

## Lesson A5–8

---

# Applying Tungsten Inert Gas (TIG) Welding Techniques

---

**Unit A.** Mechanical Systems and Technology

**Problem Area 5.** Metal Fabrication

**Lesson 8.** Applying Tungsten Inert Gas (TIG) Welding Techniques

### **New Mexico Content Standard:**

**Pathway Strand:** Power, Structural and Technical Systems

**Standard: VIII:** Plan, implement, manage, and/or provide support services to facility design and construction; equipment design, manufacture, repair, and service; and agricultural technology.

**Benchmark: VIII-B:** Follow architectural and mechanical plans to construct building and facilities.

**Performance Standard: 3.** Construct with wood and metal.

**Student Learning Objectives.** Instruction in this lesson should result in students achieving the following objectives:

1. Explain the advantages and developments of the Tungsten Inert Gas (TIG) welding process.
2. Describe applications for the Tungsten Inert Gas (TIG) welding process.
3. Explain how the Tungsten Inert Gas (TIG) welding process works.
4. Identify the types of Tungsten Inert Gas (TIG) welding equipment and accessories and relate their function.
5. Identify the types of shielding gases used for Tungsten Inert Gas (TIG) welding and explain their purposes.
6. Explain the procedures used for Tungsten Inert Gas (TIG) welding.
7. Identify the safety practices that should be observed in TIG welding.

**List of Resources.** The following resources may be useful in teaching this lesson:

**Recommended Resources.** One of the following resources should be selected to accompany the lesson:

Burke, Stanley R., and T.J. Wakeman. *Modern Agricultural Mechanics*. Danville, Illinois: Interstate Publishers, Inc., 1992. (Textbook, Chapter 7)

Minnick, William H. *Gas Tungsten Arc Welding Handbook*. Tinley Park, Illinois: The Goodheart-Willcox Company, Inc., 1996.

Phipps, Lloyd J., and Carl Reynolds. *Mechanics in Agriculture*. Danville, Illinois: Interstate Publishers, Inc., 1992. (Textbook, Chapter 13)

**Other Resources.** The following resources will be useful to students and teachers:

Tungsten Inert Gas Welding (VAS 3036). University of Illinois, Urbana, Illinois: ITCS Instructional Materials.

## List of Equipment, Tools, Supplies, and Facilities

Writing surface  
Overhead projector  
Transparencies from attached masters  
Copies of student lab sheet  
TIG/GTA welder and welding accessories  
Steel pieces

**Terms.** The following terms are presented in this lesson (shown in bold italics):

Centerless ground electrode  
Clean finished electrode  
Duty cycle  
Flowmeter  
Polarity  
Postweld purge time

**Interest Approach.** Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

*Show students welds that have been done with fuel-gas, arc, MIG, and TIG welding. Do not tell them which process did each of them. Ask students to compare and contrast each of them. Lead a discussion on the advantages and disadvantages of each process.*

# Summary of Content and Teaching Strategies

**Objective I:** Explain the advantages and developments of the Tungsten Inert Gas (TIG) welding process.

**Anticipated Problem:** What are the advantages of using the Tungsten Inert Gas (TIG) welding process? What advancements have led to the development of the TIG welding process?

- I. The Tungsten Inert Gas (TIG) welding process fuses metals by heating them between a non-consumable tungsten electrode and the base metal, while a continuous envelope of inert gas flows out around the tungsten electrode.
  - A. At one time, the American Welding Society called the process “tungsten inert gas welding.” The letters “TIG” were used to designate the process.
    1. Later, the definition was changed to “gas tungsten arc welding” and the letters “GTAW” came into popular use.
    2. Today, both of the letters and names are used.
  - B. The TIG process has several advantages that account for its popularity and increased use in the agricultural and welding industries.
    1. Welds made with a gas-shielded arc are more corrosion resistant, more ductile, and stronger because the gas is able to completely exclude atmospheric air from the welding zone. Welds are not weakened by slag inclusion in the bead because the flux used is a gas.
    2. The TIG welding process is known for its consistency in producing high quality welds.
    3. The welding process is easier than other methods because the weldor can clearly see the welding zone. There is a minimal amount of smoke, fumes, and sparks created by the TIG process.
    4. The finished weld requires little, if any, grinding or preparation before it can be painted.
    5. There is usually less distortion of the workpiece because of the small heat-affected zone.
    6. The TIG process has many applications because it can be used to make high quality welds in almost any metals and alloys.
    7. Welds can be made with the TIG process either by applying filler rod to the puddle or by fusing the base metal without a filler rod.
    8. TIG can be performed by both automatic and manual techniques.
    9. TIG may be done in all positions.
    10. TIG may be used on a wide range of metal thickness.

Use text material to strengthen student understanding of concepts. Chapter 7 in *Modern Agricultural Mechanics*, Chapter 13 in *Mechanics in Agriculture, Part 1 in Tungsten Inert Gas (TIG) Welding (VAS 3036)* and Chapter 1 and 2 in *Gas Tungsten Arc Welding handbook* are recommended.

**Objective 2:** Describe applications for the Tungsten Inert Gas (TIG) welding process.

**Anticipated Problem:** What are the applications for the Tungsten Inert Gas (TIG) process?

- II. With the technological developments made in TIG equipment, it is now the most versatile of all the fusion welding processes.
  - A. The TIG process can be used to join most metals. It welds aluminum and magnesium and their alloys, alloy steels, carbon steels, stainless steels, copper, nickel and nickel alloys, titanium, tin, silicon, aluminum bronzes, and cast iron.
  - B. The TIG process can be adapted for welding in the horizontal, vertical, and overhead positions as well as the flat position.
    1. It is used extensively in applications where weld quality is critical, such as stainless steel piping systems.
    2. One limitation of the TIG welding process is the low deposition rate of the filler and metal. The TIG process will deposit less filler metal per pass than of the other processes. Because of the increased time needed to complete welds on thick metal, the TIG process is used most often on thinner metals.

Use text material to strengthen student understanding of concepts. Chapter 7 in *Modern Agricultural Mechanics*, Chapter 13 in *Mechanics in Agriculture, Part 1 in Tungsten Inert Gas (TIG) Welding (VAS 3036)* and Chapter 1 and 2 in *Gas Tungsten Arc Welding Handbook* are recommended.

