hydraulic brakes perform better than electric brakes but require more maintenance and are more expensive. Installation requires a hydraulic connection between the tow vehicle and the trailer.

-Single servo hydraulic brakes only stop the vehicle in forward motion.

-Dual servo hydraulic brakes stop the vehicle in both forward and reverse motion.

6. Spindles

a. Straight Spindles-Straight spindles are used mostly when the bed is over the tires or when low ground clearance is not required. Examples are hay trailers and utility trailers

b. Drop Spindles-Drop spindles are used when the lowest possible ground clearance is desired. Drop spindle axles are more expensive than straight spindle axles. Examples are horse trailers and car trailers.

c. For torsion axles the drop is designated in terms of the trailing arm starting angle. Common starting angles are:

-0° (equivalent to a straight axle)
-10° up
-22.5° up
-10° down (equivalent to a 4" drop axle)
-22.5° down

7. Spring Centers

a. Spring centers is the measurement between the centers of the spring mounting pads on the axle.

b. Spring centers normally measure the same as the width of the trailer frame.

c. 60" is a common spring center

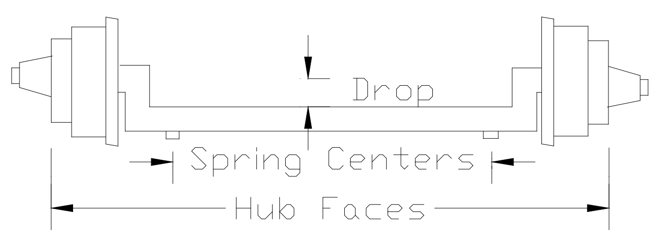
d. For torsion axles the spring center measurement is replaced with the outside frame measurement.

8. Axle length-There are several ways to describe the length of an axle, the most common is a hub face measurement.

a. Hub face is the measurement from the base of the wheel stud to the base of the wheel stud on the opposite end.

b. 96" hub face is most common. Trailers are only legal up to 102" wide. A 96" hub face will be about 102" with wheels and tires, depending on what type of wheel is used. For some trailers it may be practical to have the same hub face length as the tow vehicle. For example, snowmobile trailers so the trailer tires are in the same track as the tow vehicle to keep from getting stuck.

c. Track is another term used to describe axle length. Track is the measurement between the centers of the tires. This measurement is not very accurate for ordering axles because different wheel types will change the track measurement.

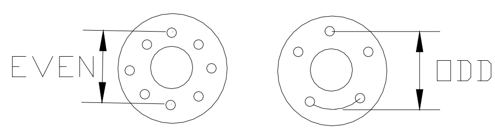


9. Bolt Patterns-Bolt patterns can vary depending on the capacity of the axle. The bolt pattern determines the type of wheel and tire to be used.

a. Hub bolt patterns are given by stating the number of studs followed by the diameter of the center of the bolt circle. For example a 6 on 5 ½ would mean 6 bolt holes with a 5 ½" bolt circle diameter between centers.

b. Determining bolt circle diameter-For an even number of bolts measure from the center of one bolt through the center of the hub to the center of the opposite bolt. For an odd number of bolts measure from the center of one bolt to an imaginary arc between the centers of the two opposite bolts.

b. It is convenient to have the same bolt pattern, wheel size, and tire size as the tow vehicle so one spare tire will fit on either the trailer or tow vehicle.



10. Springs-There are two different types of springs; slipper springs and eye springs.

a. Slipper springs have an eye on one end and a hook on the other end of the spring. The eye end is fixed and the hook end allows some movement, which allows for a better ride. Slipper springs are most commonly used for heavier capacity trailers.

b. Double eye springs are fixed by a bolt through the eyes. Double eye springs are more common on lighter trailers (less than 5000 lb GVW).

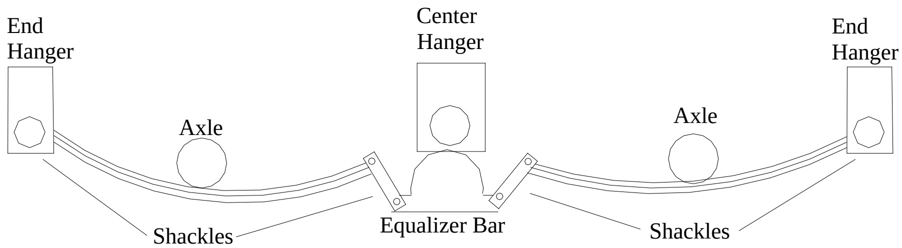
11. Spring Hanger Kits-Hanger kits are available as specified by the number of axles and type of springs and GVW.

a. Hanger kits should include all necessary hardware for the prescribed application. For example: a hanger kit ordered for a tandem axle trailer with double eye springs would include:

-2 center hangers (1 per side)
-4 end hangers (2 per side)
-2 equalizer bars (1 per side)
-8 shackle straps (4 per side)
-12 shackle bolts and nuts (6 per side)
-2 equalizer bolts and nuts (1 per side)

b. When ordering hanger kits the height of the hangers should be specified to allow for clearance between the fender and tire.

c. For torsion axles the type of frame (tubing, standard channel, or I-beam) determines the type of mounting hardware.



C. Tires and Wheels

1. Tire capacity varies between manufacturers and pressures. Larger tires have a larger capacity. Dealers should have information brochures on manufacturers recommended capacity and pressures.

2. Tire load ranges are indicated by letters A, B, D, etc. Load ranges increase beginning with A through H.

3. Wheels-Wheels are sized by the diameter and then width. For example: 15" x 6" indicates that the wheel is 15" in diameter and 6" wide. As diameter or width increases the capacity of the wheel also

increases. Wheel capacities vary between manufacturers so check with the manufacturer for specific capacities.

4. Wheel Bolt patterns-Bolt patterns on wheels are designated by the same method as hub bolt patterns described previously. Wheel capacity increases as the number of bolt holes increases and also as the diameter of the bolt pattern increases.

D. Light Requirements by Idaho Code

1. All trailers must have turn signals

2. Reflectors must be mounted at a height no less than 24 inches and no more than 60 from the ground to the center of the reflector. If the highest part of the permanent structure of the vehicle is less than 24 inches, the reflector shall be mounted as high as the permanent structure will allow. Any required red reflector on the rear of the a vehicle may be incorporated with the tail lamp.

3. Color and location of clearance lamps, side marker lamps, and reflectors

    a. Front clearance and marker lamps and reflectors or those mounted on the side near the front shall display or reflect an amber color

    b. Rear clearance and marker lamps and reflectors or those mounted on the side near the rear shall display or reflect a red color.

    c. All lighting devices and reflectors mounted on the rear of any vehicle shall display or reflect a red color, except the stoplight or other signal device, which may be red, amber, or yellow, and except that the light illuminating the license plate shall be white and the light emitted by a back-up lamp may be white, amber, or red.

    d. Clearance lamps shall be mounted on the permanent structure of the vehicle in a manner to indicate its extreme width and as near the top as practicable. Clearance lamps and side marker lamps may be mounted in combination provided illumination is visible from 600 feet to 100 feet from the vehicle when directly in front of lawful upper beams of headlamps under normal atmospheric conditions.

4. Any trailer with GVW in excess of 3000 pounds, if wider or taller than the vehicle drawing it is required to have the following:

    a. On the front,2 amber clearance lights, 1 at each side

    b. On each side, 2 side marker lamps 1 at or near the front and 1 at or near the rear.

    c. On each side, 2 reflectors, 1 at or near the front and 1 at or near the rear (marker or clearance lamps may also be reflectors)

    d. On the rear, 2 clearance lamps, 1 at each side, and 1 stoplight.

5. Any trailer with GVW in excess of 3000 pounds, if of the same or less width and height as the vehicle drawing it is required to have the following:

    a. On each side, 1 marker lamp near the rear

    b. On each side, 2 reflectors, 1 at or near the front and 1 at or near the rear.

    c. On the rear, 2 clearance lamps 1 at each side.

    d. On the rear 2 reflectors, 1 at each side and 1 stoplight.

6. Any trailer with GVW less than 3000 pounds, if the stoplights on the tow vehicle are visible.

    a. On each side, 1 reflector

E. Hitch Couplers and Jacks-Hitch couplers and jacks are selected by knowing the GVW. These parts have a rated capacity that should not be exceeded.

F. Weight distribution-Generally the tongue weight should be 10% of the GVW. The intended cargo may make a difference in the length of the tongue and the axle placement. Axle placement will be discussed later.

1. Snowmobile Trailers and car trailers-The majority of weight in a snowmobile or car is in the front 1/3 where the engine is. Therefore, the majority of the weight on the trailer is distributed farther forward than normal. In order to maintain 10% of the GVW on the tongue the axle must be placed farther forward.

2. Four Wheeler and Utility Trailers-The majority of weight in a four wheeler is in the center. Therefore, the weight should be evenly distributed similar to a utility trailer with a uniform load.

3. Horse Trailers-A horse trailer without a front tack or with a small tack has a weight distribution similar to a utility trailer. However, if a horse trailer has a large front tack then the majority of the GVW will be on the back half of the trailer. In this case the axles may need to be placed further back.

4. Equipment and Other Trailers-In unique situations weight distribution must be reasoned based on the intended cargo. For example, the majority of the weight of a tractor is in the rear end so if the tractor is to be driven onto the trailer the axle may have to be farther back. But if the tractor is to be backed onto the trailer the axle may have to be farther forward.

5. Dove Tails or Ramps-A trailer with a dove tail or ramp will have extra weight on the rear of the trailer. Therefore, the axle may have to be placed farther back.

G. Axle placement

1. Axle placement may vary according to weight distribution. See the previous section for more information on weight distribution. The best way to determine axle placement for a specific application is by taking measurements from a similar trailer. Redneck Trailer Supply Catalog has a formula to determine if the axles are in the correct position once a trailer is built. This formula can be applied to a trailer that is already built and necessary corrections can be made on the trailer in progress.

    a. Obtain the wheel weight of the trailer. If another trailer is to be built for the same application, the formula results will be more accurate if loaded weights are used versus empty weights. For example, a snowmobile trailer, the variance of weights between snowmobiles will be negligible compared to the GVW.

    b. Obtain the tongue weight of the trailer. GVW will be more accurate for specific applications.

    c. Measure the distance D in inches from the tongue to the center of the axle or to the center of the center hanger if tandem axle.

    d. Determine the total weight

    Total weight(lbs) = tongue weight(lbs.)+wheel weight(lbs.)

e. If tongue weight is greater then 10% of the total weight, then decrease distance D (inches) by X (inches) where:

X=((Tongue weight – 0.1 * total weight) / total weight) *D

f. If tongue weight is less than 10% of total weight, then increase distance D by X where:

X = ((0.1 * total weight – tongue weight) / total weight) *D

2. Bumper pull trailers-If it is not feasible to use the above formula, several other simple formulas are available for axle placement. The following formulas can be used to determine the center of the axle for single axle trailers or center of the two axles for tandem axle trailers. Experience and good judgment of the application and weight distribution should also be used when determining axle placement. The axle should be placed some distance behind the center of the bed of the trailer (tongue length is excluded) to obtain a 10% tongue weight.

a. Place the center of the axle(s) back from the front of the trailer bed a distance equal to 2/3 the length of the bed. For example:

On an18' bed the center of the axle(s) will be 12' from the front of the trailer bed (excluding the tongue).

b. Place the center of the axle(s) 1" behind center of the bed for every 1' of bed length. For example:

On an 18' bed the center of the axle(s) will be 10'6" from the front of the trailer bed (excluding the tongue).

c. Place the center of the axle(s) ½" behind center of the bed for every 1' of bed length. For example:

On an 18' bed the center of the axle(s) will be 9'9" from the front of the trailer bed (excluding the tongue).

d. Measure the trailer bed at a diagonal from the front corner to the opposite rear corner and divide the measurement by 2. Place the center of the axle(s) back from the front of the trailer bed that distance. For example:

On an 8' x 18' bed the center of the axle(s) will be 9' 6 3/8" from the front of the trailer bed (excluding the tongue).

2. Gooseneck Trailers-Generally the center of the axle(s) on a gooseneck trailer will be farther back than on a bumper pull trailer. The following formulas apply to axle placement on a gooseneck trailer:

   a. Place the center of the axle(s) back from the front of the trailer bed a distance equal to 70% the length of the bed (excluding the overhang). For example:

      On an18' bed the center of the axle(s) will be 12' 6" from the front of the trailer bed (excluding the overhang).

   b. Place the center of the axle(s) back from the front of the trailer bed a distance equal to 2/3 the length of the bed (excluding the overhang). For example:

      On an18' bed the center of the axle(s) will be 12' from the front of the trailer bed (excluding the overhang).

H. Axle Spacing

1. For spring axles the axle spacing will be determined by the length of the springs. For torsion axles it is determined based on tire diameter and fender dimensions. Longer springs can be purchased for spring axles or torsion axles can be placed farther apart if it helps with the weight distribution.

   a. There should be at least 5" of clearance between the two tires on a tandem axle trailer. There should also be at least 5" of clearance between the front or rear tire and the fender.

   b. The following is a list of approximate outside tire diameters and approximate distance between axles.

WHEEL DIAMETER	TIRE O.D.	DISTANCE BETWEEN AXLE CENTERS
13"	24"	29"
14"	26"	31"
14.5"	28"	33"
15"	30"	35"
16"	32"	37"

I. Fender Clearance-Clearances will vary between applications, axle types, spring types, and spring hanger types. Check with axle manufacturers for specific information. Below are some general measurements that apply to most axles.

1. There should be 3" of clearance between the fender and the top of the

axle when the tire is under full load.

2. Full load raises the tire about 3". If the trailer is empty allow for 6" between the top of the tire and the fender.

3. Tires may also move forward or back so at least 3" of clearance is necessary between the front or back of the tire and the fender.

4. Fenders should be ordered to fit outside tire diameter and tire width. When ordering fenders the inside tire diameter is used. Refer to the above chart for approximate outside tire diameters.

J. Tongue and Overhang Lengths

1. The length of the tongue determines how a trailer will react when backing. A shorter tongue will allow a trailer to turn quicker than a longer tongue.

2. Tongue or overhang lengths should be long enough to allow the tow vehicle to turn as sharp as possible without hitting the trailer with the corner of the bumper.

   a. Measure from the center of the ball to the outside corner of the tow vehicle. The tongue should be at least this long.

   b. Measure from the center of the gooseneck hitch to the outside rear corner of the tow vehicle. The overhang of a gooseneck trailer should be at least this long.

3. 42" to 48" is common for tongue lengths.

4. 60" to 90" is common for overhang lengths.

K. Tongue and Overhang Heights

1. For bumper pull trailers the hitch coupler should be about the same distance from the ground as the main frame of the trailer. Ball height of the tow vehicle can be adjusted to compensate any differences.

2. For gooseneck trailers the hitch coupler should be able to adjust from 24" to 36" from the bottom of the overhang to the bottom of the hitch.

L Common Trailer Sizes

1. The outside dimensions of a four wheeler are approximately 46" x 85" therefore:

a. Two place four wheeler trailers should be approximately 96" x 96"
b. Four place four wheeler trailers should be approximately 96" x 192"

2. The outside dimensions of a snowmobile are approximately 48" x 109" therefore:

   a. Two place snowmobile trailers should be approximately 102" x 120"
   b. Four place snowmobile trailers should be approximately 102" x 228"

3. Spaces for horses should be approximately 40" x 90" therefore:

   c. Slant load trailers should be 80" to 90" wide on the inside and allow 40" lengthwise for each horse.
   d. Stock trailers are typically 80" to 90" wide on the inside and lengths of 12', 14', 16', and 20' for bumper pull trailers. Goosenecks can be longer.

4. Flatbed utility trailers should be

M. Steps to building a trailer

1. Draw plans

2. Prepare a cutting list

3. Order Materials

4. Cut Materials to length-cut square corners at 45°

5. Tack frame together.

   a. Most shop floors are graded to a drain. It is not necessary to have a flat surface to build a trailer frame. The frame can be built on jack stands. Make sure that all edges of the metal line up at the joints and the frame will be flat.

6. Check that the frame is still square.

   a. The best way to square a frame is to pull a measurement diagonally from one corner to the opposite corner on the opposite end. Then pull a measurement between the other two corners. The frame will be square if these two measurements are equal length.

7. Place another tack on the frame joints opposite of the previous tack.

   a. Distortion is minimized by placing at least two tack welds at each joint.

8. Check that the frame is square one last time.

9. Weld in cross members.

   a. Spacing between cross members will vary between applications. Cross members may have to be in a specific place for decking. For example if 4' x 8' sheets or 16' lumber is to be used for decking make sure that the cross members are on 16" or 32" centers.

   b. Cross members may be placed lower than the top of the frame so when decking is installed it will be the same height as the frame. Or they can be the same height as the top of the frame if the decking is to cover the entire frame.

10. Make a center punch mark on each side of the frame where the center of the axle(s) will be.

11. Clamp two pieces to make the A-frame for the tongue to the frame.

   a. Most weld on A-frame hitch couplers are 55°. If one of these is to be used make sure that the A-frame for the tongue will fit the A-frame hitch coupler.

   b. The two pieces of the A-frame should be long enough to extend beyond the front of the trailer frame a linear distance of at least 42" back beyond the front of the trailer to outside edge of the frame.

12. Weld two pieces (material that is the same type of material or similar to the material) along the sides of the frame. These pieces should begin at the point where the tongue A-frame meets the outside of the frame. They may extend back past the axle(s) or to a point just in front of the axle(s). These pieces in combination with the tongue A-frame are the sub-frame.

a. These two pieces are used to add strength and rigidity to the frame as well as providing extra surface area to absorb the tension force of the tongue as the trailer is pulled.

b. If the sub-frame extends past the axles toward the back the bed of the trailer will be raised. This should be done if the tires are to be under the trailer bed (example: snowmobile trailer). If the tires are to be outside the trailer bed and fenders are used to cover the tires the bed can be lower for easier loading (example: horse trailer). See frame diagrams in this section.

c. Cross members or gussets may be added to the sub-frame for additional strength.

d. For gooseneck trailers the sub-frame should extend to the front of the trailer where the uprights are to be welded. A similar A-frame is welded to the uprights for the overhang.

13. Make sure that the center of the tongue is in the center of the trailer.

a. Pull measurements from the center punch marks made in step 9 to the center of the tongue. This measurement should be the same on both sides.

14. Weld the A-frame to the pieces installed step 11 and the frame. Weld a plate (¼" x the same dimensions as the square at the where the 2 A-frame pieces meet) across the front of the A-frame where the two pieces meet.

15. Weld at least one triangle shaped gusset in each corner. Depending on the size and capacity of the trailer, two gussets in each corner may be necessary. One gusset on the top of the frame and another on the bottom.

16. Install a piece of thin wall tubing down the left side of the frame as electrical conduit. Make sure there are breaks in the tubing where it will be necessary to run wires out for clearance markers and brakes.

a. If tubing is used for the frame it is a common practice to cut small holes in the frame for the electrical wires.

b. Use a wire feed gun with the ground disconnected to run hard wire through whatever will be used as conduit. This wire can be used later to pull electrical wires through.

17. If it is an enclosed trailer:

a. Install roof and nose bows. Space them on 2' or 2' 6" centers according to the width of the sheet metal that will be used for skin. If a trailer is to have a dividing wall a roof bow should be installed in that location in order to frame the dividing wall. If a trailer has a slanted dividing wall (tack room) a roof bow should be cut in the center and extended to fit at the correct angle across the trailer after the roof has been installed (so it doesn't interfere with the roof sheets). Roof bows and nose bows may be purchased from a trailer manufacturer or a trailer parts supplier.

b. Install 3 rows of material similar to roof and nose bows (usually 1" x 1" x .065" square tubing) between the roof and nose bows as cross members.

c. Install siding-Siding can be 16 gauge to 20 gauge. Siding should be installed with the longest length vertical in the same manner that sheet rock is installed. The seams and or plug welds can be ground down and filled with silicon or bond-o for a smooth finish. Siding for horse trailers should be installed on the inside of the walls to prevent horses from getting injured. Horse trailers are often double skinned for a better appearance on the outside. In this case one side of the skin has to be plug welded to the frame. If the trailer has a tack compartment in the nose the nose can be skinned on the outside. If it is a cargo trailer the siding may be on the outside. Siding and may be attached by the following methods:

   -Using clamps or a large magnet with a handle to pull the siding against the frame and tack weld it to the frame.

   -Riveted through the skin and into the frame. This is a common practice on steel framed trailers with aluminum skin. Pneumatic rivet guns are available to speed this process up. Special rivets are often used in industry they are referred to as “huck bolts”. Huck is a brand name.

