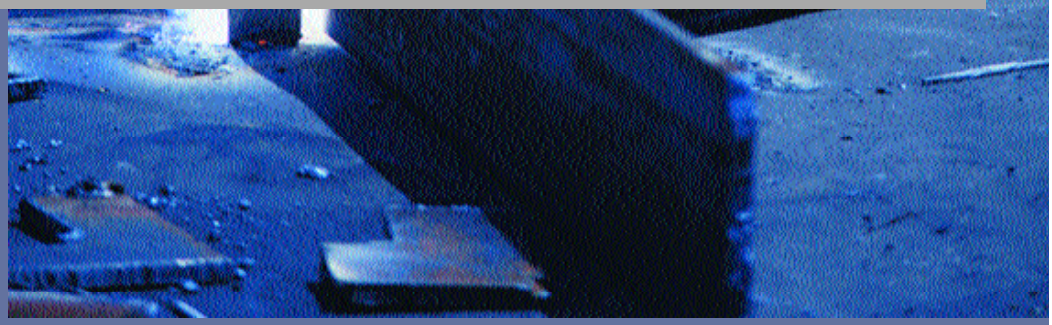
Introduction to Welding

- Introduction to Gas Metal Arc Welding and Flux Core Welding
- Introduction to Gas Tungsten Arc Welding
- Introduction to Oxyfuel Welding
- Introduction to Shielded Metal Arc Welding



Teacher's Guide

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Introduction

By learning and practicing different welding processes, welders contribute to modern industry in a variety of ways. Without welders, we would live in a world without skyscrapers, airplanes, or automobiles. Welding applications can be found almost anywhere—in the city, on the farm, at the museum, in the air. Whether you are considering a career in welding or you just want to know more, this introduction to oxyfuel welding, shielded metal arc welding, gas tungsten arc welding, and flux arc core welding will help you build a firm foundation of essential welding skills and safety procedures.

INTRODUCTION TO GAS METAL ARC AND FLUX CORE ARC WELDING

Objectives

After viewing the program, students should be able to:

- Define welding
- Correctly set up a gas metal arc welding outfit
- Recognize unsafe welding conditions
- Explain how the different components of a gas metal arc welding outfit work together
- Correctly strike an arc
- Explain how to lay a bead with a gas metal arc or flux core arc outfit
- Recognize a clean, well-made weld

Discussion Questions

1. What precautions does a welder need to take before using a gas metal arc or flux core arc welding outfit?

2. Why is a ventilation system important in gas metal arc or flux core arc welding?

3. What happens to the electrode wire used in gas metal arc or flux core arc welding?

4. What provides the shielding gas in flux core arc welding?

5. What is the proper procedure for moving and storing gas cylinders when installing or removing an inert gas cylinder?

6. What are the four steps to setting up a gas metal or flux core arc welding outfit?

7. What are the steps in shutting down a gas metal or flux core arc welding outfit?

8. What is cold lap and how can it be avoided?

Answers to Discussion Questions

1. What precautions does a welder need to take before using a gas metal arc or flux core arc welding outfit?
   Answer: Correct protective clothing, eye protection, safety inspection of equipment.

2. Why is a ventilation system important in gas metal arc or flux core arc welding?
   Answer: Both systems generate toxic fumes that are dangerous to the welder and others in the welding shop.

3. What happens to the electrode wire used in gas metal arc or flux core arc welding?
   Answer: A consumable electrode, it becomes part of the weld.

4. What provides the shielding gas in flux core arc welding?
   Answer: The electrode wire is hollow and filled with flux. The melting flux creates the shielding gas necessary to protect the weld.

5. What is the proper procedure for moving and storing gas cylinders when installing or removing an inert gas cylinder?
   Answer: Cylinders must be stored vertically and chained to a rack or other support. Before attaching the pressure regulator, the cylinder outlet should be blown clean.

6. What are the four steps to setting up a gas metal or flux core arc welding outfit?
   Answer: 1) visually inspect the outfit; 2) check the gun and make sure the electrode wire is properly inserted; 3) set the regulator and flow meter; 4) clean the base metal.

7. What are the steps in shutting down a gas metal or flux core arc welding outfit?
   Answer: 1) release the trigger on the gun; 2) close the flow meter adjustment valve completely; 3) close the cylinder valve; 4) open the flow meter adjustment valve again and press the purge switch; 5) turn the wire feeder off; 6) turn off the power to the machine.

