R E P O R T   R E S U M E S

ED 012 766 VT 000 493

METAL FUSION AND FABRICATION WELDING. AGRICULTURAL MACHINERY--SERVICE OCCUPATIONS, MODULE, NUMBER 6.
OHIO STATE UNIV., COLUMBUS, CENTER FOR VOC. EDUC.
REPORT NUMBER OSU-AGDEX-785-017-6 PUB DATE AUG 65
EDRS PRICE MF-$0.25 HC-$1.92 48P.

DESCRIPTORS- *TEACHING GUIDES, UNITS OF STUDY (SUBJECT FIELDS), *AGRICULTURAL EDUCATION, *AGRICULTURAL MACHINERY OCCUPATIONS, *WELDING, POST SECONDARY EDUCATION, BIBLIOGRAPHIES, COLUMBUS

ONE IN A SERIES DESIGNED TO HELP TEACHERS PREPARE POSTSECONDARY STUDENTS FOR THE AGRICULTURAL MACHINERY SERVICE OCCUPATIONS AS PARTS MEN, MECHANICS, MECHANIC'S HELPERS, OR SERVICE SUPERVISORS, THIS GUIDE AIMS TO DEVELOP STUDENT UNDERSTANDING OF WELDING EQUIPMENT AND SUPPLIES, AND ABILITY TO PERFORM SKILLS REQUIRED OF AGRICULTURAL MECHANICS. IT WAS DEVELOPED BY A NATIONAL TASK FORCE ON THE BASIS OF RESEARCH FROM STATE STUDIES. SUGGESTIONS FOR INTRODUCTION OF THE MODULE ARE GIVEN. EACH SUBJECT-MATTER UNIT INCLUDES COMPETENCIES TO BE DEVELOPED, SUBJECT-MATTER CONTENT, TEACHING-LEARNING ACTIVITIES, SUGGESTED MATERIALS, AND REFERENCES. SUBJECT MATTER AREAS ARE--(1) FUNDAMENTALS AND SAFE WELDING PRACTICES, (2) SELECTION AND CARE OF EQUIPMENT, (3) METAL IDENTIFICATION, (4) ELECTRODE SELECTION, (5) ARC WELDING, (6) CARBON ARC TORCH OPERATION AND MAINTENANCE, (7) FERROUS HARDSURFACING, (8) ARC AND OXYACETYLENE CUTTING, (9) NONFERROUS METAL WELDING AND BRAZING, AND (10) INERT GAS WELDING. SOURCES OF INSTRUCTIONAL MATERIALS, AND REFERENCES AND SUGGESTIONS FOR EVALUATING OUTCOMES ARE INCLUDED. SUGGESTED TIME ALLOTMENT IS 12 HOURS OF CLASS INSTRUCTION AND 36 HOURS OF LABORATORY EXPERIENCE. TEACHERS SHOULD HAVE EXPERIENCE WITH AGRICULTURAL MACHINERY. STUDENTS SHOULD HAVE MECHANICAL APTITUDE AND AN OCCUPATIONAL GOAL IN AGRICULTURAL MACHINERY. THIS DOCUMENT IS ALSO AVAILABLE FOR A LIMITED PERIOD AS PART OF A SET (VT 000 488 THROUGH VT 000 504) FROM THE CENTER FOR VOCATIONAL AND TECHNICAL EDUCATION, THE OHIO STATE UNIVERSITY, 890 KINNEAR ROAD, COLUMBUS, OHIO 43212, FOR $7.50 PER SET. (JM)

METAL FUSION
AND
FABRICATION WELDING

One of Sixteen Modules in the Course Preparing for Entry in

AGRICULTURAL MACHINERY - SERVICE OCCUPATIONS

Module No. 6

The Center for Research and Leadership Development

in Vocational and Technical Education

The Ohio State University
980 Kinnear Road
Columbus, Ohio, 43212

The development of these materials was supported by a grant from the
Division of Adult and Vocational Research
United States Office of Education

August, 1965

MEMORANDUM

TO: The ERIC Clearinghouse on Vocational and Technical Education
The Ohio State University
980 Kinnear Road
Columbus, Ohio 43212

FROM: (Person) James W. Hensel (Agency) The Center for Vocational and Technical Education

(Address) 980 Kinnear Road, Columbus, Ohio 43212

DATE: August 4, 1967

RE: (Author, Title, Publisher, Date) Module No. 6. "Metal Fusion and Fabrication Welding." The Center for Vocational and Technical Education. August. 1965.

Supplementary Information on Instructional Material

Provide information below which is not included in the publication. Mark N/A in each blank for which information is not available or not applicable. Mark P when information is included in the publication. See reverse side for further instructions.

(1) Source of Available Copies:
Agency The Center for Vocational and Technical Education
Address 980 Kinnear Road, Columbus, Ohio 43212
Limitation on Available Copies No Limit Price/Unit $ 7.50/set
(quantity prices)

(2) Means Used to Develop Material:
Development Group National Task Force
Level of Group National
Method of Design, Testing, and Trial Part of a funded project of the USOE, OE-5-85-009; materials based on research from state studies; see preface material in the course outline.