   -Plug weld through the skin to the frame.

d. Wrap siding around the nose-This siding can be the same thickness as the walls and installed in the same manner as the wall siding. Begin siding on one corner of the nose and work toward the center and then around to the other side. Or start in the center and work toward one side and then back to center and work toward the other side. Do not fasten both ends and work toward the center or the siding will not fit tight against the frame in the center.

e. Install roofing-Roofing may be 20 gauge to 24 gauge sheet metal. Remember the lighter it is the easier it is to form around the radius of the roof bows. Roofing should begin on the rear of the trailer and the next sheet forward should slightly lap over the top of the previous sheet to prevent leaking. Trim can be purchased to cover the overlaps, or the overlaps can be camouflaged with silicone or bond-o. Make sure that the first sheet is square with the framework to prevent a gap once the roofing has reached the front of the trailer. A magnet with a handle, clamps, or ratchet straps can be used to pull the roofing tight against the frame. Begin fastening the roofing to the frame on one side of the trailer and work toward the other side. Or begin in the center and work to one side and then back to center and work toward the other side. Do not fasten the roofing to the frame on both sides and work toward the center. Use one of the methods described in the siding section above to fasten the roofing to the frame. If rivets are to be used for the roof it is recommended that silicone sealer be placed on the rivets prior to installation to prevent leaks.

f. Install ball corners or roof caps-Ball corners or complete roof caps for the nose of the trailer may be purchased from a trailer supply company.

g. Framing the rear door-If the trailer is to be fully enclosed the rear door can be framed in a number of ways to fit the radius of the roof bows as follows:

   -For smaller cargo trailers a square frame can be made up to the height of the bottom of the roof bows. A roof bow can be cut in the center and welded back together slightly shorter than the other roof bows. The bottom of the roof bow on the door also needs to be trimmed off enough to fit inside the trailer. The modified roof bow can be added to the top of the door frame. The rear roof bow between the walls must be set toward the front enough to allow room for the roof bow on the door in order for the door to be flush when closed. Diagram 1.

   -A cross member can be welded at the base of the rear roof bow across the rear of the trailer to the base of the other roof bow. The area between the cross member and the top of the rear roof bow can be skinned and then a square door can be made. This may not be the best method because is creates low clearance into the rear of the door. However it is the simplest method. Diagram 2.

-The radius of the corners of the roof bow can be framed off at an angle and skinned. A door frame can then be made to fit the opening. For larger trailers this method is best because it creates the strongest door with the most clearance. Diagram 3.

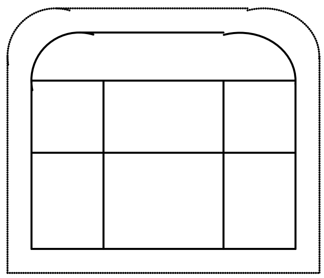


Diagram 1

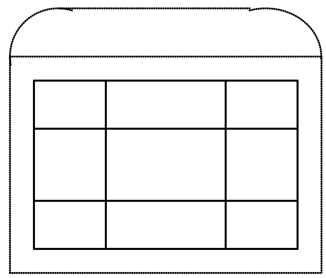


Diagram 2

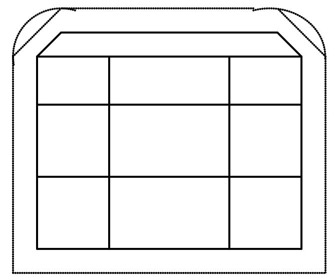


Diagram 3

Trailer Frame
Door Frame

h. Install doors, windows, and vents-Doors, windows, and vents may be fabricated or purchased from a trailer parts supplier. Use flush mount paddle latches and full length piano style (continuous) hinges when installing walk through doors or drop down windows.

   -For large rear doors hinge pins and nipple assemblies can be purchased or they can be fabricated using ½" pipe and 9/16" round stock. Cam style latches can also be purchased or fabricated. If the rear door is full size use four hinges, if it is a set of double doors two hinges on each door should be used.

i. If a dividing wall is to be installed be sure to weld in a cross member in the frame parallel with the dividing wall to secure the decking.

18. Now is the time to install:

    a. Ramps or tails

b. Framing if it is an enclosed trailer. The walls can be built in a flat position on stands or the floor and installed on the trailer frame as a complete unit. Or they can be built on the trailer in a vertical position. When framing walls are built be sure to frame in windows, doors, and vents. As the walls are being placed or fabricated on the trailer tack or clamp support brackets as needed to keep the walls square until the roof and nose bows are installed.

c. Dividers or partitions

d. Winches

e. Stake pockets or rails (if metal)

f. Tie hooks

g. Saddle racks

h. Tool boxes

i. Spare tire bracket

j. Brackets to hold snowmobile skis, ATV tires, motorcycle tires.

k. Running boards

19. Install axles, wheels, and tires. See G. Axle placement

a. Make sure that axles will be square with the frame. Center punch a mark on the center of the front cross member of the frame. Measure from this mark back to a point on each end of the axle. If this measurement is the same on each side the axle is square.

b. It is common for axles to have a slight arch or camber in them. The arch is supposed to be toward the top of the trailer so the bottoms of the tires are tilted slightly toward the inside of the trailer and the tops of the tires are tilted toward the outside of the trailer. This is called toe-in.

c. Install spring hangers and springs for spring axles.

d. Install mounting brackets for torsion axles. The mounting brackets are often welded to the frame, however, if the axle is ever damaged it is easier to replace if it is bolted to the frame. The **trailing** arm goes toward the rear of the trailer.

c. There is several ways to install axles. If the student is a good welder the best way is to support the frame with stands and weld the axles on in an overhead position. If the student is not a good welder the frame can be built upside down or can be built right side up and turned over to weld the axles on. An overhead crane is useful for turning a trailer frame over. If an overhead crane is not available it is possible to turn a trailer frame over with several students and a good drill sergeant.

20. Install Decking if metal decking is used or if it is to be painted.

21. Install hitch coupler

22. Install Jack

23. Install Fenders

    a. Teardrop style fenders give a cleaner appearance than Jeep style fenders.

24. Cover tongue A-frame with sheet metal

    b. Sheet metal should be at least 11 gauge to support a person standing on it.

25. Prepare for painting

    a. Grind all defects down

    b. Use a sanding wheel to reduce grinder scratches

    c. Use a grease and wax removing solvent to remove dirt, oil, grease, and other contaminants that may be on the metal.

    d. Fill holes, craters, dents and seams with silicone or bond-o and sand down until flush with surface.

    e. Remove tires and wheels

    f. Mask off areas where paint is not desired. In some cases it may be more feasible to install parts such as windows or chrome accessories after painting.

    g. Wipe the entire surface to be painted with a tack cloth to remove dust and debris.

    h. If the trailer is not grounded by jack stands drape a chain over the axles to the ground to avoid sparks from static electricity.

26. Prime, seal and paint.

27. Install wheels and tires

28. Install wires

29. Install lights and trailer connector-see wiring diagrams in this section

30. Install decking if wood decking is used

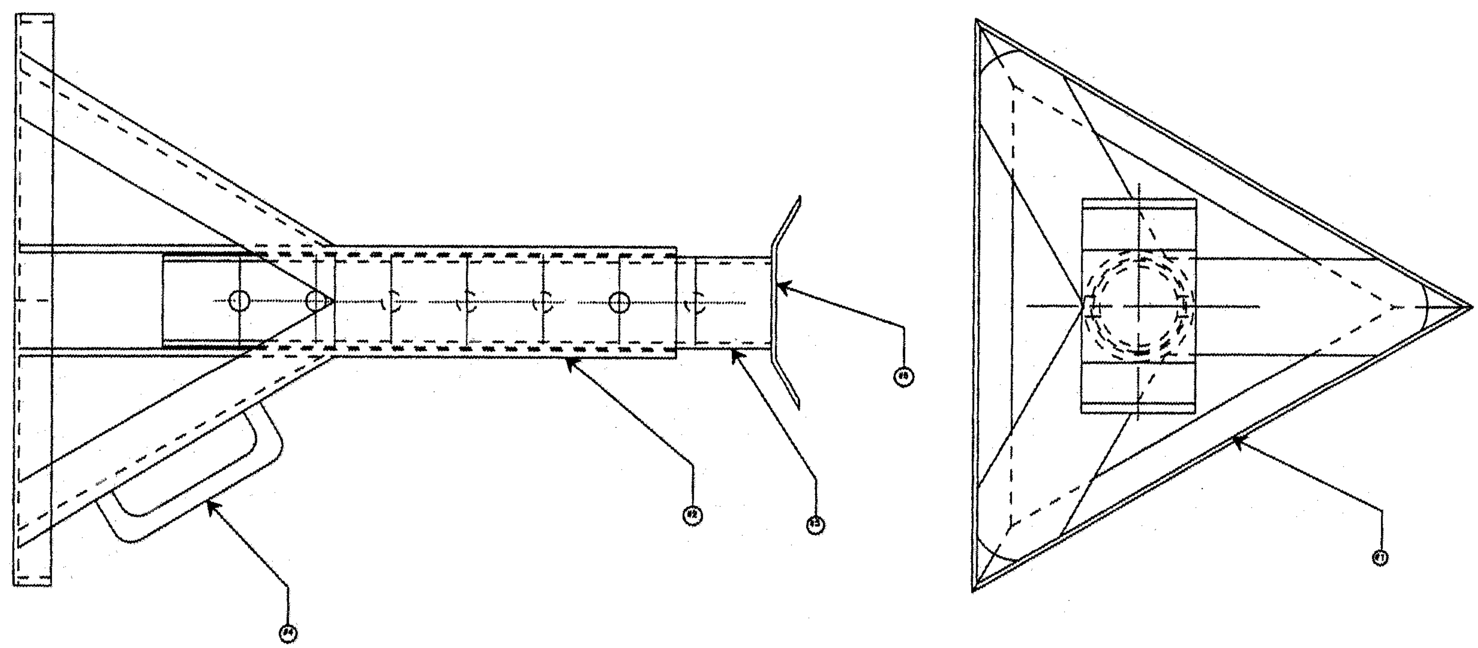
    a. Fir or pressure treated lumber is preferred

    b. Use 3/16" self tapping screws through the decking into the cross members.

    c. Coat lumber with boiled linseed oil or Thompsons Water Seal.

31. Install accessories, trim, weather stripping, pinstripes, etc.

32. Install gravel guards.



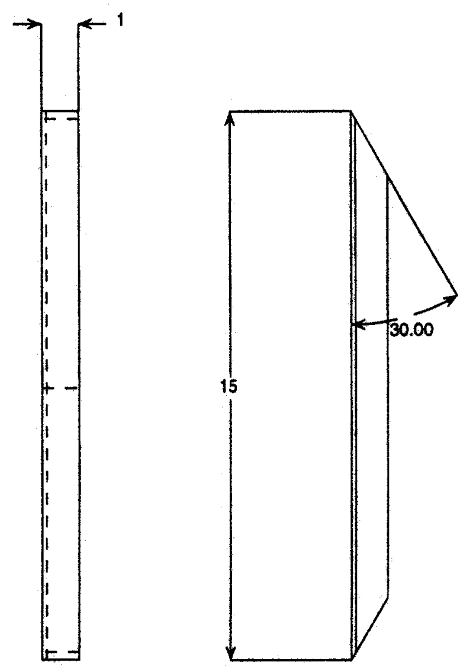
NO.	DESCRIPTION	MATL.	REQD
5	STABLIZER PLT.	STL.	1
4	HANDLE	STL RD.	1
3	ADJ. PIPE	SCH 40	1
2	STAND	SCH 40	1
1	BASE ANGLE	STL.	3

ASSEMBLED VIEW

DR.BY: M. CRAMER

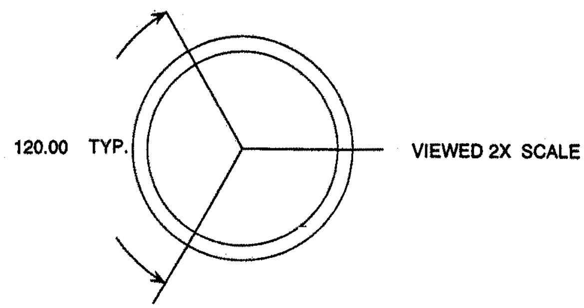
3-18-1997

1/3 SCALE



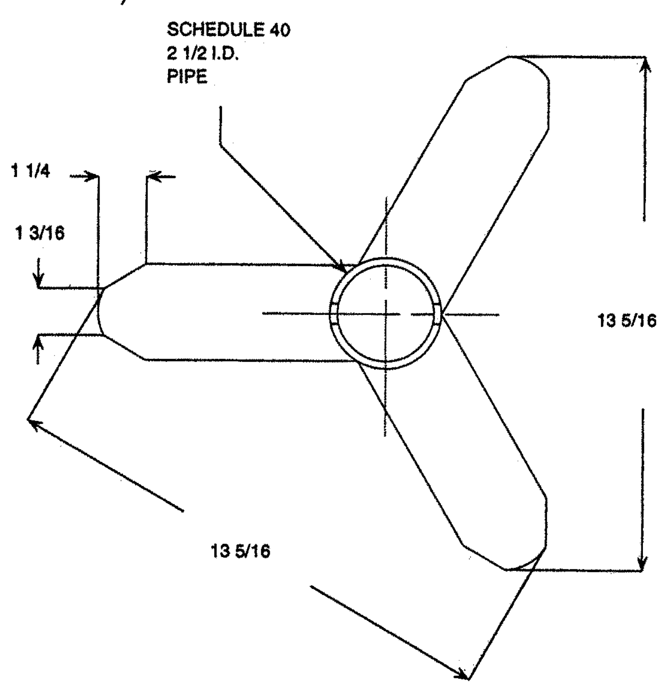
NOTES:
1X1X 1/8 ANGLE
15"LONG

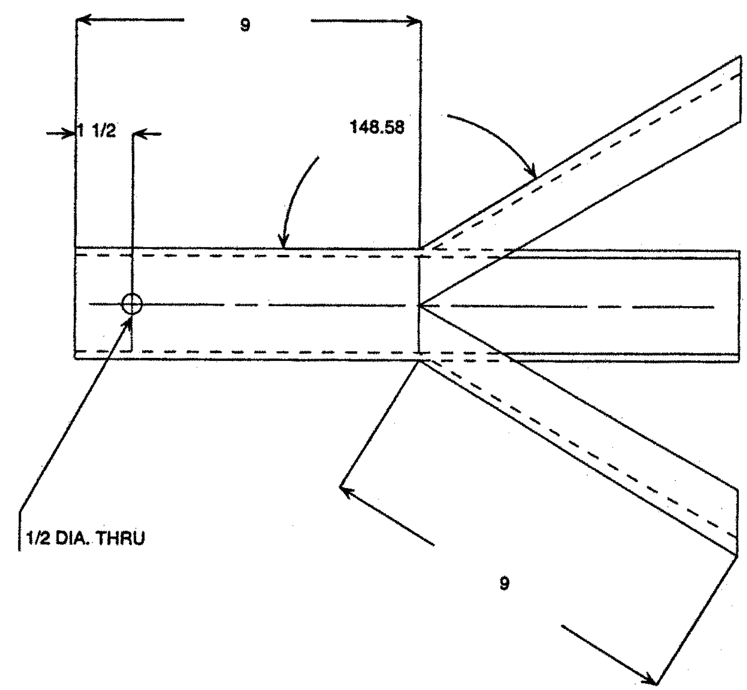
BASE	DR. BY: M. CRAMER	3- 18- 1997	1/3 SCALE	PART # 1



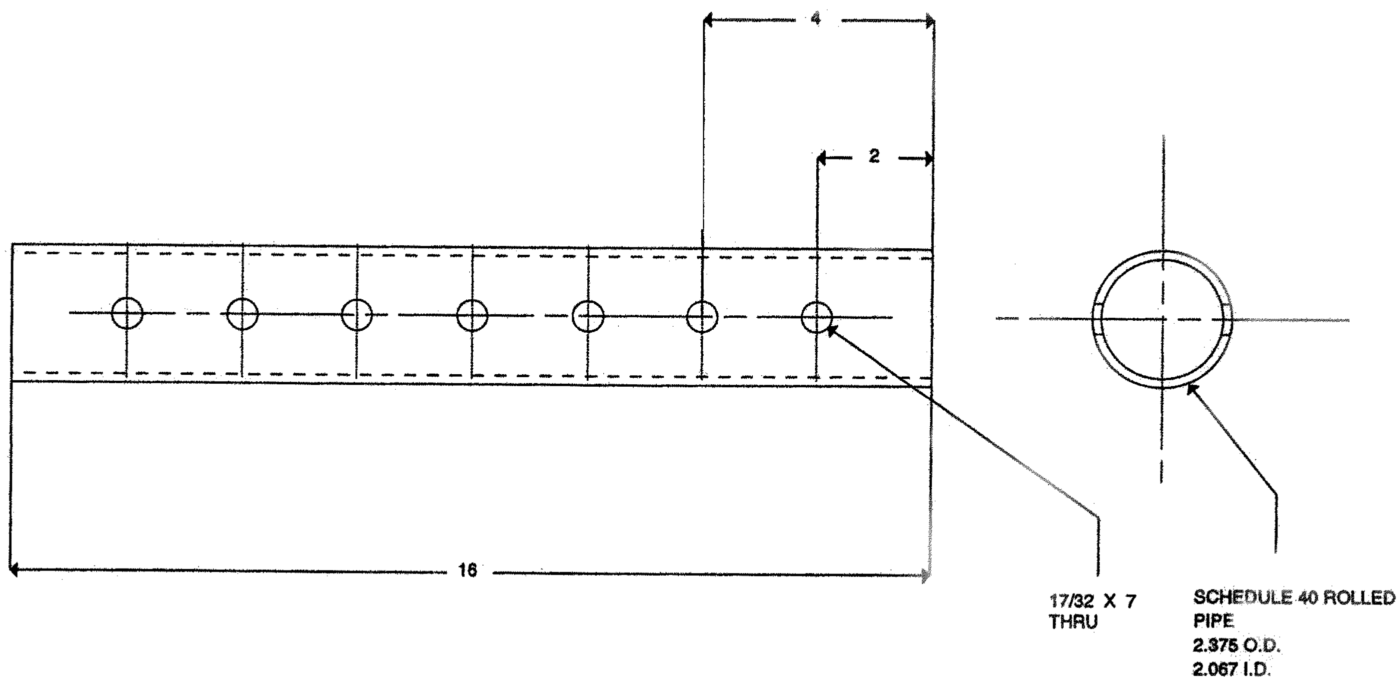
NOTES:

SCHEDULE 40
ROLLED PIPE
2 1/2 I.D.
18" LONG

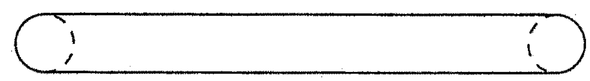




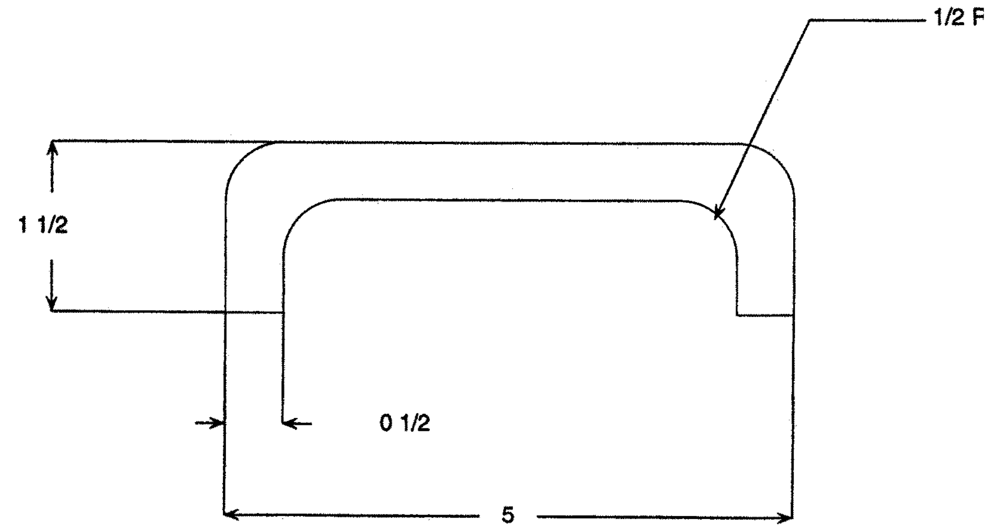
STAND	DR. BY: M. CRAMER	3- 18- 1997	1/3 SCALE	PART # 2