8. What is cold lap and how can it be avoided?
   Answer: Cold lap is a defect that develops when the filler metal is melted but the base metal is not. Concentrate heat in the weld pool area until base metal penetration occurs.

Activity: Laying a Bead on a Plate

1. Obtain a piece of mild steel measuring $^{3}/_{16}$" x 3" x 6".

2. Clean both surfaces with a wire brush.

3. Lay out five straight lines, using a ruler and soapstone.

4. Set up the welding machine for short circuiting transfer. Select the appropriate shielding gas and set the flow meter.

5. Use a backhand method.

6. Watch the metal as the welding arc starts. A molten pool develops quickly. Move the arc towards the forward edge of the pool. Note the width of the pool and the amount of penetration. Keep the same width and penetration as the weld progresses.

7. Fill the weld pool at the end of the bead.

8. Examine the bead. Change the voltage, wire feed speed, or shielding gas flow rate as required.

9. Weld beads on the other four lines on the plate.

Inspection: Each weld bead should be straight, with evenly spaced ripples and continuous reinforcement. The crater at the end of the weld should be filled. No evidence of porosity should be seen.

Turn the plate over and repeat this exercise. Set the welding machine for spray transfer. Change the shielding gas to argon or argon with oxygen.

INTRODUCTION TO GAS TUNGSTEN ARC WELDING

Objectives

After viewing the program, students should be able to:

- Define welding
- Correctly set up a gas tungsten arc welding outfit
- Recognize unsafe welding conditions
- Explain how the different components of a gas tungsten arc welding outfit work together
- Use the proper procedure for moving and storing gas cylinders
- Correctly strike an arc
- Explain how to lay a bead
- Recognize a clean, well-made bead
- Match the filler metal to the work

Discussion Questions

1. What precautions does a welder need to take before using a gas tungsten arc welding outfit?

2. Why are thinner, light-duty gloves used during gas tungsten arc welding?

3. Why is helium or argon gas used during tungsten arc welding?

4. What is the proper procedure for moving and storing gas cylinders when installing or removing an inert gas cylinder?

5. What are the four steps to setting up a gas tungsten arc welding outfit?

6. Touch starting can sometimes contaminate the electrode and cause the arc to jump and flow erratically. What must you do if this happens?

7. How can the size of the weld pool be adjusted?

8. Under what conditions does tungsten inclusion result?

Answers to Discussion Questions

1. What precautions does a welder need to take before using a gas tungsten arc welding outfit?
   Answer: Correct protective clothing, eye protection, safety inspection of equipment.

2. Why are thinner, light-duty gloves used during gas tungsten arc welding?
   Answer: Thinner gloves allow the welder to get a good feel for the torch.

3. Why is helium or argon gas used during tungsten arc welding?
   Answer: The electrode and the weld pool are protected from the environment by inert gas that does not react with the weld but protects it from contamination.

4. What is the proper procedure for moving and storing gas cylinders when installing or removing an inert gas cylinder?
   Answer: Cylinders must be stored vertically and chained to a rack or other support. Before attaching the pressure regulator, the cylinder outlet should be blown clean.

5. What are the four steps to setting up a gas tungsten arc welding outfit?
   Answer: 1) visually inspect the outfit; 2) assemble the torch and insert the electrode; 3) set the regulator and flow meter; 4) insert the filler metal.

6. Touch starting can sometimes contaminate the electrode and cause the arc to jump and flow erratically. What must you do if this happens?
   Answer: Replace or clean the electrode; grind tungsten electrodes on a grinder specifically for that purpose.

7. How can the size of the weld pool be adjusted?
   Answer: Moving the electrode closer to the base metal; changing the amount of current with the foot switch.

8. Under what conditions does tungsten inclusion result?
   Answer: Tungsten inclusion may occur when the electrode melts into the work; if the electrode is too small; if the current is too high; or if the welder has touched the weld pool with the electrode end.

Activity: Laying a Bead on Plate Without Filler Rod

1. Obtain a piece of mild steel measuring $^1/_{16}$" x 3" x 6".

2. Clean both surfaces with a wire brush.

3. Mark five straight lines lengthwise on each side of the metal. Start the lines $^1/_2$" in from one edge and end $^1/_2$" from the opposite edge. Place the metal in the flat position.

