TABLE OF CONTENTS

AG 210, ARC, OXY WELDING, & AG 211, MIG AND TIG WELDING

ARC WELDING

AG 210-A

UNIT OBJECTIVE

After completion of this unit, students will be able to operate an arc welder safely, understand the AWS electrode classification, and demonstrate different arc welding skills. 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. Pass a safety test and demonstrate proper use of arc welding equipment.
2. Be familiar with the American Welding Society (AWS) classification for electrodes.
3. Identify properly and improperly formed beads.
4. Identify different problems with arc length, amperage setting, and welding speed.
5. Strike and maintain an arc correctly.
6. Understand what causes and how to prevent undercutting and overlap.
7. Understand the different types of electrical currents and the proper current selection in using different welding electrodes.
8. Identify the basic weld joints and demonstrate the application of each in the positions required, using AC and DC equipment.

ARC WELDING EQUIPMENT AND SAFETY

A. Introduction to Arc Welding

1. An arc welding machine joins two metals together by generating an electric arc between a coated metal electrode and a base metal. The heat of the electric arc melts the metal which mixes with the molten deposits of the coated electrode. The coating of the electrode produces a gas which shields the weld from the atmosphere and helps to maintain the weld shape. This coating is later removed in the form of slag. The slag coating over the weld insulates the hot weld from contaminants in the air during cooling.

B. Equipment Used in Arc Welding

1. Power Supply

    a. The power supply of the arc welding apparatus must maintain a relatively constant current with only a slight change in voltage.
    b. Varying voltage and current will result in an uneven arc that creates splatters and uneven welds.
    c. There are three main types of power supplies.

        1) Generators

            a) Generator powered arc welding machines run on direct current.
            b) These welding machines are commonly used in industry and are noisy, expensive to purchase, and costly to operate.

        2) Transformers

            a) These machines are generally the cheapest to purchase and run on an alternating current.

        3) Rectifiers (Changes AC to DC)

            a) The rectifier is a more versatile arc welding power supply that can be run on either direct or alternating current.

2. Ground Clamp

   a. The ground clamp completes the full electrical circuit so that enough heat will be available for the welding job.
   b. The ground clamp must be securely fastened to the metal being welded or to an adjoining workbench or piece of metal.

3. Electrode Holder (or Stinger)

   a. The stinger receives the amperage and directs it through the electrode to form the arc.
   b. The electrode holder should be well insulated, have a strong spring to firmly grasp the electrode, and a release lever to exchange the electrodes easily.

4. Cables

   a. The cables allow both the ground clamp and the stinger to be mobile.
   b. The cables should also be well insulated and protected from the heat during welding.

5. Electrode

   a. The electrode consists of an internal metal core and an outer coating called flux which shields the weld. The core melts into the molten base metal to produce the metal bond.
   b. There are several types and sizes of electrodes. Each will be discussed in detail in the next lesson.

C. Protective clothing must be worn at all times when welding. The heat created during arc welding creates flying molten sparks and ultraviolet and infrared rays that can burn the skin.

1. Leather Gloves

   a. Gloves protect the hands from burns during welding.
   b. The gloves should be made of thick leather and have long cuffs to protect the wrist and prevent sparks from falling into them.

2. Leather or Cotton Sleeves

   a. A NONFLAMMABLE material should be worn on the arms to protect from burns due to sparks and intense heat.

3. Body Protection

    a. Either a leather apron or coveralls or workshirt made of a flame-retardant material will protect the body during arc welding.
    b. All protective clothing should fit properly and be free of openings or rips into which a spark might enter or the intense heat might penetrate.

4. Footwear.

    a. Leather boots should be worn while arc welding.
    b. Never wear open-toed shoes while working with hot metal or a welding apparatus.

D. Arc Welding Helmets and Shields - The brilliant light given off by the electric arc produces invisible ultraviolet and infrared rays which can severely burn the eyes and skin. NEVER LOOK AT THE ARC WITH THE NAKED EYE. Helmets and shields are equipped with special filtered lenses that reduce the intensity of the light and prevent the ultraviolet and infrared rays from reaching the eyes.

1. The welding helmet is designed specifically for the purpose of arc welding.

    a. The welding helmet fits on the head using a plastic adjustable headband.
    b. The helmet leaves both hands free for working and positioning materials.
    c. Many helmets have clear lenses under the filtered lenses that can be used when chipping slag.

2. The hand shield is used for observing.

    a. It is NOT advisable to use the hand shield when welding since one hand must be used to hold the shield in place.

3. The protective lenses come in different shades depending on the type of welding to be done. Different types of welding use different amounts of voltage and current which determine the intensity of the light and the amount of ultraviolet and infrared rays produced. Spot welding requires the fewest amperes and thus requires the least amount of shading in the lens. Arc welding machines require from less than 30 to over 400 amperes. Lens shades range from number 5 (which provides the least amount of protection) to shade 14 (which provides the most protection).

a. Shade 5 is used for light spot welding.
b. Shades 6 and 7 are suitable for welding with up to 30 amperes.
c. Shade 8 is for welding with 30-75 amperes.
d. Shade 10 can be used when welding with 75-200 amperes.
e. Shade 12 is used when welding with 200-400 amperes.
f. Shade 14 is required when welding with over 400 amperes.

4. Cover glasses are clear lenses that are used to stop flying slag or metal, thus protecting the filter lenses. There are 3 different types of cover glass currently available.

    a. Clear, unbreakable plastic is the cheapest and lasts the longest.
    b. Chemically treated glass is used to reduce pitting but it can be expensive.
    c. Plain glass is very susceptible to breaking, pitting, and splatter sticks and is NOT recommended.

5. Filter lenses must be changed if a crack or chip occurs in order to prevent ultraviolet and infrared rays from reaching the eyes. The shades of the lenses must also be changed. If the shade is too dark, the worker will be unable to see the work that is being performed. If the shade is too light, proper eye protection is not achieved. Many welding helmets have interchangeable lenses. The lens changing procedure is as follows:

    a. Remove the lift-up mechanism on the helmet or the lens frame lock.
    b. Slide the old filter lens out and insert the new one.
    c. Reinsert the lift-up mechanism or the lens frame lock.
    d. Put the helmet on and search for light leaks. If leaks are present, the lens must be readjusted.

E. Additional Welding Equipment

1. Goggles - Goggles must be worn when chipping slag if a shell lens is not provided in the helmet. NEVER CHIP SLAG WITHOUT PROTECTIVE EYEWEAR.
2. Tongs - The heat of the arc will heat all of the metal being welded. Always use tongs to carry or maneuver the metal stock.
3. Slag Hammer or Chipping Hammer - The slag hammer is used to remove slag from the weld for proper cooling.
4. Wire Brush - If a second pass is to be made with the arc, the wire brush must be used to remove all slag fragments from the welding area. If not removed, the weld will not be solid and residual stresses will result.

C. Safety in Arc Welding

SAFETY IN ARC WELDING

When arc welding, observe the following general safety practices.

1. Wear gloves and eye and face protection. The welder and all observers must wear welding helmets with a No. 10 or 12 filter lens. A welding cap or helmet with a hard hat is also recommended for head protection. When chipping slag or cleaning welds, wear a clear face shield or flip-up liftplate on the helmet.
2. Avoid electrical shock. Make certain that the electrode holder and all electrical connections and cables are properly insulated. Check to see that the welder is properly grounded. Do not dip the electrode holder in water to cool it because this practice may result in electrical shock.
3. Protect others. For small and practice welding jobs, work in a partitioned area to protect others from harmful rays. When prepared to strike the arc, inform all bystanders to cover their eyes.
4. Never weld in a damp area. Stand on a dry board or rubber mat if the floor or ground is damp or wet.
5. Never wear synthetic fiber clothing. Synthetic fibers are highly flammable. Wearing clothing made from wool or cotton is more satisfactory for welding because of their relatively high flash points.
6. Protect welding cables. Keep the cables from coming in contact with hot metal and sharp edges. Do not drive over cables. When welding, avoid wrapping electrode cables around your body.
7. Secure work. Use a welding table with a positioner to hold welds securely in place. Clamps and vises can be used to hold odd-shaped work or field work. Securing work will also prevent injury from accidental dropping of metal on your feet or body.
8. Dispose of electrode stubs properly. Keep a container in the work area in which to deposit electrode stubs. This prevents burns to shoes or falls due to stubs rolling underfoot.
9. Prevent burns. Never allow the hot electrode or electrode holder to touch bare skin. Avoid letting the electrode touch a grounded cable. Remove hot metal from the work area when you are finished welding to prevent burns to others.
10. Do not let the electrode stick. If the electrode sticks, release the electrode from the holder, allow the electrode to cool, and then break it loose with your gloved hand.
11. Use both hands. To reduce fatigue, use both hands for welding.
12. Handle hot metal with pliers or tongs. Submerge hot metal completely in water to prevent steam burns.

13. Weld in a well-ventilated area. The fumes from lead, zinc, cadmium, and beryllium are toxic and may cause sickness or death.
14. Do not carry matches or lighters, and do not allow bystanders to smoke. Before welding, make sure the welding area is free of other flammables (gas, grease, etc.).

ACTIVITY:

1. Practice changing lenses and head gear in arc welding helmets.
2. Practice identifying and handling arc welding equipment, making sure that all safety procedures are followed and that suitable clothing is being worn.
3. Quench metal by dipping it in and out of water and demonstrate the steam rising and show how it can cause steam burns.

STRIKING AND MAINTAINING AN ARC

A. Setting, Checking, and Adjusting the Equipment

1. Equipment adjustment for proper amperage is vital for arc establishment.

    a. To start the welding operation make sure that the electrode holder and ground clamps are clean and in good condition. Inspect the cable connection to make sure they are tight and that no exposed wires are present.
    b. The welding bench should be clean and dry.
    c. The ground clamp should be attached to the welding bench in a secure manner.
    d. If using D.C. polarity, it is important that the machine is set for straight or reversed current
    e. The next step is to select the proper amperage. Tentatively determine the recommended current setting for the type and size of electrode to be used; make the final adjustment after the actual welding operation has been started. The electrode selection chart gives both a low and a high setting choice. A current value midway between the two limits is recommended. The following electrodes are recommended for this exercise: E6010, E6011, E6012, E6013 or E7014.

NOTE: Some instructors like to use E-6013 and E-7014 rods because they strike and hold an arc easily and beginning welders build confidence. However, others feel that changing back to a E-6011 type rod is more difficult and they prefer to start with a fast-freeze rod of E-6011 type. It is also suggested that you use 1/8" or 5/32" electrodes for this exercise (see electrode selection chart in the addendum).

B. Striking an arc

1. Select a plate or coupon of steel 1/4" thick, 3" to 5" wide, and 6" to 10" long.

    a. There are two methods that can be used to start or strike the arc: a tapping or a scratching motion. The tapping method is the one that experienced welders use, whereas the scratching motion method is generally easier for the beginner.

        1) The scratching motion method requires that the electrode be brought down at an angle to the plate very similar to scratching a match. When the arc is started (flashes) the electrode must be quickly raised so that it will not stick to the base metal.
        2) The tapping method requires that the rod be held directly above the work. The rod is brought down and touches on the base metal. As the arc strikes, the rod must be quickly brought up to approximately the thickness of the electrode or the rod will stick to the base metal.
        3) If the rod sticks to the base metal, the current flow will cause the rod to become very hot. To remove a stuck electrode from the work, use a quick twisting or striking motion of the electrode holder. If this does not break the electrode loose, remove the electrode holder from the grip end of the electrode. Since this electrode is red hot, use pliers to twist it loose.

    b. Practice striking and stopping the arc until this action can be completed quickly and easily.

        1) A good practice coupon can be laid out in a grid pattern with center punch mark 1/2" apart. Practice starting the arc on each of these marks.

2. Practice running beads after the skill of striking and maintaining an arc has been mastered.

a. Stringer beads are an excellent bead for beginning welders to make. The beads will not be consistent but should improve with practice.

b. The beginning welder can practice with different electrode settings, arc lengths, electrode angles, and speeds until a smooth, strong weld is produced.

1) Welding done with proper amperage, voltage, and speed displays

a) Good penetration
b) No undercut or overlay
c) Smooth appearance

2) If the arc is too long, there is:

a) Poor penetration, overlap, spatter
b) Leaves weld puddle exposed to oxidizing air

3) If the welding current setting is too high, there is:

a) Spatter and undercutting, wide puddle
b) A deep crater, V shaped appearance

4) If the welding current setting is too low, there is:

a) Poor penetration with high narrow bead
b) Not enough current to fuse weld to metal
c) Hard to strike

5) If the welding speed too fast, there is:

a) Irregular bead with skips
b) Narrow bead

6) If the welding speed too slow, there is:

a) Bead too high, somewhat irregular and porous
b) Builds up too much metal and metal stays melted too long

3. After mastery of the stringer bead, practice oscillation, which entails keeping the tip of the rod weaving back and forth across the molten weld pool.

a. The weaving motion of the electrode keeps the molten metal pool agitated; this helps float the slag and impurities to the top so they can be removed by chipping and brushing and it also helps to reduce porosity within the weld bead area.
b. The weave bead also can be used to give a wide coverage (cover pass) for the weld joint.
c. The weave bead will improve penetration and thicken pieces of weld plate.
d. The basic weave bead is a crescent-shaped zig-zag.

1) Hesitate at sides to prevent undercutting and to allow the bead to build.
2) Be sure to bond the weave to the material on each side.

4. There are various other welding patterns, for example, whipping motion, semicircular motion, circular motion, V-shaped motion, back and forth or N-shaped motion, U-shaped motion, figure-8 motion, and rotary motion.
5. Metal Preparation

a. Cut a plate approximately 4" X 5" X 1/2"
b. Brush and clean plate
c. Mark 4 lines 1/2" apart down the 5" length
d. Run a stringer bead down each line with 1/8" rod
e. Chip and clean stringer beads

6. Weaving Exercise

a. Weave beads between stringers to cover plate with smooth weld
b. Fuse the weave into the stringers
c. Chip, clean, and evaluate work

ACTIVITY:

1. Strike and maintain an arc by building up a small boss on each center punch mark on coupon
2. Explain what happens when an arc is being maintained.
3. Start and restart the electrode at different places on the coupon.
4. Run and evaluate stringer bead for correctness.
5. Run and evaluate weave beads.

ELECTRICAL CURRENTS IN WELDING

A. Welding Currents – There are two types of electrical current flows used in welding and they are identified as AC and DC.

1. AC – Alternating Current, the current of electricity will change directions 60 times a second flowing back and forth from the positive to the negative.

2. DC – Direct Current, the current will flow in one direction, from the positive to the negative. In welding there are two different polarities used, reverse polarity (DCRP) and straight polarity (DCSP).

    a. DCSP – Direct Current Straight Polarity is a direct current flow, flowing from the welding electrode to the work piece being welded on. Using straight polarity more heat will be directed to the work piece (See page 210A-42)

    b. DCRP – Direct Current Reverse Polarity is a direct current flow, flowing from the work piece being welded on to the welding electrode. Using reverse polarity more heat will be directed to the welding electrode. (See page 210A-42)

AWS CLASSIFICATION SYSTEM FOR ELECTRODES

A. What are electrodes and how are they selected for various welding applications?

1. Shielded electrodes are thin metal rods having approximately the same composition as the metal to be welded. They are coated with a wide variety of types of flux.
2. Electrodes are designed not only to weld different metals but also to use AC, DC reverse, or DC straight polarity electric current.
3. Electrodes come in various diameters; the larger the diameter the higher the amperage required to properly use the electrode.
4. It is very important that the appropriate electrode be selected for a given welding operation. Poor electrode selection will cause difficulty in completing a good welding job.
5. Electrodes are classified into five main groups:

    a. Mild steel
    b. High-corbon steel
    c. Special alloy steel
    d. Cast iron
    e. Non-ferrous

B. The American Welding Society (AWS) has developed the following electrode classification system:

1. What does the classification E-7018 on an electrode mean? Reading from right to left.

    a. The right-hand digit (8) indicates the special characteristics of the electrode, such as type and genera content of the coating, weld quality, amount of penetration, and the type of arc or electrical current. The right hand-digit may be any number between 0 and 8. It is important to note that the right-hand digit cannot be considered individually but must be considered in conjunction with the second digit from the right in order to identify both the polarity and position of the electrode.
    b. The second digit from the right (1) indicates the positions the welding electrode can be used. This digit may be any number between 1 and 4.

        1) 1 indicates the electrode can be used in all positions; flat, horizontal, vertical, and overhead.
        2) 2 indicates the electrode can be used in flat or horizontal positions.
        3) 3 indicates the electrode should only be used in the flat position.
        4) 4 indicates the electrode can be used for vertical down welds only.

    c. The two or three digits to the left (70) indicate the tensile strength in thousands of pounds per square inch (i.e., 70 means 70,000 psi).

C. Selecting the correct Electrode

1. The electrode should produce a weld metal with approximately the same metallurgical properties as the parent metal. A top quality weld should be as strong as the parent material.
2. In selecting the best electrode for a particular welding situation, the aim is to choose one that will provide good arc stability, fast deposition, maximum weld strength, minimum splatter, easy slag removal, and a smooth weld bead. To achieve these characteristics from an electrode, the following factors should be considered:

a. Electrode Diameter – Generally, an electrode with the diameter larger than the thickness of the base material should not be used, If this is done, welding must be done at a very high rate of speed and this requires considerable skill in order to obtain a sound weld. When making a vertical or overhead weld, a fast freeze type electrode with the diameter of 1/8" would normally be used. Regardless of the base metal size, an electrode diameter of 3/16" is the maximum size used. Electrode diameter is also determined by the joint design such as a joint with narrow gap or V-groove base metal plates. When this is a factor, use a small diameter electrode to do the root pass or the first weld bead.

b. Joint Design – This is another important factor to consider when choosing an electrode.

   1) When welding a joint that is not beveled at the proper angle to allow easy penetration, consider using a deep penetrating, fast freeze electrode, for example, E-6010 or E-6011. The opposite of this situation would be an open or poorly fit joint where a good choice of electrode be E-6012 or E-6013.

c. Welding Position – The welding position to be used during the deposition of the weld metal is a very important factor when selecting an electrode.

d. Type of Welding Current – This is another factor to consider when choosing an electrode. Some electrodes are designed for AC and DC straight or DC reverse polarity while others are designed to function properly using either AC or DC current. Information regarding current is generally written on the outside of the package and does not have to be figured from the AWS classification number.

ACTIVITY:

1. Select six different are electrodes and outline in writing each of their characteristics. Use the Identifying sheet as a handout (Page 210-44).
2. Weld a bead with each of the six arc electrodes and describe in writing how each electrode reacts during the welding process.
3. Weld various beads using DC straight, DC reverse, and AC type currents.

210A-14

BASIC WELDS

A. Welding a Bead

1. A weld is known as a bead, made by one pass of an electrode.
2. Welding a bead is the first step after striking an arc and towards making other types of welds.
3. Stopping and restarting a bead in the middle of a weld should be practiced. Due to the fact when you run out of an electrode you will need to restart with a new one.
4. Set welding amperage to desired setting (depending on the electrode and the thickness of metal used.)
5. Keep are length between 1/16" – 1/8", listen to it (sounds like frying bacon) and keep it constant.
6. Angle the electrode 15^{o} – 20^{o} from vertical towards the direction of travel. At the same time keep the side to side angle at 90^{o}.
7. Speed of travel, watch the width of the puddle and keep it constant.

B. Butt Weld

1. The butt joint is one of the most frequently used weld joints.

    a. A butt joint consists of placing the edges of two pieces of metal together.

2. The butt joint is used when structural pieces have a flat surfaces, for example, tanks or flat decks, and when laminating pieces for machine parts.
3. There are three types of but joints: closed, open, and when laminating pieces for machine parts.
4. The closed butt should be used only if the material to be welded does not exceed 1/8” to 3/16” in thickness.
5. When using the open butt, the joints are spaced 3/32” to 1/8” apart.
6. When the material to be welded exceeds 3/16” in thickness, the butt joint should be beveled. There are three types of bevel or V joint designs:

    a. In a feather edge, the material is 1/8” to 3/16” thick, the bevel is 60 degrees and the bottom edges of the material are placed together.
    b. The shoulder edge is used for materials 1/4" or more think; 1/16” to 1/8” of the bottom of the material is not beveled and a gap of 1/8” is allowed for the root pass.

c. The double V is used for material over 3/8” thick. This V joint has a 60 degree bevel; however, a 3/32” to 1/8” face is left in the lower 1/3 of the weld joint. This root face is generally spaced 1/8” apart for proper root pass operation.

7. If the bevel on any groove joint is greater than 60 degrees, it is difficult to limit and control the amount of contraction when the metal cools.
8. A backup strip should be used in an open butt joint in order to prevent excessive burn-through.
9. A round stock weld is a variation of the butt joint weld.

   a. In order to weld rods or round solid shaft material, both ends of the stock must first be beveled, leaving a shoulder in the center. The edges should be ground so they have the same angle

C. Pad Welding

1. A pad weld is used to build up metal surfaces after it has been worn down.
2. Pad welding can be done on flat or round surfaces.
3. Pad welding consists of depositing several layers of beads.

   a. Welding a bead to cover half of the previous bead.
   b. Welding beads one over the top of another

4. Angle the electrode 15^o – 20^o from vertical towards the direction of travel. At the same time keep the side to side angle at 90^o for the first pass. For the second, third, etc. hold the electrode 10^o – 15^o from vertical.

D. Fillet Weld (Tee Joint)

1. The tee joint is formed by placing one plate at a 90 degree angle to another to form a letter T. A tee joint is a Fillet-type weld.

   a. The tee joint is weak and should not be used if heavy pressure will be applied from the opposite direction of the welded joint.
   b. There are several types of fillet joints. The basic fillet welds for tee joints are classified as square, single bevel, double bevel, single J and double J. (See page 210A-43)

      1) The square tee is used where the material can be welded on one or more side. Considerable weld metal is required for maximum strength.

2) The single bevel tee is used on material that is less than 1/2" thick. This joint will withstand more severe loading than the square tee, where welding can be done from one side only.
3) The double bevel tee is used where heavy loads are applied in all directions and where welding can be done on both sides.
4) The single J joint is used on material 1 1/2" and thicker and can be welded from both sides.

c. To start a practice fillet, use 3/16" to 1/4" thick material. Set the vertical plate on the middle of the flat plate and tack weld each end. Then start the main weld. On material of this thickness, a single pass (which is one layer of a weld bead) should be sufficient.

d. The angle of electrode is very important. The best results are obtained by holding the electrode at 45 degrees between the vertical bottom flat plate with the tip pointed toward the weld area. The direction of travel will have a 15^{o} - 25^{o} angle in the direction of travel. This first single pass bead should be a 1/4" fillet.

E. V-Butt Tension Test Weld

1. The V-Butt tension weld is designed to test the welders ability to correctly use the welding rod to its' fullest potential.
2. A copper backing plate and a small backup strip will be used.

   a) For best results and less grinding, backup strip thickness should be 22-18 gauge. If thicker than 18 gauge use shims to hold up the ends of the metal and keep the pieces as straight as possible.

3. The metal to be used should be 1/4" thick and 1 1/4" wide and should have a 30^{o} angle cut on the ends. When lined up with another piece the angle will be 60^{o}. The two pieces should be 3/32" apart.
4. The weld will be completed in two passes.

   a) On the first pass:

      1) Set amperage by starting at low setting, strike an arc, run 1/4" bead and bury the electrode in the base metal – arc should be maintained. If the rod sticks, adjust to slightly higher amperage and retest. When the amperage is set correctly proceed with your first pass.

2) Maintain a very short arc with slight side to side motion
3) Fill V approximately 1/2 full, leave excess on both ends.

b) On the second pass:

1) Turn down amps approximately 5 – 10 amps, tilt metal up hill.
2) Use a weave weld, maintain short arc, pause at edges, fill in excess on both ends.

5. Allow metal to cool slowly under another plate of metal, leave it for approximately 25 minutes before moving. Even moving it through the air can cause it to cool fast and loose strength.
6. Grind weld to same size as the parent material and grind off the backup strip. Do not nick base metal while grinding. Nicks will result in a weaker weld.

F. Vertical Up Fillet

1. Not all welds can be done in the flat or horizontal position. It is not always possible to lay a project on its' side to be welded, so the vertical up weld becomes necessary. Welds can be done moving downward (Vertical-Down), but penetration will not be as deep as compared to the vertical-up weld. Vertical-up welds are often used when welding fillet welds on trailer hitches where deep penetration is necessary.
2. Vertical up welds will be done in two passes:

   a. The first pass will be made making a fast pass using a pausing pattern. (See page 210A-37)

   b. The second pass will be made going from side to side using a similar pausing pattern. (See page 210A-37)

3. The electrode will be held at a 45^{o} between the two pieces, the same as a horizontal fillet. The electrode will be slightly pointed upwards, 15^{o} maximum.

G. Overhead Fillet

1. The overhead weld is the most difficult weld to master. A person is working above their head and standing up, which adds difficulty to this weld. At times this weld becomes necessary to weld on the bottom side of a trailer, truck frame, or any project that can not be turned up side down.

2. This weld will be made with three passes: (See page 210A-39)

   a. The first pass will be made 30^o from vertical leading 5^o in the direction of travel.
   b. The second pass will cover half of the first pass and part of the top plate.
   c. The third pass will cover the rest of the first pass, a little of the second pass and part of the side piece.

3. Suggestions:

   a. Stand up and get in close to your work.
   b. Lean against a post and steady yourself.
   c. Have the metal at least 10" above your head for a close and clear view.
   d. Work with the palms of your hands pointed down, dripping metal will be less likely to burn your hands.
   e. Keep the electrode at 45^o in your holder.
   f. Drape the welding cable over your shoulder to support the weight.

ACTIVITY:

1. Prepare and weld each of the types of welds.
2. Design and build a project utilizing at least three different types of welds.

References:

Burke, Stanley R., & Wakeman, T. J. (1997). MODERN AGRICULTURAL MECHANICS (3nd ed.). Danville, IL: Interstate Publishers.

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

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

Special Material and Equipment:

Arc welding helmet, leather gloves, aprons, coveralls, strikers, safety test, slag hammer, safety goggles

Resources:

Deere & Company. (1987). WELDING (6th ed.) (Fundamentals of Service (FOS) Series). Available from: John Deere Technical Services, Dept. F, John Deere Road, Moline, IL 61265 (Available in Spanish)

Giachino, Joseph W., & Weeks, William (1976). WELDING SKILLS AND PRACTICES (5th ed.). Available from: American Technical Society, Chicago, IL 60637
Hobart Brothers Company. (1978). TECHNICAL GUIDE FOR SHIELDED METAL ARC WELDING. Available from: Hobart Brothers Company, Troy, OH 45373

210A-20

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 welding 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 or welding leathers and leather boots will be worn at all times, without exception, in the welding and fabrication areas.

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, chipping hammers, wire brushes, and steel 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 ______________________

210A-21

Name_______________
Date________________
Score_______________

SAFETY EXAM, ARC WELDING

Multiple choice, circle the letter that bests represents the correct answer. The second part of the test is true and false questions, circle the T if the statement is true and F if the statement is false.

1. When welding, leather boots need to be worn _______________.

   a. only when welding overhead
   b. at all times
   c. only when welding in a booth
   d. when using a cutting torch

2. Breathing fumes from lead, zinc, cadmium, and beryllium can cause ____________.

   a. death
   b. sickness
   c. long term sickness
   d. all of the above

3. If electrode sticks to the work piece you should _______________________.

   a. try to break it free
   b. release the electrode
   c. shut the welder off
   d. all the above

4. Which of the following items are **not** needed when arc welding?

   a. leather gloves + coveralls
   b. leather boots + safety glasses
   c. chipping hammer + wire brush
   d. grease rags and oil

5. When quenching hot metal in water ____________ to avoid steam burns.

   a. hold it under water until it cools
   b. dip it in and out of the water
   c. hold it half way under water
   d. hold it under running water

6. If arc welding in damp areas, it's all right to weld if ______________________.

   a. your boots are dry
   b. you are standing on a dry board or a dry rubber mat
   c. you have dry gloves on
   d. none of the above

7. When arc welding, use a # ____ shade lens or higher for normal welding (100 amps or greater).

   a. 5
   b. 8
   c. 10
   d. 12

8. If someone is welding, it's all right to watch without a welding helmet if you are _________________.

   a. 20 ft away
   b. 40 ft away
   c. 60 ft away
   d. never watch anyone welding without a helmet

9. T or F If the insulation is broken off the stinger (electrode holder) it is still safe to use it if you are careful.

10. T or F Small gas or butane lighters have been known to explode in a person shirt or pants pocket while welding.

11. T or F Welding in an unventilated area is allowable for a short period of time.

12. T or F Handle hot metal with pliers and tongs, **not** leather gloves.

13. T or F When striking an arc always call out cover, so people in the surrounding area can look away before you start welding.

14. T or F Bare spots on welding cables are not a safety hazard.

15. T or F Electrode stubs need to be thrown away into a container or scrap bucket and not left on the floor.

Name________________
Date_________________
Score________________

UNIT EXAM, ARC WELDING

Multiple Choice, circle the letter that best represents the correct answer.
Short answer

1. Which of the following is not a type of welding power supply?

   a. Rectifier
   b. Transformer
   c. Alternator
   d. Generator

2. What is the purpose of the ground?

   a. To hold the work down.
   b. Compete the electrical circuit.
   c. To warn up the metal before welding.
   d. Hold the points open.

3. The flux of an electrode

   a. forms a gas
   b. creates slag
   c. forms a shield for the weld
   d. all of the above

4. The best material to use for protection clothing , footwear, and gloves is

   a. nylon
   b. leather
   c. polypropylene
   d. dacron

5. The darkest and most protective lens available for welding purposes is

   a. Shade 7
   b. Shade 10
   c. Shade 14
   d. Shade 20

6. The ground clamp should be attached to

   a. a non-conductive block of wood
   b. the project or metal worktable
   c. a properly grounded bolt mounted in the floor
   d. the electrode

7. A weld with the proper amperage, voltage, and speed displays

   a. good penetration
   b. no undercut or overlay
   c. a smooth appearance
   d. all of the above

8. When the voltage setting is too low, the weld

   a. spatters and undercuts
   b. digs a deep crater
   c. leaves the weld puddle exposed to oxidizing air
   d. provides poor penetration with a high, narrow bead

9. What is the tensile strength of an electrode marked E6013

   a. 60 lbs per in^2
   b. 600 lbs per in^2
   c. 6,000 lbs per in^2
   d. 60,000 lbs per in^2

10. Where is the best place to dispose of electrode stubs?

    a. On the floor.
    b. On the welding table.
    c. In a non-flammable container in the work area.
    d. The trash can.

11. To handle hot metal, what tool should you use?

    a. Your gloves.
    b. Pliers.
    c. The grounding clamp.
    d. Leave it until it cools.

12. Name ways to start an arc?

13. What does the E represent on an electrode marked E6011

14. What does the third and fourth digits represent on an electrode marked E7018

15. What will happen if the welding amperage is set too high?

16. What will happen if the welding amperage is set too low?

17. What will happen if the arc length is too long?

18. What will happen if the arc length is too short?

19. What will happen if welding travel speed is too fast?

20. What will happen if welding travel speed is too slow?

Answer Sheet

UNIT EXAM

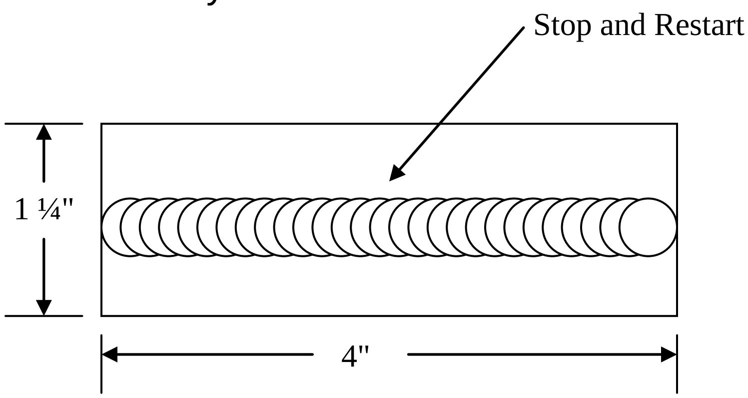
1. C
2. B
3. D
4. B
5. C
6. B
7. D
8. D
9. D
10. C
11. B
12. Scratching and Tapping
13. Electrode
14. The third digit indicates the position the rod can be used in and the fourth indicates the characteristics of that rod, 1 means all positions and the 8 means low hydrogen.
15. Wide bead with low height and spatter.
16. Poor penetration with a high narrow bead
17. Poor penetration, flat bead, overlap, and spatter
18. Poor penetration and high and wide bead.
19. Wide and flat bead and too high of heat build up.
20. Poor penetration and uneven bead.

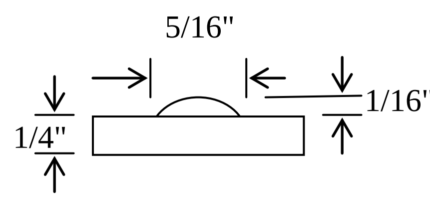
SAFETY EXAM

1. B
2. D
3. B
4. D
5. A
6. B
7. C
8. B
9. False
10. True
11. False
12. True
13. True
14. False
15. True

Arc Welding, Bead

1. Use 1/8" E6013 or E6011 electrode.
2. Use 1/4" x 1 1/4" 4" metal.
3. Stop <u>completely</u> and restart in middle of weld.
4. Fill in crater at the end of bead.
5. Clean the weld with wire brush.
6. Weld one side only.



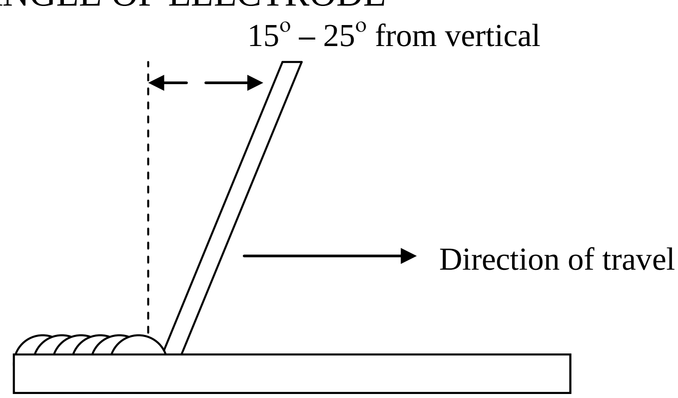


Variables that influence the bead:

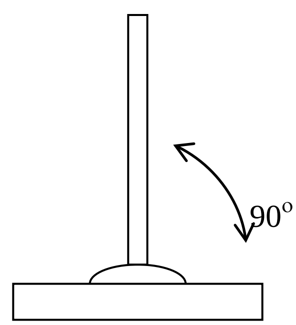
1. AMPERAGE — Use middle range from chart & adjust from there.

2. ARC LENGTH — Usually 1/16" – 1/8" Listen to it (frying bacon)
   Keep it constant.

3. ANGLE OF ELECTRODE



END VIEW



4. SPEED OF TRAVEL — Watch the width of puddle – keep it constant

210A-28

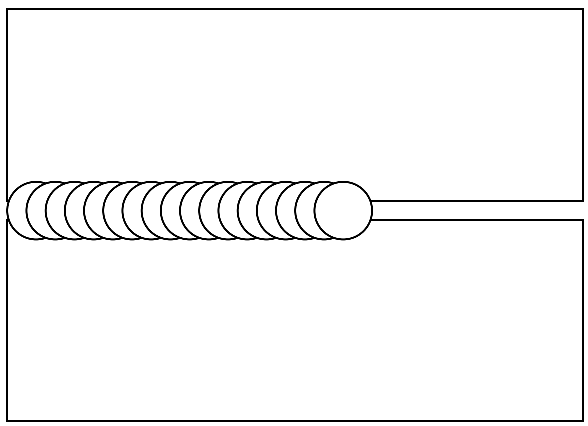
GRADE SHEET

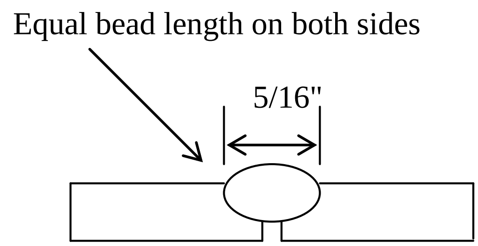
Arc Welding, Bead

Student Number	Cold Starts To -10 each Endings Not Filled	Bead Width 5/16" -1 @ 1/32 Over or Under	Eveness of Bead Width -1 @ 1/32" Difference	Overlap/Over 1/16" high Bead to -15 each	Undercut Height Eveness To -5	Eveness of Bead & Technique To -15	Restart To - 5	Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

Arc Welding, Butt Weld

1. Use 1/8" E6013 or E6011 electrode.
2. Use two pieces of 1/4" x 1 1/4" 4" metal.
3. Bead with equal length on both sides of the joint.
4. Fill in crater at the end of bead.
5. Clean the weld with wire brush.
6. Weld one side only.

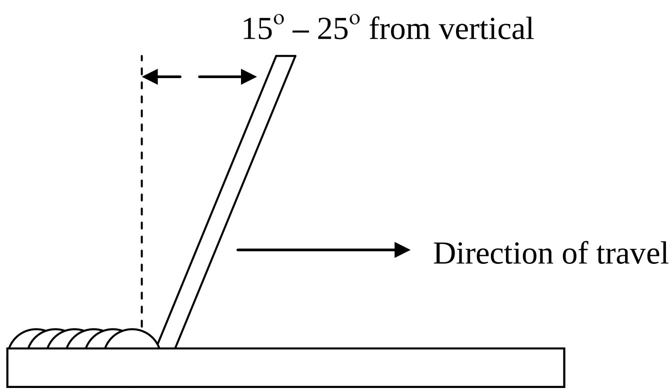




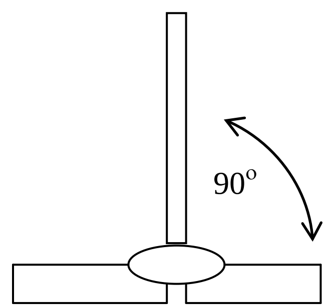
1. AMPERAGE — Use middle range from chart & adjust from there.

2. ARC LENGTH — Usually 1/16" – 1/8" Listen to it (frying bacon)
Keep it constant.

3. ANGLE OF ELECTRODE



END VIEW



4. SPEED OF TRAVEL — Watch the width of puddle – keep it constant and even on both sides

GRADE SHEET

Arc Welding, Butt Weld

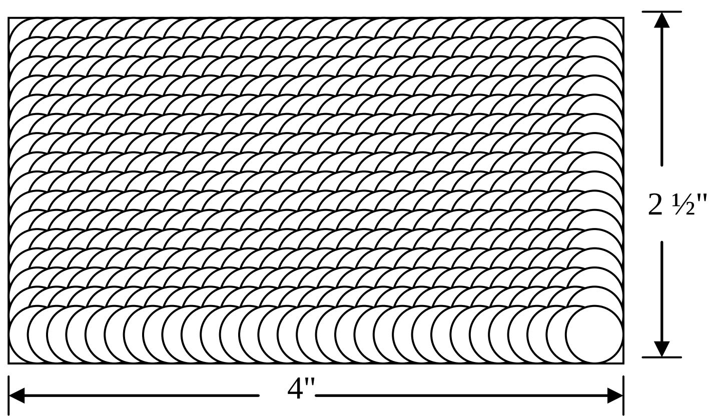
Student Number	Starts To -10 each Endings Not Filled	Bead Width 5/16" -1 @ 1/32 Over or Under	Eveness of Bead Width -1 @ 1/32" Difference	Overlap To -15 each Undercut	Height Eveness To -5	Eveness of Bead & Technique TO -15	Bead centered over joint TO - 5	Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

210A-31

Arc Welding, Pad Weld

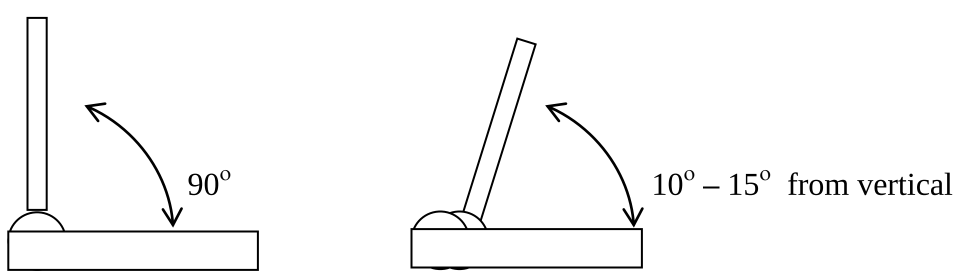
1. Use 5/32 E6013
2. Use 4” x 2 1/2" x 1/2" metal
3. Cover entire surface of the plate with overlapping welds.
4. Cover half of the previous bead.
5. Cool between beads only until red color is gone

TOP VIEW



END VIEW

WRONG RIGHT



First Pass Second Pass, etc.

6. Finished surface to be as flat as possible.

210A-32

GRADE SHEET

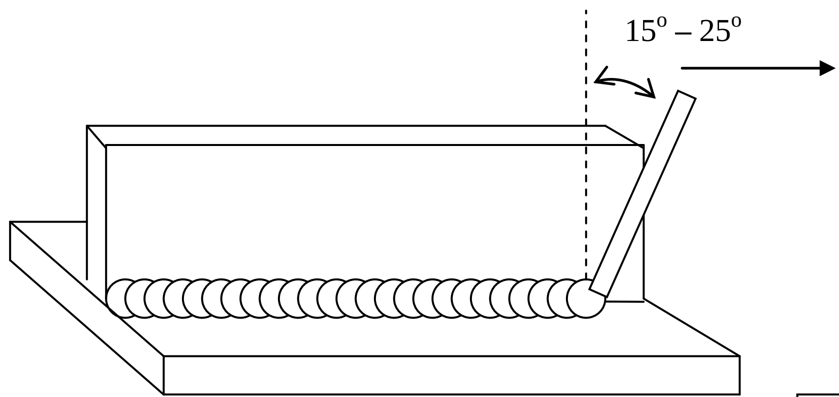
Arc Welding, Pad

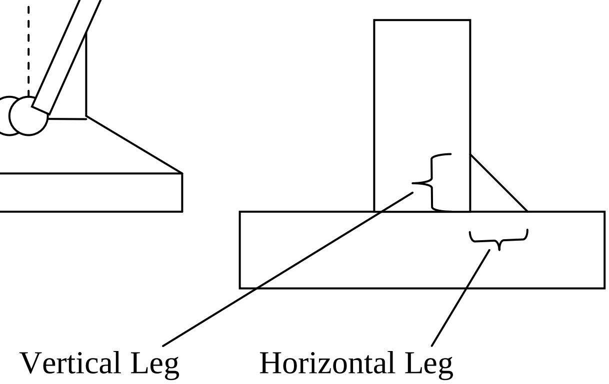
Student Number	Flatness of Pad & Techniques To -25	Slag Inclusions To -10 each	Eveness of Bead To -5 each Eveness of Crowding	Undercut To -15	Start Endings To -5	Specs Saftey Clean-up	Late -10			Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

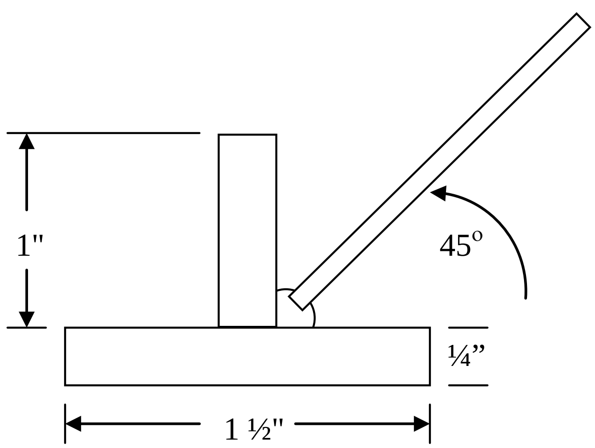
210A-33

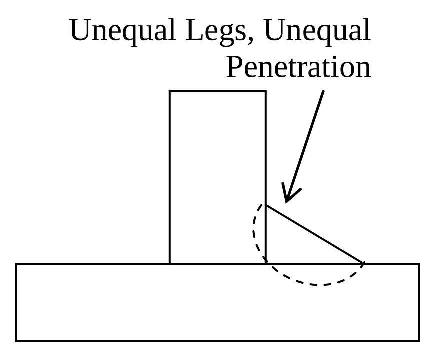
Arc Welding, Horizontal Fillet

1. Use 1/8” E6013 electrode.
2. Use 1/4" x 1 1/2" x 4” metal for the base.
3. Use 1/4" x 1” x 4” metal for the upright.
4. Use a <u>short</u> arc length.
5. Hold the electrode at a 45° angle from the base plate.
6. Hold the electrode at a 15° – 25° angle in the direction of travel.
7. Horizontal and vertical legs (1/4") need to be **<u>equal</u>.**









<u>Undercutting Caused by:</u>

1. Too long of an arc.
2. Electrode too straight up and down.
3. Too much amperage.
4. Using motion.
5. Too much lead angle.

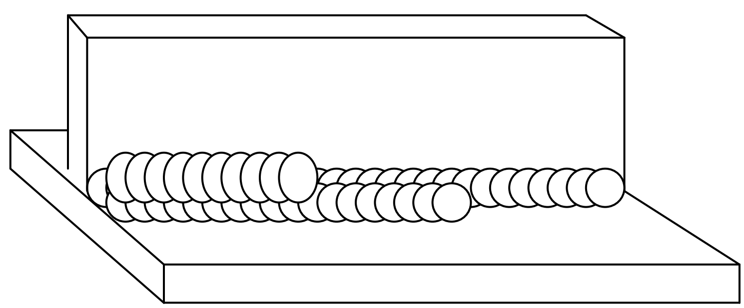
GRADE SHEET

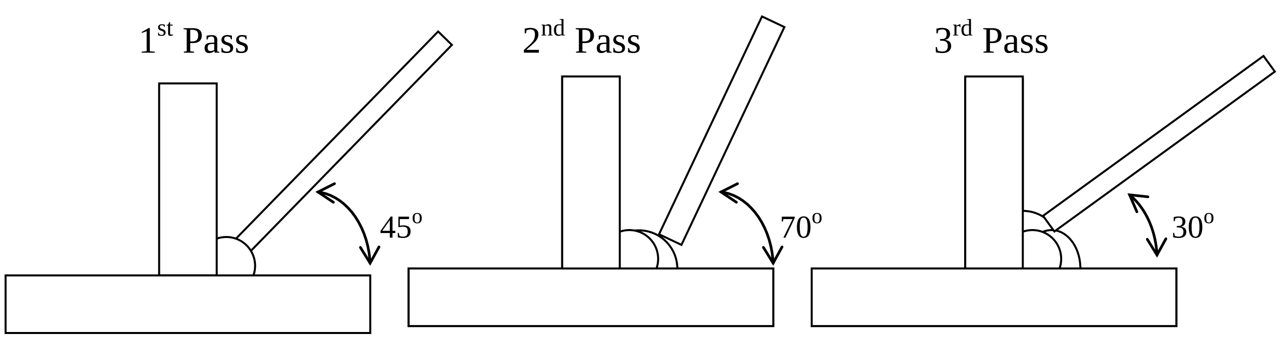
Arc Welding, Horizontal Fillet, Single Pass

Student Number	Eveness - Single Pass To -10 Technique	Slag Inclusions -3 - 20 Pts each Plates @ Right Angle To -10	1st Pass Legs, 1/4" -5 Per 1/16"	Undercut To -25 Overlap	Start To - 10 each Ending	Specs Saftey Clean-up	Late -10			Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

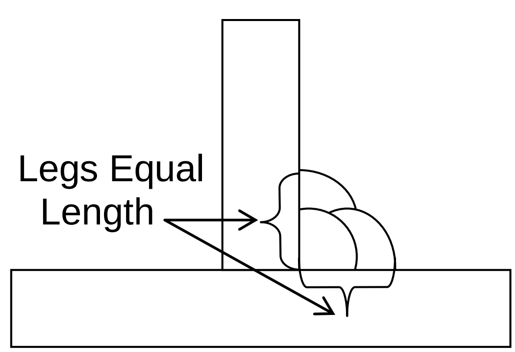
Arc Welding, Horizontal Fillet, Multi Pass

1. Use 1/8” E6013 electrode.
2. Use 1/4" x 1 1/2" x 4” metal for the base.
3. Use 1/4" x 1” x 4” metal for the upright.
4. Use a short arc length.
5. Hold the electrode at a 45^{o} angle from the base plate on the first pass, 70^{o} on the second pass, and 30^{o} on the third pass.
6. Hold the electrode at a 15^{o} – 25^{o} angle in the direction of travel.
7. Horizontal and vertical legs need to be **equal.**
8. 1st pass – full length, 2nd pass – 2/3rd length, 3rd pass – 1/3rd length.





Undercutting Caused by:
9. Too long of an arc.
10. Electrode too straight up and down.
11. Too much amperage.
12. Using motion.
13. Too much lead angle.



GRADE SHEET

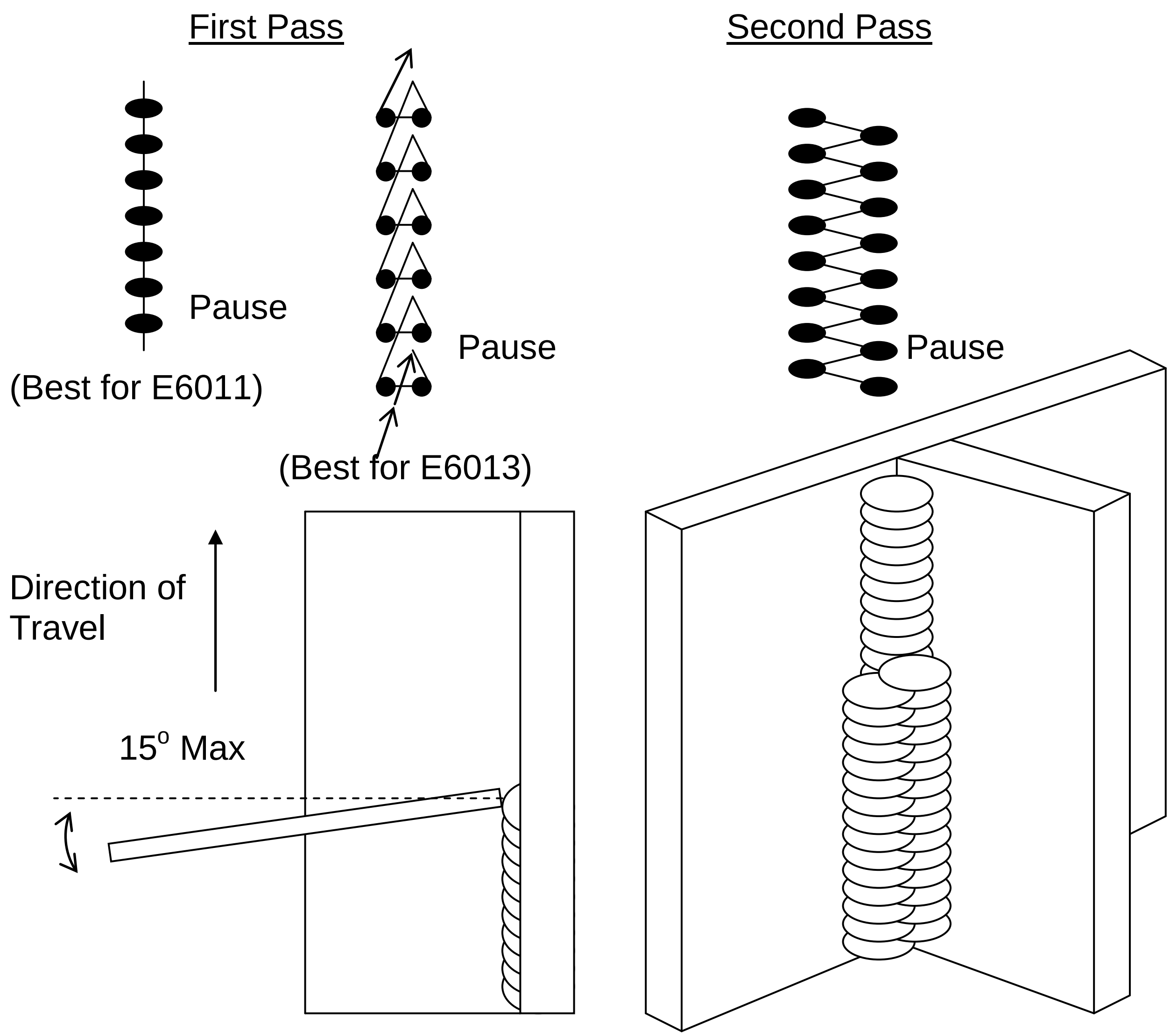
Arc Welding, Horizontal Fillet, Three Pass

Student Number	Eveness - Single Pass To -10 each Techniques - 3 Passes	Slag Inclusions -3 - 20 Pts each Plates @ Right Angle To -10	1st Pass Legs, 1/4" -5 Per 1/16" 5/16" Legs 2+3 Pass	Undercut To -25 Overlap	Starts To - 10 each Endings	Flatness of the Three Pass To -10	Specs Saftey Clean-up	Late -10		Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

Arc Welding, Vertical Up Fillet

1. Use 1/8" E6011 electrode or E6013
2. Keep metal in a true vertical position.
3. Hold electrode perpendicular, or point slightly upward.

Motions to Try



4. First pass to have 1/4" legs.
   Second pass to have 3/8" legs.
5. Leave 1/4 to 1/3 of the first pass uncovered.
   (Note: both welds must be done in the same direction)

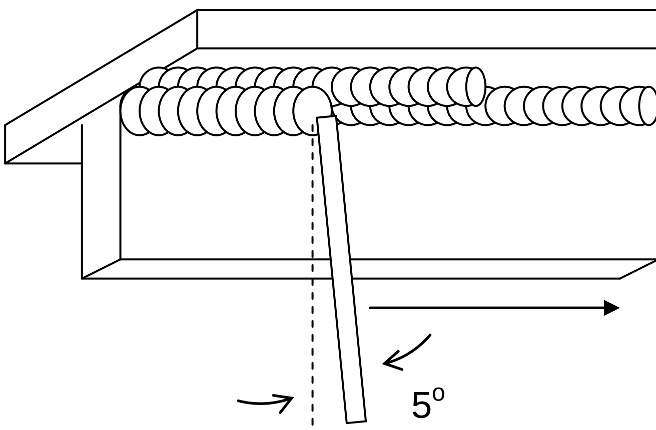
GRADE SHEET

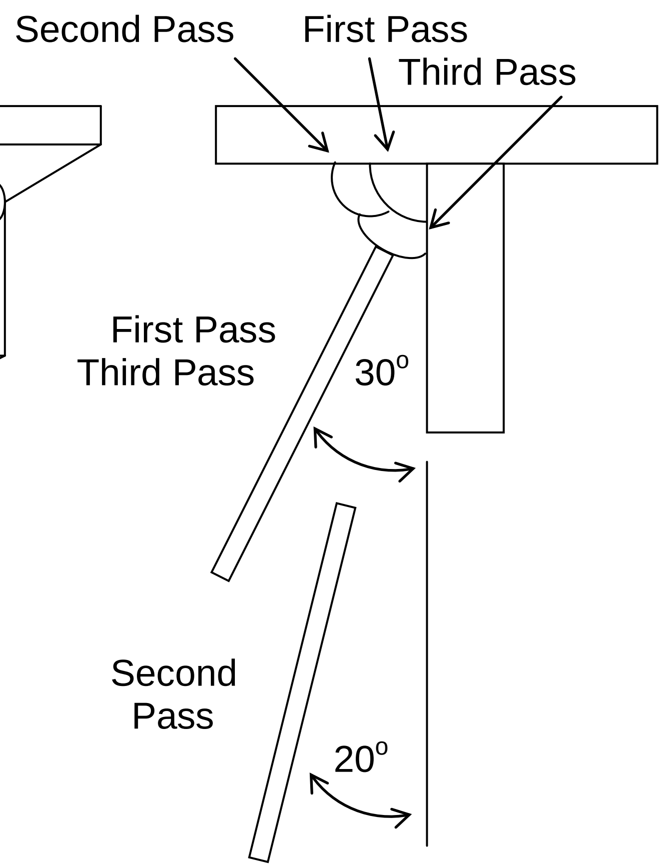
Arc Welding, Vertical-Up Fillet

Student Number	Eveness - Single Pass To -10 each Technique, 2nd Pass	Slag Inclusions -3 - 20 Pts each Plates @ Right Angle To -10	1st Pass Legs, 1/4" -5 Per 1/16" 2nd Pass Legs, 3/8"	Undercut To -25 Overlap	Starts To - 10 each Endings	Flatness of the Two Passes To -10	Specs Saftey Clean-up	Late -10		Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

Arc Welding, Overhead Fillet Weld

1. Use 1/8" E6011 or E6013 electrode
2. First pass – full length – second pass 2/3 length – third pass 1/3 length.
3. First pass – 1/4" legs, third pass 5/16" legs





<u>Reasons for Dripping:</u>

1. High amperage
2. Electrode too large
3. Electrode turned too far back into the puddle
4. Arc length too long

<u>Suggestions:</u>

1. Stand up
2. Lean against post
3. Metal at least 10" above head
4. Stand in close to work
5. Palms down
6. Electrode 45^{o} in holder
7. Keep electrode holder parallel to line of travel
8. Drape cable over shoulder

210A-40

GRADE SHEET

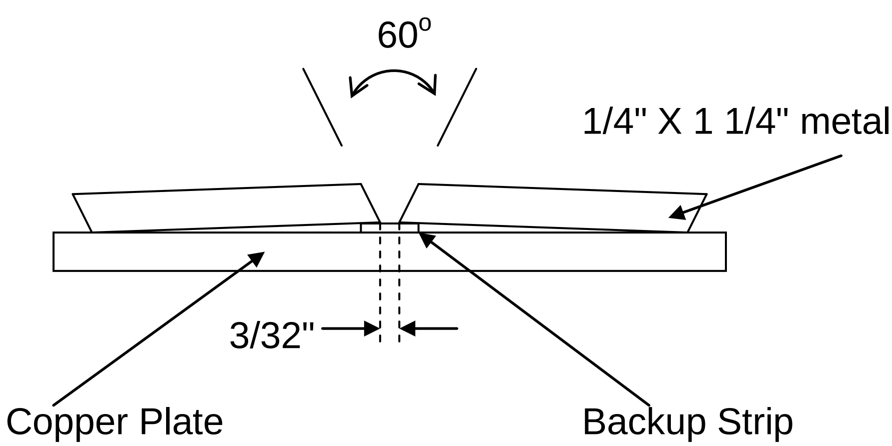
Arc Welding, Overhead Fillet

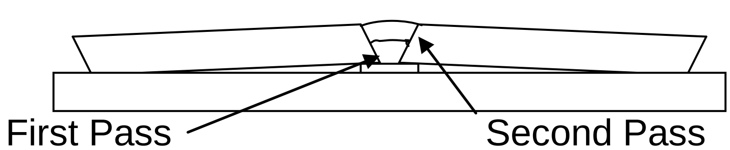
Student Number	Eveness of beads & Technique To -10 each	Slag Inclusion -3 -20 Pts each Plates @ Right angle To -10	1st Pass Legs, 1/4" -5 per 1/16" 5/16" Legs, 2+3 Passes	Overlap To -25 Undercut	Starts To -10 each Endings	Flatness of the Three Passes To -10	Specs Saftey Clean-up	Late -10		Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

Arc Welding, V-Butt Tension Test

Procedure:

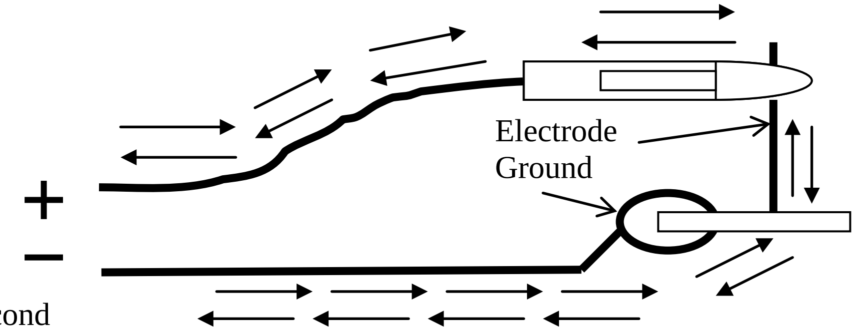
1. Use 1/8" E6011 ELECTRODE (better penetration and less slag than 6013)
2. Set amperage by starting at low setting, strike arc, run 1/4" bead and bury electrode in base metal – arc should be maintained. If rod sticks, adjust to slightly higher amps and retest.
3. Make sure backup strip is flat and is laying on clean copper plate.
4. Leave approximately 3/32" space between pieces to be butt welded.
5. On first pass:
   a. Maintain very short arc with slight side to side motion.
   b. Fill V approximately 1/2 full, leave excess on both ends.
6. On second pass:
   a. Turn down amps approximately 5 – 10 amps, tilt metal uphill.
   b. Use a weave weld, maintain short arc, pause at edges, fill in excess on both ends.
7. Important: Allow metal to cool slowly under a plate of metal approximately 25 minutes undisturbed.
8. Grind weld to same size as parent metal – Use guide (at each belt sander). Do not nick base metal while grinding.
9. Take metal to instructor for testing.





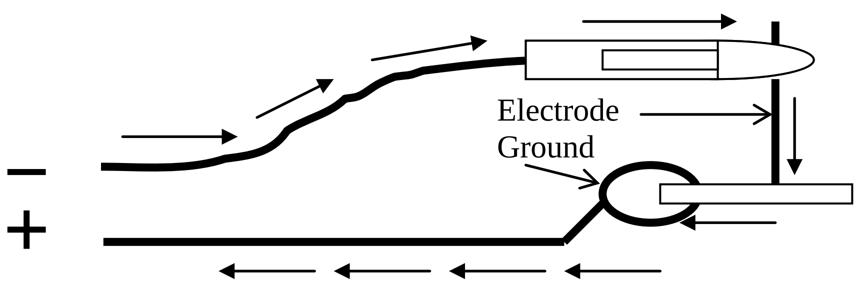
CURRENT FLOW

A.C. CURRENT DIRECTION

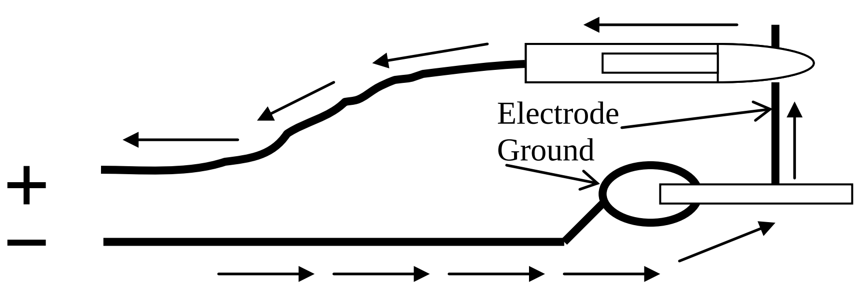


1/60th of a second

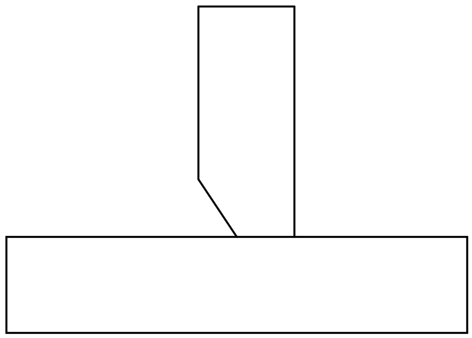
D.C. STRAIGHT POLARITY



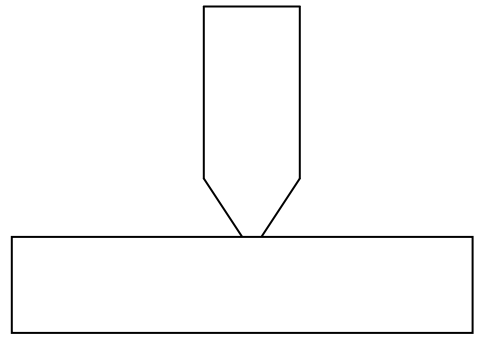
D.C. REVERSE POLARITY



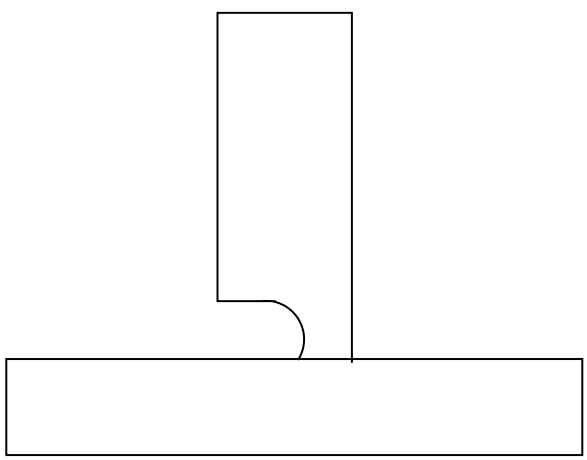
TEE – JOINT CONNECTIONS



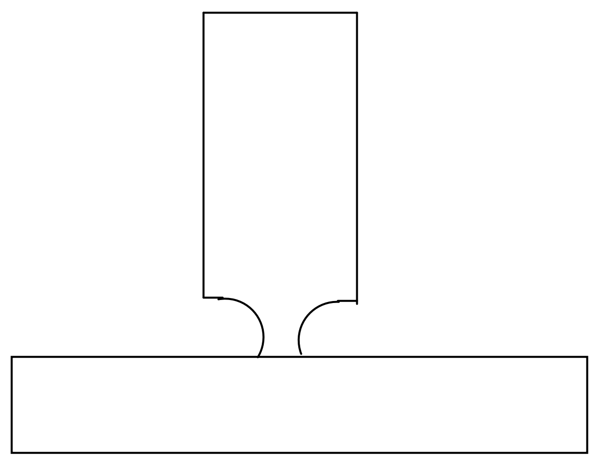
Single Bevel



Double Bevel



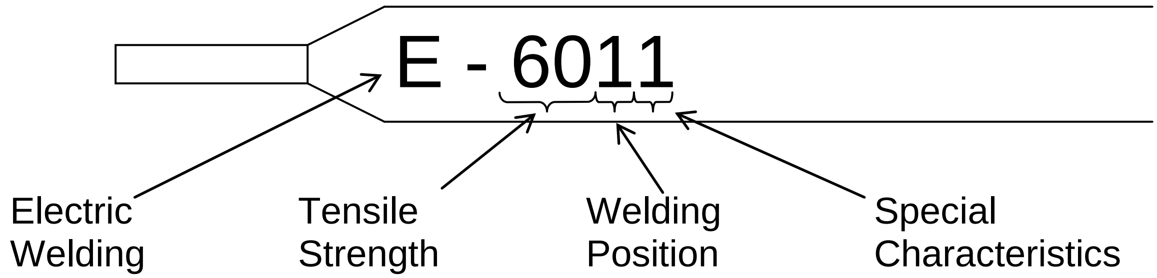
Single-J Joint



Double-J Joint

210A-44

IDENTIFYING WELDING RODS



Tensile Strength

60 = 60,000 pounds pull strength per inch

70 = 70,000 pounds pull strength per inch

110=110,000 pounds pull strength per inch

Etc.

AC = Alternating Current

DCRP=Direct Current Reverse Polarity or DC+ (Positive)

DCSP=Direct Current Straight Polarity or DC- (Negative)

Welding Position

1 = Able to weld in all positions. Flat, horizontal, overhead, etc.

2 = Flat and horizontal fillets only.

3 = Flat only (Old style not used very much anymore.)