**Objective 3:** Explain how the Tungsten Inert Gas (TIG) welding process works.

**Anticipated Problem:** How does the Tungsten Inert Gas (TIG) process work?

- III. In the TIG process, an arc is struck between the non-consumable tungsten electrode and the workpiece.
  - A. The thickness of the metal and the type of current being used determine the size of the tungsten electrode.
  - B. The possible currents available are Direct Current Straight Polarity (DCSP), Alternating Current (AC), or Direct Current Reverse Polarity (DCRP).
  - C. The arc is covered by a layer of shielding gas which acts as the flux and keeps the nitrogen and oxygen in the air from coming in contact with the molten puddle. When the puddle is formed on the base metal, the torch is moved along the joint until the workpiece is fused together.
    1. A filler rod may or may not be used.
    2. If a filler rod is used, it should be the same composition as the base metal. The filler rod is fed manually into the leading edge of the puddle.

3. The torch may be moved in a semicircular motion to vary the width of the bead.
- D. The movement of the TIG torch and applying filler rod is similar to the movement used in braze welding with an oxy-fuel gas torch.

Use TM: A5–8A to illustrate the TIG welding process. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts. Chapter 7 in *Modern Agricultural Mechanics*, Chapter 13 in *Mechanics in Agriculture*, Part 1 in *Tungsten Inert Gas (TIG) Welding (VAS 3036)* and Chapter 1 and 2 in *Gas Tungsten Arc Welding Handbook* are recommended.

**Objective 4:** Identify the types of Tungsten Inert Gas (TIG) welding equipment and accessories and relate their function.

**Anticipated Problem:** What are the types of Tungsten Inert Gas (TIG) equipment and accessories and what is their function?

- IV. The equipment used for TIG is somewhat different from that used in stick welding and much different from that used in MIG welding.
  - A. A weldor should know that with certain accessories a regular AC, DC, or AC/DC welding machine can be fitted for TIG welding.
    1. The heat energy put into the metal being welded is dependent upon the amperage, arc voltage, and polarity of the arc. The term **polarity** is used in describing DC welding circuits and refers to the direction of current flow.
    2. Direct current flowing from the electrode (–) to the workpiece (+) is direct current straight polarity, or DCSP.
    3. Current which flows from the workpiece (–) to the electrode (+) is direct current reverse polarity, or DCRP.
  - B. Most TIG welding is done with AC or DCSP current.
    1. When welding with AC, the machine will be either balanced or unbalanced.
    2. With AC machines, the current, in theory, flows in DCSP half of the time and DCRP half of the time.
    3. When the current flows in the DCRP half of the cycle, the current is flowing from the workpiece to the electrode, causing a high resistance to current flow. This resistance makes the tungsten electrode heat up. The resistance occurs because the current is flowing from a large conductor, the base metal, to a concentrated point in the tungsten electrode.
    4. When in the DCSP half of the cycle, the current is flowing from the electrode tip, a small conductor, to the workpiece, a large conductor. This direction of current flow has a cooling effect on the tungsten and enhances its current-carrying capacity.
    5. When the AC machine does not compensate for the high resistance encountered in the DCRP part of the cycle, the sinewave is unbalanced.

- a. One-half of the time the voltage is higher than expected (DCSP), and one-half of the time the voltage is lower than expected (DCRP).
  - b. If the AC machine does not have the circuitry to balance the sinewave, do not set the amperage for more than 50 percent of its rated capacity, or machine damage may result.
  - c. AC machines designed specifically for TIG welding will have a balanced sinewave. These welders have a special circuit which compensates for the DCRP part of the cycle, and the voltages in both halves of the sinewave are equal.
6. Whether AC or DC is used for TIG welding, a high frequency (HF) unit must be built into the machine, or a portable one must be attached to it.
    - a. The high frequency unit produces high frequency voltage (several thousand volts) at a frequency of several million cycles per second.
    - b. The current in the high frequency circuit is only a fraction of an ampere.
    - c. Because of the high voltage and frequency, the current is carried on the surface of the conductor rather than penetrating throughout the conductor.
    - d. When TIG welding with DC current, the high frequency unit must be on in order to start the arc. Once the arc is stabilized, the high frequency unit is turned off.
  7. On DC machines using an add-on portable high frequency unit, the high frequency circuit will need to be turned off manually.
  8. On AC machines TIG welders with high frequency units are used to stabilize the arc and to ionize gases in the arc zone. The ionized gases make the arc easier to maintain when the current changes directions.
  9. The torches used on TIG welding outfits are electrical devices and have a duty-cycle rating.
  10. The **duty-cycle** is the maximum current that the torch can safely withstand over a 10 minute period of operation.
  11. TIG welding torches contain electrical leads from the welding machine, water-coolant hoses, shielding gas hose, the collet, which holds the tungsten electrode, the electrode cap, and gas nozzle.
  12. The weldor should make sure all connections and fittings are tight.
  13. Small capacity TIG welding torches will usually be air-cooled rather than water-cooled.
  14. The purpose of the gas nozzles on TIG welding torches is to direct the flow of shielding gas over the welding zone and to decrease turbulence of the shielding gas stream.
  15. The volume of gas required and the width of the bead will determine the size of the nozzle needed.
    - a. The shapes of some nozzles are designed to decrease turbulence of the gas stream.
    - b. With some nozzles, the electrode may stick out as much as 1 inch without loss of the shielding gas and turbulence.
-