4. Set up the welding machine for use with mild steel. Use DCEN (DCSP) and 70 amps current. Place the current switch in the panel position, so the foot pedal or thumb switch can act as an on-off switch.

5. Set the shielding gas flow. The shielding gas should be argon.

6. Obtain a 2 percent thoria tungsten electrode 1/16" in diameter. Form the tip into a blunted point. Make sure the grind marks are lengthwise.

7. Select the correct size collet and collet body. Install the collet, collet body, and electrode in the torch. The electrode should extend 1/8" to 3/16".

8. Hold the torch at the correct angle about 1/8" above the base metal.

9. Press the foot pedal or thumb switch. The welding arc will start.

10. Move the electrode closer to the base metal so it is about 3/32" above the surface. Watch the weld pool as it forms. When it reaches about 3/16" in width, it will begin to sag. Move the torch forward along the line marked on the plate.

11. Maintain the same size weld pool as you move along the plate. Keep the electrode a constant distance above the surface.

12. Stop welding at the end of the line.

13. Repeat the process until you have welded five beads on each side of the plate.

Inspection: Each weld bead should be straight and have even ripples. There should be signs of slight penetration on the back side of the plate. There should not be any porosity in the weld.

INTRODUCTION TO OXYFUEL WELDING

Objectives

After viewing the program, students should be able to:

- Define welding
- Correctly set up an oxyfuel welding outfit
- Recognize unsafe welding conditions
- Explain how the different components of an oxyfuel welding outfit work together
- List areas in modern industry where welding is used
- Explain how to correctly lay a bead
- Demonstrate attachments appropriate to the work being done
- Explain how to convert an oxyfuel torch into an oxyfuel cutting torch
- Describe operation of an oxyfuel cutting torch
- Recognize a well-made weld or kerf

Discussion Questions

1. What precautions does a welder need to take before using an oxyfuel welding outfit?

2. What gas is combined with oxygen in oxyfuel welding and cutting? Why?

3. How do welders know if a gas cylinder is safe for use?

4. What is the function of a regulator?

5. What warning should a welder always give before he or she is about to ignite a torch?

6. What is the purpose of a check valve? What is the difference between a check valve and a flashback arrestor? How should they be used?

7. What is the correct grip for oxyfuel cutting?

Answers to Discussion Questions

1. What precautions does a welder need to take before using an oxyfuel welding outfit?
   Answer: Correct protective clothing, eye protection, safety inspection of equipment.

2. What gas is combined with oxygen in oxyfuel welding and cutting? Why?
   Answer: Acetylene, when burned in the presence of oxygen, produces one of the highest flame temperatures obtainable.

3. How do welders know if a gas cylinder is safe for use?
   Answer: Seamless cylinders, safety cap in good condition, store upright, clear label.

4. What is the function of a regulator?
   Answer: A pressure regulator controls both the tank and working pressure of the gasses in use.

5. What warning should a welder always give before he or she is about to ignite a torch?
   Answer: "Watch your eyes" is always a good warning to give before igniting a torch.

6. What is the purpose of a check valve? What is the difference between a check valve and a flashback arrestor? How should they be used?
   Answer: A check valve prevents gasses from flowing back into the torch or hoses. A flashback arrestor also prevents fire or flames from flowing back into the torch or hoses. Either device can be used between the torch and the hoses and between the hoses and regulator for extra safety.

7. What is the correct grip for oxyfuel cutting?
   Answer: An overhand grip is used for most oxyfuel cutting. One hand holds the torch while the other steadies the cutting hand.

Activity: Creating a Continuous Weld Pool

1. Obtain a piece of mild steel measuring $^{1}/_{16}$" x 3" x 6".

2. Clean both surfaces of the metal with steel wool or abrasive paper.

3. Lay out five straight lines on the metal using a ruler and soapstone.

4. Select the correct tip size and install the tip in the torch.

5. Set the desired welding pressures.

6. Light the torch and adjust to a neutral flame.

7. Begin the pool $^{1}/_{2}$" from the edge of the metal. Hold the flame about $^{1}/_{16}$" to $^{1}/_{18}$" from the metal. Tilt the torch tip to the appropriate angle.