Special Characteristics

0 = Deep penetration, Cellulose sodium coating, DCRP

1 = Deep penetration, Cellulose potassium coating, AC, DCRP

2 = Med. penetration, Titania sodium coating, AC DCSP

3 = Shallow penetration, Titania potassium coating, AC, DCRP, DCSP

4 = Med. penetration, Titania iron powder coating, AC, DCRP, DCSP

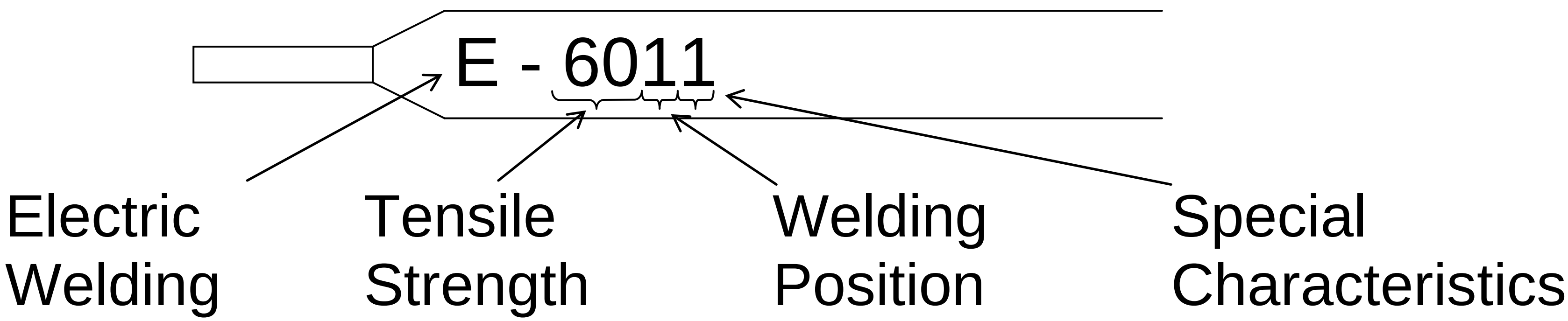
5 = Moderate penetration Low-hydrogen sodium DCRP

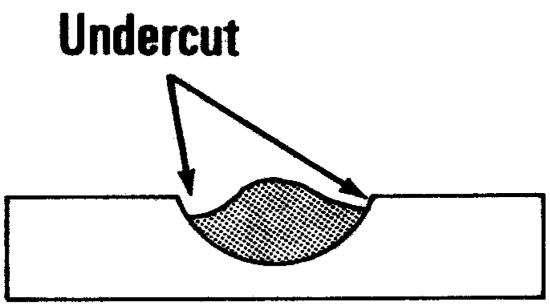
6 = Moderate penetration Low-hydrogen potassium AC, DCRP

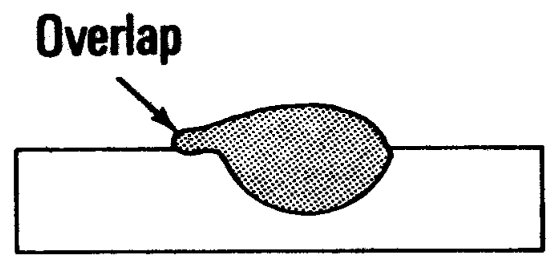
7 = Med. penetration, iron powder, iron oxide AC, DCRP, DCSP

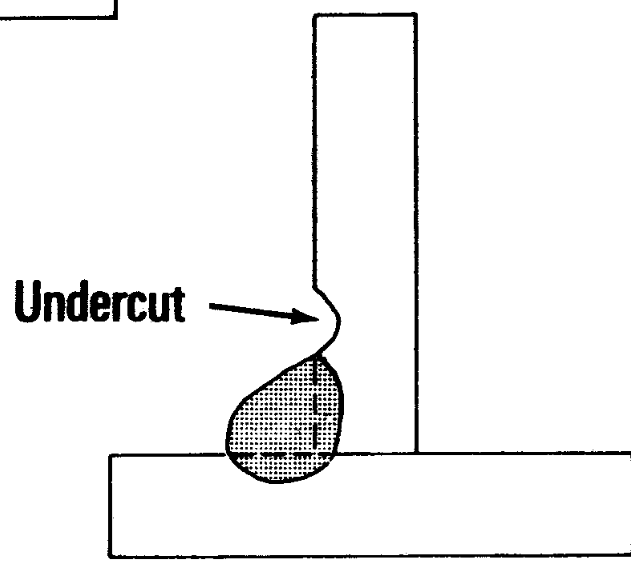
8 = Med. penetration, Iron powder, low-hydrogen, AC, DCRP

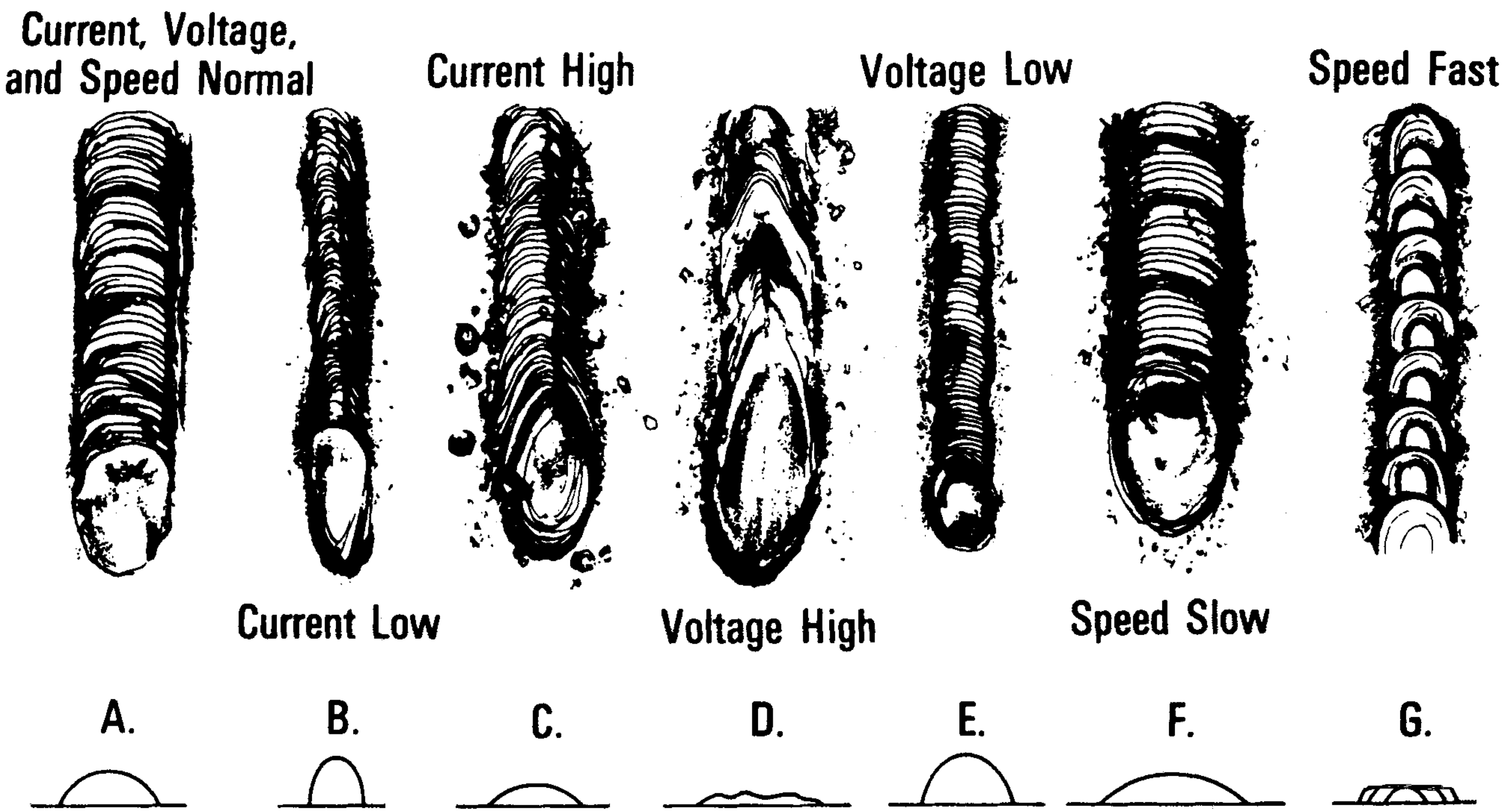
IDENTIFYING WELDING RODS




Undercut


Overlap


Undercut


Current, Voltage, and Speed Normal
Current Low
Current High
Voltage High
Voltage Low
Speed Slow
Speed Fast
A.
B.
C.
D.
E.
F.
G.

210B-1

OXYACETYLENE WELDING & CUTTING

AG 130-Y

UNIT OBJECTIVE

After completion of this unit, students will be able to operate oxyacetylene welding and cutting equipment safely and demonstrate basic oxyacetylene welds and cutting procedures. 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. Pass a safety test on oxyacetylene welding.
2. Identify the basic components of the oxyacetylene welder apparatus.
3. Set up, use, shut off, and store an oxyacetylene welder properly.
4. Use the oxyacetylene equipment to braze mild steel.
5. Run a bead with the oxyacetylene equipment with and without filler rod.
6. Select welding rods and fluxes appropriate for the job.
7. Clean the orifices in welding heads using the approved technique.
8. Use the oxyacetylene equipment to perform three basic fusion welds.
9. Make a straight cut, using the cutting head.
10. Make a bevel cut, using the cutting head.
11. Pierce a hole in steel plate.
12. Clean the orifices in welding and cutting heads, using the approved technique.
13. Cut sheet metal (14 ga. or thinner) with the cutting head.

OXYACETYLENE WELDING EQUIPMENT AND SAFETY

A. Oxyacetylene Equipment Identification

1. Gas Cylinders

a. Oxygen Cylinders

1) Oxygen

   a) Oxygen is a colorless gas (19% of the atmosphere).
   b) Oxygen has no smell or taste.
   c) Oxygen is a flammable gas.
   d) Oxygen readily supports combustion.

2) Common size oxygen cylinders hold about 244 cu. ft. of oxygen at 2,000 to 2,600 lbs. per square inch (psi) pressure.
3) Because of their high pressure, they can explode if dropped, struck, heated, or arced with an arc welder.
4) The cylinder valve, which allows the flow of gas from the cylinder to the regulator, is protected when not in use with a threaded cylinder cap.
5) The cylinder cap has two holes on its side designed to cause a cylinder with a broken-off valve to spin instead of take off like a missile from the jet effect of the escaping, high pressure gas.

b. Acetylene Cylinders

1) Acetylene

   a) Acetylene is a colorless gas (a compound of carbon and hydrogen).
   b) Acetylene has no smell, a sulfur gas is added for smell.
   c) Acetylene is flammable and highly explosive when mixed with oxygen.
   d) Acetylene is explosive when compressed above 15 psi, but is very soluble in acetone.
   e) Acetylene forms explosive compounds with silver and copper, so never use copper pipe or fittings with it.

2) Acetylene cylinders are filled with a porous form of concrete in which all the air is removed by filling the pore spaces with acetone.
3) The acetylene can be stored in these cylinders at pressures above 15 psi without becoming unstable because it combines with the acetone under pressure.
4) Large acetylene cylinders can hold around 275 cu. ft. of acetylene at 250 psi.
5) If acetylene is withdrawn too quickly, removing all the available acetylene, the cylinder pressure gauge will read empty; but after the cylinder is not used for a while, more usable acetylene will come out of the solution.
6) Acetylene cylinders must be kept upright for about eight hours before use and during use in order to prevent acetone loss.

2. Gas Regulators

a. Gas regulators reduce the high cylinder pressures to low, hose pressures suitable for welding and cutting applications.
b. Identification of the Parts of a Gas Regulator

1) Inlet (cylinder valve connection)

a) Oxygen inlets have right-handed threads.
b) Acetylene inlets have left-handed threads and their nuts are notched on the outside.

2) Pressure Adjusting Screw

a) Decreasing the pressure (out) is counterclockwise.
b) Increasing the pressure (in) is clockwise.

3) Cylinder (high) Pressure Gauge

a) Oxygen cylinder gauge reads 0-4000 psi.
b) Acetylene cylinder gauge reads 0-400 psi.

4) Working (low) Pressure Gauge

a) Oxygen working gauge reads 0-200 psi.
b) Acetylene working gauge reads 0-30 psi.

5) Outlet (connection for hoses)

a) Oxygen outlets have right-handed threads.
b) Acetylene outlets have left-handed threads.

3. Check Valves

a. Check valves allow the gases to flow in only one direction to prevent backflow.
b. Check valves are necessary safety devices attached between the hoses and the regulator outlets.

4. Gas Hoses

a. The hoses transport low-pressure gas from the regulator to the torch.
b. The oxygen hose is always black or green.
c. The acetylene hose is always red.
d. The hoses are flame retardant, but should still be kept away from an open flame, sparks, molten metal, and slag.
e. New hoses are stored with talcum powder inside, which should be blown out before connecting them to the torch.

5. Torch (Blowpipe)

a. The torch controls the mixture of oxygen and acetylene to produce the desired flame.
b. Identification of the parts of the torch:

1) Hose connections

a) Oxygen connection is usually marked "OXY."
b) Acetylene connection is usually marked "FUEL."

2) Oxygen control valve
3) Acetylene control valve
4) Barrel
5) Torch head

6. Torch Tips

a. Welding tips
b. Cutting tips
c. Heating tips
d. Tip cleaner

7. Protective Wear

    a. Goggles
    b. Leather gloves

8. Striker

    a. Hand-held piece of equipment used to produce spark.

9. Working Surfaces

    a. Welding table (fire brick does not explode under heat)
    b. Cutting table

B. Oxyacetylene Welding Safety

1. Preventing Eye Injury

    a. Wear goggles with the proper lens when welding, cutting, and grinding.
    b. Protect others' vision by using a welding shield.
    c. Make sure no one is standing in front of the cylinder valve before cracking it to prevent eye injury from blowing dust and grit.
    d. Make sure no one is standing in front of the gas regulators when turning them on to prevent injury from flying glass should they explode.

2. Preventing Burns

    a. Wear protective gloves, clothing, and boots (lace-up shoes can trap hot sparks, molten metal, and slag).
    b. Use a spark striker for lighting a torch, not matches or heated metal.
    c. Cool in water or mark your work "HOT" to keep others from touching it.
    d. Do not wear ragged clothes or cuffs on pants.
    e. Keep gloves and protective clothing free of oil and grease.

3. Preventing Respiratory Problems

    a. Ventilate the work area properly.
    b. Do not breathe the toxic fumes from welding or cutting galvanized material.

4. Preventing Equipment Damage

   a. Always use gas regulators to protect the hoses from the high cylinder pressure.
   b. Use tongs not the leather gloves to pick up hot metal.
   c. Do not over tighten hose connections and torch tips.
   d. Never lift cylinders by their valves.
   e. Never weld or cut on concrete; overheated concrete cracks and explodes.
   f. Be careful not to break tip cleaners off in the tip being cleaned.
   g. Keep hoses clear of the torch flame and dropping, molten metal when cutting.

5. Preventing Fire & Gas Explosions

   a. Never light a torch in an area full of feed or grain dust.
   b. Keep the area between you and the cylinders clear and the cylinder valves unobstructed.
   c. Keep oil and grease away from oxygen and oxygen connections.
   d. Do not try to find a gas leak with a flame; use soapy water from a soap that does not contain oil.
   e. Do not weld or cut on closed containers, tanks, or vessels.
   f. Never leave a lighted torch unattended.
   g. Never use the oxygen tank as a pressure supply to inflate tires or blow off surfaces.
   h. Always make sure the safety chain is attached and hold onto the oxygen cylinder when moving the cylinder truck.
   i. When moving or storing individual cylinders, always replace the caps to prevent valve damage.

ACTIVITY:

1. Identify all the components of an oxyacetylene welder.
2. Change lenses on welding goggles.
3. Take an oxyacetylene safety test.

OXYACETYLENE WELDING EQUIPMENT SET-UP & ADJUSTMENT

A. Oxyacetylene Equipment Setup

1. Cylinders

a. Place the oxygen and acetylene cylinders side by side in a vertical position and secure them from falling.
b. Remove the cylinder valve protection caps and store them for reuse later when the cylinders are empty.
c. Check the cylinder valve threads to verify that they are in good condition and free of dirt and oil.
d. Briefly "crack" the cylinder valves (slightly open) to blow out any dust or dirt that may be lodged there, so it does not enter the regulators.

2. Regulators

a. Verify that the regulator inlet connection is free of dirt, oil, grease, or any other obstruction.
b. Connect the oxygen and acetylene regulators to the proper cylinder valves using an open-end wrench, being careful to tighten the connection nut firmly without excessive force.
c. Turn the regulator adjusting screw out (counterclockwise) on each regulator until it is loose.
d. Stand to one side of the oxygen regulator gauge and open the oxygen cylinder valve slowly so the high-pressure regulator gauge needle gradually moves up to approximately 2000 psi if the cylinder is full, then open the valve completely.
e. Slowly open the acetylene cylinder valve only one half turn, so it can be turned off quickly in an emergency. Acetylene cylinders read about 350 psi when full.

3. Hoses and Torch

a. Connect the oxygen hose (green) to the oxygen regulator outlet and the acetylene hose (red) to the acetylene regulator outlet.

   1) The oxygen hose has right-handed thread connections.
   2) The acetylene hose has left-handed thread connections.

b. Blow out the hoses with cylinder gas to remove dust, dirt, and talcum powder (used to protect new hoses in storage), which may plug the small gas passages in the torch.

1) Turn the adjusting screw on the regulators clockwise until 5 psi shows on the low (working) pressure gauge.
2) Allow the cylinder gas to escape until the inside of the hoses are clean.

c. Connect the free end of the oxygen hose to the torch connection marked "OXY" and the free end of the acetylene hose to the torch connection marked "FUEL."
d. Select the tip or nozzle size appropriate for the metal thickness (see welding tip selection chart), and only hand-tighten the tip to the torch.
e. Test for leaks by pressuring the system (described in paragraph B-1 below) and then brushing a non-detergent, soapy water on all the connections.

1) Soap bubbles will indicate a leak; also listen for the hiss of escaping oxygen and try to discern the smell of acetylene.
2) If a leak is found in a connection, retighten it or replace the faulty connection.
3) Leaking cylinders should be returned to the supplier.

B. Adjusting the Torch

1. Pressurizing the System

a. Close both control valves on the torch handle clockwise, finger tight only.
b. Verify that the regulator screws are turned out and loose.
c. Standing to one side of the regulator, slowly open the oxygen cylinder valve until the pressure gauge responds, and then open the valve all the way.
d. Slowly open the acetylene cylinder valve 1/2 turn or one turn of the wrist.
e. Open the torch oxygen valve 1/8 turn and then screw in the oxygen regulator valve until the desired working pressure is indicated on the regulator working pressure gauge. Close the torch oxygen valve.
f. Open the torch acetylene valve 1/8 turn and then screw in the acetylene regulator valve until the desired working pressure is indicated on the regulator working pressure gauge. Close the torch acetylene valve.

2. Lighting and Adjusting the Torch

   a. Be sure all-protective clothing and goggles (No. 5 shaded lens) are on before proceeding to light the torch.
   b. Hold the torch in one hand and the striker (spark lighter) in the other.
   c. Open the torch acetylene valve no more than 1/4 turn and ignite the gas with the striker.
   d. Open the torch acetylene valve until the flame is no longer smoking.
   e. To set a carbonizing flame (excess amount of acetylene):

      1) Open the torch oxygen valve until a feathered cone exists in the flame.
      2) Three flame zones are present. They are the inner cone, the acetylene feather, and the outer envelope.

   f. To set a neutral flame (equal amounts of oxygen and acetylene):

      1) Open the torch oxygen valve until the acetylene feather disappears and only the inner cone and outer envelope exist.
      2) When the feathery edges of the inner cone disappear, a neutral flame is present.

   g. To set an oxidizing flame (excess amount of oxygen):

      1) Open the torch oxygen valve beyond a neutral flame to a point where the flame is pale blue.
      2) The inner cone will be shorter, will become slightly pointed, and the flame will be more noisy than the neutral flame.

C. Oxyacetylene Equipment Shut-down and Storage

1. Torch Shut-down:

   a. First, turn off the torch acetylene valve. If a small flame remains on the tip, the acetylene valve is leaking.
   b. Turn off the torch oxygen valve last.

2. Depressurize the system:

   a. Close both cylinder valves.

b. Open the torch acetylene valve to depressurize the acetylene gauges and hose.
c. Close the torch acetylene valve.
d. Open the torch oxygen valve to depressurize the oxygen gauges and hose.
e. Close the torch oxygen valve.
f. Turn out the adjusting screws on the oxygen and acetylene regulator valves.

3. Storage of Cylinders

a. Store cylinders in a well-ventilated, fireproof room or cage with flameproof electrical fittings.
b. Do not store oxygen and combustible gases such as acetylene together.
c. Store acetylene cylinders in an upright position--liquid acetone from within the cylinder can leak into valves.
d. Write "empty" with chalk or soapstone on empty cylinders and keep them separate from full cylinders.
e. Store cylinders away from sources of heat, since heat increases the pressure of gas and may weaken the cylinders.
f. Store cylinders away from oil and grease, since these combustibles may ignite spontaneously when in contact with pure oxygen.
g. Keep the cylinder caps on cylinders while in storage to prevent cylinder valve damage, which could result in an oxygen cylinder taking off like a missile.

ACTIVITY:

1. Set up oxyacetylene equipment.
2. Select a tip size using a tip chart.
3. Pressurize the system and light a torch.
4. Adjust for carbonizing, neutral, and oxidizing flames.
5. Dismantle the oxyacetylene equipment and put the cylinders in storage.

OXYACETYLENE FUSION WELDING

A. Oxyacetylene Fusion Welding Definition and Applications

1. Definition

a. Fusion welding is the joining of metal pieces by melting them together.
b. This is accomplished by heating the adjoining edges of metal to their melting point, allowing them to flow together, and then cool to harden as one piece.

1) The combustion of the oxygen-acetylene gas mixture provides the heat for fusion.
2) The flame from the combustion shields the weld from atmospheric contamination.
3) A filler rod may be used to provide additional metal to help the two metal pieces join.
4) The basic skill required in fusion welding is to form, maintain, and move a puddle of molten base metal along the weld, keeping it uniform in both size and shape.

2. Applications

a. Fusion welding is used extensively for joining steel.
b. Oxyacetylene fusion welding is usually applied only to thin steel.

B. Oxyacetylene Welding Terminology

1. Forehand Welding

a. The filler rod precedes the torch in the direction of the weld.
b. The filler rod and torch tip are both manipulated in opposite rotating directions.
c. This is the best technique for welding metal up to 1/8 inch thick.

2. Backhand Welding

a. The torch tip precedes the filler rod in the direction of the weld.
b. Little or no manipulation of the torch tip and filler rod is required.
c. This is the best technique for welding metal over 1/8 inch thick.

3. Welding Angles

    a. Work angle is the angle of the torch or filler rod perpendicular to the direction of the welding bead.
    b. Lead angle is the angle of the torch or filler rod parallel to the direction of the welding bead.

4. Base Metal (the metal to be welded)
5. Filler Rod

    a. It is a rod or wire of filler metal of the same composition as the base metal.
    b. A mild steel rod is used to weld mild steel; an aluminum rod is used to weld aluminum, etc.
    c. The diameter of the filler rod should equal the thickness of the base metal or bead.

6. Bead is the appearance of the finished weld, normally viewed as neat ripples formed by the metal while it was in its semiliquid state.
7. Tack Weld

    a. Tack welds are small, spaced welds along the weld joint made before running the continuous bead along the same joint.
    b. Tack welds prevent expansion or contraction of the weld joint during continuous welding.

C. Oxyacetylene Fusion Welding Procedures

1. Running a bead without filler rod (pushing a puddle)

    a. Prepare a piece of mild steel 1/8 inch thick.
    b. Use an 0 or 00 welding tip.
    c. Adjust the working pressures to about 3 psi for acetylene and 10 psi for oxygen.
    d. Wear appropriate protective gear, then light and adjust the torch to a neutral flame.
    e. Hold the torch at a 90 degree work angle and a 30 degree to 45 degree lead angle, with the inner cone of the flame 1/16 to 1/8 inch above the base metal.
    f. Hold that position over a spot just inside the right edge of the base metal until a molten puddle is established.
    g. Move the torch in a series of arcs or circles to make the puddle circular in shape and about 1/4 inch in diameter.

h. Advance the torch from right to left across the base metal at a speed that will maintain a uniform puddle size and shape.

1) If advanced too rapidly, the puddle will become too small and may be lost completely.
2) If advanced too slowly, the puddle will become too large and may burn through the base metal.

2. Running a Bead with a Filler Rod

a. The steps are the same as above until the molten puddle is formed.
b. Once the puddle is formed, dip the end of the 1/16 inch diameter steel filler rod into the puddle and begin moving the torch in a series of vertical ovals, while at the same time moving the rod up and down, in and out of the puddle.

1) As the flame rises, the rod lowers, and vice versa.
2) Do not allow molten metal to drip from the end of the filler rod, but add the filler metal directly by dipping the end of the rod into the puddle.

c. As the torch is advanced from right to left, maintain uniform bead width and height with a smooth ripple effect.

1) If advanced too rapidly, the bead will become narrow and have the appearance of having been deposited on top of the base metal.
2) If advanced too slowly, the bead will become too large and may burn through the base metal.

D. Oxyacetylene Welding Problems

1. Backfire (popping noise)

a. Backfire is a momentary burning back of the flame into the tip ending with a loud pop (explosion at the tip).
b. The causes can include the following:

1) Insufficient gas velocity (open torch valves more).
2) Overheated tip (hold tip farther away from the work or change the lead angle).
3) Inadvertently moving the torch tip into the molten puddle (clean out the tip).

4) Sparks flying into the tip.
5) Improper seals or grommets within the torch (examine and replace).

2. Flashback (popping with shrill squealing or hissing)

a. Flashback is an explosion occurring at the tip accompanied by gases burning back into the hoses and regulator.
b. The symptoms are as follows:

1) The flame goes out with a pop.
2) A loud squealing or hissing noise occurs.
3) Black smoke and sparks emerge from the tip.

c. The action required to remedy the problem is as follows:

1) Quickly close the torch valves and shut down the regulators and cylinder valves; allow the apparatus to cool.
2) Do not relight until the cause has been found and remedied

d. Extremely hazardous, is the flame reaches the tank, so long building. Possible causes could happen by any of the following:

1) Clogged tip
2) Improper oxygen-acetylene gas mixture ratio
3) Loose connections
4) Kinked hose

ACTIVITY:

1. Make a bead with and without a filler rod.

210B-15

OXYACETYLENE BRAZING

A. Brazing

1. Brazing is the bonding (adhesion), rather than fusing (melting) of two metal objects.
2. This adhesion connection is made with a minimum of alloy (bronze) which melts above 800 degrees Fahrenheit and flows by capillary action between close-fitting metal. Surface areas should be ground or cleaned with a wire brush or bead blaster before brazing.
3. Brazing differs from braze welding in the following ways:

    a. Brazing requires a close fitting joint, as when overlapping sheet metal. Gaps in the joint should fall between 0.001 and 0.100 of an inch. Gaps grater than 0.100" will not completely fill.
    b. Braze welding joints resemble those of fusion welding; there is more bonding metal at the joint as compared to brazing.

4. Brazing and braze welding can be used to join dissimilar metals.
5. Brazing can be used to join thin pieces of metal in order to decrease the danger of melting through.
6. Brazing can be used on most commercial metals, where fusion welding may have limitations.

B. Brazing Equipment

1. Brazing uses the same welding apparatus as oxyacetylene welding, but gases other than acetylene can be used. (Mapp-Gas, Propane, etc.)
2. Flux required for bronze or brass brazing is usually a borax type consisting of sodium borate with other additives. (Flux is any substance or mixture used to promote the fusion of metals or minerals, for example, alkalis, borax, lime, fluorite, etc.)

    a. Flux removes all oxides from the metal surfaces to be welded.
    b. Flux forms a protective coating over the heated metal surfaces that prevents oxidation.
    c. Flux floats the oxides and their impurities with which it combines to the top of the molten metal.

3. Bronze filler rods come in different sizes and have a lower melting point than the metal being bonded depending on their alloy composition.

    a. Silicon bronze is used for copper sheet and mild steel.
    b. Nickel bronze is used for mild steel, cast iron, and wrought iron.

C. Operating the Oxyacetylene Equipment to Braze and Braze Weld

1. Basic Brazing Technique:

   a. Set up the metal pieces to be joined.
   b. Select the appropriate torch tip.
   c. Adjust the torch to the appropriate gas pressures.
   d. Put on appropriate protective goggles and gloves.
   e. Light the torch with the striker and adjust the flame to a neutral flame.
   f. Heat the bronze filler rod with the torch flame and dip it in the flux so that it becomes coated with flux.
   g. Heat the area on the metal to be bonded to 800^{o} (before a dull red color appears) and "tin" it by applying a light coating of fluxed filler rod. (Braze Welding)
   h. After "tinning," finish the braze weld by filling in the joint with a fluxed filler rod. (Braze Welding)

2. Brazing and Braze Weld Demonstrations

   a. Overlap Joint (Brazing)

      1) Overlap two pieces of sheet metal by approximately 1/4 inch.
      2) Using the proper gas pressure and flame adjustment, the joint will be connected by capillary action.
      3) After the metal is joined by capillary action, go back over the joint with a filler rod to smooth the joint.

   b. Fillet Joint (Braze Welding)

      1) Set up the two pieces of sheet metal at right angles.
      2) Using the proper gas pressure and flame adjustment, heat the area on the metal to be bonded to 800^{o} (before a dull red color appears) and "tin" it by applying a light coating of fluxed filler rod.
      3) After "tinning," go back over the joint with a filler rod to smooth the joint.

ACTIVITY:

1. Bond sheet metal by brazing.
2. Bond mild steel plate by braze welding.

210B-17

BASIC OXYACETYLENE FUSION WELDS

A. Corner Weld Without Filler Rod

1. Place two pieces of mild steel (1/16 inch thick) so that their edges form a 90 degree angle with their inside corners touching.
2. Select the appropriate tip by consulting a tip chart.
3. Adjust the working pressures to about 5 psi for oxygen and 5 psi for acetylene or according to manufacturer's recommendation for tip.
4. Wear appropriate protective gear, then light and adjust the torch to a neutral flame.
5. Tack weld the two pieces together:

    a. Hold the torch at a 90 degree work angle and a 45 degree lead angle with the inner cone of the flame 1/16 to 1/8 inch above the base metal.
    b. Place the torch over the two edges of the joint just inside the right corners of the base metals until a single molten puddle is established.
    c. Remove the flame to allow the puddle to solidify.
    d. Make another tack weld at the opposite end of the joint.

6. Play the flame on the right-hand tack weld to remelt a puddle on its surface, then advance the puddle from right to left along the joint at a speed that will maintain a uniform puddle size and shape.

B. Bead weld with filler rod:

1. Prepare a piece of mild steel 1/8 inch thick.
2. Select the appropriate tip by consulting a tip chart.
3. Adjust the working pressures to about 5 psi for oxygen and 5 psi for acetylene or according to manufacturer's recommendation for tip.
4. Wear appropriate protective gear, then light and adjust the torch to a neutral flame.
5. Hold the torch at a 90 degree work angle and a 45 degree lead angle with the inner cone of the flame 1/16 to 1/8 inch above the base metal.
6. Hold the filler rod in the outer part of the flame away from the joint until two tiny molten puddles begin to form on the corners, then add some filler metal from the rod to bridge the two puddles.
7. Continue to heat the puddle and add filler metal until the puddle is about 1/4 inch in diameter, then remove the flame to allow the puddle to solidify.
8. Using a forehand technique, advance the puddle from right to left at a speed that will maintain a uniform puddle size and shape.

9. Make sure that the filler rod is added only to the puddle, not just melting onto the pieces.

C. Butt weld with filler rod:

1. Prepare two pieces of mild steel 1/8 inch thick.
2. Select the appropriate tip by consulting a tip chart.
3. Adjust the working pressures to about 5 psi for oxygen and 5 psi for acetylene or according to manufacturer's recommendation for tip.
4. Wear appropriate protective gear, then light and adjust the torch to a neutral flame.
5. Tack weld the two pieces together so that they are spaced about 1/8 inch at the left and 1/16 inch at the right to allow for normal expansion from heating.

    a. Hold the torch at a 90 degree work angle and a 45 degree lead angle with the inner cone of the flame 1/16 to 1/8 inch above the base metal.
    b. Play the torch over the two edges of the joint just inside the right edges of the base metals until a molten puddle is established.
    c. Hold the filler rod in the outer part of the flame away from the joint until two tiny molten puddles begin to form on the corners, then add some filler metal from the rod to bridge the two puddles.
    d. Continue to heat the puddle and add filler metal until the puddle is about 1/4 inch in diameter, then remove the flame to allow the puddle to solidify.
    e. Make another tack weld at the opposite end of the joint.

6. Play the flame on the narrower, right-hand tack weld to re-melt a puddle on its surface, then add metal from the filler rod.
7. Using a forehand technique, advance the puddle from right to left along the joint at a speed that will maintain a uniform puddle size and shape.

    a. Make sure that the puddle melts into both pieces of metal at all times.
    b. Make sure that the filler rod is added only to the puddle, not just melting onto the pieces.

D. Lap Weld with filler rod

1. Overlap two pieces of 1/8" thick mild steel.
2. Select the appropriate tip by consulting a tip chart.

3. Adjust the working pressures to about 10 psi for oxygen and 5 psi for acetylene or according to manufacture's recommendation for the tip selected.
4. Wear appropriate protective gear, then light and adjust the torch to a neutral flame.
5. Tack weld both overlapping edges together at each and of the workpiece.
6. Hold the torch at a 45^o lead angle and a 75^o work angle with the inner cone of the flame 1/16" to 1/8" above the base metal and directed more towards the overlapping metal surfaces.

    a. Metal edges conduct heat faster than metal surfaces.
    b. Direct the flame more towards the metal surface to prevent the edge piece from being melted away before the surface piece reaches the proper welding temperature.

7. Play the flame on the right-hand tack weld to re-melt a puddle on its surface, then add metal from the filler rod.
8. Using a forehand technique, advance the puddle from right to left along the joint at a speed that will maintain a uniform puddle size and shape.
9. Add filler rod to the front edge of the puddle is advanced.
10. Turn the metal over and weld the other overlapping edge.

E. Fillet weld with filler rod

1. Position two piece of 1/8" mild steel so that one joins the other to form a T, and support the vertical piece with a fire brick until tacked.
2. Select the appropriate tip by consulting a tip chart.
3. Adjust the working pressures to about 10 psi for oxygen and 5 psi for acetylene or according to manufacture's recommendation for tip size used.
4. Wear appropriate protective gear, then light and adjust the torch to a neutral flame.
5. Tack weld the two pieces together, then remove the support.
6. Hold the torch at a 45^o work angle and a 30^o to 45^o lead angle with the inner cone of the neutral flame 1/16" to 1/8" above the base metal.

    a. Metal edges conduct heat faster than metal surfaces.
    b. Direct the flame, therefore, more towards the horizontal metal surface to prevent the vertical edge piece from being melted away before the horizontal surface piece reaches the proper welding temperature.

7. Play the flame on the right-hand tack weld to re-melt a puddle on its surface, then add metal from the filler rod.

8. Using a forehand technique, advance the puddle from right to left along the joint at a speed that will maintain a uniform puddle size and shape.
9. Add filler rod to the front of the puddle and withdraw the rod as the puddle is advanced.
10. Weld the other side of the fillet joint in similar fashion.

F. Metal Behavior Under Applied Stress

1. Stresses are internal forces set up in the welded pieces due to heating and cooling.
2. Two types of stresses result from the welding process:

    a. Stresses that develop while the weld is being made but which disappear on cooling.
    b. Stresses that remain after the weld has cooled off (residual stresses).

3. There are several factors that affect distortion and residual stresses:

    a. Distortion (warping of the welded part) occurs if the expansion due to heating is resisted.
    b. A residual stress results if the contraction due to cooling is resisted. Residual stresses can result in cracking of the welded part.

4. Methods of Reducing Distortion:

    a. Decrease the welding speed and use the smallest flame possible to obtain the correct penetration and fusion of metals.
    b. Line up the work at a slight angle opposite the direction of distortion during cooling to ensure correct alignment.
    c. Use skip or step-back method of welding.
    d. Use clamps to prevent movement.

5. Methods of Reducing or Relieving Stress

    a. Run the weld bead from the fixed end to free end.
    b. Use the round end of a ball peen hammer to peen the weld lightly as it cools.
    c. Heat treat the welded material and then allow slow cooling

ACTIVITY:
1. Perform a corner weld without filler rod and have students practice the weld.
2. Perform a bead weld and butt weld with filler rod and have students practice the welds.

210B-21

OXYACETYLENE CUTTING

A. Oxyacetylene Cutting Process and Applications

1. Oxyacetylene Cutting Process:

    a. Oxyacetylene cutting is a rapid oxidation or burning of metal at high temperature.

    b. Oxidation is the combining of oxygen with any other substance

        1) When oxygen slowly combines with a substance, the process is called oxidation.
        2) When oxygen rapidly combines with a substance, the process is called burning.

    c. This rapid oxidation process is accomplished by gas flame accompanied by a jet action which blows the oxides away from the cut.

2. Oxyacetylene Cutting Applications:

    a. The process can be applied to all carbon steels up to 0.25% carbon.

    b. The process can also be applied to higher carbon steels, but only with some difficulty.

    c. The process cannot be applied to copper, aluminum, or high-nickel alloys.

B. Oxyacetylene Cutting Equipment

1. Basic oxyacetylene welding apparatus with a cutting torch attachment is used for cutting.
2. Cutting torch valves:

    a. Cutting torch (blow pipe) oxygen and fuel valves

        1) The fuel valve adjusts the flow of acetylene into the preheat section of the cutting torch attachment.
        2) The oxygen valve on the welding torch (blowpipe) is left fully open to supply the attachment with both preheat and cutting oxygen.

    b. Cutting torch attachment preheat-oxygen valve

1) This valve adjusts the flow of oxygen into the preheat section of the cutting torch attachment.
2) Oxygen is supplied through a different tube than that which supplies the cutting-oxygen valve.

c. Cutting torch attachment cutting-oxygen valve

1) This valve injects pure oxygen into the cut when its lever is depressed.
2) The resulting set action greatly increases combustion and removes the molten metal and oxides from the cut.

3. Cutting Tip

a. It is designed to accommodate both an oxyacetylene preheat flame and a jet stream of pure oxygen for cutting.
b. It has smaller holes surrounding a larger center orifice.

1) The small holes direct the mixed gases into the preheat flame.
2) The larger center orifice permits the jet action of pure oxygen from a separate oxygen tube in the attachment.

c. The tip should be cleaned regularly as it becomes clogged with metallic particles during use.

1) Use a tip cleaner that is equal to or smaller in size than the tip holes.
2) Use an up-and-down motion; do not twist the tip cleaner in the tip holes.

C. Oxyacetylene Cutting Equipment Setup and Operation

1. Cutting Equipment Setup

a. Attach the cutting attachment to the welding torch and hand tighten the fittings.
b. Select the proper cutting tip size for the job and inspect the taper cone seat to be sure it is not damaged and is free of dirt.
c. Insert the cutting tip into the tip nut, screw it onto the cutting attachment, and then tighten it with the appropriate wrench.

2. Cutting Torch Pressurization

a. Loosen pressure adjusting screws on the regulators.

b. Open the oxygen cylinder valve slowly and completely.
c. Acetylene cylinder valve.

1) Open the valve slowly one half turn (one turn maximum).
2) Never use over 15 psi.

d. Open the torch (blow pipe) oxygen valve completely.
e. Set working pressures according to tip size with the gas flowing.

1) Set the recommended oxygen hose pressure by opening the preheat oxygen valve and adjusting the pressure with the oxygen regulator screw.
2) Set the recommended acetylene hose pressure by opening the torch acetylene valve and adjusting the pressure with the acetylene regulator screw.

f. Purge (blow out) the cutting oxygen passages by depressing the cutting torch oxygen lever before lighting the torch.

3. Cutting Torch Lighting and Adjustment

a. Open the acetylene valve 1/2 turn and light the torch tip.

1) Add acetylene until the smoke stops and the flame is about 1/8 inch from the tip.
2) Reduce the acetylene until the flame touches the tip.

b. Open the preheat oxygen valve on the attachment and adjust to a neutral flame.
c. Depress the cutting-oxygen lever and readjust to a neutral flame.

4. Cutting Equipment Shutdown

a. Close the preheat valves.

1) Close the preheat-oxygen valve on the attachment first to avoid popping.
2) Then close the acetylene valve on the torch (blow pipe).

b. Close both cylinder valves.
c. Open the acetylene valve to bleed the acetylene gauges, hose, and torch, and then close it.

d. Open the preheat-oxygen valve on the attachment to bleed the oxygen gauges and hose, and to purge the torch.
e. Loosen the regulator adjustment screws.

D. Oxyacetylene Cutting Procedure

1. Cutting a straight line

a. Set the metal to be cut on a cutting table and mark a straight line on it with soapstone or clamp a length of angle iron on the line to guide the tip.

1) For a perpendicular cut, place one side of the angle iron on the surface of the metal so that the other side forms a 90-degree angle to the surface.
2) For a bevel cut, place the edges of the two outside surfaces of the angle iron on the metal surface so the surface aligned with the cutting line forms a 45-degree angle.

b. Select appropriate cutting tip size for metal thickness.
c. Adjust gas pressures according to tip size selected.
d. Light torch and adjust flame.
e. Hold the torch with one hand and guide it with the other, keeping the preheat cone 1/16 to 1/8 inch above the metal surface.
f. Heat the edge of the metal to a cherry red.
g. Depress the cutting-oxygen lever slowly.
h. When the cut starts, continue it by moving the cutting tip along the line keeping the preheat cones just above the metal surface.

1) Cutting angle to direction of travel

a) For thick metal, the preheat cones are kept perpendicular to the direction of travel.
b) For thin metal, the preheat comes are slightly angled in the direction of travel.

2) Cutting speed

a) Moving too slow will allow the metal to refuse at the bottom of the cut.
b) Moving too fast will cause the metal edges to lose heat and halt the cut.

h. If the cut is lost, release the cutting-oxygen lever and reheat the metal before proceeding.

2. Piercing holes

a. Preheat the spot by keeping the preheat cones slightly above the metal surface.
b. Lift the torch slightly and slowly depress the cutting-lever.
c. Tilt the torch slightly to blow the sparks away.
d. Continue to feed cutting oxygen onto the spot until the hole is pierced in the metal.

ACTIVITY:

1. Identify which metals can be cut with an oxyacetylene torch.
2. Select appropriate cutting tip, gas pressures, flame for metal size being cut.
3. Cut a straight line in 1/8 and 1/2 inch mild steel plate.
4. Make a straight bevel cut in 1/2 inch mild steel plate.
5. Cut sheet metal (14 gauge or less).
6. Pierce a hole in 1/8 inch mild steel plate.

References:

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

Resources:

Deere & Company. (1987). WELDING (6th ed.) (Fundamentals of Service (FOS) Series). Available from: John Deere Technical Services, Dept. F, John Deere Road, Moline, IL 61265 (Available in Spanish)

Special Material and Equipment:

Oxygen and acetylene cylinders, regulators and hoses, torch, tips, open-end wrench, striker, gloves, goggles, and protective clothing filler rods, 1/8 & 1/16 inch mild steel.

210B-26

Name____________________
Date_____________________
Score____________________

UNIT & SAFETY EXAM, OXYACELETINE WELDING AND CUTTING

Answer the following true and false questions, T if the statement is true and F if the statement is false.

1. _____ A pop will may be heard if the torch acetylene is turned off first when shutting down the torch.

2. _____ Acetylene outlets have a right-handed threads.

3. _____ Acetylene is very soluble in acetone.

4. _____ Gas regulators increase low cylinder pressure to high hose pressure.

5. _____ The pressure adjusting screw on a gas regulator should be turned counterclockwise (out) to decrease the pressure.

6. _____ Keep gloves and protective clothing free of oil and grease to avoid combustion if oxygen comes into contact them.

7. _____ Fumes from a cutting or welding galvanized metal are toxic.

8. _____ Cylinders may be lifted by their valves if care is taken not to drop them.

9. _____ The oxygen tank may be used as a pressure supply to inflate tires or blow off surfaces as long as a acetylene is not mixed.

10. _____ Use soapy water from a soap that does not contain oil to find gas leaks.

11. _____ Never cut or weld on concrete because overheated concrete may crack and explode.

12. _____ In an oxidizing flame, the inner cone will be shorter and the flame will be more noisy than the neutral flame.

13. _____ A bead may be run without a filler rod.

14. _____ Brazing uses the same welding apparatus as oxyacetylene welding.

15. _____ Bronze filler rods usually have a higher melting point than the metal being bonded.

Match the following descriptions with the best possible answer.

16. _____ Joining metal pieces by melting them together. — A. Work angle

17. _____ The filler rod precedes the torch in the direction of the weld — B. Oxidation

18. _____ The torch tip precedes the filler rod in the direction of the weld. — C. Backfire

19. _____ The angle of the torch or filler rod perpendicular to the direction of the welding bead. — D. Flashback

20. _____ The angle of the torch or filler rod parallel to the direction of welding bead — E. Fusion Welding

21. _____ The momentary burning back of the flame into the tip ending in a loud pop (explosion at the tip) — F. Backhand Welding

22. _____ An explosion occurring at the tip accompanied by gasses burning back into the hoses and regulator (shrill squealing or hissing). — G. Forehand Welding

23. _____ The bonding of two metal objects by adhesion with a minimum of alloy. — H. Lead Angle

24. _____ The combining of oxygen with any other substance. — I. Oxyacetylene Cutting

25. _____ The rapid oxidation or burning of metal at high temperatures. — J. Brazing

Multiple Choice

26. _____ Which is not a true description of oxygen?

a. Oxygen is a colorless gas
b. Oxygen has no smell or taste.
c. Liquid Oxygen is flammable
d. Oxygen readily
e. All of the above

27._____ Which is NOT a true description of acetylene?

a. Acetylene is a colorless gas.
b. Acetylene has no smell.
c. Acetylene is flammable
d. None of the above.

28._____ Which of the following statements about oxyacetylene cutting applications is not true?

a. It can be applied to all carbon steels up to 0.25% carbon.
b. It can also be applied to higher carbon steels, but only with some difficulty.
c. It can be applied to copper, aluminum, or high-nickel alloys.

29._____ Which range does an oxygen cylinder gauge read?

a. 0 – 30 psi
b. 0 – 200 psi
c. 0 – 400 psi
d. 0 – 4000 psi

30._____ Which range does an acetylene working gauge read?

a. 0 – 30 psi
b. 0 – 200 psi
c. 0 – 400 psi
d. 0 – 4000 psi

31._____ Which range does an oxygen working gauge read

a. 0 – 30 psi
b. 0 – 200 psi
c. 0 – 400 psi
d. 0 – 4000 psi

32._____ Which range does an acetylene cylinder gauge read

a. 0 – 30 psi
b. 0 – 200 psi
c. 0 – 400 psi
d. 0 – 4000 psi

33. _____ Which is the best description of a carbonizing flame?
a. Excess amount of oxygen.
b. Excess amount of acetylene.
c. Equal amounts of oxygen and acetylene.

Answer Sheet

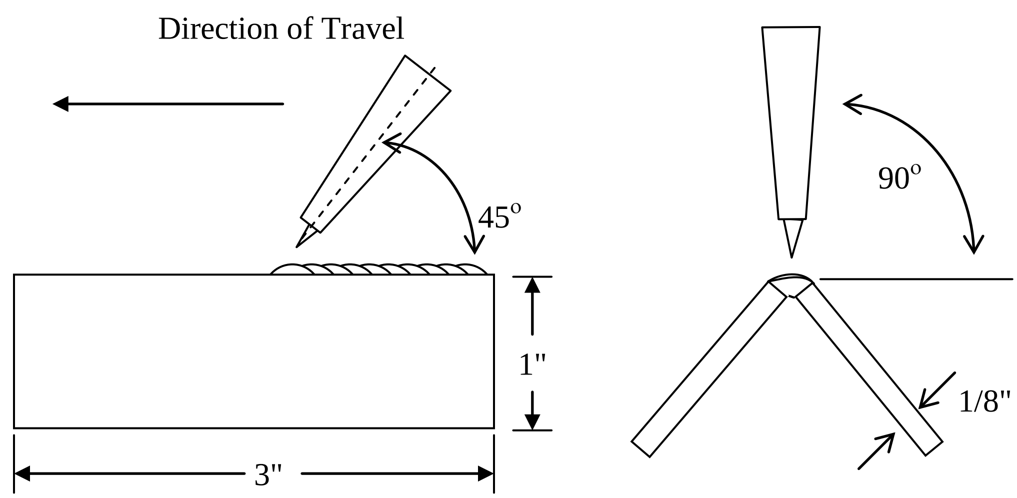
1. T
2. F
3. T
4. F
5. T
6. T
7. T
8. F
9. F
10. T
11. T
12. T
13. T
14. T
15. F

16. E
17. G
18. F
19. A
20. H
21. C
22. D
23. J
24. B
25. I

26. E
27. D
28. C
29. D
30. A
31. B
32. C
33. B

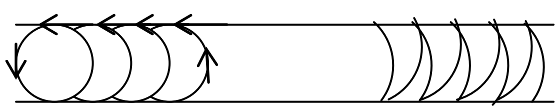
Fusion Weld Without Rod

1. Suggested tip, use manufactures' chart (#0 for Victor).
2. Use assigned metal.
3. Set gauges, see chart (victor equipment, 5 psi oxy and 5 psi acet).
4. Maintain about 1/8" between cone & puddle.
5. Maintain 45^{o} travel angle, 90^{o} work angle.
6. Tip should point straight with direction of welding.



Bead: 3/8" wide, full length of metal

7. Use circular or semi-circular motion.



8. Right handed persons start on the right side – work towards left
9. Methods to control heat.
   A. Change tip size – for more heat , larger tip
   B. Change flame angle – for more heat, straighter up and down
   C. Change speed of travel – for more heat, slow down
   D. Change flame to puddle distance – for more heat, get closer

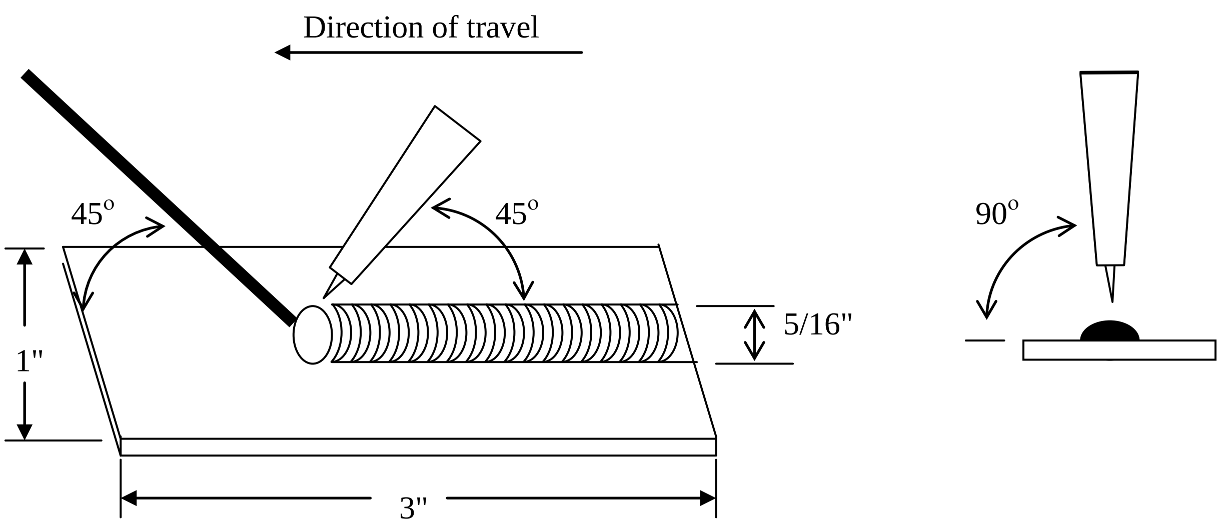
GRADE SHEET

Fusion Weld

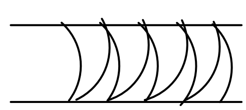
Student Number	3/8" Bead Width -1 @ 1/32" Over or under	Evenness of Bead Width -1 @ 1/32 Over or Under	Tip Pointed straight with Bead to -10	Other than neutral flame to -10	Eveness & Depth of Penetration to -10	Eveness of Bead & Technique To -10	Bead full length of metal - 5 @ 1/4 "	Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

Fusion Bead Weld, With Rod

1. Suggested tip, use manufactures' chart (#0 or #1 for Victor).
2. Use two pieces of the assigned metal.
3. Set gauges, see chart (for Victor equipment, 5 psi oxy and 5 psi acet).
4. Maintain about 1/8" between cone & puddle.
5. Maintain 45° torch angle, 90° work angle.
6. Use filler rod approximately same diameter as metal thickness.
7. Maintain a 45° rod angle and use slight up and down motion into the puddle.
8. Tip should point straight in direction of welding.



9. Use semi-circular motion with the torch



10 Right handed persons start on the right side – work towards left
11 Methods to control heat.
   A. Change tip size – for less heat, use smaller tip
   B. Change flame angle – for less heat, use more angle
   C. Change speed of travel – for less heat, speed up
   D. Change flame to puddle distance – for less heat, get farther away

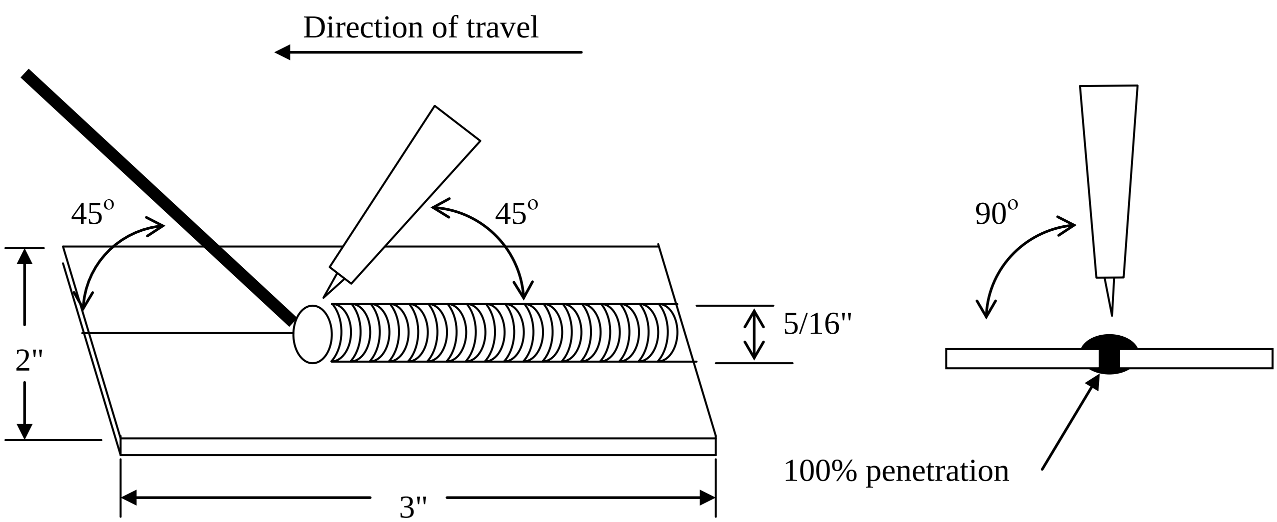
GRADE SHEET

Fusion Bead Weld, With Rod

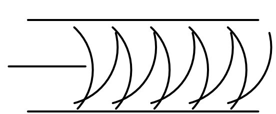
Student Number	5/16" Bead Width -1 @ 1/32" Difference	Evenness of Width & Technique -1 @ 1/32 Difference	Excess Penetration to -10 each Evenness of Ropples	Overlap To -10 each Undercut	Ending to be Filled to -5 each Cold Starts	Correct Torch Angle to -5 each Bead to be Crowned in Center	Full Length of Metal Within 1/4" -1 @ 1/32" under	Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

Fusion Butt Weld, With Rod

1. Suggested tip, use manufactures chart (#0 or #1 for Victor).
2. Use assigned metal.
3. Set gauges, see chart (for Victor equipment, 5 psi oxy and 5 psi acet).
4. Maintain about 1/8" between cone & puddle.
5. Maintain 45^o torch angle, 90^o work angle.
6. Start with a 1/16" gap on the starting end and 1/8" on the finishing end.
7. Use filler rod approximately same diameter as metal thickness.
8. Maintain a 45^o rod angle and use slight up and down motion into the puddle, keeping the bead equal on both sides of the joint.
9. Tip should point straight in direction of welding.



10. Use semi-circular motion with the torch.



11. Right handed persons start on the right side – work towards left
12 Methods to control heat.
    A. Change tip size.
    B. Change flame angle.
    C. Change speed of travel
    D. Change flame to puddle distance

210B-35

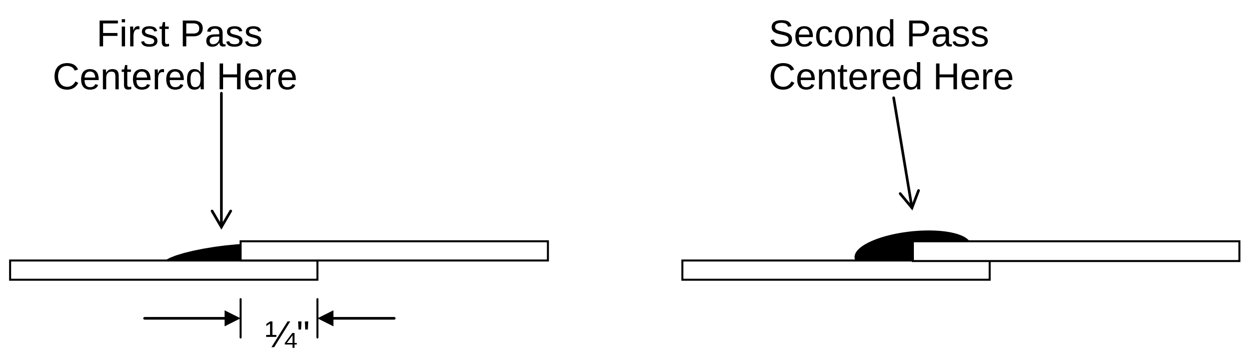
GRADE SHEET

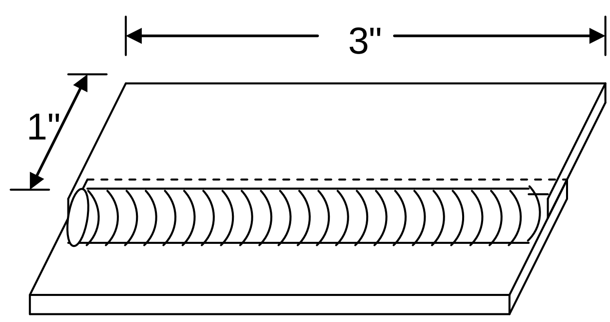
Fusion, Butt Weld

Student Number	3/8" Bead width -1 @ 1/32 Over or Under Evenness of Width	Not Crowned, to -10 Evenness of Bead & Technique to -15	Complete Penetration to -15	Overlap To -10 each Undercut	Starts & Endings to -5 each			Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

Braze Lap Weld

1. Use assigned metal, clean with wire brush, belt sander or bead blast before brazing.
2. Use 00 or 0 Victor tip and neutral flame.
3. Adjust angle of torch to move puddle to desired location.
4. Use tinning layer with metal showing dull red color.
5. On second pass, metal doesn't show red color.
6. Overheating will cause bronze to boil and will leave a rough pimply weld which may show copper color.
7. Use same torch and rod angle as used in welding a bead.





Material: 2 pieces, 14 gauge x 1" x 3"
3/32" braze flux coated rod

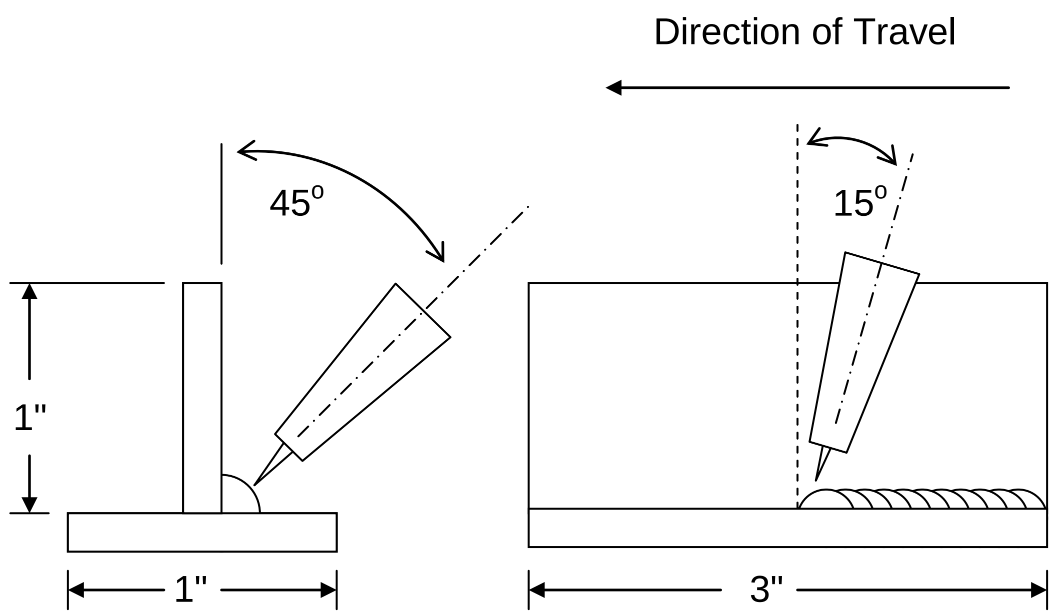
GRADE SHEET

Braze, Lap Weld

Student Number	Bead width 3/8" -1 @ 1/32 Over or under	Eneness of Width -1 @ 1/32	Starts to -5 each Endings	Correct Heat to -10	Excess Bead & Technique to -10	Top to be Crowned to -10	Edge of Top Plate Covered to -10	Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

Braze Fillet Weld

1. Use assigned metal, clean with wire brush, belt sander or bead blast before brazing.
2. Place metal in position by using a firebrick to support vertical piece.
3. Use slightly oxidizing flame.
4. Tack weld opposite starting end and remove firebrick.
5. Hold torch at approximately 45^o work angle and 15^o travel angle.
6. Use a tinning layer with metal showing a dull red color.
7. On second pass metal doesn't need to show dull red color.
8. Overheating will cause bronze to boil and will leave a rough, pimply weld which may show a copper color, also you will have trouble controlling the puddle.



Material: 2 pieces, 14 gauge x 1" x 3"
3/32" braze flux coated rod

GRADE SHEET

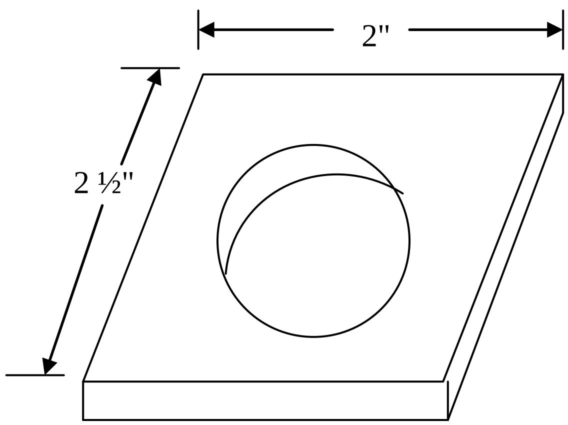
Braze, Fillet Weld

Student Number	Bead Width 1/4" -1 @ 1/32	Legs Equal Length -1 @ 1/32"	Width Eveness to -10 Hight	Starts to -5 each Endings	Overlap to -10	Correct Heat to -10	Excess Bronze & technique to - to	Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

Oxyacetylene Cutting

1. Choose proper tip from chart, clean tip frequently.
2. Set oxy-acet pressure according to chart.
3. Light torch – turn up acet until smoke clears or until flame leaves tip then turn down until the flame is back on the tip.
4. Adjust to neutral flame, depress oxy-lever and adjust again.
5. Torch should produce cutting lance about 6" long.
6. Preheat, when edge of metal turns red, gently depress cutting lever to full-on position.

Use 3/8" to 5/8" steel



7. Move as rapidly and steadily as possible without losing cut; observe spark steam – sparks go straight down with proper speed.
8. Torch tip should be held vertical to plate with tips of preheat flames 1/8" above metal.
9. When making practice cuts, cool between each cut.

SPECS:

1. Do not grind the end to be graded.
2. Use chipping hammer and wire brush.
3. Cut hole in the center ________ inch (es) in diameter.
4. Pipe must slide thru hole easily.
5. Cuts to be straight & square with side.
6. To have no slag or top edge melting.