(3) Utilization of Material:
Appropriate School Setting Post high school
Type of Program General post high school class in agricultural machinery
Occupational Focus Agricultural machinery service occupations
Geographic Adaptability Nationwide
Uses of Material Instructor course planning
Users of Material Teachers

(4) Requirements for Using Material:
Teacher Competency Background in agricultural machinery
Student Selection Criteria Post high school, mechanical aptitude, high school background, goal in agricultural machinery service occupation.
Time Allotment Estimated time listed in module. (P)

Supplemental Media --
Necessary x
Desirable
(Check Which)

Describe Suggested references given in module. (P)

Source (agency)
(address)

METAL FUSION AND FABRICATION WELDING

CONTENTS

METAL FUSION AND FABRICATION
"WELDING"

Major Teaching Objective

To develop (1) an understanding of welding equipment and supplies and (2) the ability to perform welding skills required of agricultural mechanics.

Suggested Time Allotment

At school				
Class instruction	12	hours		
Laboratory experience	36	hours		
Total at school			48	hours
Occupational experience			0	hours
Total for module			48	hours

Suggestions for Introducing the Module

History shows that the ability of a country or race of people to progress depends upon their ability to use and fabricate (fasten or put together) metals. A country's standard of living, and even its survival, depends upon how well its craftsmen can fabricate metals. In modern agriculture metal products are commonly used. Their fabrication is necessary to protect and maintain our high standard of living.

A person preparing for employment as an agricultural machinery mechanic must have an understanding of welding equipment and supplies, and be able to weld and fabricate metals. Welding may be used to repair broken machinery, to rebuild surfaces that have been worn or battered in use, and to make new parts to replace parts damaged beyond repair. Welding may also be used to fabricate many articles of general or special character.

Following are some suggested techniques for use in creating interest in the module:

1. Thought questions

    a. What is welding?

    b. What are the different methods of welding?

    c. What are the advantages of the agricultural mechanic's possessing welding skills?

2. Demonstrate to the class the strength of a strong weld as compared to the strength of a poor weld.

3. Observe a piece of farm machinery and count the number of welds used in its construction

4. Films

Magic Wand of Industry

Arc Welding at Work

Competencies to be Developed

I. To understand the fundamentals and safe practices of welding

Teacher Preparation

Subject Matter Content

A knowledge of fundamental welding terms is necessary for selecting equipment and materials and for learning welding skills.

Welding is not a hazardous operation. In most instances personal injuries and property damage resulting from welding are caused by negligence on the part of the operator. Weldors can best protect themselves by acquiring a thorough knowledge of the operation of equipment when they first learn to weld.

This competency is intended to increase knowledge of fundamental welding terms and to develop an awareness of potential hazards of welding.

1. Fundamental terms of welding

a. Arc blow
b. Arc length
c. Arc voltage
d. Backing
e. Back-step welding
f. Base metal
g. Butt weld
h. Crater
i. Direct current
j. Alternating current
k. Face of weld
l. Fillet weld
m. Flux
n. Gas pocket
o. Lap joint
p. Pass
q. Peening
r. Penetration
s. Porosity
t. Pre-heating
u. Puddle
v. Reversed polarity
w. Root of weld
x. Slag inclusion
y. Spatter
z. Straight polarity
aa. Tack weld
ab. Throat of fillet weld
ac. TIG welding
ad. Toe of weld

ae. Undercut
af. Weaving
ag. Welding rod
ah. Welded metal
ai. Duty cycle
aj. Bead
ak. Ferrous
al. Helmet
am. Welder
a Weldor
ao. Electrode
ap. Electrode holder
aq. Brazing
ar. Cone
as. Hardfacing
at. Neutral flame
au. Welding tip
av. Welding torch
aw. Cylinder
ax. Carburizing flame
ay. Oxidizing flame
az. Acetylene
ba. Whipping
bb. Butt joint
bc. Tee joint

2. Safe practices in welding

A properly installed welder will give safe, trouble-free service if a reasonable amount of care is used in its operation. However, very serious injuries are likely to occur unless safe practices are followed carefully.

a. Avoid shock hazards.

1) Be sure both arc welders and the power supply system are grounded. Do not ground the ground terminal to the welder frame.
2) Always open the main power switch before working on the welder.
3) Turn off the welder to adjust the current setting.
4) Do not operate arc welders in wet locations.
5) Keep cables, electrode holders, and connections in good condition.
6) Turn off machines when the job is finished.

b. Protect the eyes and skin. The intense light of the electric arc is very injurious, as are flying pieces of hot slag and metal.

1) Use a face shield with a suitable density color lens; never look at an electric arc with the naked eye.

a) A welding glass of shade 10 density is suitable for most arc welders.
b) A welding glass shade density of 4 or 5 is suitable for oxyacetylene welding.

2) Before striking an arc, make sure fellow workers are shielded or are looking the opposite direction.

3) Keep helmets and shields in excellent condition.
4) Use clear goggles to protect eyes when chipping slag.
5) Wear leather gloves to protect hands from rays and spatter.
6) Wear long-sleeved shirts or jackets to protect the skin from arc-burn.

c. Provide good ventilation.