16. Nozzles are made from ceramic, metal, plastic, and Pyrex glass materials.
  - a. Ceramic nozzles are used on jobs up to 275 amps.
  - b. Metal nozzles or metal-coated ceramic nozzles are used on jobs where 300 or more amps of current are needed.
  - c. High-temperature plastic and Pyrex glass are transparent and are used in some special applications.
17. The electrodes used in TIG welding may be pure tungsten, tungsten with 1 or 2 per cent thoria, tungsten with 0.15 to 0.40 per cent zirconia, or pure tungsten with a core of 1 to 2 per cent thoria.
  - a. Pure tungsten electrodes are the least expensive. However, they have less current-carrying capacity and are easily contaminated. This makes them the least desirable for critical welds.
  - b. To improve the electrical conductivity, add small amounts of thoria or zirconia.
  - c. Electrodes with 1 or 2 per cent thoria have good current-carrying capacity, maintain their shape longer, have good resistance to contamination, and make the arc easier to strike.
  - d. Electrodes with 1 per cent thoria are good for general purpose welds. Two per cent thoriated electrodes are used for critical welds on aircraft, missiles, nuclear reactors, and heat exchangers.
18. The quality of the tungsten-zirconia electrodes is between pure tungsten electrodes and the tungsten-thoria electrodes.
19. Electrodes may be purchased with a clean finish or a centerless ground finish.
  - a. **Clean-finished electrodes** have a smooth surface, are free of defects, and are good for most GTAW jobs.
  - b. **Centerless ground electrodes** have a mirror-like finish and are used on jobs where the highest-quality welds are needed.
20. When selecting an electrode, consider the following criteria: electrode diameter, amperage, type of current, type of shielding gas, and whether the high frequency wave is balanced or unbalanced.
21. Electrodes must be shaped and sized before being used for TIG welding.
22. Electrodes which are contaminated or those which are too long to fit into the electrode cap must be shortened.
23. The desired shape of an electrode after it is properly broken is a square, blunt edge.
  - a. Electrodes may be broken with pliers, wire cutters, or a hammer.
  - b. The electrode end must be correctly shaped after it has been broken.
24. Some TIG welding jobs call for an electrode with a specific shape, which are used for critical welds.
25. For most TIG welding jobs, a sharp, pointed electrode is used for welding with DCSP current, and a rounded, or balled, electrode end is used for welding with alternating current.

26. The **flowmeter** is used to adjust the flow of shielding gas and is calibrated in cu. ft. per hour (cfh) or liters per minute (L/min.), or both. To get a correct reading of the volume of gas flow, the flowmeter must be installed so it is vertical.
27. Water-cooled TIG welding units have three hoses going to the torch.
  - a. One hose will carry the shielding gas and is made of plastic to prevent chemical reactions that might cause contamination.
  - b. One hose carries a combination of coolant and the electrode lead. The lead is a woven metal tube with good current-carrying capacity. The tube is covered by rubber or plastic-insulating material. Current travels through the woven metal tube, and coolant passes through the middle of the tube.
  - c. The third hose carries the return coolant to the storage reservoir or to a drain.
28. Light-duty torches are air-cooled and usually have only one hose connected to them, which is a combination electrode lead and shielding gas hose. The electrode lead may be either a woven tube or a flexible cable, and the shielding gas acts to cool the electrode lead as it flows to the torch.

Use TM: A5–8B, A5–8C, A5–8D and A5–8E to illustrate current flow, torch parts, prepared tungstens, and a flowmeter. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts. Chapter 7 in *Modern Agricultural Mechanics*, Chapter 13 in *Mechanics in Agriculture*, Section 1 in *Tungsten Inert Gas (TIG) Welding (VAS 3036)* and Chapter 2 and 3 in *Gas Tungsten Arc Welding Handbook* are recommended.

**Objective 5:** Identify the types of shielding gases used for Tungsten Inert Gas (TIG) and explain their purposes.

**Anticipated Problem:** What are the types of shielding gases used for Tungsten Inert Gas (TIG) and what are their purposes?

- V. The purpose of a shielding gas in TIG welding is to protect the arc, electrode, and puddle from nitrogen, oxygen, and hydrogen in the air.
  - A. When the arc, electrode, or puddle comes into direct contact with the air, contamination in the form of oxides is formed on the electrode and in the weld. A brownish-yellow fume from the weld zone indicates that the shielding gas cover has been lost and that oxides are forming.
  - B. The shielding gases used for TIG welding are mostly argon, helium, and mixtures of argon and helium.
    1. Argon is the most commonly used gas because it is cheaper and 10 times heavier than helium.
      - a. Argon is 1.4 times heavier than air and gives better control of the arc and weld puddle because it is a heavier gas than helium.
      - b. Since argon is heavy, lower flow rates are needed for welding in the flat position.

2. The heavy shielding gas is a disadvantage for welding in the overhead position.
  - a. Argon has a lower arc voltage than helium does at any given amperage and arc length. The low arc voltage produces less heat and results in low base metal distortion and reduced chance of burn through, which allows it to be used for welding thin sections of metal.
  - b. Argon has a quieter, smoother arc than that obtained with helium.
  - c. Helium shielding gas is used for welding thick sections of metal and when higher arc voltages and higher weld zone temperatures are needed.
- C. The major problems to be overcome in shielding are insufficient gas flow, long electrode extension, and not enough postweld purge time. **Postweld purge time** is the length of time the shielding gas continues to flow over the weld puddle after the arc has been extinguished. This allows the puddle to solidify before it is exposed to the air.

Use text material to strengthen student understanding of concepts. Chapter 7 in *Modern Agricultural Mechanics*, Chapter 13 in *Mechanics in Agriculture*, Section 1 in *Tungsten Inert Gas (TIG) Welding (VAS 3036)* and Chapter 5 in *Gas Tungsten Arc Welding Handbook* are recommended.

**Objective 6:** Explain the procedures used for Tungsten Inert Gas (TIG) welding.

**Anticipated Problem:** What procedures are used with Tungsten Inert Gas (TIG) welding?

- VI. The techniques used to perform TIG welds are quite similar to those used for braze welding with the oxy-fuel gas torch.
  - A. For TIG welding, the machine should be set on the smallest ampere setting that will get the job done. The welding speed should be as fast as possible.
    1. In TIG welding, the puddle is small and results in a small heat-affected zone. Since there is no transfer of metal through the arc, there is no spatter.
    2. The width of a TIG bead should be two to three times the diameter of the filler rod.
  - B. The TIG welding torch should be held at a 60 to 70 degree angle to the work. The filler rod should be at a 20 to 30 degree angle to the work.
    1. After the arc has been struck and the puddle has formed, add the filler rod to the leading edge of the puddle. When welding is stopped, the shielding gas should continue for a few seconds to prevent contaminating the molten puddle, tungsten electrode, and filler rod.
    2. A forehand welding technique is used for TIG welding. Most TIG welding is performed in the flat position.
  - C. Set the shielding gas flow according to the recommended volume for the size metal and gas nozzle being used.
  - D. Adjust the welding machine to the recommended amperage and type of current.
  - E. Place the foot control in a convenient location and turn on the welder.