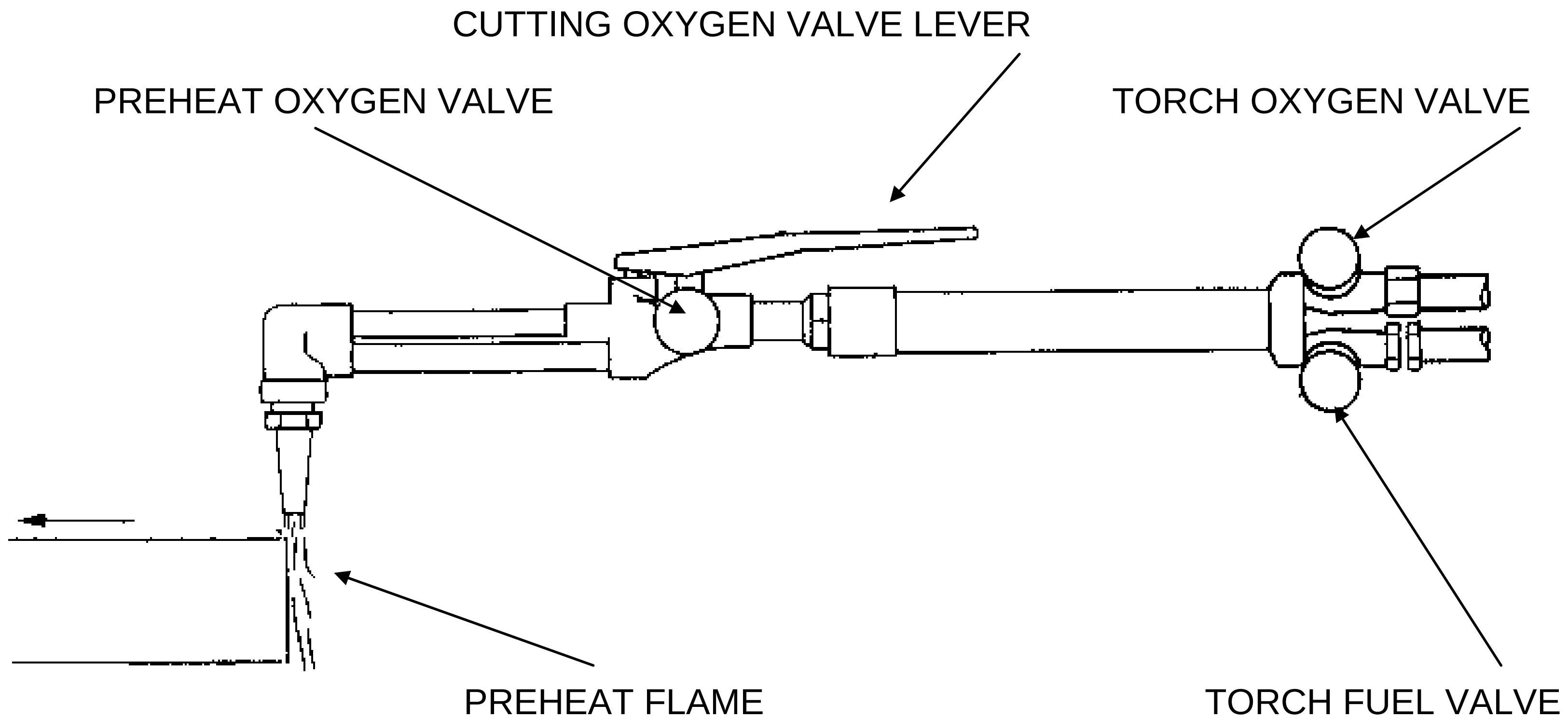
GRADE SHEET

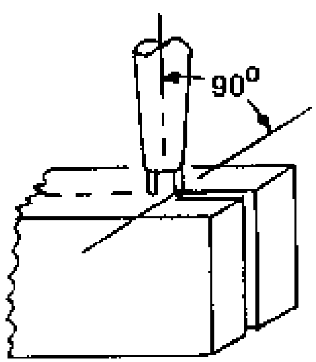
Cutting Torch, Project

Student Number	90° Cut: Evenness of Cut to -20	90° Cut: Square with side -1 @ 1/32"	90° Cut: Hard Slag to - 10 Top Edge Melt to -5	90° Cut: Length 2 1/2" + or - 1/16" -1 per 1/16"	Sides Square with Top to -10	Hole: -10 Undersize Oversize to + 1/16" -1 @ 1/32" Over 1/16"	Hole: Top Edge Melt to -5 Hard Slag to -10	Hole: Roundness to -5 each Evenness of Cut	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

210B-42

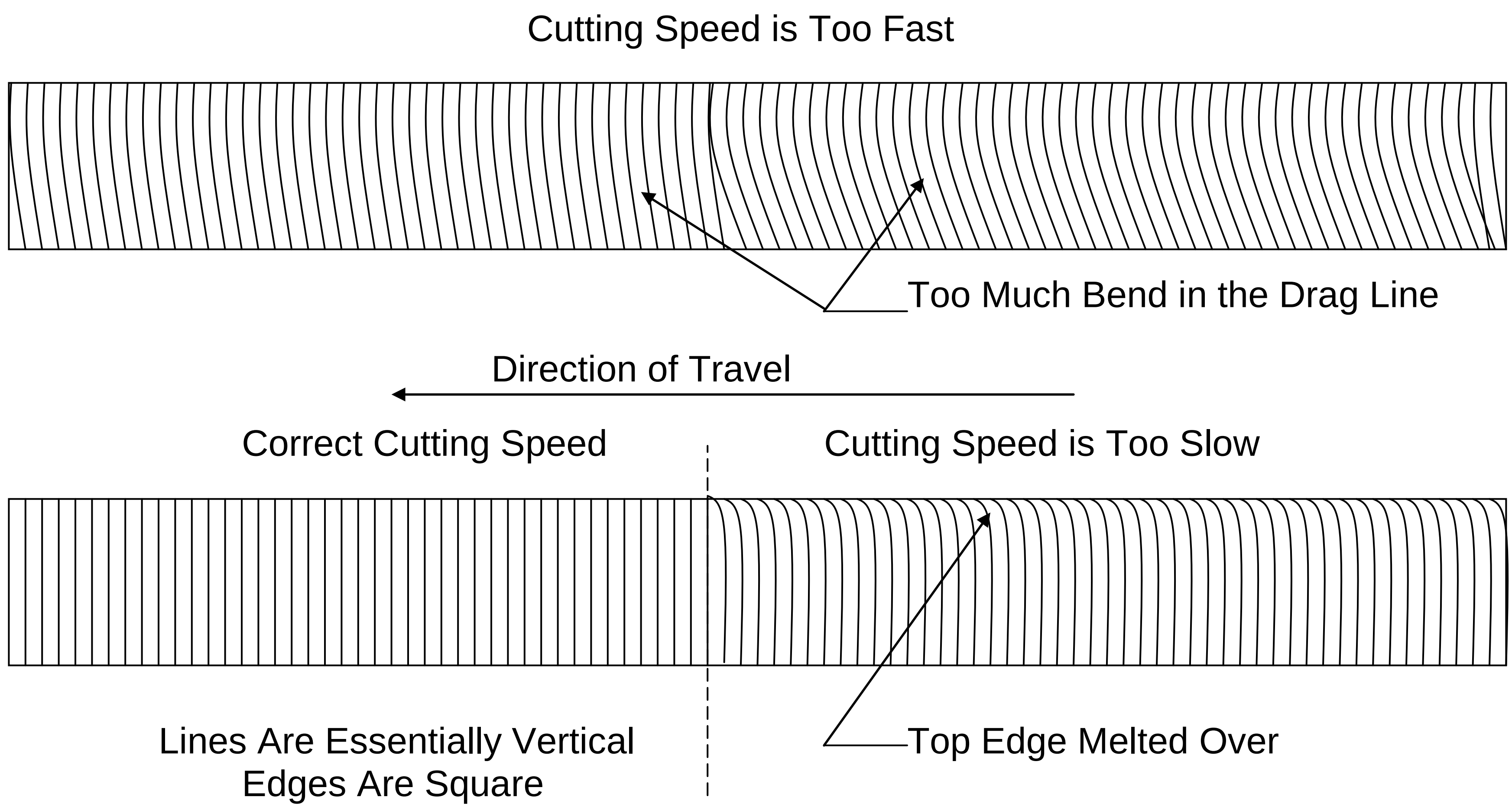
OXYACETYLENE CUTTING TORCH





210B-43

Cutting Patterns

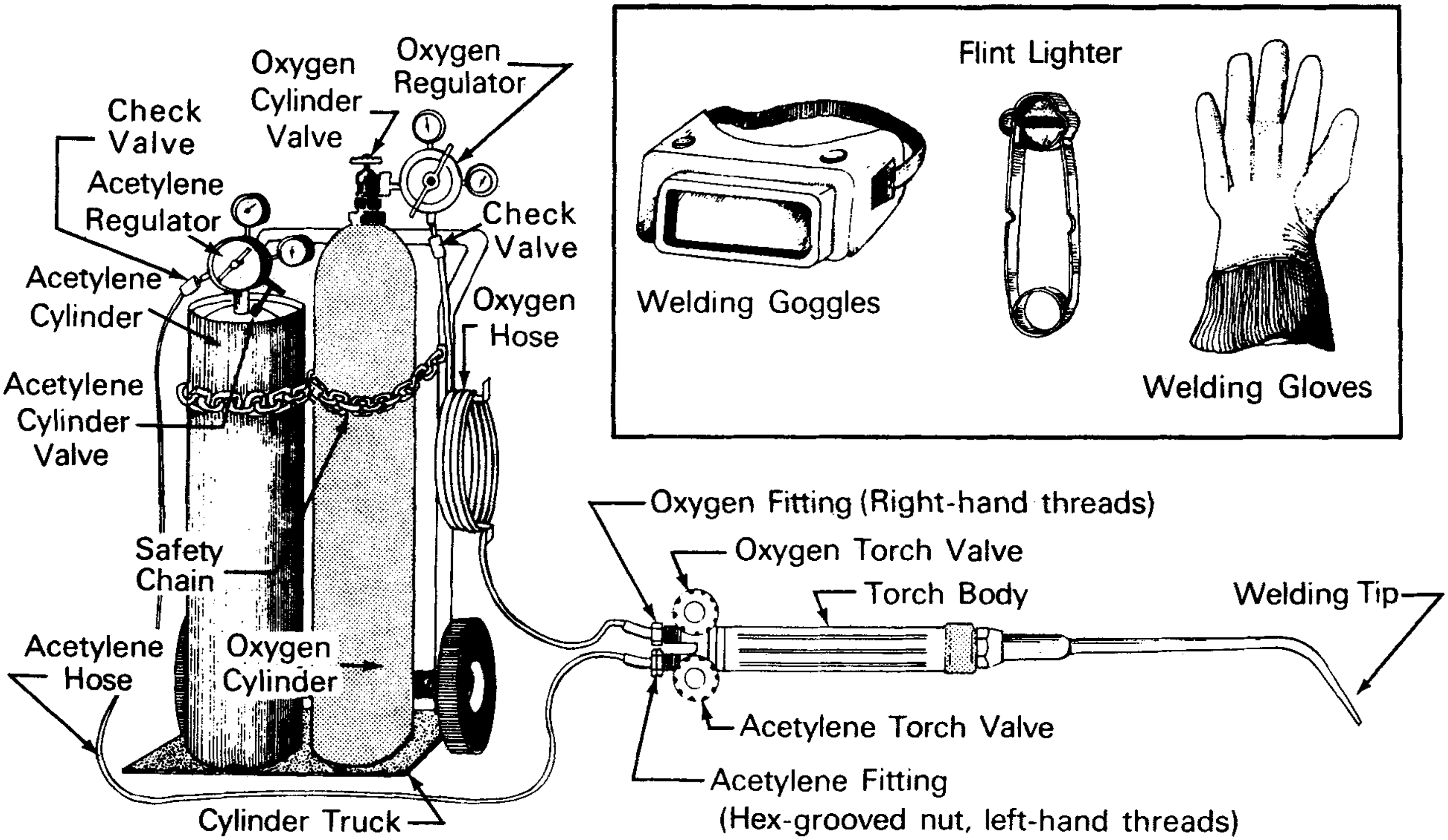


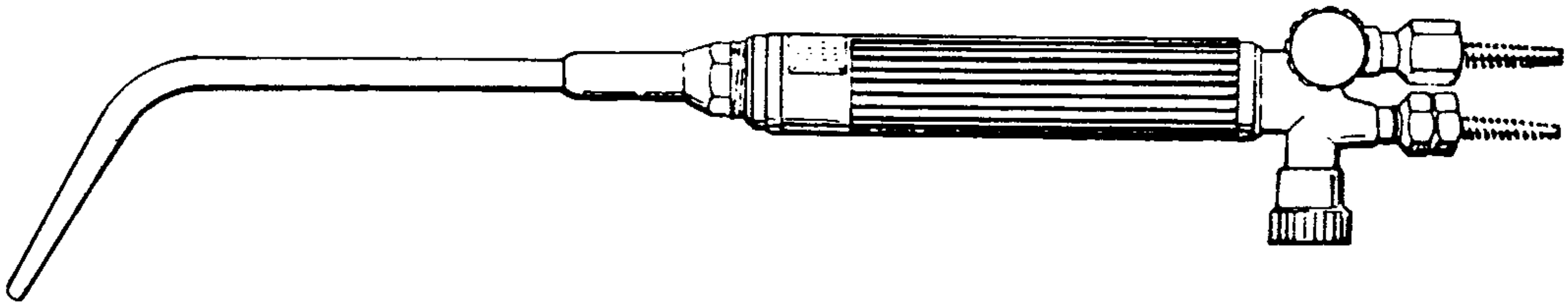
Cutting Tips, Victor
Types 1-101, 3-101, & 5-101

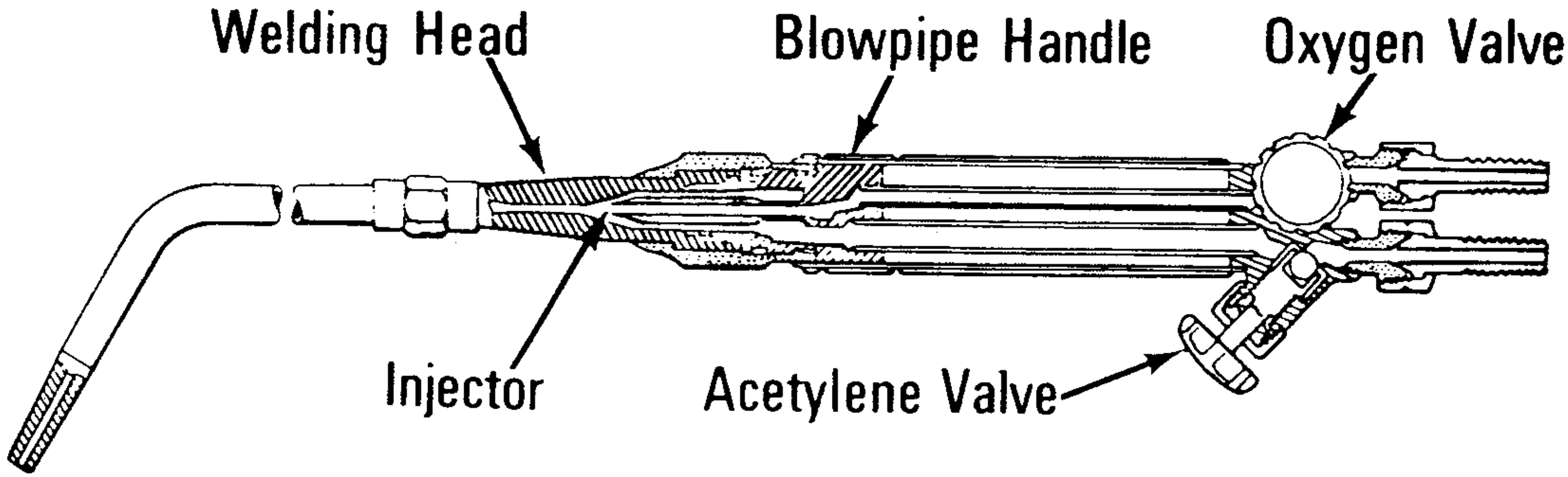
Metal Thickness	Tip Size	Oxygen Pressure, PSI	Acetylene Pressure, PSI	Speed IPM
1/8"	000	20 – 25	3 – 5	20 – 30
1/4"	00	20 – 25	3 – 5	20 – 28
3/8"	0	25 – 30	3 – 5	18 – 26
1/2"	0	30 – 35	3 – 5	16 – 22
3/4"	1	30 – 35	3 – 5	15 – 20
1"	2	35 – 40	3 – 6	13 – 18
2"	3	40 – 45	4 – 8	10 – 12

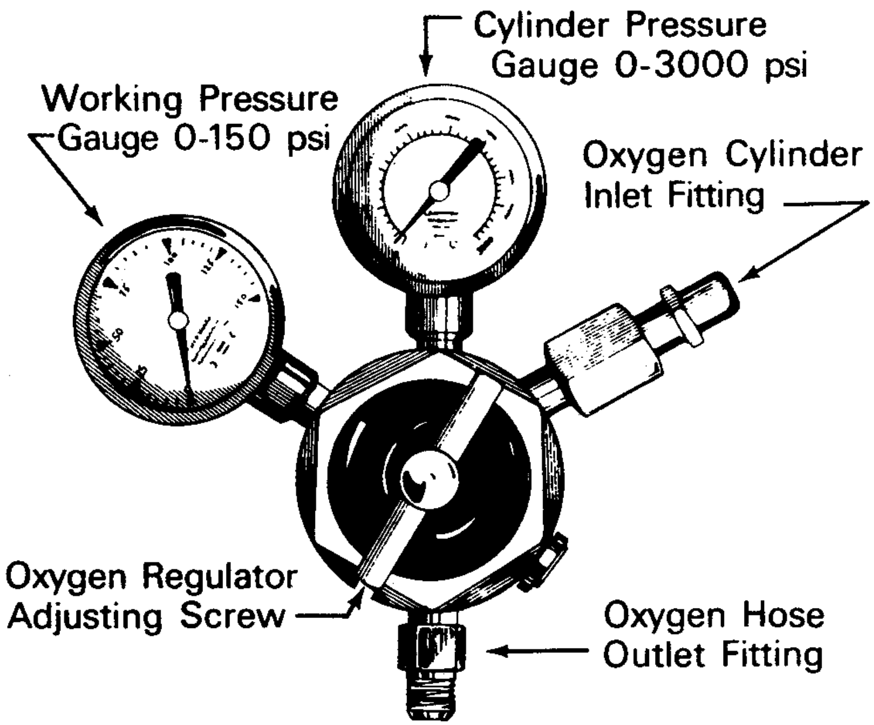
Welding Tips, Victor
Nozzle Flow Data

Metal Thickness	Tip Size	Oxygen Pressure, PSI	Acetylene Pressure, PSI
Up to 1/32"	000	3 – 5	3 – 5
1/16" – 3/64"	00	3 – 5	3 – 5
1/32" – 5/64"	0	3 – 5	3 – 5
3/64" – 3/32"	1	3 – 5	3 – 5
1/16" – 1/8"	2	3 – 5	3 – 5
1/8" – 3/16"	3	4 – 7	3 – 6
3/16" – 1/4"	4	5 – 10	4 – 7
1/4" – 1/2"	5	6 – 12	5 – 8
1/2" – 3/4"	6	7 – 14	6 – 9
3/4" – 1 1/4"	7	8 - 16	8 – 10

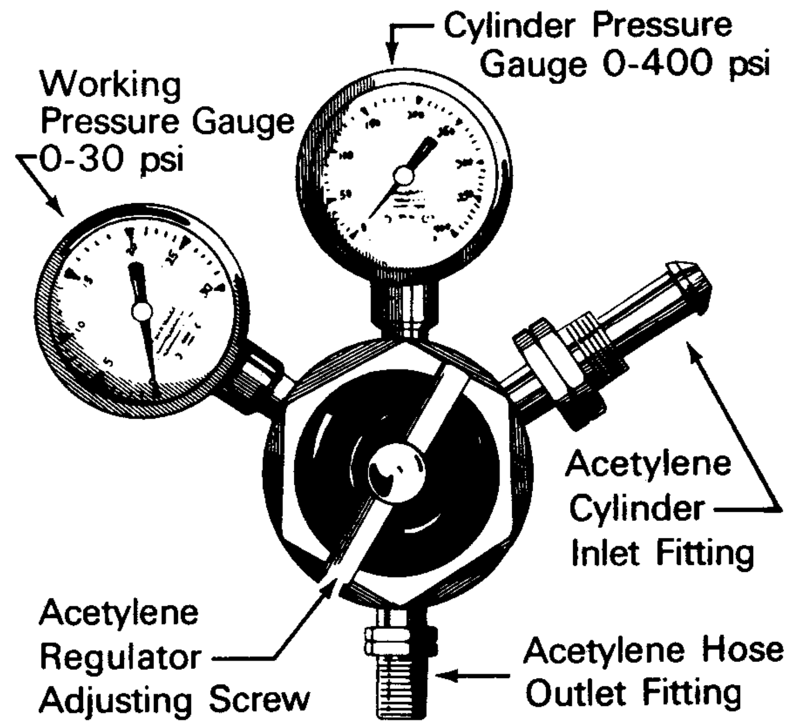

Oxygen Cylinder Valve
Oxygen Regulator
Check Valve
Acetylene Regulator
Check Valve
Acetylene Cylinder
Oxygen Hose
Acetylene Cylinder Valve
Safety Chain
Acetylene Hose
Oxygen Cylinder
Cylinder Truck
Flint Lighter
Welding Goggles
Welding Gloves
Oxygen Fitting (Right-hand threads)
Oxygen Torch Valve
Torch Body
Welding Tip
Acetylene Torch Valve
Acetylene Fitting
(Hex-grooved nut, left-hand threads)




Welding Head
Blowpipe Handle
Oxygen Valve
Injector
Acetylene Valve



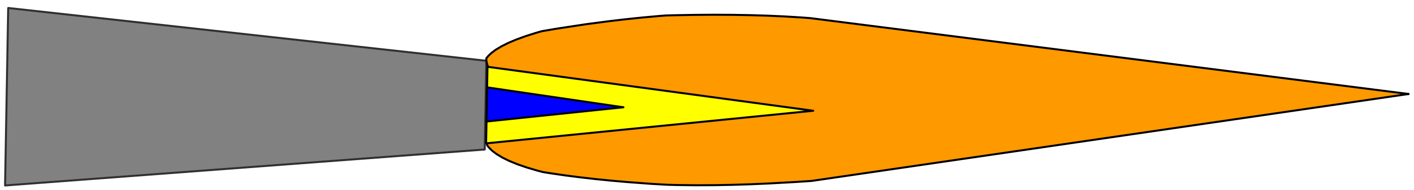
Oxygen Regulator



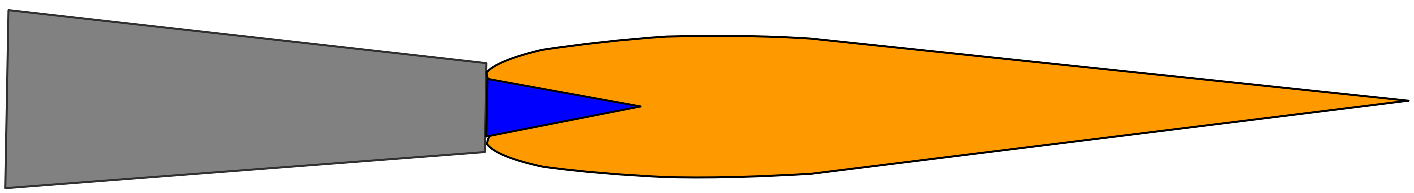
Acetylene Regulator

Note: **Never exceed 15 psi in working pressure in an acetylene regulator!**

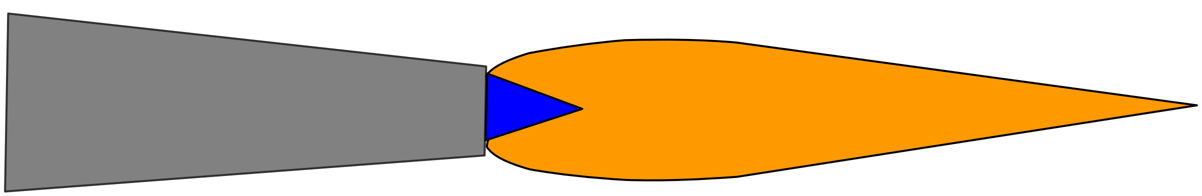
OXYACETYLENE FUSION WELDING FLAMES



Carburizing Flame



Neutral Flame



Oxidizing Flame

TABLE OF CONTENTS

AG 210, ARC, OXY WELDING, & AG 211, MIG AND TIG WELDING

MIG WELDING

AG 211-A

UNIT OBJECTIVE

After completion of this unit, students will be able to operate a MIG welder safely, understand the basic operations and principles, and demonstrate different MIG welding skills. 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. Pass a safety test and demonstrate proper use of MIG welding equipment.
2. Be familiar with the different applications and uses of a MIG welder.
3. Identify properly and improperly formed beads.
4. Identify different problems with MIG welding, wire speed, arc length, and amperage for different thickness of metal.
5. Understand the different wire sizes and AWS classifications.
6. Understand the differences and similarities between MIG and Arc welding
7. Understand causes and effects of poor welds and how to correct them.
8. Understand and practice safe use of MIG welding equipment.
9. Understand the different uses of MIG welding in Industry.

211A-2

MIG WELDING EQUIPMENT AND SAFETY

A. Introduction to MIG Welding

1. MIG (**M**etal **I**nert **G**as) welding or GMAW (**G**as **M**etal **A**rc **W**elding) derives it name from the moving metal core that is protected by an inert gas.
2. MIG welders work off the same principle as arc welders. They both have an electrode but with the MIG welder it is a continuos wire fed from a spool within the MIG welder. They both have a way to protect the weld from oxidizing. The arc welder use a protective coating called flux, on most MIG welders the weld is protected by a CO_2 or argon gas. Some MIG welding wires come with an inner flux core, both ways keep the oxygen away from the weld.

B. Advantages

1. The arc is more clearly visible by the operator with the absence of smoke from the flux.
2. The MIG has a higher welding speed, less time is spent on stopping and removing the slag and replacing welding rods.
3. Welds in all positions.
4. High quality welds.
5. Large gaps filled easily, making repairs efficiently.
6. Less electrode loss as compared to covered electrodes.

C. Disadvantages

1. Limited use outdoors, wind will blow the inert gas away from the arc during the welding process.
2. Arc welding cables can run up to fifty feet or longer while the MIG welder is limited to within fifteen feet of the welder.

D. Equipment

1. Ground Clamp

   a. The ground clamp completes the full electrical circuit so that enough heat will be available for the welding job. Serves the same purpose as in arc welding.

2. Welding Gun

   a. The gun is used to carry the electrode wire and inert gases from the cable assembly to the weld.

b. The gun has a trigger or lever that engages and disengages the wire feed control unit, the gas flowmeter, and the welding current.

3. Welding Cable Assembly

a. Connects the wire feed control unit and the gas flowmeter to the welding gun.
b. Carries the welding wire and the inert gases to the welding gun.
c. The cable assembly has a thick plastic cover to protect it from sparks and insulate it from being grounded.
d. While welding, keep the cable as straight as possible. There will be less resistance in the wire as it moves through a straight cable assembly.

4. Wire Feed and Control Unit

a. Controls the speed of wire being fed.
b. Different size drivers are needed for different size wires.
c. Holds the wire spool as it's being used.

5. Changing Electrode Wire

a. Make sure the welding and wire feed units are turned off.
b. Cut off the ball or tip of the wire and remove the nozzle and contact tip.
c. If the spool did not run out of wire, cut the wire at the spool and tie off to the edge. Loosen the drive wheels.
d. Grip the wire at the torch end pull the remaining wire out of the cable assembly.
e. Remove the old spool of wire and replace it with a new or different one.
f. Thread the new wire through the driver wheels and into the liner tube.
g. Tighten the wheel drivers and (make sure the gas is turned off) and pull the torch trigger and feed the wire though the cable assembly.
h. Release the trigger when the electrode wire has extended at least four inches beyond the end of the torch.
i. Place the contact tip and the nozzle on the torch and cut the wire to a desirable length.
j. You are ready to start welding again.
k. <u>Note:</u> If the new spool of wire is a different size, you must also change the wire feed drivers and the contact tip size as well.

6. Combination Regulator and Flowmeter

    a. Controls the flow of inert gases to the welding.
    b. Works the same as a regulator on the Oxy & Acetylene bottles.
    c. Reads in Cubic Foot per Hour (cfh).

E. Protective clothing must be worn at all times when welding. The heat created during MIG welding creates flying molten sparks and ultraviolet and infrared rays that can burn the skin. Many of the same protective clothing used in arc welding are also used in MIG welding.

1. Leather Gloves

    a. Gloves protect the hands from burns during welding.
    b. The gloves should be made of thick leather and have long cuffs to protect the wrist and prevent sparks from falling into them.

2. Leather or Cotton Sleeves

    a. A NONFLAMMABLE material should be worn on the arms to protect from burns due to sparks and intense heat.

3. Body Protection

    a. Either a leather apron or coveralls or workshirt made of a flame-retardant material will protect the body during arc welding.
    b. All protective clothing should fit properly and be free of openings or rips into which a spark might enter or the intense heat might penetrate.

4. Footwear.

    a. Leather boots should be worn while MIG welding.
    b. Never wear open-toed shoes while working with hot metal or a welding apparatus.

F. Welding Helmets and Shields - The brilliant light given off by the electric arc produces invisible ultraviolet and infrared rays, which can severely burn the eyes and skin. NEVER LOOK AT THE ARC WITH THE NAKED EYE. Helmets and shields are equipped with special filtered lenses that reduce the intensity of the light and prevent the ultraviolet and infrared rays from reaching the eyes.

1. The welding helmet is designed specifically for the purpose of arc welding.

    a. The welding helmet fits on the head using a plastic adjustable headband.
    b. The helmet leaves both hands free for working and positioning materials.

2. The hand shield is used for observing.

    a. It is NOT advisable to use the hand shield when welding since one hand must be used to hold the shield in place.

3. The protective lenses come in different shades depending on the type of welding to be done. Different types of welding use different amounts of voltage and current which determine the intensity of the light and the amount of ultraviolet and infrared rays produced. Spot welding requires the fewest amperes and thus requires the least amount of shading in the lens. Arc welding machines require from less than 30 to over 400 amperes. Lens shades range from number 5 (which provides the least amount of protection) to shade 14 (which provides the most protection).

    a. Shade 5 is used for light spot welding.
    b. Shades 6 and 7 are suitable for welding with up to 30 amperes.
    c. Shade 8 is for welding with 30-75 amperes.
    d. Shade 10 can be used when welding with 75-200 amperes. (Most Suitable for MIG Welding)
    e. Shade 12 is used when welding with 200-400 amperes.
    f. Shade 14 is required when welding with over 400 amperes.

4. Cover glasses are clear lenses that are used to stop flying sparks, thus protecting the filter lenses. There are 3 different types of cover glass currently available.

    a. Clear, unbreakable plastic is the cheapest and lasts the longest.
    b. Chemically treated glass is used to reduce pitting but it can be expensive.
    c. Plain glass is very susceptible to breaking, pitting, and splatter sticks and is NOT recommended.

5. Filter lenses must be changed if a crack or chip occurs in order to prevent ultraviolet and infrared rays from reaching the eyes. The shades of the lenses must also be changed. If the shade is too dark, the worker will be unable to see the work that is being performed. If the shade is too light, proper eye protection is not achieved. Many welding helmets have interchangeable lenses. The lens changing procedure is as follows:

    a. Remove the lift-up mechanism on the helmet or the lens frame lock.
    b. Slide the old filter lens out and insert the new one.
    c. Reinsert the lift-up mechanism or the lens frame lock.
    d. Put the helmet on and search for light leaks. If leaks are present, the lens must be readjusted.

G. Additional Welding Equipment

1. Safety Glasses - Safety glasses must be worn when chipping slag if a shell lens is not provided in the helmet. NEVER CHIP SLAG WITHOUT PROTECTIVE EYEWEAR. Slag will occur on MIG welds, when the flux core wire is used. Otherwise slag will not appear.
2. Pliers - The heat of the arc will heat all of the metal being welded. Always use tongs or heavy pliers to carry or maneuver the metal stock.
3. Wire Brush – The metal must be free of dirt and other impurities before welding can begin. Use the wire brush to clean the metal before welding.

SAFETY IN MIG WELDING

When MIG welding, observe the following general safety practices.

1. Wear gloves and eye and face protection. The welder and all observers must wear welding helmets with a No. 10 or 12 filter lens. A welding cap or helmet with a hard hat is also recommended for head protection. When chipping slag or cleaning welds, wear a clear face shield or flip-up liftplate on the helmet.
2. Avoid electrical shock. Make certain that the MIG torch and all electrical connections and cables are properly insulated. Check to see that the welder is properly grounded. Do not dip the MIG torch in water to cool it because this practice may result in electrical shock.
3. Protect others. For small and practice welding jobs, work in a partitioned area to protect others from harmful rays. When prepared to start a MIG weld, inform all bystanders to cover their eyes.
4. Never weld in a damp area. Stand on a dry board or rubber mat if the floor or ground is damp or wet.

5. Never wear synthetic fiber clothing. Synthetic fibers are highly flammable. Wearing clothing made from wool or cotton is more satisfactory for welding because of their relatively high flash points.
6. Protect welding cables. Keep the cables from coming in contact with hot metal and sharp edges. Do not drive over cables. When welding, avoid wrapping welding cables around your body.
7. Secure work. Use a welding table with a positioner to hold welds securely in place. Clamps and vises can be used to hold odd-shaped work or field work. Securing work will also prevent injury from accidental dropping of metal on your feet or body.
8. Prevent burns. Never adjust the gas nozzle with your bear hand, even after welding for just a few moments the nozzle can become very hot. Remove hot metal from the work area when you are finished welding to prevent burns to others.
9. Use both hands. To reduce fatigue, use both hands for welding.
10. Handle hot metal with pliers or tongs. Submerge hot metal completely in water to prevent steam burns.
11. Weld in a well-ventilated area. The fumes from lead, zinc, cadmium, and beryllium are toxic and may cause sickness or death.
12. Do not carry matches or lighters, and do not allow bystanders to smoke. Before welding, make sure the welding area is free of other flammables (gas, grease, etc.).

ACTIVITY:

1. Practice identifying and handling MIG welding equipment, making sure that all safety procedures are followed and that suitable clothing is being worn.
2. Burn a piece of cotton cloth and a piece of polyester and cotton blend and compare the difference in the ash. The cotton will simply turn into ash while the blended material will melt and keep burning.
3. Quench metal by dipping it in and out of water and demonstrate the steam rising and show how it can cause steam burns.
4. Change inert gas bottles and set flowmeter regulator.
5. Change electrode wire spools

STRIKING AND MAINTAINING AN ARC

A. Setting, Checking, and Adjusting the Equipment

1. Equipment adjustment for proper amperage is vital for good welds and proper use of the machine.

    a. To start the welding operation, inspect the welding torch and ground clamps are clean and in good condition. Make sure the gas nozzle and control tip is clean and free of spatter before welding. Inspect the cable connection to make sure they are tight and that no exposed wires are present.
    b. The welding bench should be clean and dry.
    c. The ground clamp should be attached to the welding bench in a secure manner.

2. Know the thickness of the metal you are welding on and consult the welding chart for proper amperage and wire feed speed settings.
3. Turn on the inert gas and set the regulator or flowmeter according to the manufactures recommendations.

B. Striking an Arc

1. Select a plate or coupon of steel 1/4" thick, 3" to 5" wide, and 6" to 10" long.
2. Place the welding torch in position, the wire can touch the metal without it arcing. The wire will not become “hot” until the lever is pressed.
3. Striking an arc is as simple as pressing the lever.

    a. Pressing the lever charges the wire with electricity and starts the wire feed at the same time
    b. Arc length will be automatic but you must keep your work distance (distance from the nozzle to the work piece) at a maximum of 3/8th of an inch. Any longer will increase the resistance and your amperage will change and not weld properly.
    c. Practice starting and stopping the arc until this action can be completed quickly and easily.

4. Practice running beads after the skill of starting and maintaining an arc has been mastered.

    a. Stringer beads are an excellent bead for beginning welders to make. The beads will not be consistent but should improve with practice.

1) Welding done with proper amperage, voltage, wire speed, and travel speed displays

   a) Good penetration
   b) No undercut or overlay
   c) Smooth appearance

2) If the work distance is too long, there is:

   a) Poor penetration, overlap, spatter
   b) Leaves weld puddle exposed to oxidizing air
   c) High narrow bead or Convex bead
   d) Wire stubble or whiskers occur along the bead

3) If the welding current setting is too high, there is:

   a) Undercutting
   b) A deep crater
   c) Burn through

4) If the welding current setting is too low, there is:

   a) Poor penetration with high narrow bead
   b) Not enough current to fuse the weld to metal
   c) Excessive spatter and poor starts
   d) Wire stubble or whiskers occur along the bead

5) If the welding speed too fast, there is:

   a) Irregular bead with skips
   b) Whiskers (small pieces of wire) will occur when the wire touches the metal outside the puddle while welding.
   c) Undercutting

6) If the welding travel speed is too slow, there is:

   a) Bead too high, somewhat irregular and porous
   b) Builds up too much metal and metal stays melted too long and causes cold overlap
   c) Lack of fusion
   d) Burn though

7) If the gas pressure is set to high or too low complete shielding will not occur.

   a) If the gas is too low it will not completely cover the arc and air will get into the weld.
   b) If the setting is too high the pressure will result in air turbulence and an uneven weld.

8) Incorrect wire speed

   a) Unstable arc
   b) Stubble along the bead, too fast

5. Hold the torch at the end of the puddle for a moment after releasing the lever. The left over gas and heat from the torch tip will help the weld cool slower and prevent cracks.
6. There are various other welding patterns, for example, whipping motion, semicircular motion, circular motion, V-shaped motion, back and forth or D-shaped motion, U-shaped motion, figure-8 motion, and rotary motion.
7. Metal Preparation

   a. Cut a plate approximately 4" X 5" X 1/2"
   b. Brush and clean plate
   c. Mark 4 lines 1/2" apart down the 5" length
   d. Run a stringer bead down each line.
   e. Wire brush the bead to clean away any slag from impurities that might form.

6. Weaving Exercise

   a. Weave beads between stringers to cover plate with smooth weld
   b. Fuse the weave into the stringers
   c. Chip, clean, and evaluate work

ACTIVITY:

1. Starting and maintain an arc by running beads across a piece of metal.
2. Explain what happens when the correct speed and working distance are being maintained.
3. Run and evaluate stringer bead for correctness.
4. Run beads with the gas turned off, wire speed too fast and too slow, volts too high and too low.

ELECTRICAL CURRENTS IN MIG WELDING

A. Welding Currents – MIG welding uses a DC current, AC current does not apply to MIG welding.

1. DC – Direct Current, the current will flow in one direction, from the positive to the negative. In welding there are two different polarities used, reverse polarity (DCRP) and straight polarity (DCSP).

    a. DCRP – Direct Current Reverse Polarity is a direct current flow, flowing from the welding torch to the work piece being welded on. Using reverse polarity for MIG welding is mostly done while using solid core wires.

    b. DCSP – Direct Current Straight Polarity is a direct current flow, flowing from the work piece being welded on to the welding torch. Using straight polarity for MIG welding is mostly done while using inter shield wires.

AWS CLASSIFICATION SYSTEM FOR ELECTRODES

A. MIG electrode wires and how they are selected.

1. In MIG welding the electrodes are thin metal continuous wires having approximately the same composition as the metal to be welded. Mostly the wires are bare and are used in combination with a wide variety of inert gases to protect the weld from oxidation. Sometimes a flux core wire will be used with a wide variety of types of flux and the inert gases are not needed.
2. Selection of MIG wires are based on the types of base material, position to be welded in, and the types of beads to be welded.

    a. MIG welders can weld mild steel, aluminum, and a variety of other metals. Use the correct electrode wire to match your base material.
    b. Most MIG electrode wires are rated for all positions but a few are designated for flat and horizontal only.
    c. Many MIG electrode wires are designed for a specific weld. Some electrode wires are designed for only a single pass, do not try to weld a multi pass weld with this type of electrode wire.

B. MIG wire identification is similar to identifying electrodes used in arc welding. The American Welding Society (AWS) has developed a the following electrode classification system:

1. What does the classification of ER70S-6 on the label of a spool of MIG wire mean? Reading from left to right.

    a. The beginning of the code will begin with an E or ER, the E meaning use as an electrode only and ER means it can be used as electrode or as a rod.
    b. The 70 are read as tensile strength, similar to electrodes used in arc welding.
    c. The letter S indicates the wire is solid (example, no flux core).
    d. The 6, indicates a special characteristic of the electrode.

2. The chart on page 211A-41 gives detail explanation of the AWS code.

MIG WELDING SETUP AND SHUT DOWN

A. Setup and Preliminary Checks

1. Look the MIG welder over before starting.

    a. Inspect the welding torch and leads for any damage. If damaged, make repairs before using the welder.

        1) Inspect the welding tip and nozzle for excess spatter, damaged caused by overheating, and any arc damage. Clean or replace parts if necessary.
        2) Make sure the correct size tip is being used with the proper size wire.
        3) The orifices are clear and free from obstruction.
        4) Inspect the welding cable assembly for bear spots and cracks in the insulation; if damaged, repair or replace if necessary.

2. Turn the machine on.
3. Turn on the inert gas and adjust accordingly. Adjust gas flow to a working pressure by engaging the torch trigger and letting both the gas and the electrode wire come out the torch tip.
4. Cut electrode wire to proper stick out length <u>with a pair of wire cutters.</u>
5. Adjust the amperage or voltage to the prescribed setting. (Minor adjustment may be required after welding begins.)

B. MIG Welding Procedure

1. With the MIG welder set to the proper adjustments, start welding a scrap piece of metal. Make any adjustment needed before starting to weld on your project.

2. Start your arc and move in the direction of the joint keeping your speed and movement constant.
3. Reaching the end of the weld, release the trigger, stopping the wire feed and arc. DO NOT remove the torch from the weld right away. Hold the torch over the weld a few seconds after finishing the weld. The warn tip will help the weld cool slower and the gases still coming out the nozzle will help prevent the weld from oxidizing.

C. Shutting Down a MIG Welder

1. After the weld is complete,

    a. Turn off the wire feed control
    b. Shut off the inert gas cylinder
    c. Engage the torch trigger, releasing the gases still in the lines
    d. Turn off the welder

WELDING TECHNIQUES

A. Forehand

1. The welding torch is feeding the wire in the opposite the direction of travel. Generally know as pulling the weld. The most common method used in MIG welding.

    a. Characteristics of a backhand weld:

        1) Deeper penetration
        2) Less spatter
        3) Greater arc stability
        4) Easier visibility of the weld

B. Backhand

1. The welding torch is feeding the wire in the same direction as the direction of travel. Generally know as pushing the weld. Mostly used on light gauge material when burn through creates a problem.

    a. Characteristics of a backhand weld:

        1) Less penetration
        2) Greater amount of spatter
        3) Less arc stability

4) Harder visibility of the weld
5) Faster

Note: In industry the majority of the welds are welded using the forehand technique. This is due to the fact that in industry most of the electrode wires are fluxed core wires, thus deeper penetration with a faster weld. Speed of production plays a large role in industry. Most farmsteads will use the cheaper solid core wire.

ACTIVITY:

1. Use overheads and handouts with students to explain the AWS code for MIG electrode wire.
2. Demonstrate the differences between backhand and forehand welding.
3. Demonstrate proper start up and shut down procedures.

BASIC WELDS

A. Welding a Bead

1. A weld is known as a bead, made by a single pass.
2. Welding a bead is the first step after striking an arc and towards making other types of welds.
3. Set welding amperage and wire speed to the desired setting (depending on the electrode wire size and the thickness of metal used.)
4. Keep the work distance constant, length between 1/4" – 3/8", listen to it (sounds like frying bacon) and keep it constant. Increasing the work distance during welding will result in a higher resistance and higher heat. Decreasing the work distance will result in a lower resistance and lower heat.
5. Angle the welding torch tip 15^o – 20^o from vertical towards the direction of travel. At the same time keep the side to side angle at 90^o.
6. Speed of travel, watch the width of the puddle and keep it constant.

B. Butt Weld

1. The butt joint is one of the most frequently used weld joints.

   a. A butt joint consists of placing the edges of two pieces of metal together.

2. The butt joint is used when structural pieces have a flat surfaces, for example, tanks or flat decks, and when laminating pieces for machine parts.

3. There are three types of but joints: closed, open, and when laminating pieces for machine parts.
4. The closed butt should be used only if the material to be welded does not exceed 1/8” to 3/16” in thickness.
5. When using the open butt, the joints are spaced 3/32” to 1/8” apart.
6. When the material to be welded exceeds 3/16” in thickness, the butt joint should be beveled. There are three types of bevel or V joint designs:

    a. In a feather edge, the material is 1/8” to 3/16” thick, the bevel is 60 degrees and the bottom edges of the material are placed together.
    b. The shoulder edge is used for materials 1/4" or more think; 1/16” to 1/8” of the bottom of the material is not beveled and a gap of 1/8” is allowed for the root pass.
    c. The double V is used for material over 3/8” thick. This V joint has a 60 degree bevel; however, a 3/32” to 1/8” face is left in the lower 1/3 of the weld joint. This root face is generally spaced 1/8” apart for proper root pass operation.

7. If the bevel on any groove joint is greater than 60 degrees, it is difficult to limit and control the amount of contraction when the metal cools.
8. A backup strip should be used in an open butt joint in order to prevent excessive burn-through.
9. A round stock weld is a variation of the butt joint weld.

    a. In order to weld rods or round solid shaft material, both ends of the stock must first be beveled, leaving a shoulder in the center. The edges should be ground so they have the same angle

C. Pad Welding

1. A pad weld is used to build up metal surfaces after it has been worn down.
2. Pad welding can be done on flat or round surfaces.
3. Pad welding consists of depositing several layers of beads.

    a. Welding a bead to cover half of the previous bead.
    b. Welding beads one over the top of another

4. Angle the welding torch tip 15^{o} – 20^{o} from vertical towards the direction of travel. At the same time keep the side to side angle at 90^{o} for the first pass. For the second, third, etc. hold the welding torch tip 10^{o} – 15^{o} from vertical.

D. Fillet Weld (Tee Joint)

1. The tee joint is formed by placing one plate at a 90 degree angle to another to form a letter T. A tee joint is a Fillet-type weld.
2. The tee joint is weak and should not be used if heavy pressure will be applied from the opposite direction of the welded joint.
3. There are several types of fillet joints. The basic fillet welds for tee joints are classified as square, single bevel, double bevel, single J and double J.

    a. The square tee is used where the material can be welded on one or more side. Considerable weld metal is required for maximum strength.
    b. The single bevel tee is used on material that is less than 1/2" thick. This joint will withstand more severe loading than the square tee, where welding can be done from one side only.
    c. The double bevel tee is used where heavy loads are applied in all directions and where welding can be done on both sides.
    d. The single J joint is used on material 1 1/2" and thicker and can be welded from both sides.

4. To start a practice fillet, use 3/16" to 1/4" thick material. Set the vertical plate on the middle of the flat plate and tack weld each end. Then start the main weld. On material of this thickness, a single pass (which is one layer of a weld bead) should be sufficient.
5. The angle of welding torch tip is very important. The best results are obtained by holding the torch tip at 45 degrees between the vertical bottom flat plate with the tip pointed toward the weld area. The direction of travel will have a 10^o - 15^o angle in the direction of travel. This first single pass bead should be a 1/4" fillet.
6. In a multi pass fillet weld, a second and third pass are added over the first weld.

    a. The second pass will start by covering have the first weld and a portion of the base plate. Like the first pass the second pass will have a travel angle of 10^o – 15^o but the work angle will rise from 45^o to 50^o – 55^o angle.
    b. The third pass will start by covering a small part of the second pass, the rest of the first pass and part of the vertical plate. Like the first pass and second pass the third pass will have a travel angle of 10^o – 15^o but the work angle will decrease to 40^o – 35^o angle.

E. V-Butt Tension Test Weld

1. The V-Butt tension weld is designed to test the welders ability to correctly use the welding torch and techniques to its' fullest potential.
2. A copper backing plate and a small backup strip will be used.

    a) For best results and less grinding, backup strip thickness should be 22-18 gauge. If thicker than 18 gauge use shims to hold up the ends of the metal and keep the pieces as straight as possible.

3. The metal to be used should be 1/4" thick and 1 1/4" wide and should have a 30^o angle cut on the ends. When lined up with another piece the angle will be 60^o. The two pieces should be 3/32" apart.
4. The weld will be completed in two passes.

    a. On the first pass:

        1) Set amperage according to the thickness of 1/4" metal.
        2) The first pass will be a forehand weld with slight side to side motion.
        3) Fill V approximately 1/2 full, leave excess on both ends.

    b. On the second pass:

        1) The second pass will be a backhand weld at the same setting used on the first pass.
        2) Use a weave weld filling in the rest of the V, pause at edges, fill in excess on both ends.

5. Allow metal to cool slowly under another plate of metal, leave it for approximately 25 minutes before moving. Even moving it through the air can cause it to cool fast and loose strength.
6. Grind weld to same size as the parent material and grind off the backup strip. Do not nick base metal while grinding. Nicks will result in a weaker weld.

F. Vertical Up Fillet

1. Not all welds can be done in the flat or horizontal position. It is not always possible to lay a project on its' side to be welded, so the vertical up weld becomes necessary. Welds can be done moving downward (Vertical-Down), but penetration will not be as deep as compared to the vertical-up weld. Vertical-up welds are often used when welding fillet welds on trailer hitches where deep penetration is necessary.

2. Vertical up welds will be done in two passes:

   a. The first pass will be made making a fast pass using a pausing pattern. (See page 211A-36)
   b. The second pass will be made going from side to side using a similar pausing pattern. (See page 211A-36)

3. The welding torch tip will be held at a 45^o between the two pieces, the same as a horizontal fillet. The welding torch tip will be slightly pointed upwards, 15^o maximum.

G. Overhead Fillet

1. The overhead weld is the most difficult welds to master. A person is working above their head and standing up, which adds difficulty to this weld. At times this weld becomes necessary to weld on the bottom side of a trailer, truck frame, or any project that can not be turned up side down.
2. This weld will be made with three passes: (See page 211A-38)

   a. The first pass will be made 45^o from vertical leading 5^o –10^o in the direction of travel.
   b. The second pass will be made 50^o from vertical, the second pass will cover half of the first pass and part of the vertical plate.
   c. The third pass will be made 40^o from vertical, the third pass will cover the rest of the first pass, a little of the second pass and part of the top piece.

3. Suggestions:

   a. Stand up and get in close to your work.
   b. Lean against a post and steady yourself.
   c. Have the metal at least 10" above your head for a close and clear view.
   d. Work with the palms of your hands pointed down, dripping metal will be less likely to burn your hands.
   e. Drape the welding cable assembly over your shoulder to support the weight.

ACTIVITY:

1. Prepare and weld each of the types of welds.
2. Design and build a project utilizing at least three different types of welds.

References:

Burke, Stanley R., & Wakeman, T. J. (1997). MODERN AGRICULTURAL MECHANICS (3nd ed.). Danville, IL: Interstate Publishers.

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

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

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

Special Material and Equipment:

Arc welding helmet, leather gloves, aprons, coveralls, strikers, safety test, safety goggles, MIG welder

Resources:

Deere & Company. (1987). WELDING (6th ed.) (Fundamentals of Service (FOS) Series). Available from: John Deere Technical Services, Dept. F, John Deere Road, Moline, IL 61265 (Available in Spanish)

Giachino, Joseph W., & Weeks, William (1976). WELDING SKILLS AND PRACTICES (5th ed.). Available from: American Technical Society, Chicago, IL 60637
Hobart Brothers Company. (1978). TECHNICAL GUIDE FOR SHIELDED METAL ARC WELDING. Available from: Hobart Brothers Company, Troy, OH 45373

The Lincoln Electric Company, Cleveland, Ohio, 44117-1199
TEL (216) 481-8100 www.lincolnelectric.com

Name_______________
Date________________
Score_______________

SAFETY EXAM, MIG WELDING

Multiple choice, circle the letter that bests represents the correct answer. The second part of the test is true and false questions, circle the T if the statement is true and F if the statement is false.

1. If excess electrode wire is sticking out of the torch, it needs to be _______________.

    a. Cut off with a pair of wire cutters
    b. Left alone, it will fall off after welding begins
    c. Burned off on the side of the welding table
    d. Bent to the side

2. Breathing fumes from lead, zinc, cadmium, and beryllium can cause ____________.

    a. death
    b. sickness
    c. long term sickness
    d. all of the above

3. The heat generated in MIG welding is ______________________.

    a. Less dangerous than heat generated by an arc welder
    b. Just as dangerous as heat generated by an arc welder
    c. Nothing to worry about
    d. None of the above

4. When you lay the MIG torch down DO NOT ____________________.

    a. Set it down on the trigger
    b. Hang it up properly
    c. Lay it flat on the welding table
    d. Both A and C

5. When quenching hot metal in water ____________ to avoid steam burns.

    a. hold it under water until it cools
    b. dip it in and out of the water
    c. hold it half way under water
    d. hold it under running water

6. If welding in damp areas, it’s all right to weld if _____________________.

    a. your boots are dry
    b. you are standing on a dry board or dry rubber mat
    c. you have dry gloves on
    d. none of the above

7. When MIG welding, use a # ____ shade lens or higher.

    a. 5
    b. 8
    c. 10
    d. 12

8. Inert gas bottles on MIG welders ________________.

    a. Have less safety requirements than Oxy bottles.
    b. Have the same safety requirements as Oxy bottles.
    c. Don’t need to be chained or held in place
    d. Have no dangers

9. T or F If the insulation is broken off the MIG torch it is still safe to use it if you are careful.

10. T or F Try to keep the cable assembly as straight as possible while welding, this will cause less drag or resistance on the wire.

11. T or F Welding in an unventilated area is allowable for a short period of time.

12. T or F MIG welding causes less fumes and less ventilation is needed.

13. T or F When starting to weld always call out cover, so people in the surrounding area can look away before you start welding.

14. T or F There is less spatter and heat with MIG welding and protective clothing are not as important as compared to Arc welding.

15. T or F Handle bottles of inert gases with the same safety and precautions as you would with Oxy and Acetylene bottle.

211A-22

Name________________
Date_________________
Score________________

UNIT EXAM, MIG WELDING

Multiple Choice, circle the letter that best represents the correct answer.
Short answer

1. The contact tip is allowed to stick out when welding _______________________.

   a. a butt weld
   b. a fillet weld
   c. an overhead weld
   d. indoors

2. What is the purpose of the ground?

   a. To hold the work down.
   b. Compete the electrical circuit.
   c. To warn up the metal before welding.
   d. Hold the points open.

3. The flux core electrode is used

   a. By its' self
   b. In combination with inert gases
   c. For deep penetrating welds
   d. all of the above

4. The two MIG welding techniques covered in this section is backhand and ________.

   a. Right hand
   b. Left hand
   c. Forehand
   d. None of the above

5. Using the backhand technique, the weld ___________________________.

   a. Is easier to see
   b. Has deeper penetration
   c. Slower travel speed
   d. All the above

6. The ground clamp should be attached to

   a. a non-conductive block of wood
   b. the project or worktable
   c. a properly grounded bolt mounted in the floor
   d. the electrode

7. A weld with the proper amperage, voltage, wire speed, and travel speed displays

   a. good penetration
   b. no undercut or overlay
   c. a smooth appearance
   d. all of the above

8. If you change the wire size on the spool, what else do you need to change?

   a. The nozzle.
   b. The contact tip.
   c. The ground clamp.
   d. The torch trigger.

9. What is the tensile strength of an electrode wire marked E70S-6

   a. 70 lbs
   b. 700 lbs
   c. 7,000 lbs
   d. 70,000 lbs

10. What will happen if an inert gas is not used with a solid wire electrode?

    a. The weld will be normal.
    b. The weld will be oxidized and week.
    c. The weld will be clean.
    d. The weld will be unaffected.

11. To handle hot metal, what tool should you use?

    a. Your gloves.
    b. Pliers.
    c. The grounding clamp.
    d. Leave it until it cools.

12. Name two disadvantages to using a MIG welder as compared to an arc welder?

13. What does the ER represent on an electrode marked ER70C-1

14. What does the C represent on an electrode wire marked ER70C-3

15. What will happen if you change to a smaller wire size and forget to change the wire feed drivers?

16. What will happen if the inert gas pressure is to high?

17. What will happen if the wire speed is too fast?

18. What will happen if the wire speed is too slow?

19. What will happen if welding travel speed is too fast?

20. What will happen if welding travel speed is too slow?

211A-25

Answer Key

Safety Exam

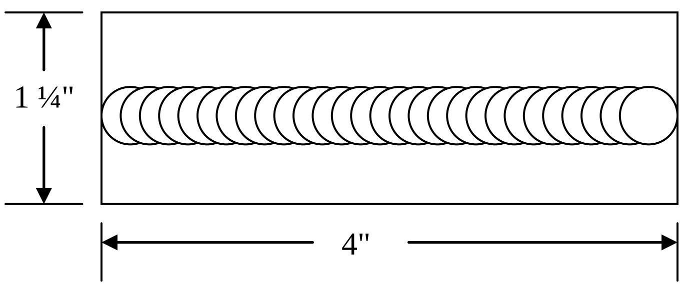
1. A
2. D
3. B
4. A
5. A
6. B
7. C
8. B
9. F
10. T
11. F
12. F
13. T
14. F
15. T

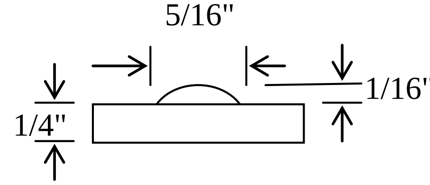
Unit Exam

1. B
2. B
3. D
4. C
5. D
6. B
7. D
8. B
9. D
10. B
11. B
12. Ability to work outdoors, working distance from the welder
13. Electrode Rod
14. Composite
15. The driver will be too big and not work efficiently
16. Result in air turbulence and an uneven weld
17. Stubble along the bead, unstable arc
18. The wire will burn back into the tip
19. Shallow penetration, high narrow bead, irregular bead, undercutting
20. Burn through, pours weld, overlap

MIG Welding, Bead

1. Use assigned electrode wire.
2. Use 1/4" x 1 1/4" 4" metal.
3. Fill in crater at the end of bead.
4. Use backhand welding technique.
5. Clean the weld with wire brush.
6. Weld one side only.



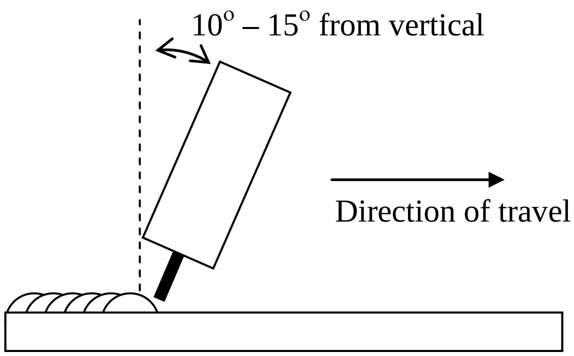


Variables that influence the bead:

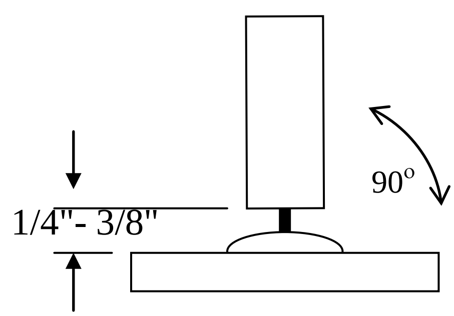
1. AMPERAGE Use chart specifications for amps (or volts) and gas flow, adjust accordingly from there.

2. WORK DISTANCE 1/4"– 3/8" Listen to it (frying bacon) Keep it constant.

3. ANGLE OF TORCH



END VIEW



4. SPEED OF TRAVEL Watch the width of puddle – keep it constant

GRADE SHEET

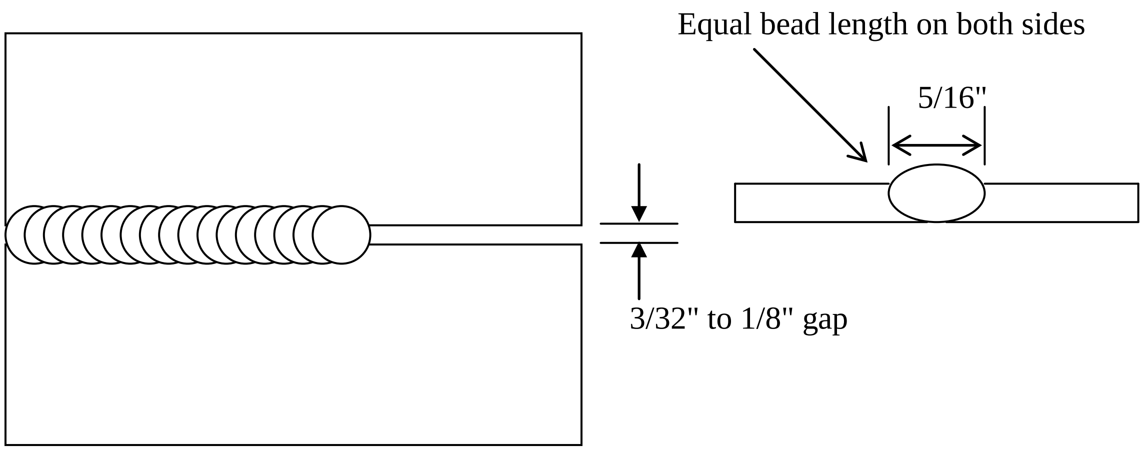
MIG Welding, Bead

Student Number	Cold Starts To -10 each Endings Not Filled	Bead Width 5/16" -1 @ 1/32 Over or Under	Eveness of Bead Width -1 @ 1/32" Difference	Overlap/Over 1/16" high Bead to -15 each	Undercut Height Eveness To -5	Eveness of Bead & Technique To -15	Penetration to - 15	Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

211A-28

MIG Welding, Butt Weld

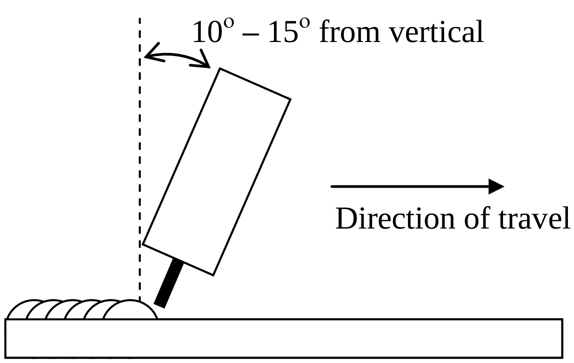
1. Use assigned electrode wire.
2. Use two pieces of 1/4" x 1 1/4" 4" metal.
3. Bead with equal length on both sides of the joint.
4. Fill in crater at the end of bead.
5. Clean the weld with wire brush.
6. Weld one side only.

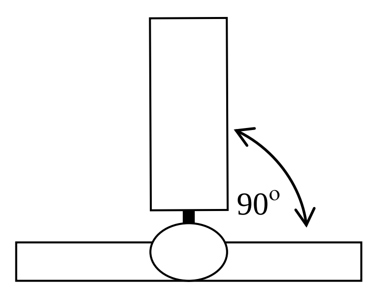


1. AMPERAGE   Use chart specifications for amps (or volts) and gas flow, adjust accordingly from there.

2. WORK DISTANCE   1/4"– 3/8" Listen to it (frying bacon) Keep it constant.

3. ANGLE OF TORCH   END VIEW





4. SPEED OF TRAVEL   Watch the width of puddle – keep it constant

GRADE SHEET

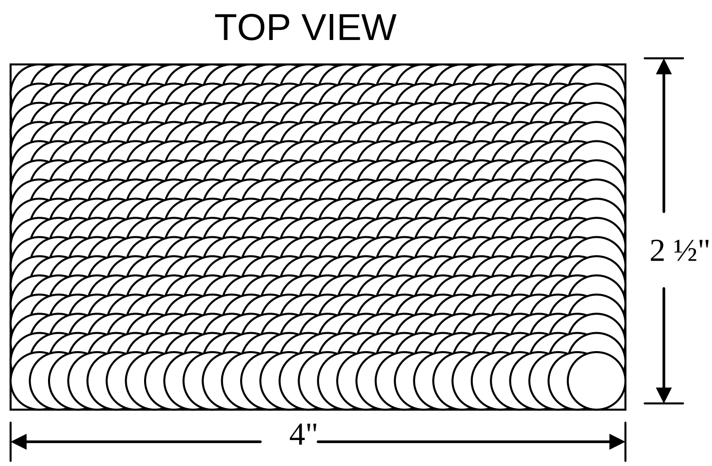
MIG Welding, Butt Weld

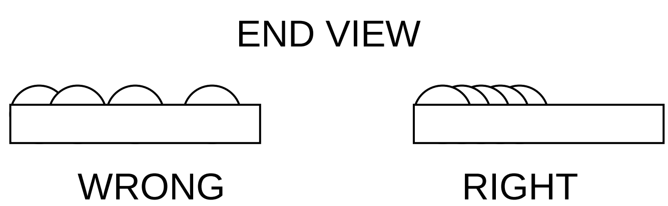
Student Number	Starts To -10 each Endings Not Filled	Bead Width 5/16" -1 @ 1/32 Over or Under	Eveness of Bead Width -1 @ 1/32" Difference	Overlap To -15 each Undercut	Height Eveness To -5	Eveness of Bead & Penetration To -15	Bead centered over joint To - 5	Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

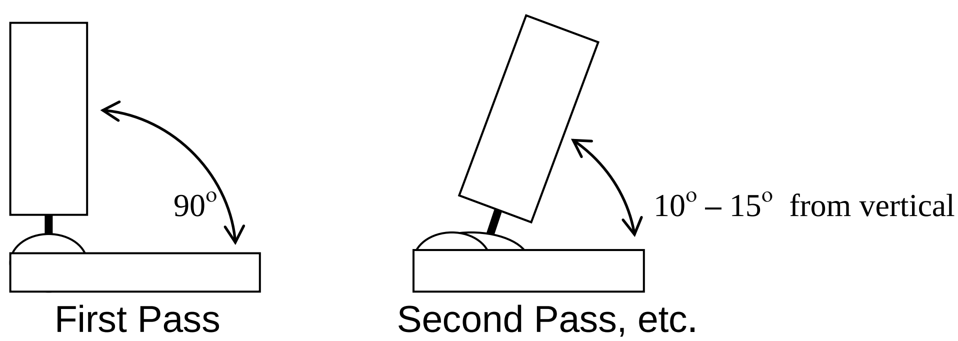
211A-30

MIG Welding, Pad Weld

1. Use assigned electrode wire
2. Use 4” x 2 1/2" x 1/2" metal
3. Cover entire surface of the plate with overlapping welds.
4. Cover half of the previous bead.
5. Use backhand welding technique.
6. Cool between beads only until red color is gone







6. Finished surface to be as flat as possible.

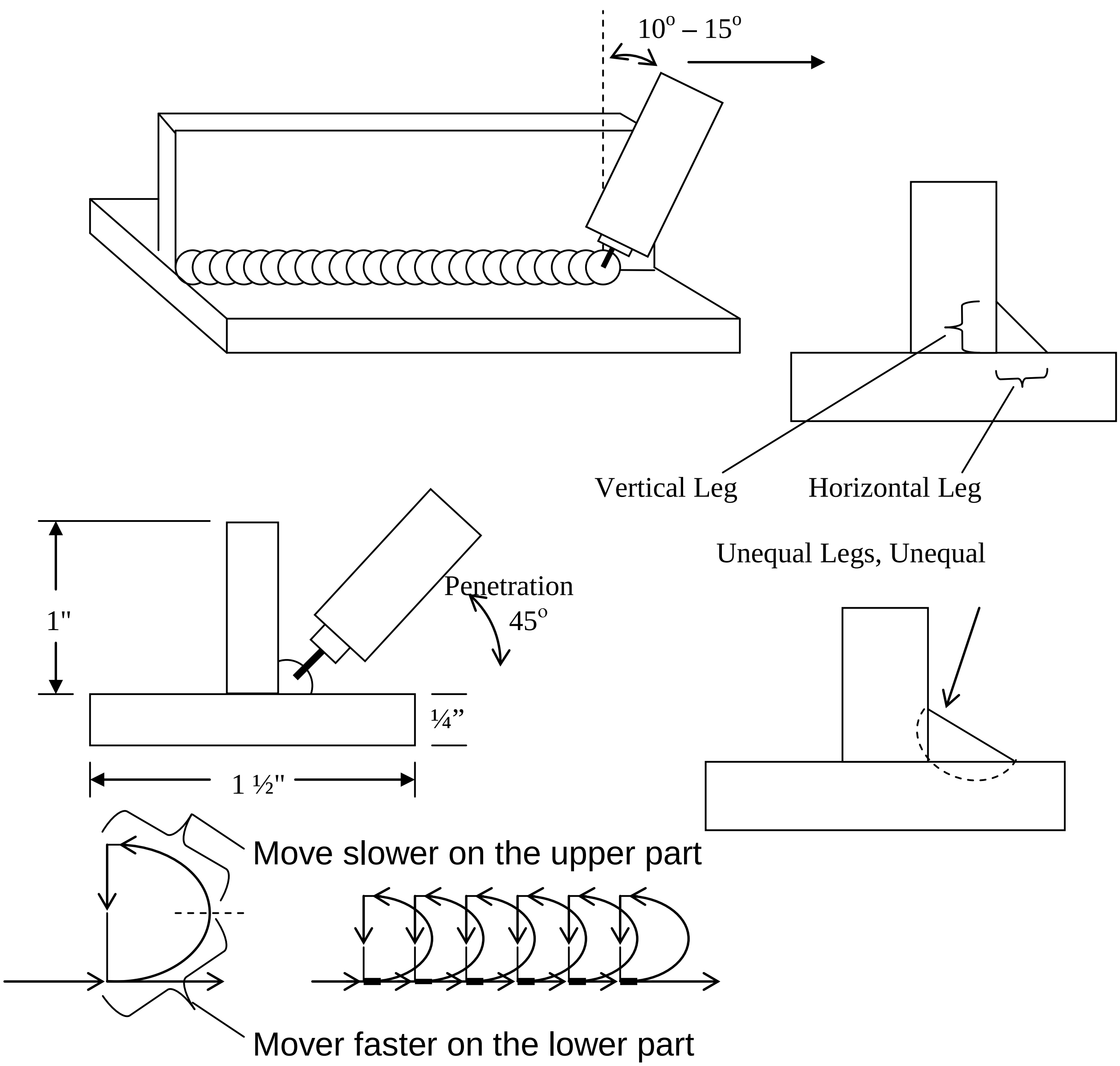
GRADE SHEET

MIG Welding, Pad

Student Number	Flatness of Pad & Techniques To -25	Eveness of Bead To -5 each Eveness of Crowding	Undercut To -15	Penetration To -15	Start Endings To -5			Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

MIG Welding, Horizontal Fillet

1. Use assigned electrode wire.
2. Use 1/4" x 1 1/2" x 4” metal for the base.
3. Use 1/4" x 1” x 4” metal for the upright.
4. Allow the Contact Tip to extent 1/8" beyond the nozzle.
5. Hold the torch at a 45° angle from the base plate.
6. Hold the torch at a 10° – 15° angle in the direction of travel.
7. Horizontal and vertical legs (1/4") need to be **equal.**
8. Use D motion as illustrated below.