HEIGHT ADJ PIPE	DR. BY: MATTHEW CRAMER	MARCH 18,1997	HALF SCALE	PART # 3

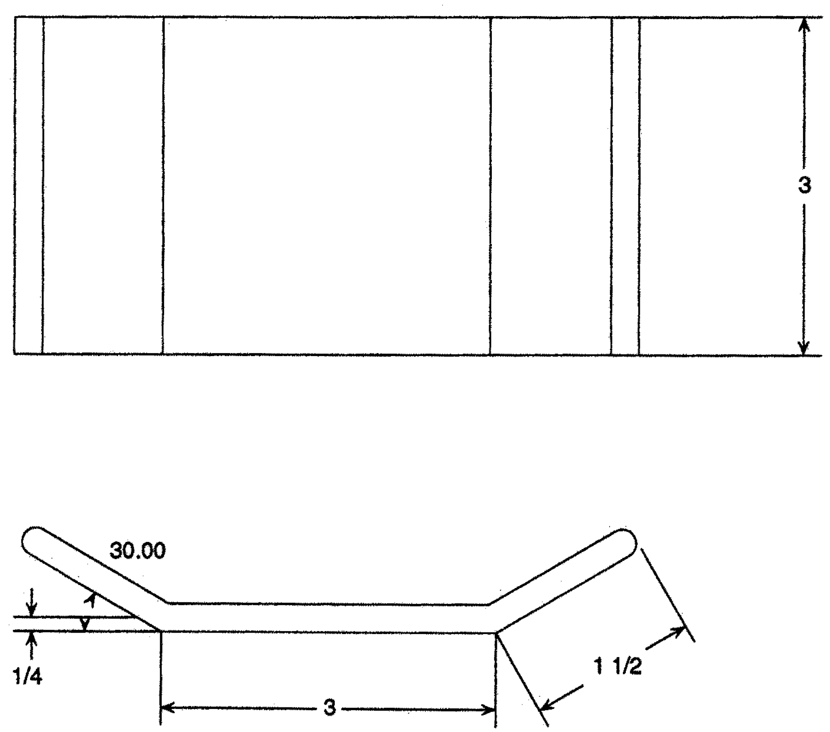


NOTE:
1/2 steel rod
8" long



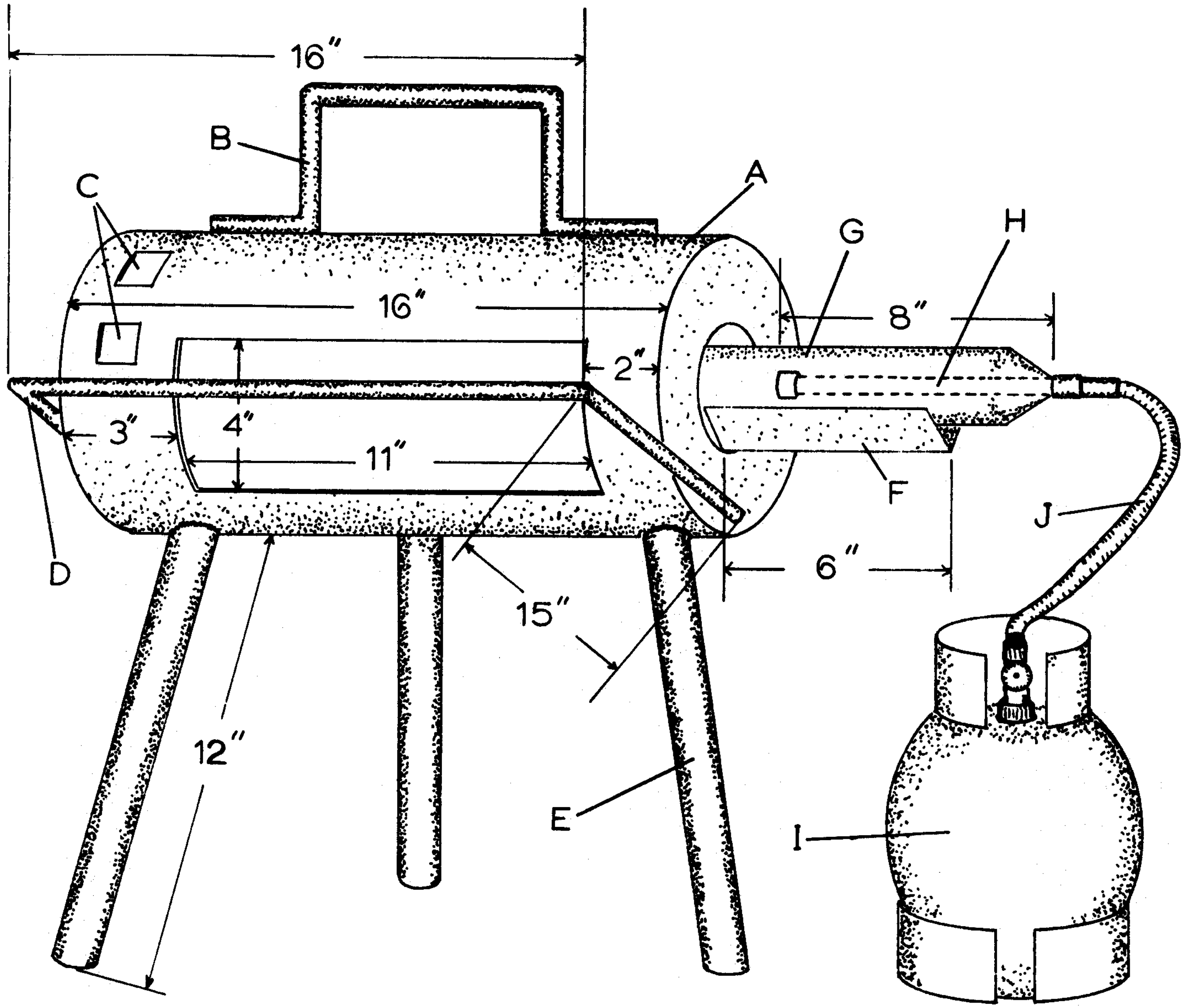
HANDLE	DR. BY: MATTHEW CRAMER	MARCH 18,1997	FULL SCALE	PART #4

NOTES:
1/4 STEEL PLATE
3X6



STABILIZER PLATE	DR. BY: MATTHEW CRAMER	MARCH 18,1997	FULL SCALE	PART #5

BRANDING IRON HOLDER AND HEATER



A - 6" or 8" Pipe

B - Handle ½" Steel Rod

C - Three 1" Vents

D - ½" Steel Rod Tilted Up 30°

E - 1 ¼" Pipe for Legs

F - 1" Angle Iron Holder for Burner

G - 2" Pipe - 9" Long

H - ¼" Nipple with Cap with Small Holt Drilled in the End

Drill No. 60 - .0400"
Drill No. 56 - .046"

I - 5 Gallon Butane Bottle

J - Flexible Hose

Compliments of:
Joe Barton
Welding Specialist
Agricultural Education Specialist Program
Texas A & M University
College Station, Texas

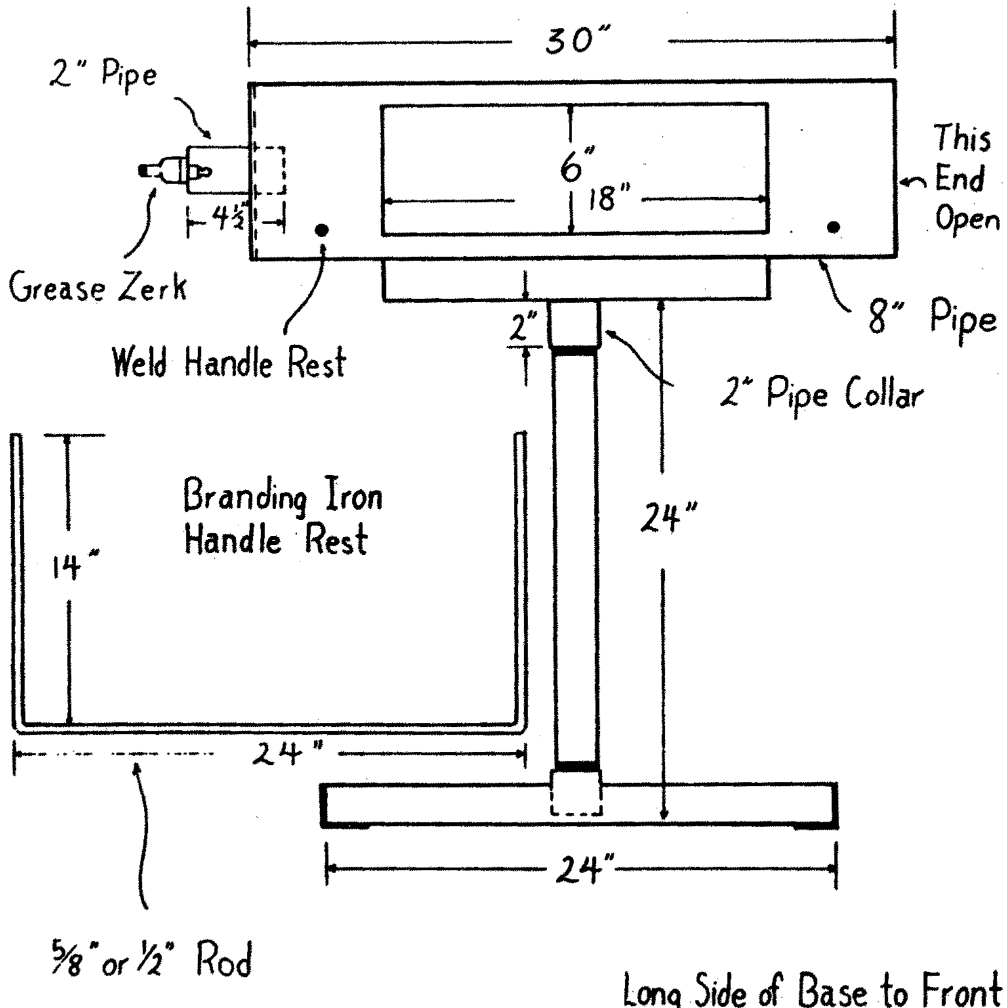
#21.015

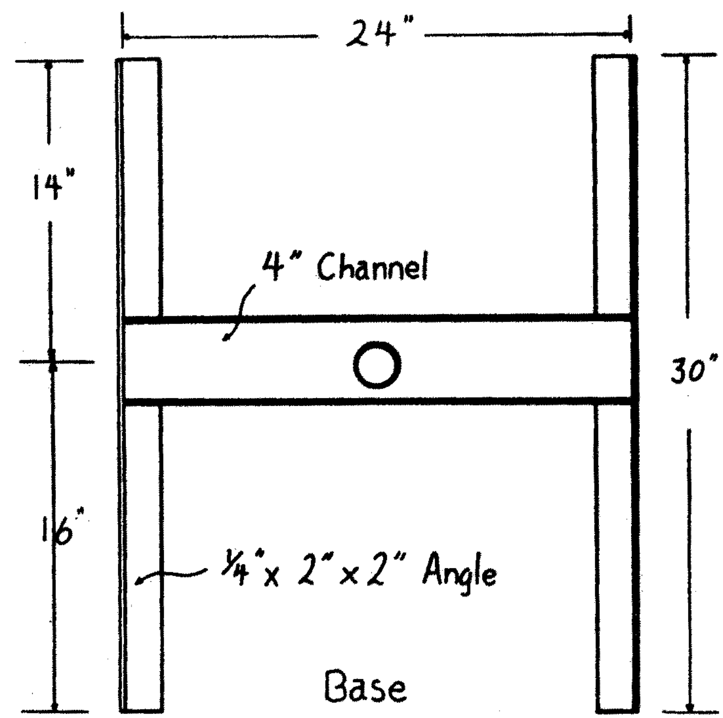
Branding Iron Heater

Scale: 3/16"=1"

BILL OF MATERIAL

2 Pieces of 2" Pipe Collar 2" Long
1 Piece of 2" Threaded Pipe 23" Long
1 Piece of 2" Pipe 4 1/2" Long
1 Piece of 8" Pipe 30" Long
1 Piece of 1/8" Flat Metal 8" Diameter
1 Piece of 4" Channel 18" Long
1 Piece of 4" Channel 24" Long
2 Pieces of 1/4" X 2" X 2" Angle 30" Long
1 Piece of 1/2" or 5/8" Rod 52" Long
1 Piece of 1/2" Pipe to Hose Gas Connector
1 Piece of 1/2" X 1/4" Reducer
1 Piece of 1/4" X 1/8" Reducer
1 Grease Zerk with Spring and Ball Removed

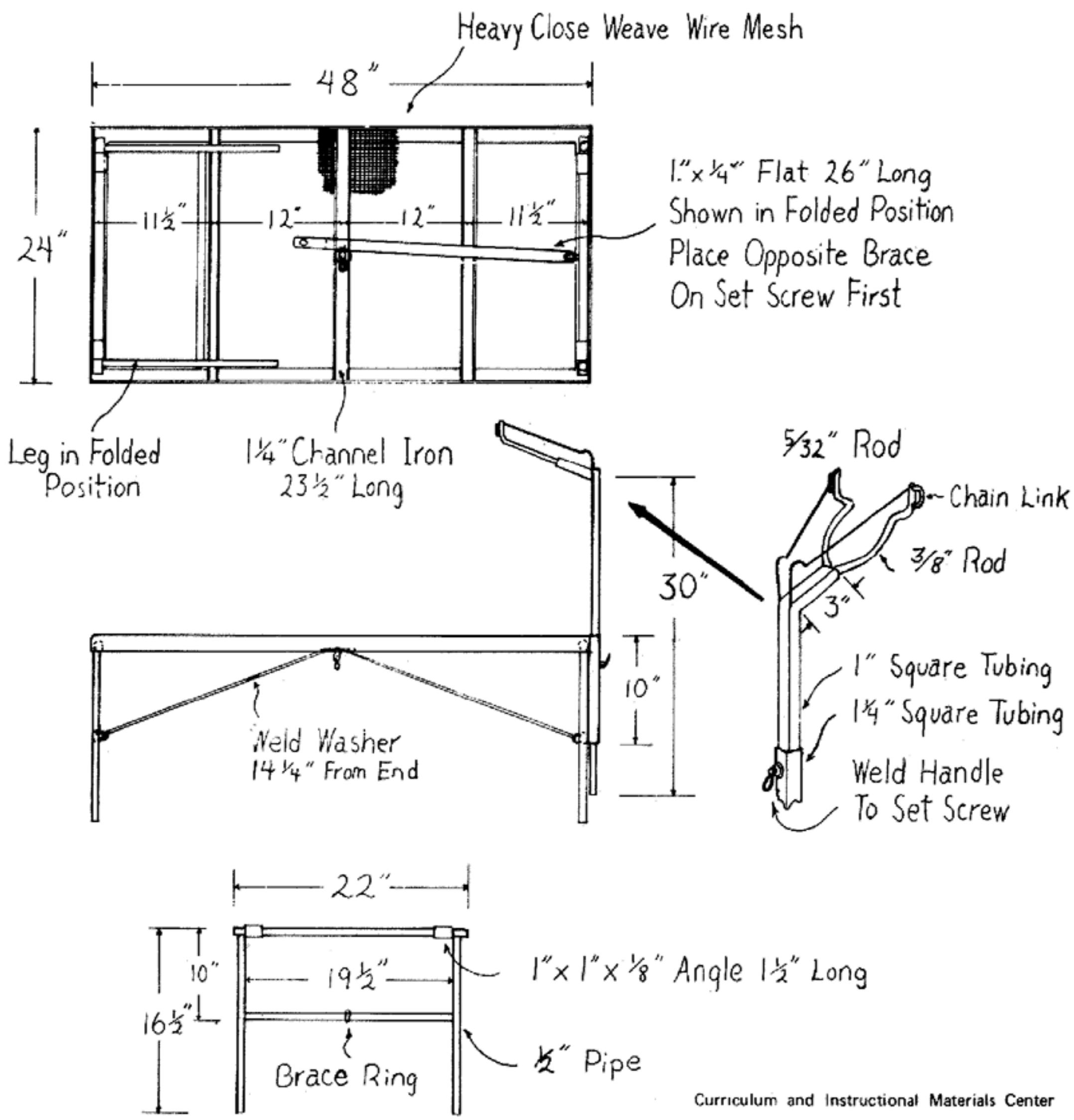




Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

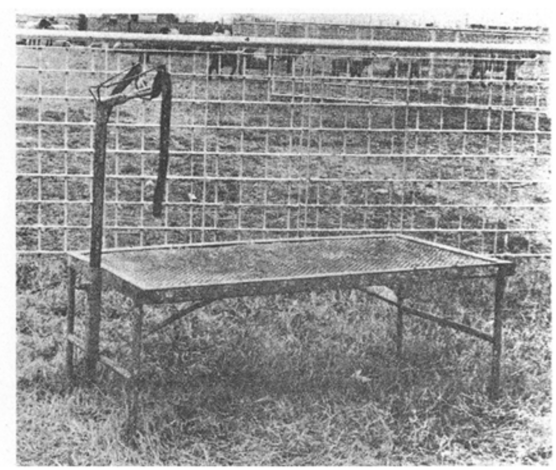
Folding Sheep Blocking Stand

Scale:3/32"=1'



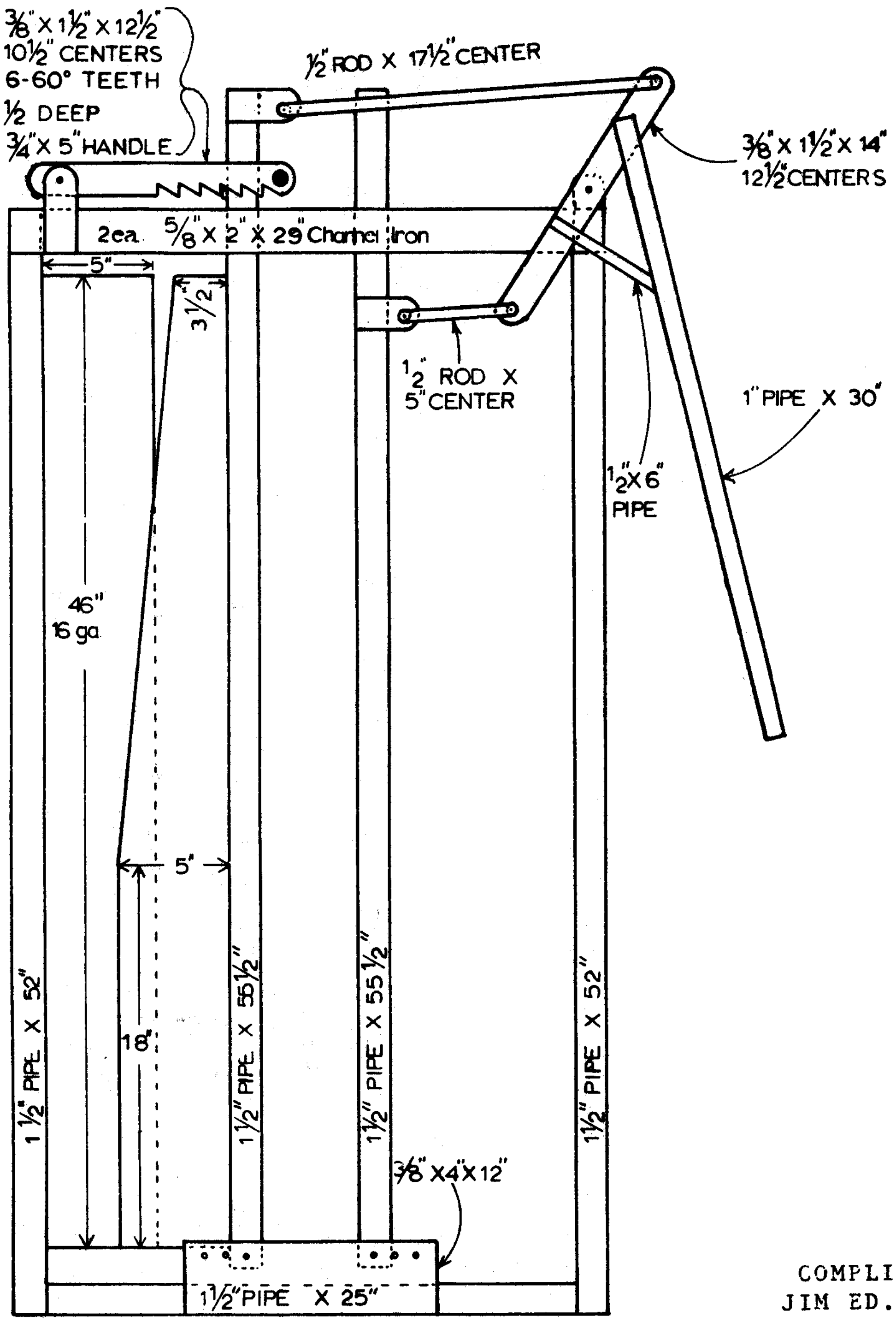
BILL OF MATERIAL

2 Pieces of 1½" x 1½" Angle Iron 48" Long
1 Piece of Heavy Mesh Wire 24" x 48"
1 Piece of 1 1/4" Square Tubing 10" Long
1 Piece of 1" Square Tubing 33" Long
2 Pieces of 3/8" Rod 8" Long
4 Pieces of 1" x 1" x 1/8" Angle Iron 1½" Long
4 Pieces of ½" Pipe 16½" Long
2 Pieces of ½" Pipe 19½" Long
2 Pieces of ½" Pipe 22" Long
3 Pieces of 1 1/4" Channel Iron 23½" Long
2 Pieces of 1/4" x 1" Flat Metal 26" Long
2 Pieces of 5/32" Rod 10" Long
1 Washer, 2 Set Screws, and 2 Brace Rings