1) Always ensure an adequate supply of fresh air. Use an exhaust fan.
2) Do not inhale fumes from zinc or lead-coated metals. Weld these meterials out-of-doors.

d. Prevent burns from hot metal.

Mark hot welds so that others will know they are hot.

e. Prevent fires and explosions.

1) Keep combustible materials away from the welding operation.
2) Keep heat away from gas cylinders.
3) Do not weld on materials which have contained combustible materials.
4) Use soap suds to check for oxygen and acetylene leaks. The soap used should not contain petroleum bases.
5) Always keep oxygen and acetylene cylinders in an upright position. Keep them fastened to prevent being knocked over.

f. Practice good housekeeping.

1) Electrode and rod stubs should not be allowed on the floor.
2) Welding cables and gas hoses should be coiled neatly after each job.

Suggested Teaching-Learning Activities

1. Have students define fundamental welding terms.

2. Require students to become familiar with safety precautions pertaining to welding.

3. Demonstrate the proper electrical hookup of a welder.

4. Demonstrate the proper hose hookup of a gas welder.

5. Demonstrate proper handling of fire extinguishers.

Suggested Instructional Materials and References

Instructional materials

1. Charts on safety precautions
2. Arc welder
3. Gas welder
4. Fire extinguishers

References

S*1. Hobart Vest Pocket Guide, pp. 26-30.

S 2. Smith's Short Course for Gas Cutting, Welding, Brazing, p. 20.

S 3. Arc Welding Lessons, pp. 96-104.

S 4. The Farm Shop, pp. 135-136, 167-168.

S 5. Farm Mechanics Text and Handbook, pp. 244-245, 282.

*The symbol T (teacher) or S (student) denotes those references designed especially for the teacher or for the student.

II. To select and care for welding equipment

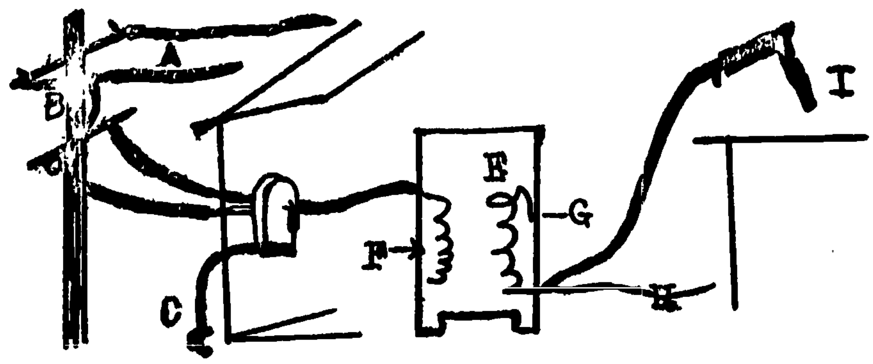
Teacher Preparation

Subject Matter Content

To qualify as an agricultural machinery mechanic and welder, one must know how to select and care for welding equipment and accessories.

Arc Welders are of two basic types: those that provide alternating welding current (AC) and those that provide direct welding current (DC).

The AC welder has a step-down transformer which steps the 240-volt-line voltage down and the amperage up so that the heat can be safely used for welding. The control for stepping up the amperage, which varies on different makes of welders, is necessary to provide different degrees of heat for welding various thicknesses of metals.



A. Power line, B. Transformer, C. Ground, D. Wall outlet. E. Welder, F. Primary winding, G. Secondary winder, H. Ground cable, I. Electrode

The transformer-welder is popular for several reasons:

1. Low initial cost
2. Low operation and maintenance cost
3. Convenience to use
4. Lack of moving parts
5. Use of single-phase current
6. Quiet operation
7. No arc blow

The DC welder has some advantages over the AC machine: it may be used with a wider variety of electrodes; it is better for welding thin metal; and gas-engine-driven models furnish welding current where there are no electric power lines.

The source of DC welding current is usually a generator. The electric-motor generator welder is a self-contained machine that requires three-phase current. The line current runs the motor, which turns a generator to produce DC current. Portable DC welders have the generator powered by an engine.

Another type of DC welder does not use a generator but converts 240-volt AC line current into DC current by the use of a rectifier. The rectifier is made of silicon or selenium.

Still another type of welder is the universal welder, which combines both AC and DC. This type operates on single-phase 240-volt-line current and provides either AC transformed welding current or DC rectified welding current, thus providing the current best suited to the particular job.

The UL mark of the Underwriters Laboratory should appear on the name-plate of any welder purchased, showing that it will deliver its rated current and meet adequate safety standards.

All welders should be kept in a dry area, since dampness is harmful to transformer generator windings. Whenever a welder is installed, help or advice should be sought from the power-supplier or a competent electrician.

Standard accessories for the arc welder include a wire brush, an electrode holder, a head shield, and welding cables.

Other accessories are

1. Cable lugs
2. Ground clamps
3. Arc torch
4 Electrodes
5. Gloves
6. Aprons
7. Safety goggles
8. Chipping hammer
9. Tongs and pliers

Oxyacetylene welders are divided into two general classes, depending upon the level of acetylene pressure used. The injector type can use acetylene at pressure under one pound per square inch, whereas the medium-pressure type requires that acetylene be supplied at pressures from one to 15 pounds per square inch.