GRADE SHEET

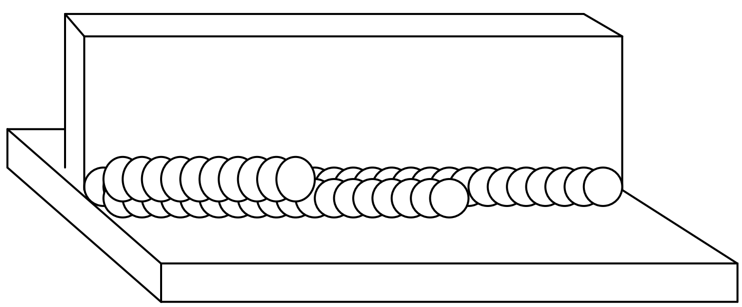
MIG Welding, Horizontal Fillet, Single Pass

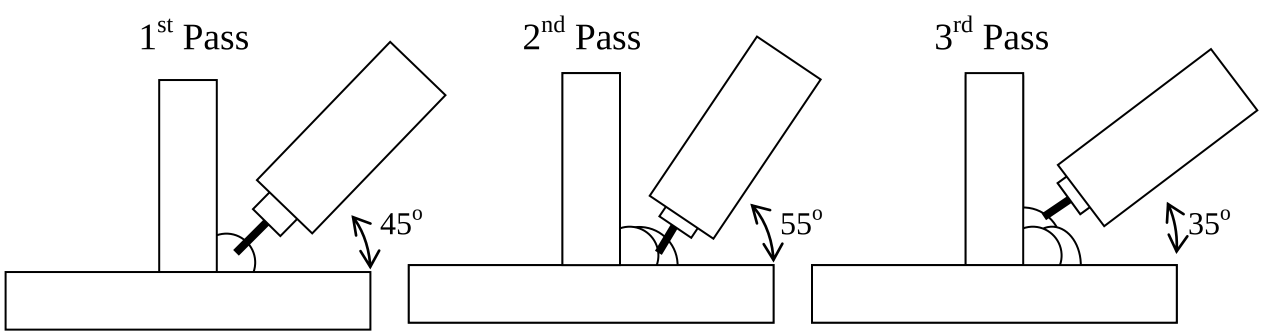
Student Number	Eveness - Single Pass To -10 Technique	Slag Inclusions -3 - 20 Pts each	Plates @ Right Angle To -10	Bead Legs, 1/4" -5 Per 1/16"	Undercut To -25 Overlap	Start To - 10 each Ending		Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

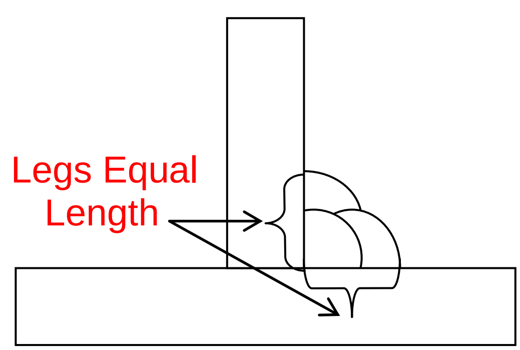
211A-34

MIG Welding, Horizontal Fillet, Multi Pass

1. Use assigned electrode wire.
2. Use 1/4" x 1 1/2" x 4” metal for the base.
3. Use 1/4" x 1” x 4” metal for the upright.
4. Allow the Contact Tip to extent 1/8" beyond the nozzle.
5. Hold the torch at a 45° angle from the base plate on the first pass, 55° on the second pass, and 35° on the third pass.
6. Hold the torch at a 10° – 15° angle in the direction of travel.
7. Horizontal and vertical legs need to be **equal.**
8. 1st pass – full length, 2nd pass – 2/3rd length, 3rd pass – 1/3rd length.
9. Use the same D motion as in the single pass fillet







GRADE SHEET

MIG Welding, Horizontal Fillet, Three Pass

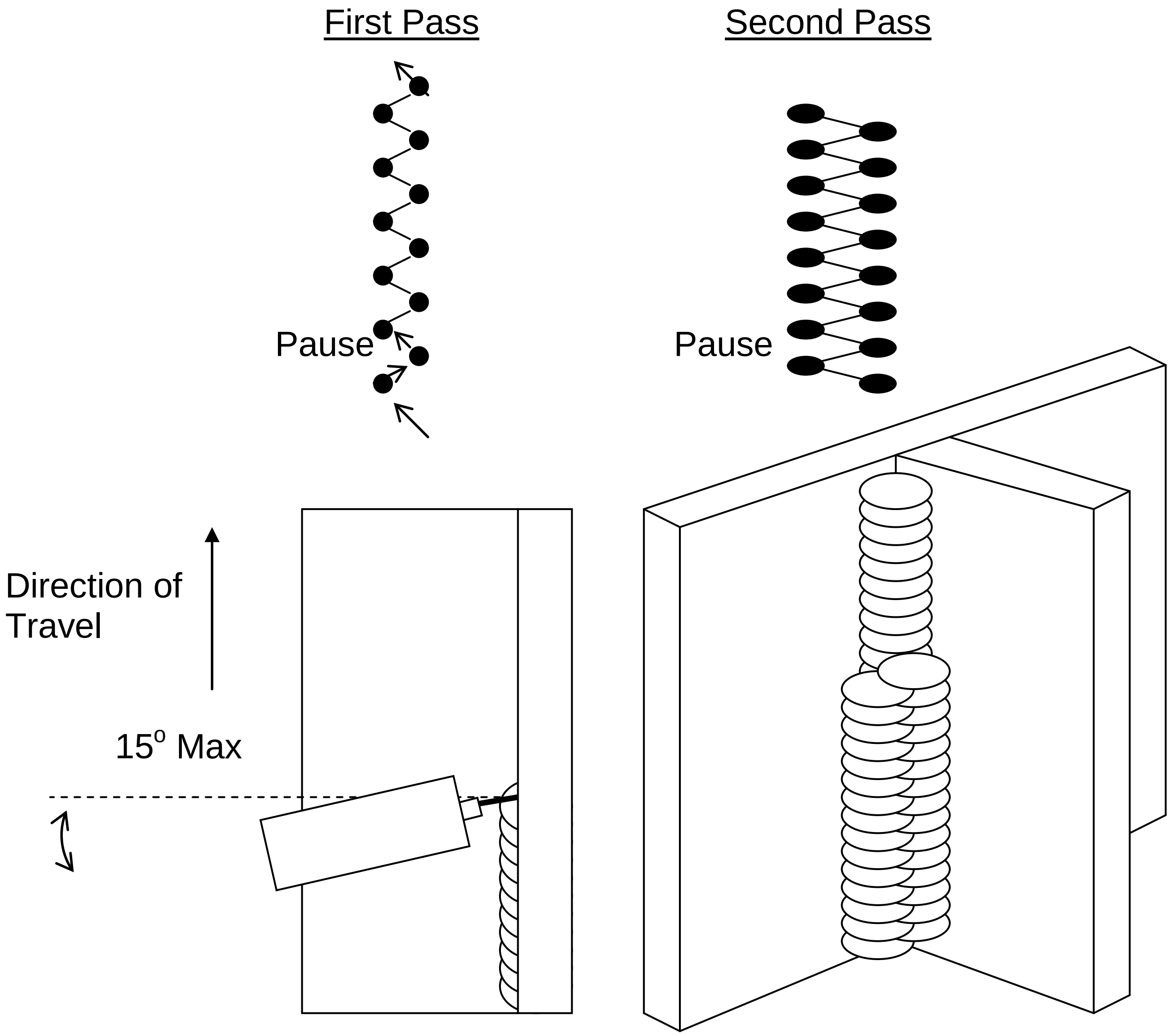
Student Number	Eveness - Single Pass To -10 each Techniques - 3 Passes	Penetration To - 15 Plates @ Right Angle To -10	1st Pass Legs, 1/4" -5 Per 1/16" 5/16" Legs 2+3 Pass	Undercut To -25 Overlap	Starts To - 10 each Endings	Flatness of the Three Pass To -10		Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

211A-36

MIG Welding, Vertical Up Fillet

1. Use assigned electrode wire.
2. Keep metal in a true vertical position.
3. Hold torch perpendicular, or point slightly upward.
4. Allow Contact Tip to extent 1/8" beyond nozzle.

Motions to Try



4. First pass to have 1/4" legs.
   Second pass to have 3/8" legs.
5. Leave 1/4 to 1/3 of the first pass uncovered.
   (Note: both welds must be done in the same direction)

GRADE SHEET

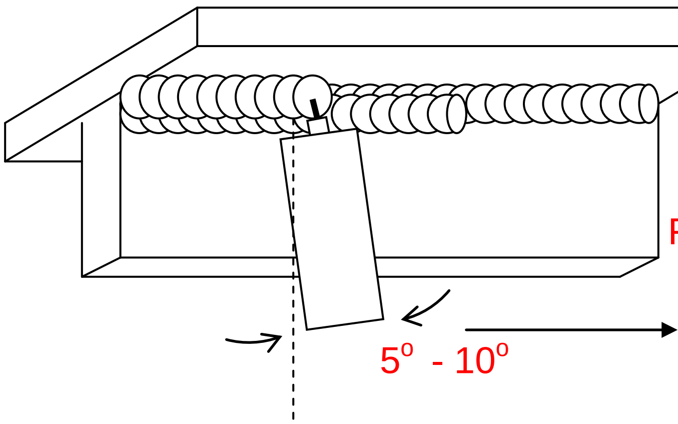
MIG Welding, Vertical-Up Fillet

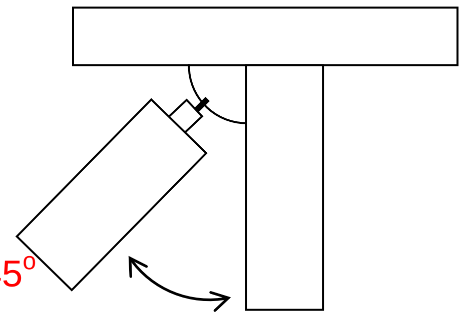
Student Number	Eveness - Single Pass To -10 each Technique, 2nd Pass	Slag Inclusions -3 - 20 Pts each Plates @ Right Angle To -10	1st Pass Legs, 1/4" -5 Per 1/16" 2nd Pass Legs, 3/8"	Undercut To -25 Overlap	Starts To - 10 each Endings	Flatness of the Three Passes To -10		Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

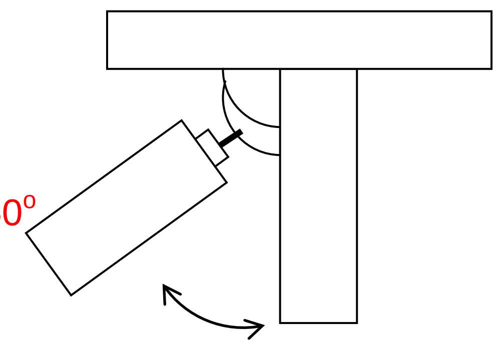
211A-38

MIG Welding, Overhead Fillet Weld

1. Use assigned electrode wire.
2. First pass – full length – second pass 2/3 length – third pass 1/3 length.
3. First pass – 1/4" legs, second & third pass 5/16" legs

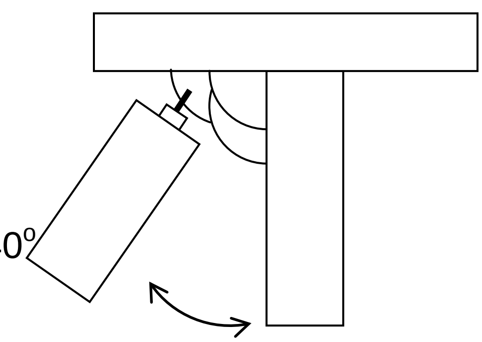






Suggestions:

1. Stand up
2. Lean against post
3. Metal at least 10" above head
4. Stand in close to work
5. Palms down
7. Keep MIG torch parallel to line of travel
8. Drape cable assembly over shoulder



211A-39

GRADE SHEET

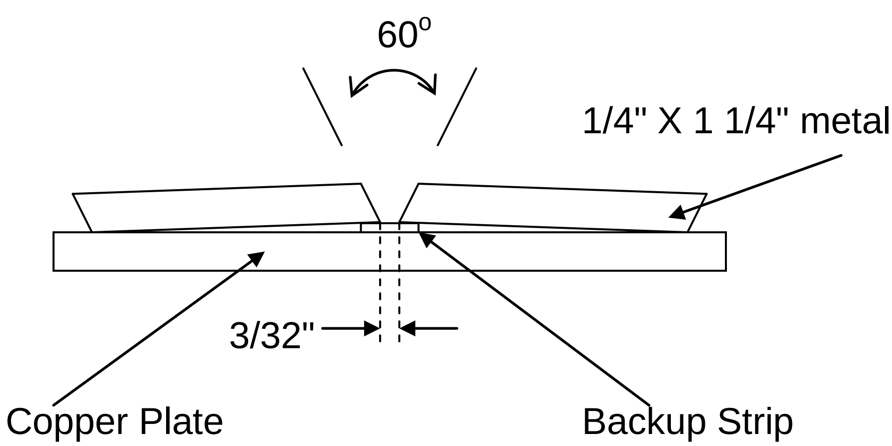
MIG Welding, Overhead Fillet

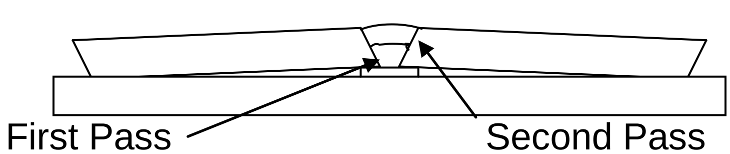
Student Number	Eveness of beads & Technique To -10 each	Penetration To - 15	Plates @ Right angle To -10	1st Pass Legs, 1/4" -5 per 1/16" 5/16" Legs, 2+3 Passes	Overlap To -25 Undercut	Starts To -10 each Endings	Flatness of the Three Passes To -10		Specs Saftey Clean-up	Late -10	Grade
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											

MIG Welding, V-Butt Tension Test

<u>Procedure:</u>

1. Use assigned electrode wire.
2. Make sure backup strip is flat and is laying on <u>clean</u> copper plate.
3. Leave approximately 3/32" space between pieces to be butt welded.
4. On first pass:
   a. A forehand weld with a slight side to side motion.
   b. Fill V approximately 1/2 full, leave excess on both ends.
5. On second pass:
   a. A backhand weld, tilt metal uphill.
   b. Use a weave weld, pause at edges, fill in excess on both ends.
6. Important: Allow metal to cool slowly under a plate of metal approximately 25 minutes undisturbed.
7. Grind weld to same size as parent metal – Use guide (at each belt sander). Do not nick base metal while grinding.
8. Take metal to instructor for testing.





IDENTIFYING MIG ELECTRODES

AWS: ER 70 S- X Y

E – Carbon Steel Electrode (solid, composite stranded, and composite metal core)
R – Rods (solid)

70 – 70,000 lbs tensile strength

S – The filler metal is solid
C – The filler metal is a composite

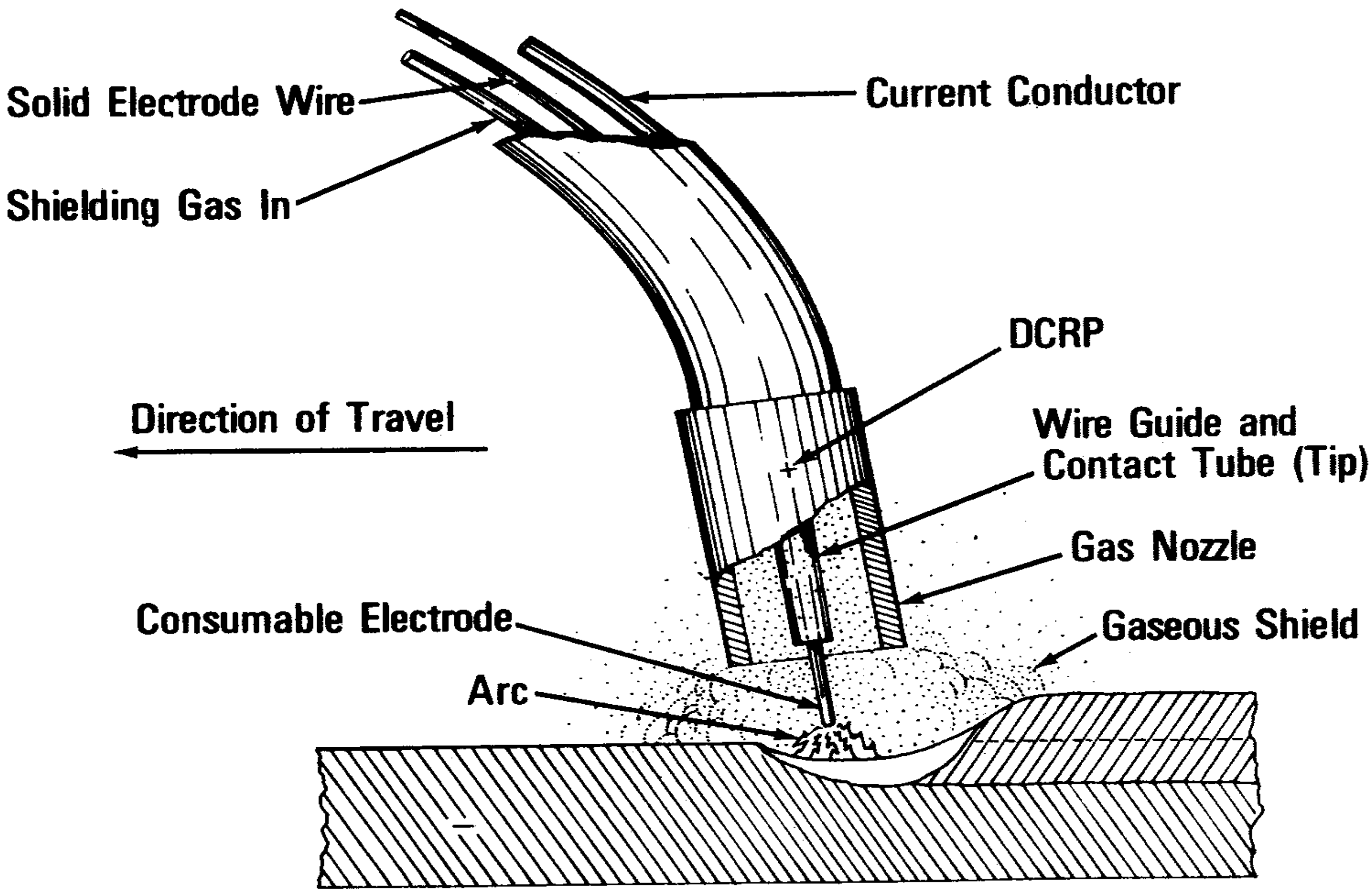
X – This position in the suffix will indicate the chemical composition of a solid electrode or chemical composition of a composite

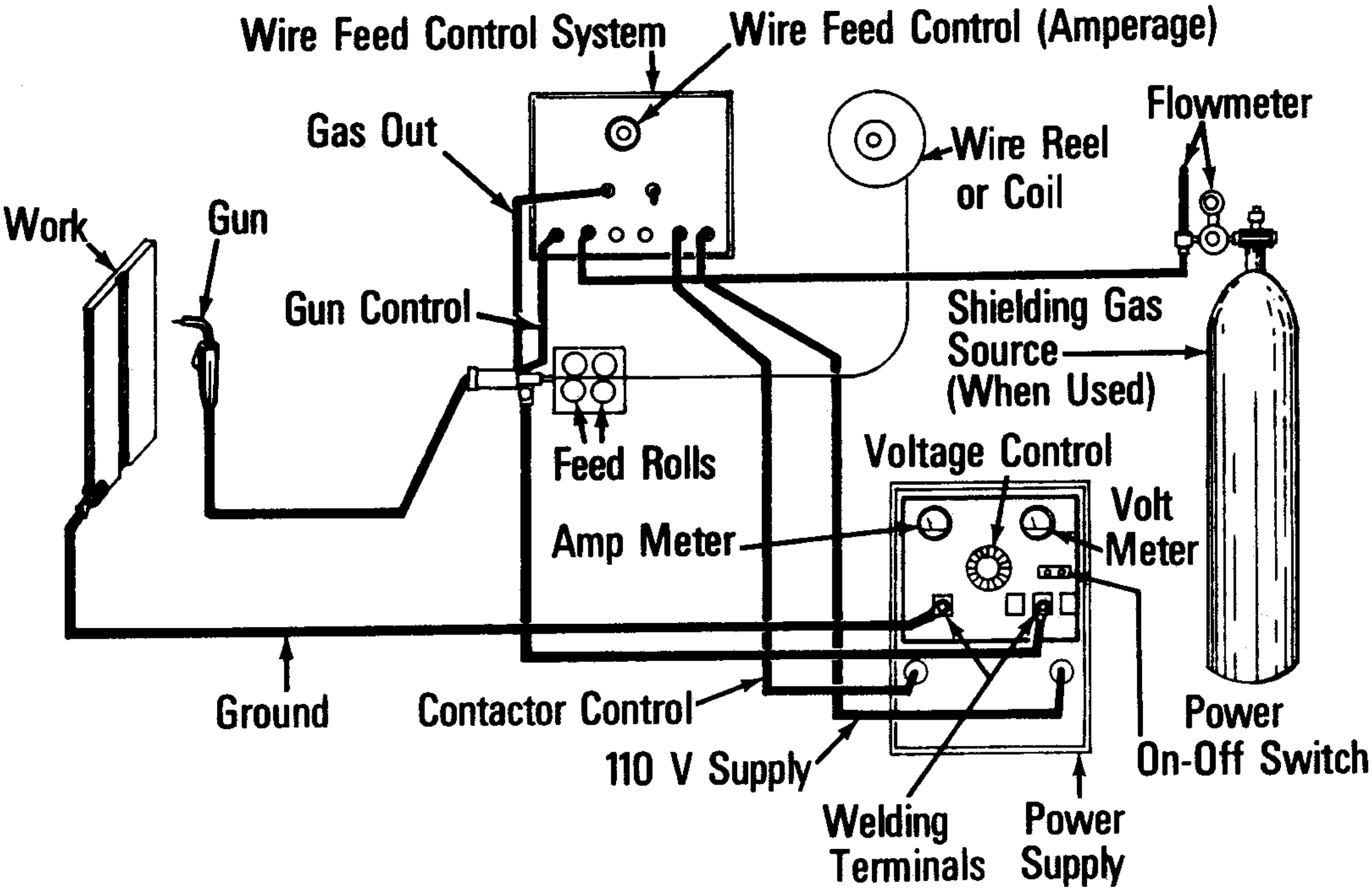
Numbers 1 – 6 in this position would indicate different the types of chemical composition

G – Indicates the electrode can be used in multi pass welds (may not be labeled, still safe to use in multi pass welds)
GS – Indicates the electrode can be used ONLY for single pass welds.

Y – This position the type of inert gas or gas mix to be used with the electrode. C requires 100% CO_2 and M requires an Argon CO_2 mix of 75-80%.

Note: The above only works on ferrous metals.
Different codes are used on non-ferrous metal, instead of a tensile strength number a type or alloy identification number will be in place.


Solid Electrode Wire
Shielding Gas In
Current Conductor
DCRP
Direction of Travel
Wire Guide and Contact Tube (Tip)
Gas Nozzle
Consumable Electrode
Gaseous Shield
Arc
+
–


Wire Feed Control System
Wire Feed Control (Amperage)
Flowmeter
Gas Out
Wire Reel
or Coil
Work
Gun
Gun Control
Shielding Gas
Source
(When Used)
Feed Rolls
Voltage Control
Volt
Meter
Amp Meter
Ground
Contactor Control
110 V Supply
Power
On-Off Switch
Welding
Terminals
Power
Supply

MIG Welding Electrode Wire Characteristics

AWS CLASS	CARBON	MANG.	SILICON	SULFUR	SHILDING GAS	TENSILE STRENGTH Min. PSI	CURRENT POLARITY
E70S-1	0.07-0.19	0.90-1.40	0.30-0.50	0.035	Ar 1-5% O_2	72,000	DCRP
E70S-2	0.06	0.90-1.40	0.40-0.70	0.035	Ar 1-5% O_2 CO_2	72,000	DCRP
E70S-3	0.06-0.15	0.90-1.40	0.45-0.70	0.035	Ar 1-5% O_2 CO_2	72,000	DCRP
E70S-4	0.07-0.15	0.90-1.40	0.65-0.85	0.035	$CO_2$1	72,000	DCRP
E70S-5	0.07-0.19	0.90-1.40	0.30-0.60	0.035	$CO_2$1	72,000	DCRP
E70S-6	0.07-0.15	1.40-1.85	0.80-1.15	0.035	$CO_2$1	72,000	DCRP

INITIAL SETTINGS FOR MIG WELDING

METAL THICKNESS (decibel/ Inches)		ELECTRODE SIZE	VOLTS	AMPS	GAS FLOW (cfh)	TRAVEL SPEED (ipm)
0.037	---	0.035	15-17	65-85	15-20	35-40
0.050	---	0.035	17-19	80-100	15-20	35-40
0.062	1/16"	0.035	17-19	90-110	20-25	30-35
0.078	5/64"	0.035	18-20	110-130	20-25	25-30
0.125	1/8"	0.035	19-21	140-160	20-25	20-25
0.187	3/16"	0.035	19-21	140-160	20-25	14-19
0.250	1/4"	0.035	19-21	140-160	20-25	10-15

TIG WELDING

AG 211-B

UNIT OBJECTIVE

After completion of this unit, students will be able to operate a TIG welder safely, understand the basic operations and principles, and demonstrate different TIG welding skills on different types of 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. Pass a safety test and demonstrate proper use of TIG welding equipment.
2. Be familiar with the different applications and uses of a TIG welder.
3. Be familiar with the different welding techniques that apply to different metals
4. Identify different problems with TIG welding, arc length, and amperage settings for different thickness of metal.
5. Identify properly and improperly formed beads.
6. Understand causes and effects of poor welds and how to correct them.
7. Understand and practice safe use of TIG welding equipment.
8. Understand the different uses of TIG welding in Industry.

TIG WELDING EQUIPMENT AND SAFETY

A. Introduction to TIG Welding

1. TIG (**T**ungsten **I**nert **G**as) welding or GTAW (**G**as **T**ungsten **A**rc **W**elding) derives it name from the tungsten electrode used to create heat with an arc without melting the electrode and protecting the weld with an inert gas.
2. TIG welders work off the similar principles as arc welders, oxy welders and MIG welders. It is similar to the arc welder for creating an electrical arc with the tungsten electrode but the electrode does not melt. Tungsten is one of the hardest know metals and has a melting point of $6{,}900^{o}$. It is similar to oxy welding for the ability to fusion weld and for having to feed filler rod with the opposite hand and holding the torch with the other. It is also similar to the MIG welder for using an inert gas to protect the weld from oxidation.

B. Advantages

1. The arc is more clearly visible by the operator with the absence of smoke from the flux.
2. No flux is used in TIG welding, welds do not need to have slag removed.
3. Welds in all positions.
4. High quality welds, no spatter.
5. Low distortion next to the welding area.
6. TIG welders can fusion weld almost any type metal.

C. Disadvantages

1. Limited use outdoors, wind will blow the inert gas away from the arc during the welding process.

D. Equipment

1. Ground Clamp

    a. The ground clamp completes the full electrical circuit so that enough heat will be available for the welding job. Serves the same purpose as in arc and MIG welding.

2. Welding Torch or TIG Torch

    a. The Torch Body – The main body of the torch provides a handle to hold the torch. It is holds the collets and tungsten electrode and carries current (amps) to the electrode and directs the inert gases from the cable assembly to the weld. See page 211B-51

b. The Collets – In the torch assembly you will have an electrode collet and a collet holder. The electrode collet will hold the tungsten electrode in place and the collet holder houses the electrode collet. The collets come in different sizes for different size electrodes and when a different size electrode is used a different size collets must be used at the same time.
c. Collet Cap Assembly – The cap assembly covers and protects the tungsten electrode. Caps come in different lengths, as well as the electrodes. Sometimes a short electrode and cap are necessary to weld inside of a pipe.
d. The Gas Nozzle – The nozzle directs the protective inert gases to the weld keeping oxygen away from the weld. Nozzles come in different shapes and sizes and they are used accordingly to different metals, metal thickness, and type of weld.
e. The TIG torch is controlled by a foot lever that engages and disengages the current flow and the gas flowmeter. The torch can also be controlled on the torch it self with a thumb control.

3. Changing The Tungsten Electrode

a. Make sure the welding unit is turned off.
b. Remove the gas nozzle.
c. Remove electrode cap assembly and O ring.
d. Remove the collet holder and the electrode collet (on some torches the collet holder and the electrode collet is a single unit).
e. Remove the electrode from the electrode collet.
f. Select the proper size electrode and collets for your next weld.
g. Screw collet holder back into the torch body.
h. Screw the correct size gas nozzle in place.
i. Place the new electrode and electrode collet into the collet holder.
j. Adjust the stick out length of the electrode.
k. Make sure the O ring is in place, screw on and tighten cap assembly.

4. Welding Cable Assembly

a. Carries the current to the torch body.
b. Connects the gas flowmeter and carries the gases to the welding torch.
c. The torch is water-cooled and the cable assembly carries water to the torch and back to the drain, some torches are air cooled.
d. The cable assembly has a thick plastic cover to protect it from sparks and insulate it from being grounded. A leather cover is available for extra protection and is also recommended.
d. While welding, keep the cable draped over your shoulder to help support the cable assembly.

5. Combination Regulator and Flowmeter

    a. Controls the flow of inert gases to the welding.
    b. Works the same as a regulator on the Oxy & Acetylene bottles.
    c. Reads in Cubic Foot per Hour (cfh).

        1) Adjust the regulator while the gas is flowing. Press down on the foot pedal and release to engage gas flow, the gas will flow for about 10 seconds after the pedal is released, more than enough time to make adjustments. Make sure the TIG torch is not on the welding table during adjustment, this will prevent accidental arcing.
        2) TIG and MIG gas flow meter are very similar.

E. Protective clothing must be worn at all times when welding. The heat created during TIG welding creates ultraviolet and infrared rays that can burn the skin. Many of the same protective clothing used in arc welding are also used in TIG welding.

1. Leather Gloves

    a. Gloves protect the hands from burns during welding.
    b. The gloves should be made of <u>thin</u> leather and have long cuffs to protect the wrist and prevent sparks from falling into them. The thin leather is used because of less spatter and the need for better feel of the filler rod.

2. Leather or Cotton Sleeves

    a. A NONFLAMMABLE material should be worn on the arms to protect from burns due to sparks and intense heat.

3. Body Protection

    a. Either a leather apron or coveralls or workshirt made of a flame-retardant material will protect the body during arc welding.
    b. All protective clothing should fit properly and be free of openings or rips into which a spark might enter or the intense heat might penetrate.

4. Footwear.

    a. High top leather boots should be worn while TIG welding.
    b. Never wear open-toed shoes while working with hot metal or a welding apparatus.

F. Welding Helmets and Shields - The brilliant light given off by the electric arc produces ultraviolet and infrared rays, which can severely burn the eyes and skin. NEVER LOOK AT THE ARC WITH THE NAKED EYE. Helmets and shields are equipped with special filter lenses and some have auto darkening lenses that reduce the intensity of the light and prevent the ultraviolet and infrared rays from reaching the eyes.

1. The welding helmet is designed specifically for the purpose of arc welding.

    a. The welding helmet fits on the head using a plastic adjustable headband.
    b. The helmet leaves both hands free for working and positioning materials.

2. The hand shield is used for observing.

    a. It is NOT advisable to use the hand shield when welding since one hand must be used to hold the shield in place.

3. The protective lenses come in different shades depending on the type of welding to be done. Different types of welding use different amounts of voltage and current which determine the intensity of the light and the amount of ultraviolet and infrared rays produced. Spot welding requires the fewest amperes and thus requires the least amount of shading in the lens. Arc welding machines require from less than 30 to over 400 amperes. Lens shades range from number 5 (which provides the least amount of protection) to shade 14 (which provides the most protection).

    a. Shade 5 is used for light spot welding.
    b. Shades 6 and 7 are suitable for welding with up to 30 amperes.
    c. Shade 8 is for welding with 30-75 amperes.
    d. Shade 10 can be used when welding with 75-200 amperes. (Most Suitable for MIG Welding)
    e. Shade 12 is used when welding with 200-400 amperes.
    f. Shade 14 is required when welding with over 400 amperes.

Note: Many people mistakenly think that the lens shade number corresponds to the amount of protection that is provided to the eyes and hence the higher the number, the higher the protection. But in reality, all well-constructed welding lenses, such as those manufactured by Lincoln Electric, have a screen that filters out 100% of the harmful ultraviolet (UV) and infrared (IR) wavelengths and provides protection to the eyes. The number just denotes the amount of darkness provided by that particular lens and should

be used by operators as a guide to select the one that is most comfortable and desired for their particular application.
Since the welding lens provides full UV and IR protection at all times – weather fully darkened or not – those who are concerned about being exposed to ultraviolet and infrared rays in those fractions of milliseconds while an auto-darkening helmet is tinting shouldn't be worried. Once the helmet is on, the eyes are protected from the ultraviolet frequency emitted by the welding arc.
Always select a shade that allows you to see the weld puddle clearest and that most aids your welding ability. (Stabilized, Volume 70, No. 1.)

4. Cover glasses are clear lenses that are used to stop flying sparks, thus protecting the filter lenses. There are 3 different types of cover glass currently available.

   a. Clear, unbreakable plastic is the cheapest and lasts the longest.
   b. Chemically treated glass is used to reduce pitting but it can be expensive.
   c. Plain glass is the cheapest but it's very susceptible to breaking, pitting, and splatter sticks and is NOT recommended.

5. Filter lenses must be changed if a crack or chip occurs in order to prevent ultraviolet and infrared rays from reaching the eyes. The shades of the lenses must also be changed. If the shade is too dark, the worker will be unable to see the work that is being performed. If the shade is too light, proper eye protection is not achieved. Many welding helmets have interchangeable lenses. The lens changing procedure is as follows:

   a. Remove the lift-up mechanism on the helmet or the lens frame lock.
   b. Slide the old filter lens out and insert the new one.
   c. Reinsert the lift-up mechanism or the lens frame lock.
   d. Put the helmet on and search for light leaks. If leaks are present, the lens must be readjusted.

G. Additional Welding Equipment

1. Safety Glasses - Safety glasses must be worn at all times.
2. Pliers - The heat of the arc will heat all of the metal being welded. Always use tongs or heavy pliers to carry or maneuver the metal stock.
3. Wire Brush – The metal must be free of dirt and other impurities before welding can begin. Use the wire brush to clean the metal before welding. Use a clean stainless steel brush on aluminum before you begin welding.

SAFETY IN TIG WELDING

When TIG welding, observe the following general safety practices.

1. Wear gloves and eye and face protection. The welder and all observers must wear welding helmets with a No. 10 or 12 filter lens. A welding cap or helmet with a hard hat is also recommended for head protection. When cleaning a weld with a wire brush be sure your safety glasses are being wore properly.
2. Avoid electrical shock. Make certain that the TIG torch and all electrical connections and cables are properly insulated. Check to see that the welder is properly grounded. Do not dip the TIG torch in water to cool it because this practice may result in electrical shock. The TIG torch will be water cooled internally or it may be air cooled.
3. Protect others. For small and practice welding jobs, work in a partitioned area to protect others from harmful rays. When prepared to start a TIG weld, inform all bystanders to cover their eyes.
4. Never weld in a damp area. Stand on a dry board or rubber mat if the floor or ground is damp or wet.
5. Never wear synthetic fiber clothing. Synthetic fibers are highly flammable. Wearing clothing made from wool or cotton is more satisfactory for welding because of their relatively high flash points.
6. Protect welding cables. Keep the cables from coming in contact with hot metal and sharp edges. Do not drive over cables.
7. Secure work. Use a welding table with a positioner to hold welds securely in place. Clamps and vises can be used to hold odd-shaped work or field work. Securing work will also prevent injury from accidental dropping of metal on your feet or body.
8. Prevent burns. Never adjust the gas cup with your bear hand, even after welding for just a few moments the cup can become very hot. Remove hot metal from the work area when you are finished welding to prevent burns to others.
9. Handle hot metal with pliers or tongs. Submerge hot metal completely in water to prevent steam burns.
10. Weld in a well-ventilated area. The fumes from lead, zinc, cadmium, and beryllium are toxic and may cause sickness or death.
11. Do not carry matches or lighters, and do not allow bystanders to smoke. Before welding, make sure the welding area is free of other flammables (gas, grease, etc.).

ACTIVITY:

1. Practice identifying and handling TIG welding equipment, making sure that all safety procedures are followed and that suitable clothing is being worn.
2. Burn a piece of cotton cloth and a piece of polyester and cotton blend and compare the difference in the ash. The cotton will simply turn into ash while the blended material will melt and keep burning.
3. Quench metal by dipping it in and out of water and demonstrate the steam rising and show how it can cause steam burns.
4. Change inert gas bottles and set flowmeter regulator.

TIG WELDING SETUP AND SHUT DOWN

A. Setup and Preliminary Checks

1. Look the TIG welder over before starting.

    a. Inspect the welding torch and leads for any damage. If damaged, make repairs before using the welder.

        1) Inspect the gas nozzle for excess spatter, damaged caused by overheating, cracks, and any other damage. Clean or replace parts if necessary.
        2) Make sure the correct size electrode is being used with the proper size electrode collet and collet holder.
        3) The orifices are clear and free from obstruction.
        4) Inspect the welding cable assembly for bear spots and cracks in the insulation; if damaged, repair or replace if necessary.

2. Turn the machine on.
3. Turn on water (if the torch body is water cooled).
4. Turn on remote switch (this switch gives control to the foot lever).
5. Turn on the inert gas and adjust accordingly. Adjust gas flow to a working pressure by engaging the torch with the foot lever and letting the gas come out the torch tip.
6. Set Polarity.
5. Adjust the tungsten electrode to proper stick out length.
6. Adjust the amperage or voltage to the prescribed setting. Know the thickness and the type of metal you are welding on and consult the welding chart for proper amperage settings. (Minor adjustment may be required after welding begins.)

B. TIG Welding Procedure

1. Equipment adjustment for proper amperage is vital for good welds and proper use of the machine.

    a. The welding bench should be clean and dry.
    b. The ground clamp should be attached to the welding bench in a secure manner.

2. Striking an Arc

    a. Select a plate or coupon of mild steel 1/8" thick, 2" to 3" wide, and 4" to 5" long.
    b. Place the welding torch in position, the tungsten electrode about 1/4" above the work surface. The electrode will not become “hot” until the foot lever is pressed. Be sure your hand is stabilized by rest your elbow or forearm on the table.
    c. Striking an arc is as simple as pressing the foot lever.

        1) Hold the torch with the electrode 1/8" to 1/4" above the base metal or work plate.
        2) Pressing the foot lever 3/4 the way down, charging the tungsten electrode with a high amperage of electricity and an arc will appear. After the arc has appeared and is stable and the weld pool is established, back off on the foot lever a to the desired amperage.
        3) Arc length needs to be 1/16" – 1/8". Any longer will increase the resistance and your amperage will change and not weld properly.
        4) Practice starting and stopping the arc until this action can be completed quickly and easily.

    d. Practice running fusion beads (without filler rod) and the circular motion, after the skill of starting and maintaining an arc has been mastered.
    e. Practice running fusion beads with filler rod and the circular motion, after the skill of running fusion beads has been mastered.

        1) Similar to running beads in Oxy-acety welding you will need to use one hand to hold the torch and the other to feed the filler rod. Stringer beads are an excellent bead for beginning welders to make. The beads will not be consistent but should improve with practice.

2) Welds done with proper amperage, voltage, and travel speed displays

a) Good penetration
b) No undercut or overlap
c) Smooth appearance

f. Hold the torch at the end of the puddle for a moment after releasing the foot lever. The gases will continue to flow for a few seconds after the foot lever is released. The torch will also provide heat from the tip, this will help the weld cool slower and prevent cracks and the gases will help prevent oxidizing.

C. Shutting Down a TIG Welder

1. After the weld is complete,

a. Shut off the inert gas cylinder.
b. Shut off water.
c. Engage the foot lever, releasing the gases still in the lines
d. Turn off the welder

ACTIVITY:

1. Starting and maintain an arc by running beads across a piece of metal.
2. Explain what happens when the correct speed and working distance are being maintained.
3. Run and evaluate stringer bead for correctness and penetration.
4. Run beads with the gas turned off and volts too high and too low.
5. Change tungsten electrode and demonstrate the proper way to sharpening.

ELECTRICAL CURRENTS IN TIG WELDING

A. Welding Currents –

1. DC – Direct Current, the current will flow in one direction, from the positive to the negative. In welding there are two different polarities used, reverse polarity (DCRP) and straight polarity (DCSP).

a. DCSP – Direct Current Straight Polarity is a direct current flow, flowing from the welding torch being welded on to the work piece.

1) DCSP is mostly used to weld; carbon steels (mild steel), stainless steels, copper and copper alloys, nickel steels, brass and bronzes, and titanium.
2) Using straight polarity more heat will be directed to the work piece. Approximately $1/3_{rd}$ of the heat will be in the electrode and $2/3_{rds}$ of the heat will be in the work piece.
3) With less heat in the electrode, smaller electrodes can be used to weld with DCSP.
4) DCSP is used for welding mild steel, stainless steel, copper, and titanium. Produces a narrow bead with deep penetration.

b. DCRP – Direct Current Reverse Polarity is a direct current flow, flowing from the work piece to the welding torch.

1) DCRP can weld the same materials as DCSP but with less heat in the work piece, thinner material can be welded.
2) Using reverse polarity more heat will be directed to the electrode. Approximately $2/3_{rds}$ of the heat will be in the electrode and $1/3_{rd}$ of the heat will be in the work piece.
3) With more heat in the electrode, larger electrodes are needed to weld with DCRP. Produces a wide bead with shallow penetration.
4) DCRP is usually reserved for preparing tungsten electrode for aluminum welding and heavy oxidized cast aluminum welding. See page 211B-50 for preparing electrode for aluminum welding.

c. When using a direct current the tungsten electrode needs to be ground to a sharp point, like a pencil.
d. The length of the point will need to be 2 ½ times the diameter of the electrode.
e. See sharpening procedures on page 211B-49.

2. AC – Alternating Current or ACHF Alternating Current High Frequency, the current of electricity will change directions 120 times a second, flowing back and forth from the positive to the negative. Sixty changes to the positive and 60 changes to the negative. ACHF is mostly used in welding aluminum.

a. Sense the current travels back and forth, equal heat appears in the electrode and the work piece. Higher amps are sometimes required when welding with AC. Produces a medium width bead with medium penetration.
b. When using an alternating current the tungsten electrode needs to be rounded or balled at the end.
c. A superimposed high frequency (added over the top of the existing current) is added to prevent the current from reaching zero. See illustration on page 211B-44.

d. The roundness of the balled end will be the same size of the electrode and up to 1 ½ time the diameter of the electrode.
e. See rounding procedures on page 211B-50.
f. Square Wave Current – The square wave current eliminates the build time of a graduated wave current for a better arc stability while welding. See illustration on page 211-45.

AWS CLASSIFICATION SYSTEM FOR ELECTRODES AND FILLER ROD

A. TIG electrodes and how they are selected.

1. In TIG welding the electrodes are thin and made primarily of tungsten, a Thorium or Zirconium alloy will be added to raze the melting temperature to a higher degree.
2. Generally there are five different types of tungsten electrodes. Each kind of electrode will be identified by different colors. Each electrode has a special purpose.

   a. A pure tungsten electrode will be identified by a green color. (EWP) Designed for welding aluminum and magnesium welding only.
   b. An electrode with 1% Thorium will be identified by a yellow color. (EWTH1) Designed for welding copper and copper alloys.
   c. An electrode with 2% Thorium will be identified by a red color. (EWTH2) Designed for all carbon steels, stainless steel, nickel alloys, and titanium. Note: This electrode will weld aluminum, magnesium, and copper, but it's cheaper to use pure tungsten and the 1% Thorium. Pure tungsten will keep a balled end better than 1% or 2% Thorium. The red colored electrode is the most commonly used electrode in educational programs.
   d. An electrode with 3% Thorium will be identified by a blue color. (EWTH3) Designed for all the same welds as 2% but more expensive.
   e. An electrode with Zirconium will be identified by a brown color. (EWP) Designed for x-ray quality aluminum and magnesium welds. Higher amps can be run through the Zirconium electrode than the pure tungsten.

3. The different types of electrodes will come in different diameters. Starting at 0.010" up to 1/4". See charts on pages 211-47 & 48.
4. With the different sizes of tungsten electrodes there are different sizes of gas cups to be used. Cup numbering is determined by size in 16ths of an inch. For example, cup size #5 is 5/16ths of an inch and #6 is 6/16ths or 3/8ths of an inch. See charts on pages 211B-47 & 48 for matching electrodes with gas cup size.

B. Selection of TIG Filler Rods

1. Selection of TIG filler rods are based on the types of base material and the types of beads to be welded.
2. TIG filler rod identification is similar to identifying electrodes used in MIG welding. The American Welding Society (AWS) has developed a the following electrode classification system:

    a. What does the classification of ER316 L on the label of a box of TIG filler rod mean? Reading from left to right.

        1) The beginning of the code will begin with an E or ER, the E meaning use as an electrode only and R means it can be used as a rod.
        2) The 316 is identifying the type of stainless steel alloy in the filler rod.
        3) The letter L indicates the filler rod is a "low carbon".

ACTIVITY:

1. Use overheads and handouts with students to explain the AWS code for TIG electrodes and filler rod.
2. Demonstrate proper start up and shut down procedures.
3. Demonstrate stating an arc and welding a bead.
4. Demonstrate holding the torch over the weld to allow the inert gases to flow over the weld.

BASIC WELDS

A. Welding a Fusion Bead, Mild Steel

1. Welding a fusion bead is the first step after striking an arc and towards making other types of welds.
2. Set welding amperage and the gas flow to the desired setting (depending on the electrode size and the thickness of metal used.)
3. Use DCSP and sharpen the tungsten electrode to a sharp point.
4. Keep the arc length constant, about 1/16" – 1/8", listen to the sound and keep it constant. Increasing the arc length during welding will result in a higher resistance and higher heat. Decreasing the arc length will result in a lower resistance and lower the heat.
5. Angle the welding torch tip 15^o – 20^o from vertical away from the direction of travel. At the same time keep the side to side angle at 90^o.
6. Speed of travel, watch the width of the puddle and keep it constant.
7. See page 211B-25

B. Welding a Bead, Mild Steel

1. Welding a bead with filler rod is the first step after running a fusion bead.
2. Set welding amperage and the gas flow to the desired setting (depending on the electrode size and the thickness of metal used.)
3. Use DCSP and sharpen the tungsten electrode to a sharp point.
4. Keep the arc length constant, about 1/16" – 1/8", listen to the sound and keep it constant.
5. Angle the welding torch tip 15^o – 20^o from vertical away from the direction of travel. At the same time keep the side to side angle at 90^o. Hold the filler rod 15^o to 20^o above the base plate.
6. Speed of travel, watch the width of the puddle and keep it constant.
7. See page 211B-29

C. Welding a Bead, Aluminum

1. Set welding amperage and the gas flow to the desired setting (depending on the electrode size and the thickness of metal used.)
2. Use AC (ACHF if available) and round the tungsten electrode to a balled end.
3. Keep the arc length constant, between 1/16" – 1/8", listen to the sound and keep it constant.
4. Angle the welding torch tip 15^o – 20^o from vertical away from the direction of travel. At the same time keep the side to side angle at 90^o. Hold the filler rod 15^o to 20^o above the base plate.
5. Speed of travel, watch the width of the puddle and keep it constant.

6. Note: Aluminum is a good conductor of heat, it might take a few seconds before a puddle forms but once it does back off on the heat (amperage) a little and then weld the bead. See page 211B-52
7. See page 211B-31

Note: Do not try to weld on 7000 or 2000 series aluminum. This is a high-grade aluminum but it cannot be welded. It's mostly used in the aircraft industry BUT they are riveted together and not welded. It can be found at surplus auctions at a cheap price but its' uses are limited.
The most common grade of aluminum used is the 5000 series. This grade is not crack sensitive and filler metal is readily available.

D. Welding a Bead, Stainless Steel

1. Set welding amperage and the gas flow to the desired setting (depending on the electrode size and the thickness of metal used.)
2. Use DCSP and sharpen the tungsten electrode to a sharp point.
3. Keep the arc length constant, between 1/16" – 1/8", listen to the sound and keep it constant.
4. Angle the welding torch tip 15^{o} – 20^{o} from vertical away from the direction of travel. At the same time keep the side to side angle at 90^{o}. Hold the filler rod 15^{o} to 20^{o} above the base plate.
5. Speed of travel, watch the width of the puddle and keep it constant.
6. Note: Stainless steel does not conduct heat very well (directly opposite of aluminum), a puddle will form shortly after the arc is started. High warpage is common in stainless steel welds. See page 211B-xx
7. See page 211B-xx

E. Butt Weld, Mild Steel & Stainless Steel

1. Welding a butt weld is the first step after running a bead. The butt joint is one of the most frequently used weld joints.
2. Set welding amperage and the gas flow to the desired setting (depending on the electrode size and the thickness of metal used.)
3. Use DCSP and sharpen the tungsten electrode to a sharp point.
4. Keep the arc length constant, about 1/16" – 1/8", listen to the sound and keep it constant.
5. Angle the welding torch tip 15^{o} – 20^{o} from vertical away from the direction of travel. At the same time keep the side to side angle at 90^{o}. Hold the filler rod 15^{o} to 20^{o} above the base plate.
6. Speed of travel, watch the width of the puddle and keep it constant.
7. Use a closed butt weld, the closed butt weld should be used only if the material to be welded does not exceed 3/16" in thickness.
8. See page 211B-33

F. Butt Weld, Aluminum

1. Welding a butt weld on aluminum is a lot different than welding a butt weld on mild steel. Due to the fact that aluminum conducts heat faster.
2. Set welding amperage and the gas flow to the desired setting (depending on the electrode size and the thickness of metal used.)
3. Use AC (ACHF if available) and round the tungsten electrode to a balled end.
4. Keep the arc length constant, about 1/16" – 1/8", listen to the sound and keep it constant.
5. Angle the welding torch tip 15^o – 20^o from vertical away from the direction of travel. At the same time keep the side to side angle at 90^o. Hold the filler rod 15^o to 20^o above the base plate.
6. Speed of travel, watch the width of the puddle and keep it constant.
7. Use a closed butt weld, the closed butt weld should be used only if the material to be welded does not exceed 3/16" in thickness.
8. See page 211B-35

G. Fillet Weld, Stainless Steel & Mild Steel

1. The tee joint is formed by placing one plate at a 90 degree angle to another to form a letter T. A tee joint is a Fillet-type weld. Welding a fillet weld is the next step after welding a butt weld.
2. Set welding amperage and the gas flow to the desired setting (depending on the electrode size and the thickness of metal used.)
3. Use DCSP and sharpen the tungsten electrode to a sharp point.
4. Keep the arc length constant, about 1/16" – 1/8", listen to the sound and keep it constant. Stick out length can be up to 1/4" on a fillet weld to allow for correct arc length.
5. Angle the welding torch tip 15^o from vertical away from the direction of travel. At the same time keep the torch at a 45^o from the side plate. Hold the filler rod 20^o above the base plate and 20^o from the side plate.
6. Speed of travel, watch the width of the puddle and keep it constant.
7. See page 211B-37

H. Fillet Weld, Aluminum

1. Set welding amperage and the gas flow to the desired setting (depending on the electrode size and the thickness of metal used.)
2. Use AC (ACHF if available) and round the tungsten electrode to a balled end.
3. Keep the arc length constant, about 1/16" – 1/8", listen to the sound and keep it constant. Stick out length can be up to 1/4" on a fillet weld to allow for correct arc length.

4. Angle the welding torch tip 15^o from vertical away from the direction of travel. At the same time keep the torch at a 45^o from the side plate. Hold the filler rod 20^o above the base plate and 20^o from the side plate.
5. Speed of travel, watch the width of the puddle and keep it constant.
6. See page 211B-39

I. Pad Welding, Aluminum

1. A pad weld is used to build up metal surfaces after it has been worn down.
2. Pad welding can be done on flat or round surfaces.
3. Pad welding consists of depositing several layers of beads.

    a. Welding a bead to cover half of the previous bead.
    b. Welding beads one over the top of another.

4. Set welding amperage and the gas flow to the desired setting (depending on the electrode size and the thickness of metal used.)
5. Use AC (ACHF if available) and round the tungsten electrode to a balled end.
6. Keep the arc length constant, about 1/16" – 1/8", listen to the sound and keep it constant.
7. Angle the welding torch tip 15^o – 20^o from vertical away from the direction of travel. At the same time keep the side to side angle at 90^o on the first pass and 10^o off 90^o on the second, third, etc. Hold the filler rod 15^o to 20^o above the base plate.
8. Speed of travel, watch the width of the puddle and keep it constant.
9. See page 211B-41

ACTIVITY:

1. Prepare and weld each of the types of welds.
2. Design and build a project utilizing at least three different types of welds.

Name_______________
Date________________
Score_______________

SAFETY EXAM, TIG WELDING

Multiple choice, circle the letter that bests represents the correct answer. The second part of the test is true and false questions, circle the T if the statement is true and F if the statement is false.

1. Using a water cool torch without water will cause _____________________.

    a. The torch to malfunction.
    b. The torch to overheat.
    c. The torch to melt down.
    d. All the above.

2. Breathing fumes from lead, zinc, cadmium, and beryllium can cause ____________.

    a. death
    b. sickness
    c. long term sickness
    d. all of the above

3. Thin leather gloves can be worn while TIG welding because ________________.

    a. There is less danger of being burned.
    b. The need for a better feel of the fill rod.
    c. Thinner gloves are cheaper.
    d. Less amperage is used in TIG welding.

4. When you lay the TIG torch down DO NOT ____________________.

    a. Set it on its' tip.
    b. Hang it up properly
    c. Lay it flat on the welding table
    d. Both A and C

5. When quenching hot metal in water ____________ to avoid steam burns.

    a. hold it under water until it cools
    b. dip it in and out of the water
    c. hold it half way under water
    d. hold it under running water

6. If welding in damp areas, it's all right to weld if ______________________.

    a. your boots are dry
    b. you are standing on a dry board or rubber mat
    c. you have dry gloves on
    d. none of the above

7. While sharpening an electrode to a pencil point, you should never _______________.

    a. Use a fine grinding stone
    b. Use a contaminated grinding stone.
    c. Cup the bottom end of the electrode with you hand or support it with you finger.
    d. All the above.

8. Inert gas bottles on TIG welders _________________.

    a. Have less safety requirements than Oxy bottles.
    b. Have the same safety requirements as Oxy bottles.
    c. Don't need to be chained or held in place
    d. Have no dangers

9. T or F If the insulation is broken off the TIG torch it is still safe to use it if you are careful.

10. T or F A sharp tungsten electrode is can puncture the skin very easily.

11. T or F Welding in an unventilated area is allowable for a short period of time.

12. T or F TIG welding causes less fumes and less ventilation is needed.

13. T or F When starting to weld always call out cover, so people in the surrounding area can look away before you start welding.

14. T or F Safety glasses are less important for TIG welding.

15. T or F Handle bottles of inert gases with the same safety and precautions as you would with Oxy and Acetylene bottle.

211B-20

Name_______________
Date________________
Score_______________

UNIT EXAM, MIG WELDING

Multiple Choice, circle the letter that best represents the correct answer.
Short answer

1. The electrode is allowed to stick out further when welding __________________.

    a. a butt weld
    b. a fillet weld
    c. an overhead weld
    d. indoors

2. What is the purpose of the ground?

    a. To hold the work down.
    b. Compete the electrical circuit.
    c. To warn up the metal before welding.
    d. Hold the points open.

3. What is the correct cup size for a 1/16" electrode?

    a. # 1
    b. # 2
    c. # 3
    d. # 4

4. What motion is used in TIG welding?

    a. Circular
    b. Dab
    c. Zig-Zag
    d. Up and down

5. Using DCRP, the weld will __________________________.

    a. Have tall bead with deep penetration
    b. Have a wide bead with shallow penetration
    c. Have a tall bead with shallow penetration
    d. Have a wide bead with deep penetration

6. The ground clamp should be attached to

   a. a non-conductive block of wood
   b. the project or worktable
   c. a properly grounded bolt mounted in the floor
   d. the electrode

7. A weld with the proper amperage, voltage, wire speed, and travel speed displays

   a. good penetration
   b. no undercut or overlay
   c. a smooth appearance
   d. all of the above

8. If you change the size of the electrode, what else do you need to change?

   a. The nozzle.
   b. The nozzle, electrode collet.
   c. The nozzle, electrode collet, collet holder.
   d. The nozzle, electrode collet, collet holder, gas pressure.

9. What does the red colored tip of the tungsten electrode indicate?

   a. Pure tungsten.
   b. 1% thorium
   c. 2% thorium
   d. 3% thorium

10. What will happen if an inert gas is not used while TIG welding?

    a. The weld will be normal.
    b. The weld will be oxidized and week.
    c. The weld will be clean.
    d. The weld will be unaffected.

11. To handle hot metal, what tool should you use?

    a. Your gloves.
    b. Pliers.
    c. The grounding clamp.
    d. Leave it until it cools.

12. Name three advantages to using a TIG welder as compared to an arc welder?

13. What is the cheapest electrode for aluminum welding?

14. Name two advantages for using the 2% thorium electrode.

15. What will happen if you change to a smaller electrode and forget to change the gas cup?

16. What will happen if the inert gas pressure is too high?

17. Approximately what length do you sharpen an electrode for stainless steel welding?

18. What is the maximum roundness of the balled end of an electrode?

19. What will happen if welding travel speed is too fast?

20. What will happen if welding travel speed is too slow?

211B-23

Answer Key

Safety Exam

1. D
2. D
3. B
4. A
5. A
6. B
7. D
8. B
9. F
10. T
11. F
12. F
13. T
14. F
15. T

Unit Exam

1. B
2. B
3. D
4. B
5. B
6. B
7. D
8. D
9. C
10. B
11. B
12. The arc is more clearly visible by the operator with the absence of smoke from the flux, no flux is used in TIG welding, welds do not need to have slag removed, welds in all positions, high quality welds, no spatter, low distortion next to the welding area, TIG welders can fusion weld almost any type metal
13. Pure Tungsten
14. Less likely to contaminate the weld, can be used for both AC and DC welding.
15. The gasses will not cover the weld properly.
16. Result in air turbulence and an uneven weld
17. 2 ½ times the diameter of the electrode.
18. 1 ½ times the diameter of the electrode.
19. Shallow penetration, high narrow bead, irregular bead, undercutting
20. Burn through, pours weld, overlap

References:

Burke, Stanley R., & Wakeman, T. J. (1997). MODERN AGRICULTURAL MECHANICS (3nd ed.). Danville, IL: Interstate Publishers.

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

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

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

STABILIZED, Vol. 70 No.1, The Lincoln Electric Company, Cleveland, Ohio, 1-888-355-3213, www.lincolnelectric.com

Special Material and Equipment:

Arc welding helmet, leather gloves, aprons, coveralls, strikers, safety test, safety goggles, TIG welder

Resources:

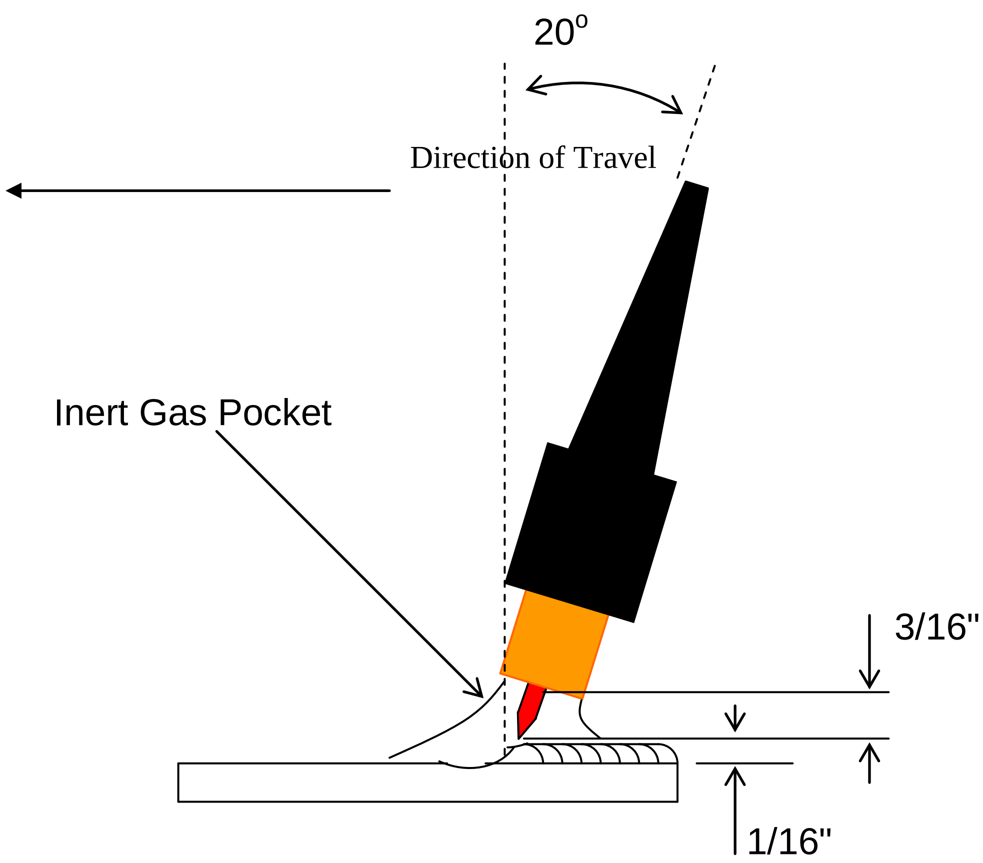
Deere & Company. (1987). WELDING (6th ed.) (Fundamentals of Service (FOS) Series). Available from: John Deere Technical Services, Dept. F, John Deere Road, Moline, IL 61265 (Available in Spanish)

Giachino, Joseph W., & Weeks, William (1976). WELDING SKILLS AND PRACTICES (5th ed.). Available from: American Technical Society, Chicago, IL 60637
Hobart Brothers Company. (1978). TECHNICAL GUIDE FOR SHIELDED METAL ARC WELDING. Available from: Hobart Brothers Company, Troy, OH 45373

The Lincoln Electric Company, Cleveland, Ohio, 44117-1199
TEL (216) 481-8100 www.lincolnelectric.com

TIG Welding, Mild & Stainless Steel Fusion Bead

1. Use a 2% Thorium, 1/16" electrode (Red colored end).
2. Set proper amperage, gas flow, and use proper cup size, consult chart for stainless and mild steel.
3. Use 1/8" X 2" X 3" mild steel or stainless steel.
4. Sharpen electrode to a pencil point, 3/16" stickout length.
5. Bead width, 3/16".
6. Hold torch at a 20^{o} travel angel, 90^{o} work angle.



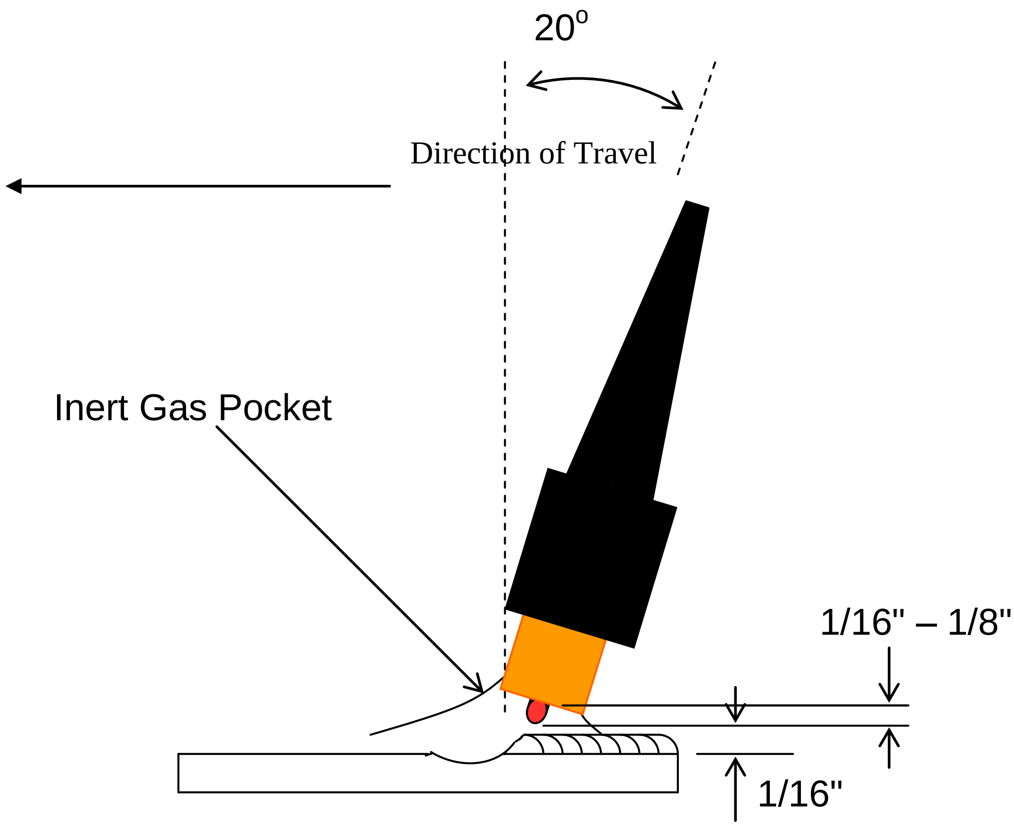
GRADE SHEET

TIG Welding, Fusion Bead – Mild or Stainless Steel

Student Number	Starts and Endings Bead full length of metal To -10 each end	Bead Width 3/16" -1 @ 1/32 Over or Under	Eveness of Bead Width -1 @ 1/32" Difference	Eveness of Bead & Technique To -15	Penetration of Bead To -10			Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

TIG Welding, Aluminum Fusion Bead

1. Use a 2% Thorium, 1/16" electrode (Red colored end) or pure tungsten.
2. Set proper amperage, gas flow, and use proper cup size, consult chart for aluminum.
3. Use 3/16" X 2" X 3" aluminum.
4. Prepare electrode with a balled end, 1/16" – 1/8" stickout length.
5. Hold torch at a 20° travel angel, 90° work angle.
6. Bead width, 3/16", use back and forth motion.



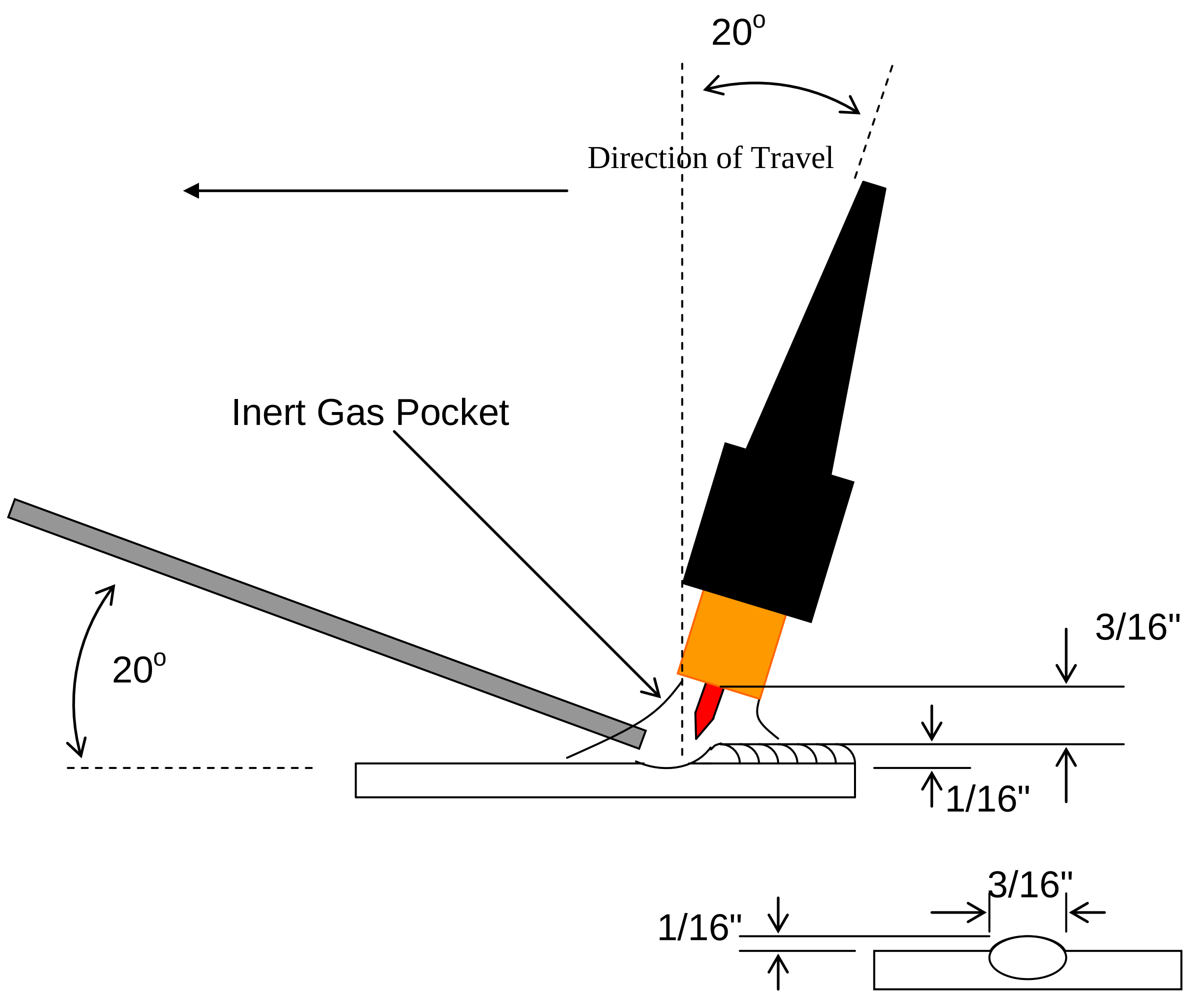
GRADE SHEET

TIG Welding, Fusion Bead – Aluminum

Student Number	Starts and Endings Bead full length of metal To -10 each end	Bead Width 3/16" -1 @ 1/32 Over or Under	Eveness of Bead Width -1 @ 1/32" Difference	Eveness of Bead & Technique To -15	Penetration of Bead To -10			Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

TIG Welding, Mild & Stainless Steel Bead

1. Use a 2% Thorium, 1/16" electrode (Red colored end).
2. Set proper amperage, gas flow, use proper cup size, and correct size filler rod. Consult chart for stainless and mild steel.
3. Use 1/8" X 2" X 3" mild steel or stainless steel.
4. Sharpen electrode to a pencil point, 3/16" stickout length.
5. Use dab motion, arc length 1/16".
6. Bead width, 3/16" & height 1/16".
7. Hold torch at a 20° travel angel, 90° work angle, hold filler rod 20° above work.
8. Keep the end of the filler rod within the protective gas pocket.