8. Watch the metal melt as the weld pool forms. When the metal sags, quickly note the pool width. Begin to move the flame ahead slowly and carry the weld pool forward. Maintain a steady forward speed and a consistent side-to-side motion. This keeps the pool the same width as it is carried along. Continue the pool to the end of the line. Inspect your first pass. Try to prevent any defects in your next pass.

9. Carry a weld pool along the length of the other four lines. Inspect each pass as it is completed.

Inspection: Turn the metal over, using pliers. A small continuous deformation (bump) should appear on the underside. The weld pool width should be uniform. This indicates continuous penetration and good torch and flame control. Holes should not be present.

INTRODUCTION TO SHIELDED METAL ARC WELDING

Objectives

After viewing the program, students should be able to:

- Define welding
- Correctly set up a shielded metal arc welding outfit
- Recognize unsafe welding conditions
- Explain how the different components of a shielded metal arc welding outfit work together
- List areas in modern industry where welding is used
- Distinguish between AC and DC welding machines and their uses
- Correctly strike an arc
- Safely shut down a shielded metal arc welding outfit
- Explain how to lay a bead
- Recognize a clean, well-made bead
- Demonstrate the appropriate electrode for the work being done

Discussion Questions

1. What precautions does a welder need to take before using a shielded metal arc welding outfit?

2. Why are alternating current welders also called constant current machines?

3. Why shouldn't welding leads be laid across an aisle or other heavy traffic area?

4. What is the purpose of the flux (outer coating) on the electrode?

5. What are the five steps to setting up a shielded metal arc welding outfit?

6. What are the two methods of striking an arc?

7. What are the two primary kinds of beads? How are they made?

8. How do you solve the problem of arc blow during direct current welding?

Answers to Discussion Questions

1. What precautions does a welder need to take before using a shielded metal arc welding outfit?
   Answer: Correct protective clothing, eye protection, safety inspection of equipment.

2. Why are alternating current welders also called constant current machines?
   Answer: They provide a relatively steady current to the work.

3. Why shouldn't welding leads be laid across an aisle or other heavy traffic area?
   Answer: They may be damaged and cause injuries.

4. What is the purpose of the flux (outer coating) on the electrode?
   Answer: It creates the shielding gas that protects the weld from impurities.

5. What are the five steps to setting up a shielded metal arc welding outfit?
   Answer: 1) visually inspect the leads and machine; 2) inspect the welding area; 3) make coarse and fine amperage adjustments on the machine; 4) select the correct electrode; 5) turn on the machine.

6. What are the two methods of striking an arc?
   Answer: Scratching the electrode on the base metal; tapping the electrode straight up and down on the base metal.

7. What are the two primary kinds of beads? How are they made?
   Answer: Stringer beads are made along a straight line with a steady, straight motion. Weaving beads are made when the electrode is moved from side to side.

8. How do you solve the problem of arc blow during direct current welding?
   Answer: Reposition the ground lead; use a shorter arc.

Activity: Running a Bead Using an Open Arc

1. Obtain one low-carbon steel plate measuring 1/4" x 3" x 6".

2. Also obtain five 1/8"-diameter E6013 electrodes.

3. Mark three 6"-long lines on the plate, each 3/4" apart.

4. Determine the amperage range and polarity for this electrode. Refer to an electrode manufacturer's guide.

5. Make a safety inspection of the arc welding outfit or station.

6. Set the amperage near the low end of the suggested range.

7. Make certain that the work table or practice plate is attached to the workpiece lead.

8. Strike the arc using the scratching or tapping method.

9. Run a bead of correct width and height along the marked line.

10. Chip and wire-brush the bead. Chipping goggles must be worn.

11. Read the finished bead.

12. Change the amperage, arc length, or travel speed as required. Run two additional beads. Read each bead while it is being made. Clean the completed welds and make changes in your welding method as required.

13. Make three additional beads on the opposite side of the metal about 3/4" apart.

Inspection: Each bead should be the proper width and height. The ripples should be bullet-shaped and evenly spaced. Each bead should improve as errors are read and corrected.

Key Welding Terms

Acetylene: A colorless fuel gas. When burned in the presence of oxygen, it produces one of the highest flame temperatures obtainable.