Pieces of equipment and accessories making up an oxyacetylene welder are

1. Oxygen cylinder
2. Acetylene cylinder
3. Oxygen regulator
4. Acetylene regulator

5. Blowpipe (torch)
6. Blowpipe tips (torch tips)
7. Hos
8. Hose connections
9. Friction lighter
10. Goggles
11. Wrenches
12. Gloves
13. Pliers

Some general maintenance precautions of the oxyacetylene welder are as follows:

1. Use no oil on regulators under any circumstance.

2. Have equipment inspected at frequent intervals by a competent operator.

3. Do not use blowpipes, regulators, or other equipment in need of repair.

4. If orfices in the tips of nozzles become clogged, clean them with the proper size of twist drill tip cleaner or a soft brass or copper wire.

5. If leakage develops around the blowpipe stem, tighten the packing nut, and repack it if necessary.

6. If a valve does not shut off completely, clean the seat.

7. If a regulator creeps, have it repaired at once.

8. If the safety relief disk of the regulator ruptures, have a new one installed immediately.

9. Always maintain a gas-tight connection between regulators and cylinders.

10. When regulators are not to be used for several weeks or longer, relieve the pressure on the delivery-pressure valve seat.

11. Test hose frequently for leaks.

12. Do not repair hose with tape.

Suggested Teaching-Learning Activities

1. Have students identify major parts of an oxyacetylene welder.

2. Have students become familiar with welding equipment through reading assignments.

3. Have the class visit a local dealer or welding shop to identify different welding equipment.

4. Demonstrate the proper hookup of an oxyacetylene welder. Then have students demonstrate and practice hookup.

Suggestion ıstructional Materials and References

Instructional materials

1. Overhead transparencies of oxyacetylene equipment

2. Oxyacetylene welder

3. AC welder

4. DC generator-type welder

5. AC-DC transformer-rectifier welder

References

S 1. The Oxyacetylene Handbook, pp. 49-72.

S 2. Modern Arc Welding, pp. 187-229.

3. Arc Welding Lessons, pp. 10-25.

4. The Farm Shop, pp 128-133, 166-169.

III. To identify metals commonly welded

Teacher Preparation

Subject Matter Content

To use the welding procedure best suited to a job, the welder must first identify the metal to be welded, since procedures vary with different metals. A practical identifying test must be simple and easy to make with ordinary equipment in the shop.

Metals can often be identified by their use or appearance, or by the spark test on a grinding wheel, the fracture test (observing if the metal bends prior to breaking), or the magnetic test.

The spark test is both simple and commonly used. Different kinds of iron and steel make different spark patterns when they are touched lightly to the grinding wheel. Cast iron gives off red sparks that travel in a straight line with clublike sparks at the ends. Mild steel gives off yellow sparks otherwise similar to those made by cast iron. Medium carbon steel gives off larger quantities of yellow sparks with explosive bursts or stars at the ends. High carbon steel gives off brighter and more explosive sparks.

When making spark tests, use a clean grinding wheel and touch each part of the metal to the wheel with approximately the same pressure. The metal being tested should be compared with known samples and the operator should stand to one side of the grinding wheel to see the spark pattern most easily.

Chart I

Kinds of Iron and Steel Used in Farm Machinery

	Mild and medium carbon steel	High carbon steel	Cast iron	Malleable iron
Tool or part	Blacksmith iron Pipe Machinery frames Forgings Bolts Rivets Sheetmetal Fenders	Plowshares Cultivator sweeps Harrow disks Rake teeth Gears Axles Shafts Springs Bearing races	Rough gears Sprockets Bearing brackets Mower wheels Cylinder heads Transmission cases	Beam brackets and castings subject to shock

The common nonferrous (not containing iron) metals used in farm machinery are aluminum, brass, copper, and pot-metal. With the exception of copper, they are difficult to weld unless the TIG process is used. Aluminum can be identified by its white color and light weight. Copper, which is for plumbing, gas lines, etc., is rust red in color and can be brazed with silver solder or bronze-welded. Brass which is used chiefly in the form of castings is yellow in color and is used to make valves and small plumbing fittings; it can be welded by the oxyacetylene process. Pot-metal resembles aluminum, but it is darker in color and heavier and very difficult to weld.

Suggested Teaching-Learning Activities

1. Have students clean and dress a grinding wheel.
2. Demonstrate metal identification by the spark test.
3. Have students identify metals by the spark test.
4. Have students identify metals by appearance only.
5. Have students identify ferrous from nonferrous metals by the magnetic test.
6. Have students identify nonferrous metals by color.
7. Have students identify high carbon metals from low carbon metals by the sound method.

