

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Arc Welding
Lesson	Selecting and Maintaining Electrodes and Safety Lenses
Estimated Time	50 minutes
Student Outcome	

Describe the factors in selecting and maintaining electrodes and safety lenses.

Learning Objectives

1. Identify the two parts of an arc welding electrode and what the functions of each of them are.
2. Describe some of the factors to take into consideration when selecting an electrode.
3. Explain how electrodes are identified.
4. Explain what the letters and numbers in the AWS classification system mean.
5. Explain how electrodes should be stored and cared for.
6. Explain how the correct safety lenses are selected for arc welding.
7. Describe how filter lenses and welding helmets should be cared for.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
 - ☐ PPT 1 – Electrode Color Markings
 - ☐ PPT 2 – AWS Classification and Designators
 - ☐ PPT 3 – Electrode Classification
 - ☐ PPT 4 – Protective Eyewear
2. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
3. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II, "Unit II – Arc Welding."* University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplemental Information

1. Internet Sites
 - ☐ Arc Welding. Division of Safety and Hygiene of the Ohio Industrial Commission. Vermont Safety Information Resources, Inc. Accessed October 8, 2007, from <http://siri.org/library/ind/Welding/arc.html>.
 - ☐ Fluegel, L., and B. Rein. "Arc Welding Safety." University of Arizona Cooperative Extension. National Ag Safety Database. Accessed October 8, 2007, from <http://www.cdc.gov/nasd/docs/d000801-d000900/d000873/d000873.html>.

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- ❑ Harris, J. Commonly Asked Questions About Welding Helmets and Eye Protection. Lincoln Electric. Accessed on October 8, 2007 from <http://www.lincolnelectric.com/knowledge/articles/content/weldinglenses.asp>.
 - ❑ Recommended Filter Lenses for Various Welding Operations. Integrated Publishing. Accessed October 8, 2007, from http://www.tpub.com/content/construction/14250/css/14250_71.htm.
 - ❑ Welding, Cutting, and Brazing. Occupational Safety and Health Administration. U. S. Department of Labor. Accessed October 8, 2007, <http://www.osha.gov/SLTC/weldingcuttingbrazing/index.html>.
2. Print
- ❑ Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding*. Tinley Park, IL: Goodheart-Willcox, 2000.
 - ❑ Jeffus, L. *Welding Principles and Applications*. 5th ed. Clifton Park, NY: Thomson-Delmar Learning, 2004.
 - ❑ Phipps, L. *Mechanics in Agriculture*. 4th ed. Danville, IL: Interstate Publishers, 1992.
 - ❑ Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics*. Upper Saddle River, NJ: Prentice Hall Interstate, 2004.
3. Electronic Media
- ❑ Smartflix offers a line of videos related to metalworking that can be rented from their Web site. Accessed September 12, 2007, from <http://smartflix.com/store/category/115/Metalworking>.
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Interest Approach

Have students examine a number of electrodes to identify how they are different and similar. Are they different in diameter, length, and application? What features could be used for classifying electrodes? Are there any electrodes that are different in only one way – length, for example – but otherwise are the same? What are important factors for choosing the right electrode for the job?

Communicate the Learning Objectives


1. Identify the two parts of an arc welding electrode and what the functions of each of them are.
2. Describe some of the factors to take into consideration when selecting an electrode.
3. Explain how electrodes are identified.
4. Explain what the letters and numbers in the AWS classification system mean.
5. Explain how electrodes should be stored and cared for.
6. Explain how the correct safety lenses are selected for arc welding.
7. Describe how filter lenses and welding helmets should be cared for.