Curriculum and Instructional Materials Center
State Department of Vocational and Technical Educatioı
Stillwater, Oklahoma

LIVESTOCK HEAD GATE



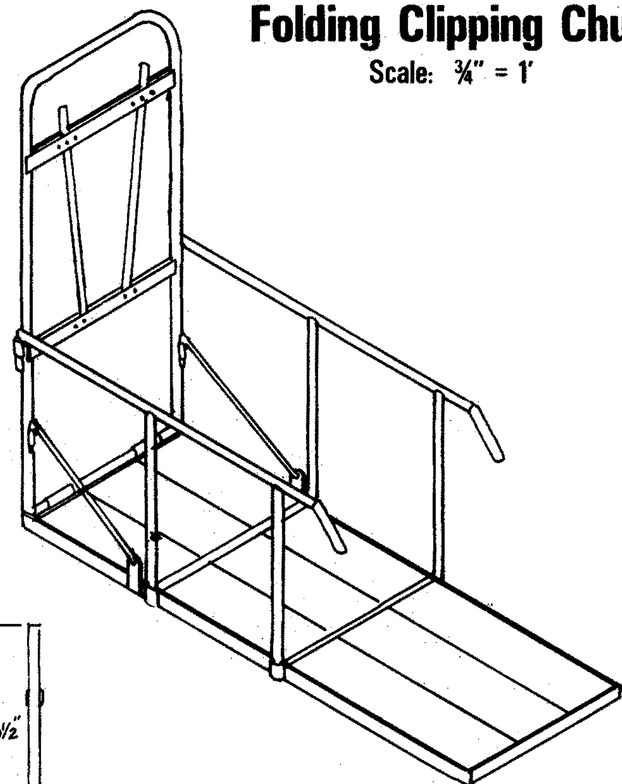
COMPLIMENTS OF
JIM ED. MUCKLEROY

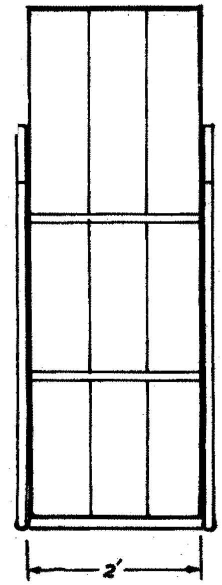
GARRISON, TEXAS

21.003

Folding Clipping Chute

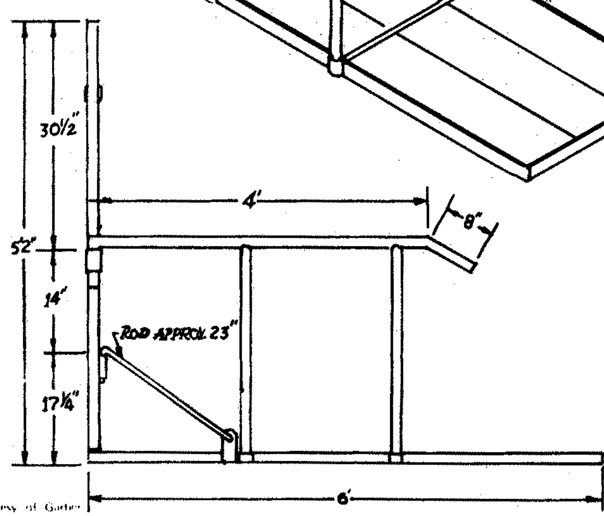
Scale: ¾" = 1'



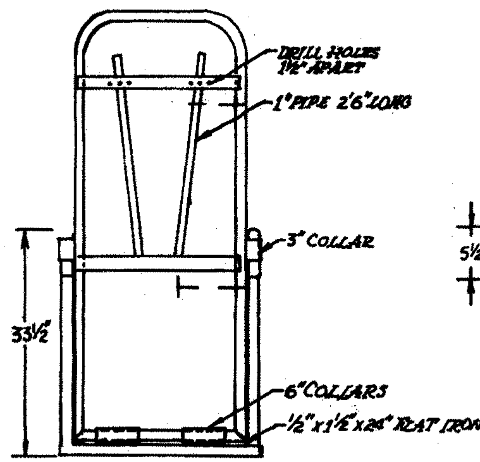


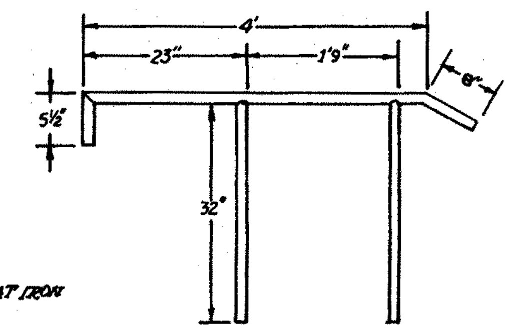
BILL OF MATERIAL

2 PIECES OF 2" ANGLE IRON 6' LONG
2 PIECES OF 2" ANGLE IRON 2' LONG
1 PIECE OF ½" x 1½" x 24" FLAT IRON
2 PIECES OF ¼" x 1" x 24" FLAT IRON
4 PIECES OF ¼" x 2" x 23" FLAT IRON
2 PIECES OF ½" x 2" x 4' FLAT IRON
2 PIECES OF 1½" PIPE 5' 2" LONG
2 PIECES OF 1½" PIPE 2" LONG
2 PIECES OF 1½" PIPE 8" LONG
4 PIECES OF 1½" PIPE 32" LONG
2 PIECES OF 1½" PIPE 4' LONG
2 PIECES OF 1½" PIPE 5½" LONG
2 PIECES OF 5/8" ROD APPROX. 25" LONG
2 PIECES OF ¾" PIPE 3" LONG
2 PIECES OF 1¾" PIPE 6" LONG
2 PIECES OF 1¾" PIPE 3" LONG
4 PIECES OF 1¾" PIPE 2" LONG
2 PIECES OF 1" PIPE 30" LONG



Courtesy of Garber Vocational Agriculture Department



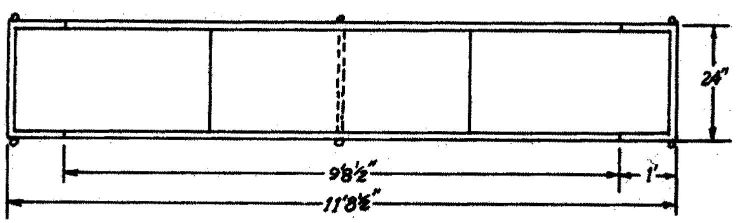


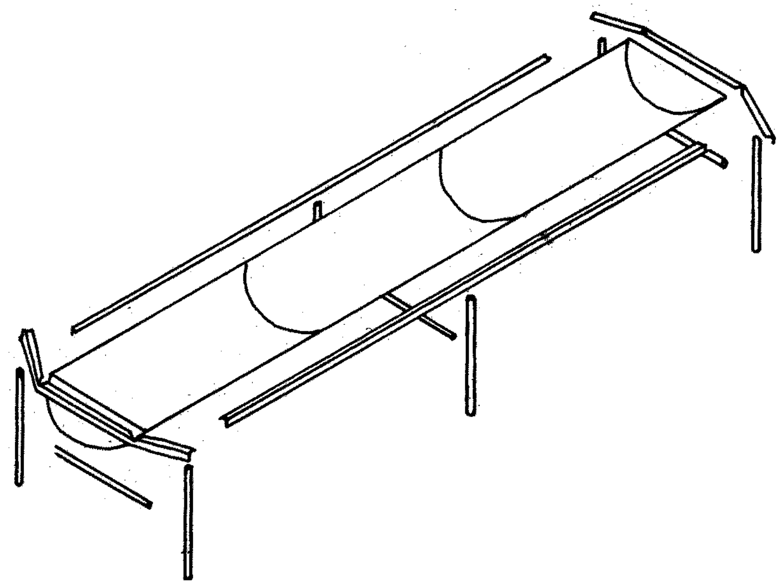
Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

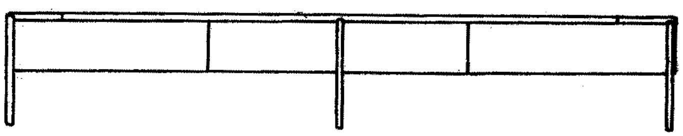
Barrel Feeder

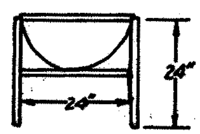
Scale: ½" = 1'

BILL OF MATERIAL
2 PIECES OF 1½" ANGLEIRON 9'8½" LONG
2 PIECES OF 1½" ANGLEIRON 4' LONG
9 PIECES OF 1½ PIPE 24" LONG
3 - 55 GAL BARREL HALVES









Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

Courtesy of Jet-Nash
Vocational Agriculture Department

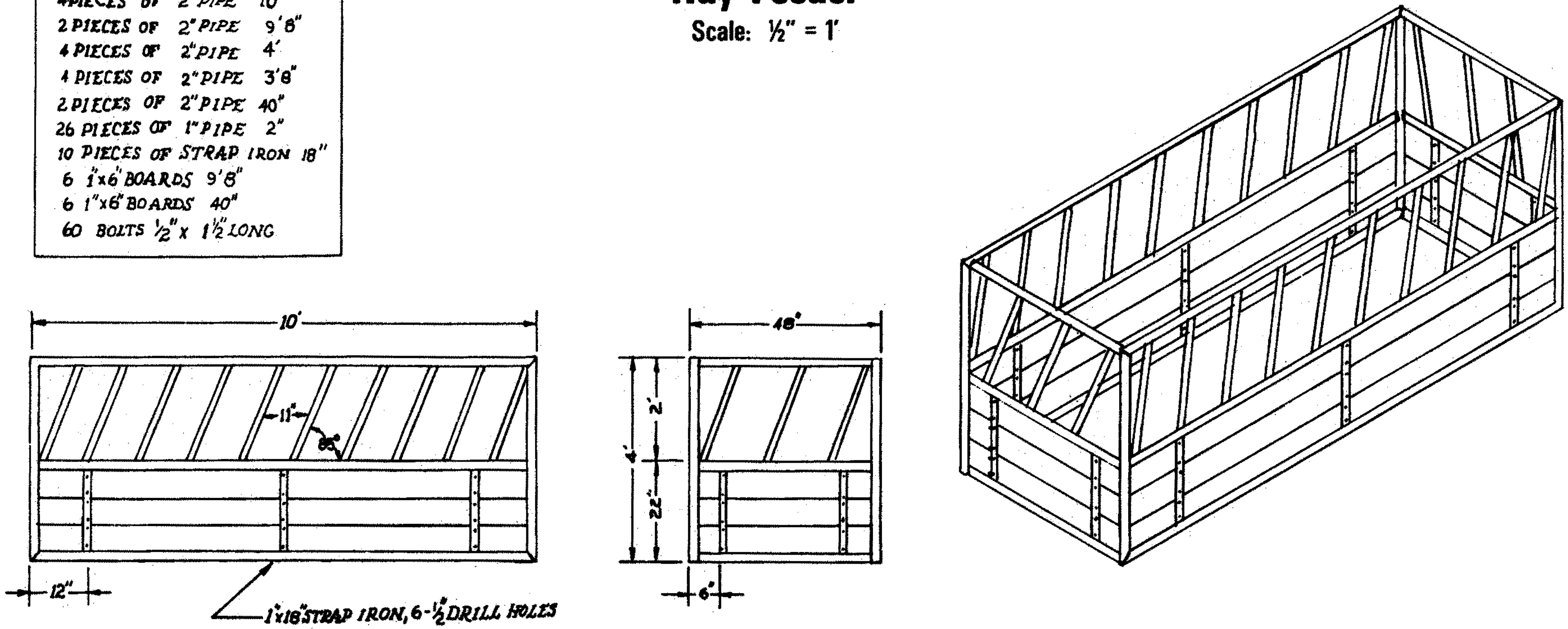
DWN BY: JOHN McEACHERN

Hay Feeder

Scale: ½" = 1'

BILL OF MATERIAL

4 PIECES OF 2" PIPE 10'
2 PIECES OF 2" PIPE 9'8"
4 PIECES OF 2" PIPE 4'
4 PIECES OF 2" PIPE 3'8"
2 PIECES OF 2" PIPE 40"
26 PIECES OF 1" PIPE 2'
10 PIECES OF STRAP IRON 18"
6 1"x6" BOARDS 9'8"
6 1"x6" BOARDS 40"
60 BOLTS ½" x 1½" LONG



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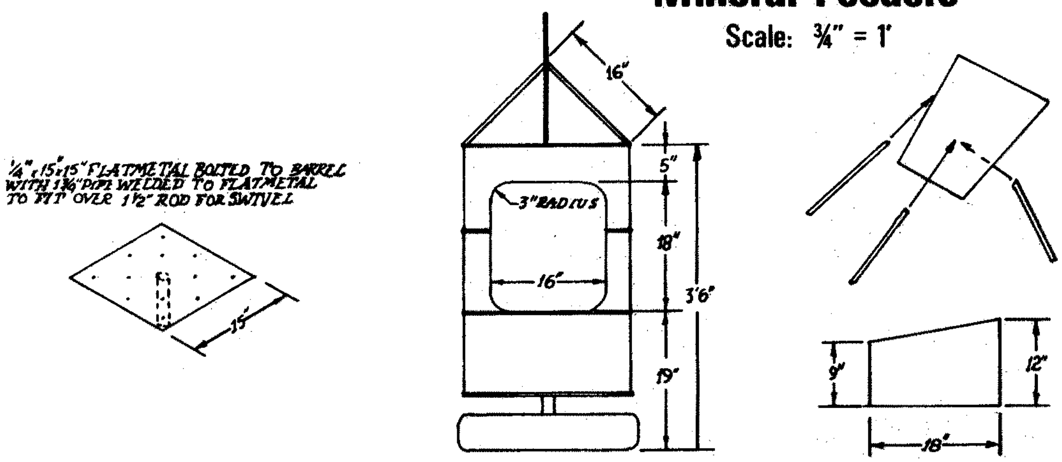
State Department of Vocational and Technical Education
Stillwater, Oklahoma

DWN BY: JOHN McEACHERN

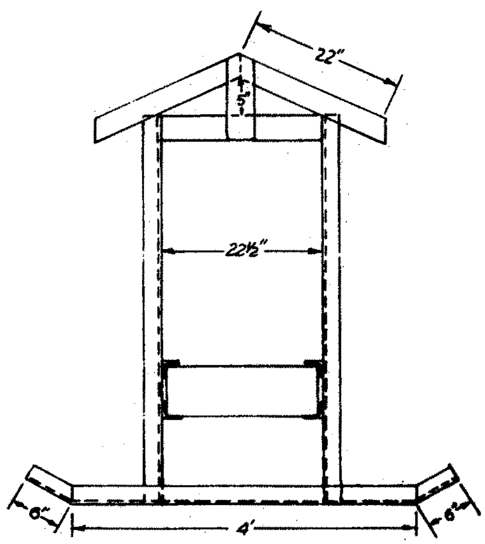
Courtesy of Jet-Nash
Vocational Agriculture Department

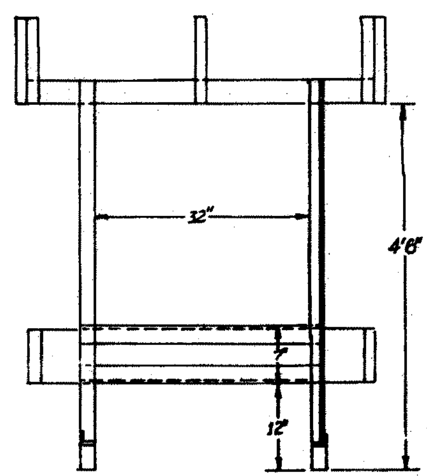
Mineral Feeders

Scale: ¾" = 1'



BILL OF MATERIAL
1-55GAL BARREL
1 PIECE OF 1½" ROD APPROX. 5" LONG
1 PIECE OF 1¾" PIPE APPROX 4" LONG
1 WHEEL & TIRE CEMENTED
1 PIECE OF SHEETMETAL 18" x 12"
3 WEATHER VAIN BRACES 16" LONG
1 PIECE OF ¼" x 15" x 15" FLATMETAL



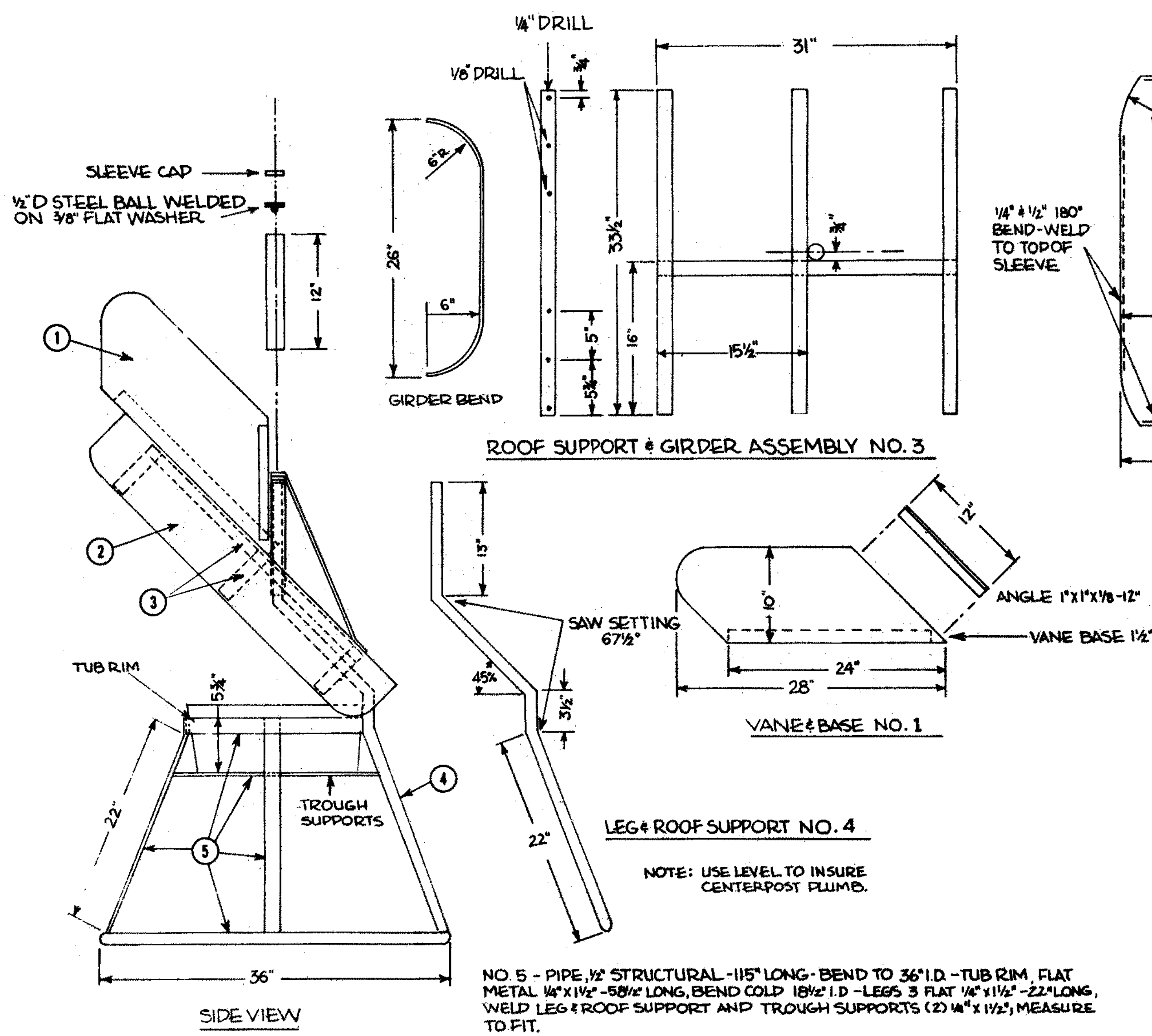


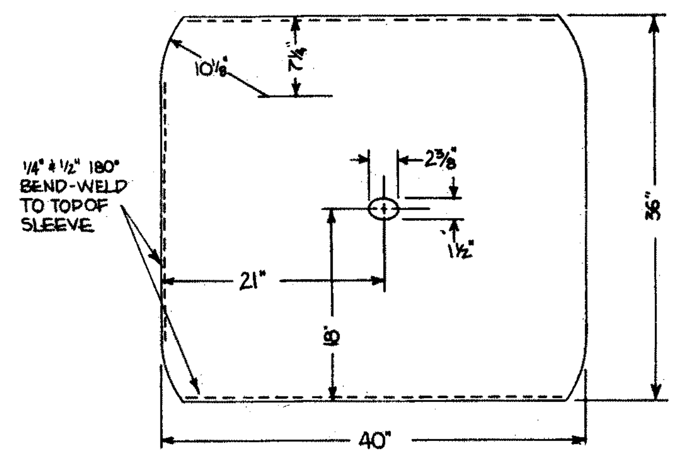
BILL OF MATERIAL
2 PIECES OF 2½" ANGLEIRON 5' LONG
4 PIECES OF 2½" ANGLEIRON 4'6" LONG
4 PIECES OF 2½" ANGLEIRON 32" LONG
4-2" x 6" BOARDS 3'9" LONG
2-2" x 6" BOARDS APPROX 22" LONG
2-2 x 4" BOARDS 4' LONG
2-2" x 4" BOARDS 19½" LONG
6-2" x 4" BOARDS 22" LONG
2-2" x 4" BOARDS 12" LONG

Courtesy of Coalgate Vocational Agriculture Department

Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

DRWN BY: JOHN McEACHERN





ROOF DETAIL NO. 2

BEND TO FIT GIRDER BEND.