211B-30

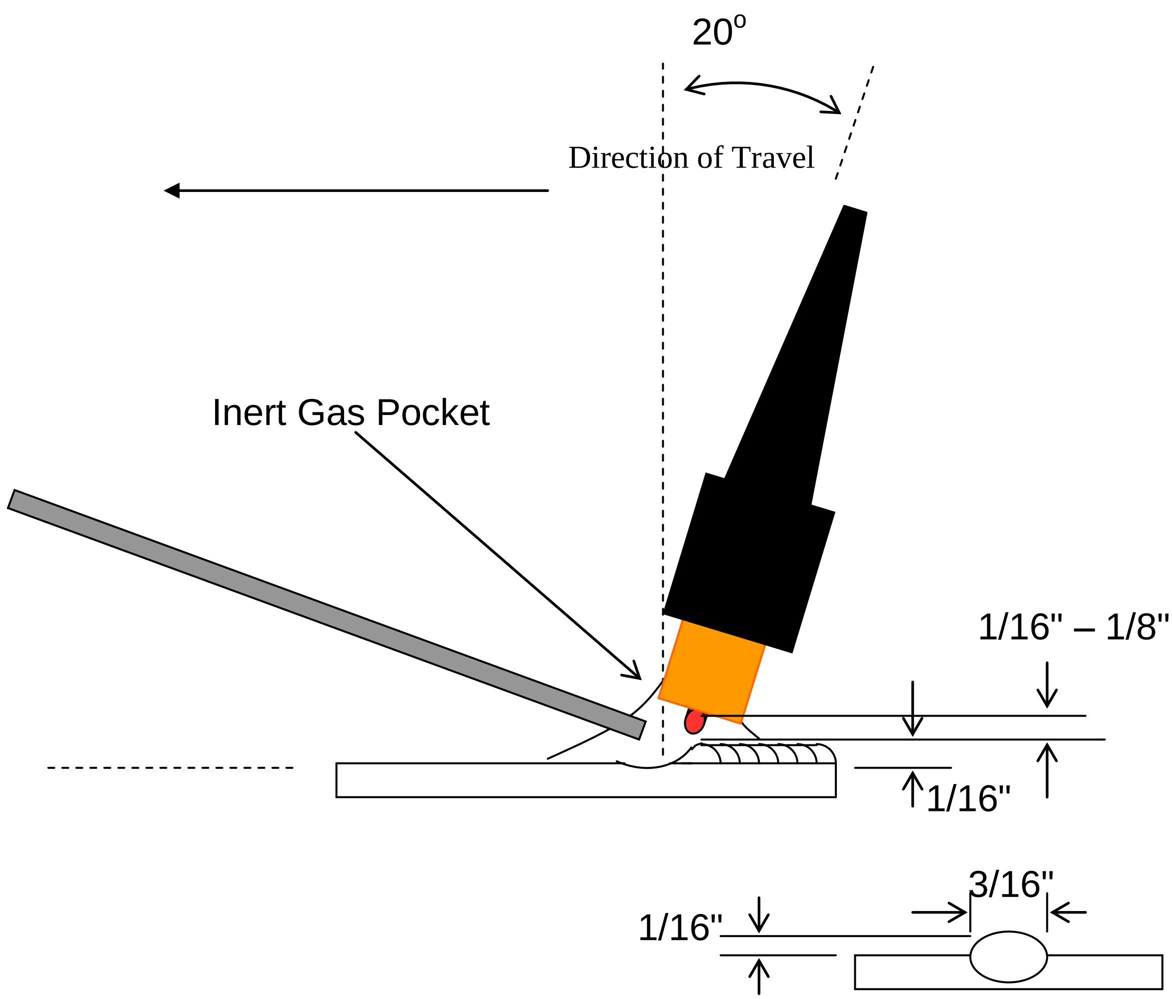
GRADE SHEET

TIG Welding, Bead – Mild or Stainless Steel

Student Number	Starts and Endings Bead full length of metal To -10 each end	Bead Width 3/16" -1 @ 1/32 Over or Under	Eveness of Bead Width -1 @ 1/32" Difference	Eveness of Bead & Technique To -15	Bead Height 1/16" -1 @ 1/32" over or under To -5	Penetration of Bead To -10		Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

TIG Welding, Aluminum Bead

1. Use a pure tungsten or a 2% Thorium, 1/16" electrode.
2. Set proper amperage, gas flow, and use proper cup size, consult chart for aluminum.
3. Use 3/16" X 2" X 3" aluminum.
4. Prepare electrode with a balled end, 1/16" – 1/8" stickout length.
5. Use dab motion, arc length 1/16".
6. Bead width, 3/16" & height 1/16".
7. Hold torch at a 20^{o} travel angel, 90^{o} work angle, hold filler rod 20^{o} above work.
8. Keep the end of the filler rod within the protective gas pocket.



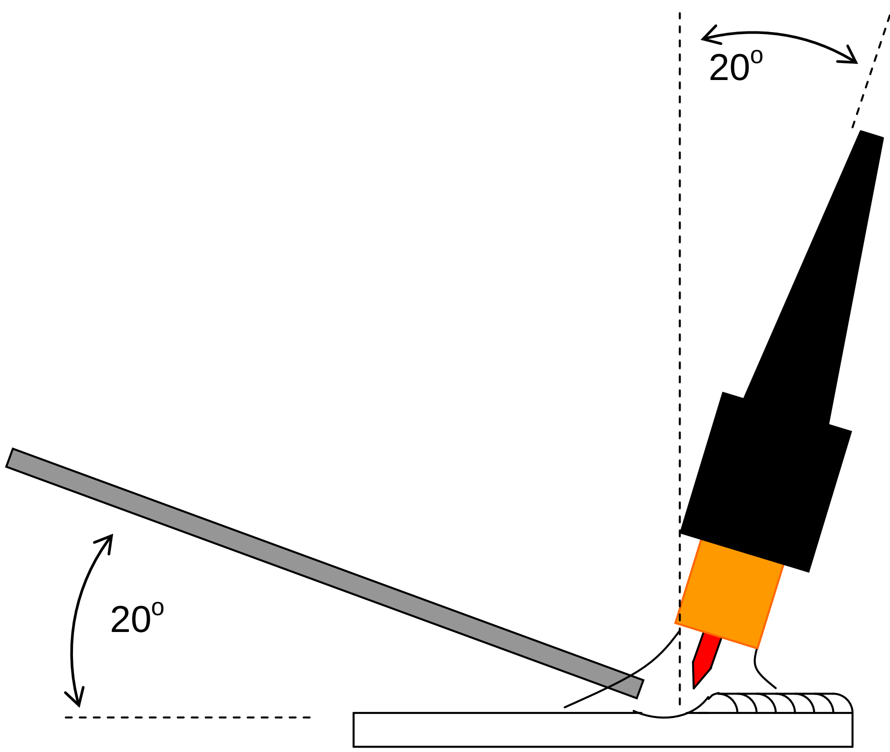
GRADE SHEET

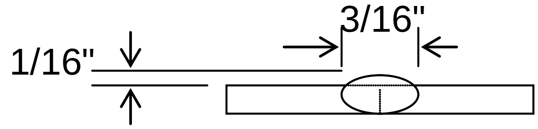
TIG Welding, Bead – Aluminum

Student Number	Starts and Endings Bead full length of metal To -10 each end	Bead Width 3/16" -1 @ 1/32 Over or Under	Eveness of Bead Width -1 @ 1/32" Difference	Eveness of Bead & Technique To -15	Bead Height 1/16" -1 @ 1/32" over or under To -5	Penetration of Bead To -10		Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

TIG Welding, Mild & Stainless Steel Butt Weld

1. Use a 2% Thorium, 1/16" electrode (Red colored end).
2. Set proper amperage, gas flow, use proper cup size, and correct size filler rod. Consult chart for stainless and mild steel.
3. Use 1/8" X 1" X 3" mild steel or stainless steel.
4. Sharpen electrode to a pencil point, 3/16" stickout length.
5. Use dab motion, arc length 1/16".
6. Bead width, 3/16" & height 1/16".
7. Hold torch at a 20° travel angel, 90° work angle, hold filler rod 20° above work.
8. Keep the end of the filler rod within the protective gas pocket.
9. Bead width must be equal on both pieces of metal.





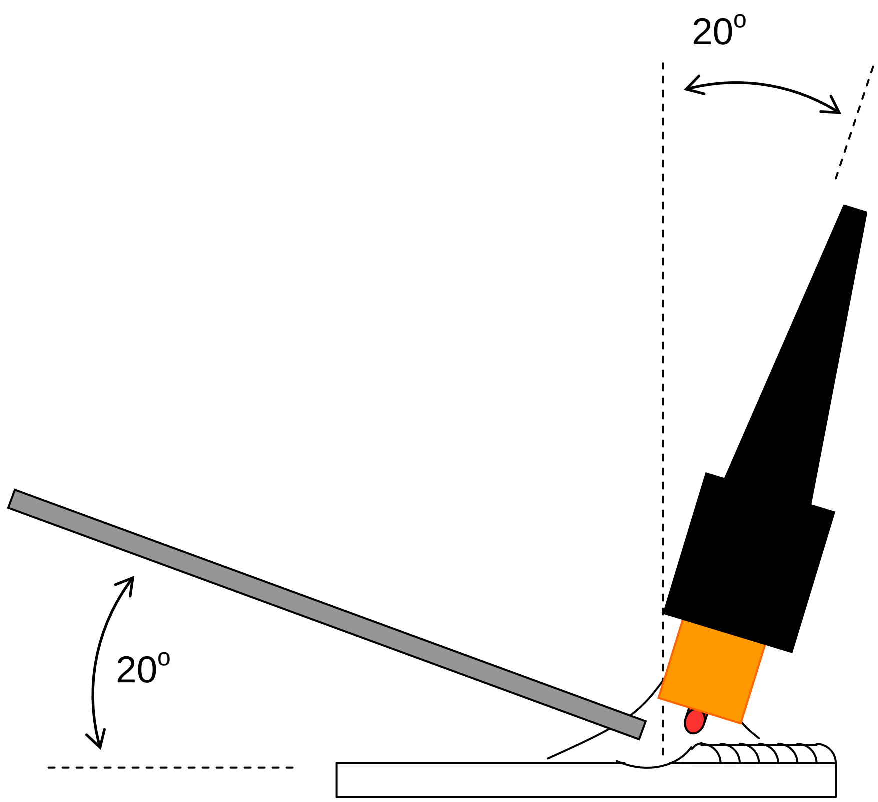
GRADE SHEET

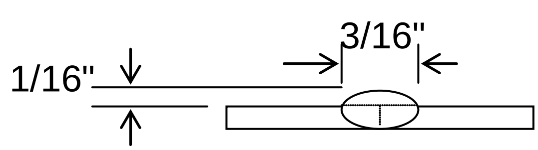
TIG Welding, Butt Weld – Mild or Stainless Steel

Student Number	Starts and Endings Bead full length of metal To -10 each end	Bead Width 3/16" -1 @ 1/32 Over or Under	Eveness of Bead Width on both pieces -1 @ 1/32" Difference	Eveness of Bead & Technique To -15	Bead Height 1/16" -1 @ 1/32" over or under To -5	Penetration of Bead To -10		Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

TIG Welding, Aluminum Butt Weld

1. Use a pure tungsten or a 2% Thorium, 1/16" electrode.
2. Set proper amperage, gas flow, and use proper cup size, consult chart for aluminum.
3. Use 3/16" X 1" X 3" aluminum.
4. Prepare electrode with a balled end, 1/16" – 1/8" stickout length.
5. Use dab motion, arc length 1/16".
6. Bead width, 3/16" & height 1/16".
7. Hold torch at a 20^{o} travel angel, 90^{o} work angle, hold filler rod 20^{o} above work.
8. Keep the end of the filler rod within the protective gas pocket.
9. Bead width must be equal on both pieces of metal.





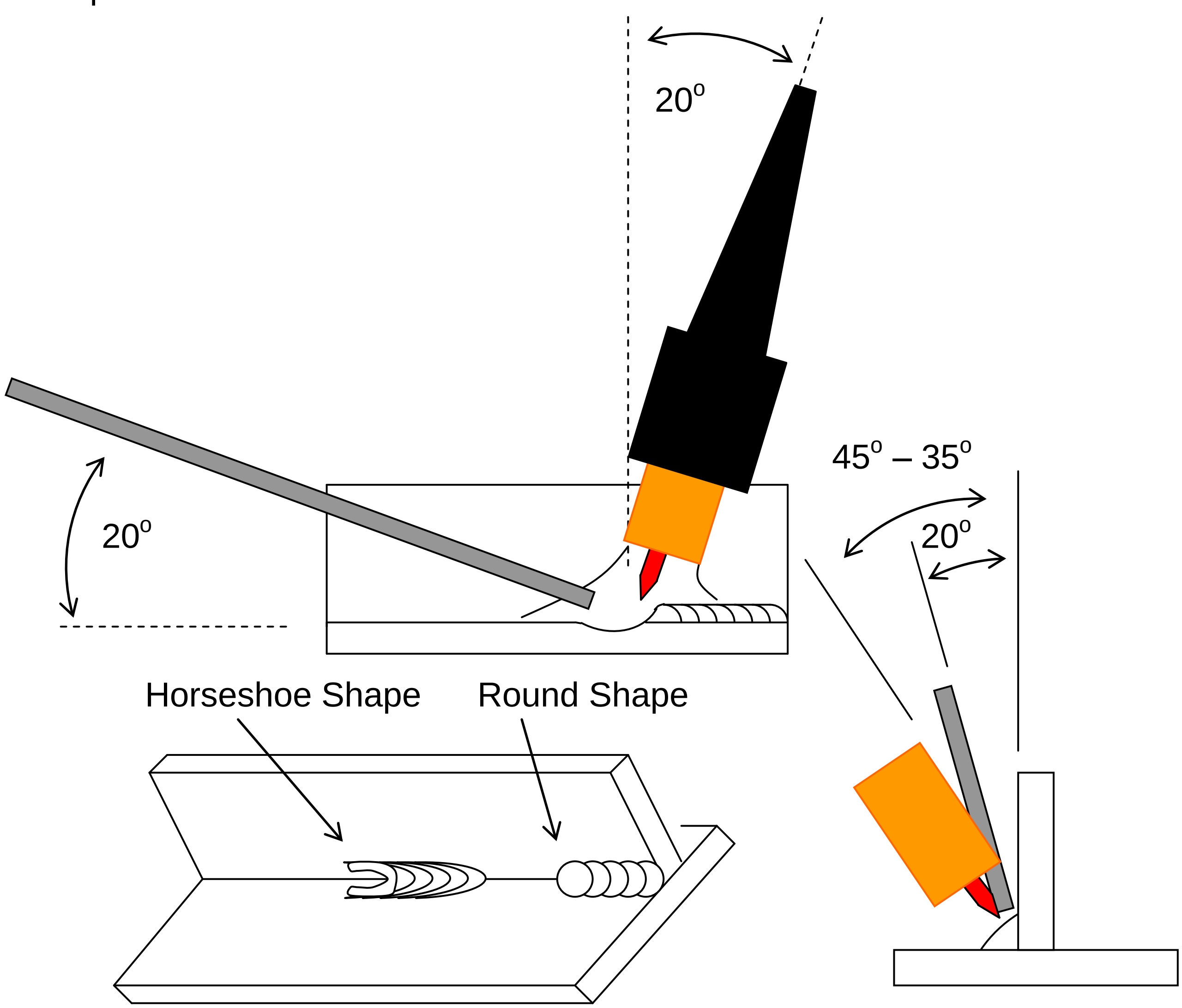
GRADE SHEET

TIG Welding, Butt Weld – Aluminum

Student Number	Starts and Endings Bead full length of metal To -10 each end	Bead Width 3/16" -1 @ 1/32 Over or Under	Eveness of Bead Width on both pieces -1 @ 1/32" Difference	Eveness of Bead & Technique To -15	Bead Height 1/16" -1 @ 1/32" over or under To -5	Penetration of Bead To -10		Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

TIG Welding, Mild & Stainless Steel Fillet Weld

1. Use a 2% Thorium, 1/16" electrode (Red colored end).
2. Set proper amperage, gas flow, and use proper cup size, consult chart for stainless and mild steel.
3. Use 1/8" X 1" X 3" stainless or mild steel.
4. Sharpen electrode to a pencil point, 1/4"-3/8" stickout length.
5. Use dab motion, arc length 1/16".
6. Bead width, 1/4" & legs 3/16".
7. Hold torch at a 20° travel angel, 45° – 55° work angle, hold filler rod 20° above work and 20° from the side plate.
8. Keep the end of the filler rod within the protective gas pocket.
9. Keep a round puddle, a horseshoe shaped puddle will result in a poor weld.



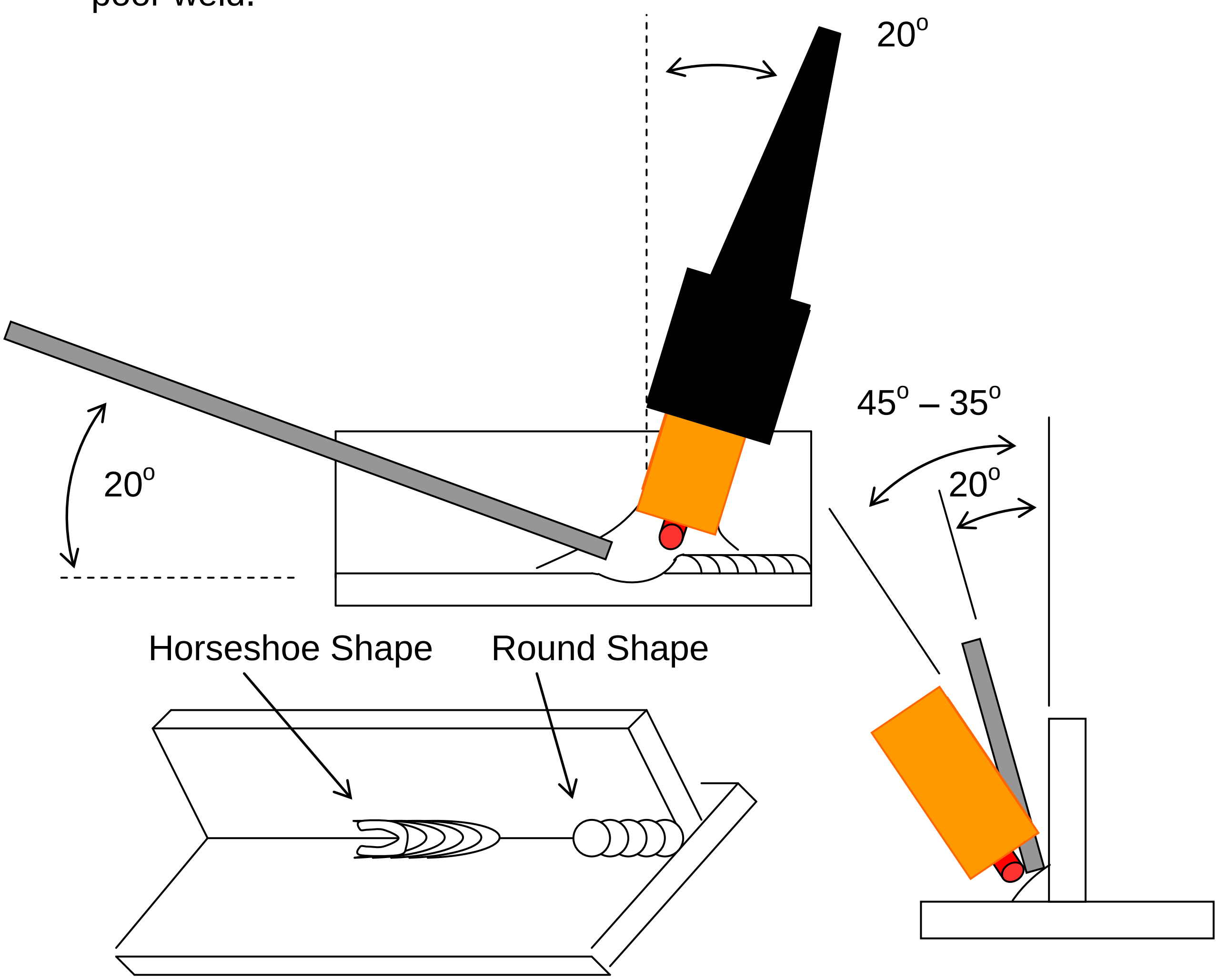
GRADE SHEET

TIG Welding, Fillet Weld – Mild or Stainless Steel

Student Number	Starts and Endings Bead full length of metal To -10 each end	Bead Width 1/4" -1 @ 1/32 Over or Under	Eveness of Legs on both sides -1 @ 1/32" Difference	Eveness of Bead & Technique To -15	Penetration of Bead on both sides To -10	Top Plate 90 degrees From Bottom Plate To - 10		Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

TIG Welding, Aluminum Fillet Weld

1. Use a 2% Thorium or pure tungsten, 1/16" electrode.
2. Set proper amperage, gas flow, and use proper cup size, consult chart for aluminum.
3. Use 1/8" X 1" X 3" aluminum.
4. Prepare electrode with a balled end, 1/8"-3/8" stickout length.
5. Use dab motion, arc length 1/16".
6. Bead width, 1/4" & legs 3/16".
7. Hold torch at a 20^{o} travel angel, 45^{o} – 55^{o} work angle, hold filler rod 20^{o} above work and 20^{o} from the side plate.
8. Keep the end of the filler rod within the protective gas pocket.
9. Keep a <u>round</u> puddle, a horseshoe shaped puddle will result in a poor weld.



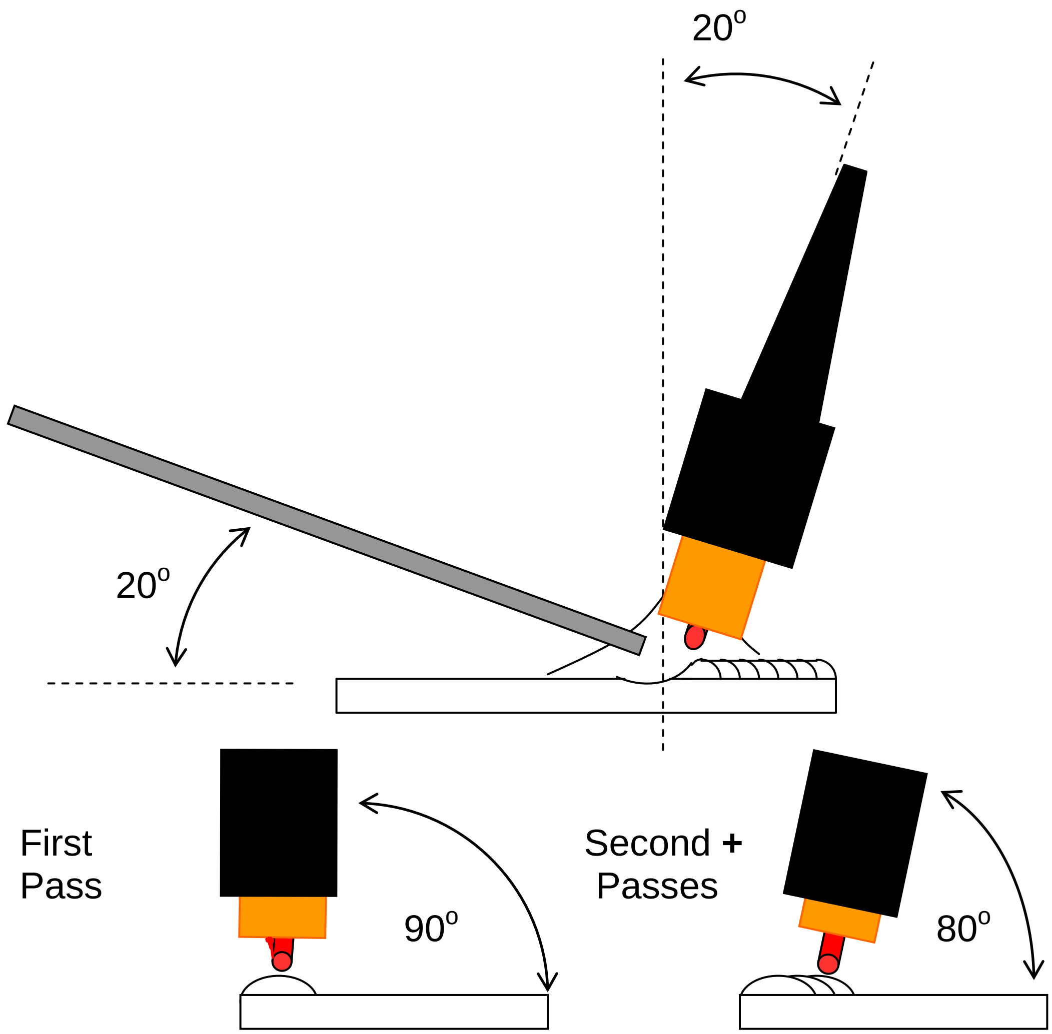
GRADE SHEET

TIG Welding, Fillet Weld – Aluminum

Student Number	Starts and Endings Bead full length of metal To -10 each end	Bead Width 1/4" -1 @ 1/32 Over or Under	Eveness of Legs on both sides -1 @ 1/32" Difference	Eveness of Bead & Technique To -15	Penetration of Bead on both sides To -10	Top Plate 90 degrees From Bottom Plate To - 10		Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

TIG Welding, Aluminum Pad

1. Use a pure tungsten or a 2% Thorium, 1/16" electrode.
2. Set proper amperage, gas flow, and use proper cup size, consult chart for aluminum.
3. Use 3/16" X 2" X 3" aluminum.
4. Prepare electrode with a balled end, 1/16" – 1/8" stickout length.
5. Use dab motion, arc length 1/16".
6. Bead width, 3/16" & height 1/16".
7. Hold torch at a 20^o travel angel, 90^o work angle on the first bead and 80^o on the remaining passes, hold filler rod 20^o above work.
8. Keep the end of the filler rod within the protective gas pocket.

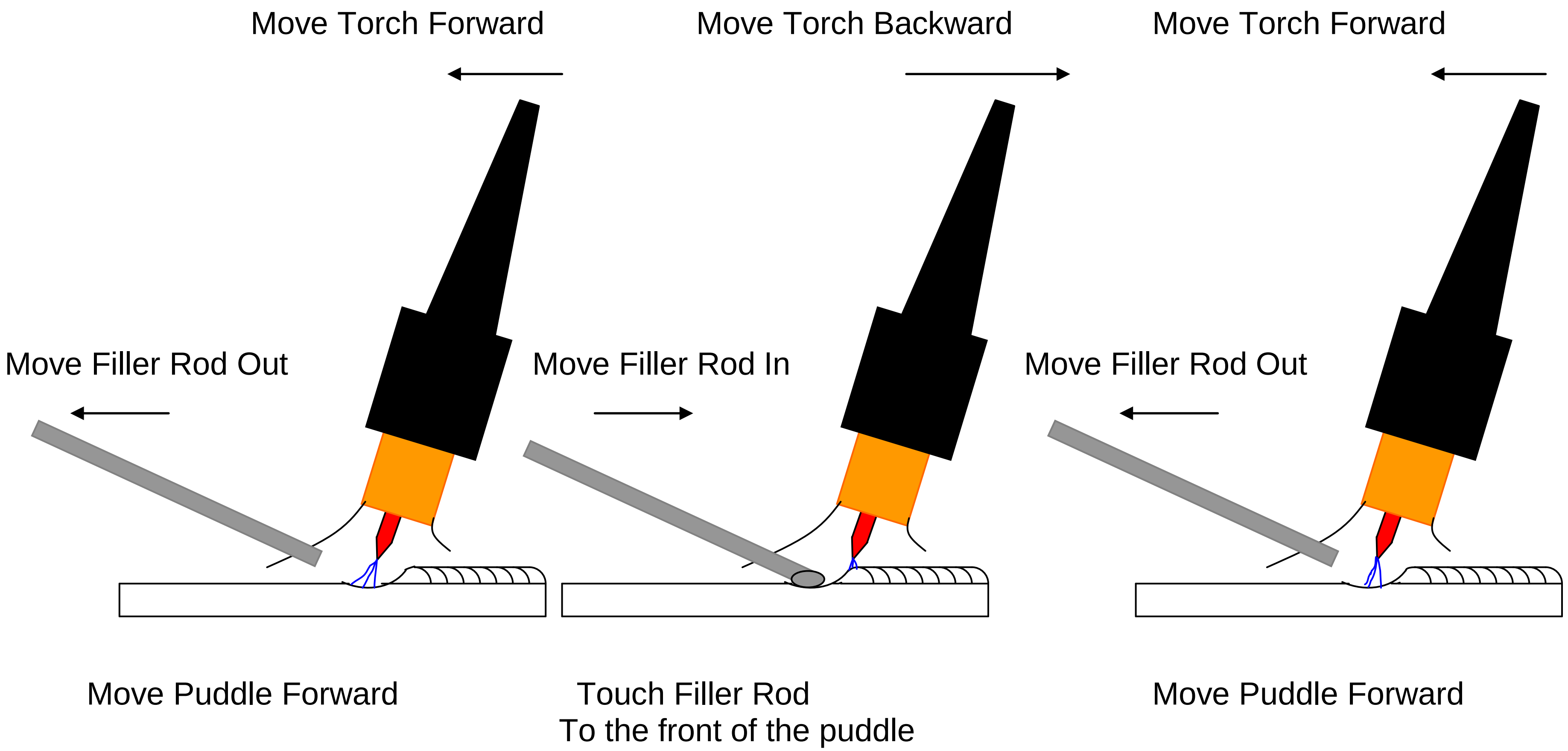


GRADE SHEET

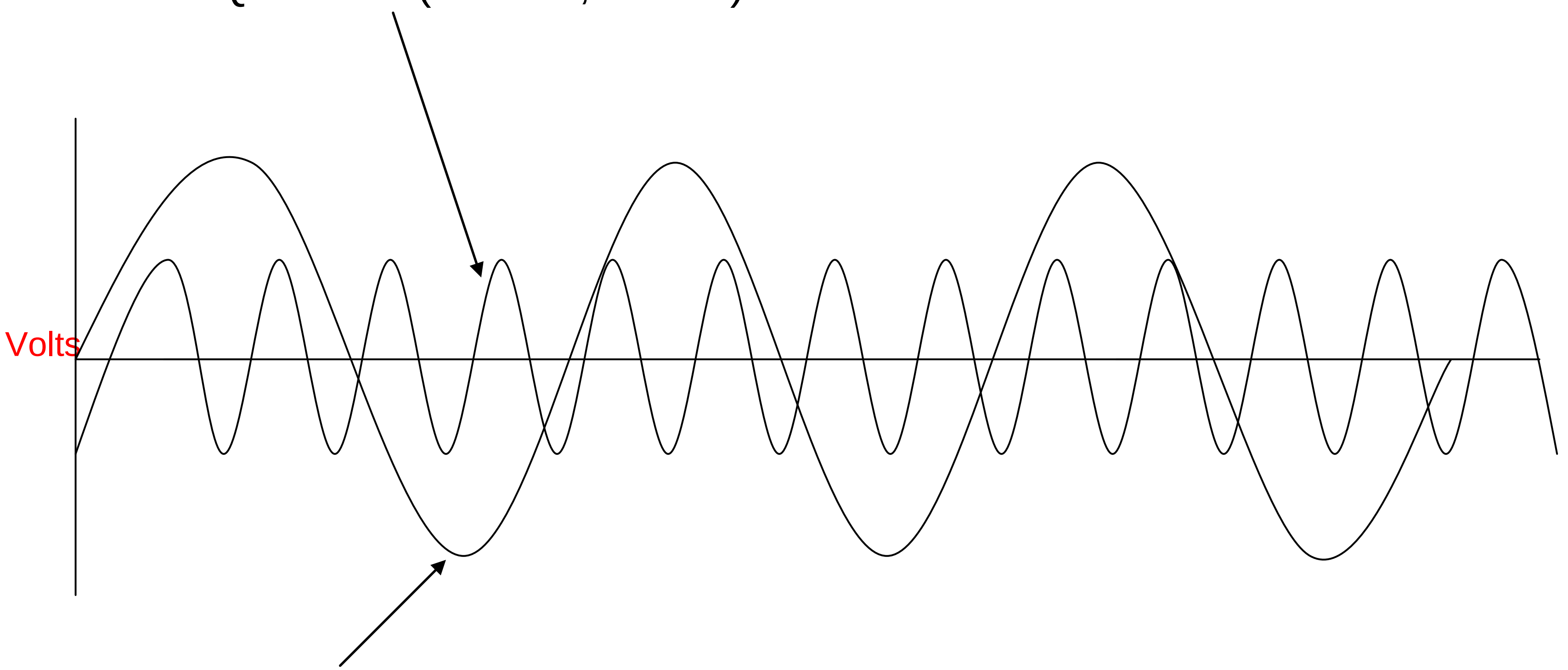
TIG Welding, Pad

Student Number	Flatness of Pad & Techniques To -25	Eveness of Bead To -5 each Eveness of Crowding	Undercut To -15	Penetration To -15	Start Endings To -5			Specs Saftey Clean-up	Late -10	Grade
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

DAB MOTION

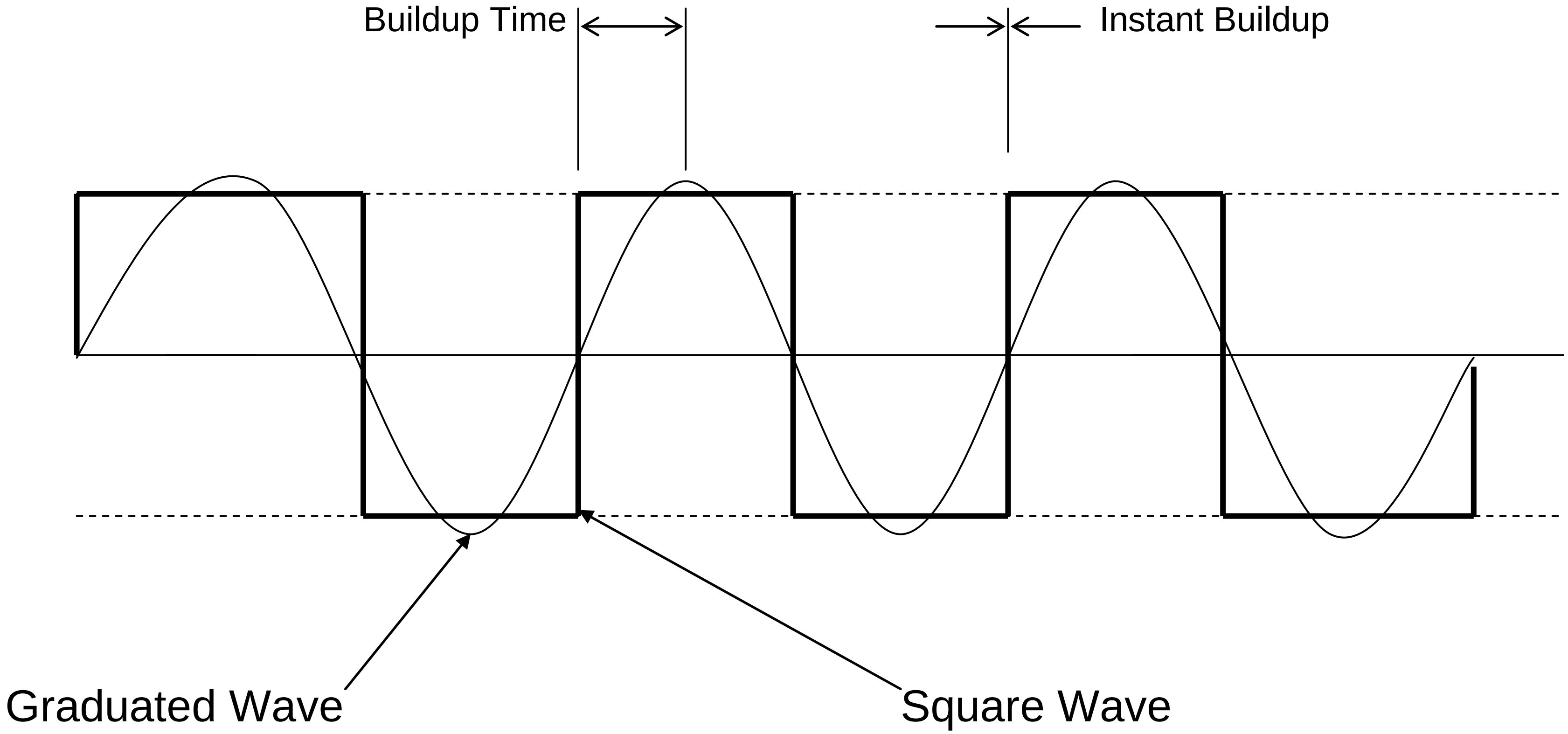

Move Torch Forward
Move Torch Backward
Move Torch Forward
Move Filler Rod Out
Move Filler Rod In
Move Filler Rod Out
Move Puddle Forward
Touch Filler Rod
To the front of the puddle
Move Puddle Forward

HIGH FREQUENCY (over 16,000 Hz)

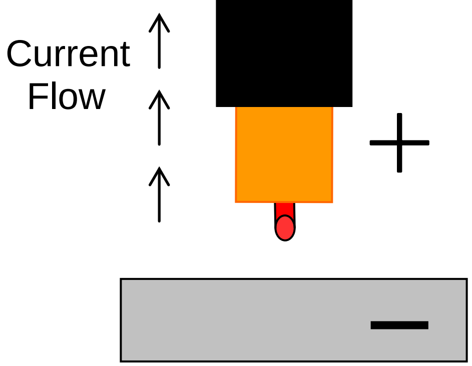


PRIMARY CURRENT (60 Hz)

SQUARE WAVE



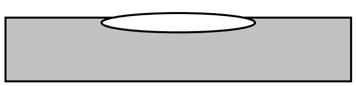
TIG Welding Polarities & Penetration

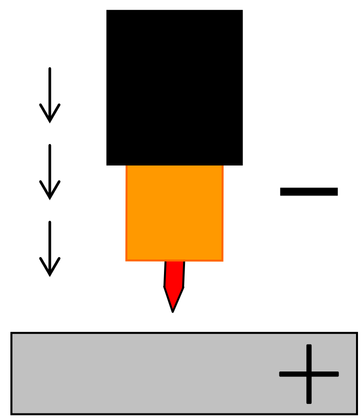


DCRP

1/3 Heat in Work
2/3 Heat in Electrode
(used to prepare tungsten
for aluminum welding)

SHALLOW WIDE BEAD

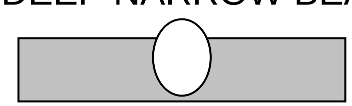


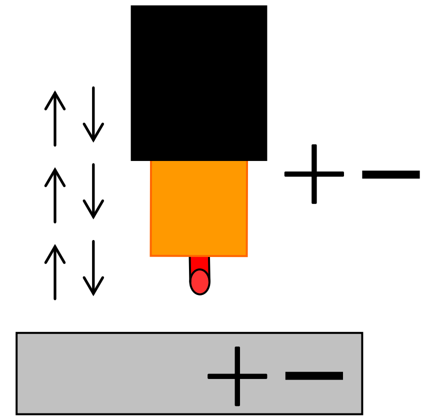


DCSP

2/3 Heat in Work
1/3 Heat in Electrode
(used on mild and stainless steel)

DEEP NARROW BEAD

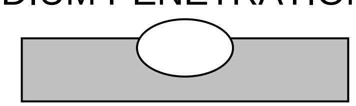




AC

1/2 Heat in Work
1/2 Heat in Electrode
(used on aluminum)

MEDIUM WIDTH
MEDIUM PENETRATION

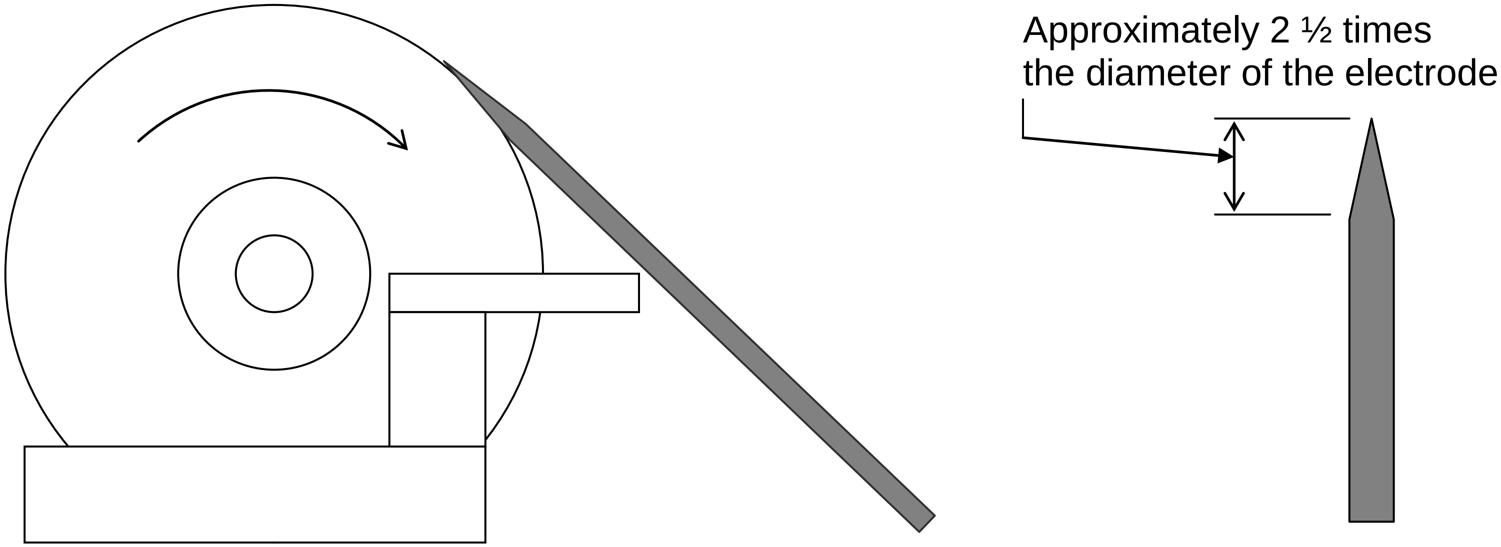


DATA FOR ALIMINUM WELDS

Metal Thickness	Weld Type	ACHF Amps	Tungsten electrode	Welding speed, ipm	Filler Rod Diameter	GAS Flow	Cup Size
1/16	Butt Fillet	60 – 80 70 – 90	1/16	12 10	1/16	15 to 20	4,5,6
1/8	Butt Fillet	125 – 145 140 – 160	3/32	12 10	3/32 or 1/8	17 to 25	6,7
3/16	Butt Fillet	190 – 220 210 – 240	1/8	11 9	1/8	21 to 30	7,8
1/4	Butt Fillet	260 – 300 280 – 320	3/16	10 8	1/8 or 3/16	25 to 35	8,10
3/8	Butt Fillet	330 – 380	3/16, 1/4	5	3/16 or 1/4	29 to 40	10
1/2	Butt Fillet	400 – 450	3/16, 1/4	3	3/16 or 1/4	31 to 40	10

DATA FOR MILD & STAINLESS STEEL WELDS							
Metal Thickness	Weld Type	DCSP Amps	Electrode Size	Welding speed, ipm	Filler Rod Diameter	GAS Flow	Cup Size
1/16	Butt Fillet	80 – 100 90 – 100	1/16	12 10	1/16	11	4,5,6
3/32	Butt Fillet	100 – 120 110 – 130	1/16	12 10	3/32	11	4,5,6
1/8	Butt Fillet	120 – 140 130 – 150	1/16	12 10	3/32	11	4,5,6
3/16	Butt Fillet	200 – 250 225 – 275	3/32 1/8	10 8	1/8	13	6,7 7,8
1/4	Butt Fillet	275 – 350 300 – 375	1/8	5	3/16	13	7,8
1/2	Butt Fillet	350 – 450 375 – 475	3/16	3	1/4	15	8 – 12

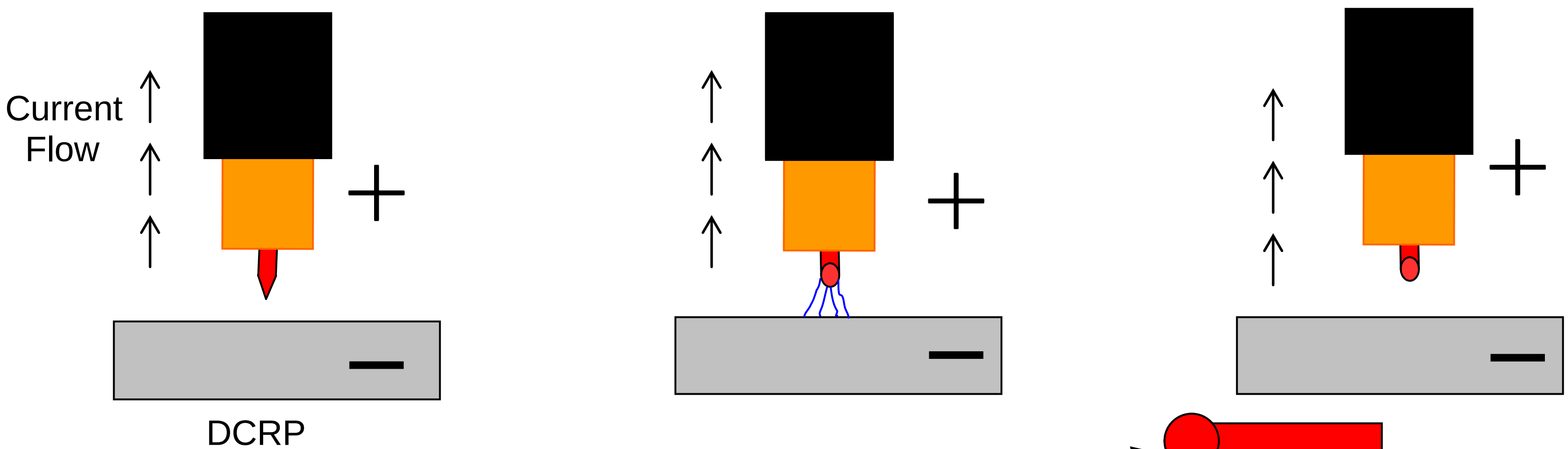
Tungsten Tip Preparation for Mild & Stainless Steel
Sharpening Tungsten to a Sharp Point

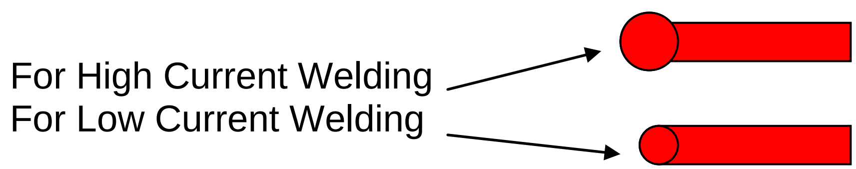


Procedure:

1. Use a fine grinding stone that is designated for <u>TUNGSTEN ONLY</u>, sharpening tungsten on a stone that has been used for mild steel will contaminate the tungsten electrode.
2. Use the upper portion of the grinding stone.
4. <u>DO NOT</u> cup the bottom end of the electrode with your hand while grinding, the grinder might drive the electrode into you hand or fingers. Hold the sides of the electrode with your fingers while sharpening.
5. Sharpen the electrode to a maximum of 2 ½ times the diameter of the electrode.

Tungsten Tip Preparation for Aluminum
Balling the end of an Electrode



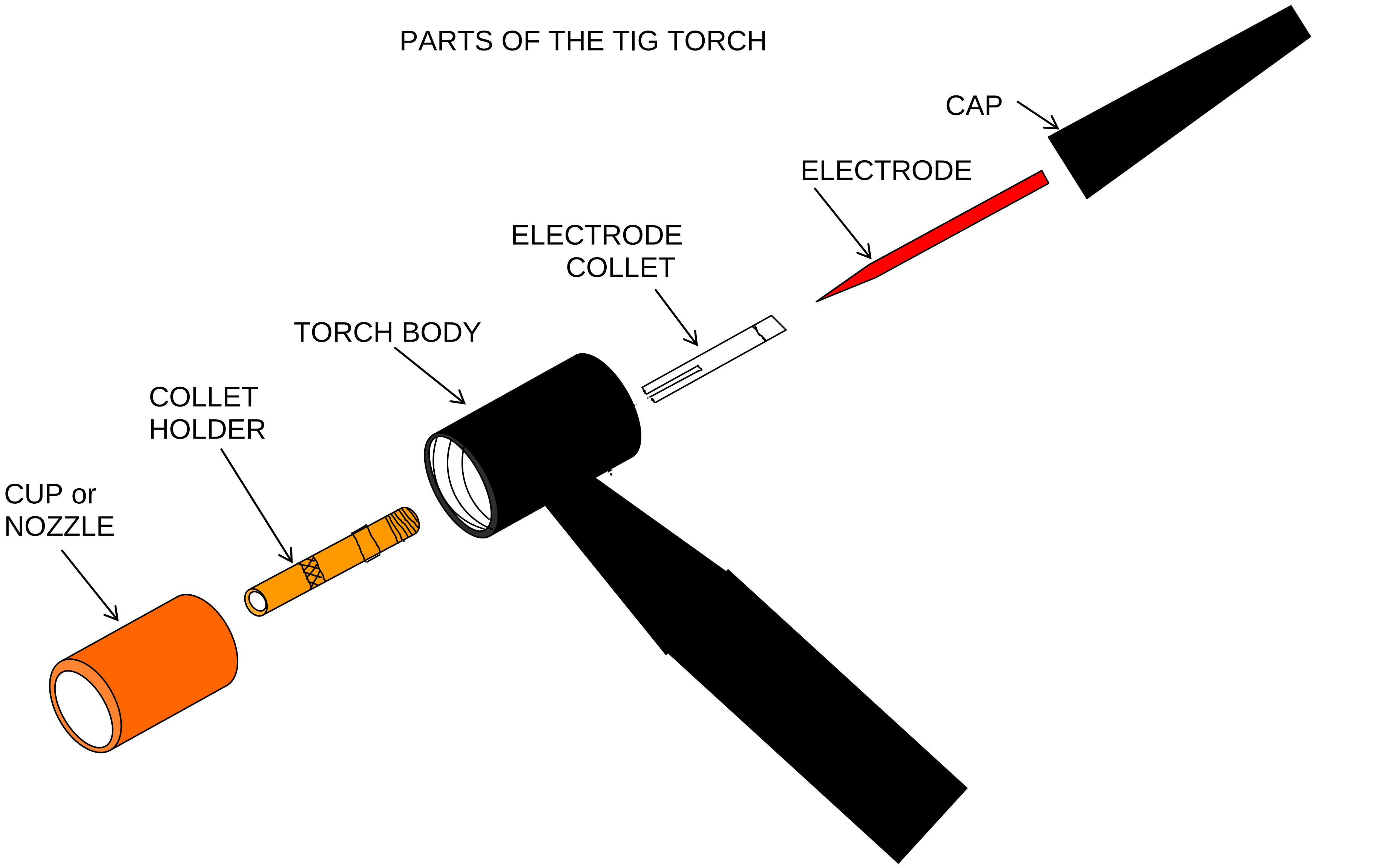


Procedure:

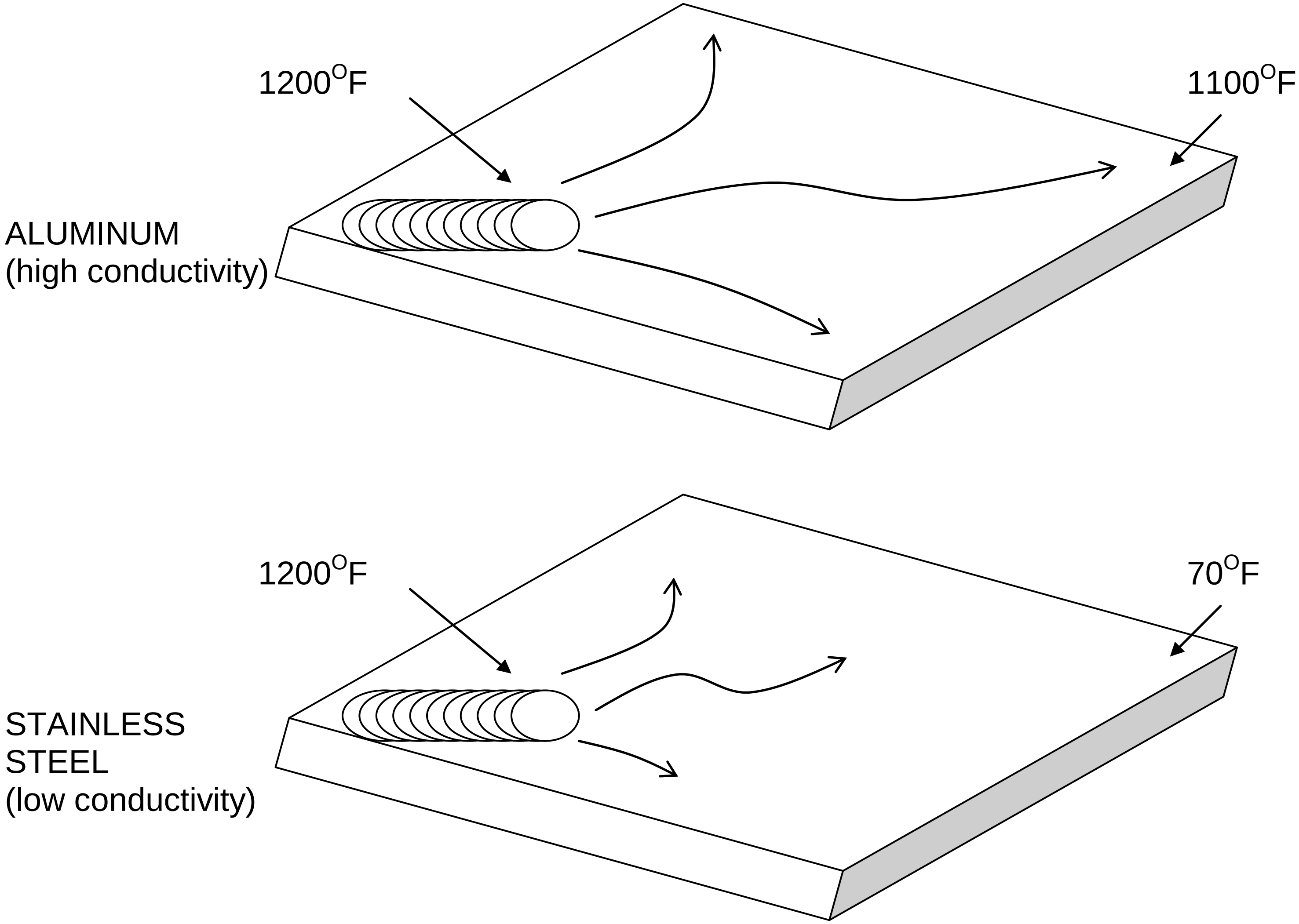
1. Set the current flow to DCRP at approximately 100 amps or higher, depending on electrode size.
2. Hold electrode tip 1/8 inch above base metal (usually a copper plate, DO NOT USE CARBON).
3. Engage current flow (press down on the foot pedal or thumb level) and increase amperage until a ball forms on the end of the electrode.
4. The electrode will collect enough heat the tip will melt and ball up.
5. Check the balled end for diameter, <u>ball should not exceed 1 ½ times the electrode diameter</u>.

211B-51

PARTS OF THE TIG TORCH



HEAT CONDUCTIVITY



AWS WELDING SYMBOLS

AG 211-C

UNIT OBJECTIVE

After completion of this unit, 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 blueprint 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 weld symbols used by AWS and their meaning.

2. Identify the different joint symbols used by AWS and their meaning.

3. Know the importance of the placement of each symbol.

4. Draw the different symbols and lines used by AWS.

5. Make the proper welds in the proper locations using an AWS blueprint or diagram.

6. Make fabrication plans using the AWS symbols.

211C-2

AWS WELDING SYMBOLS

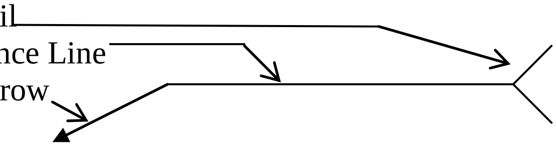
A. Introduction to AWS Welding Symbols

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

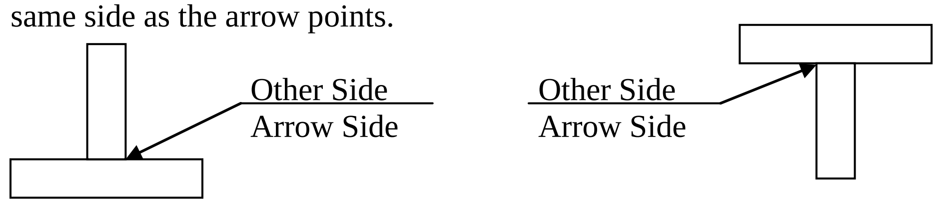
1. The welding symbol is made up of three parts.

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

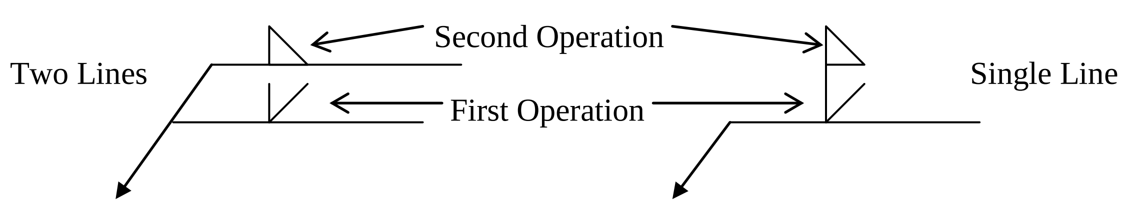


2. The Reference Line

   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.

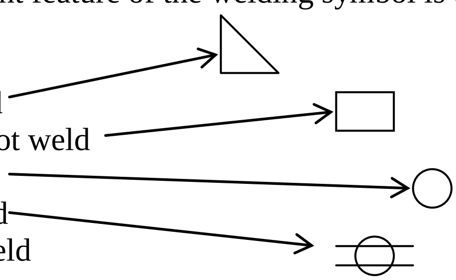
Straight Arrow Line   Broken-Arrow Line

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.

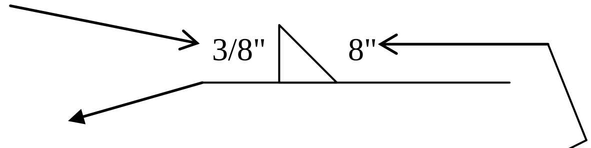


   a. Fillet weld
   b. Plug or Slot weld
   c. Spot weld
   d. Seam weld
   e. Groove weld

      1) Square Groove
      2) V-Groove
      3) Bevel–Groove
      4) U-Groove
      5) J-Groove
      6) Flare-V
      7) Flare-Bevel
      (see chart, 211C-15)

D. Size of Welds

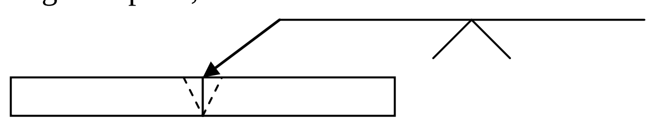
1. The size of the weld will be indicated on the weld symbol.
2. The size will be expressed in decimals, fractions, or metric unit (mm).
3. The size will be located in front of the weld symbol on the reference line.



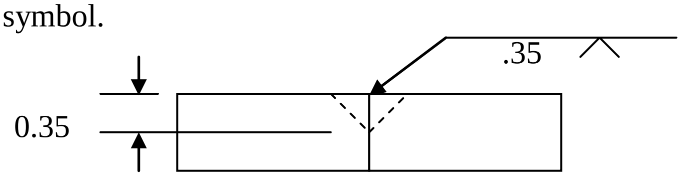
4. The length of the weld will be placed after the weld symbol.
5. If the length of the legs on a fillet weld are meant to be unequal they will be labeled with two dimensions.
6. If a note gives the size of the welds, no dimensions will appear on the symbol. (See Chart 211X-16)

E. Sizes, Gaps, and Angle of Grooves

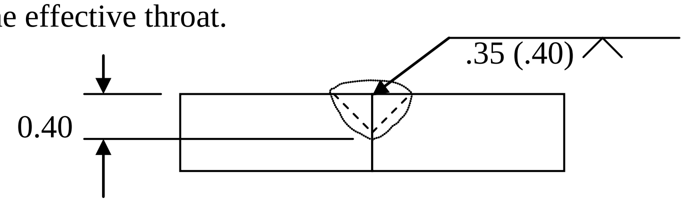
1. If the groove goes through the plate, a measurement of distance is not needed.



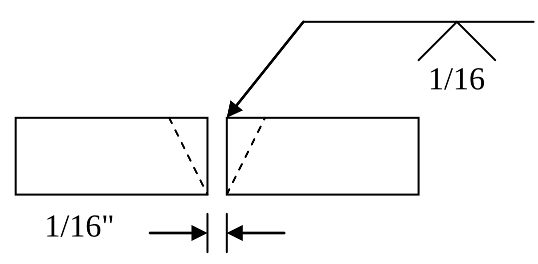
2. If the groove only goes a certain depth through the metal, a measurement will be given before the weld symbol.



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



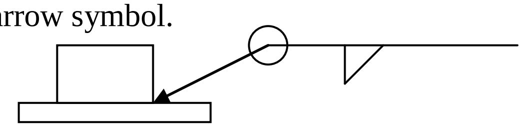
4. If a gap between the two pieces of metal is needed, it will be indicated on the weld symbol.

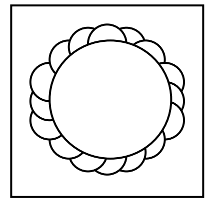


F. Other Symbols

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.

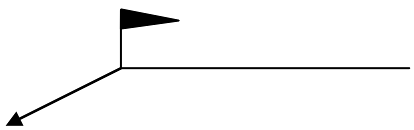
Side View



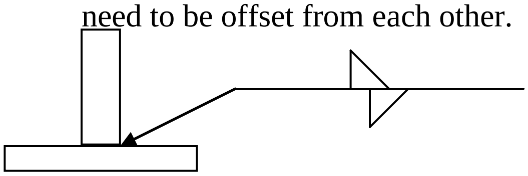


Top View

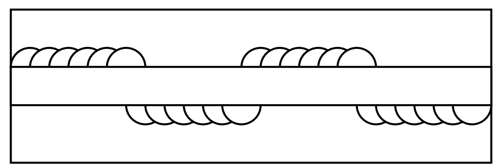
2. Field Weld, Symbol – When a weld is to be made or inspected out in the field a flag will appear on the reference line's connection with the arrow symbol.



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.

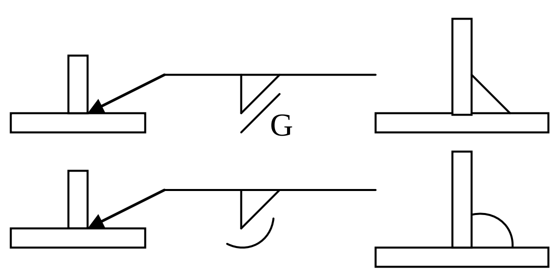
   

   c. Concave – The concave symbol will be used when the finished surface needs to concave, this is very seldom used but it has its' purpose.

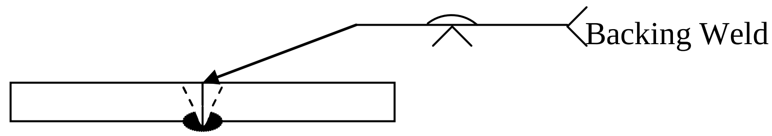
   d. Finish Method – Most of the time the welding process will determine the finished surface. If a mechanical means of surfacing are needed it will be indicated by a letter, otherwise a letter will not appear.

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

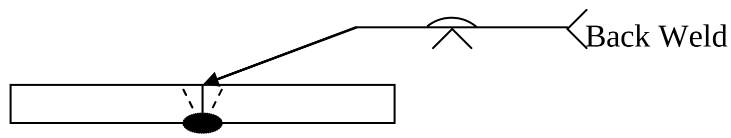


5. Back and Backing Welds

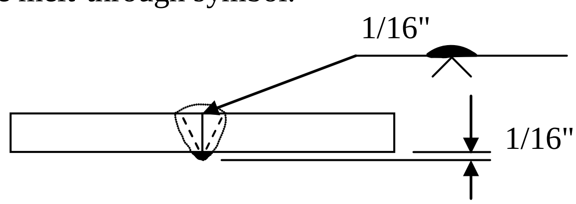
a. A Backing weld will be made on the opposite side of a groove before the groove weld is made and will also appear on the opposite side of the reference line. It will also be noted in the tail as to be a Back or Backing weld.



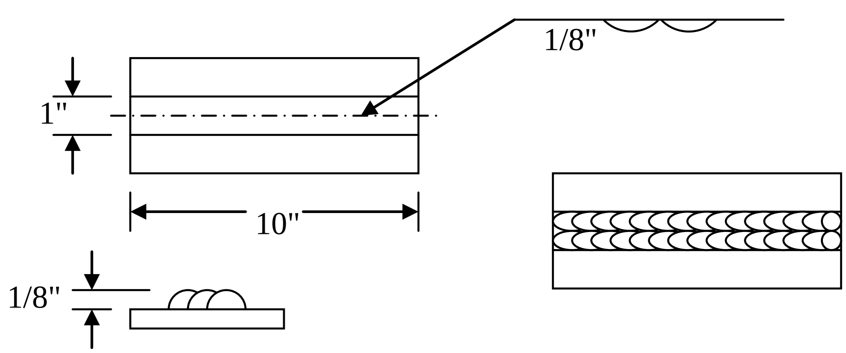
b. A Back weld will be made on the opposite side of a groove weld after the groove weld and will also appear on the opposite side of the reference line. It will also be noted in the tail as to be a Back or Backing weld.



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.



ACTIVITY:

1. Have students perform one, two, or all three welds on page 211C-8

References:

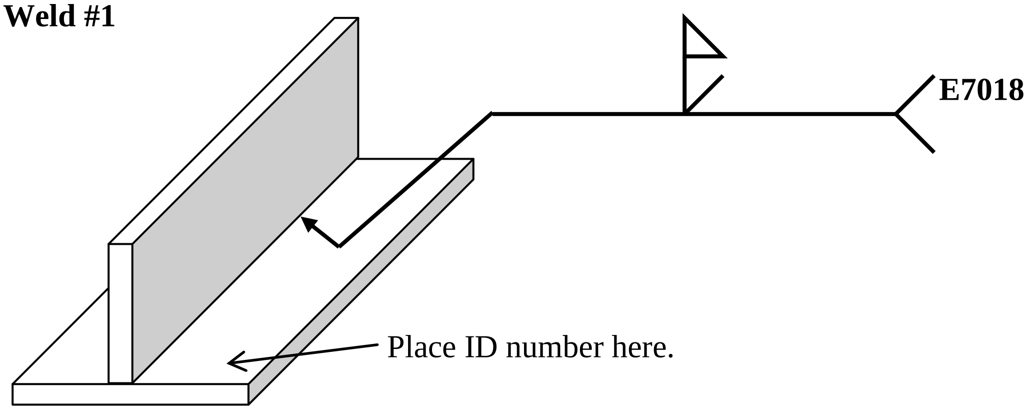
Burke, Stanley R., & Wakeman, T. J. (1997). MODERN AGRICULTURAL MECHANICS (3nd ed.). Danville, IL: Interstate Publishers.

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

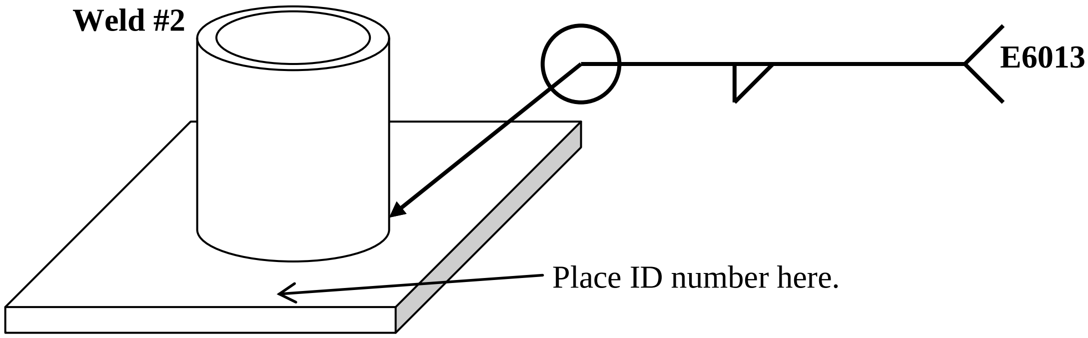
Griffin, Ivan H., Roden, Edward M., Briggs, Charles W. (1984) BASIC TIG & MIG WELDING, THIRD EDITION, Albany, NY: Delmar Publishers

Welding Assignments

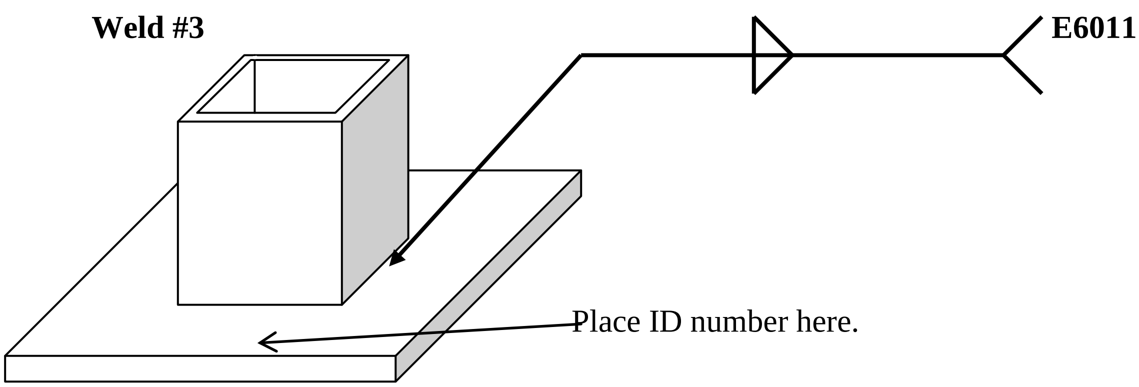
Weld #1



Weld #2



Weld #3

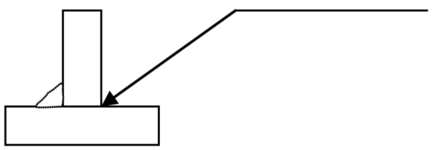


Quiz

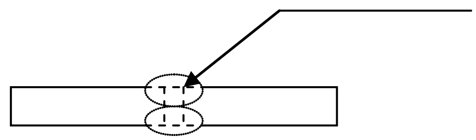
Name___________________
Date____________________
Score___________________

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

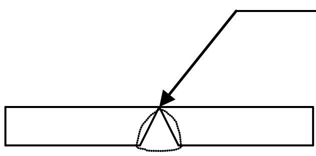
1.