Instructor Directions	Content Outline
Objective 1	<p>Identify the two parts of an arc welding electrode and what the functions of each of them are.</p> <p>A solid metal core – adds filler metal to the weld as it melts</p> <p>A flux coating – may do any or all of the following:</p> <ol style="list-style-type: none">1. Adds filler metal to the weld2. Stabilizes the arc3. Produces a gas shield that protects the weld4. Adds flux to the weld<ol style="list-style-type: none">a. Flux removes impurities that rise to the surface of the weld.b. Flux promotes the formation of slag (a protective layer over the weld).5. Adds alloying elements to improve the weld6. Determines the polarity of the electrode
Objective 2	<p>Describe some of the factors to take into consideration when selecting an electrode.</p> <p>Type of metal being welded and its tensile strength</p> <p>Thickness of the metal</p> <p>Condition of the base metal</p>

Instructor Directions	Content Outline
	<p>Welding position (i.e., flat, vertical, horizontal, and overhead)</p> <p>Experience of the welder</p> <p>Rate at which the filler metal should be added</p> <p>Design or alignment of the joint</p> <p>Properties of the alloying elements contained in the flux</p> <p>Type of electric current being used</p>
<p>Objective 3</p> <p><i>Refer to PPTs 1 and 2.</i></p> <p><input type="checkbox"/> PPT 1 – Electrode Color Markings</p> <p><input type="checkbox"/> PPT 2 – AWS Classification and Designators</p>	<p>Explain how electrodes are identified.</p> <p>National Electrical Manufacturers Association (NEMA) color coding</p> <ol style="list-style-type: none"> 1. This system identifies electrodes by placing a code color on the end of the electrode (end marking), on the bare metal core (spot marking), and the flux coating (group marking). 2. Manufacturers who use the NEMA system use the same color markings. 3. The NEMA color code is not the same as the manufacturer's trademarks or coating colors. <p>American Welding Society (AWS) classification</p> <ol style="list-style-type: none"> 1. This is the standard classification system adopted by the welding industry. 2. A series of letters and numbers gives information about the properties of the electrode, such as tensile strength, weld position, coating, welding current, and polarity. 3. The AWS classification code is stamped on the side of the electrode.
<p>Objective 4</p> <p><i>Refer to PPTs 2 and 3. Main elements of the AWS system for electrode classification are</i></p>	<p>Explain what the letters and numbers in the AWS classification system mean.</p> <p>Prefix letter or letters provide information about the filler (e.g., "E" indicates the electrode is used in arc welding).</p>

Instructor Directions	Content Outline
<p><i>summarized in the outline at right. Supplement this discussion with additional information as needed to cover materials or procedures used in the shop.</i></p> <p><input type="checkbox"/> PPt 2 – AWS Classification and Designators</p> <p><input type="checkbox"/> PPt 3 – Electrode Classification</p>	<p>First two digits of a four-digit number or first three digits of a five-digit number indicate the minimum tensile strength of the weld metal.</p> <ol style="list-style-type: none"> 1. Minimum tensile strength is usually expressed in pounds per square inch (psi). Thus, a 60-series electrode has a minimum tensile strength of 60,000 psi. 2. Tensile strength can also be expressed in kilopounds per square inch (ksi). 3. Tensile strength may be given for welds that have undergone postheating treatment to remove stress (referred to as “stress-relieved”) or those that have not been postheated (termed “as-welded”). The manufacturer’s specifications identify which is the case. <p>The second digit from the right indicates recommended welding position.</p> <ol style="list-style-type: none"> 1. The number “1” indicates the electrode can be used in all positions – flat (F), vertical (V), overhead (OH), and horizontal (H). 2. The number “2” indicates the electrode can be used in flat and horizontal positions. 3. The number “3” formerly indicated that the electrode was used in the flat position. This code is no longer used but continues to appear in some textbooks and references. 4. The number “4” indicates the electrode can be used in flat, horizontal, overhead, and vertical-down positions. <p>The last digit on the right provides information about operating characteristics, such as welding current and/or depth of penetration.</p> <ol style="list-style-type: none"> 1. “DCEN” stands for “direct current electrode negative” and was formerly referred to as “direct current straight polarity” (DCSP). It means that the electrode is the negative pole and the work is positive. The preferred term is now DCEN, but some references to DCSP may still be encountered. 2. “DCEP” stands for “direct current electrode positive” and was formerly referred to as “direct current