- F. Depress the foot control and strike the arc. When the puddle appears, add the filler rod to the leading edge. By moving the TIG welding torch to the rear of the puddle when the filler rod is added, you reduce the possibility of contaminating the tungsten.
- G. Metal cleaning and joint preparation are the same for TIG welding as for other types of welding.
1. TIG welding is seldom used for metals over  $\frac{1}{4}$  inch, except for aluminum and magnesium.
  2. When metals are less than  $\frac{3}{16}$  inch, they may not require edge preparation.
  3. If the metals are thicker than  $\frac{3}{16}$  inch, the edges should be ground or machined so full bead penetration can be achieved.
- H. When welding a square butt joint, maintain the tungsten in the center line of the two pieces being joined.
1. Use a 60 to 70 degree drag angle, a 90 degree work angle, and a 20 to 30 degree electrode angle.
  2. Strike the arc and hold the tungsten approximately  $\frac{1}{8}$  inch above the base metal.
  3. When the puddle forms, add filler rod to the leading edge of the puddle.
  4. Move the bead forward as rapidly as possible.
- I. When welding lap and T-joints in the flat position, tack weld the base metal pieces every 3 inches.
1. The joints should then be set so the resulting welds are made in the flat position.
  2. Hold the torch at a 60 to 70 degree drag angle and a 10 to 20 degree work angle.
  3. The work angle should point the electrode more toward the horizontal edge to be welded than the vertical edge.
  4. Strike the arc and allow the puddle to form. A "C"-shaped puddle should develop indicating that both edges of the metal are melting.
  5. Hold the tungsten electrode approximately  $\frac{1}{8}$  inch above the base metal.
  6. When the puddle forms, move the electrode toward the rear of the puddle and then add the filler rod to the front of the puddle. Then, move the electrode back to the middle of the puddle. Repeat this process as you move the bead forward.
  7. When the end is reached, move the electrode toward the rear of the puddle to fill the crater with the filler rod and then withdraw it from the weld zone.
  8. Raise the TIG welding torch slowly to provide a gas shield while the puddle solidifies.
- J. For welding in the horizontal position, the drag angle of the torch should be 60 to 75 degrees and the work angle should be a 15 to 30 degree angle.
1. To keep the molten metal from sagging, maintain a smaller puddle than that used in the flat position.
  2. Add filler rod at the upper edge of the puddle to help prevent sagging.
  3. Maintaining a 15 to 30 degree work angle will help the force of the arc to keep the puddle from drooping.

Display TM: A5–8F and TM: A5–8G to illustrate TIG electrode position. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts. Chapter 7 in *Modern Agricultural Mechanics*, Chapter 13 in *Mechanics in Agriculture*, Section 1 in *Tungsten Inert Gas (TIG) Welding (VAS 3036)* and Chapter 10 in *Gas Tungsten Arc Welding Handbook* are recommended.

**Objective 7:** Identify the safety practices that should be observed in TIG welding.

**Anticipated Problem:** What are the safety practices that should be observed when TIG welding?

VII. Observe the following general safety practices for working with TIG welding.

- A. Obtain the instructor's permission before using any tool or machine.
- B. Wear a No. 11 or 12 shaded filter lens. The larger the tungsten electrode, the higher the lens shade number should be to prevent eye burn, strain, or fatigue.
- C. Good ventilation is essential for TIG welding. Ultraviolet rays may be 5 to 30 times more intense with TIG welding. These ultraviolet rays cause ozone to form. Ozone is harmful to breathe for extended time periods.
- D. Wear hearing protection when working with pulsed power and high current settings. Power pulses cause the arc to emit sound waves. Because the noise produced may be loud at high current pulses, hearing protection should be worn.
- E. Always wear gloves to insulate yourself from possible shock.
- F. Never touch the tungsten electrode with the filler rod. The tungsten electrode is charged with electric current, which may charge the filler rod and shock the person welding. The current potential at the tungsten electrode is at the arc voltage level or higher. A shock from the filler electrode could be deadly. To protect yourself from such a shock, wear gloves and dry clothing and never touch the tungsten electrode with the filler rod.
- G. Never touch your body with the tungsten electrode when the TIG welder is turned on. The high frequency unit built into the TIG welder is designed to stabilize the arc and to make arc starting easier. If touched while turned on, it will cause the unit to arc and can cause body burns. The danger of electrical shock is less with high frequency current than with current phasing at 60 cycles per second. The shock factor is reduced because high frequency current is conducted on the surface of the conductor rather than by penetrating into it. The surface conduction feature helps to minimize the danger for higher frequency current used in the TIG welding machine.
- H. Adjust the TIG high frequency unit only within the limits recommended by the manufacturer. This will help to reduce the possibility of shock and body burns.
- I. Make sure the TIG welder is grounded as recommended by the manufacturer in order to prevent shock.

Use text material to strengthen student understanding of concepts. Chapter 7 in *Modern Agricultural Mechanics*, Chapter 13 in *Mechanics in Agriculture*, Section 1 in *Tungsten Inert Gas (TIG) Welding (VAS 3036)* and Chapter 2 in *Gas Tungsten Arc Welding Handbook* are recommended.

**Review/Summary.** Focus the review and summary of the lesson around the student learning objectives. Call on the students to explain the content associated with each objective. Use their responses as the basis for determining any areas that need re-teaching. Questions at the end of each chapter in the recommended textbooks may also be used in the review/summary. Use the lab activities in reviewing and reinforcing student learning.

**Application.** Application can involve the following student activity using the attached lab sheet. It is understood that before attempting the lab activities, proper safety precautions in the agriculture mechanics shop must be covered thoroughly.

LS: A5–8A—TIG Welding Exercises

**Evaluation.** Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance, on the application activities. A sample written test is attached.

## **Answers to Sample Test:**

### **Part One: Matching**

1 = f, 2 = d, 3 = a, 4 = g, 5 = b, 6 = e, 7 = c

### **Part Two: Completion**

1. shielding gas
2. direct current straight polarity (DCSP)
3. ceramic, metal, plastic, Pyrex glass
4. tungsten electrode
5. nozzle
6. brownish-yellow

### **Part Three: Short Answer**

1. Electrode diameter, amperage, type of current, type of shielding gas, balanced or unbalanced frequency wave.
2. Corrosion resistant, more ductile and stronger, high quality welds, easier to weld due to seeing clearer, little preparation for painting, causes less distortion, welds almost any metal or alloy, welds can be made with or without filler rod, can be done with both automatic and manual techniques, done in all positions and on a wide range of metal thicknesses.

---

# Test

---

## Lesson A5–8: Applying Tungsten Inert Gas (TIG) Welding Techniques

### Part One: Matching

*Instructions.* Match the term with the correct response. Write the letter of the term by the definition.

