Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Arc Welding
Lesson	Identifying Metals
Estimated Time	Two 50-minute blocks

Student Outcome

Analyze the characteristics of different metals, including their ability to be welded.

Learning Objectives

1. Explain why it is important to be able to identify metals.
2. Explain what ferrous and nonferrous metals are.
3. Explain some common methods of identifying metals.
4. Identify common ferrous metals, their characteristics, and their uses.
5. Identify common nonferrous metals, their characteristics, and their uses.

Grade Level Expectations

SC/ME/1/A/09-11/b SC/ME/1/A/09-11/c SC/ME/1/F/09-11/b

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. Activity Sheets
   - AS 1 – Identifying Ferrous Metals Using Spark Testing (Instructor)
   - AS 1 – Identifying Ferrous Metals Using Spark Testing (Student)
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.

Supplies & Equipment

- ❑ See AS 1 for materials and equipment needed to complete the Activity Sheet.

Supplemental Information

1. Internet Sites
   - ❑ Brain, M. How Iron and Steel Work. HowStuffWorks. Accessed October 8, 2007, from http://science.howstuffworks.com/iron.htm.
   - ❑ Martin, T. The Spark Test of Steel. Shopswarf. Accessed October 8, 2007, from http://shopswarf.orcon.net.nz/spark.html.
2. Print
   - ❑ Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding.* Tinley Park, IL: Goodheart-Willcox, 2000.
   - ❑ Brandt, D., and J. Warner. *Metallurgy Fundamentals*. Tinley Park, IL: Goodheart-Willcox, 1999.

- ❑ Camp, W., and T. Daugherty. *Managing our Natural Resources*. Albany, NY: Delmar Publishers, 1988.
- ❑ 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.
- ❑ Walker, J. *Modern Metalworking*. Tinley Park, IL: Goodheart-Willcox, 2000.

3. Electronic Media
   - ❑ *It All Starts With Dirt.* A three-minute video on how aluminum is made. Alcoa, Inc. Accessed October 8, 2007, from http://www.alcoa.com/global/en/about_alcoa/dirt_video.asp.

Interest Approach

Show students an assortment of common items made of various metals, such as a piece of copper tubing, a brass screw, and objects made of different types of steel. Ask them to identify the metal and explain how they identified it or how they might test it to determine the type of metal. Examples of ways to identify metals might be by color or whether or not the metal is magnetic. Write the characteristics on the board. Are there any metals that do not totally fit their tests or expectations? An example would be stainless steel, which is not always magnetic. Ask whether they think it would be necessary to further identify the steel items. Why? How would they go about identifying these?

Communicate the Learning Objectives

1. Explain why it is important to be able to identify metals.
2. Explain what ferrous and nonferrous metals are.
3. Explain some common methods of identifying metals.
4. Identify common ferrous metals, their characteristics, and their uses.
5. Identify common nonferrous metals, their characteristics, and their uses.

Instructor Directions	Content Outline
Objective 1 *Introduce the lesson by discussing why it is important to be able to identify metals from the point of view of welding.*	**Explain why it is important to be able to identify metals.** There are over 1,000 different metals with industrial applications. Not all welding procedures can be used on all metals with acceptable results. It is important to know what kind of metal is being worked with in order to determine which welding procedure or procedures are required to produce strong, functional joints.
Objective 2	**Explain what ferrous and nonferrous metals are.** There are two basic categories of metal - ferrous and nonferrous. 1. Ferrous refers to iron and metals with a high iron content. a. "Ferrous" comes from the Latin word *ferrum*, which means iron. b. Common ferrous metals include wrought iron, all steels, and cast iron. 2. Nonferrous refers to metals that contain little or no iron.