Suggested Instructional Materials and References

Instructional materials

1. Grinder
2. Selection of known and identified metals (ferrous and nonferrous)
3. Selection of unknown metals to be identified
4. Metal identification charts and transparencies
5. Magnet
6. Tools necessary for dressing grinder and making test
7. Safety goggles

References

1. The Oxyacetylene Handbook, pp. 117-118.

2. Hobart Vest-Pocket Guide, pp. 12-13.

3. Arc Welding Lessons, pp. 64-89.

IV. To select the proper electrode

Teacher Preparation

Subject Matter Content

Matching arc welding electrodes with materials begins by identifying the metal to be welded. There are many different alloys of steel. The welder using Chart I can classify most of the iron or steel materials he welds, but he should check some metals further by the spark test and a known sample of metal. It may also be advisable to compare the spark from a weld bend of a particular welding electrode with the metal to be welded. If the sparks are identical, the metals should be alike.

Electrodes for Low and Medium Carbon Steels

Ten basic kinds of electrodes are available for welding low-to-medium carbon steel. All are shielded electrodes with heavy coatings of flux over a core wire of low carbon steel, but they differ in the type and combination of chemical substances in the coating.

Each substance in the flux has a particular function for the arc welding process, but the main objectives are (1) to stabilize the arc and (2) to protect the molten metal from the atmosphere. After the arc is started, current flows across the gap between the end of the electrode and the work. It does not jump the gap like a high-voltage ignition spark but is conducted by a mass of ionized gas coating which are vaporized by the heat of the arc. The nature of this gas determines the stability of the arc, or the ease of striking and maintaining it.

Arc stability is generally good when welding with DC current, which flows steadily in one direction. It is more a problem with AC welding, as the arc tends to be extinguished and restarted 60 times per second as the current alternates. Sodium compounds are generally used in the flux of DC electrodes; whereas potassium compounds are common in the flux of AC electrodes because potassium compounds ionize more easily. The arc stability problem is more acute with a farm-type AC welder that may have a lower open-circuit voltage than an industrial-type AC welder. It is also troublesome when using low amperage to weld thin materials.

Classification of Electrodes

Even though the sparks from the bead of one type of electrode match the work, several other types may also be suited to the work. Choosing the electrodes most often used for farm welding is not difficult because almost all manufacturers make rods of the same types and use a standard numbering system. Because these types have been defined by the American Welding Society (AWS) and the American Society for Testing Materials (ASTM), the letters AWS followed by a number such as AWS-ASTM E6013 appear on every package of rods. The E stands for electrode and the 60 shows the tensil and strength of the rod. If the third number were 2, the rod could be used in flat and vertical welding, but not for overhead. The number 3 signifies that the rod is designed for flat position only. If the third number is a "1" the rod can be used for all positions. The last digit quite often indicates the approximate penetration and 0 maximum. The last two digits, however, may be used in combination to mean entirely different things; therefore the manufacturer's recommendations for his rod should be referred to.

Identification by Color Code

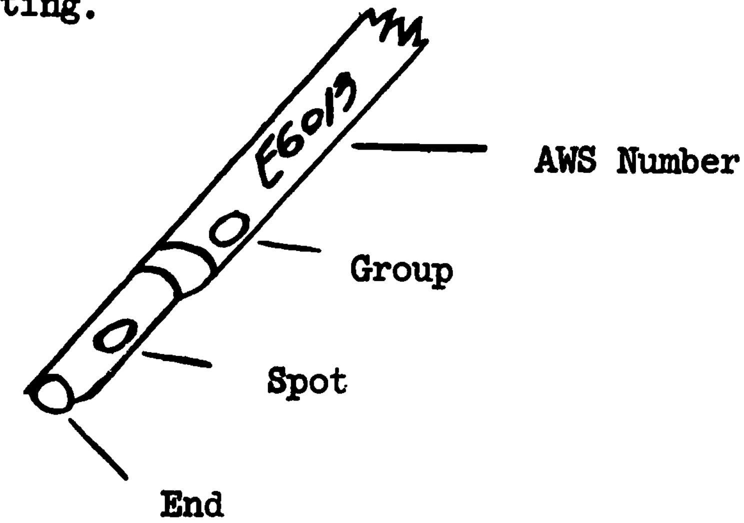
Almost any manufacturer who sells an AWS E6013 rod also identifies it by a color code written by the National Electrical Manufacturing Association. The E6013 rod, for example, is marked with a brown dot of paint, called spot color, which is located on the side of the end which is gripped by the electrode holder.

1. Primary color is located on the end of the bare part of the electrode.

2. Secondary color is located on the side of the bare part of the electrode.

3. Group color is located on the flux coating near the bare end of the electrode.

4. Some manufacturers are stamping the AWS number on the flux coating.



Color Spots for Identifying Electrodes

In recent years rods with iron powder in the coating have been much used, but for farm use smaller amounts of iron powder actually make for better welding rods. Welding rods with considerable amounts of iron powder in the flux coating are not suitable for most farm-type AC welders because of the low open-circuit voltage design of the welding machine. Heavy coated (iron powder) E-6014 or E-6024 electrodes do not have the penetration or arc force compared to an E-6011, which has very little coating but a forceful arc. An E-6011 electrode is excellent for farm use because it will weld through paint, rust, light dirt, etc. It is easy to use for vertical or overhead welding.