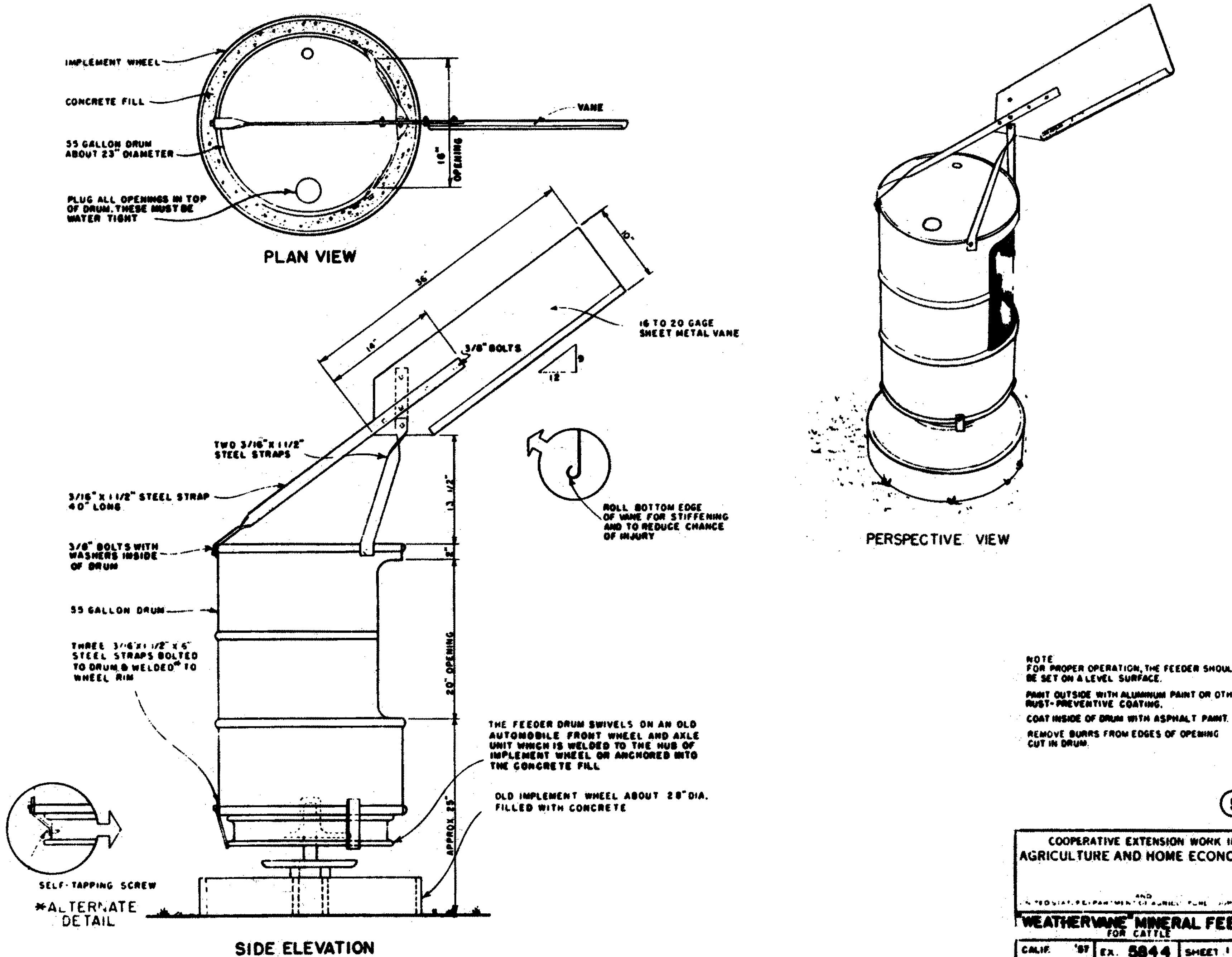
Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

Salt and Mineral Feeder

Scale: 3/32"=1"

BILL OF MATERIALS

1 - 1/2" Pipe 10' long
1 - 1" Pipe 5' long
1 - 1 1/4" Pipe 1' long
24' Flat metal 1/4" X 1 1/2"
3' Angle 1 1/2" X 1 1/2" X 3/16"
2' Angle 1 1/2" X 1 1/2" X 1/8"
1' Angle 1" X 1" X 1/8"
1 pc. Flat metal 1/4" X 1" - 2' long
1 pc. 22 ga. Galvanized sheet metal 36" X 40"
1 pc. 22 ga. Galvanized sheet metal 20'. X 28"
1 - 3/8" Flat washer
1 - 1/2" Ball Bearing
12 - 1/4" X 1/2" Sheet metal bolts
12 - Pop rivets, 1/8" X 3/8"
1 - Rubber Tub, 50 lb. capacity
3 - 1/4" X 1" Sheet metal bolts



NOTE
FOR PROPER OPERATION, THE FEEDER SHOULD BE SET ON A LEVEL SURFACE.

PAINT OUTSIDE WITH ALUMINUM PAINT OR OTHER RUST-PREVENTIVE COATING.

COAT INSIDE OF DRUM WITH ASPHALT PAINT.

REMOVE BURRS FROM EDGES OF OPENING CUT IN DRUM.

9

COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS

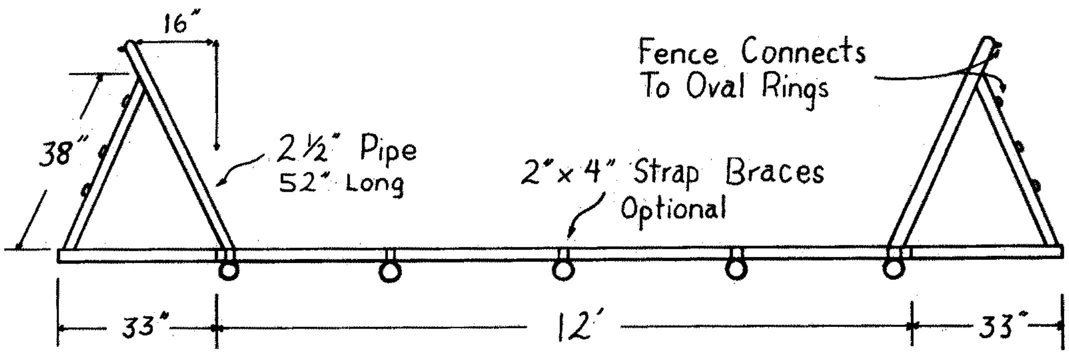
AND

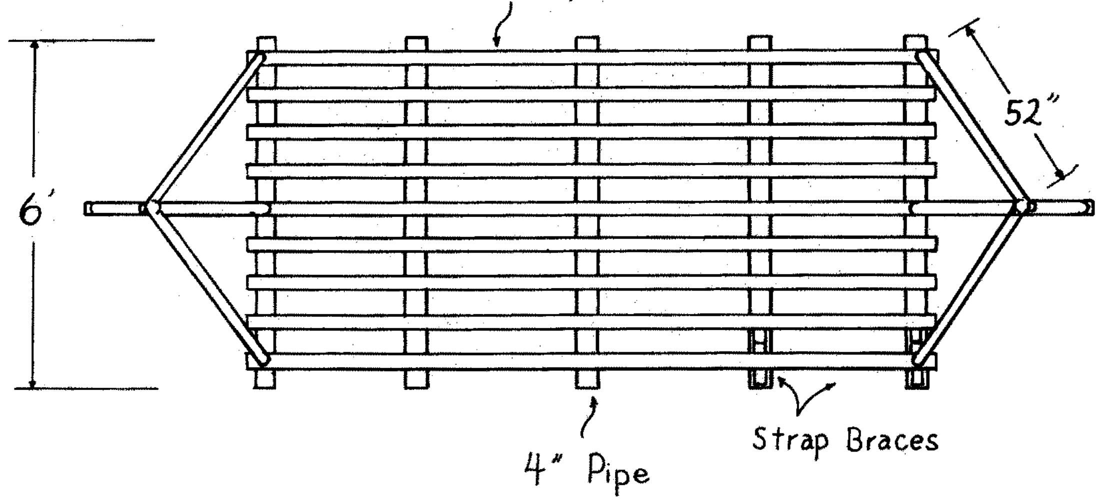
"WEATHERVANE" MINERAL FEEDER
FOR CATTLE

CALIF. '57	EX. 5844	SHEET 1 OF 1

Cattle Guard

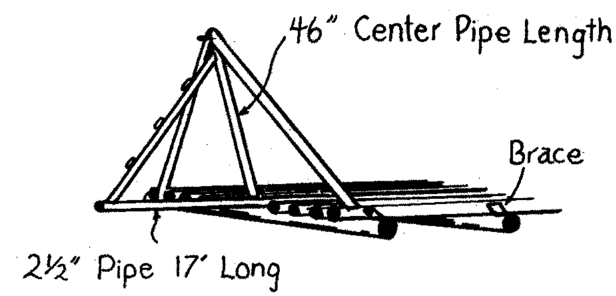
Scale: 1/2"=1'





BILL OF MATERIAL

5 Pieces of 4" Pipe 72" Long
8 Pieces of 2½" Pipe 12' Long
1 Piece of 2½" Pipe 17' Long
4 Pieces of 2½" Pipe 52" Long
2 Pieces of 2½" Pipe 47" Long
2 Pieces of 2½" Pipe 38" Long
20 Pieces of 2" x 4" Strap Metal
70 Pieces of 1½" x 3" Strap Metal
8 Pieces of Oval Shaped Rings



Pictorial View of One End

Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

Courtesy of Coweta
Vocational Agriculture Department

Rea

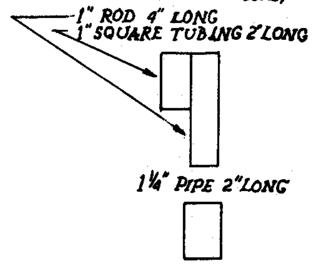
Pickup Stock Racks

Scale: ¾" = 1'

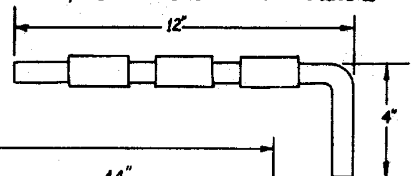
BILL OF MATERIALS

4 PIECES OF 1¼" SQ. TUBING 4'2" LONG
2 PIECES OF 1¼" SQ. TUBING 3'10" LONG
2 PIECES OF 1" SQ. TUBING 7' 10½" LONG
14 PIECES OF 1" SQ TUBING 7'8" LONG
4 PIECES OF 1" SQ TUBING 5' 7½" LONG
2 PIECES OF 1" SQ TUBING 7" LONG
2 PIECES OF 1" SQ TUBING 6" LONG
4 PIECES OF 1" SQ TUBING 1'10¾" LONG
2 PIECES OF 1" SQ TUBING 5' 4¾" LONG
2 PIECES OF 1" SQ TUBING 5' LONG
4 PIECES OF 1" SQ TUBING 4'10" LONG
4 PIECES OF 1" SQ TUBING 4' 7" LONG
6 PIECES OF 1" SQ TUBING 4' 5" LONG
8 PIECES OF 1" SQ TUBING 3½" LONG
1 PIECE OF WIRE MESH 1'11" x 4'4½" LONG
1 PIECE OF ¾" ROD 16" LONG
4 PIECES OF 1" ROD 4" LONG
8 PIECES OF 1" SQ. TUBING 2" LONG
4 PIECES OF 1½" PIPE 2" LONG
3 PIECES OF 1" PIPE 2" LONG
4 PIECES OF 5/8" PIPE 1'4" LONG
4 MACHINE BOLTS-NUTS-WASHERS ½" x 5½"

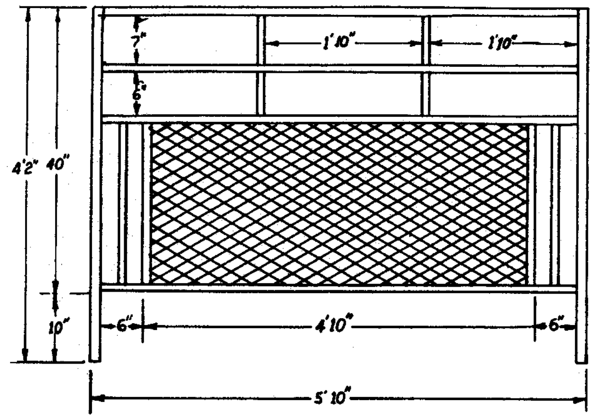
(GATE HINGE DETAIL)

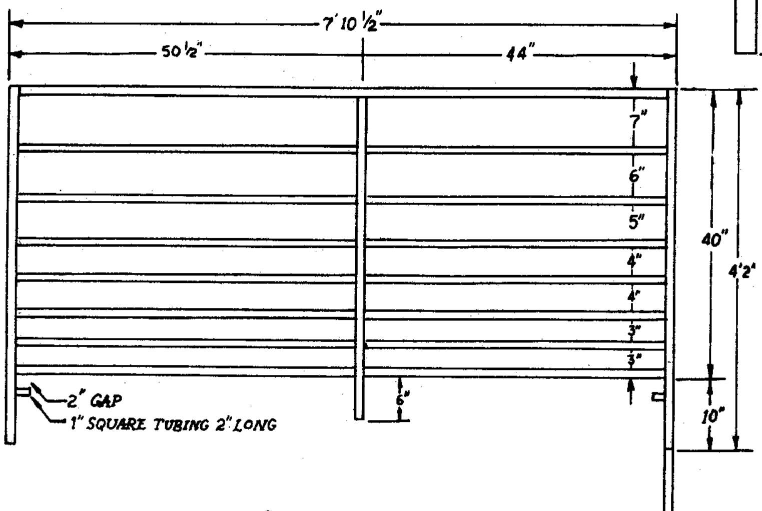


(GATE LATCH DETAIL)
3 PIECES OF 1" PIPE 2" LONG
¾" ROD 12" LONG WITH 4" HANDLE

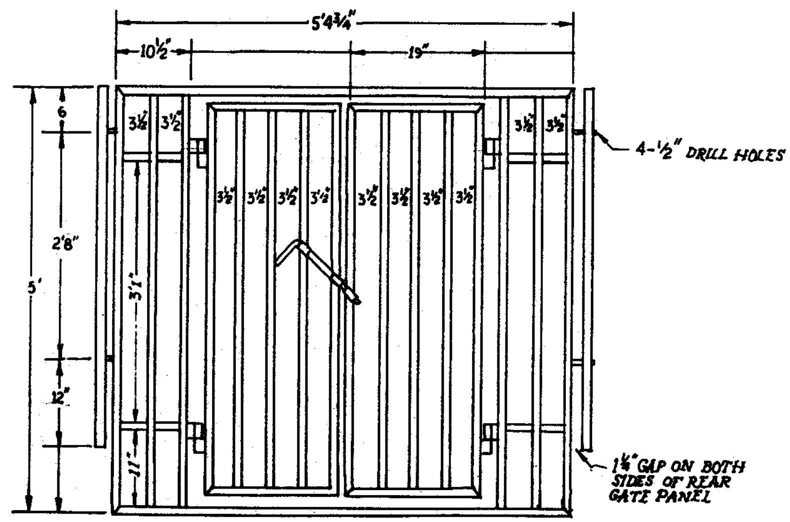


FRONT





SIDE



1" GAP BETWEEN GATES
1" GAP ON TOP OF GATES
2" GAP ON BOTTOM OF GATES
GATE LATCH ON 45° ANGLE

BACK

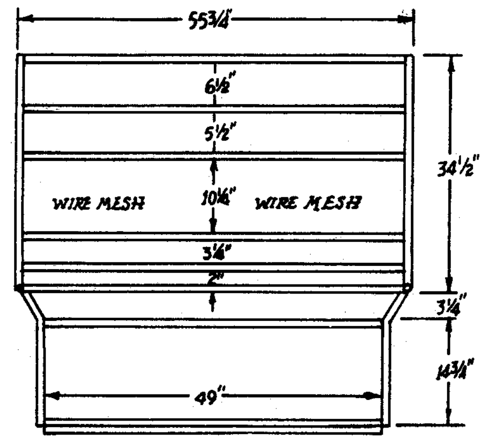
DWN BY: JOHN McEACHERN

Courtesy of Vinita
Vocational Agriculture Department

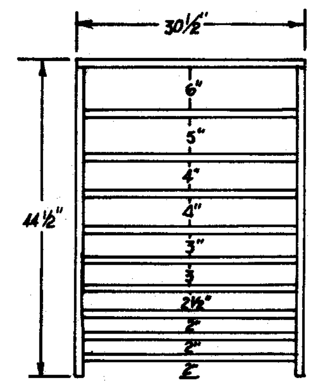
Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

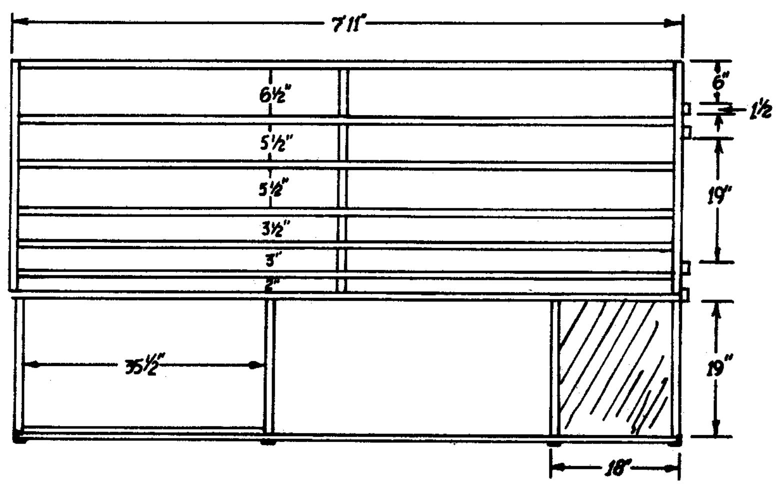
Pickup Stock Racks

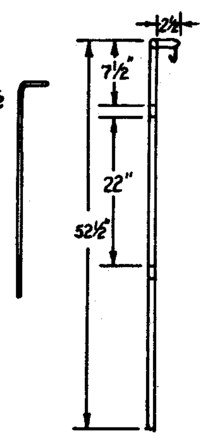
Scale: ¾" = 1'

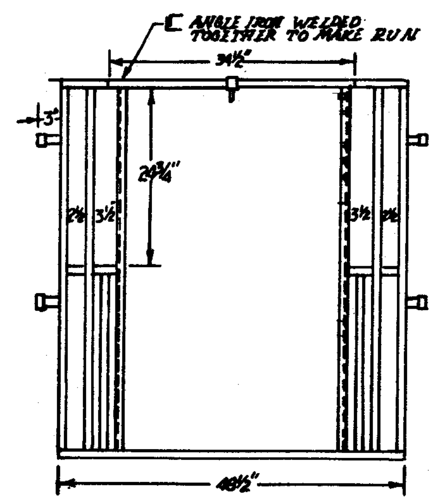


BILL OF MATERIAL*
4 SQUARE FEET OF EXPANSION STEEL
4 SQUARE FEET OF 18 GUAGE SHEETMETAL
8' OF 1" STRAP IRON
12 - 2½" ROUND HEAD STOVE BOLTS
24' OF 1" x 6" FENCING LUMBER
7' OF ¼" PIPE
265' OF ¾" PIPE