- |                      |                 |             |
|----------------------|-----------------|-------------|
| a. argon             | d. clean finish | f. GTAW     |
| b. centerless ground | e. flowmeter    | g. polarity |
| c. clean finish      |                 |             |

- \_\_\_\_\_ 1. Gas tungsten arc welding.
- \_\_\_\_\_ 2. Maximum current that the torch can withstand over a 10 minute period of operation.
- \_\_\_\_\_ 3. Most commonly used gas because it is cheaper and 10 times heavier than helium.
- \_\_\_\_\_ 4. Refers to the direction the current flows.
- \_\_\_\_\_ 5. Electrodes have a mirror-like finish and are used where the highest quality welds are needed.
- \_\_\_\_\_ 6. Used to adjust the flow of shielding gas.

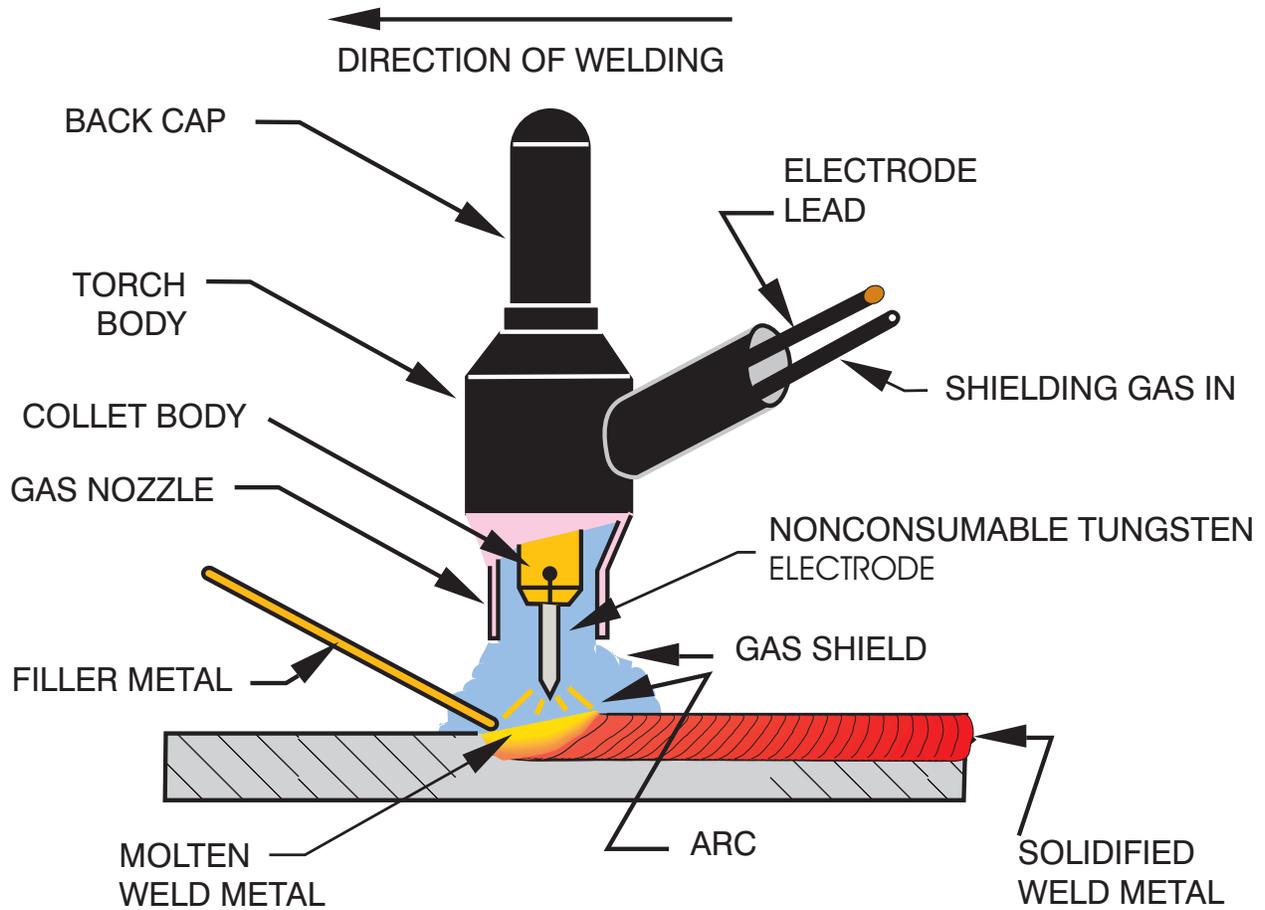
### Part Two: Completion

*Instructions.* Provide the word or words to complete the following statements.

1. The purpose of a \_\_\_\_\_ is to protect the arc, electrode, and puddle from the air.
2. Direct current flowing from the electrode to the workpiece is called \_\_\_\_\_.
3. Nozzles are made from \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_ materials.
4. The thickness of the metal and the type of current being used determine the size of the \_\_\_\_\_.
5. The volume of gas required and width of the bead will determine the size of the \_\_\_\_\_ needed.