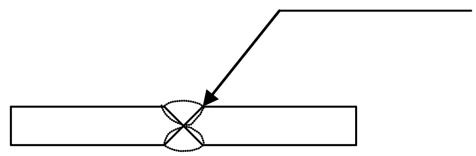
2.



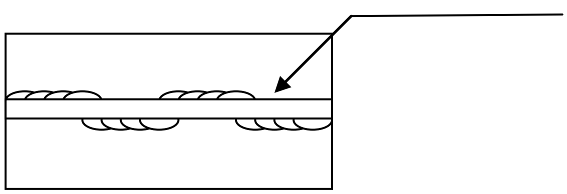
3.



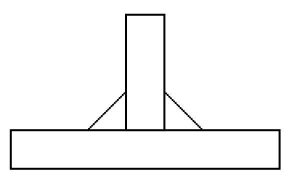
4.



5. (Top View)



(End View)



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

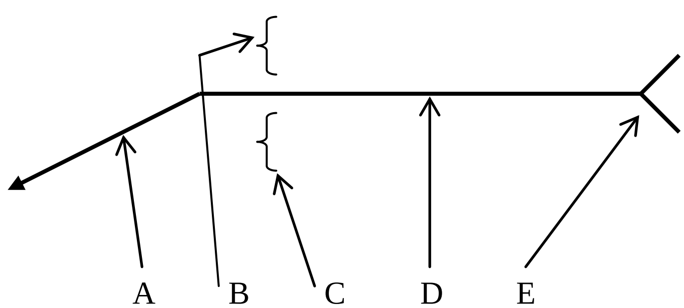
A.___________________

B.___________________

C.___________________

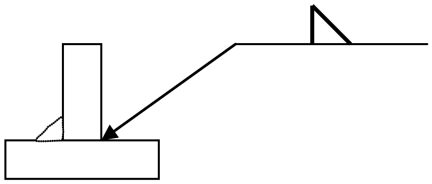
D.___________________

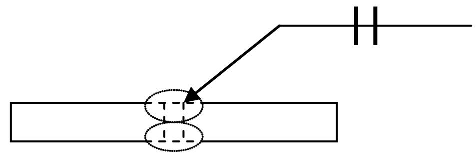
E.___________________

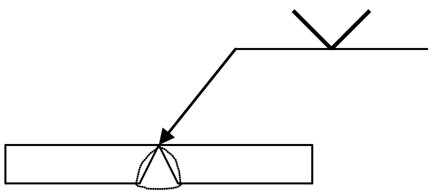


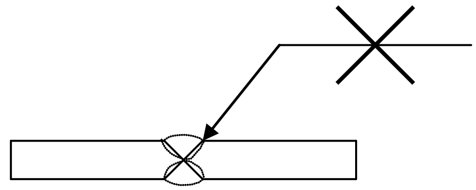
Name________KEY_____
Date___________________
Score__________________

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

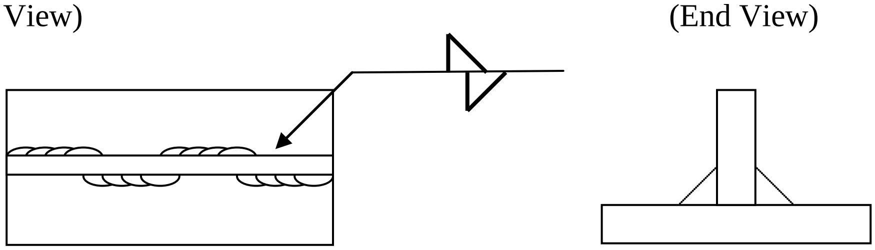
1. 

2. 

3. 

4. 

5. (Top View) (End View)



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

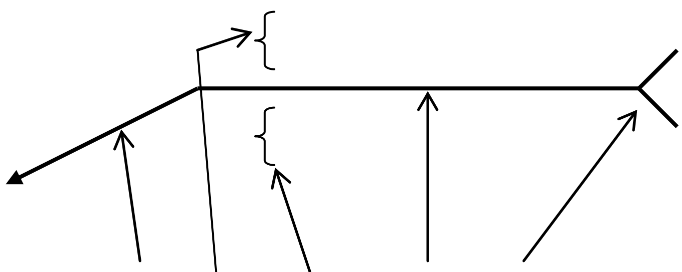
A.______Arrow_______

B.______Other Side___

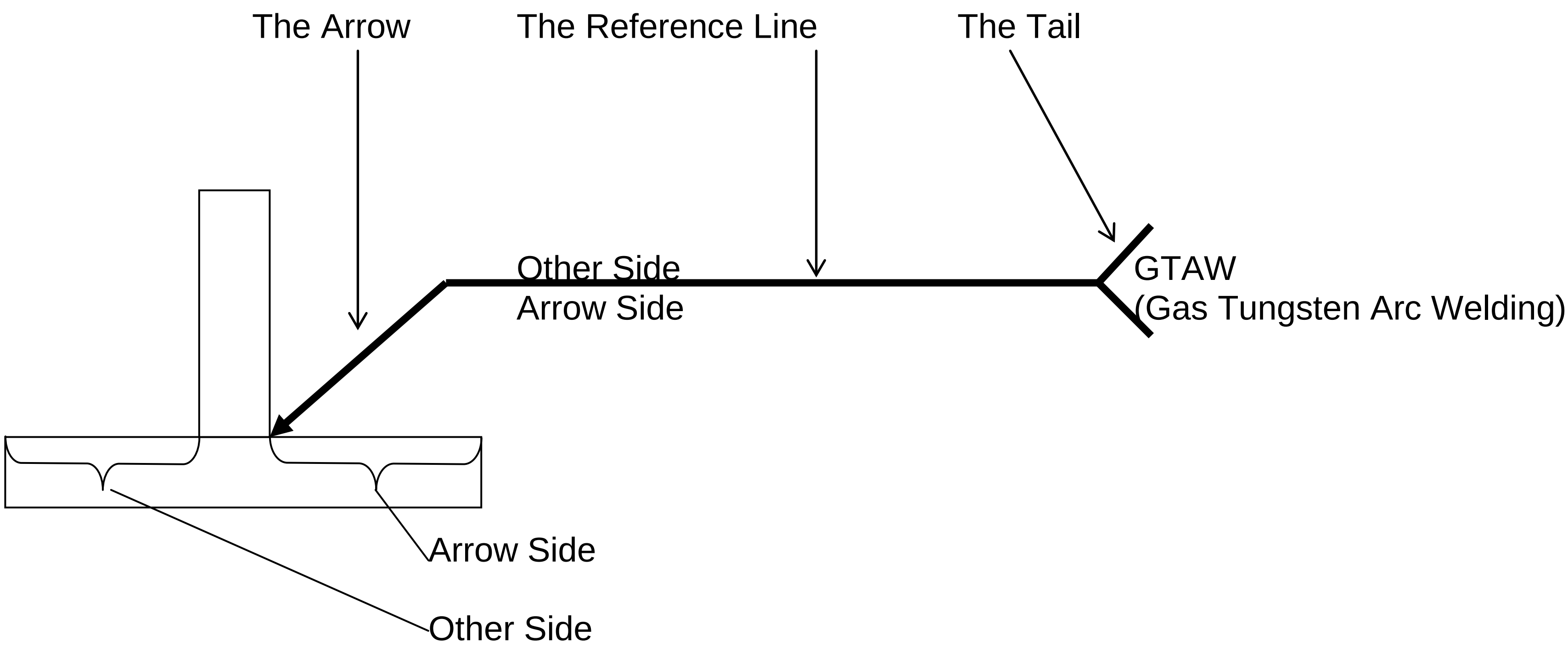
C.______Arrow Side__

D.______Reference Line

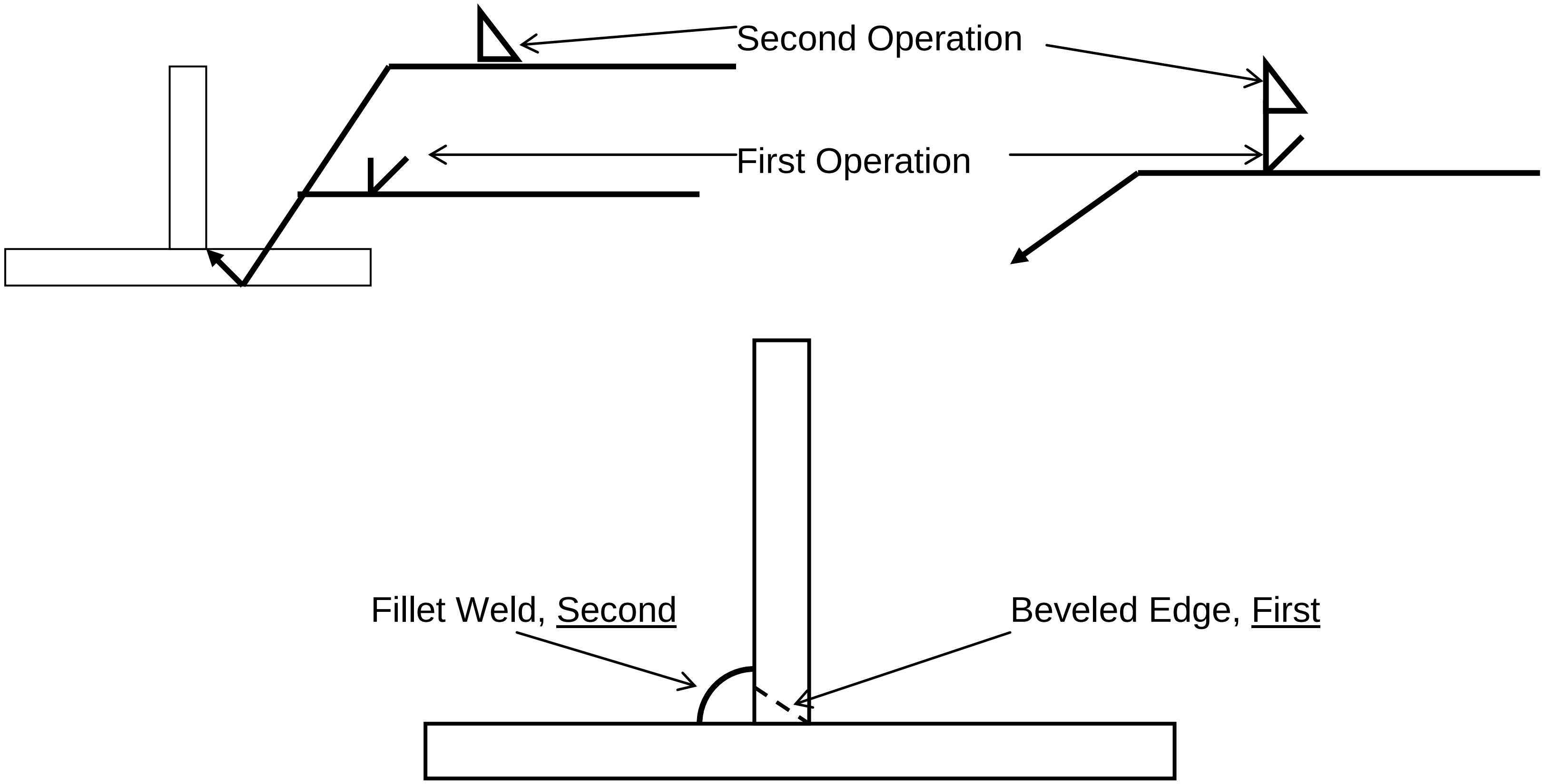
E.______Tail_________



THE WELDING SYMBOL



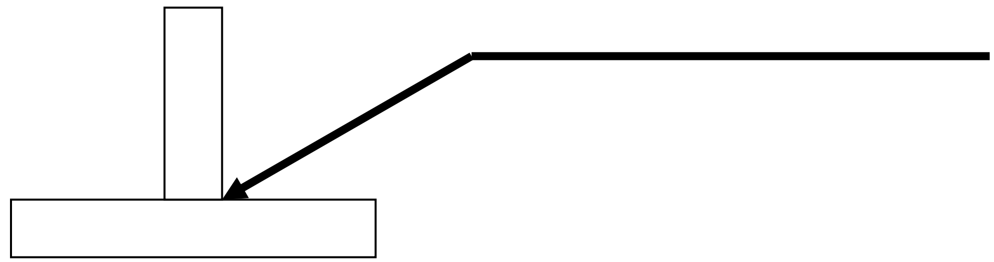
Additional Reference Lines



ARROW LINES

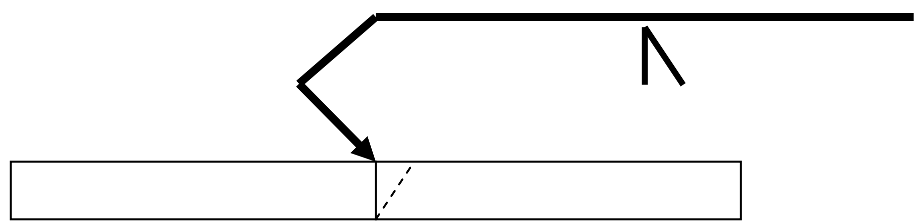
Straight Arrow Line

Arrow points to the joint that needs to be welded.



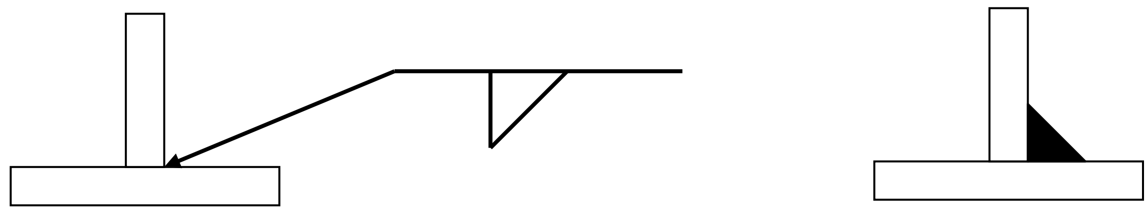
Broken-Arrow Line

Arrow points to the side that needs to be beveled

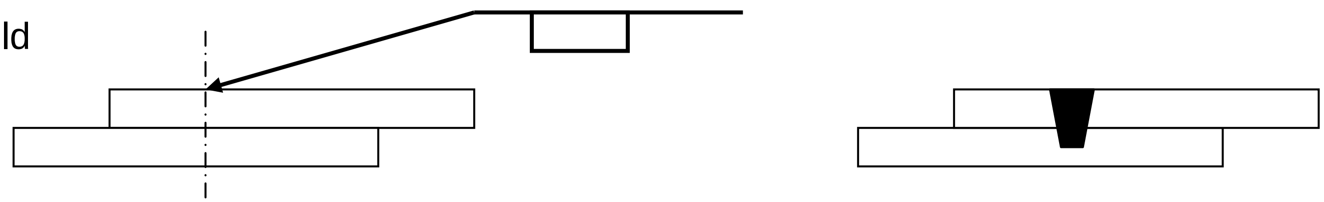


TYPE OF WELDS

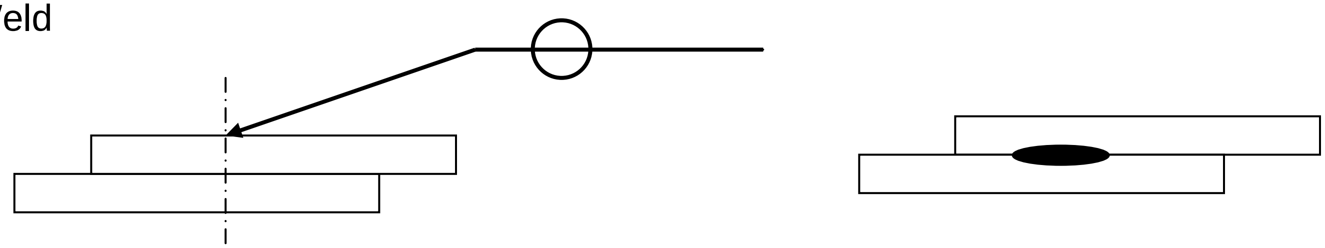
Fillet Weld



Plug Weld

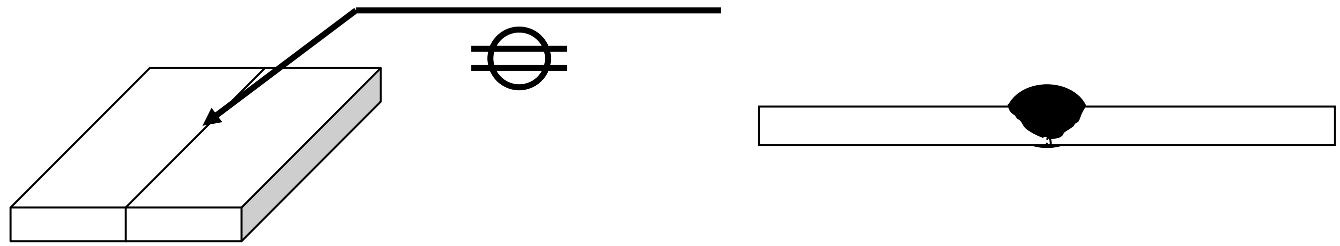


Spot Weld



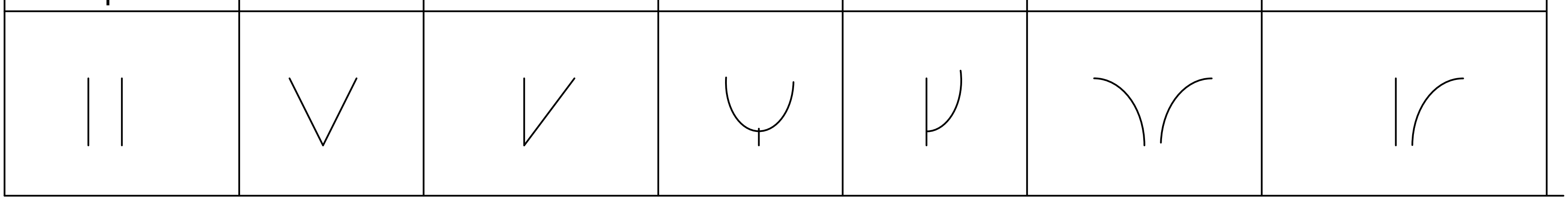
TYPE OF WELDS

Seam Weld

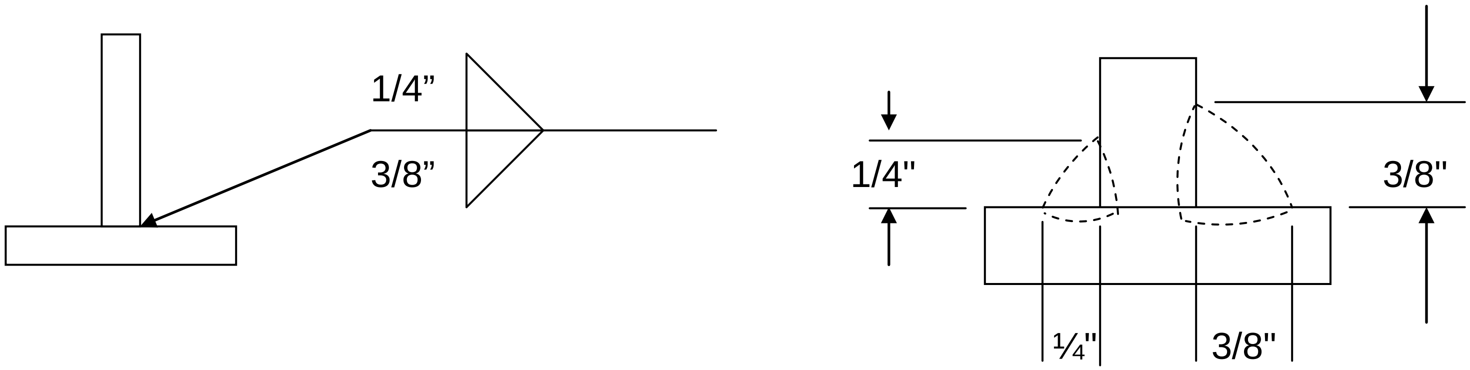


Groove Welds

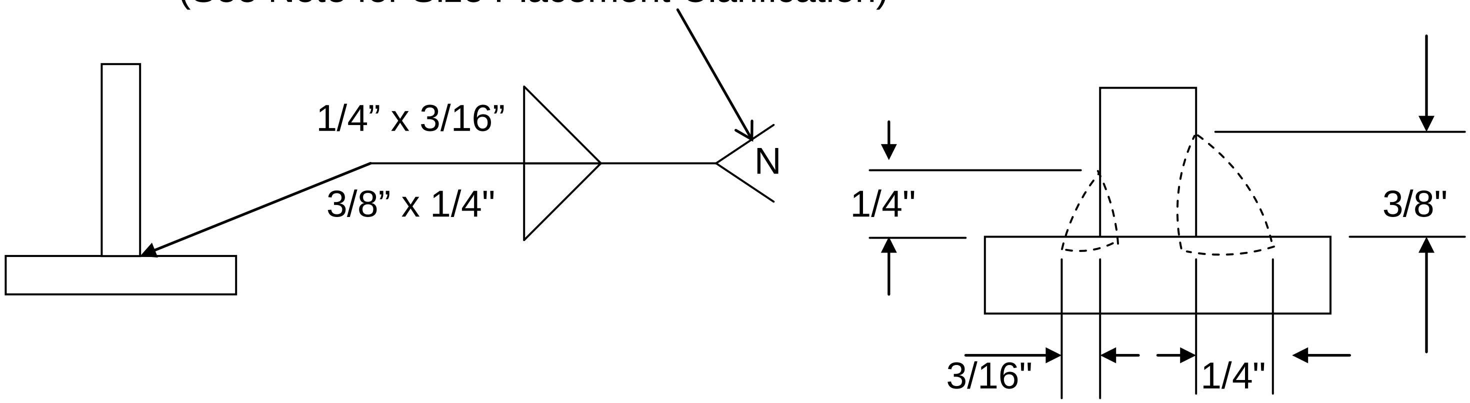
Square	V	Bevel	U	J	Flare-V	Flare-Bevel



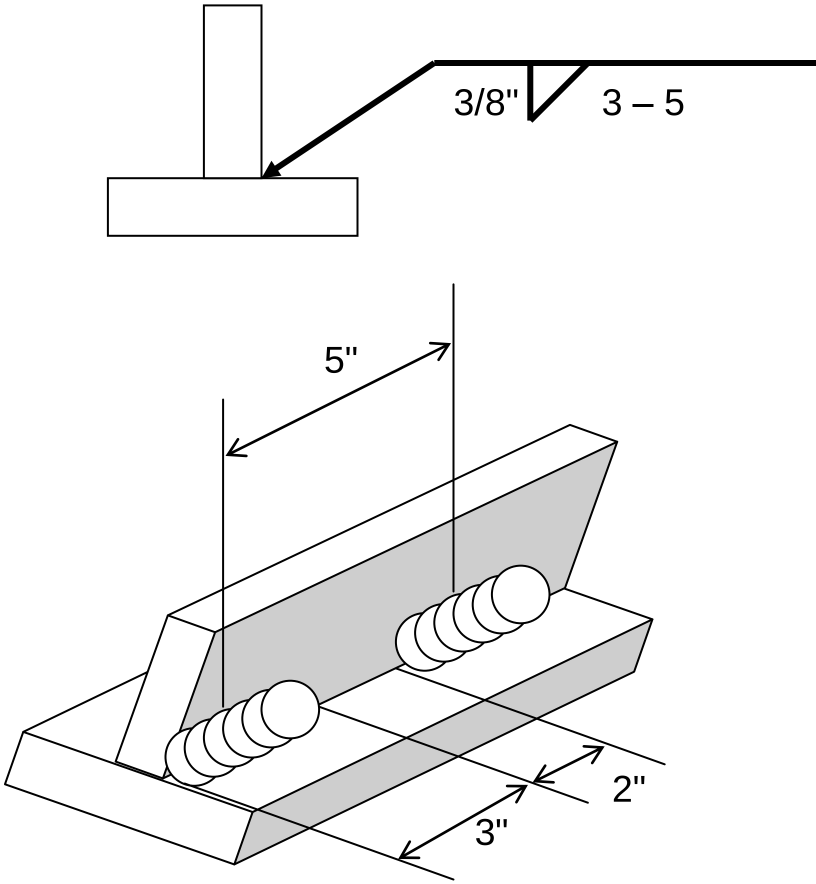
Sizes of Welds

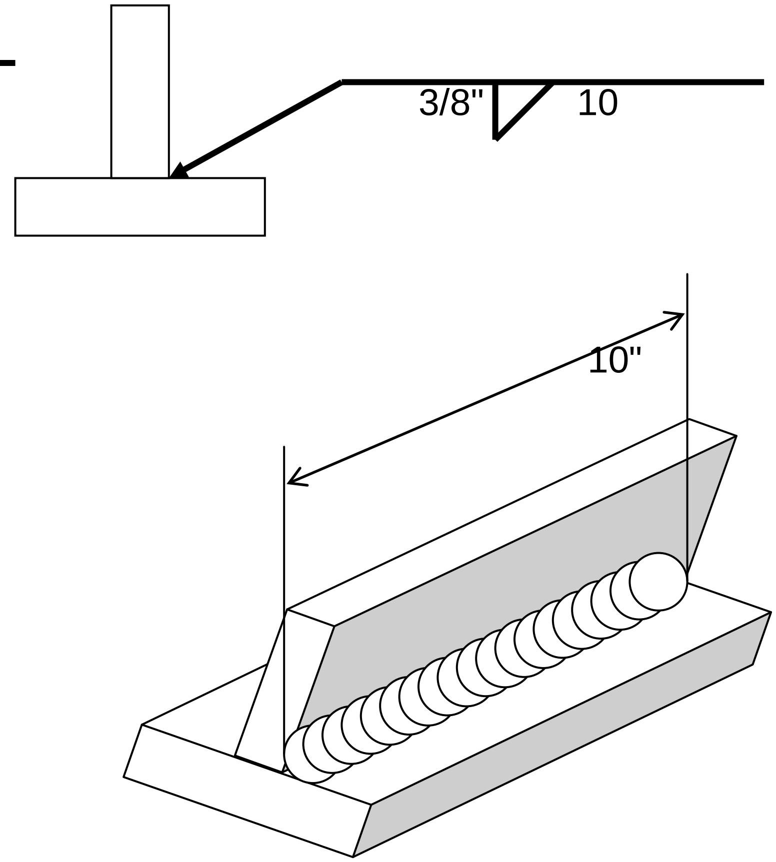


(See Note for Size Placement Clarification)

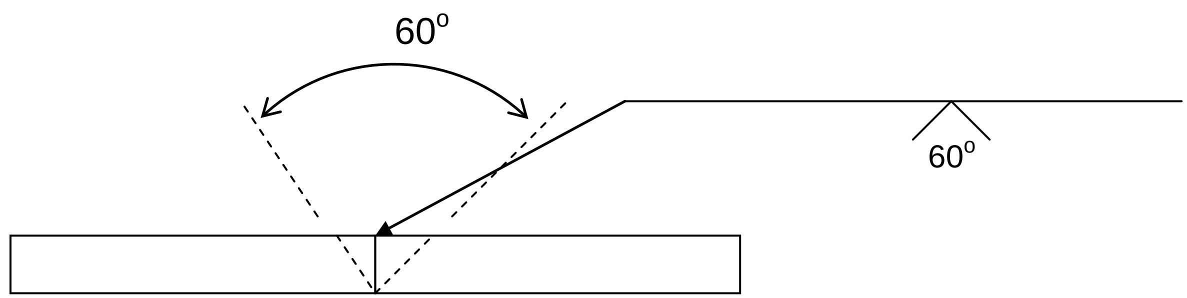


Length of Welds

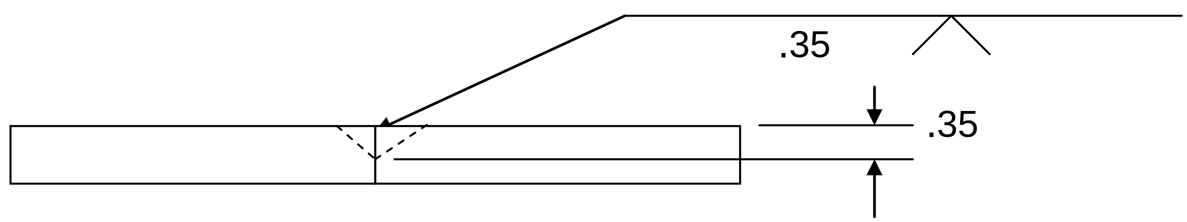




Sizes, Gaps, and Angle of Grooves

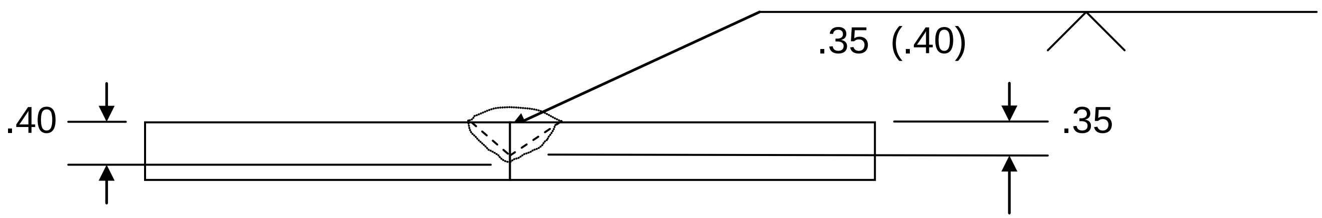


No measurement on depth, the Bevel goes all the way to the other side.

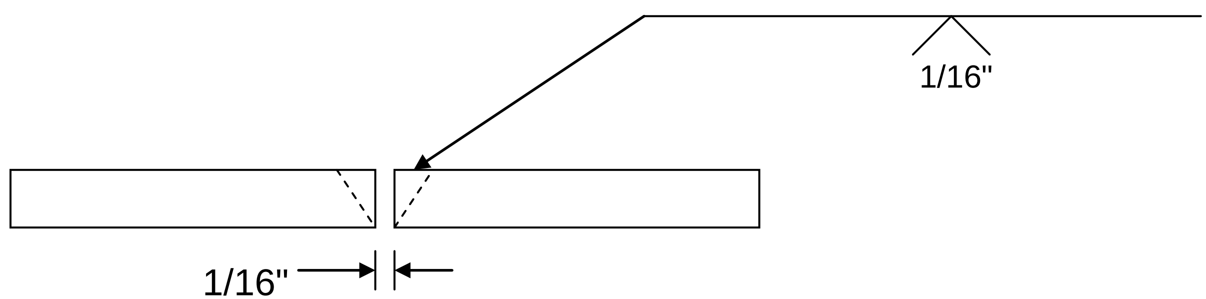


Measurements left of the weld symbol will indicate the depth of the grove.

Sizes, Gaps, and Angle of Grooves

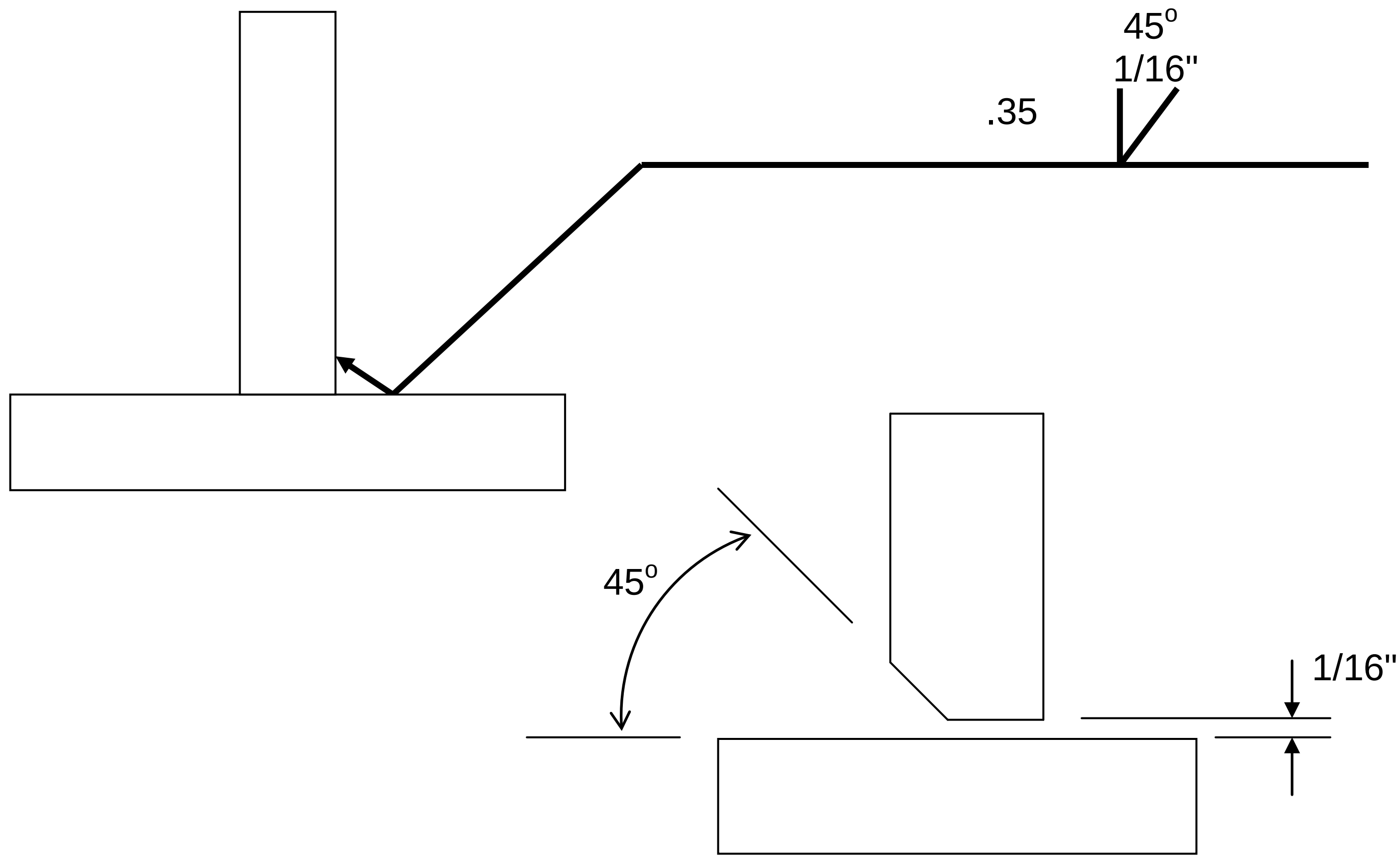


The effective throat measurement will be given in parentheses, left of the weld symbol.



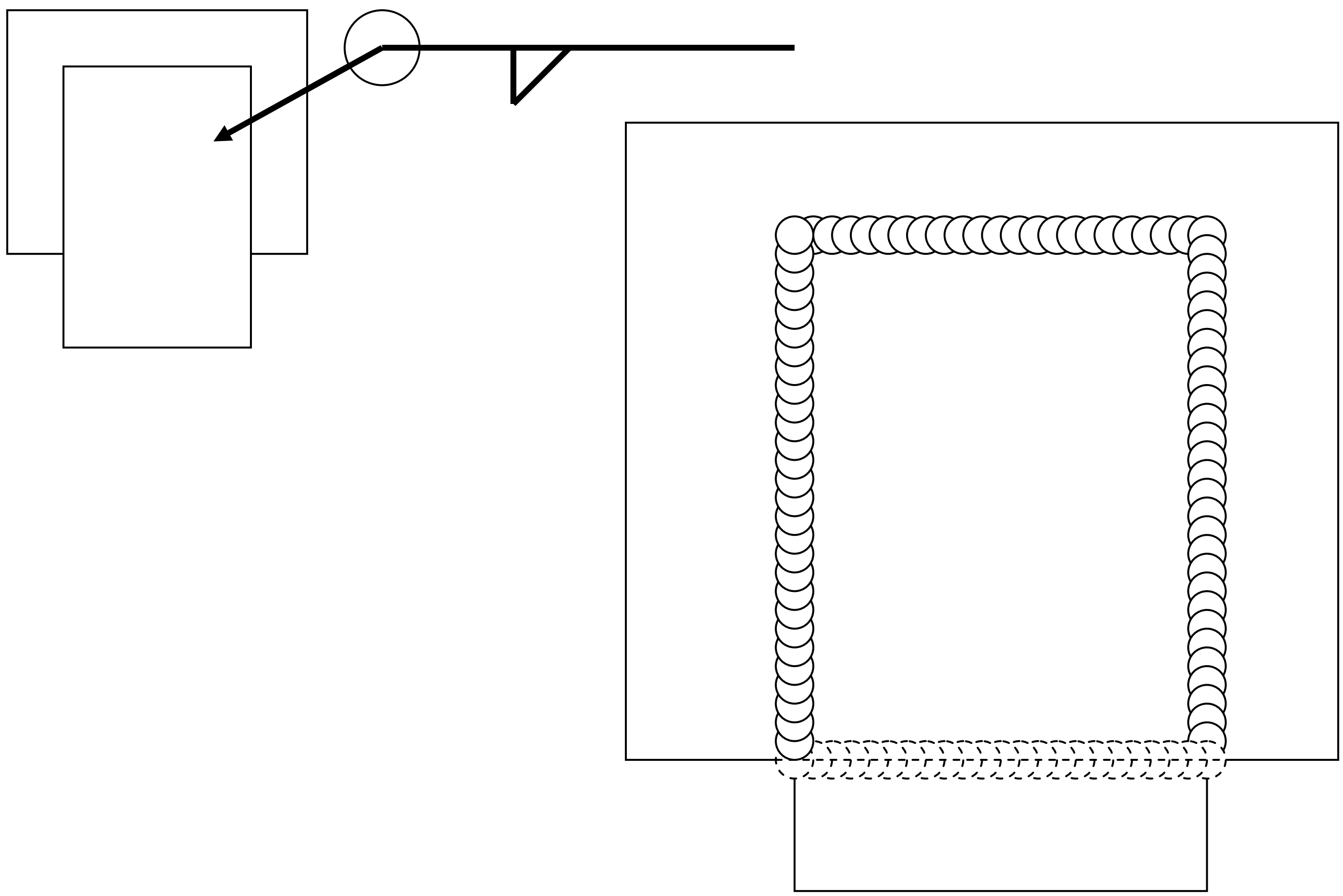
Gaps between the metal will be indicated on the weld symbol.

Sizes, Gaps, and Angle of Grooves

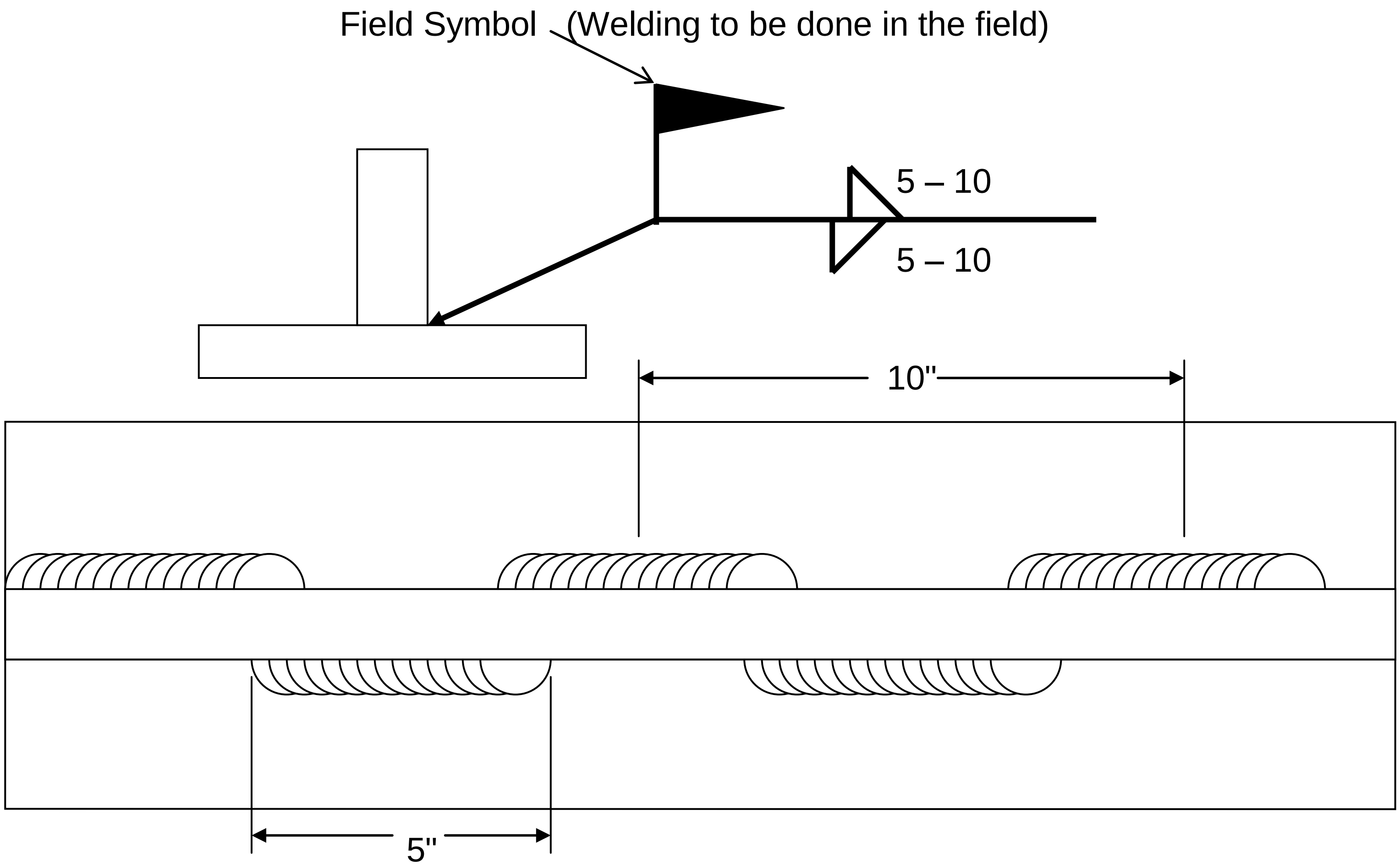


OTHER SYMBOLS

Welding All the way around

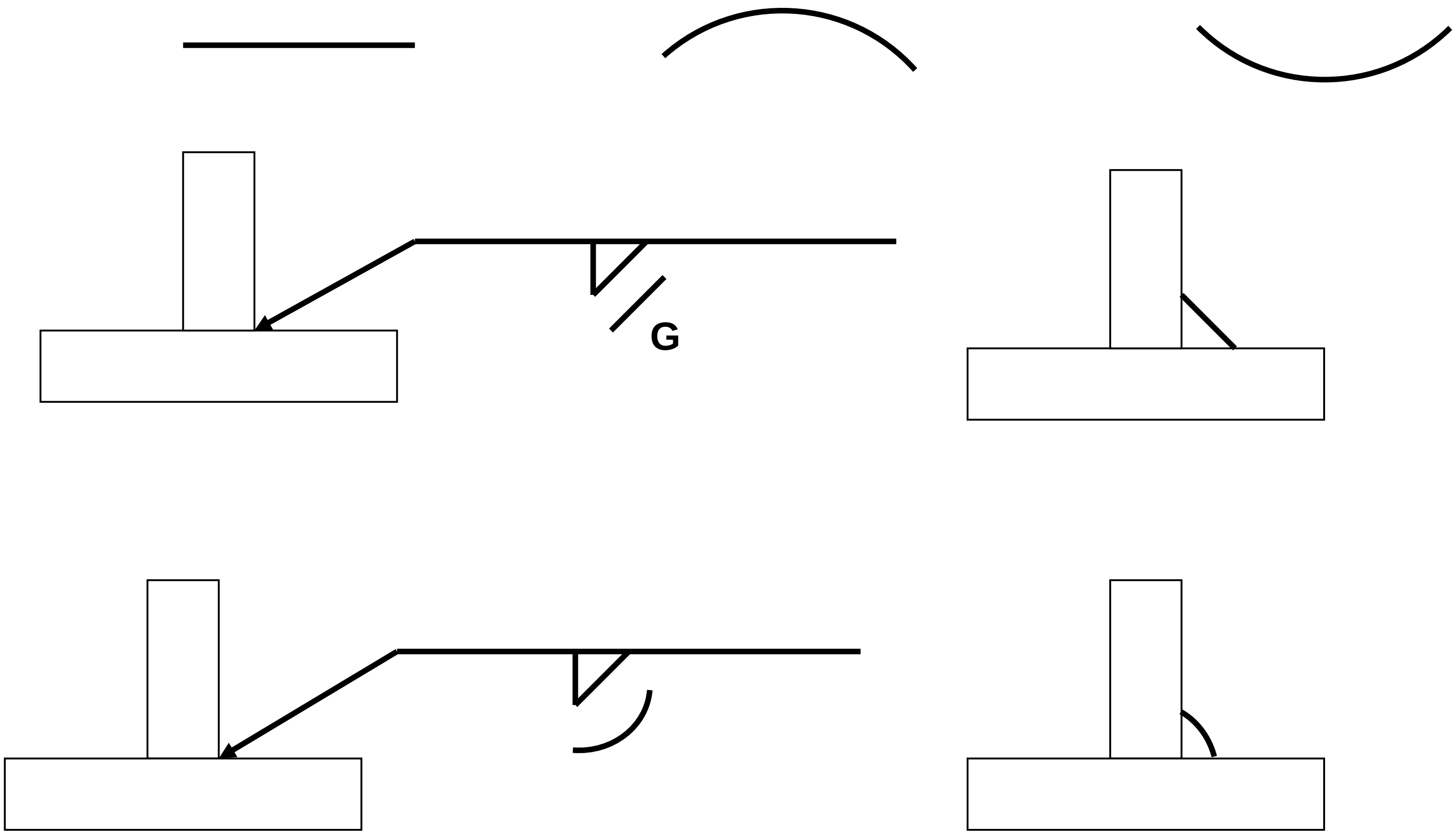


OFFSET WELDING and FIELD WELDING

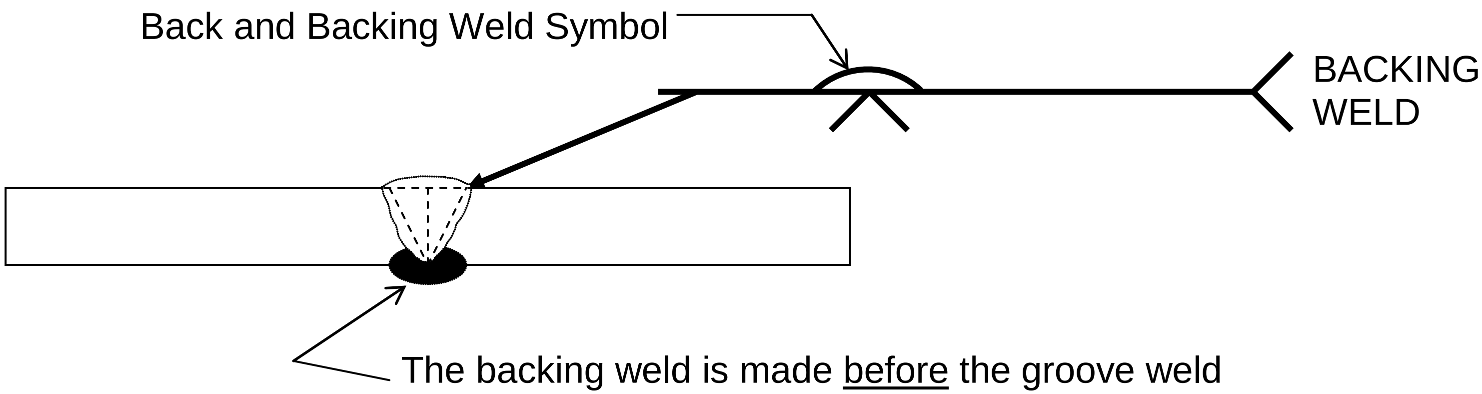


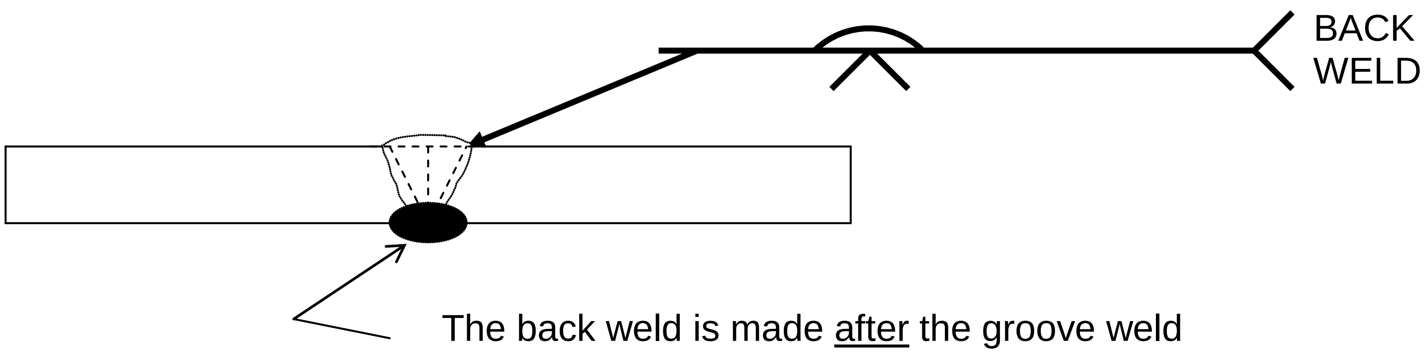
CONTOUR and FINISH SYMBOLS

Flush | Convex | Concave

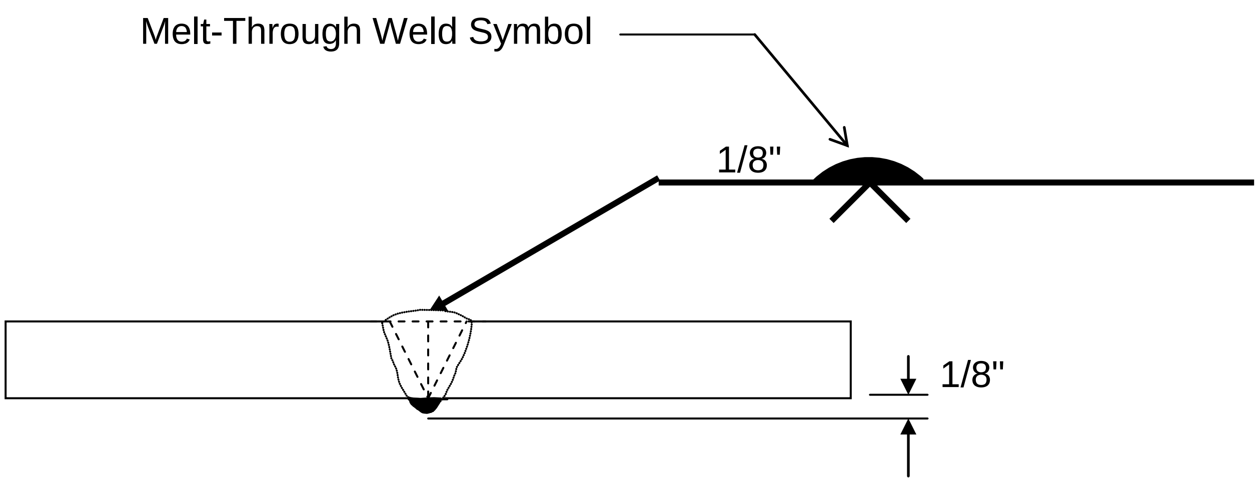


BACK and BACKING WELDS

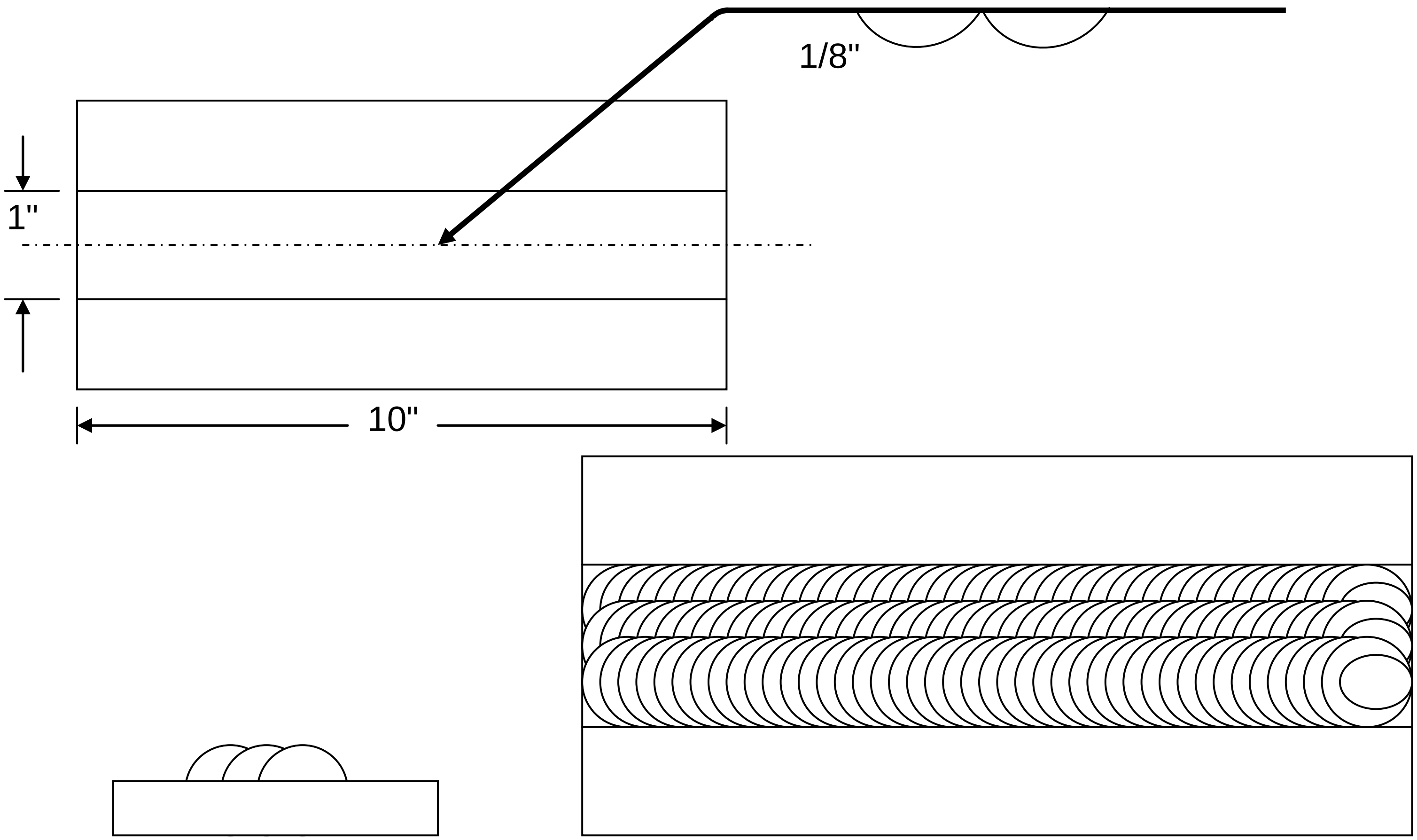




MELT-THROUGH WELDS



SURFACING and HARDFACING WELDS



PLASMA CUTTING

AG 211-D

UNIT OBJECTIVE

After completion of this unit, students will be able to understand and operate a plasma cutter safely and properly. 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 parts of a plasma cutter.
2. Identify the materials that can be cut with a plasma cutter.
3. Know how to use a plasma cutter safely.
4. Know how to setup and operate a plasma cutter correctly.
5. Cut out patterns with a plasma cutter.

A. Introduction to Plasma Cutting

1. History – After the invention of the TIG welding process during World War II it didn't take engineers long to develop a similar process to be use for cutting. Instead of using a tungsten electrode to fuse metals together and inert gases to protect it from oxidation, plasma cutting uses a tungsten electrode to melt the metal and a high-pressure inert gas to remove the melted material and an inert gas to protect it from oxidation. This process was first used by Union Carbide in 1957.
2. Advantages of Plasma Cutting versus Oxyacetylene Cutting

   a. No preheating is required.
   b. Faster cutting, a plasma cutter can cut 100% to 700% faster than oxyacetylene cutting.
   c. Less heat is spread throughout the material resulting in less warping and twisting of the material.
   e. The increase of cutting speed cuts costs by 40 to 90 percent.
   f. The ability to cut nonferrous metals (aluminum, stainless steel, etc.), accurately and without oxidizing the ends of the metal

B. Types of Plasma Cutters and Gases

1. Mode of Operation (How it works)

   a. A "plasma arc" is a current of electricity being carried by an ionized gas is stead of a conventional conductor. Plasma is also considered the 4th state of matter, the first three being solids, liquids, and gases.
   b. Using the plasma arc and a high-pressure gas to direct the arc through a constricted opening, it becomes a very useful cutting tool. The plasma arc melts the metal and the gas pressure blows the melted metal away. Using an inert gas for pressure will prevent the cut areas from oxidizing. For most ferrous metals, compressed air works just fine, nonferrous metals the inert gas is essential to prevent oxidation.

2. Types of Plasma Cutters

   a. Transferred – In the transferred system the arc is completed by making contact with the workpiece.
   b. Non-transferred – In the non-transferred system the arc is completed by making contact with nozzle, it can produce an arc without touching the grounded workpiece and <u>can be very dangerous</u>.

3. Types of Gases

    a. Primary Plasma Gas – used to create the plasma arc

        1) Nitrogen – Is a mixture of 30% hydrogen and 70% argon mixture.
        2) Argon
        3) Hydrogen
        4) Compressed Air (The most common type used in high school Ag Mech shops.)

    b. Secondary Shielding Gas – used to protect the cut metals from oxidation.

        1) CO_2
        2) Compressed Air (The most common type used in high school Ag Mech shops.)

C. Safe Use of a Plasma Cutter

1. Safety is a very while using a plasma cutter, it can cut through a person's clothes, skin, and bones just as easily as it can cut through stainless steel. A non-transfer type of plasma cutter does not need to be grounded to create a plasma arc. Extra safety precautions need to be taken if you are using this type of plasma cutter. Be sure to read the manufacture safety precautions before using their plasma cutter.

D. Operating a Plasma Cutter

1. Set the amperage and gas pressure to the manufacture's specification. The metal thickness, type, and type of gas being used should be considered.
2. When making straight cuts, use a straight edge guide. Steady you elbow or forearm on the worktable or workpiece while cutting.
3. Use at least a #9 gauge or higher welding helmet while cutting with a plasma cutter. The plasma arc is just as bright as an arc using for TIG, MIG, or Arc welding.
4. To start your cut, move the plasma torch into position. Cover with your welding helmet and press down on the start button. The arc will appear when you press down on the button, move the arc along the marked area where the cut is to be made. Keep a working distance at least 1/8" and up to3/16", the distance between the workpiece and the nozzle.
5. After the cut is made, inspect the cut for slag, rough areas, and uncut areas. Adjust travel speed and amperage accordingly.

ACTIVITY:

1. Demonstrate the proper set and shutdown procedures, according to the manufactures' recommendations.
2. Use the owner's manual, take apart the torch and show students the different parts of a plasma torch.
3. Demonstrate cutting mild steel, stainless steel, and aluminum with the plasma cutter.
4. Have students make cuts using the plasma cutter.

References:

Burke, Stanley R., & Wakeman, T. J. (1997). MODERN AGRICULTURAL MECHANICS (3nd ed.). Danville, IL: Interstate Publishers.

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

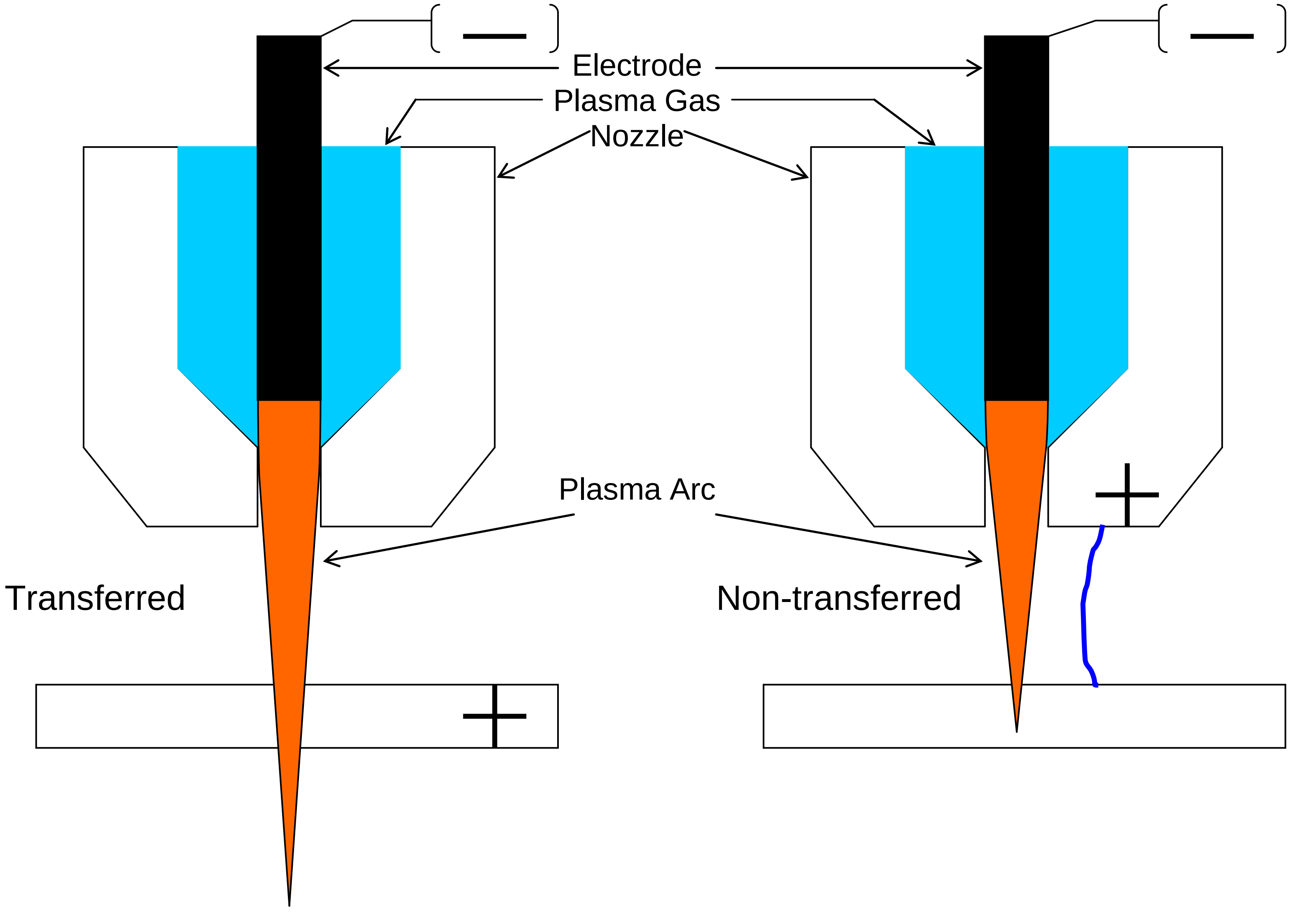
Griffin, Ivan H., Roden, Edward M., Briggs, Charles W. (1984) BASIC TIG & MIG WELDING, THIRD EDITION, Albany, NY: Delmar Publishers

Additional Resources:

http://www.hypertherm.com/technology/plasma_history.htm
http://www.manufacturing.net/magazine/planteng/6000/articles/99/126050.htm
http://www.cncplasmacutter.com/
http://www.vulcanpub.com/cso/
http://www.plasmas.org/world.htm

211D-5

PLASMA ARC CUTTING



PLASTIC WELDING
WITH A HOT AIR GUN

AG 211-E

UNIT OBJECTIVE

After completion of this unit, students will be able to understand the basics of welding thermoplastics. Students will be able to identify different types of plastics and know how to weld different joints. 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 different types of plastics.

2. Know how to handle and operate a hot air plastic welder safely.

3. Know and understand the proper setup and use of a hot air plastic welder.

4. Know the different joint connections use in plastic welding.

5. Demonstrate a PVC weld correctly and safely.

A. Introduction to Plastic Welding

1. Plastics have been around for over 100 years. They have become a part of our everyday lives. It's hard for a person to make it through the day without using something made of plastic. Coke bottles, food containers, and even many car parts are made from a type of plastic.

    a. 1862 – First man made plastic
    b. 1891 – Rayon is first discovered
    c. 1926 – Polyvinyl Chloride, PVC is invented
    d. 1933 – Polyethylene is discovered
    e. 1938 – Teflon is discovered
    f. 1938 – Nylon Stocking first hit the market

B. Hot Air Plastic Welding

1. Hot Air plastic welding works by using a hand held torch that has an electric heating element. A low-pressure of compressed air passes through the heating element and directs the heat towards the groove melting the plastic and the filler rod together.
2. All most any plastic material that can be molded and shaped with heat can be welded with a hot air welder.
3. Plastics that have a thickness of 1/16" or greater can be welded.
4. Hot Air plastic welding can be used for fabricating or repairing.

C. Types of Plastic and Identification

1. The most common types of plastic material are:

    a. Polyethylene (PE)
    b. Polypropylene (PP) – clear in color
    c. Acrylonitrile Butadiene Styrene (A.B.S.) – black in color
    d. Polyvinyl Chloride (PVC) – white or gray in color
    e. Polyurethane (TPUR)

2. Identifying different types of plastic. Looking at the color is a good place to start when identifying plastics but it will not always hold true. Sometimes polyurethane can be colored black and mistaken for ABS. Burning a small piece of the plastic that needs to be welded can be used to identify the material. Looking at the color of the flame, the smoke, the burning process, and the smell can help you determine the type of plastic.

a. Polyethylene – No smoke, blue flame, and a candle wax odor.
b. Polypropylene – No smoke, orange flame, acid odor
c. Acrylonitrile Butadiene Styrene – Black sooty smoke hangs in the air, sweet odor
d. Polyvinyl Chloride – Self-extinguishing, will not flame
e. Polyurethane – Black smoke, sputtering effect

3. Filler Rod Selection

   a. The filer rod needs to be made of the same material as being welded. When buying filler rod, the type will be labeled on the package.
   b. The size of the filler rod being used depends on the thickness of the plastic be welded. Use a filler rod close to the thickness of the base material.

BASE MATERIAL THICKNESSS	WELDING ROD SIZE
1/16"	1/8" diameter
1/8"	1/8" diameter
3/16"	3/16" diameter
1/4"	3 rods of 3/16" diameter
> 1/4" use multi-passes	5/32" or 3/16" diameter

4. Welding Temperature – Each type of plastic needs to be welded at the right temperature for proper effectiveness. In most Hot Air welding torches air pressure helps to determine the temperature.

   a. Polyethylene – 575^{o}F
   b. Polypropylene – 550^{o}F
   c. Acrylonitrile Butadiene Styrene – 500^{o}F
   d. Polyvinyl Chloride – 525^{o}F
   e. Polyurethane – 575^{o}F

D. Plastic Welding Setup and Operations

1. When using a Hot Air plastic welder <u>always</u> turn the air pressure on before turning on the heating element.
2. After the heating element has reached the desired temperature, you can start the welding process.
3. Cut the end of the filler rod at a 60^{o} angle.
4. Hold the cut end of the rod just above the welding starting point at a 90^{o} angle.
5. Apply heat to the rod end and the base material seam at the same time until both are tacky.

6. Press the tacky end of the rod down into the tacky starting point of the base materials.
7. Only the surface of the rod and base materials will be tacky, but will bond properly.
8. The rod will continue to hold its' basic shape for the most part throughout the welding process.
9. Holding the rod at a 90^o angle directly above the weld seam, pressing firmly, evenly down into the weld point as you apply heat in the direction of the weld seam with a short fanning motion (See page 211E-6)
10. As the rod and base material become tacky, if you are welding at proper temperature, a loop will form where rod joins weld of base materials and small beads will form an either side of completed welded sections.
11. At the end of the weld, cut the rod with knife or pliers at a 30^o angle.
12. Cut a new end for the rod at 60^o to start a new weld. The end of the rod should be free from discoloration and warping if proper heat was applied.
13. Do not start a new weld if the end of the rod is distorted, stretched, discolored, or damaged in any way. This will weaken the next weld.
14. After turning off the heating element, <u>always</u> let the compressed air flow through the torch until the heating element has cooled off.

ACTIVITY:

1. Demonstrate the proper setup and use of a Hot Air plastic welder.
2. Have students identify different types of plastic using the burn test.
3. Have students plastic weld a piece of PVC pipe, see page 211E-6.

References:

SEELYE Inc., Minneapolis, Minnesota, 1-800-258-2936

http://www.laramyplasticwelders.com/
http://www.modernplasticwelding.com.au/

HOT AIR PLASTIC WELDING

TO AVOID BURNING OUT THE HEATING ELEMENT – Always start the airflow before starting the heating element.