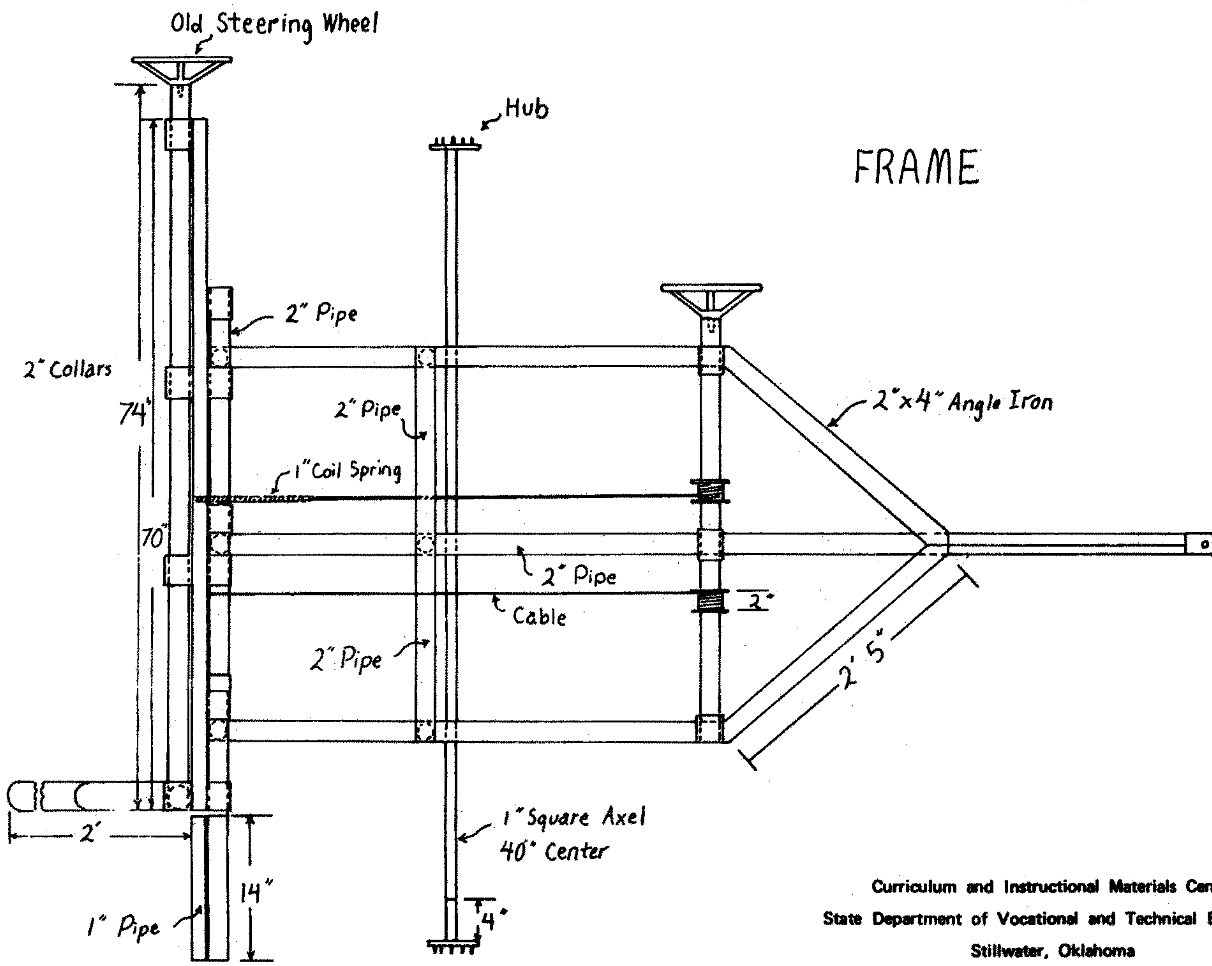
Courtesy of Guthrie
Vocational Agriculture Department

DRAWN BY: JOHN McEACHERN

Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

Tilting Calf Hoof Trimming Table

Scale: 1"=1'

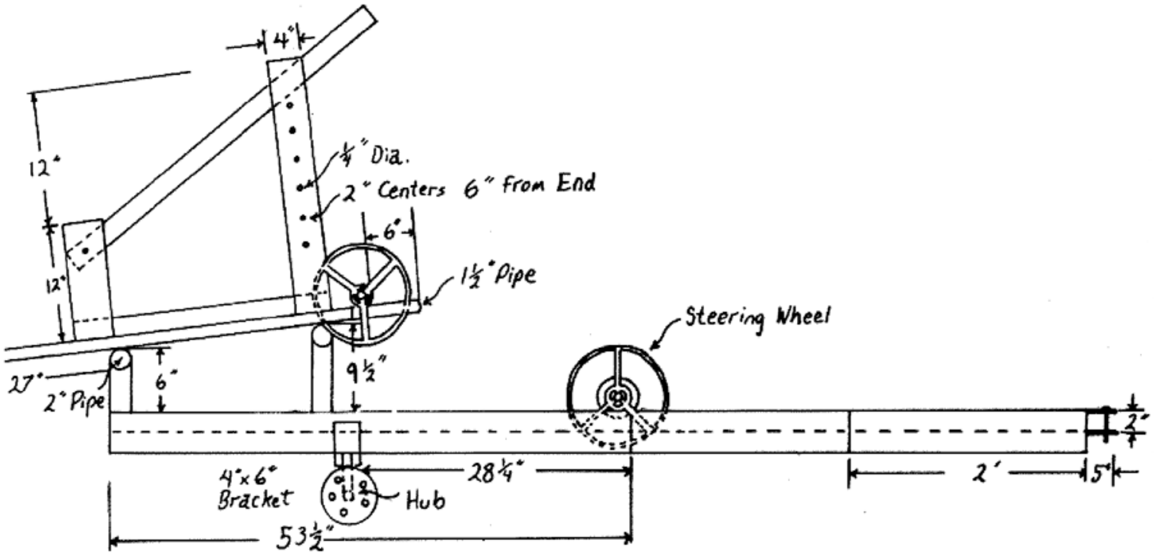


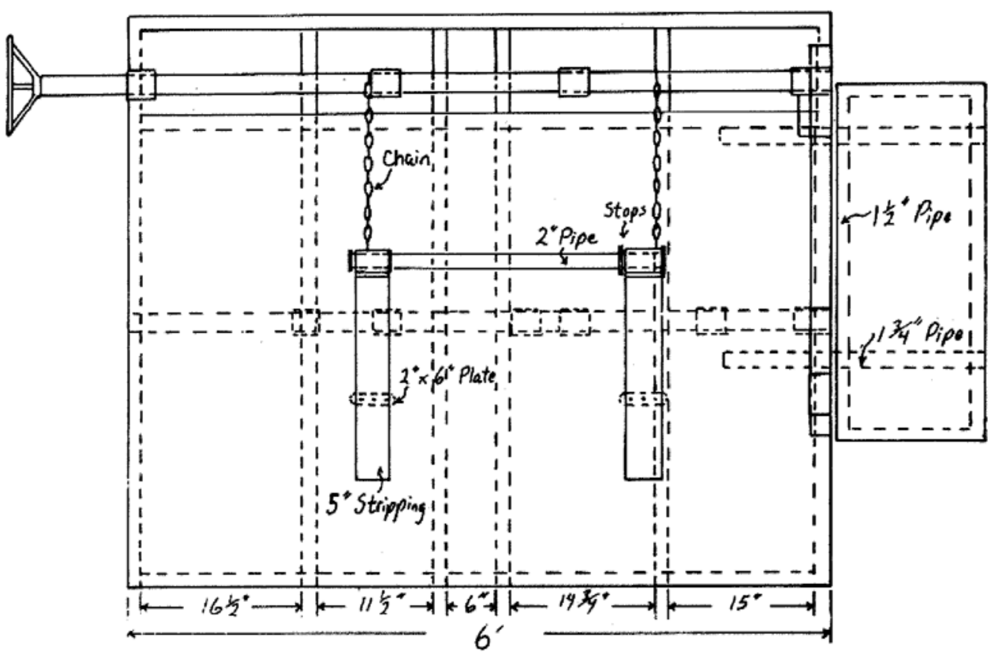
BILL OF MATERIAL

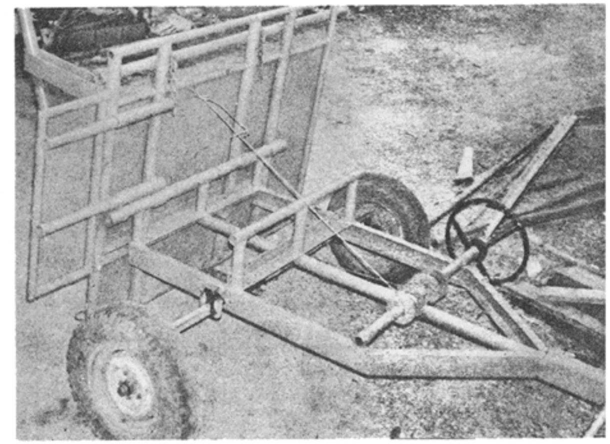
1 Piece of Sheet Metal 6' x 4'
1 Piece of 2" Pipe 32" Long
1 Piece of Sheet Metal 4' x 16"
4 Pieces of 1 1/2" Pipe 6' Long
6 Pieces of 1 1/2" Pipe 4' Long
2 Pieces of 1 1/2" Pipe 16" Long
2 Pieces of 1 1/2" Pipe 36" Long
2 Pieces of 1 3/4 Pipe 28" Long
12 Pieces of 1 3/4 Pipe 4" Long
1 Piece of 2" Pipe 72" Long
2 Pieces of 2" x 4" Angle Iron 50" Long
2 Pieces of 2" x 4" Angle Iron 2'5" Long
2 Pieces of 2" x 4" Angle Iron 24' Long
2 Pieces of 2" Pipe 40" Long
1 Piece of 1" Square Axel 80" Long
1 Piece of 2" Pipe 68" Long
2 Pieces of 4" x 5" Strap Metal
1 Piece of 2" Pipe 74" Long
1 Piece of 1" Pipe 19" Long
13 Pieces of 2" Pipe Collar 4" Long
2 Pieces of 2" x 4" Angle Iron 40" Long
3 Pieces of 2" Pipe 6" Long
3 Pieces of 2" Pipe 9 1/2" Long
2 Pieces of 1/4" Metal Strap 4" x 12"
2 Pieces of 1/4" Metal Strap 4" x 26"
1 Piece of 2" Pipe 40" Long
1 Piece of 2" Pipe 26" Long
2 Wheel Brackets 4" x 6"
2 Steering Wheels, 2 wheel hubs, 2 Cable Spools
2 Pieces of Metal Plate 2" x 6"
4 Pieces of Circular Metal 3" Diameter
2 Pieces of 5" Stripping and Medium Chain

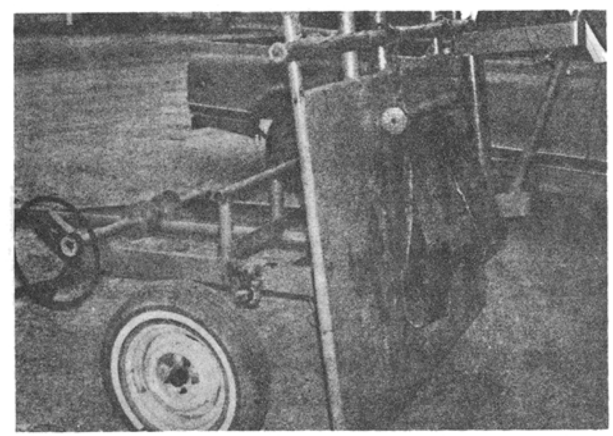
Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

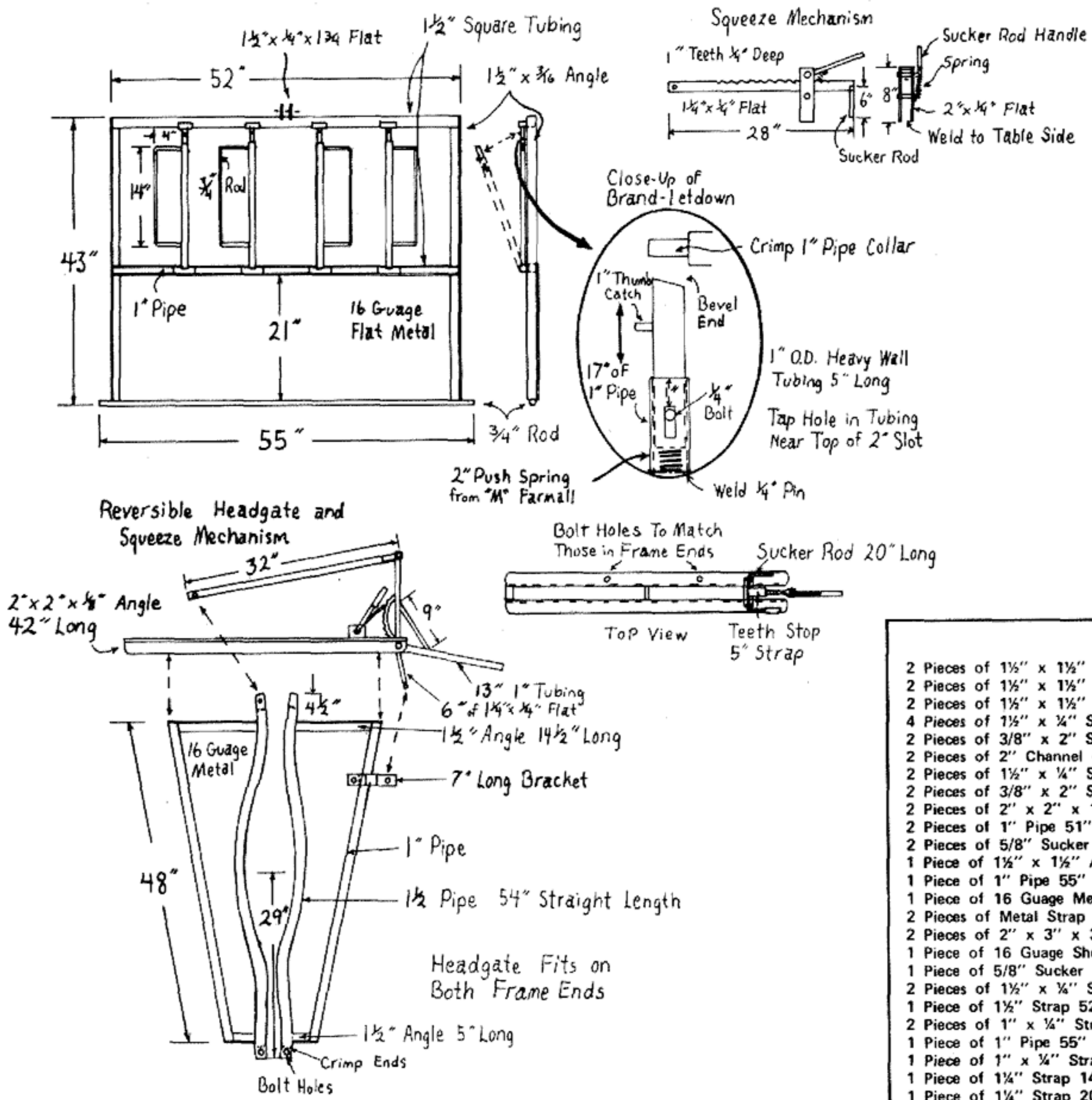
Courtesy of Davis
Vocational Agriculture Department

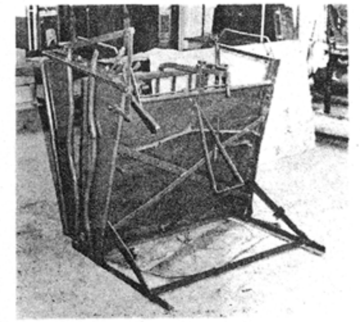

4"
12"
12"
27°
2" Pipe
6"
1/4" Dia.
2" Centers 6" From End
6"
1 1/2" Pipe
9 1/2"
Steering Wheel
2"
4"x6" Bracket
Hub
28 1/4"
2'
5"
53 1/2"

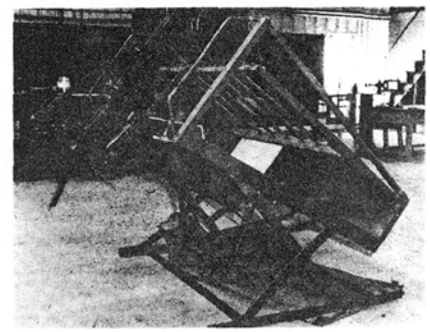

Chain
Stops
2" Pipe
1 1/2" Pipe
1 3/4" Pipe
2"x6" Plate
5" Stripping
16 1/2"
11 1/2"
6"
14 3/4"
15"
6'









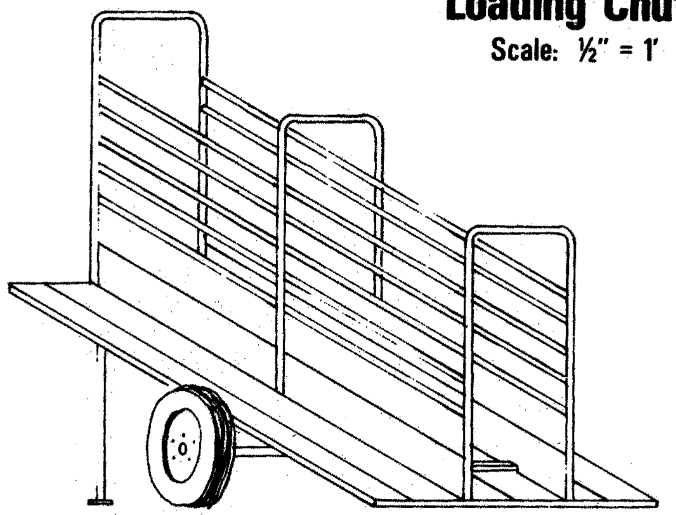


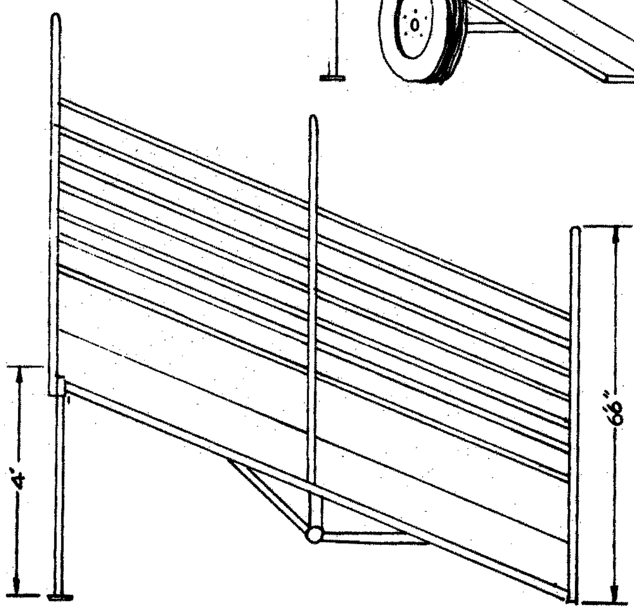
BILL OF MATERIAL

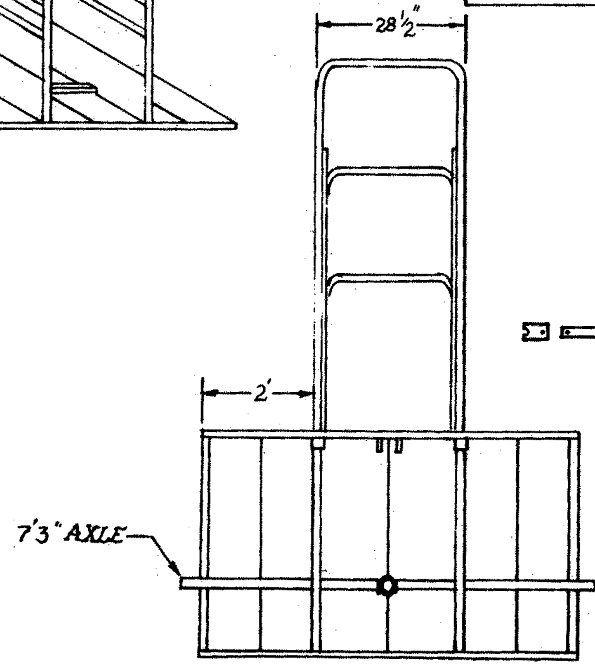
2 Pieces of 1½" x 1½" Angle Iron 55½" Long
2 Pieces of 1½" x 1½" Angle Iron 45" Long
2 Pieces of 1½" x 1½" Angle Iron 4" Long
4 Pieces of 1½" x ¼" Strap 7" Long
2 Pieces of 3/8" x 2" Strap 29" Long
2 Pieces of 2" Channel 4" Long
2 Pieces of 1½" x ¼" Strap 59" Long
2 Pieces of 3/8" x 2" Strap 45½" Long
2 Pieces of 2" x 2" x 1/8" Angle Iron 28" Long
2 Pieces of 1" Pipe 51" Long
2 Pieces of 5/8" Sucker Rod 30" Long
1 Piece of 1½" x 1½" Angle Iron 52" Long
1 Piece of 1" Pipe 55" Long
1 Piece of 16 Guage Metal 7" x 55"
2 Pieces of Metal Strap 10" Long
2 Pieces of 2" x 3" x 3/16" Angle Iron 50½" Long
1 Piece of 16 Guage Sheet Metal 55" x 41½"
1 Piece of 5/8" Sucker Rod 45" Long
2 Pieces of 1½" x ¼" Strap 7" Long
1 Piece of 1½" Strap 52" Long
2 Pieces of 1" x ¼" Strap 27½" Long
1 Piece of 1" Pipe 55" Long
1 Piece of 1" x ¼" Strap 40" Long
1 Piece of 1¼" Strap 14" Long
1 Piece of 1¼" Strap 20' Long
1 Piece of 16 Guage Sheet Metal 21" x 52"
1 Piece of 1½" Square Tubing 52" Long
1 Piece of ¾" Rod 55" Long
1 Piece of 1" Pipe 52" Long
4 Pieces of 1" Pipe 17" Long
4 Pieces of 1" O.D. Heavy Wall Tubing 5" Long
4 Pieces of 1" Pipe Collar 1" Long
4 Pieces of ¼" Bolt & ¼" Pin
4 Pieces of 2" Push Spring
4 Pieces of ¾" Rod 22" Long
2 Pieces of 1" Pipe 48" Long
2 Pieces of 1½" Pipe 54" Long
2 Pieces of 1½" Angle Iron 14½" Long
2 Pieces of 1½" Angle Iron 5" Long
1 Piece of 16 Guage Metal 28" x 48"
1 Piece 1¼" x ¼ Flat 7" Long
2 Pieces of 2" x 2" x 1/8" Angle Iron 42" Long
1 Piece of ¾" Tubing 13" Long
1 Piece of 1¼" x ¼" Flat 55" Long
1 Piece of 5/8" Rod 20" Long
1 Piece of 1¼" x ¼" Flat 28" Long
1 Piece of 5/8" Rod 16" Long
2 Pieces of 2" x ¼" Flat 8" Long
1 Piece of old Flywheel with Teeth