Electrodes for Cast Iron Welding

Cast iron, because of its high carbon content and relative brittleness, requires special electrodes for welding. Two common types of cast-iron-welding electrodes are available, machinable and non-machinable.

Machinable cast iron electrodes have a high nickel content and produce a soft weld that can be drilled, filed, or otherwise machined after it cools. They are classified as E Ni and have an orange end, a blue spot, and a white group color. E Ni electrodes are relatively expensive in price per pound.

Non-machinable cast iron electrodes have a steel core wire with a special flux coating. During cooling, carbon migrates from the deposit, which becomes hardened in the cooling process. The weld, therefore, cannot be cut with a drill, a file, or any ordinary machine tool. These electrodes are classified E St and have an orange end, no spot, and no group color.

Comparing Electrodes from Various Manufacturers

A comparison chart with AWS numbers and brand names of electrodes made by various manufacturers aids in recognizing and comparing electrodes and reveals that manufacturers often have several electrodes for each AWS number. Specific information from a manufacturer should be obtained for detailed use characteristics.

In addition to this information, choice of the electrode should be finally determined by experience in working with different materials and actually trying different rods for different situations. Practice beads with any rod should be run before making the weld to see how it performs and to check the four fundamentals for getting a good weld. Good technique is just as important as matching the electrode with the material.

Ferrous Oxyacetylene Welding Rods

All-purpose mild-steel welding rods are used for welding all kinds of mild and low-carbon steel. They are satisfactory and probably better than other kinds for most farm machinery and shop welding. Flux is not needed in fusion welding steel.

Alloy-nickel cast-iron rods made strong, high-quality machinable welds on cast iron. Flux is needed for this welding process.

Nonferrous Welding Rods

These include, among others, the bronzes, copper, silver alloys, and aluminum. A suitable flux is required for each.

Bronze welding rods are used for steel, malleable iron, and cast iron. A good bronze rod has smooth-flowing qualities, makes deposits that are non-porous, and does not fume excessively during the welding operation.

Silver alloy rods are made of silver, copper, and phosphorus. They make strong welds in steel, copper, and brass. Sometimes they are called low-temperature rods because they melt at lower temperatures than other kinds of rods.

Welding Flux

When welding with cast iron and nonferrous rods, a welding flux must be used. For good quality work, always select a reliable flux recommended for the kind of work being done. The most commonly-used fluxes are bronze, cast iron, brazing, and aluminum.

Suggested Teaching-Learning Activities

1. Have students study reading assignments on electrode identification and selection.

2. Have students identify welding rods and fluxes and give uses of each rod or flux.

3. Demonstrate cross-reference charts and have students use them.

4. Have students explain the AWS classification system of electrodes.

5. Have students explain the NEMA color code system of electrode indentification.

Suggested Instructional Materials and References

Instructional materials

1. Examples of electrodes, rods, and fluxes

2. Electrode-usage charts from manufacturers

3. Arc Welding Electrode Selection

4. Factors to Consider in Selecting Electrodes

5. Cross-reference charts from manufacturers

References

1. Modern Arc Welding.

2. Hobart Vest Pocket Guide, pp. 32-65.

3. Arc Welding Lessons, pp. 42-54.

4. The Oxyacetylene Handbook, pp. 505-514.

5. The Farm Shop, p. 134.

V. To become proficient in striking an arc, carrying a puddle, and re-starting the arc

Teacher Preparation

An experienced welder always checks the condition of his equipment before beginning to weld. The bench top must be clean, dry, and free from rust, grease, and paint to insure a direct flow of current.

To strike an arc, the electrode is moved at an angle to the plate in a striking motion similar to that used when striking a match. For the proper arc length, it should be drawn slowly to a height of about 3/16 inch. This should give a sharp egg-frying sound. A too-short arc will cause the electrode to freeze to the metal and a too-long arc will give a humming sound and cause spatter and will finally go out.

The electrode is tipped about 15 degrees in the direction of travel, and held at 90 degrees to the metal being welded. Correct speed of travel is indicated by the size of the bead which should be about twice the diameter of the electrode being used.

The correct amperage setting must be made to obtain a proper bead with penetration and very little spatter. It depends upon thickness of the metal, size of the electrode and type of electrode being used. Always refer to electrode manufacturer's recommendation for correct amperage setting for the electrode and job.

To re-establish a bead, first strike the arc; then move the electrode to the crown of the crater and resume forward travel.

Suggested Teaching-Leaning Activities

1. Familiarize the student with welding machines and equipment.

2. Demonstrate striking an arc, proper arc length, correct speed of travel, and width of bead.

3. Have students run several beads with correct arc length, current setting, speed of travel, and electrode angle.

4. Have students study reading assignments; then have them correct their errors.

5. Demonstrate the effects of various arc lengths, current settings, and speed of travel.

Suggested Instructional Materials and References

Instructional materials

1. Welder AC or DC
2. Protective clothing
3. Helmet
4. Chipping hammer
5. Wire brush

Hereafter referred to as welder and equipment

6. Steel plate 3/16 inch thick
7. E-6013 or E-6012 electrodes of 18 inch size

References

S 1. Good and Bad Weld Plastic Replicas.