Set air flow at 3 psi

CAUTION – Never touch metal parts on the welding gun until they have cooled. Use pliers to change a tip on a welding gun while operating.

TO AVOID BURNING OUT THE HEATING ELEMENT – Disconnect the electricity on the gun before turning off the airflow. The gun will cool faster and the electric heating element will last longer.

Use the same kind of plastic to weld as what is being welded.

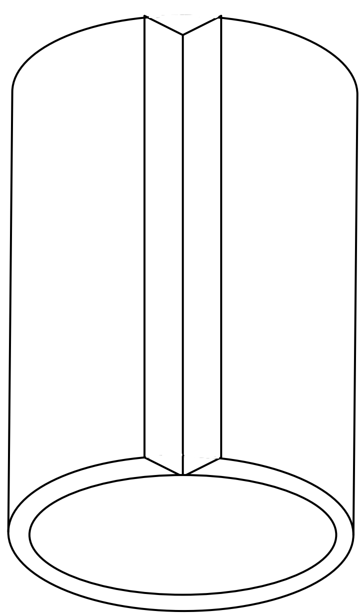
Selecting Rod Diameter

BASE MATERIAL THICKNESSS	WELDING ROD SIZE
1/16"	1/8" diameter
1/8"	1/8" diameter
3/16"	3/16" diameter
1/4"	3 rods of 3/16" diameter
> 1/4" use multi-passes	5/32" or 3/16" diameter

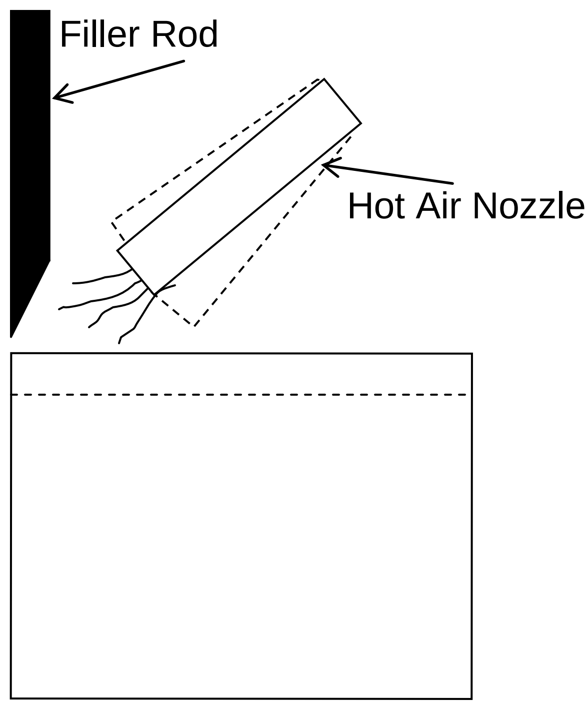
PVC Pipe Weld:

Procedure:

1. Start with a piece of 1" PVE pipe 1 ½" long and with a groove cut along the side.
2. Set the Hot Air torch at 525^{o}F.
3. Cut the end of the filler rod at a 60^{o} angle.
4. Hold the end of the filler rod 90^{o} from the groove.
5. Heat the end of the filler rod and the starting point of the weld until the edges are tacky and start the weld. Move the Hot Air welding torch side to side while melting the plastic.
6. After reaching the end of the groove, remove the heat and let the weld cool, after it has cooled cut the rod off at a 30^{o} angle.

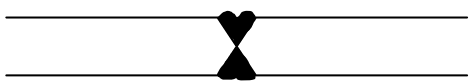


Top View

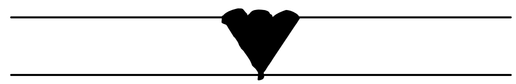


Side View

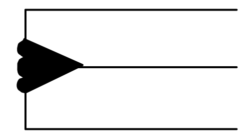
TYPE OF WELDS



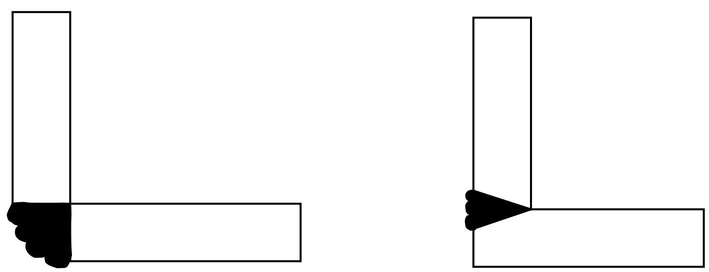
Double "V" Butt Weld



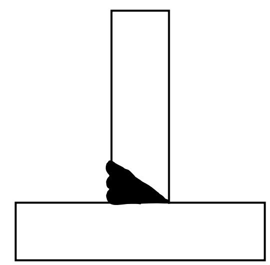
Single "V" Butt Weld



Edge Weld

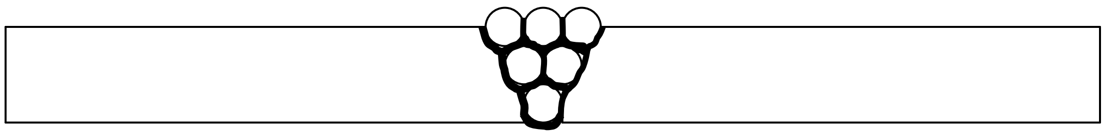


Outside Corner Welds

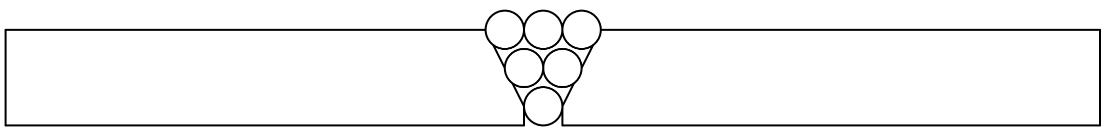


Inside Corner Weld

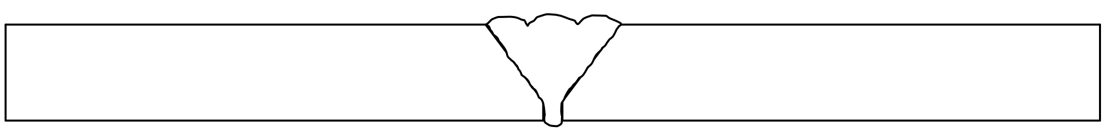
QUALITY OF PLASTIC WELDS



TOO HOT

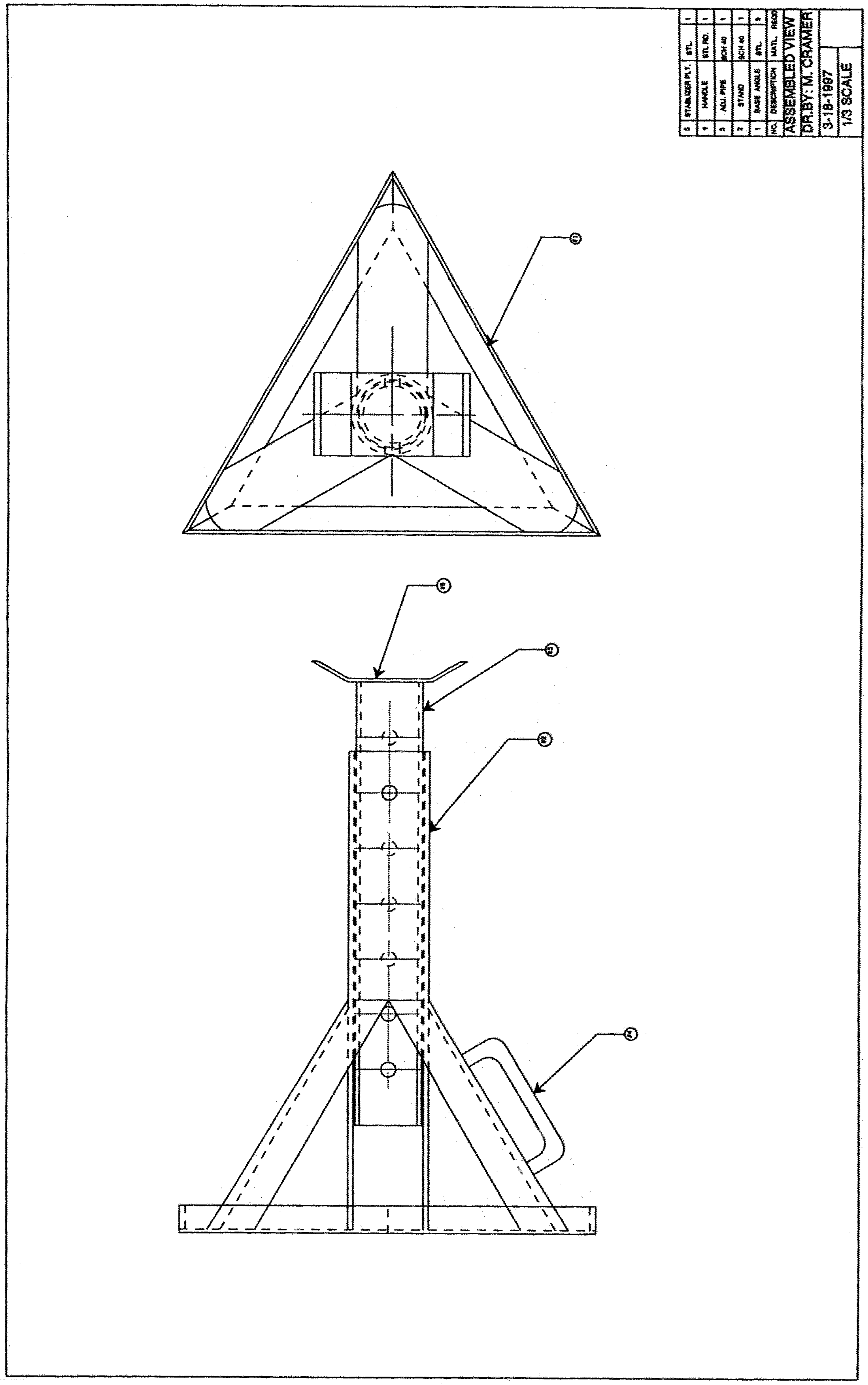


TOO COLD

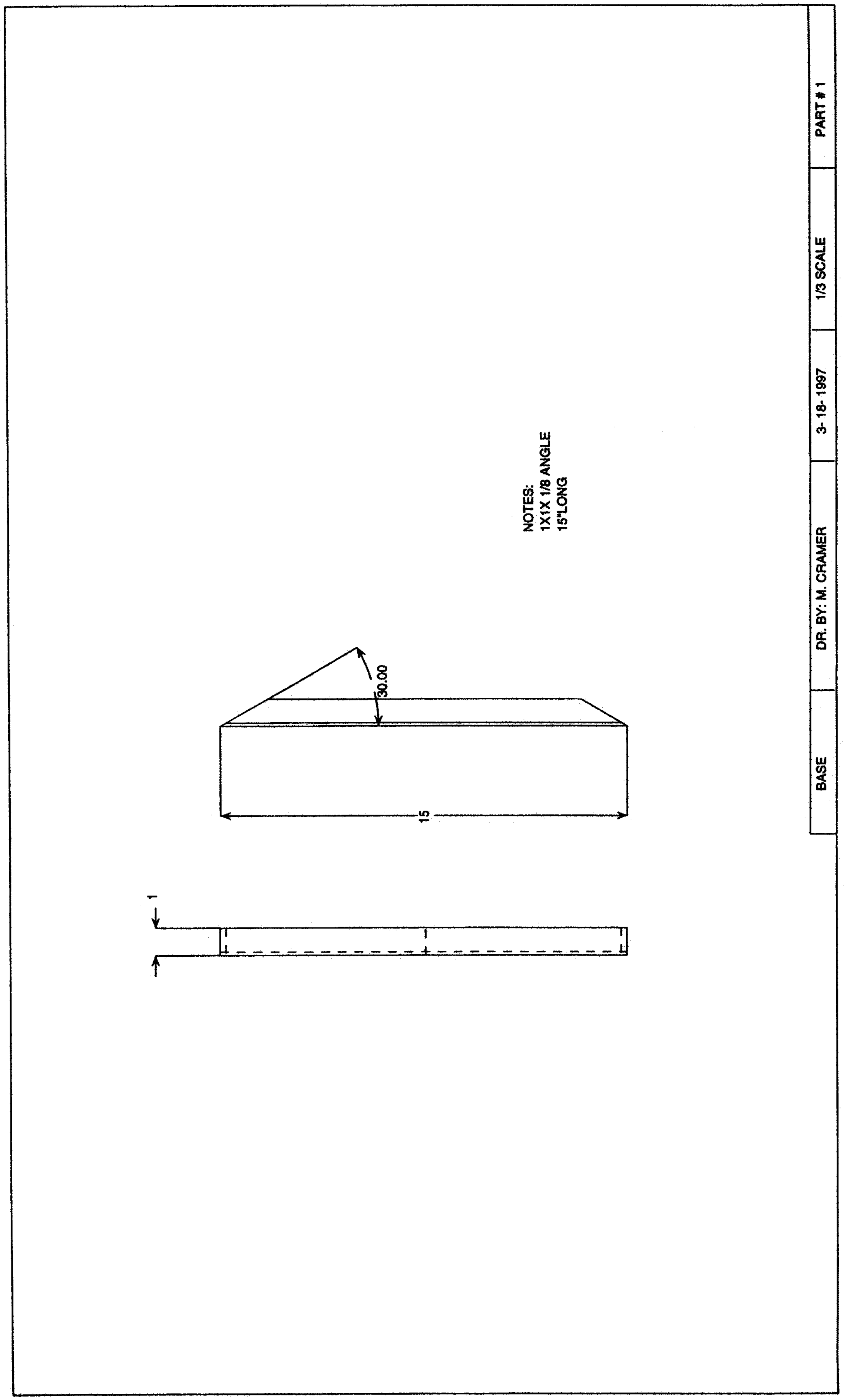


GOOD WELD

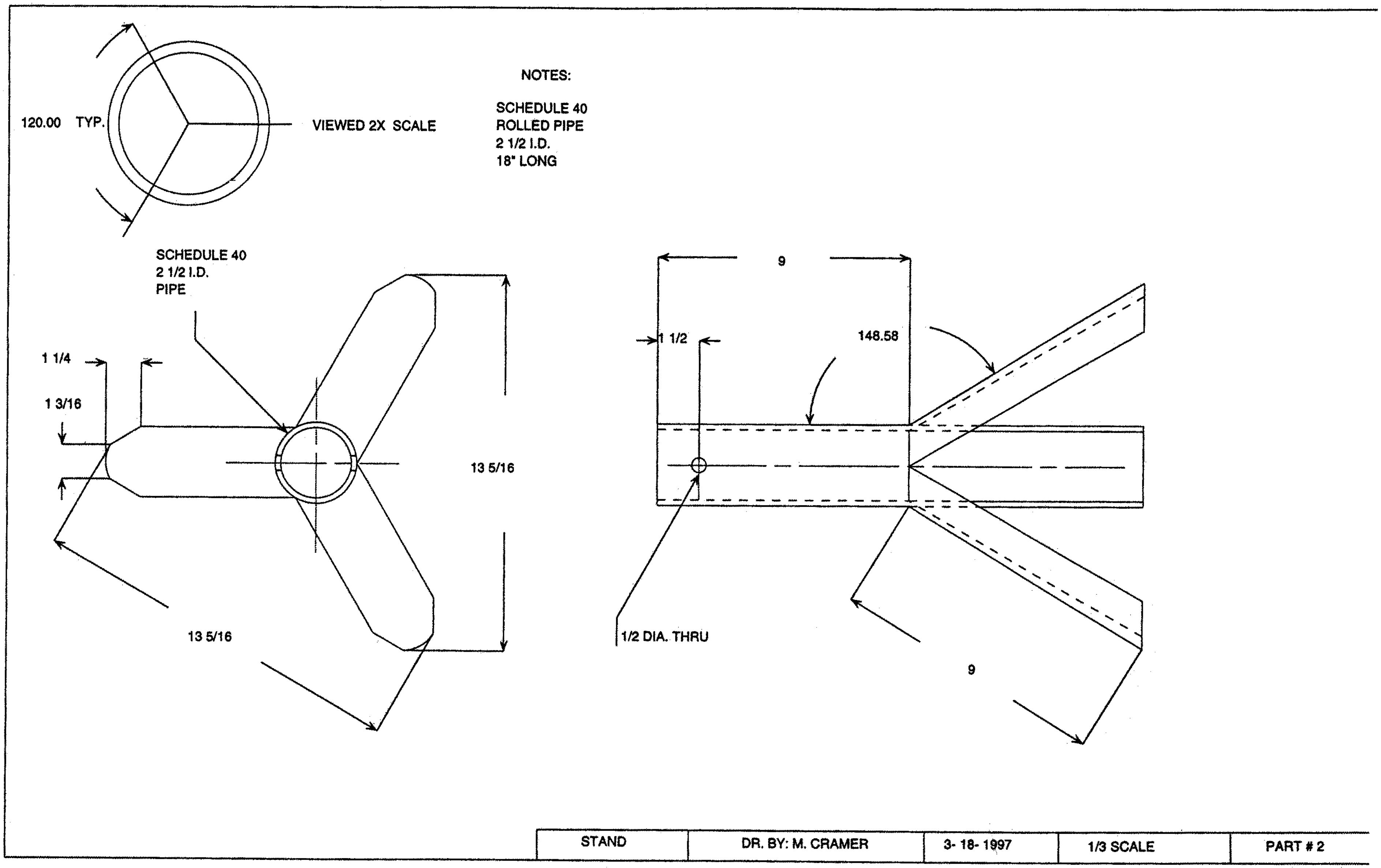
211F-1

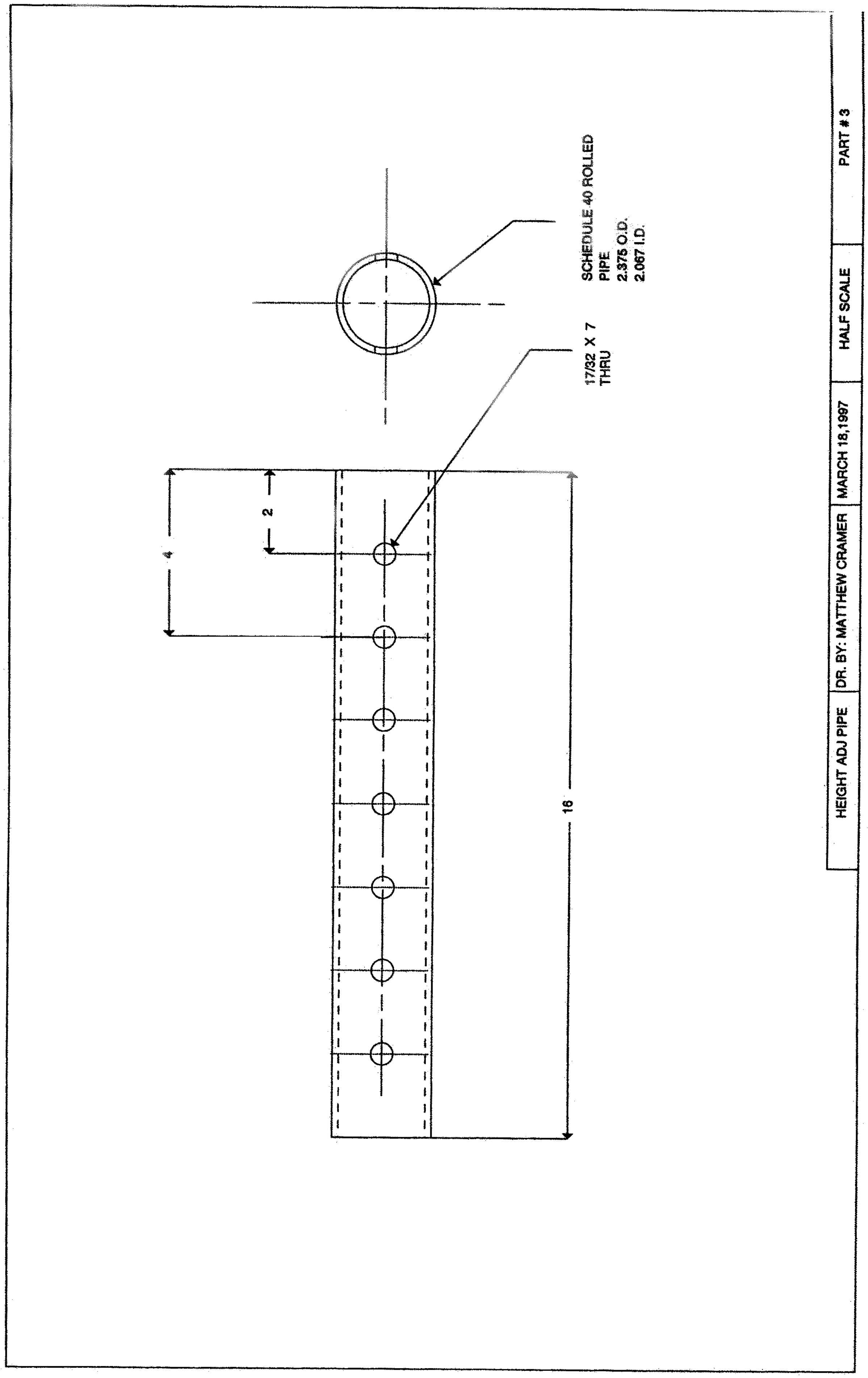


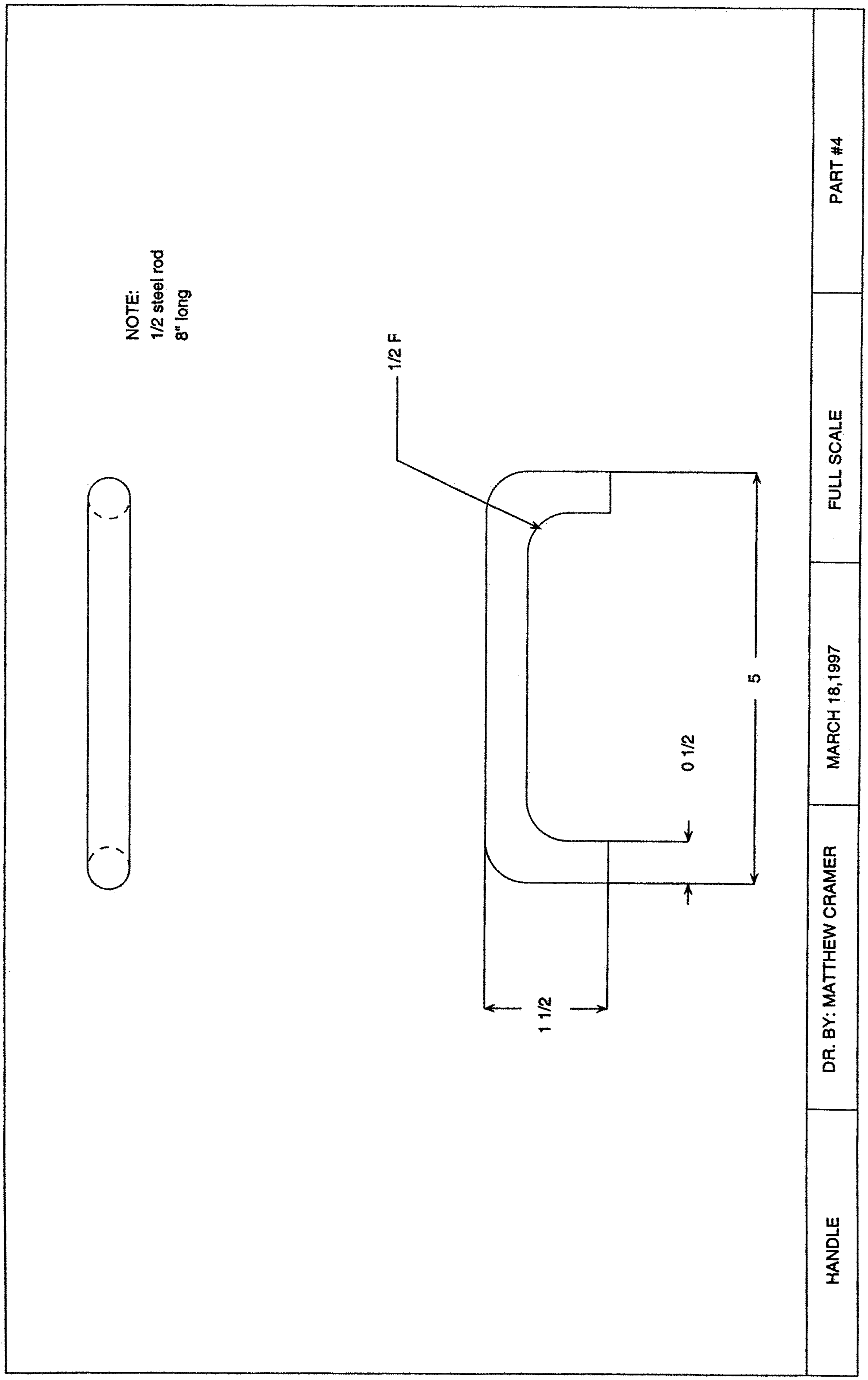
5 STABILIZER PLT. STL. 1
4 HANDLE STL RD. 1
3 ADJ. PIPE SCH 40 1
2 STAND SCH 40 1
1 BASE ANGLE STL. 3
NO. DESCRIPTION MATL. REQD
ASSEMBLED VIEW
DR.BY: M. CRAMER
3-18-1997
1/3 SCALE

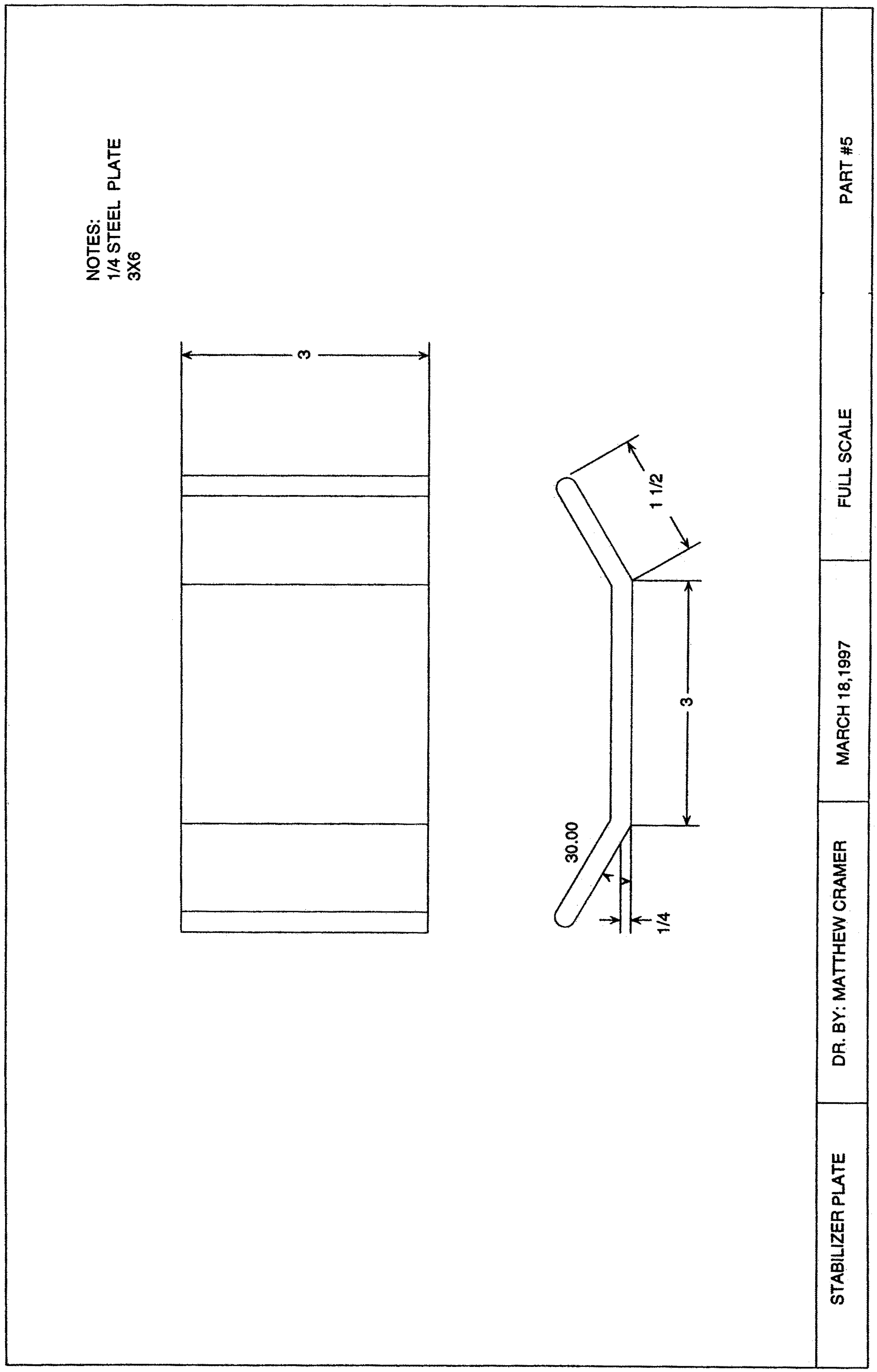


PART # 1
1/3 SCALE
3- 18- 1997
DR. BY: M. CRAMER
BASE
NOTES:
1X1X 1/8 ANGLE
15"LONG
30.00
15
1

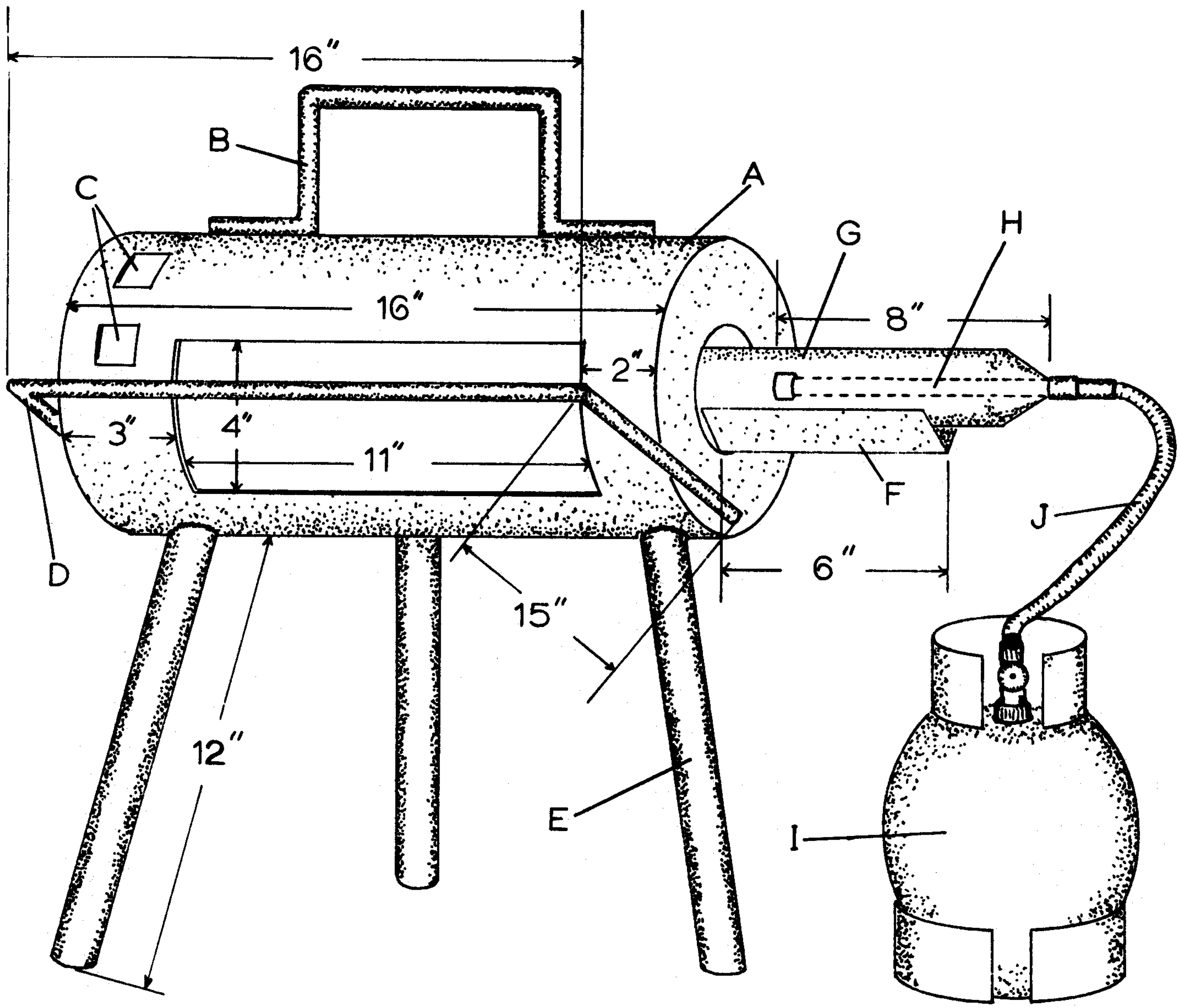

120.00 TYP.
VIEWED 2X SCALE
NOTES:
SCHEDULE 40
ROLLED PIPE
2 1/2 I.D.
18" LONG
SCHEDULE 40
2 1/2 I.D.
PIPE
1 1/4
1 3/16
13 5/16
13 5/16
9
1 1/2
148.58
1/2 DIA. THRU
9
STAND
DR. BY: M. CRAMER
3- 18- 1997
1/3 SCALE
PART # 2


SCHEDULE 40 ROLLED
PIPE
2.375 O.D.
2.067 I.D.
17/32 X 7
THRU
2
4
16
HEIGHT ADJ PIPE
DR. BY: MATTHEW CRAMER
MARCH 18,1997
HALF SCALE
PART # 3


NOTE:
1/2 steel rod
8" long
1/2 F
0 1/2
5
1 1/2
HANDLE
DR. BY: MATTHEW CRAMER
MARCH 18,1997
FULL SCALE
PART #4


NOTES:
1/4 STEEL PLATE
3X6
3
1 1/2
3
30.00
1/4
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

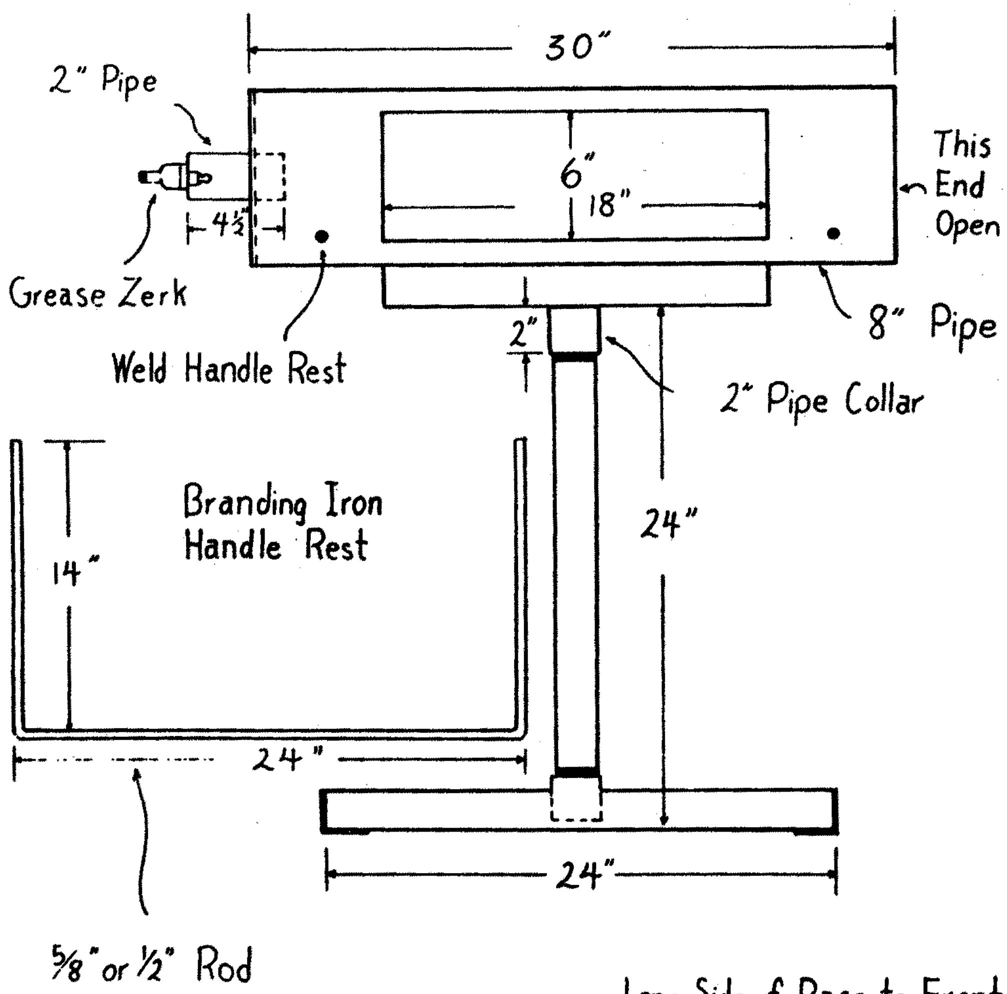
#21.015

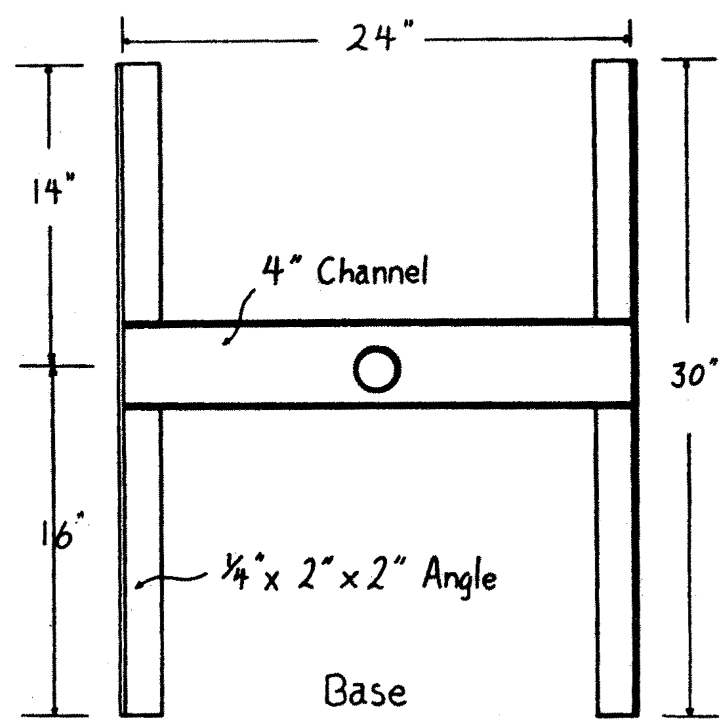
Branding Iron Heater

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



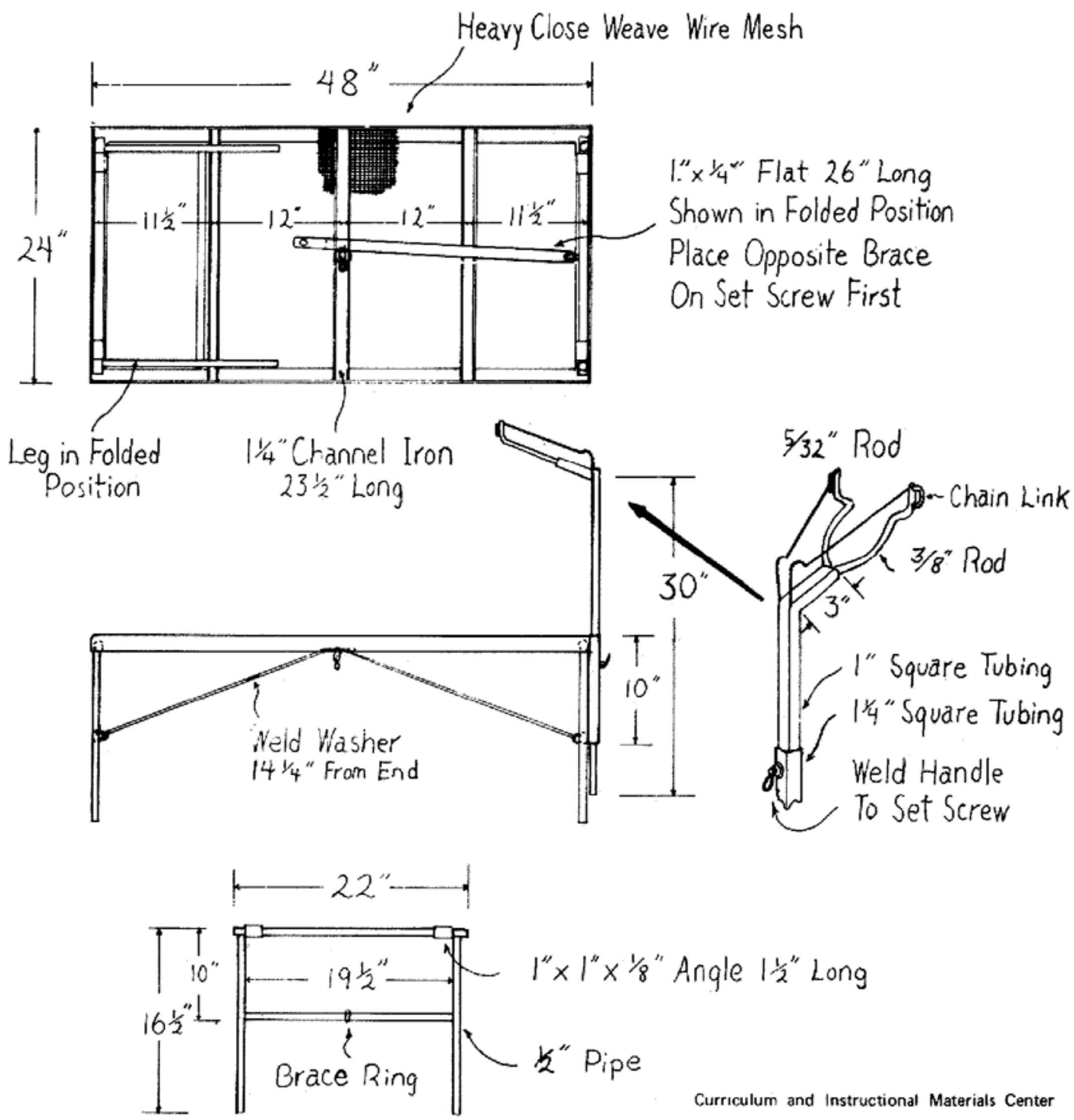


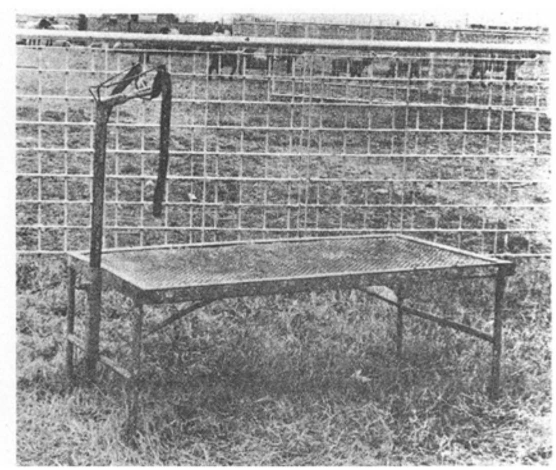
Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

Folding Sheep Blocking Stand

Scale:3/32"=1'

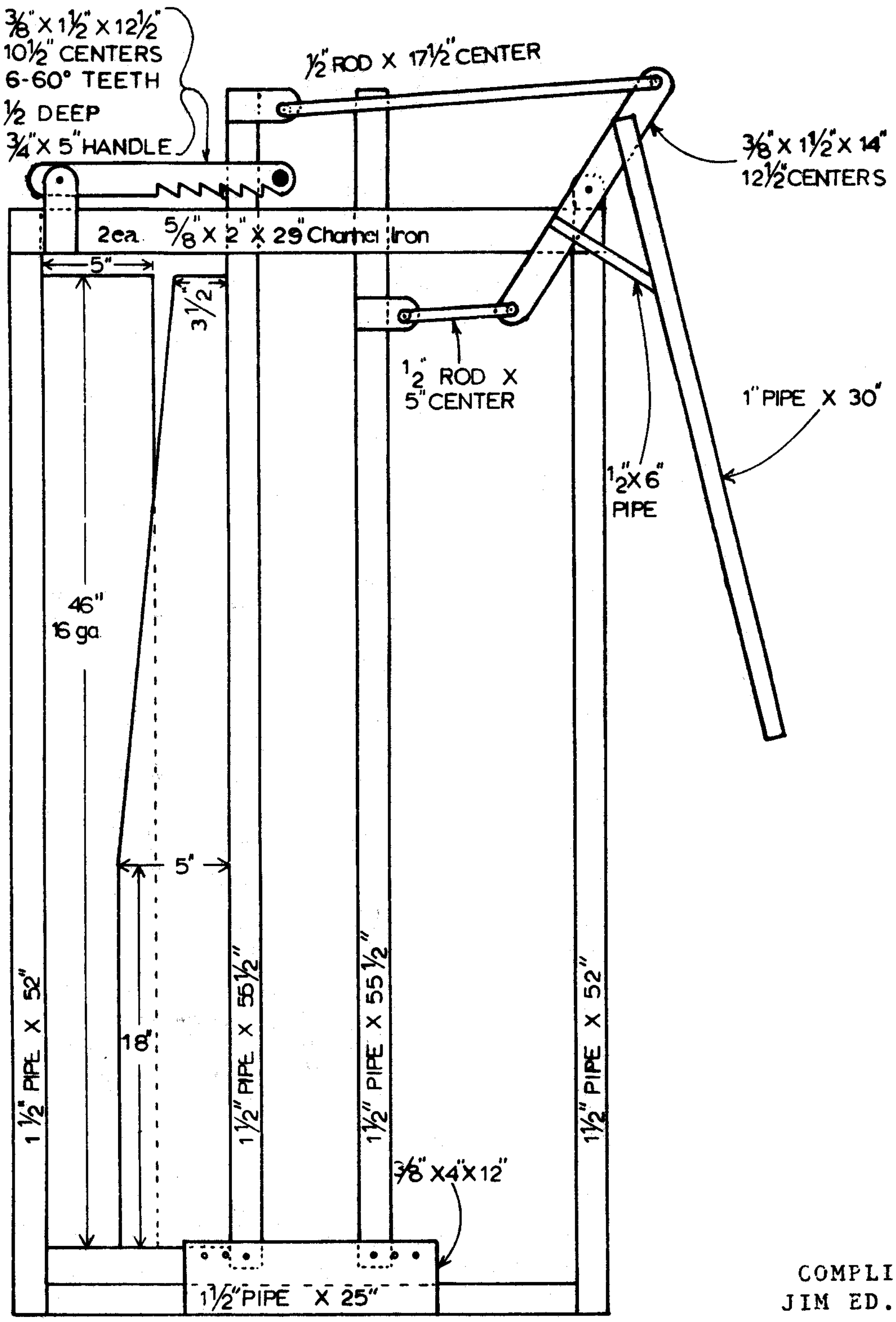
BILL OF MATERIAL
2 Pieces of 1½" x 1½" Angle Iron 48" Long
1 Piece of Heavy Mesh Wire 24" x 48"
1 Piece of 1 1/4" Square Tubing 10" Long
1 Piece of 1" Square Tubing 33" Long
2 Pieces of 3/8" Rod 8" Long
4 Pieces of 1" x 1" x 1/8" Angle Iron 1½" Long
4 Pieces of ½" Pipe 16½" Long
2 Pieces of ½" Pipe 19½" 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



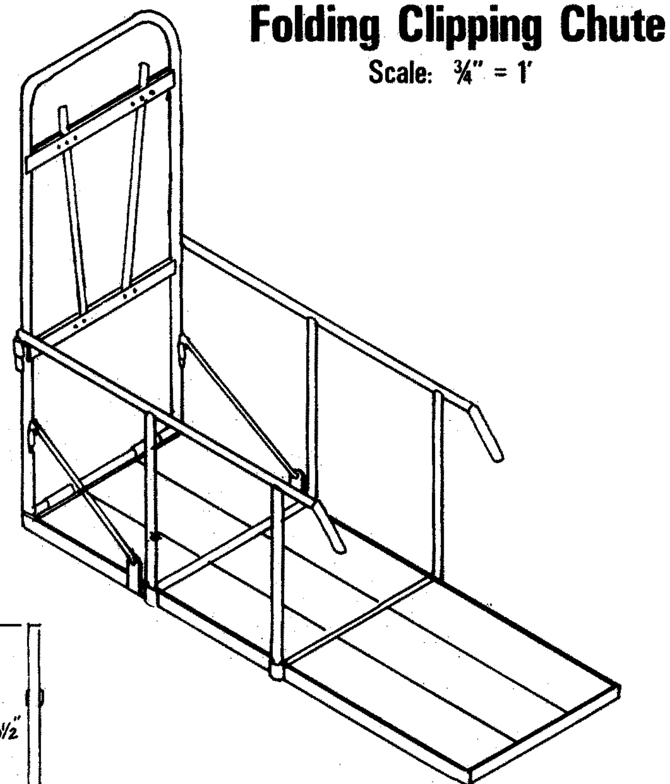
COMPLIMENTS OF
JIM ED. MUCKLEROY

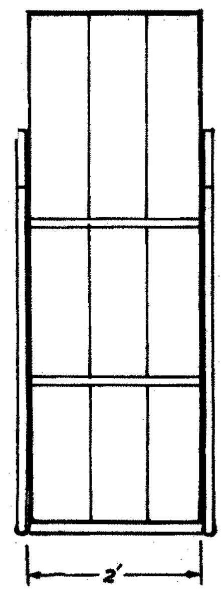
GARRISON, TEXAS

21.003

Folding Clipping Chute

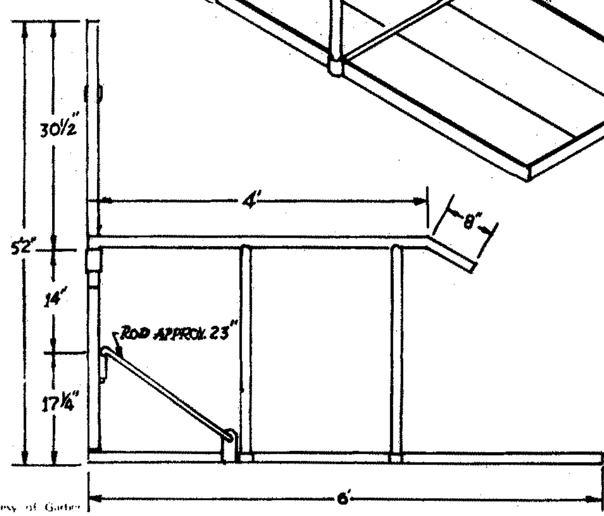
Scale: ¾" = 1'

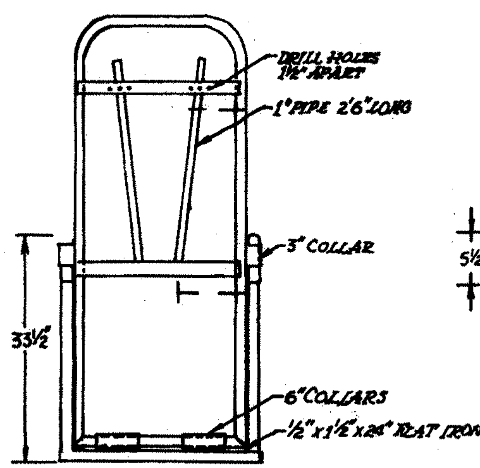


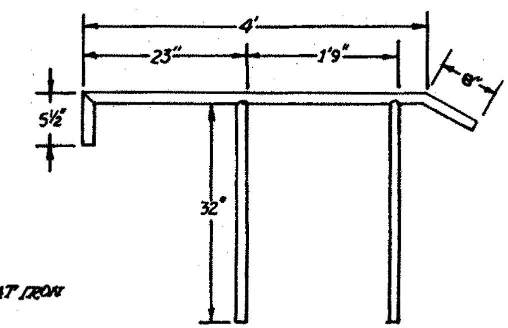


BILL OF MATERIAL

- 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







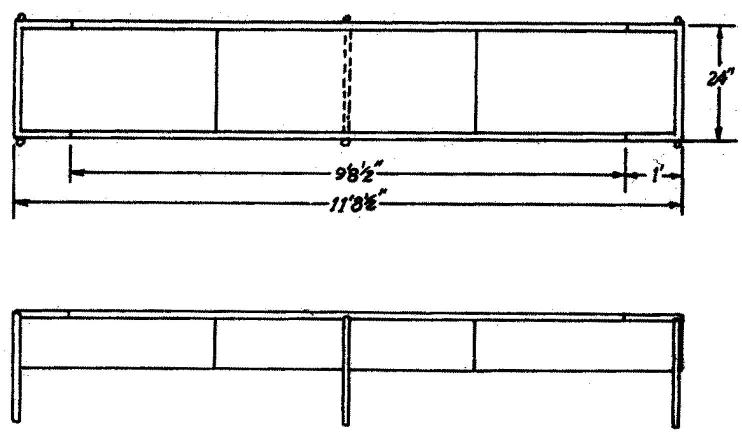
Courtesy of Garber Vocational Agriculture Department

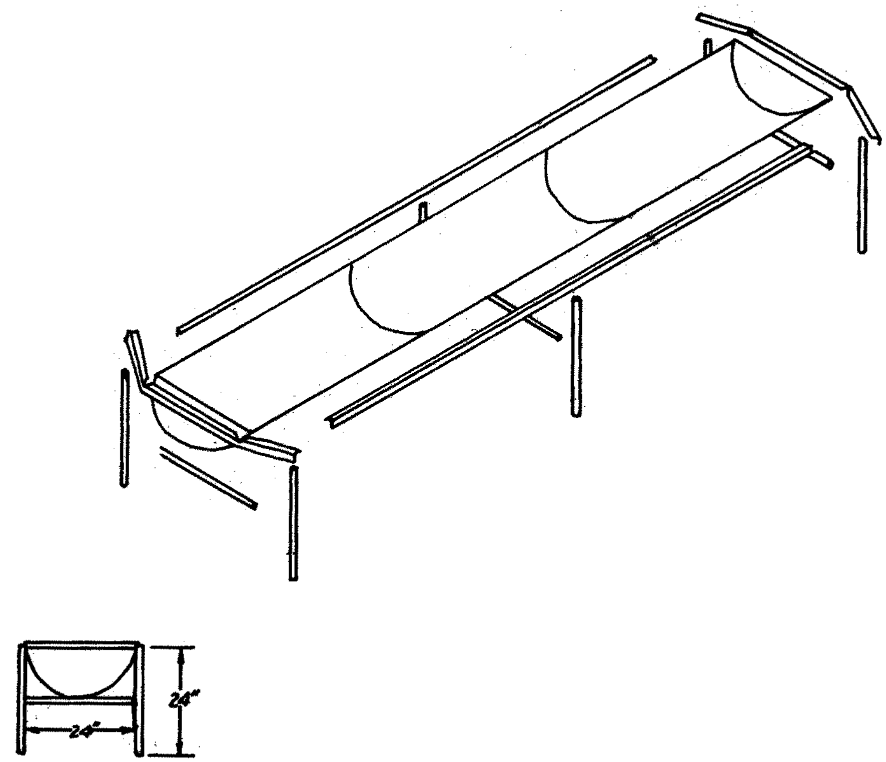
Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

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

DWN BY: JOHN McEACHERN

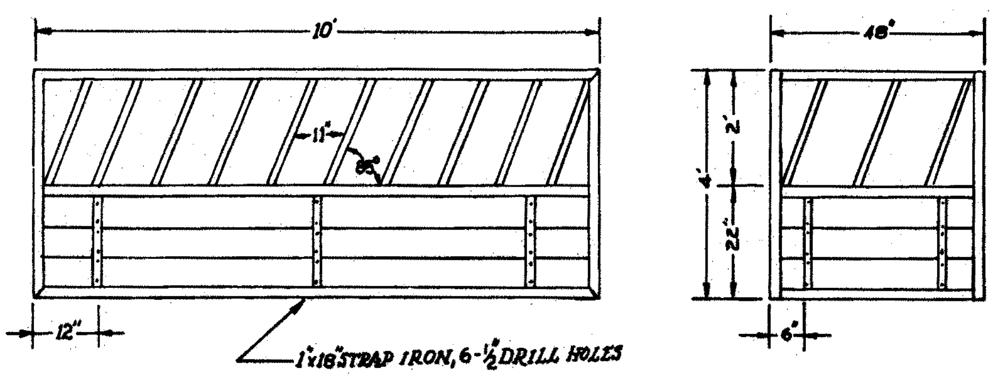
Courtesy of Jet-Nash
Vocational Agriculture Department

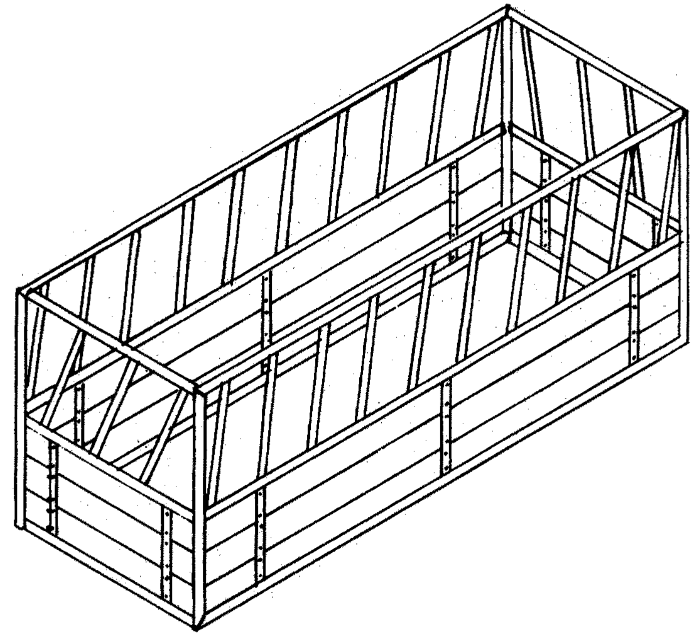
BILL OF MATERIAL

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 1/2" x 1 1/2" LONG

Hay Feeder

Scale: ½" = 1'





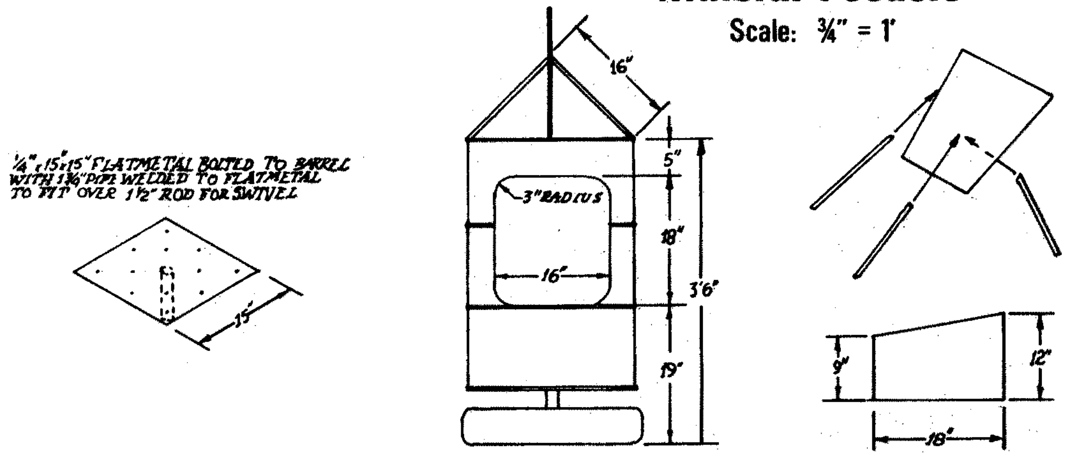
Courtesy of Jet-Nash
Vocational Agriculture Department

Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

DWN BY: JOHN McEACHERN

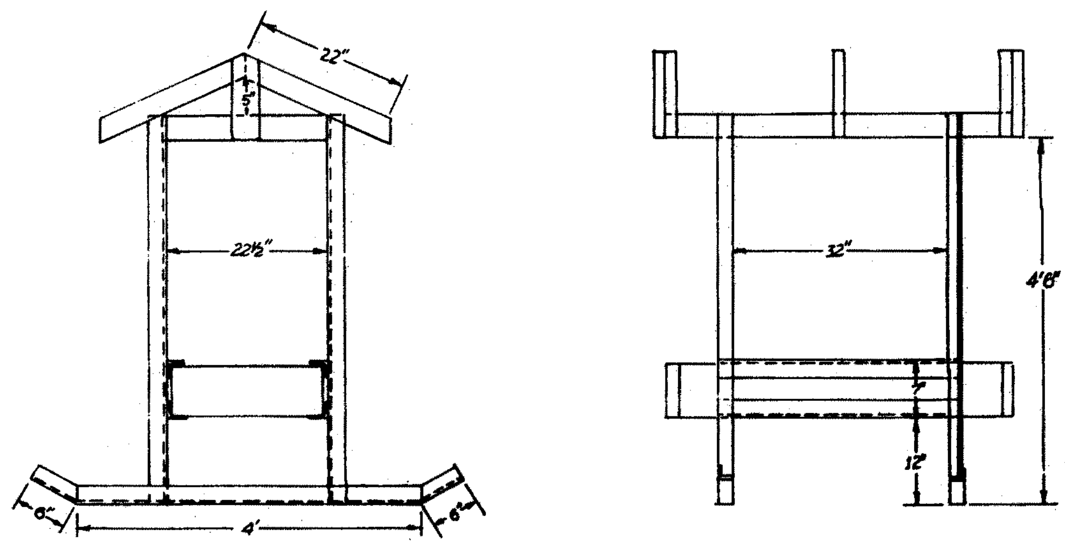
Mineral Feeders

Scale: 3/4" = 1'



BILL OF MATERIAL

1-55GAL BARREL
1 PIECE OF 1 1/2" ROD APPROX. 5' LONG
1 PIECE OF 1 3/4" PIPE APPROX 4" LONG
1 WHEEL & TIRE CEMENTED
1 PIECE OF SHEETMETAL 18" x 12"
3 WEATHER VAIN BRACES 16" LONG
1 PIECE OF 1/4" x 15" x 15" FLATMETAL



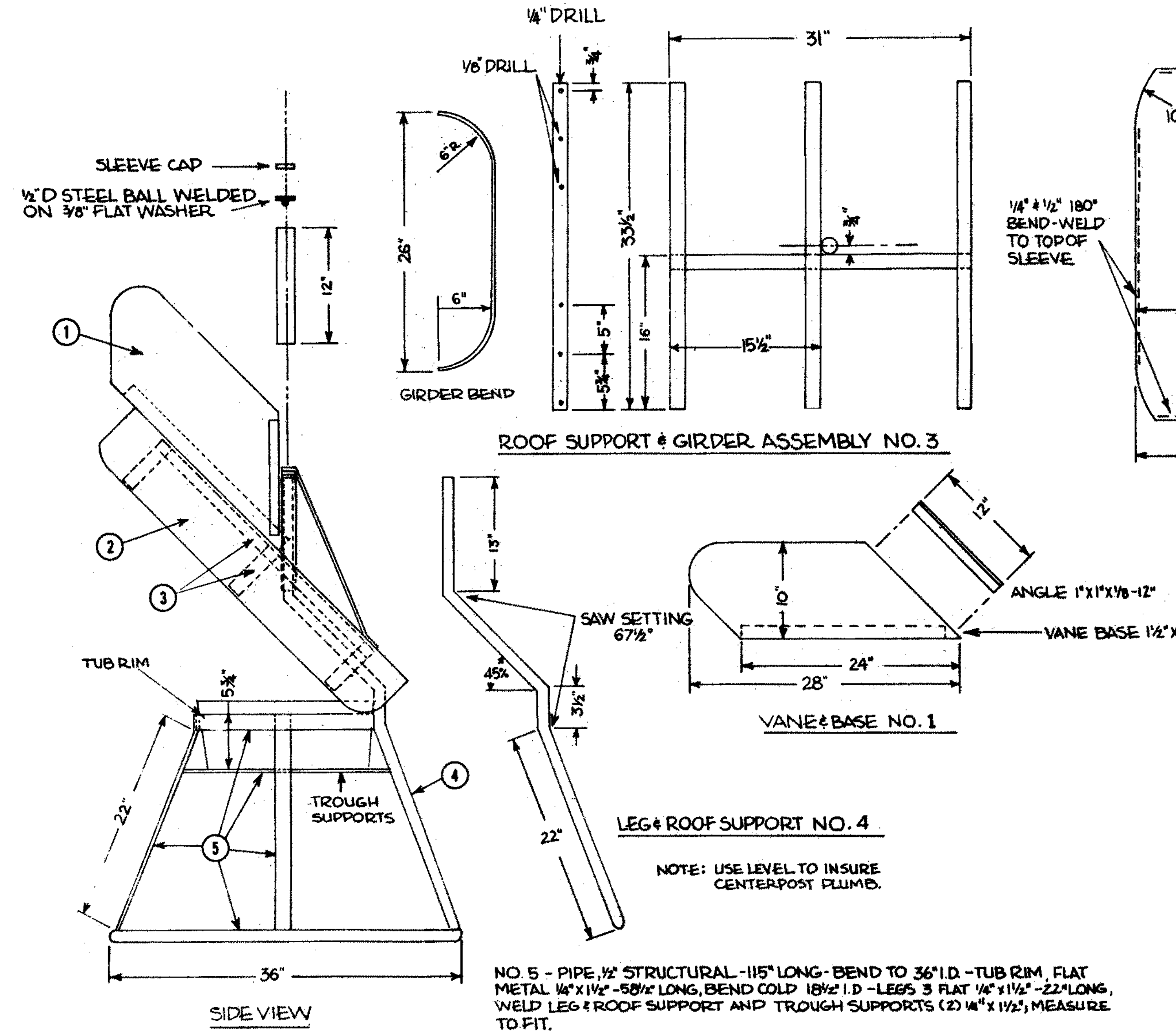
BILL OF MATERIAL

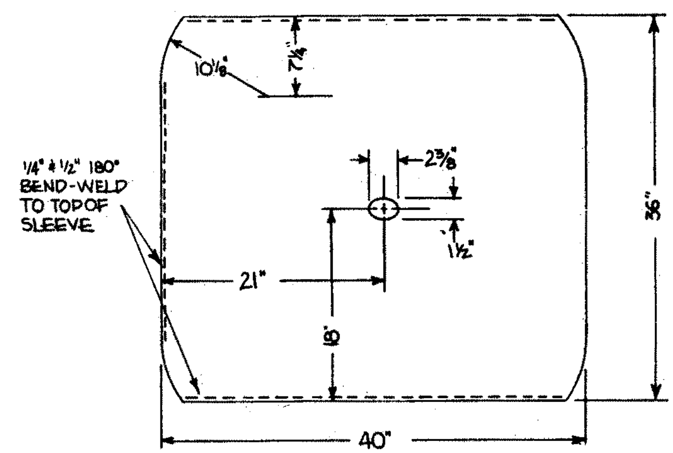
2 PIECES OF 2 1/2" ANGLEIRON 5' LONG
4 PIECES OF 2 1/2" ANGLEIRON 4'6" LONG
4 PIECES OF 2 1/2" ANGLEIRON 32" LONG
4-2" x 6" BOARDS 3'9" LONG
2-2" x 6" BOARDS APPROX 22" LONG
2-2 x 4" BOARDS 4' LONG
2-2" x 4" BOARDS 19 1/2" LONG
6-2" x 4" BOARDS 22" LONG
2-2" x 4" BOARDS 12" LONG

Courtesy of Coalgate Vocational Agriculture Department

Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

DWN BY: JOHN McEACHERN





ROOF DETAIL NO. 2

BEND TO FIT GIRDER BEND.