Loading Chute

Scale: ½" = 1'

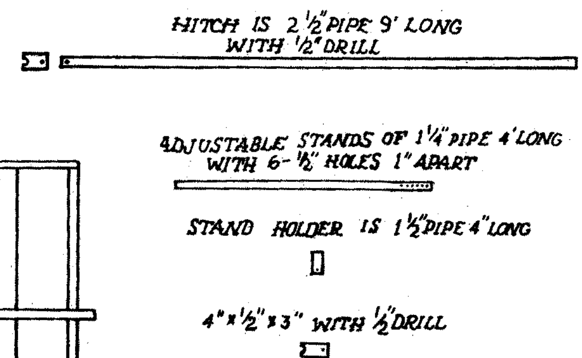






BILL OF MATERIAL

10 PIECES OF 1" SQUARE TUBING 10' LONG
6 PIECES OF 1¼" SQUARE TUBING 5' LONG
8 PIECES OF 1" SQUARE TUBING 26" LONG
1 PIECE OF 2½" PIPE 7' 3" LONG
5 PIECES OF 1¼" PIPE 4' LONG
2 PIECES OF 1½" PIPE 4" LONG
1 PIECE OF 2½" PIPE 9' LONG
4 PIECES OF 2"×1½" ANGLEIRON 10' LONG
2 PIECES OF 2"×1½" ANGLEIRON 6'7" LONG
4 PIECES OF 2"×1½" ANGLEIRON 2' LONG
2 PIECES OF 2"×1½" ANGLEIRON 8" LONG
4 PIECES OF FLATIRON 4"×3"×½"
4 PIECES OF FLATIRON 4"×4"×½"
4 BOARDS 2"×10" – 10' LONG
24 - ¼" CARRIAGE BOLTS 2½" LONG
2 - ¼" MACHINE BOLTS 2½" LONG
1 - ½" MACHINE BOLTS 3½" LONG



Courtesy of Jet-Nash
Vocational Agriculture Department

Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

DWN BY: JOHN McEACHERN

All Purpose Trailer

Scale: 1/2"=1'

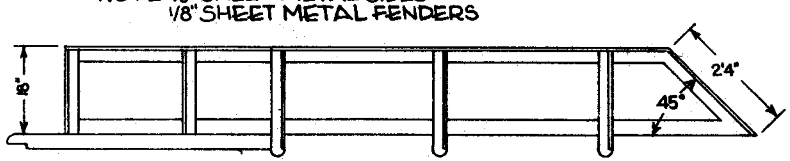
NOTE: CENTER OF AVELS ARE LOCATED
1/2" BACK OF CENTER FOR EVERY
FOOT OF LENGTH

TOTAL LENGTH: 12'
TOTAL WIDTH: 7'6"

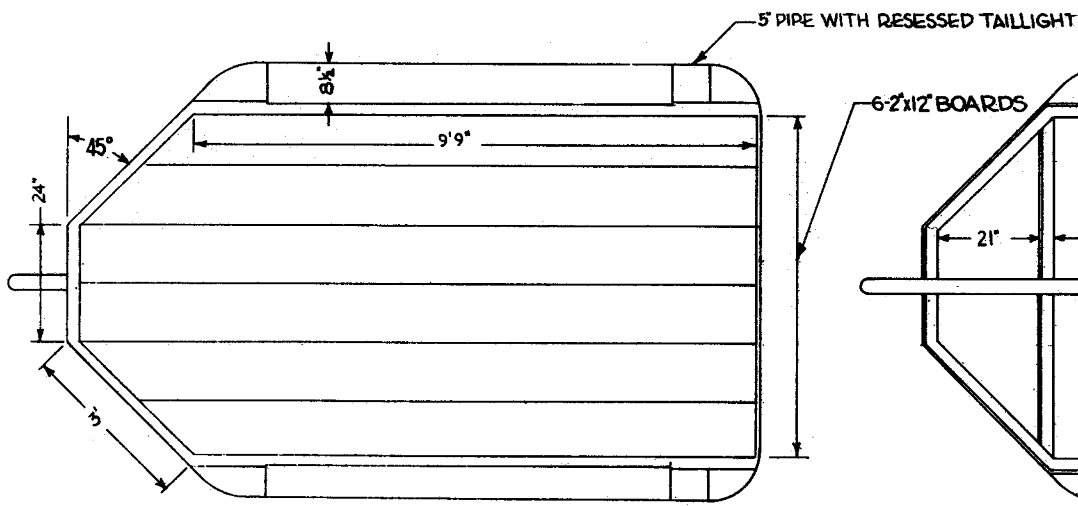
NOTE: 1/8" SHEET METAL SIDES
1/8" SHEET METAL FENDERS

BILL OF MATERIAL

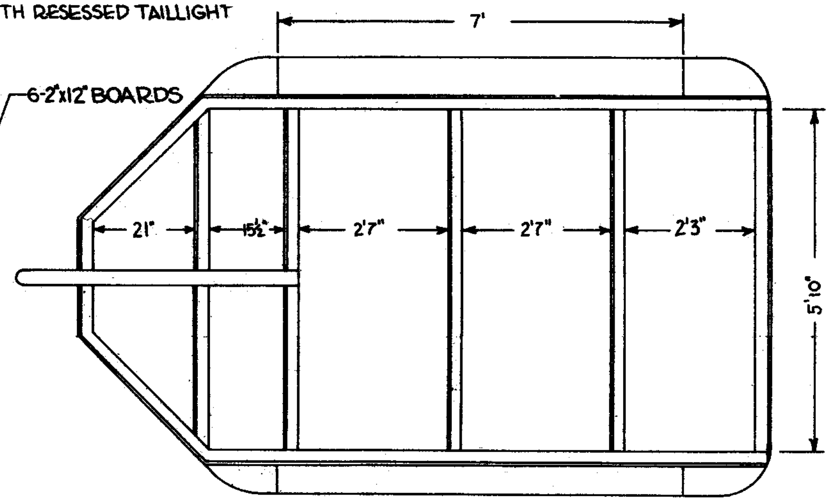
4 Pieces of 3" Angle Iron 10'1" Long
4 Pieces of 3" Angle Iron 3' Long
2 Pieces of 3" Angle Iron 2" Long
4 Pieces of 3" Angle Iron 6'2" Long
1 Piece of 3" Angle Iron 6' Long
10 Pieces of 3" Angle Iron 17 1/2" Long
2 Pieces of 3" Angle Iron 2'4" Long
2 Pieces of 1/8" Sheetmetal 7' X 8 1/2"
2 Pieces of 1/8" Sheetmetal 2'4" X 8 1/2"
2 Pieces of 1/8" Sheetmetal 1'11" X 8 1/2"
6 - 2" X 12" X 11'9" Boards
2 Pieces of 1/2" Sheetmetal 7'9" X 17"
2 Pieces of 1/8" Sheetmetal 3' X 17"
1 Piece of 1/8" Sheetmetal 2' X 17"



SIDE VIEW



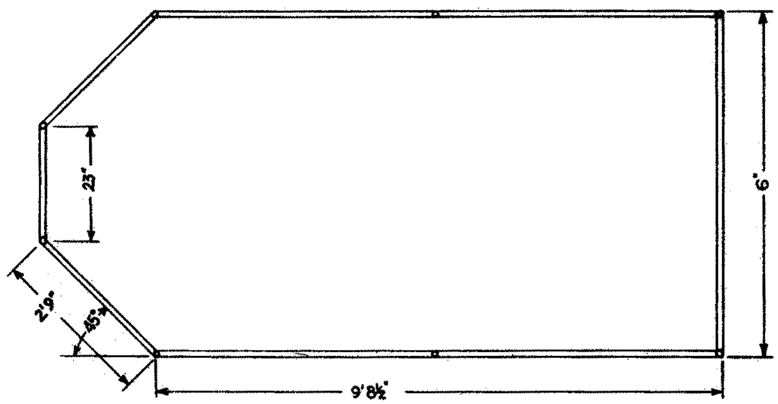
TOP VIEW



BOTTOM FRAME VIEW

NOTE: ALL FRAME WORK-3" ANGLE IRON

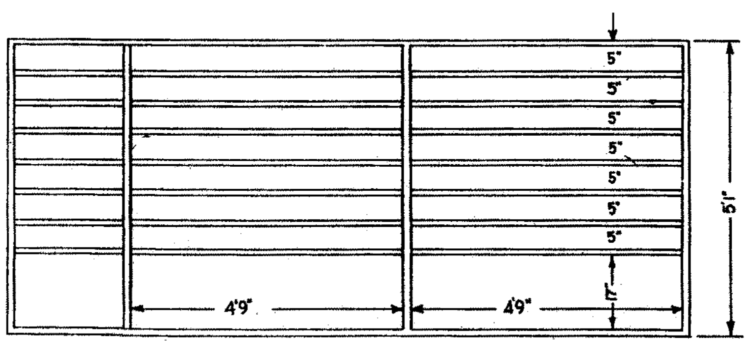
Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

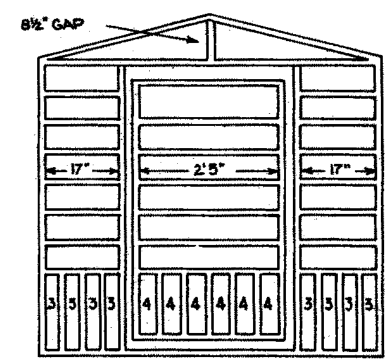


BILL OF MATERIAL

8 Pieces of 1" Pipe 5" Long
2 Pieces of 1" Pipe 4'1" Long
2 Pieces of 1" Pipe 4'6" Long
6 Pieces of 1" Pipe 17" Long
5 Pieces of 1" Pipe 1'2" Long
9 Pieces of 1" Pipe 23" Long
18 Pieces of 1" Pipe 2'9" Long
36 Pieces of 1" Pipe 4'9" Long
2 Pieces of 1" Pipe 5'10" Long
2 Pieces of 1" Pipe 2'7" Long
14 Pieces of 1" Pipe 17" Long
6 Pieces of 1" Pipe 2'5" Long
1 Piece of 1" Pipe 8 1/2" Long
2 Pieces of 1" Pipe 37" Long
2 Pieces of 1" Pipe 4" Long
1 Piece of 1" Pipe 7" Long
3 Pieces of 1 1/2" Pipe 3" Long
4 Pieces of 1 1/2 Pipe 1 1/2" Long

NOTE: RACKS ARE HELD IN WITH SPRING LOADED BOOMERS

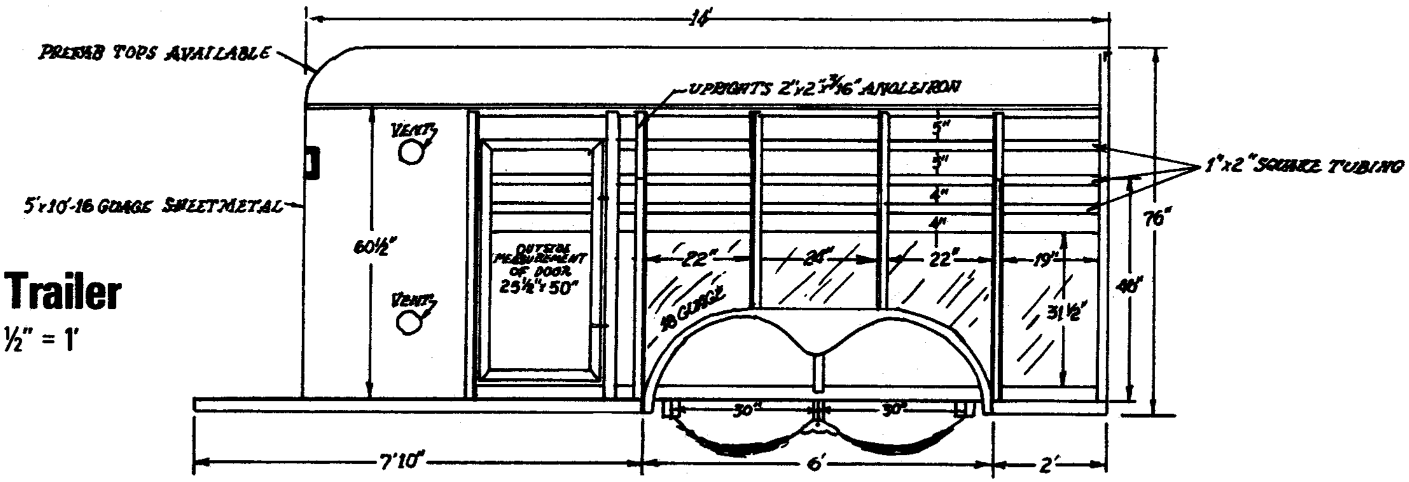




GATE OUTSIDE MEASUREMENTS 4'6" X 2'7"

Stock Trailer

Scale: ½" = 1'



BILL OF MATERIAL

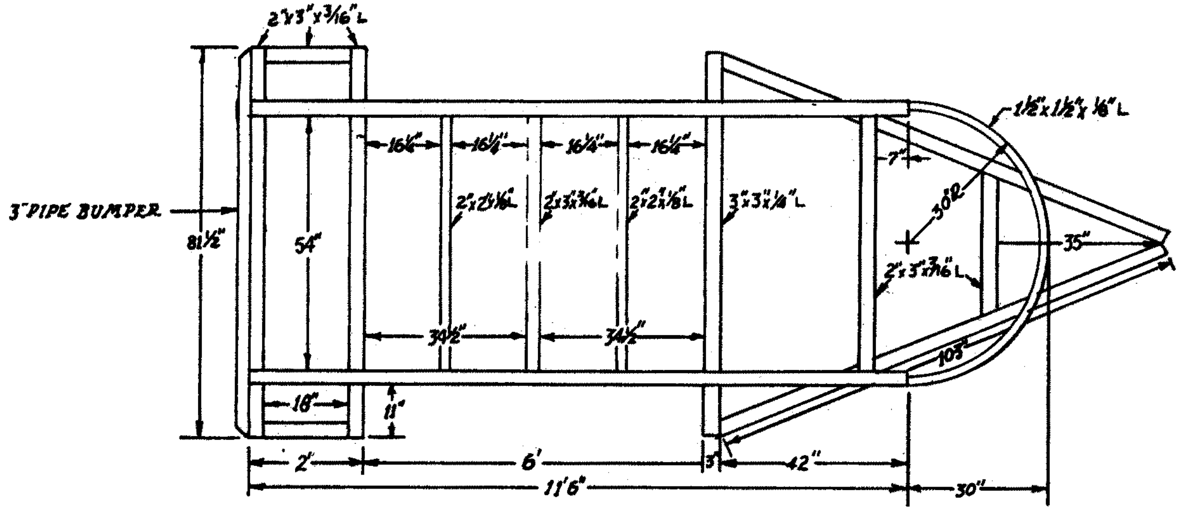
2 PIECES OF 3" ANGLEIRON 11'6" LONG	2 PIECES OF 1¼" PIPE 4'9" LONG
3 PIECES OF 3" ANGLEIRON 81½" LONG	4 PIECES OF 1½" PIPE 1½" LONG
2 PIECES OF 3" ANGLEIRON 103" LONG	4 PIECES OF STRAPIRON 1½"x4"x3/8"
2 PIECES OF 3" ANGLEIRON 54" LONG	12 PIECES OF ¾" PIPE 1½" LONG
2 PIECES OF 2" ANGLEIRON 54" LONG	2 - ½" PINS 5" LONG
1 PIECE OF 1½" ANGLEIRON 15'8½" LONG	1 - ½" ROD 4' LONG
1 PIECE OF 3" PIPE 81½" LONG	4 PIECES OF FLATMETAL 2½"x2½"
2 PIECES OF 2½" ANGLEIRON 6'1" LONG	2 PIECES OF 1"x2" SQ TUBING 4'7" LONG
1 PREFAB TOP	4 PIECES OF 1"x2" SQ TUBING 47" LONG
8 PIECES OF 2" ANGLEIRON 5' LONG	1 PIECE OF 1"x2" SQ TUBING 43" LONG
4 PIECES OF 2" ANGLEIRON 3'5" LONG	7 PIECES OF 1"x2" SQ TUBING 25" LONG
2 PIECES OF 2" ANGLEIRON 6' LONG	2 PIECES OF 1"x2" SQ TUBING 26½" LONG
6 PIECES OF 1" SQ TUBING 4' LONG	7 PIECES OF 1"x2" SQ TUBING 22½" LONG
2 PIECES OF 1"x2" SQ TUBING 4'9" LONG	2 PIECES OF 1"x2" SQ TUBING 25½" LONG
2 PIECES OF 1"x2" SQ TUBING 4'7" LONG	2 PIECES OF 1"x2" SQ TUBING 50" LONG
2 PIECES OF 1"x2" SQ TUBING 4'6" LONG	2 PIECES OF 1"x2" SQ TUBING 21½" LONG
2 PIECES OF 1"x2" SQ TUBING 2'2" LONG	3 PIECES OF SHEETMETAL 2'x2'6"
1 PIECE OF 1"x2" SQ TUBING 4'5" LONG	1 PIECE OF SHEETMETAL 2'x2'4"
6 PIECES OF 1"x2" SQ TUBING 1'10" LONG	2 PIECES OF SHEETMETAL 8'6"x31½"
8 BOARDS 2"x8"	1 PIECE OF SHEETMETAL 5'x10'

Courtesy of Guthrie
Vocational Agriculture Department

Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

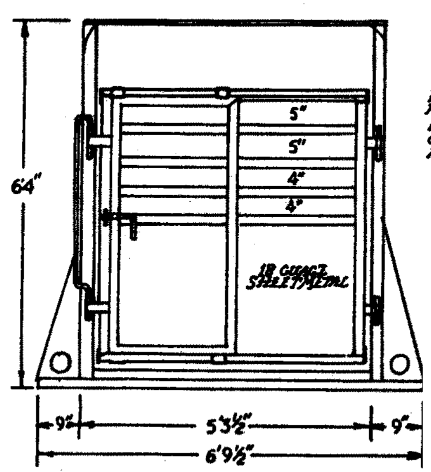
Stock Trailer

Scale: ½" = 1'



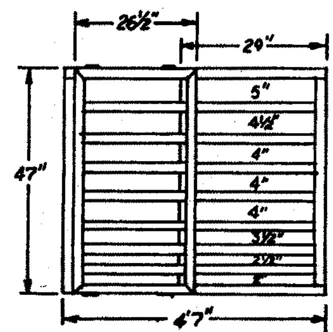
MAIN FRAME

REAR VIEW



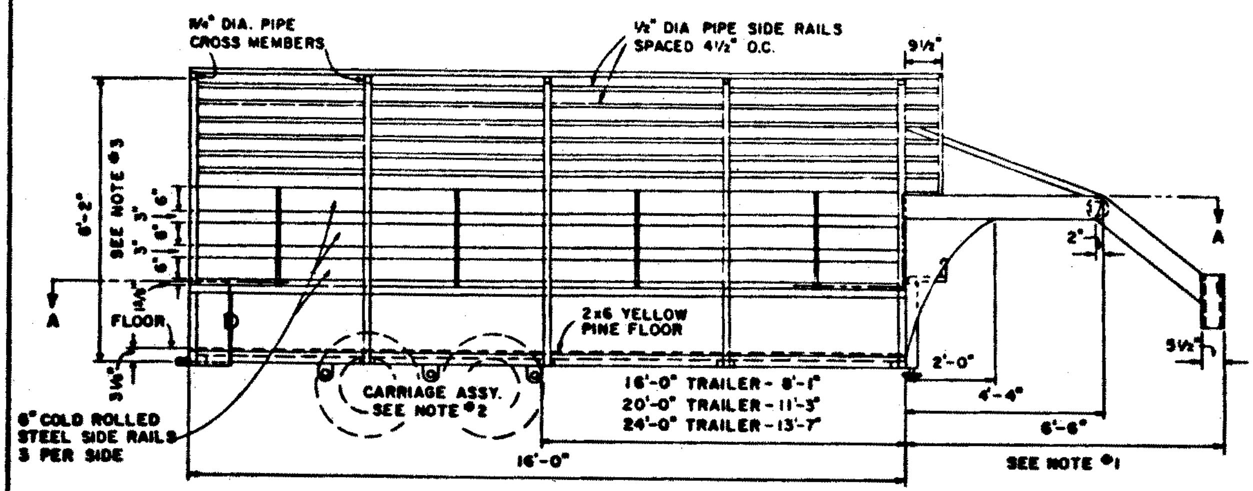
REAR GATE OUTSIDE MEASUREMENTS 4'7"x4'9"
REAR GATE DOOR SLIDES ON ½" PIPE; OUTSIDE MEASUREMENTS 2'2"x4'6"