2. Arc Welding Lessons, pp. 121-129.

3. Modern Arc Welding, pp. 309-314.

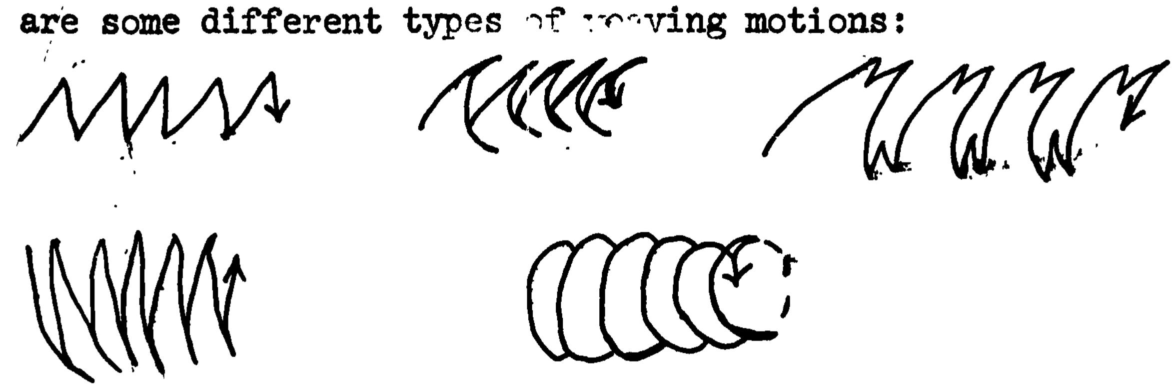
4. Hobart Vest Pocket Guide, pp. 6-7.

VI. To run a bead in a weaving motion

Teacher Preparation

Subject Matter Content

Running a bead with a weaving motion has many uses. It is used where a wider bead is desired than normally can be laid when running a straight bead and where finish passes are needed on flat welds and in padding or built-up repair jobs. The following are some different types of weaving motions:



Always remove slag when depositing a weld on top of another weld. The shape of the weld is determined by the closeness of the weaves.

Suggested Teaching-Learning Activities

1. Have students study text assignments.
2. Demonstrate different types of weaves to students.
3. Have students practice weaves.

Suggested Instructional Materials and References

Instructional materials

1. Welder and equipment
2. Steel plates 3/16 inch thick
3. E-6013 or E-6012 electrodes of 1/8 inch size

References

1. Arc Welding Lessons, pp. 131-134.
2. Modern Arc Welding.
3. The Farm Shop, pp. 138-142.

VII. To make a butt weld

Teacher Preparation

Subject Matter Content

Butt welds are one of the easiest kinds of welds to make. They are used in sheet steel (steel up to 1/8 inch thick) and in plate steel up to 1/4 inch. (Plate steel is thicker than 1/8 inch.) Beveling is required on plate thicker than 1/4 inch to ensure full penetration.

When welding two pieces together, always tack both ends prior to starting to weld to avoid metal expansion that pulls the pieces of metal apart. Long pieces should be tacked at 4-to-6 intervals.

Always make closely-fitted joints. Never space parts more than one-half their thickness. Always use a steel backing-strip when a joint cannot be closely-fitted. Weld on both sides of a joint for resistance to bending stresses.

Suggested Teaching-Learning Activities

1. Have students study text assignments.

2. Demonstrate butt welding to students.

3. Have students practice butt welding in flat and horizontal positions.

Suggested Instructional Materials and References

Instructional materials

1. Welder and equipment

2. Steel plates 3/16 inch thick

3. E-6013 or E-6012 electrodes of 1/8 inch size

References

1. Arc Welding Lessons, pp. 137-146.

2. Modern Arc Welding.

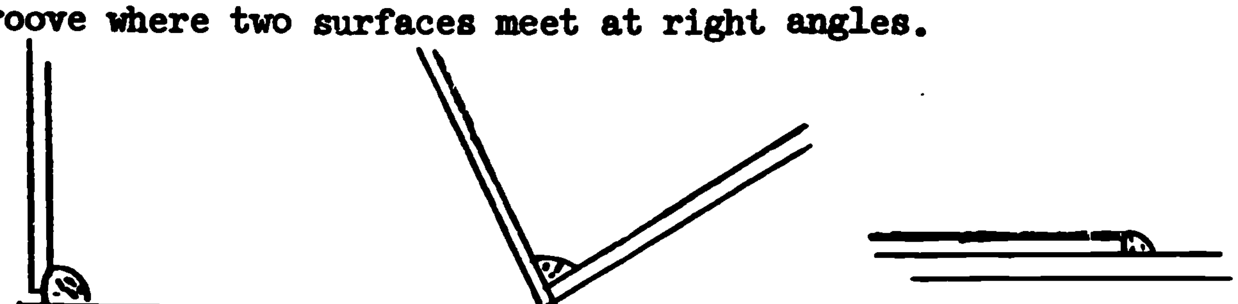
3. The Farm Shop, pp. 142-143.