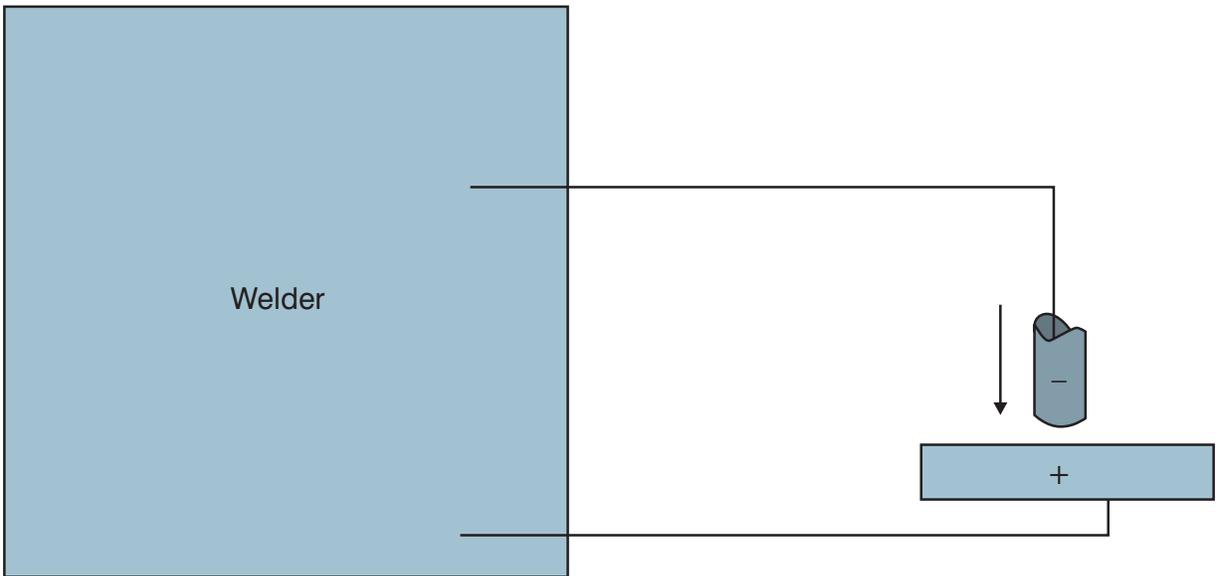


# TIG WELDING PROCESS

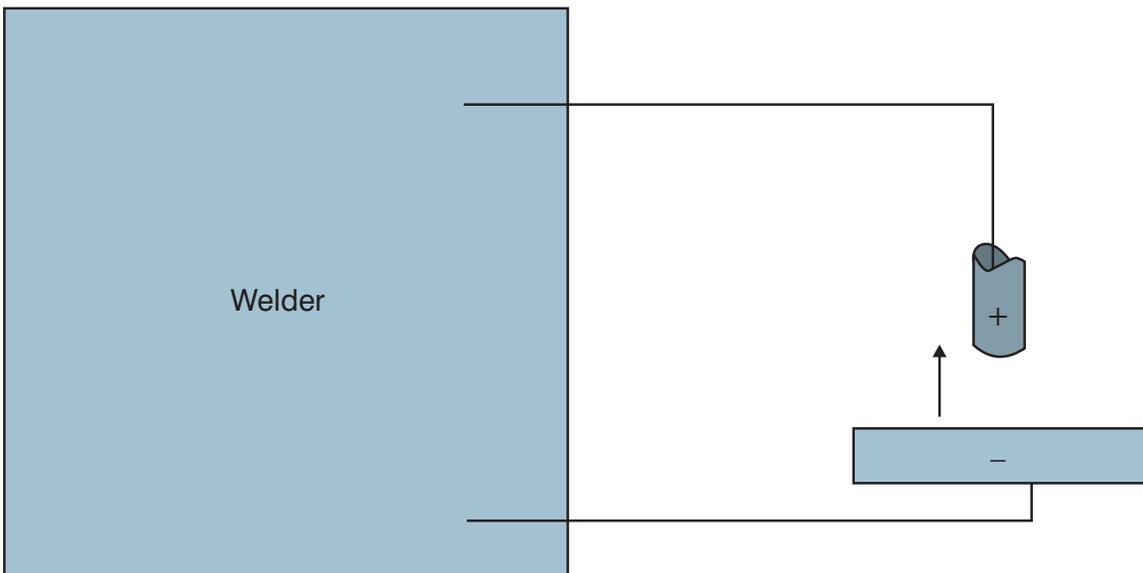


(Courtesy, Interstate Publishers, Inc.)

# CURRENT FLOW



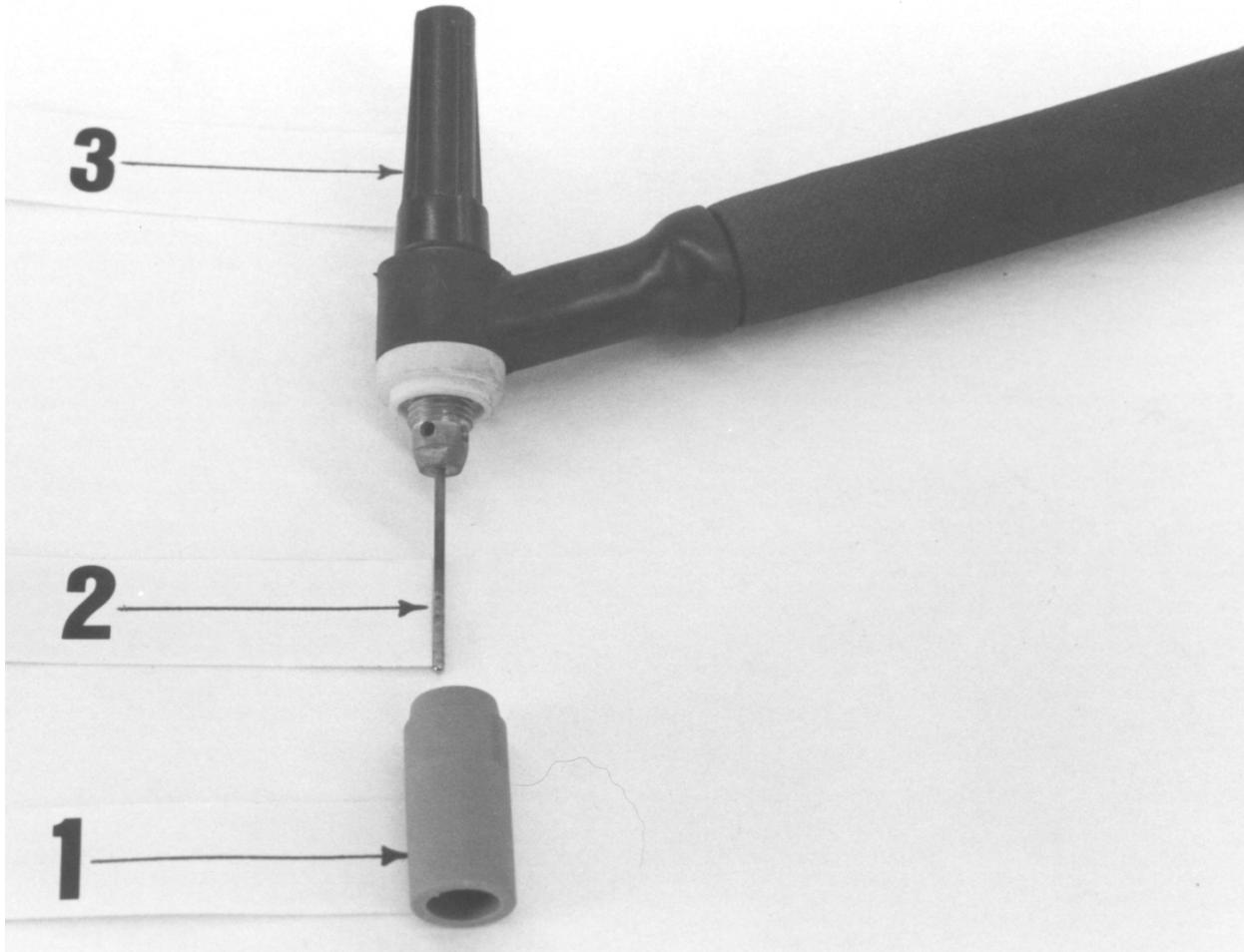
**Current flow in direct current straight polarity (DCSP) circuits.**