Alternating Current (AC): Type of electricity in which the direction of electron flow reverses at regular intervals; also called constant current.

Arc: Flow of electricity across a gaseous space (air gap).

Arc Welding: A group of welding processes used to melt and weld metal using the heat of an electric arc with or without filler metal.

Backfire: Short "pop" of the torch flame, followed by extinguishing of the flame or continued burning of the gases.

Base Metal: Metal to be welded, cut, or brazed.

Check Valve: Valve designed to allow a gas or fluid to flow in only one direction, used to prevent the reverse flow of gases through the torch, hoses, and/or regulators.

Chipping Hammer: Cleaning tool with a sharp pointed pick at one end of its head, used to remove slag from welding beads.

Cold Lap: A defect that develops when the filler metal is melted but the base metal is not.

Collet: A sleeve used in a gas metal arc welding gun or gas tungsten arc welding torch to hold the electrode tightly enough to ensure electrical contact with the welding power supply.

Cylinder Valve: Device that can be opened or closed to control the flow of gas from a cylinder.

Cylinder Pressure Gauge: Gauge on a pressure regulator that shows pressure of the gas in the cylinder.

Direct Current (DC): Electric current that flows in only one direction.

Electrode: Terminal point to which electricity is brought to produce the arc for welding. In many electric arc welding processes, the electrode is melted and becomes part of the weld.

Electrode Lead: The electrical conductor between the welding machine and the electrode holder.

Filler Metal: Metal or alloy to be added to the base metal to make welded, brazed, or soldered joints.

Filter Lenses: Lenses in welding goggles with optical properties that protect the welder's eyes from infrared, ultraviolet, and visible radiation.

Fitting: Threaded connectors on the ends of fuel gas hoses, used to join them to regulators and torches.

Flash Goggles: Goggles worn under their helmets by arc welders to protect their eyes from flashes from the rear.

Flashback Arrestor: A device usually installed between the torch and welding hose to prevent the flow of a burning fuel gas and oxygen mixture from the torch into the hoses, regulators, and cylinders.

Flow Meter: Device that controls the amount of gas that goes to the welding torch.

Flux: Material used to prevent, dissolve, or facilitate removal of oxides and other undesirable surface substances.

Foot Pedal: Foot-operated rheostat used for remote control of the output of an arc welding machine.

Inert Gases: Shielding gases, such as argon and helium, that do not react with the weld.

Kerf: The slot or opening produced in the metal when cutting.

Neutral Flame: Flame resulting from combining oxygen and a fuel gas in perfect proportions.

Nonconsumable Electrode: An electrode that does not melt and become part of the weld.

Nozzle: A ceramic or metal cup used on a torch to direct the shielding gas to the weld area.

Outfit: All the welding equipment needed to made a weld.

Oxidization: The process in which oxygen combines with a material to form a chemical compound called an oxide.

Oxyfuel Welding: A group of welding and cutting processes and methods that use heat produced by a gas flame.

Penetration: The depth of fusion of the weld below the surface.

Pressure Regulator: Device used to reduce the cylinder pressure of a gas to a usable (working) pressure for welding.

Post Flow: Shielding gas flow that continues for a short time after the weld current stops.

Post Flow Timer: Control on a welding machine that allows variation in the length of time that post flow continues.

Reading the Bead: The process of visually inspecting the weld bead to determine whether the weld was made properly.

Regulator: Device used to control the volume and pressure of a welding or shielding gas as it flows from the cylinder to the torch.

Safety Cap: Forged steel cap that should be screwed over the cylinder valve to protect it when the cylinder is stored or moved.

Safety Valve: A device that prevents a gas cylinder from exploding when exposed to high temperatures.

Shielding Gas: A gas, usually inert, that is used to blanket the weld area and prevent contamination from the air.

Slag: The hard, brittle metal that covers a finished welding bead; metal oxides and other materials that form on the underside of flame or arc cuts.

Stringer Bead: Bead made by moving a torch or electrode holder along the weld without any side-to-side motion.

Torch Valves: Valves that control the flow of oxygen and fuel gas into the torch.

Tungsten Inclusion: A weld defect caused by getting tungsten from the electrode in the weld.

Undercut: A depression at the toe of the weld—the weld metal is below the level of the base metal.