Curriculum and Instructional Materials Center

State Department of Vocational and Technical Education

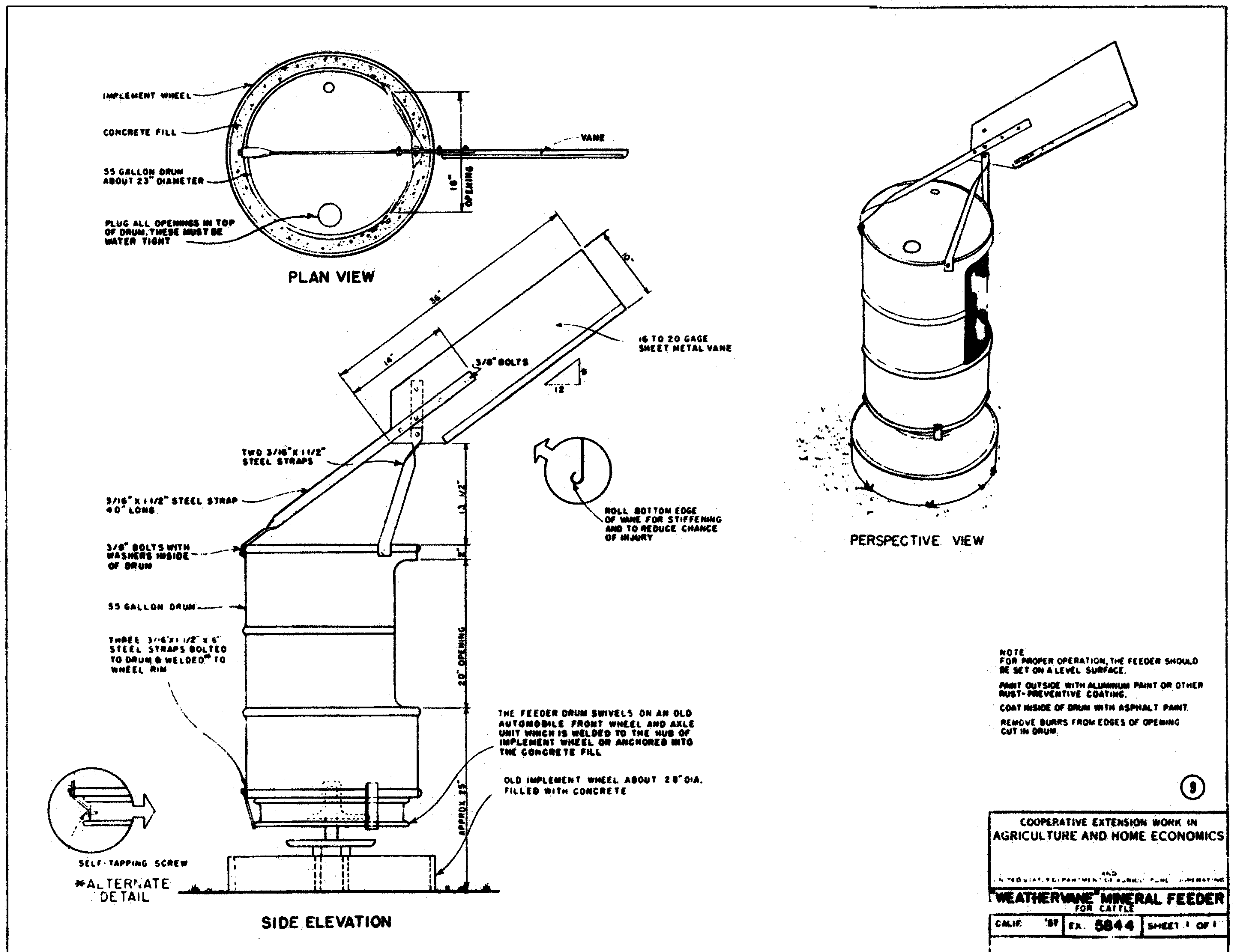
Stillwater, Oklahoma

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

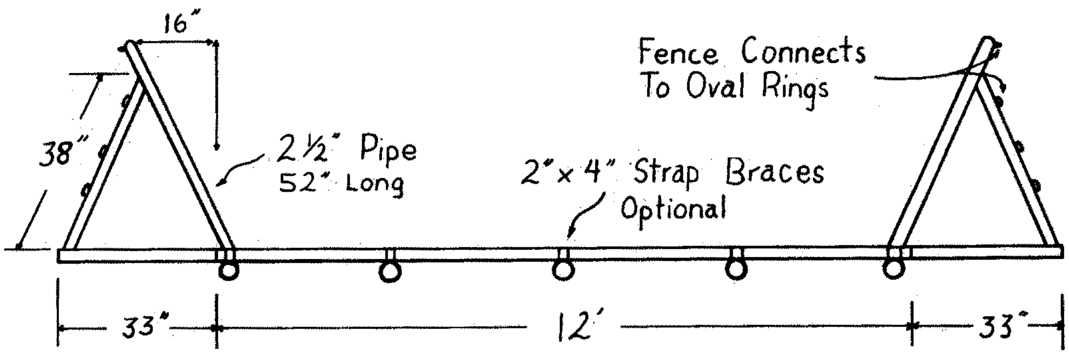

IMPLEMENT WHEEL
CONCRETE FILL
55 GALLON DRUM ABOUT 23" DIAMETER
PLUG ALL OPENINGS IN TOP OF DRUM. THESE MUST BE WATER TIGHT
VANE
16" OPENING
PLAN VIEW
36"
10"
16"
3/8" BOLTS
16 TO 20 GAGE SHEET METAL VANE
9
12
TWO 3/16" X 1 1/2" STEEL STRAPS
3/16" X 1 1/2" STEEL STRAP 40" LONG
3/8" BOLTS WITH WASHERS INSIDE OF DRUM
55 GALLON DRUM
THREE 3/16"X1 1/2" X 6" STEEL STRAPS BOLTED TO DRUM & WELDED* TO WHEEL RIM
13 1/2"
3"
20" OPENING
APPROX 25"
ROLL BOTTOM EDGE OF VANE FOR STIFFENING AND TO REDUCE CHANCE OF INJURY
THE FEEDER DRUM SWIVELS ON AN OLD AUTOMOBILE FRONT WHEEL AND AXLE UNIT WHICH IS WELDED TO THE HUB OF IMPLEMENT WHEEL OR ANCHORED INTO THE CONCRETE FILL
OLD IMPLEMENT WHEEL ABOUT 28" DIA. FILLED WITH CONCRETE
SELF-TAPPING SCREW
*ALTERNATE DETAIL
SIDE ELEVATION
PERSPECTIVE VIEW
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
"WEATHERVANE" MINERAL FEEDER
FOR CATTLE
CALIF.
EX. 5844
SHEET 1 OF 1

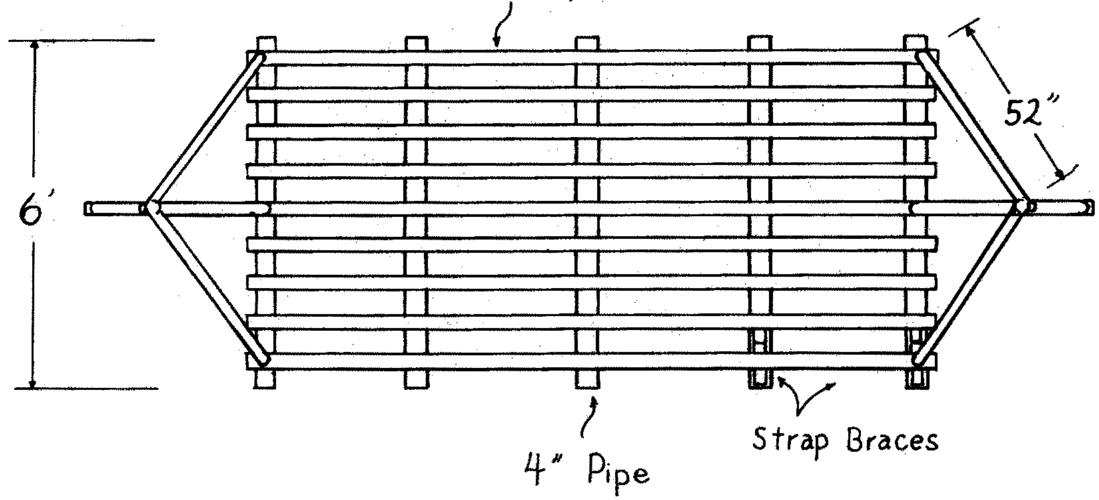
Cattle Guard

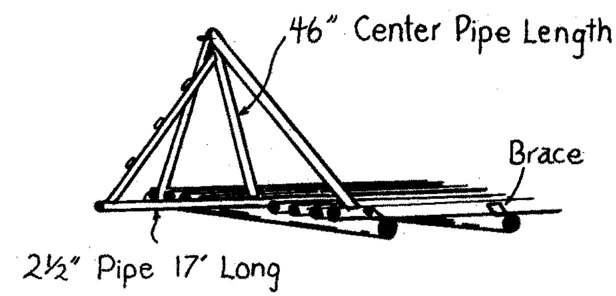
Scale: 1/2"=1'

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

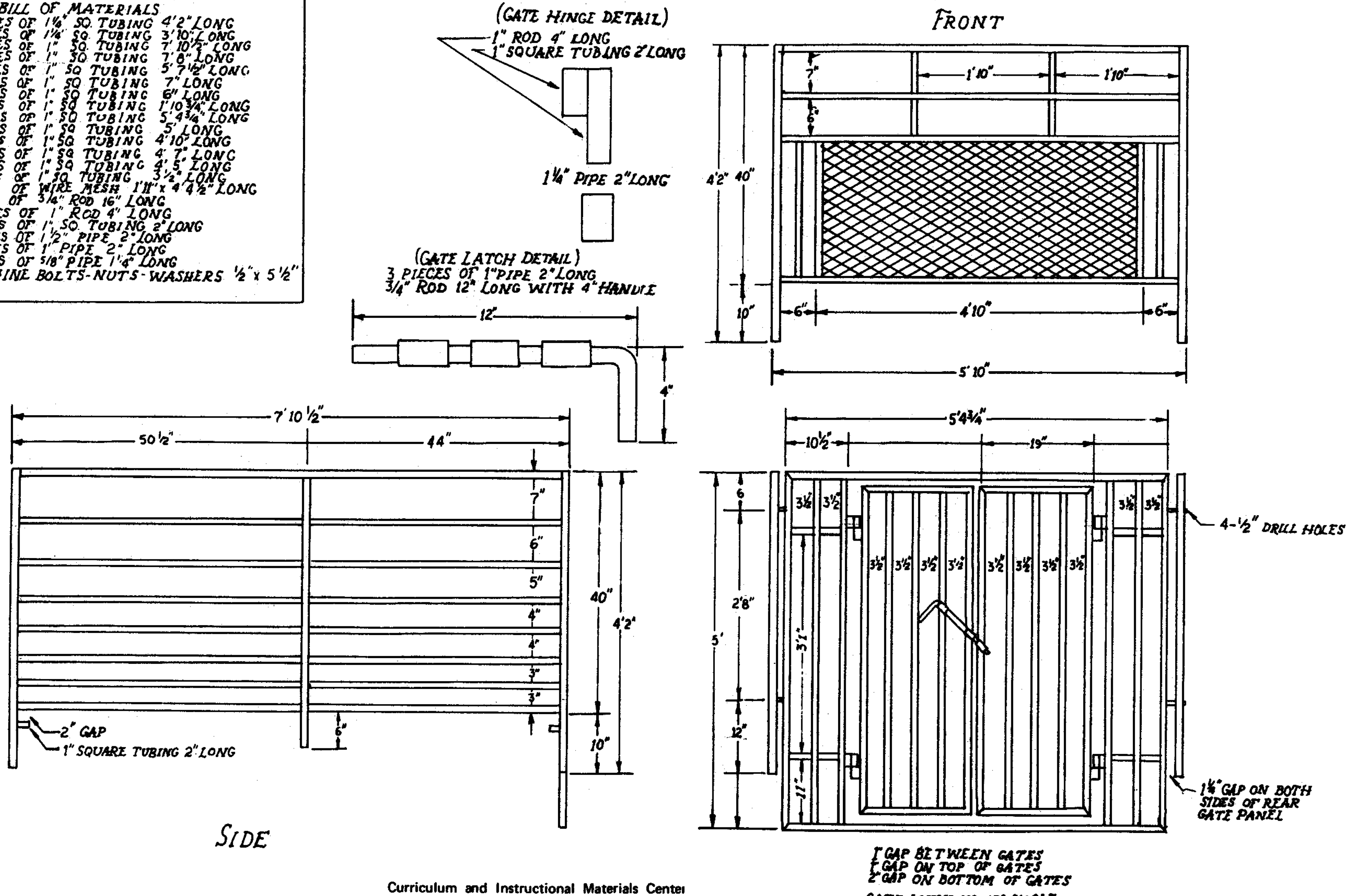
Rea

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 3/4" 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"

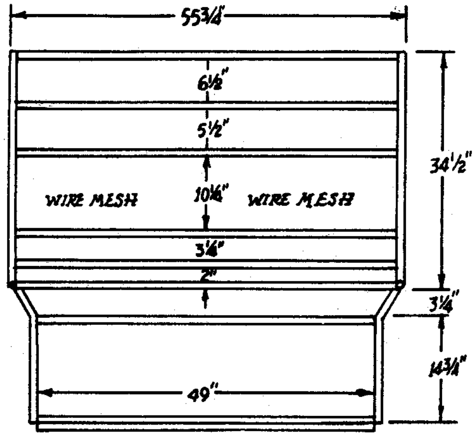


Courtesy of Vinoss
Vocational Agriculture Department

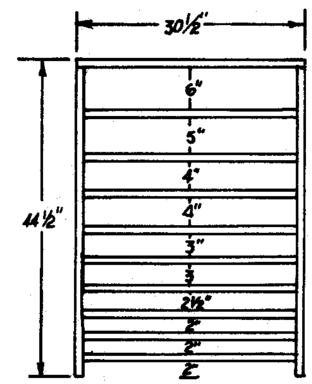
Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

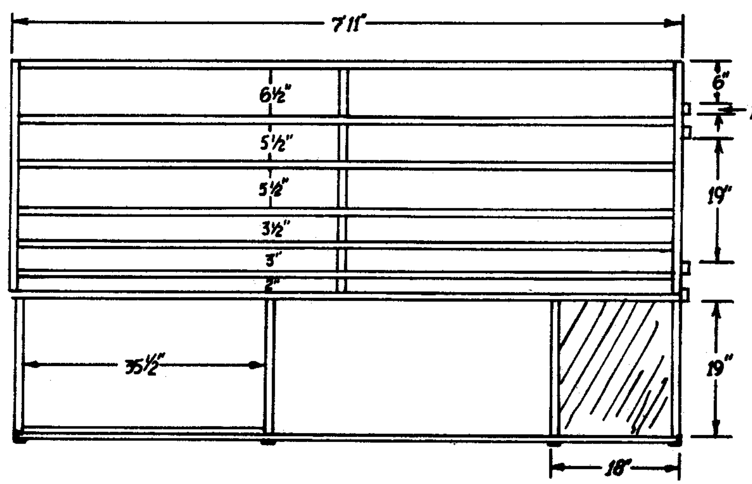
Pickup Stock Racks

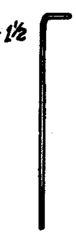
Scale: ¾" = 1'

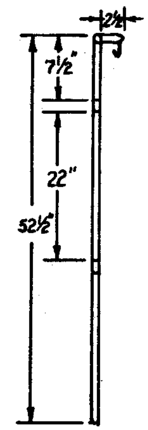


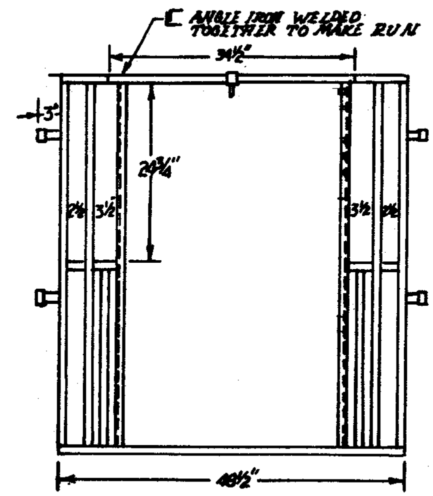
BILL OF MATERIAL*
4 SQUARE FEET OF EXPANSION STEEL
4 SQUARE FEET OF 18 GUAGE SHEETMETAL
8' OF 1" STRAP IRON
12-2½" ROUND HEAD STOVE BOLTS
24' OF 1"x6" FENCING LUMBER
7' OF ¼" PIPE
265' OF ¾" PIPE











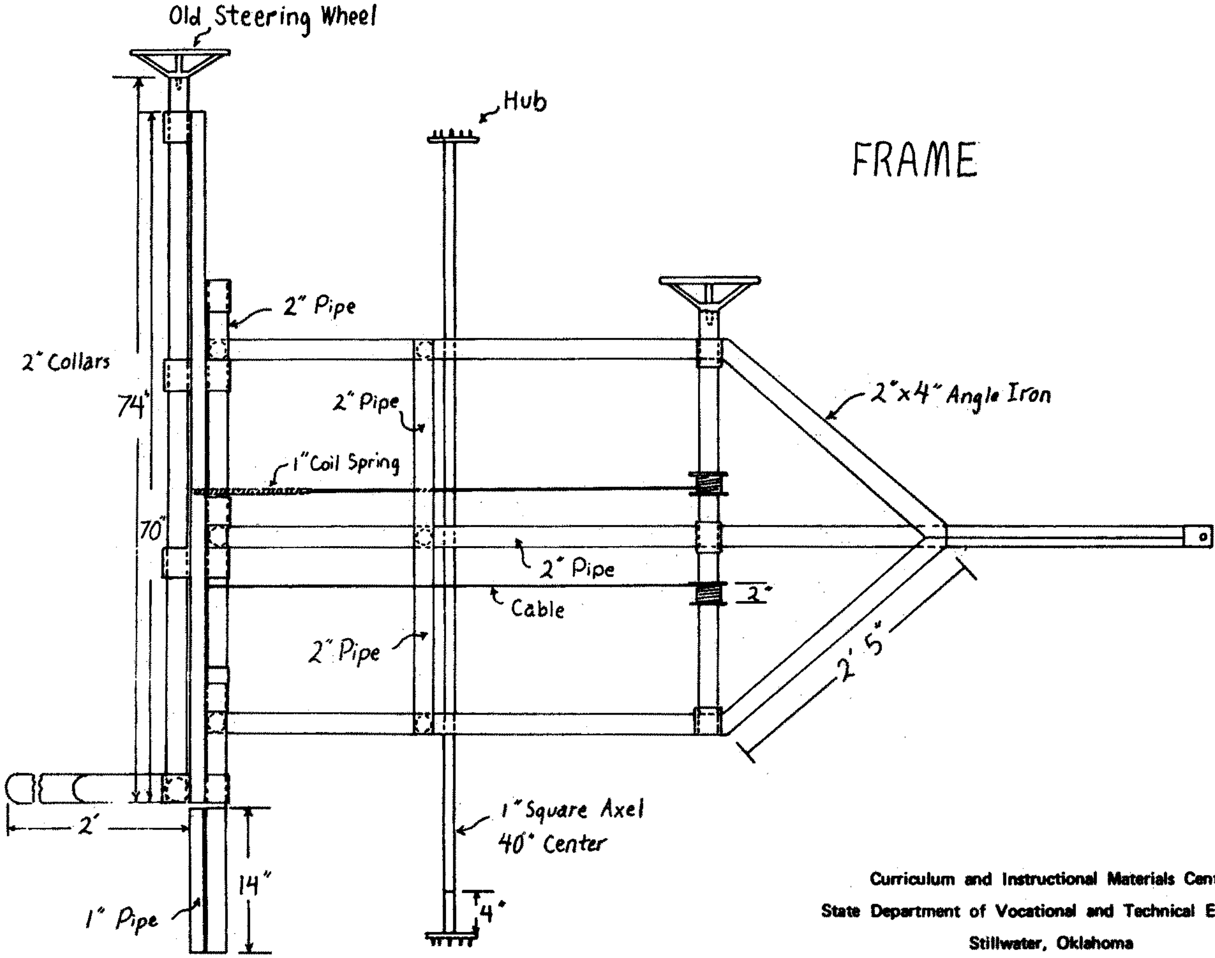
Courtesy of Guthrie
Vocational Agriculture Department

Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

DRAWN BY: JOHN McEACHERN

Tilting Calf Hoof Trimming Table

Scale: 1"=1'

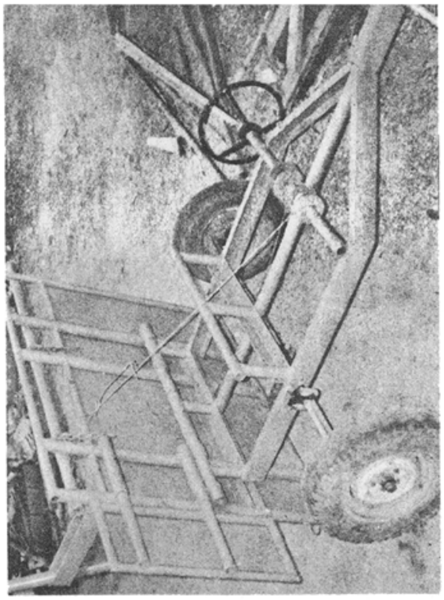


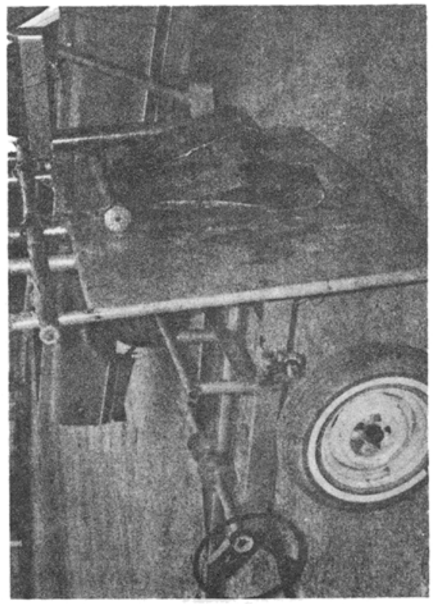
BILL OF MATERIAL

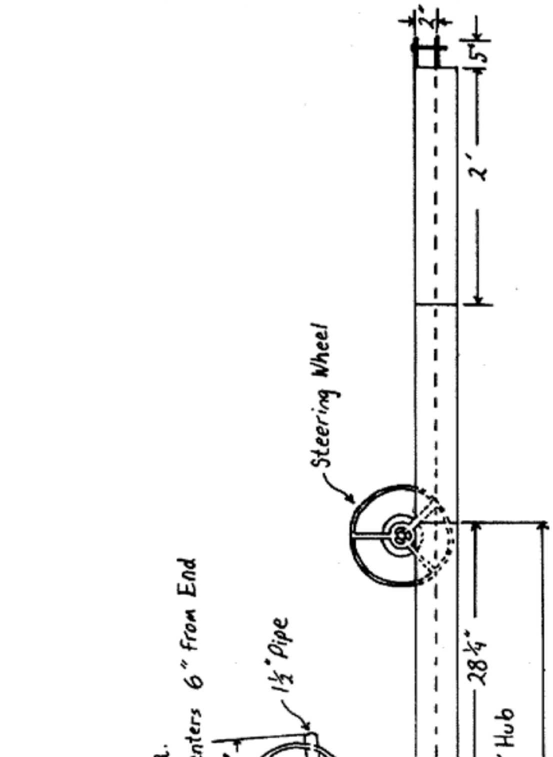
1 Piece of Sheet Metal 6' x 4'
1 Piece of 2" Pipe 32" Long
1 Piece of Sheet Metal 4' x 16"
4 Pieces of 1 1/2" Pipe 6' Long
6 Pieces of 1 1/2" Pipe 4' Long
2 Pieces of 1 1/2" Pipe 16" Long
2 Pieces of 1 1/2" Pipe 36" Long
2 Pieces of 1 3/4 Pipe 28" Long
12 Pieces of 1 3/4 Pipe 4" Long
1 Piece of 2" Pipe 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

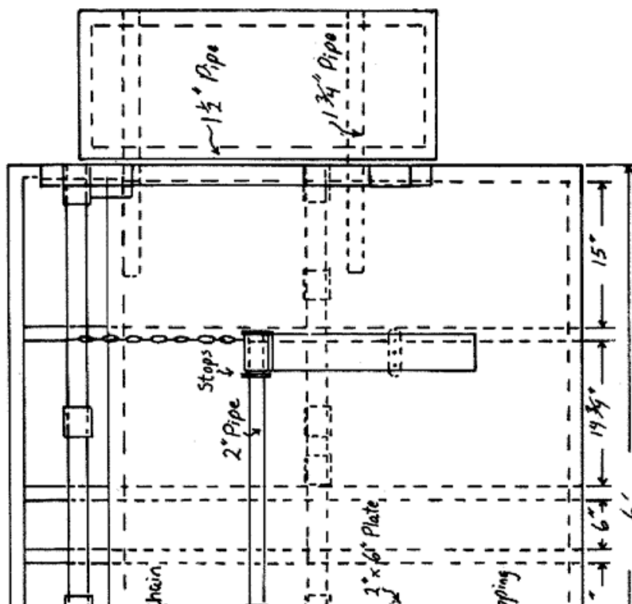
Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

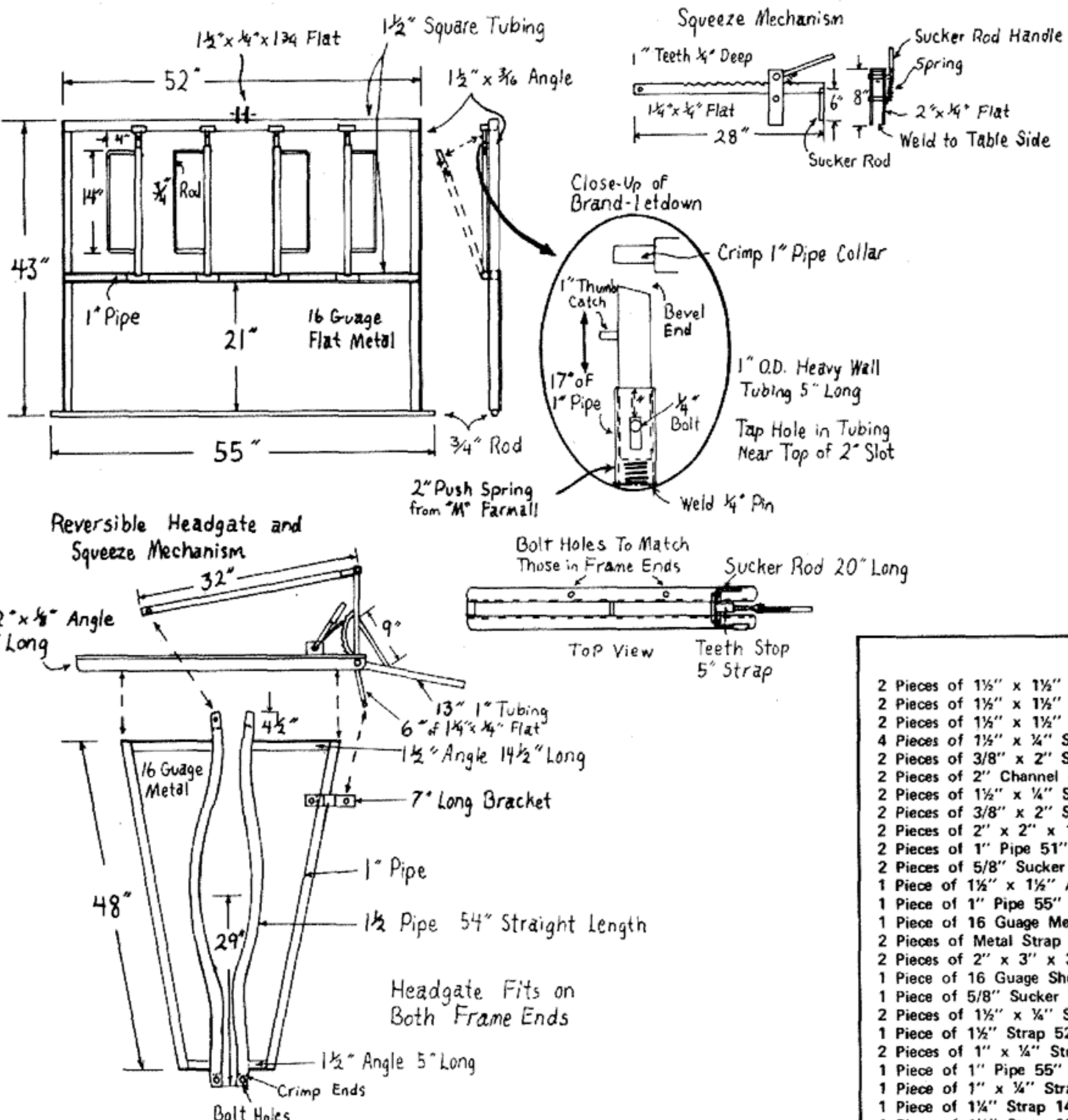
Courtesy of Davis
Vocational Agriculture Department

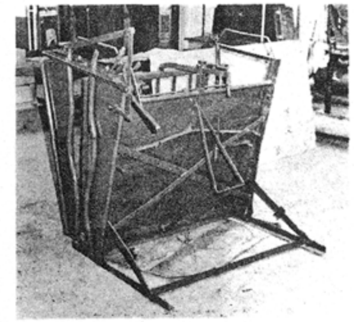


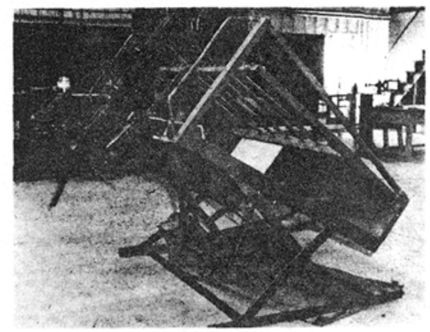



Steering Wheel
¼" Dia.
2" Centers 6" From End
1½" Pipe
Hub
4"x6" Bracket
2" Pipe
28¼"
53½"
9½"
2'


1½" Pipe
1¾" Pipe
Stops
2" Pipe
Chain
5" Stripping
15"
14¾"
11½"
16½"
6'





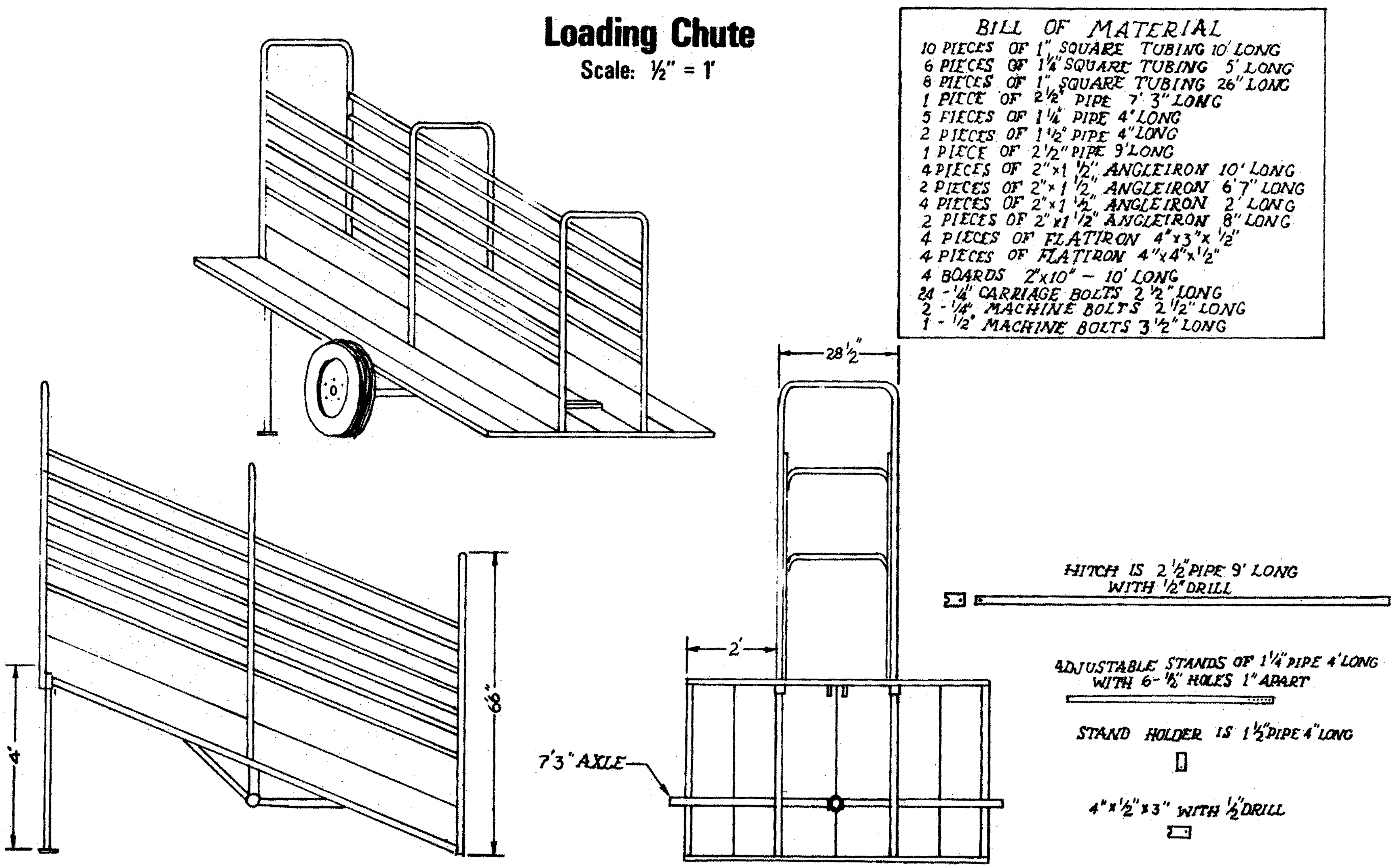


BILL OF MATERIAL

2 Pieces of 1½" x 1½" Angle Iron 55½" Long	1 Piece of 16 Guage Sheet Metal 21" x 52"
2 Pieces of 1½" x 1½" Angle Iron 45" Long	1 Piece of 1½" Square Tubing 52" Long
2 Pieces of 1½" x 1½" Angle Iron 4" Long	1 Piece of ¾" Rod 55" Long
4 Pieces of 1½" x ¼" Strap 7" Long	1 Piece of 1" Pipe 52" Long
2 Pieces of 3/8" x 2" Strap 29" Long	4 Pieces of 1" Pipe 17" Long
2 Pieces of 2" Channel 4" Long	4 Pieces of 1" O.D. Heavy Wall Tubing 5" Long
2 Pieces of 1½" x ¼" Strap 59" Long	4 Pieces of 1" Pipe Collar 1" Long
2 Pieces of 3/8" x 2" Strap 45½" Long	4 Pieces of ¼" Bolt & ¼" Pin
2 Pieces of 2" x 2" x 1/8" Angle Iron 28" Long	4 Pieces of 2" Push Spring
2 Pieces of 1" Pipe 51" Long	4 Pieces of ¾" Rod 22" Long
2 Pieces of 5/8" Sucker Rod 30" Long	2 Pieces of 1" Pipe 48" Long
1 Piece of 1½" x 1½" Angle Iron 52" Long	2 Pieces of 1½" Pipe 54" Long
1 Piece of 1" Pipe 55" Long	2 Pieces of 1½" Angle Iron 14½" Long
1 Piece of 16 Guage Metal 7" x 55"	2 Pieces of 1½" Angle Iron 5" Long
2 Pieces of Metal Strap 10" Long	1 Piece of 16 Guage Metal 28" x 48"
2 Pieces of 2" x 3" x 3/16" Angle Iron 50½" Long	1 Piece 1¼" x ¼ Flat 7" Long
1 Piece of 16 Guage Sheet Metal 55" x 41½"	2 Pieces of 2" x 2" x 1/8" Angle Iron 42" Long
1 Piece of 5/8" Sucker Rod 45" Long	1 Piece of ¾" Tubing 13" Long
2 Pieces of 1½" x ¼" Strap 7" Long	1 Piece of 1¼" x ¼" Flat 55" Long
1 Piece of 1½" Strap 52" Long	1 Piece of 5/8" Rod 20" Long
2 Pieces of 1" x ¼" Strap 27½" Long	1 Piece of 1¼" x ¼" Flat 28" Long
1 Piece of 1" Pipe 55" Long	1 Piece of 5/8" Rod 16" Long
1 Piece of 1" x ¼" Strap 40" Long	2 Pieces of 2" x ¼" Flat 8" Long
1 Piece of 1¼" Strap 14" Long	1 Piece of old Flywheel with Teeth
1 Piece of 1¼" Strap 20' Long	

Loading Chute

Scale: ½" = 1'



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'

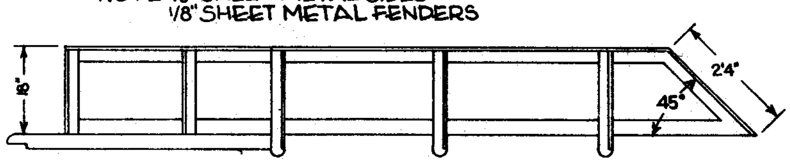
NOTE: CENTER OF AVELS ARE LOCATED
1/2" BACK OF CENTER FOR EVERY
FOOT OF LENGTH

TOTAL LENGTH: 12'
TOTAL WIDTH: 7'6"

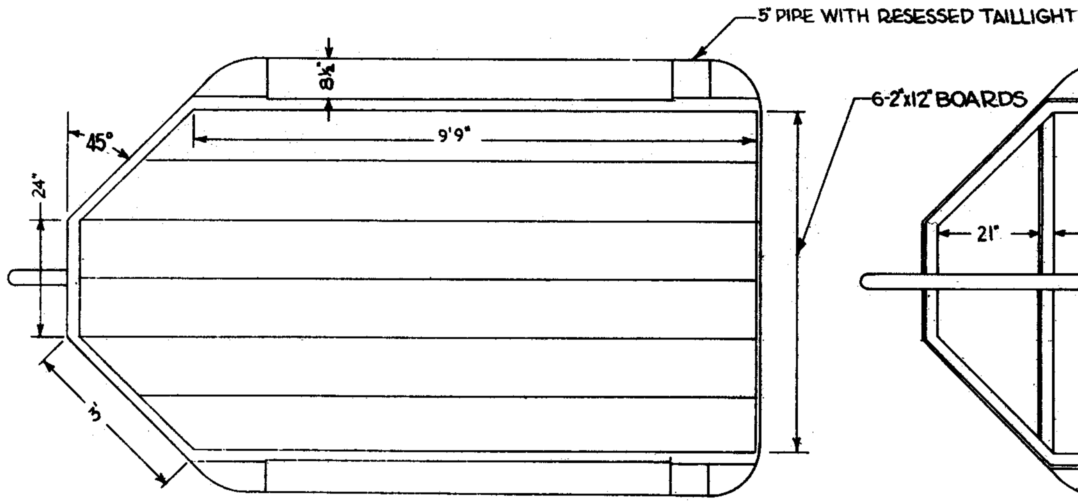
NOTE: 1/8" SHEET METAL SIDES
1/8" SHEET METAL FENDERS

BILL OF MATERIAL

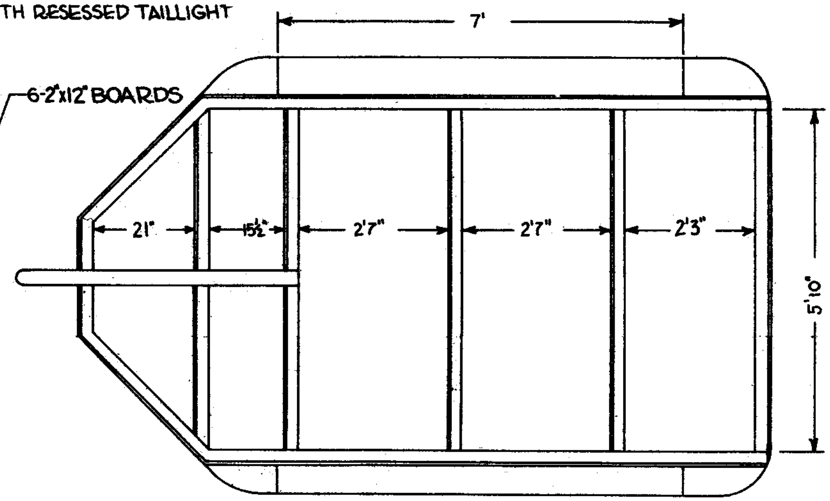
4 Pieces of 3" Angle Iron 10'1" Long
4 Pieces of 3" Angle Iron 3' Long
2 Pieces of 3" Angle Iron 2" Long
4 Pieces of 3" Angle Iron 6'2" Long
1 Piece of 3" Angle Iron 6' Long
10 Pieces of 3" Angle Iron 17 1/2" Long
2 Pieces of 3" Angle Iron 2'4" Long
2 Pieces of 1/8" Sheetmetal 7' X 8 1/2"
2 Pieces of 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



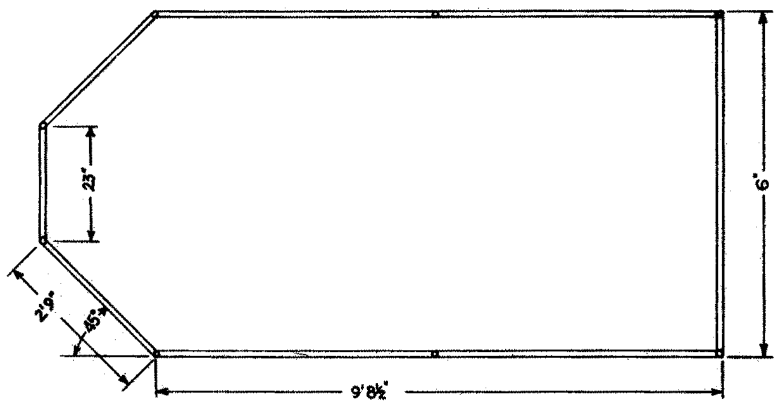
TOP VIEW



BOTTOM FRAME VIEW

Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

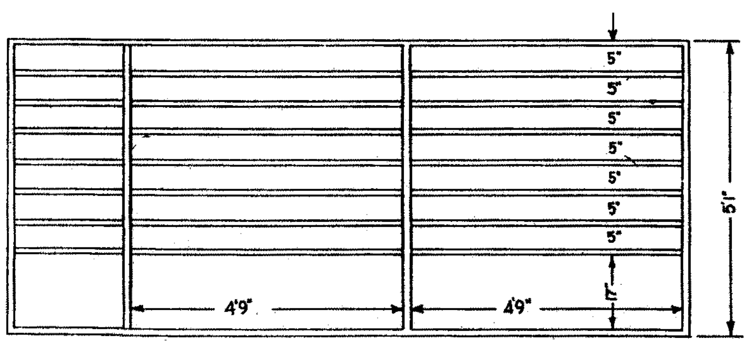
NOTE: ALL FRAME WORK-3" ANGLE IRON

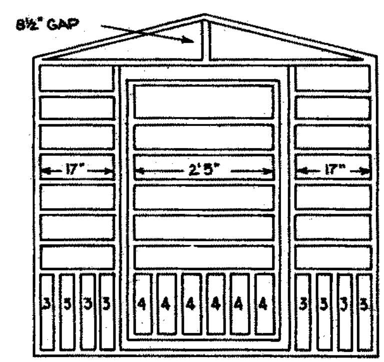


BILL OF MATERIAL

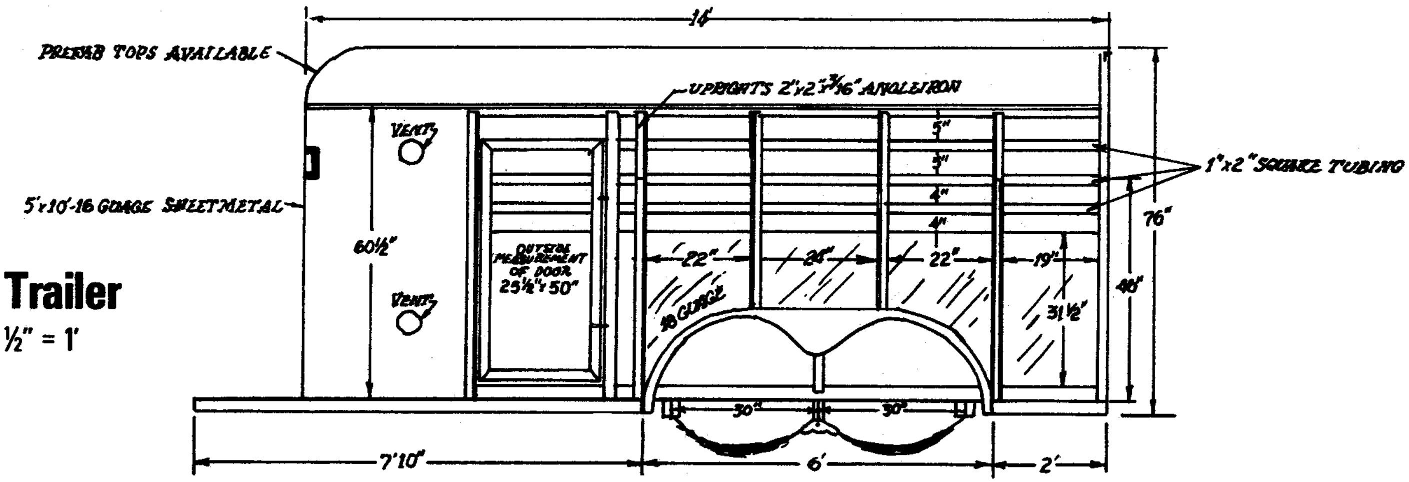
8 Pieces of 1" Pipe 5" Long
2 Pieces of 1" Pipe 4'1" Long
2 Pieces of 1" Pipe 4'6" Long
6 Pieces of 1" Pipe 17" Long
5 Pieces of 1" Pipe 1'2" Long
9 Pieces of 1" Pipe 23" Long
18 Pieces of 1" Pipe 2'9" Long
36 Pieces of 1" Pipe 4'9" Long
2 Pieces of 1" Pipe 5'10" Long
2 Pieces of 1" Pipe 2'7" Long
14 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'

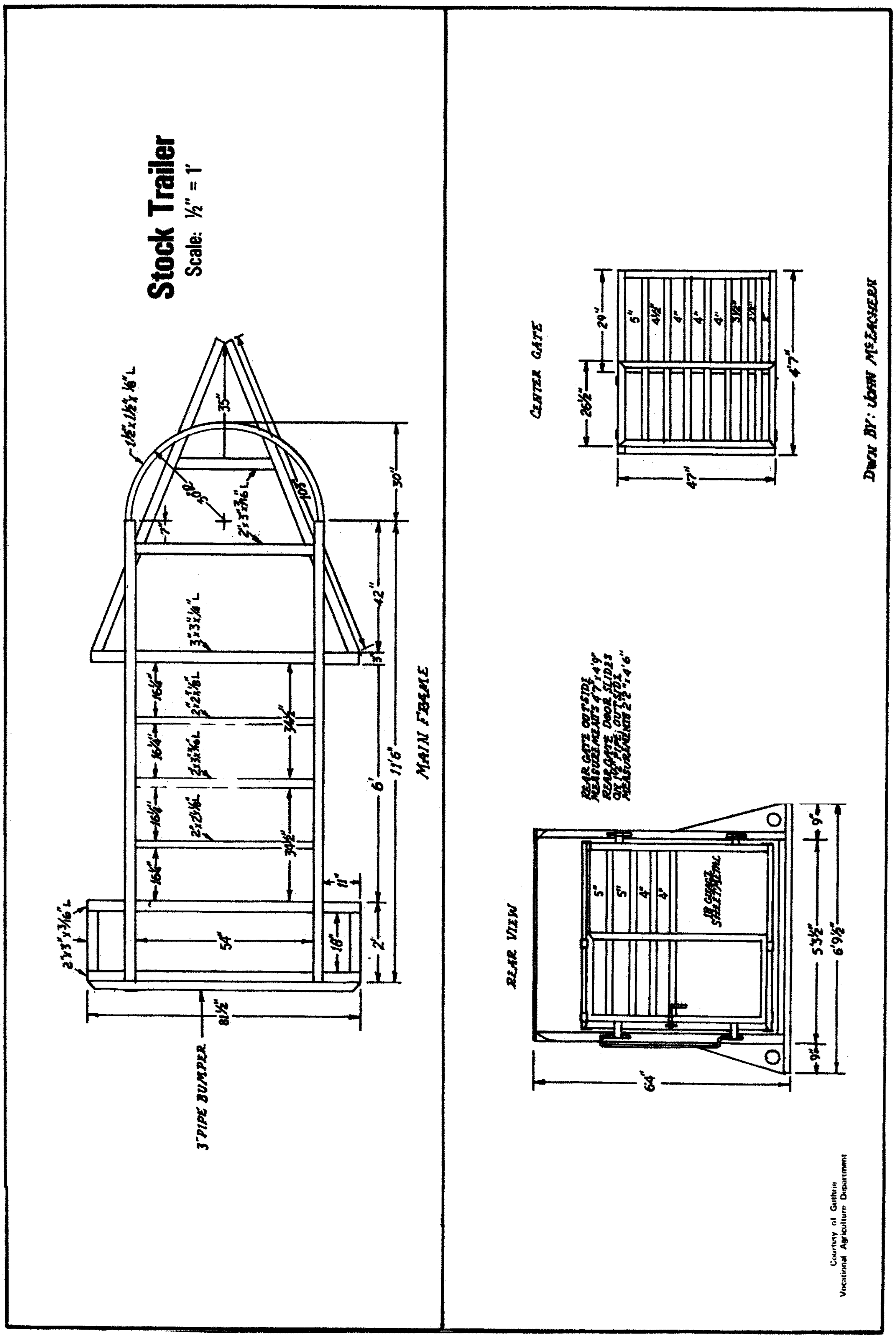
BILL OF MATERIAL

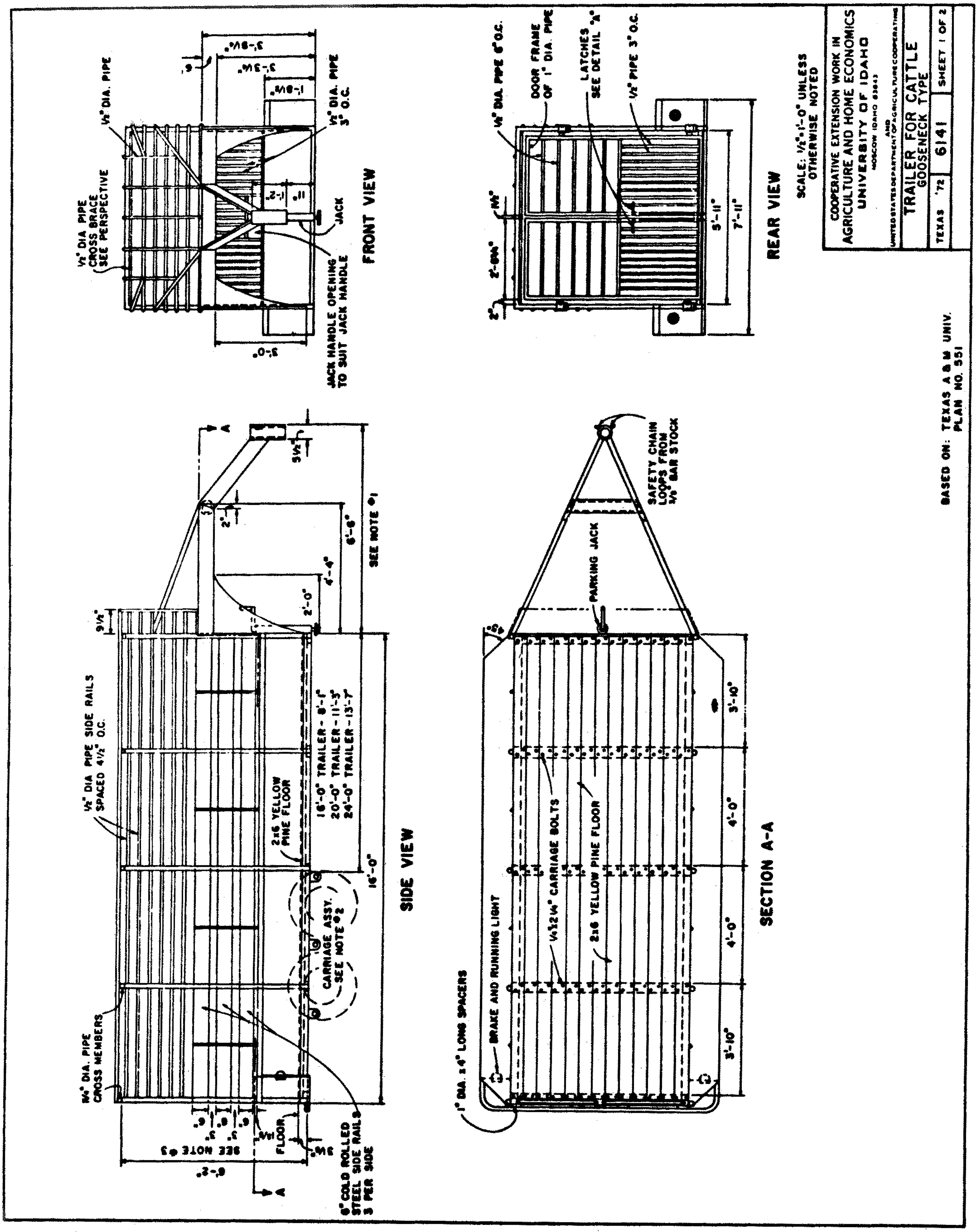
2 PIECES OF 3" ANGLEIRON 11'6" LONG
3 PIECES OF 3" ANGLEIRON 81½" LONG
2 PIECES OF 3" ANGLEIRON 103" LONG
2 PIECES OF 3" ANGLEIRON 54" LONG
2 PIECES OF 2" ANGLEIRON 54" LONG
1 PIECE OF 1½" ANGLEIRON 15'8½" LONG
1 PIECE OF 3" PIPE 81½" LONG
2 PIECES OF 2½" ANGLEIRON 6'1" LONG
1 PREFAB TOP
8 PIECES OF 2" ANGLEIRON 5' LONG
4 PIECES OF 2" ANGLEIRON 3'5" LONG
2 PIECES OF 2" ANGLEIRON 6' LONG
6 PIECES OF 1" SQ TUBING 4' LONG
2 PIECES OF 1"x2" SQ TUBING 4'9" LONG
2 PIECES OF 1"x2" SQ TUBING 4'7" LONG
2 PIECES OF 1"x2" SQ TUBING 4'6" LONG
2 PIECES OF 1"x2" SQ TUBING 2'2" LONG
1 PIECE OF 1"x2" SQ TUBING 4'5" LONG
6 PIECES OF 1"x2" SQ TUBING 1'10" LONG
8 BOARDS 2"x8"

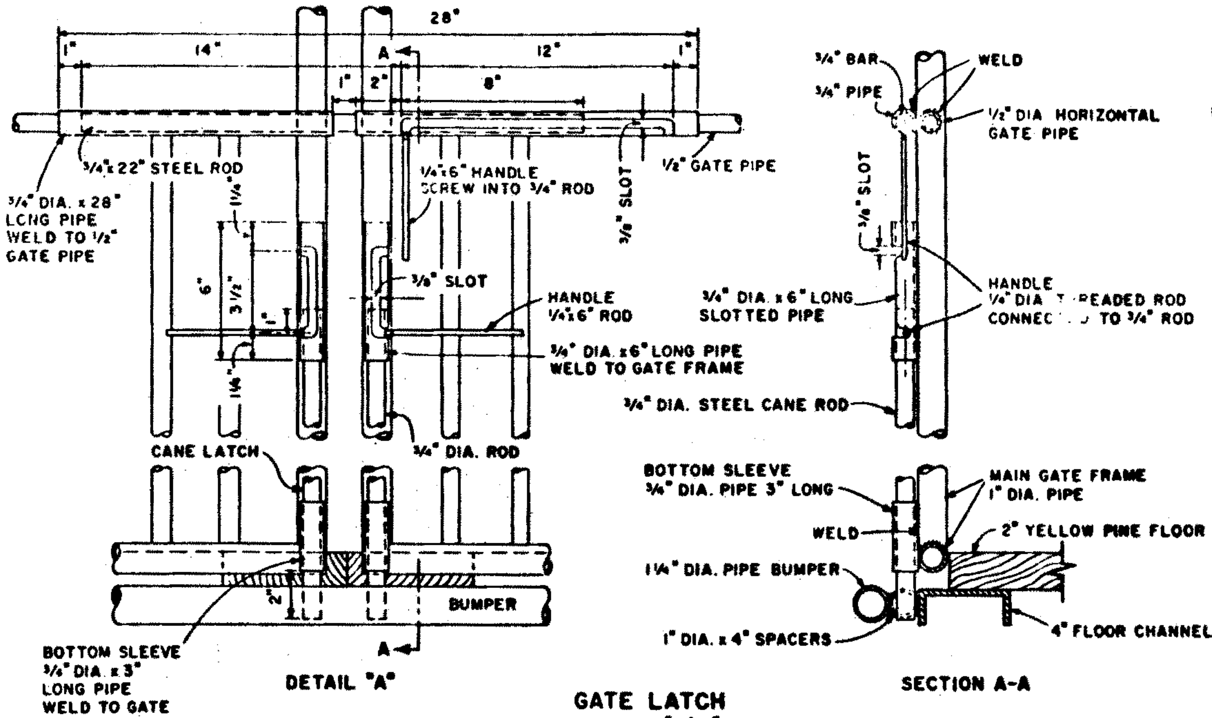
2 PIECES OF 1¼" PIPE 4'9" LONG
4 PIECES OF 1½" PIPE 1½" LONG
4 PIECES OF STRAPIRON 1½"x4"x3/8"
12 PIECES OF ¾" PIPE 1½" LONG
2 - ½" PINS 5" LONG
1 - ½" ROD 4' LONG
4 PIECES OF FLATMETAL 2½"x2½"
2 PIECES OF 1"x2" SQ TUBING 4'7" LONG
4 PIECES OF 1"x2" SQ TUBING 47" LONG
1 PIECE OF 1"x2" SQ TUBING 43" LONG
7 PIECES OF 1"x2" SQ TUBING 25" LONG
2 PIECES OF 1"x2" SQ TUBING 26½" LONG
7 PIECES OF 1"x2" SQ TUBING 22½" LONG
2 PIECES OF 1"x2" SQ TUBING 25½" LONG
2 PIECES OF 1"x2" SQ TUBING 50" LONG
2 PIECES OF 1"x2" SQ TUBING 21½" LONG
3 PIECES OF SHEETMETAL 2'x2'6"
1 PIECE OF SHEETMETAL 2'x2'4"
2 PIECES OF SHEETMETAL 8'6"x31½"
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
3" PIPE BUMPER
REAR VIEW
CENTER GATE
Courtesy of Guthrie
Vocational Agriculture Department


FRONT VIEW
1/2" DIA PIPE CROSS BRACE SEE PERSPECTIVE
1/2" DIA. PIPE
1/2" DIA. PIPE 3" O.C.
JACK
JACK HANDLE OPENING TO SUIT JACK HANDLE
REAR VIEW
1/2" DIA. PIPE 6" O.C.
DOOR FRAME OF 1" DIA. PIPE
LATCHES SEE DETAIL "A"
1/2" PIPE 3" O.C.
SCALE: 1/2"=1'-0" UNLESS OTHERWISE NOTED
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
SIDE VIEW
1/2" DIA PIPE SIDE RAILS SPACED 4 1/2" O.C.
2x6 YELLOW PINE FLOOR
16'-0" TRAILER - 8'-1"
20'-0" TRAILER - 11'-5"
24'-0" TRAILER - 13'-7"
SEE NOTE #1
CARRIAGE ASSY. SEE NOTE #2
1 1/4" DIA. PIPE CROSS MEMBERS
SEE NOTE #3
FLOOR
6" COLD ROLLED STEEL SIDE RAILS 3 PER SIDE
SECTION A-A
SAFETY CHAIN LOOPS FROM 1/4" BAR STOCK
PARKING JACK
1/4"x2 1/4" CARRIAGE BOLTS
2x6 YELLOW PINE FLOOR
BRAKE AND RUNNING LIGHT
1" DIA. x 4" LONG SPACERS
BASED ON: TEXAS A&M UNIV. PLAN NO. 551



DETAIL "A"

SECTION A-A

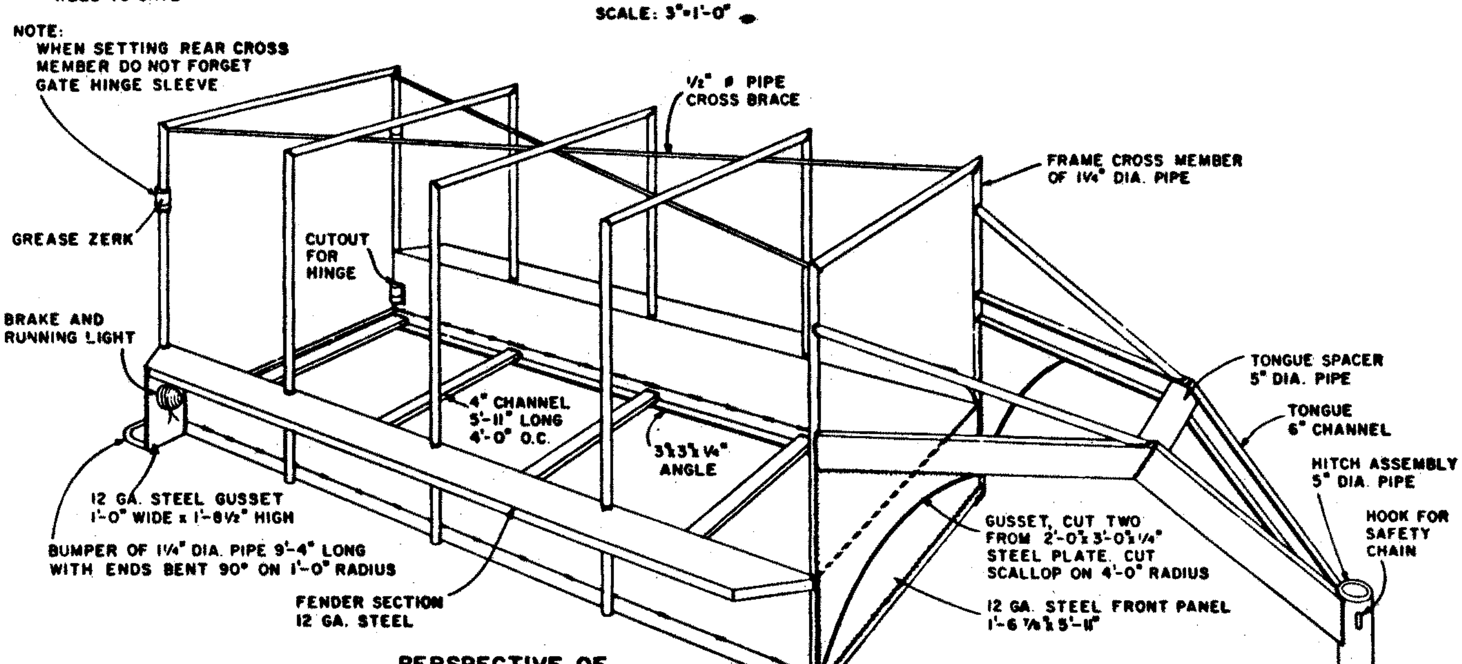
GATE LATCH
SCALE: 3"=1'-0"

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

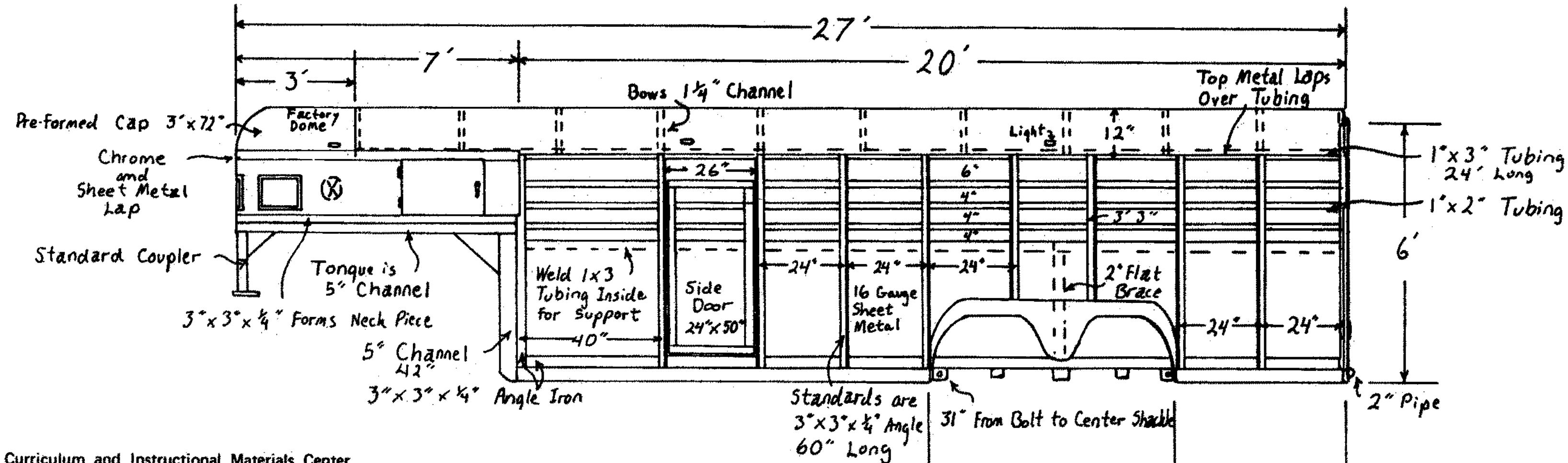
COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS
UNIVERSITY OF IDAHO
MOSCOW IDAHO 83843
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

TRAILER FOR CATTLE
GOOSENECK TYPE

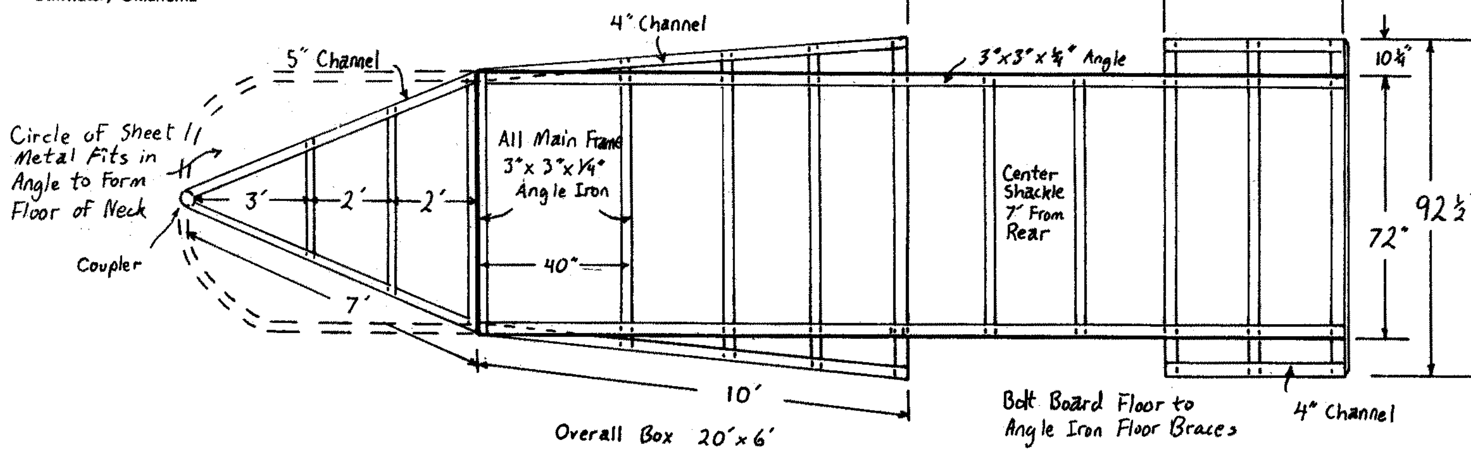
TEXAS '72	6141	SHEET 2 OF 2

Gooseneck Stock Trailer

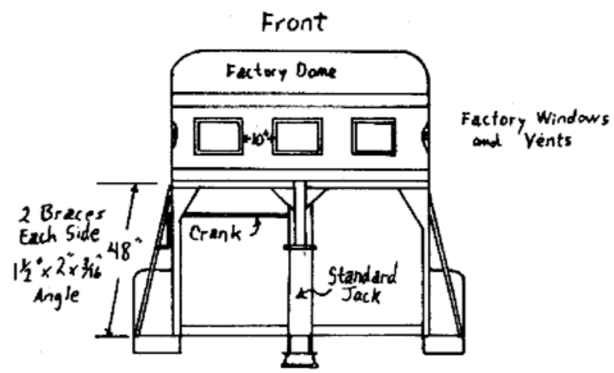
Scale: 3/8"=1'

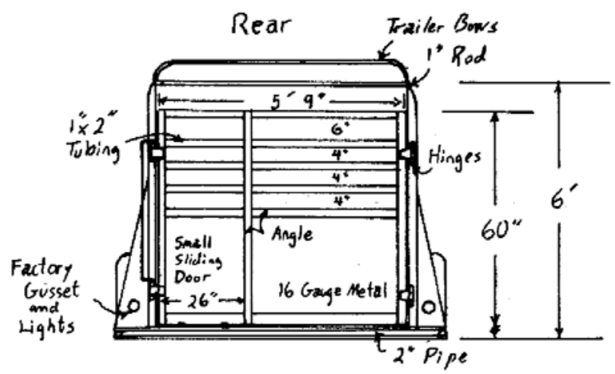


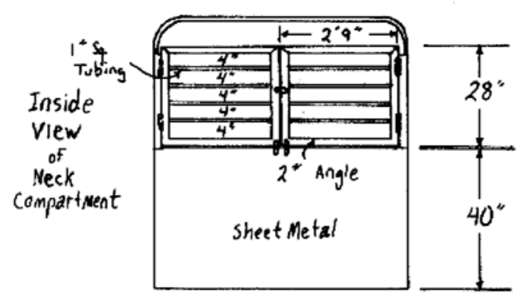
Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma



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