**Current flow in direct current reverse polarity (DCRP) circuits.**

*(Courtesy, Interstate Publishers, Inc.)*

# TIG TORCH PARTS



1. Nozzle

2. Electrode

3. Electrode Cap

*(Courtesy, Interstate Publishers, Inc.)*

# PREPARED TUNGSTENS

## Prepared Tungstens for AC and DCSP Current

AC  
Current



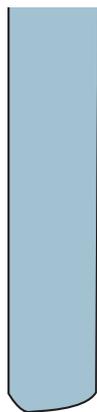
Balled

DCSP  
Current



Pointed

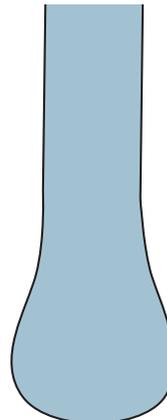
## Tungstens Balled for AC TIG Welding



Too Narrow



Correct Size

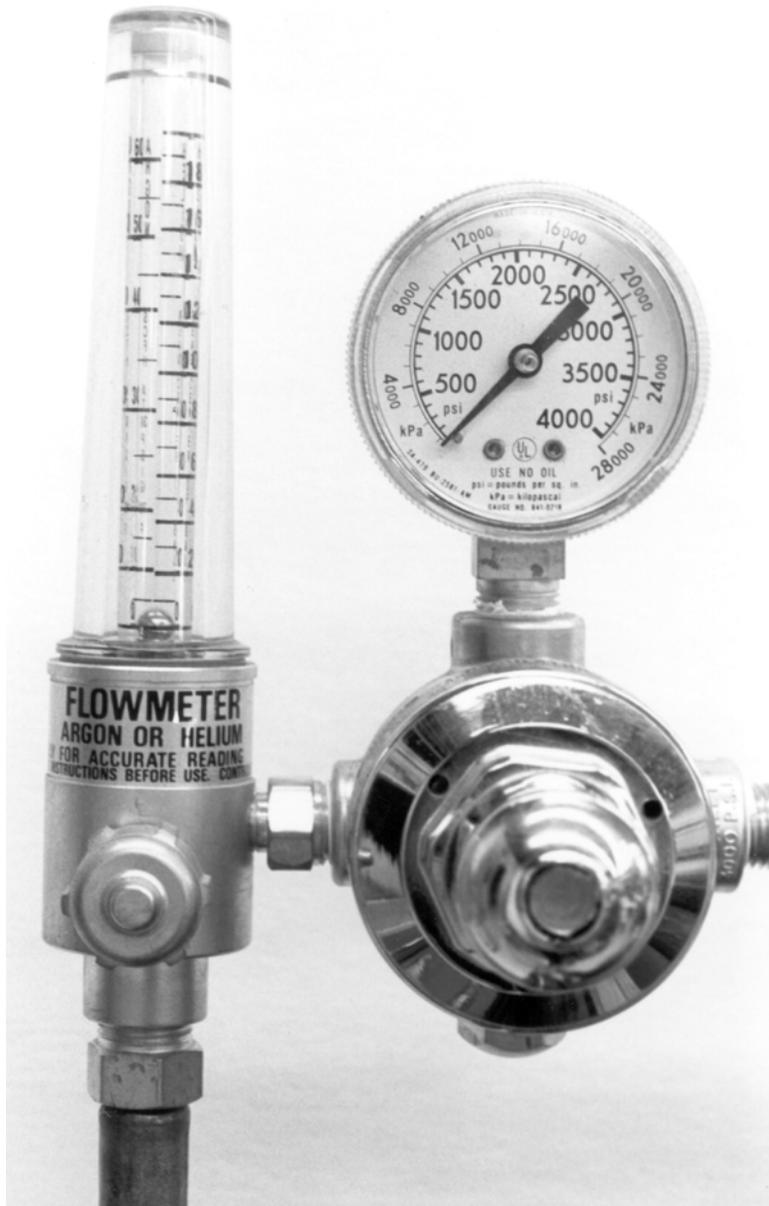


Too Large

*(Courtesy, Interstate Publishers, Inc.)*

TM: A5-8E

# FLOWMETER

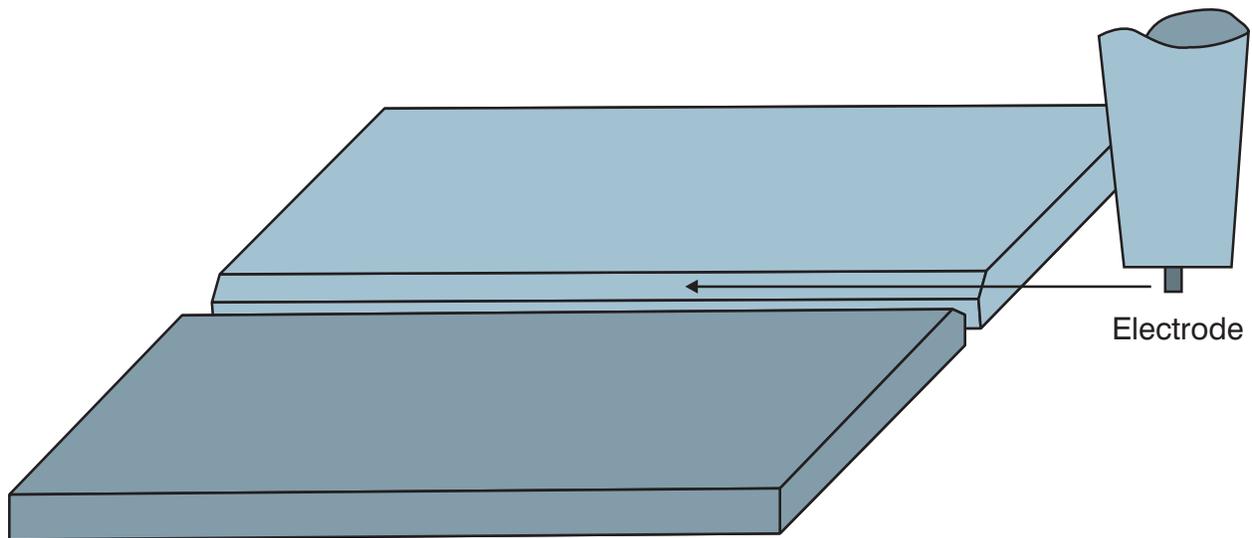


**Flowmeter and tank gauge for argon and helium shielding gases.**

*(Courtesy, Interstate Publishers, Inc.)*

TM: A5-8F

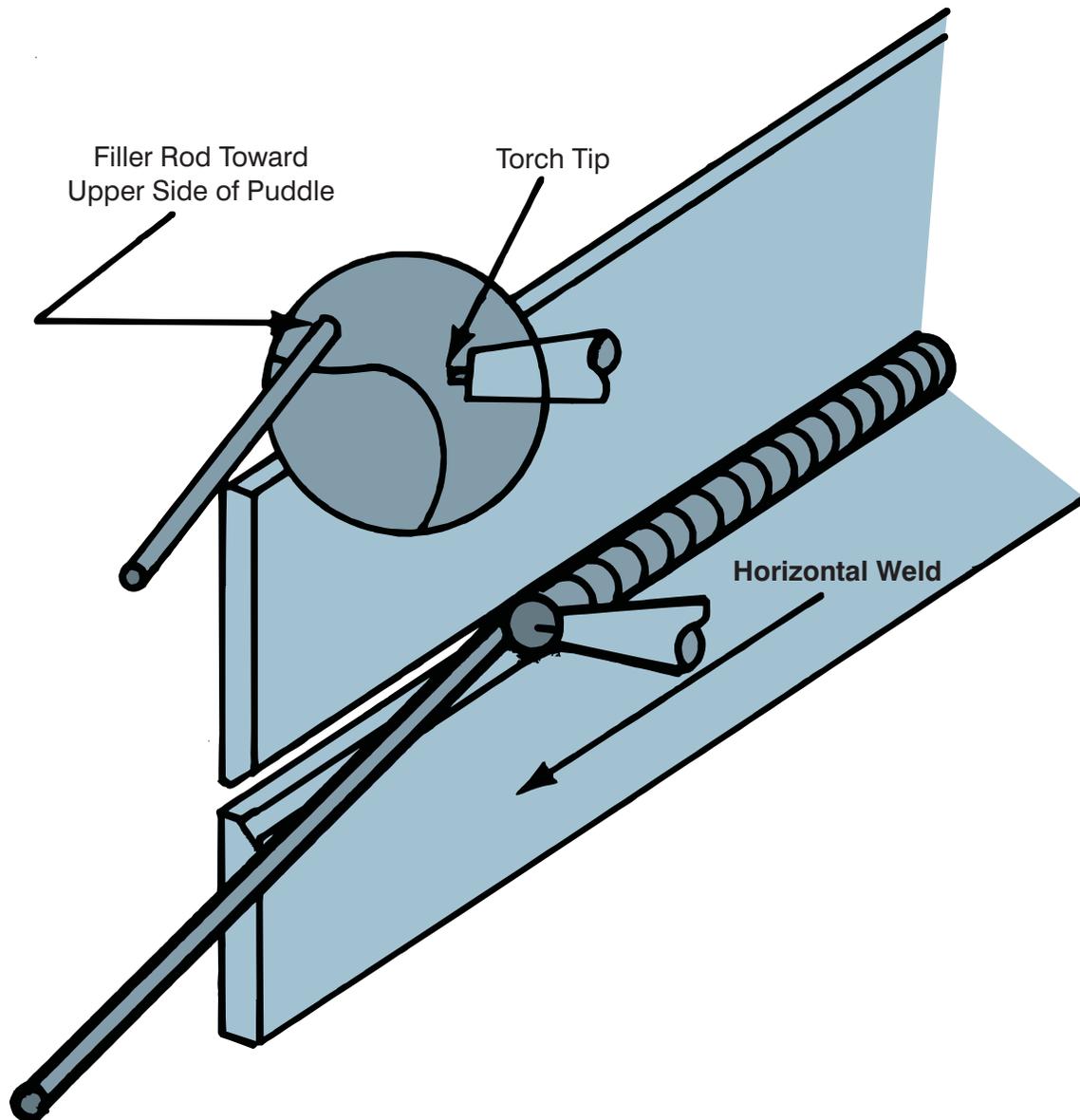
# TIG ELECTRODE POSITION— FLAT



**The tungsten electrode is positioned  
in the centerline of the weld joint.**

*(Courtesy, Interstate Publishers, Inc.)*

# TIG ELECTRODE POSITION— HORIZONTAL



**The filler rod position for  
horizontal TIG welding.**