Instructor Directions	Content Outline
	<p>reverse polarity” (DCRP). In this situation, the electrode is positive and the work is negative. The preferred term is DCEP, but some references to DCRP may be encountered.</p> <p>The last two digits on the right together give additional information, such as coating composition and proper application.</p> <p>Some electrodes are labeled with suffixes after the numerical code.</p> <ol style="list-style-type: none"> 1. These additional designators identify any alloying elements added to the weld. 2. The manufacturer’s specifications should be consulted for the exact chemical composition of the coating.
<p>Objective 5</p> <p><i>Introduce the topic of proper handling of electrodes by asking students to describe how electrodes are stored in the shop and any storage procedures that must be followed. Why do they believe electrodes are stored and handled in such ways?</i></p>	<p>Explain how electrodes should be stored and cared for.</p> <p>Store electrodes in a dry, waterproof place.</p> <ol style="list-style-type: none"> 1. Moisture can produce steam during welding, which can carry away the shielding gases that protect the weld. 2. Damp electrodes can cause such problems as increased spatter and poor slag removal. 3. Hydrogen from water can be added to welds and weaken them. 4. Welds made with damp electrodes may be porous and subsequently crack. 5. Repairing or replacing faulty welds made with damp electrodes costs time and money. 6. Failure to recognize faulty welds could pose a safety threat if the weld breaks down. <p>Know the moisture-pickup time for electrodes being used.</p> <ol style="list-style-type: none"> 1. The moisture-pickup time is defined as the time it takes an electrode to absorb moisture from the air. 2. Manufacturers designate moisture-pickup time period for all electrodes. 3. To avoid exceeding the moisture-pickup time, take only the number of electrodes needed for a job or

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	<p>only the number that can be used within the moisture-pickup time period.</p> <p>Make sure electrodes exposed to moisture are dried in an electrode-drying oven before they are used.</p> <p>Handle electrodes carefully to avoid damaging the flux coating. Electrodes with chipped coating often cannot be used.</p>
<p>Objective 6</p> <p><i>Refer to PPt 4. Review general information about the need for protection from arc rays in Unit II Lesson 1 or amend or supplement any information in the outline as needed for the equipment and procedures used in the shop.</i></p> <p> PPt 4 – Protective Eyewear</p>	<p>Explain how the correct safety lenses are selected for arc welding.</p> <p>Good quality filter lenses should filter out about 99.5% of the infrared rays and 99.75% of the ultraviolet rays produced by the welding arc.</p> <ol style="list-style-type: none"> 1. Arc rays can damage the retina and cause vision loss. 2. Arc rays can burn the whites of the eyes; such burns are painful and can easily become infected. 3. The shade strengths of filter lenses often used in welding are no. 10, no. 12, and no. 14. 4. The darker the filter lens, the greater the shade number. 5. The brighter the arc is, the darker the filter lens should be. <p>Electrode size can be helpful in determining the correct shade of filter lens.</p> <ol style="list-style-type: none"> 1. Electrode diameter of up to 5/32 in. – no. 10 filter shade 2. Electrode diameter of 3/16 in. to 1/4 in. – no. 12 filter shade 3. Electrode diameter of 5/16 in. to 3/8 in. – no. 14 filter shade <p>Other filter shades should be used if necessary. Students should consult the instructor and the manufacturer's guidelines.</p> <p>Too dark of a lens can cause eyestrain. The view through the lens should be clear so the welder can see comfortably while welding.</p>