CENTER GATE

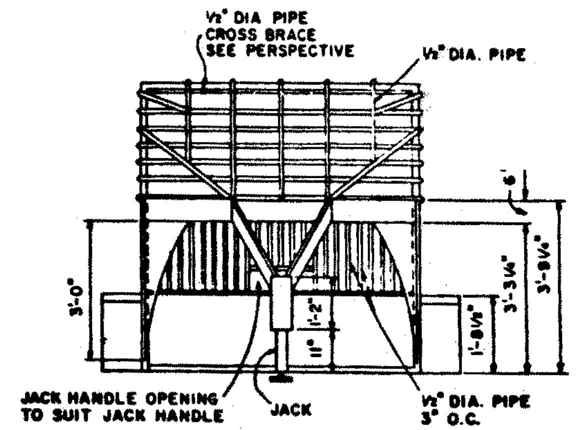


DWN BY: JOHN McEACHERN

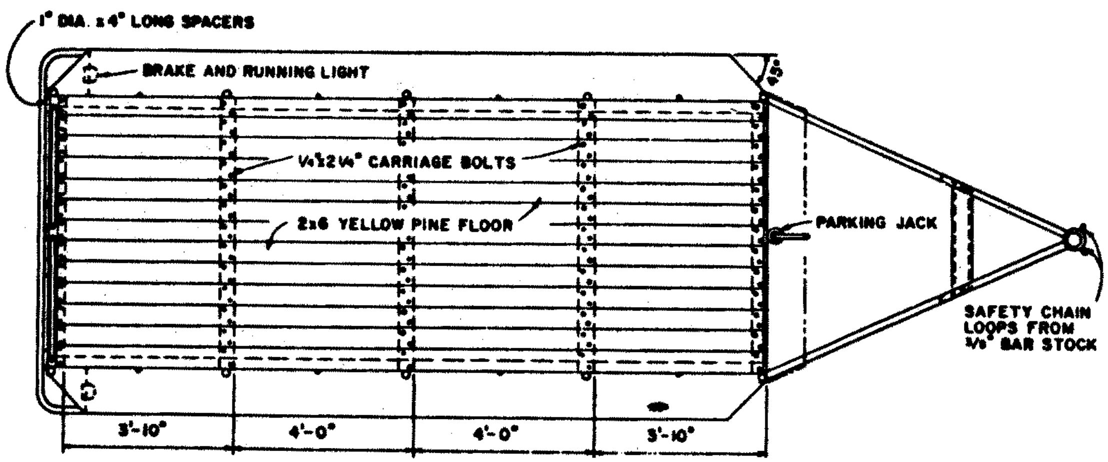
Courtesy of Guthrie
Vocational Agriculture Department



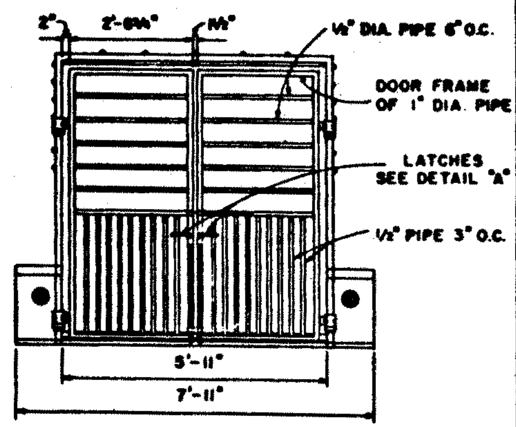
SIDE VIEW



FRONT VIEW



SECTION A-A

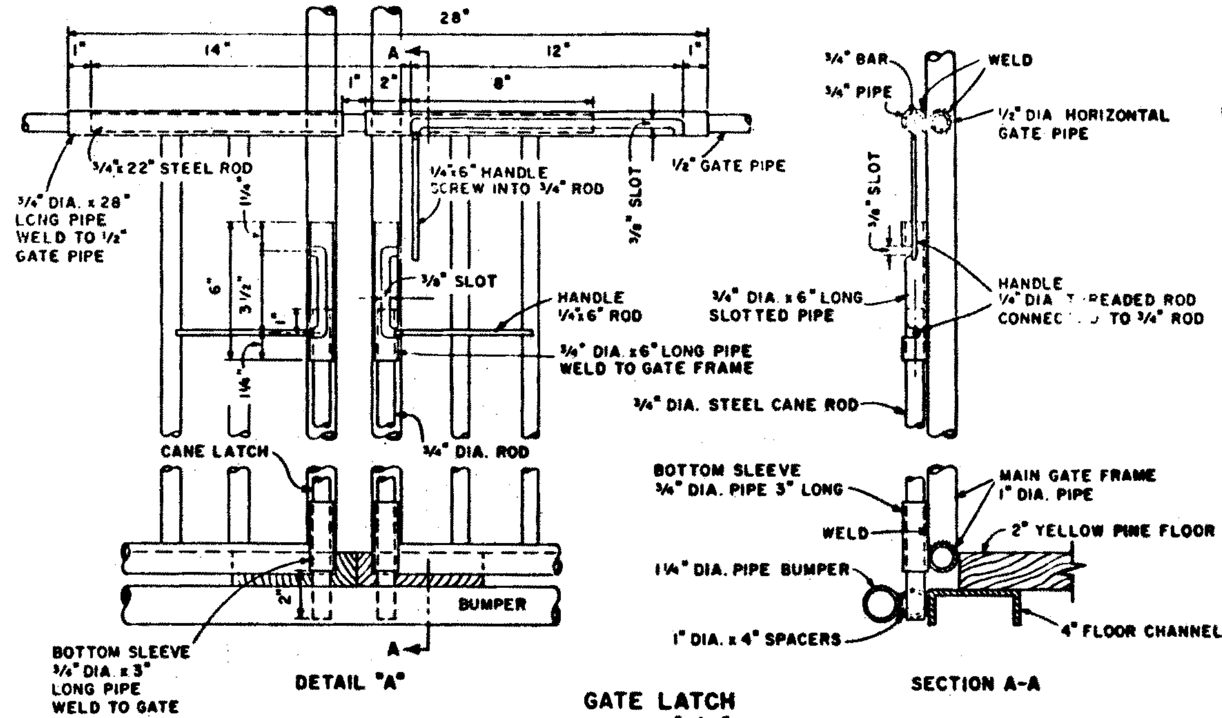


REAR VIEW

SCALE: ½"=1'-0" UNLESS OTHERWISE NOTED

BASED ON: TEXAS A & M UNIV. PLAN NO. 551

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS UNIVERSITY OF IDAHO MOSCOW IDAHO 83843 AND UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING		
TRAILER FOR CATTLE GOOSENECK TYPE		
TEXAS '72	6141	SHEET 1 OF 2



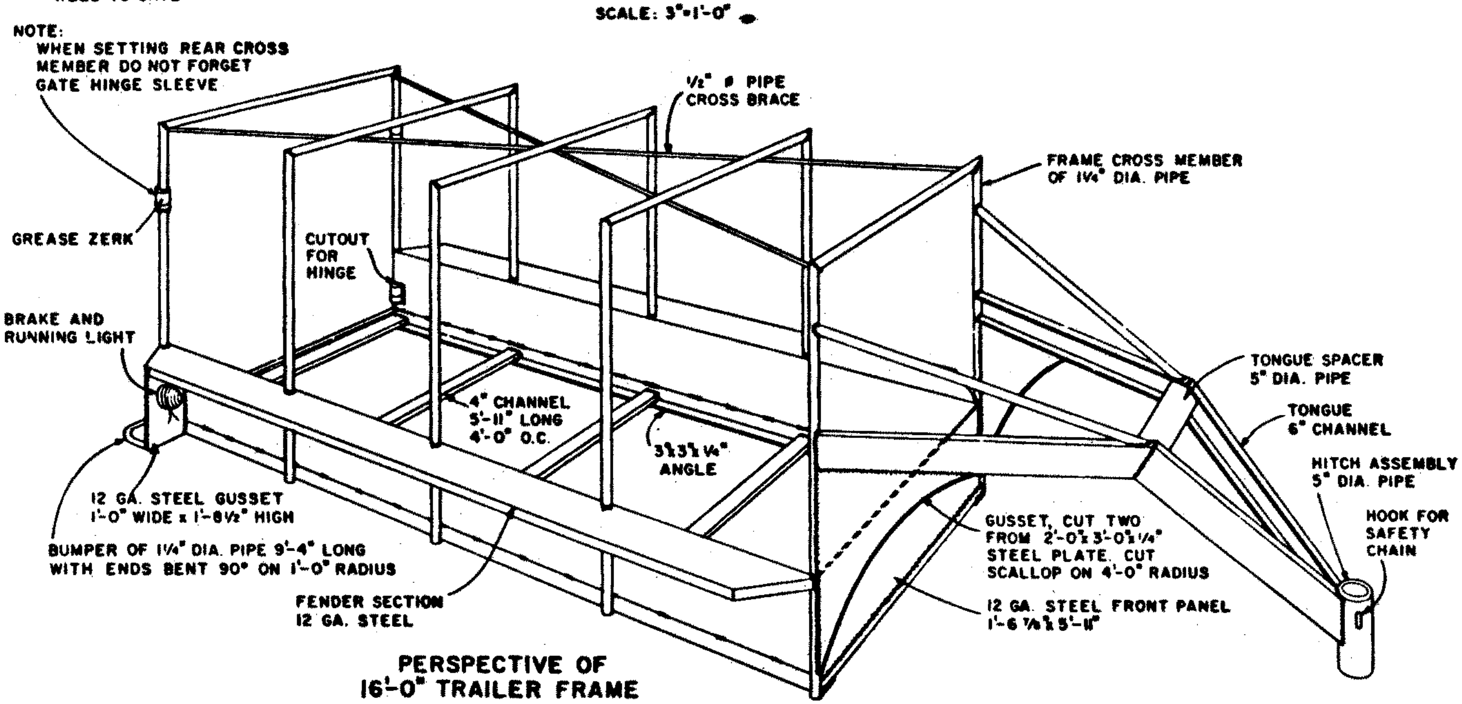
GATE LATCH
SCALE: 3"=1'-0"

NOTE #1:
CHECK YOUR PICKUP OR TRUCK FOR THE DISTANCE BETWEEN OUTSIDE REAR BUMPER OR CORNER OF BED TO POINT OVER AXLE IN CENTER OF BED. MAKE THE DISTANCE BETWEEN HITCH AND TRAILER 2'-0" LONGER THAN YOUR MEASUREMENT. TO EXTEND INCREASE LENGTH OF THE DOWNWARD ANGLED 6" CHANNELS.

NOTE #2:
THE CARRIAGE ASSEMBLY OF YOUR CHOICE MAY BE USED IN TANDEM
1. STRAIGHT AXLE AND NO SPRINGS
2. STRAIGHT AXLE AND LEAF SPRINGS
3. FOR HIGHWAY USE MAINLY, A DROP AXLE MAY BE USED.

NOTE #3:
CAUTION: THE EXPECTED MAXIUM LOAD WILL APPROACH 7 TONS. THEREFORE, SPECIFY EACH AXLE AND WHEEL ASSEMBLY TO CARRY 3 1/2 TONS HIGHWAY AND NON HIGHWAY USE, WHEN ORDERING FROM CARRIAGE MANUFACTURER. TIRES SHOULD BE 8 PLY AND MATCHED TO AXLE AND USE.

THIS DESIGN HEIGHT IS FOR CATTLE, IF HORSES ARE TO BE HAULED FREQUENTLY RAISE HEIGHT 6".



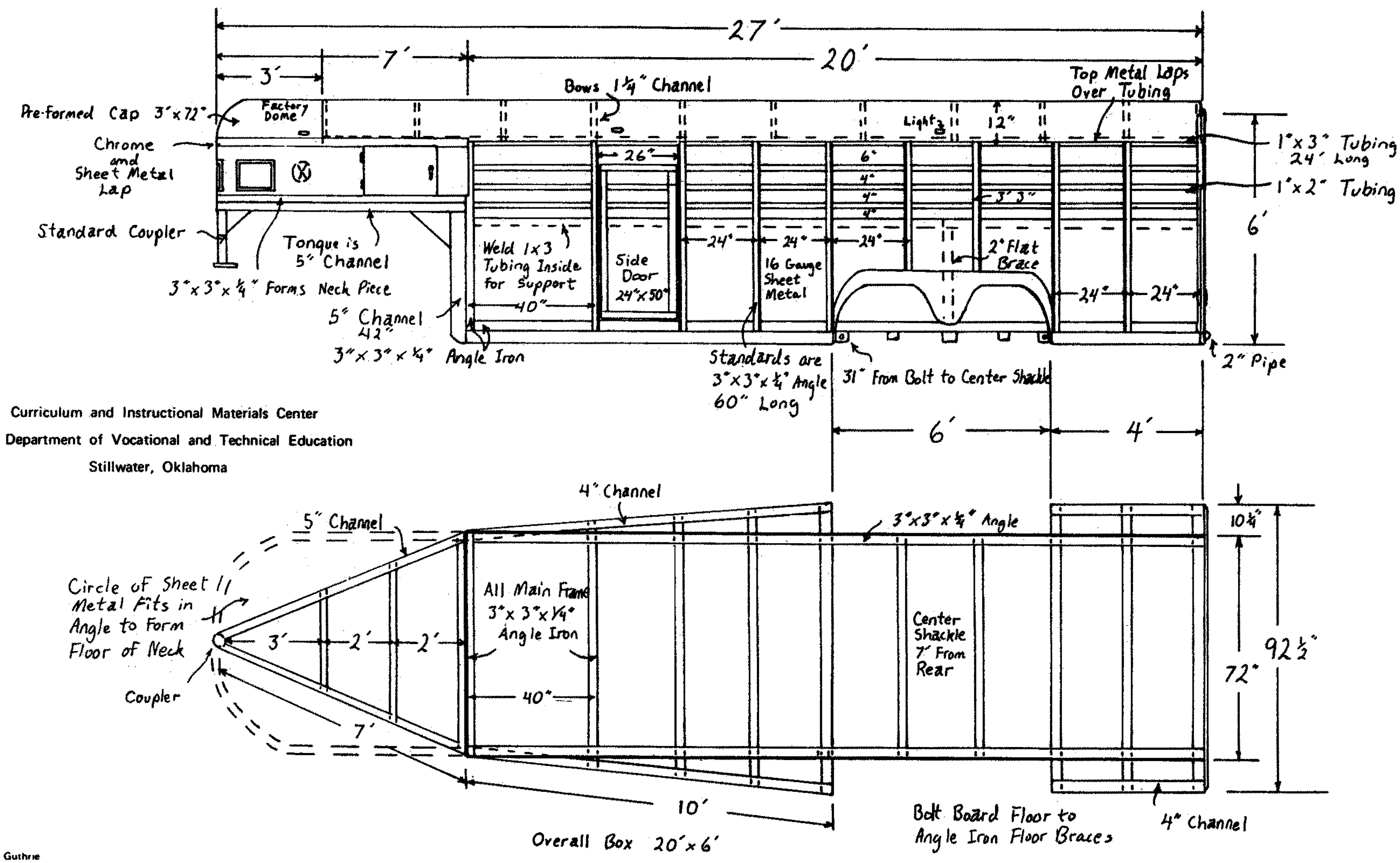
PERSPECTIVE OF
16'-0" TRAILER FRAME

COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS
UNIVERSITY OF IDAHO
MOSCOW IDAHO 83843
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

TRAILER FOR CATTLE GOOSENECK TYPE		
TEXAS '72	6141	SHEET 2 OF 2

Gooseneck Stock Trailer

Scale: 3/8"=1'



Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
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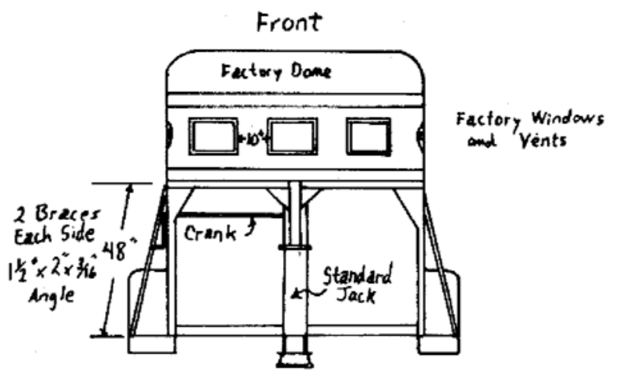
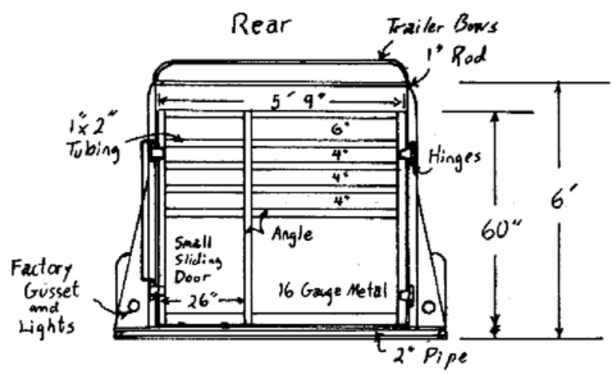
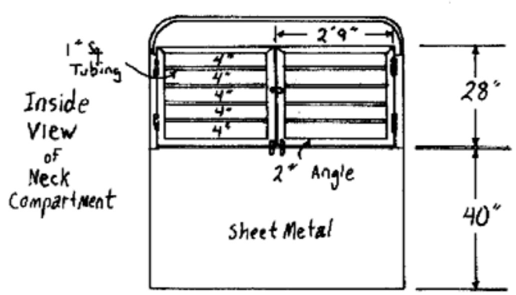
Courtesy of Guthrie
Vocational Agriculture Department







BILL OF MATERIAL

2 Pieces of D5086 Brake Axles
1 Pair of 10 3/4" x 72" Fenders
1 Set of 6 Leaf Springs
1 Set of 2" 4 Bolts w/Plates
1 Goose Neck Hitch
1 Landing Gear
1 Pair of Tail Light Gussets
2 Pair of 1/4" Gussets
1 Piece of 3/4" Pipe 21' Long
1 Piece of 9/16" Rod 20' Long
1 Piece of 3/4" Rod 20' Long
1 Piece of 9/16" Strap 10' Long
2 Sets of Gate Channel
1 Piece of 5" Channel 20' Long
100' of 3" X 3" X 1/4" Angle Iron
40' of 4" Channel Iron
40' of 3" X 3" X 1/8" Angle Iron
40' of 4" Channel Iron
40' of 3" X 3" X 1/4" Angle Iron
40' of 3" X 2" X 3/16" Angle Iron
100' of 2" X 2" X 1/8" Angle Iron
100' of 2" X 1 1/2" X 3/16" Angle Iron
20' of 2 1/2" X 2 1/2" X 3/16" Angle Iron
48' of 1" X 3" Tubing
200' of 1" X 2" Tubing
20' of 1" Tubing
1 Piece of 16 Guage Nose Sheet 60" X 120"
2 1/2 Pieces of 16 Guage Sheet 60" X 109"
100 Floor Screws and 1 2 5/16" Ball
1 Piece of Crown 72" Wide
3 Pieces of 20 Guage Sheet Metal 72" X 96"
9 Pieces of Trailer Bows 72" Wide
5 Pieces of 16 Guage Sheet Metal 11' X 36"
Also Flush Mount Tail Lights, Wiring, Jack Handle, 150 X 16-8 Ply Tires, Vents, Dome Lights, 16" Wheels, Plastic Windows, Nose Side Door, and Chrome

Middle Gate Inside, is 10' From Rear Made of 1" x 2" Tubing and Angle Iron 4' x 6' Overall 4" Gap Between Tubing with Angle Standard in Center