*(Courtesy, Interstate Publishers, Inc.)*

# Lab Sheet

## TIG Welding Exercises

Each student is to complete the following lab exercises in the order shown. A lab sheet should accompany each exercise. Before moving to the next exercise, gain instructor approval and directions.

- #1 Bead
- #2 Butt Weld
- #3 Lap Weld
- #4 Tee (Fillet) Weld

1. Lab exercise no. and type of weld: \_\_\_\_\_
2. Welding position: \_\_\_\_\_
3. Type and size of rod used: \_\_\_\_\_
4. Type and thickness of base metal: \_\_\_\_\_
5. Current setting: \_\_\_\_\_ Wire speed setting: \_\_\_\_\_ Flowmeter setting: \_\_\_\_\_

6. SCORECARD:

a. General appearance (smooth, uniform ripples)	5	4	3	2	1	0
b. Width (uniform)	5	4	3	2	1	0
c. Height (uniform)	5	4	3	2	1	0
d. Penetration	5	4	3	2	1	0
e. Starting	5	4	3	2	1	0
f. Stopping	5	4	3	2	1	0
g. Safety procedures followed	5	4	3	2	1	0
h. Other	5	4	3	2	1	0

i. TOTAL POINTS EARNED \_\_\_\_\_

7. Comments: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

8. Grading scale	36-40	A- to A+
	32-35	B- to B+
	28-31	C- to C+
	24-27	D- to D+
	1-23	F
	0	0