Instructor Directions	Content Outline
	a. Common nonferrous metals include aluminum, copper, brass, and bronze.
Objective 3 *Discuss ways in which metals can be identified. If the earlier motivation or a similar introduction to the material was used, this question could be introduced by reviewing procedures the students suggested for identifying metals. In many cases, such as doing repairs, a welder will not know exactly what kind of metal he or she is working with. Some common ways of identifying unmarked metals are presented at right. Supplement with other means of identifying unmarked metals or a discussion of standardized systems, such as the American Iron and Steel Institute (AISI) system, as needed. The instructor version of AS 1 can be used to demonstrate spark testing on known and unknown metals. The student version of AS 1 can be assigned to evaluate student competency.* AS 1 – Identifying Ferrous Metals Using Spark Testing	**Explain some common methods of identifying metals.** Magnetic testing 1. A magnet can be used to separate most ferrous metals from nonferrous ones. 2. Most ferrous metals are magnetic; nonferrous metals are not. 3. An exception is stainless steel. Not all stainless steel is magnetic. Color 1. Color is another general way in which ferrous metals can be distinguished from nonferrous ones. 2. Ferrous metals (irons and steels) tend to be gray, gray-white, bright silver, or black in appearance. 3. Nonferrous metals tend to be white, yellow, or reddish in color. Oxyacetylene torch testing 1. A neutral flame can be used to heat metal. This can be used to determine the melting point of the metal. Information about the metal can also be gained by observing it as it is heated and after it cools. 2. Torch testing can be used to determine whether or not steel and steel alloys have good welding properties. a. The melted metal should not produce excessive sparks or boil. b. When it has solidified, the metal should be smooth and shiny, not rough, dull, or porous. c. Boiling generally indicates the presence of significant amounts of an alloy or alloys. d. Special fluxes may be needed to weld alloy steels. Spark testing of ferrous metals 1. The metal is held lightly against a grinding wheel. Small heated particles of metal oxidize or burn as they are thrown off by the wheel. 2. Because ferrous metals and their alloys produce distinctive spark patterns, these patterns can be used to identify the metals.

Instructor Directions	Content Outline
	3. By comparing sparks made by an unknown type of metal to those from a known metal, the beginning welder can learn to identify ferrous metals by spark testing. 4. Sparks are observed for the following characteristics. a. Color b. Length c. Explosions along the length of the spark d. Shape of the explosions 5. Spark testing is used to identify ferrous metals. 6. In general, as carbon content of steel increases, the number of explosions increases and the length of the spark decreases. 7. Nonferrous metals do not produce sparks. a. If a nonferrous metal or a metal suspected of being nonferrous is to be spark tested, consult the instructor before proceeding. b. Grinding is not recommended for nonferrous metals because they can frequently clog the grinding wheel and some nonferrous metals produce toxic oxides. c. The operator must wear approved breathing apparatus and the grinding wheel must be equipped with an exhaust system.
Objective 4 *The characteristics and uses of some common ferrous metals are discussed below.*	**Identify common ferrous metals, their characteristics, and their uses.** Wrought iron 1. Wrought iron is almost pure iron and contains very little carbon. 2. Low carbon means wrought iron has low strength and hardness, but it also means it is very ductile (easy to shape without fracturing). 3. It rusts slowly. 4. It is easily welded. 5. Once an important structural metal, it is now used mostly for ornamental work. Carbon steel 1. This is the most common type of steel (about 90% of manufactured steel). 2. Generally, as carbon increases, so do hardness, tensile strength, resistance to wear, and cost.

Instructor Directions	Content Outline
	3. As carbon increases, ductility is lost and the melting point is lowered. 4. It is cheaper than alloy steel. 5. There are three basic types. a. Low-carbon steel – Low-carbon steel cannot be hardened. – It is easy to machine, can be used with all welding processes, and produces high-quality welds. – Applications include wire, pipe, auto bodies, and storage tanks. b. Medium-carbon steel – Medium-carbon steel can be strengthened and hardened with heat treating. – Heat treatment before and after welding generally produces the best results. – Applications are similar to those of low-carbon steel, but it can withstand greater stress. Medium-carbon steel is used in crankshafts, gears, and hammer heads. c. High-carbon steel – High-carbon steel can be heat treated to produce high strength and hardness. – It is more difficult to weld than low- or medium-carbon steel. – Heat treatment before and after welding is used to reduce brittleness. – It is used in making tools, dies, and railroad wheels. Alloy steel 1. Alloy steel refers to steels to which other elements besides carbon have been added in large enough amounts to produce qualities not found in carbon steel. 2. Common alloying elements include the following. a. Manganese – strengthens steel, increases resistance to shock b. Nickel – adds strength and corrosion resistance c. Tungsten – makes steel self-hardening and able to withstand high temperature 3. As alloying elements increase, welding difficulty generally increases.