Weaving Bead: Bead formed by moving a torch or electrode holder from side to side as the pass progresses along the welding joint.

Weld Pool: The small molten volume of metal under the torch flame or electrode, prior to its solidification as weld metal.

Welding: The joining of one material to another through the application of heat.

Wire Feeder: In gas metal arc welding, the device that continuously feeds consumable electrode wire to the welding gun.

Working Pressure Gauge: Gauge on a pressure regulator that shows pressure of the gas being supplied to the torch.

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Welding (from the series *Auto Body Repair*)

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- **Order #32777**

This video puts safety first as it explains how to use a MIG (GMAW) welder. Weld types, welder setup, destructive tests, and general welding techniques are covered. The causes of contact burnback, incomplete fusion, and other problems are identified. A Shopware Production. (23 minutes) © 2005.

Welding (from the series *Vo-Tech Ins and Outs*)

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- **Order #24224**

Vo-Tech Ins and Outs is a fast-paced, entertaining, and intriguing series that introduces several occupations in the vast career pathway of vocational and technical trades. Viewers are taken on a journey through many different facets of vocational interest areas including welding, masonry, electrical, residential construction, and HVAC. Each program focuses on one of these particular trades and includes interviews with students preparing for each career and working professionals on the job. The programs carefully define how the participant began in the field, what the vocation means to them, educational requirements, immediate job opportunities, and how they envision the future of each particular occupation. A Shopware Production. (15 minutes) © 2001.

Multimedia Welding Safety (from the series *Shop Safety*)

- **CD-ROM**
- **Order #20461 (Windows)**
- **Order #20462 (Macintosh)**

This multimedia CD-ROM examines not only the welding process itself, but also safety practices. Through a combination of schematic diagrams, video and animation sequences, and still photos of tanks, regulators, and gauges, welding makes sense, even to the novice. The user is led to explore topics including welding torches, resistance spot welding, arc welding, and wire-feed welding. Navigation through the program is user-friendly, with options that allow users to review or bypass lesson segments. A teacher's utilities section is also included, allowing teachers to monitor student performance. A Shopware Production. © 1996.

Safety First: Welding Shop Safety (from the series *Safety First: Shop Safety*)

- **VHS/DVD**
- **Closed captioned**
- **Order #14465**

Specific protective gear for welders is examined in detail. The necessity of having a good attitude and concentrating on the task you are performing are also discussed. Shows the proper

way to store tanks, hoses, gauges, and cutting/brazing torches. Also covers the basics of testing lines for leaks, attaching gauges to tanks, and adjusting pressure settings to proper levels. Covers a variety of welding processes including MIG, TIG, and oxyacetylene. The most common concerns of welders are discussed including proper grounding of the machine and the work piece, correct applications of commercial gases, and maintaining weld tips.
A Cambridge Educational Production. (30 minutes) © 1995.

Performing SMAW Weld Tests—2G, 3G & 4G

- **VHS**
- **Order #19213**

This video demonstrates procedures for welding in the 2G, 3G, and 4G positions using the E-6010 and E-7018 electrodes. Viewers see each weld through the filter lens in a welding hood. Includes running the root pass, hot pass, filler pass, and cap weld. Viewers also see root penetration from the inside of the pipe, something most welders never see. (35 minutes) © 1994.

Performing SMAW Weld Tests—5G

- **VHS**
- **Order #19212**

This video demonstrates procedures for welding in the 5G position using the E-6010 and E-7018 electrodes. Viewers see each weld through the filter lens in a welding hood. Includes running the root pass, hot pass, filler pass, and cap weld. Viewers also see root penetration from the inside of the pipe, something most welders never see. (26 minutes) © 1994.

Performing SMAW Weld Tests—6G

- **VHS**
- **Order #19211**

This video demonstrates procedures for welding in the 6G position using the E-6010 and E-7018 electrodes. Viewers see each weld through the filter lens in a welding hood. Includes running the root pass, hot pass, filler pass, and cap weld. Viewers also see root penetration from the inside of the pipe, something most welders never see. (24 minutes) © 1994.

www.meridianeducation.com

2572 Brunswick Pike, Lawrenceville, NJ 08648

Toll Free: 1 800/727-5507
Fax: 1 888/340-5507

meridian education corporation

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