Instructor Directions	Content Outline
	<p>If the helmet does not incorporate a lens made out of safety glass, safety glasses must be worn under the helmet.</p> <p>Safety glasses or goggles should also be worn to protect the eyes while chipping slag and doing other work.</p> <p>Persons in the welding area should wear eye protection, such as flash glasses, to avoid eye injury from the reflected light.</p>
Objective 7	<p>Describe how filter lenses and welding helmets should be cared for.</p> <p>A clear outer lens of glass or plastic should be used to protect the filter lens from damage.</p> <p>An inner plastic lens is also recommended to protect the inner surface of the filter lens.</p> <p>Clear cover lenses should be inspected regularly and replaced if they are damaged.</p> <p>Filter lenses should be inspected regularly for cracks or other damage. Do not use a filter lens that is damaged.</p> <p>The filter shade number must be readily identifiable to be certain the correct filter lens is selected. The shade number should be on the lens or the lens should be kept in its properly labeled container.</p> <p>Make sure that the lens gasket is in good shape and all parts of the lens assembly are installed correctly to eliminate the risk of light leakage.</p> <p>Examine the helmet for signs of wear, cracks, and other damage. Damage must be repaired or the helmet must be replaced.</p>
Application:	<p>Other activities</p> <ol style="list-style-type: none"> 1. Have students examine a selection of welding helmets, filter lenses, and safety glasses in good and bad condition. Which ones are acceptable for shop

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	<p>use and which ones are not? Why? Point out any inspection procedures they might miss.</p> <p>2. Develop various welding scenarios involving metals of different types, thicknesses, and conditions, as well as requiring different welding positions. Ask students which electrode they would choose for each scenario and why.</p>
Closure/Summary	<p>When selecting electrodes for a welding job consider several factors, such as the type, thickness, and condition of the base metal; the weld position and design of the joint; properties of the alloying elements in the flux; and the type of electric current. Two methods of electrode classification are the NEMA color-coding system and the AWS letter-and-number system, the standard of the welding industry. Another key to creating a quality weld is proper storage and care of electrodes to avoid moisture. Electrode characteristics serve as a guide for the selection of a proper safety lens. The brighter the arc produced by the electrode, the darker the filter lens should be. As with electrodes, it is important to handle filter lenses and welding helmets with care.</p>
Evaluation: Quiz	<p>Answers:</p> <ol style="list-style-type: none"> 1. Answers should include five of the following. <ol style="list-style-type: none"> a. Type of metal being welded and its tensile strength b. Thickness of the metal c. Condition of the base metal d. Weld position, such as flat, vertical, horizontal, and overhead e. Experience of the welder f. Rate at which the filler metal should be added g. The design or alignment of the joint h. Properties of the alloying elements contained in the flux i. Type of electric current being used 2. <ol style="list-style-type: none"> a. The letter "E" means that it is an electrode used in arc welding. b. 60,000 pounds per square inch, or 60,000 psi, or 60 ksi

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	<ul style="list-style-type: none"> c. The electrode can be used in all positions. Student could also list flat, vertical, overhead, and horizontal. 3. Answers should include three of the following. <ul style="list-style-type: none"> a. Moisture can produce steam, which can carry away the shielding gases that protect the weld. b. Damp electrodes can cause such problems as increased spatter and poor slag removal. c. Hydrogen from the water can be added to welds and weaken them. d. Welds made with damp electrodes may be porous and crack. e. Time and money are lost repairing and replacing these faulty welds. f. If faulty welds are not undetected, they are at risk of failing and posing a safety threat. 4. Answers should include three of the following. <ul style="list-style-type: none"> a. Use a clear outer lens of glass or plastic to protect the filter lens from damage. b. Use an inner plastic lens to protect the inner side of the filter lens. c. Inspect and replace cover lenses regularly. d. Inspect filter lenses regularly for cracks and other damage. e. Be sure the shade number of a filter lens is readily identifiable. f. Be sure the lens gasket is in good shape and all parts of the lens assembly are installed correctly to avoid any light leakage. g. Examine the helmet for signs of wear, cracks, and other damage. This damage must be repaired or the helmet replaced. 5. c 6. b