Instructor Directions	Content Outline
	Stainless steel 1. Stainless steel refers to steels with enough chromium to resist corrosion. 2. There are over 100 different kinds. 3. It is more difficult to weld than carbon steel. Cast iron 1. Cast iron contains more carbon than steel does. 2. High-carbon content helps cast iron withstand high-compression loads. 3. The carbon content also lowers the melting point, making it good for casting. 4. High carbon can also mean the cast iron is more brittle. 5. Most cast iron can be welded, though white cast iron in considered almost unweldable. 6. Oxyacetylene and shielded metal arc welding generally produce the most favorable results. 7. Uses include brake drums, engine blocks, and furnace grates.
Objective 5 *The characteristics and uses of some common nonferrous metals are discussed below.*	**Identify common nonferrous metals, their characteristics, and their uses.** Aluminum 1. In its pure state, aluminum is much weaker than steel. 2. The addition of alloys, heat treatment, and cold working can make aluminum, pound for pound, stronger than structural steel. 3. Aluminum alloys are lighter than most metals and resistant to corrosion. 4. Aluminum oxide must be removed to ensure the quality of the weld. 5. Aluminum does not change color before reaching its melting point. The surface of the metal can be scratched as it is heated to determine if it is softening. 6. Uses include wheels, airplane parts, cans, and castings. Copper 1. Pure copper is very soft, but processes such as alloying and cold working can increase its ductility

Instructor Directions	Content Outline
	and malleability (ability to be forged, hammered, or rolled). 2. It is second only to silver as an electrical conductor. 3. Most copper and copper alloys can be joined by common welding methods, brazing, and soldering. 4. Like many other nonferrous metals, copper has a tendency toward "hot shortness" (easily distorting when heated to its melting point). Because of this property, it must be firmly clamped when heated to this temperature. 5. Uses include wire, pipe, and radiator parts. Brass 1. Brass is an alloy of copper and zinc. 2. It has working characteristics similar to copper. 3. It is resistant to acids and has high formability. 4. It is a good brazing alloy. 5. Uses include plumbing parts, castings, and ornamental work. Bronze 1. Bronze is an alloy of copper and tin. 2. It resists corrosion like copper, but is stronger and easier to cast. 3. It behaves similarly to brass when welded. 4. Uses include gears, castings, and decorative parts.
Application: AS 1 – Identifying Ferrous Metals Using Spark Testing	AS 1 Results will vary. Other activities 1. Create an identification board that displays different types of metals and their characteristics and uses. In addition, have students bring metal samples from home and discuss the type, characteristics, and purpose of each sample.
Closure/Summary	Metal selection governs the welding technique that can be applied, so it is important to properly identify the metal used in each job. The more than 1,000 available metals come in two categories: ferrous, which has high iron content, and nonferrous, which contains little or no iron.

Instructor Directions	Content Outline
	Common methods of identifying metals include magnetic testing, color, oxyacetylene torch testing, and spark testing. Common types of ferrous metals are wrought iron, carbon steel (low, medium, high), alloy steel (which combine iron with such elements as manganese, nickel, or tungsten), stainless steel, and cast iron. Common nonferrous metals are aluminum, copper, brass, and bronze.
Evaluation: Quiz	Answers: 1. a 2. d 3. c 4. b 5. a 6. d 7. b 8. d 9. c 10. a. Ferrous metals – A group of metals with high iron content. Students should list two of the following: wrought iron, carbon steel, alloy steel, stainless steel, and cast iron. b. Nonferrous metals – A group of metals with little or no iron. Students should list two of the following: aluminum, copper, brass, and bronze.