VIII. To fillet weld in the flat and horizontal position

Teacher Preparation

Subject Matter Content

A fillet weld is made by one or more bends welded in the V groove where two surfaces meet at right angles.



Horizontal Fillet Flat Fillet Lap Fillet

Fillet welds may be used in any position. They are easiest to make when the metal is in the flat or horizontal position.

Suggested Teaching-Learning Activities

1. Have students study reading assignments.

2. Demonstrate fillet welding.

3. Have students practice fillet welding.

Suggested Instructional Materials and References

Instructional materials

1. Welder and equipment

2. Mild steel plates 3/16 inch thick

3. E-6013 or E-6012 electrodes of 1/8 inch 5/32 inch size

References

1. Arc Welding Lessons, pp. 150-158.

2. Modern Arc Welding.

3. The Farm Shop, pp. 142-143.

IX. To weld in the vertical position

Teacher Preparation

Subject Matter Content

Two methods are used to weld joints in the vertical position: welding up and welding down.

Vertical Up-Welding

Vertical up-welding is used whenever a strong, dependable weld with a deep penetration is desired on something that has to be welded with the joint running vertically in relation to the ground.

The problem, when welding vertical up, is to put the molten metal where it is wanted and make it say there. Because gravity pulls the molten metal downward, making it drip, certain techniques must be followed:

1. Use a fast-freezing electrode (example: E-6011).

2. Put the electrode in the holder so that it sticks straight out the end.

3. When welding, have the electrode-holder slightly lower than the tip of the electrode.

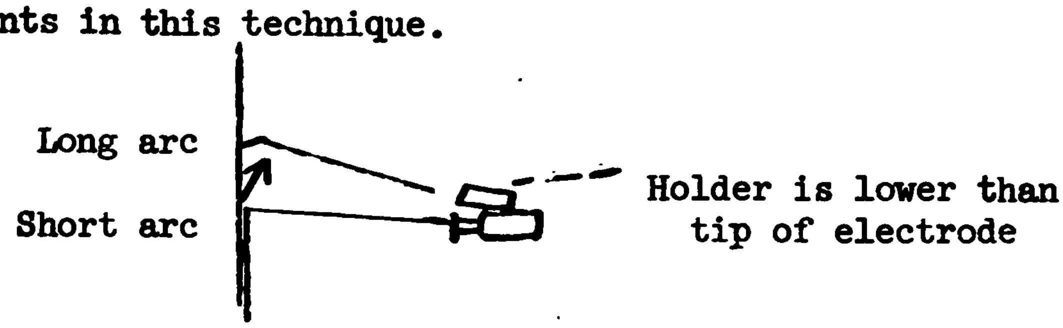
4. Deposit the metal at the bottom of the two pieces to be welded together, working upward toward the top.

5. Before too much metal is deposited, move the arc 3/4 inch upward with a slight wrist movement. This takes the heat away from the molten puddle and allows it to solidify.

6. During this entire process, look at the molten puddle, not the arc.

7. When bringing the arc down to deposit metal, make it very short in order to deposit metal as fast as possible; when lifting the arc, make it long or metal will be deposited all up and down the plate.

8. Make very slow movements. There are no fast movements in this technique.



Vertical Down-Welding

Vertical down-welding can be learned rapidly because there are only a few requirements.

1. Use an E-6011 electrode.

2. Put the electrode straight out of the holder.

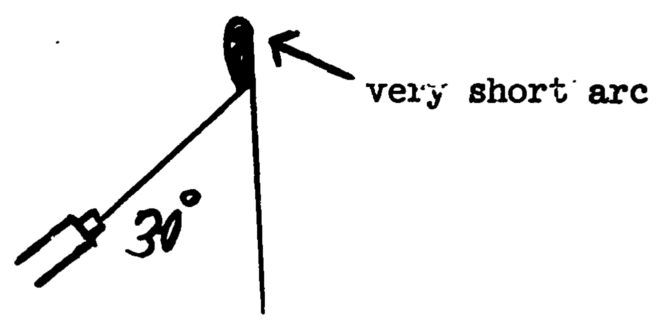
3. Use thin (14 or 16 guage) metal.

4. Hold the electrode in a 30-degree angle pointing upward.

5. Hold a short arc, but do not touch the metal.

6. Use up-and-down whipping motion to help prevent burning through on very thin metal.

7. Carefully watch the molten metal.



It is important to continue lowering the entire arm as the weld is made, so that the angle of the electrode does not change; and to move the electrode so fast that the molten slag does not catch up with the arc. Vertical down-welding gives thin, shallow welds. It should, therefore, never be used on heavy materials, where strong welds are required.

Suggested Teaching-Learning Activities

1. Have students study reading assignments.

2. Demonstrate vertical up-welding in various positions.

3. Demonstrate vertical up-welding in various position welds.

4. Have students practice vertical up-welding.

5. Have students practice vertical down-welding.

Suggested Instructional Materials and References

Instructional materials

1. Welder and equipment

2. Mild steel plate 3/16 inch thick

3. Metal of 14 or 16 guage thickness

4. E-6011 electrodes of 1/8 inch size

References

1. Modern Arc Welding, pp. 339-351.

2. Arc Welding Lessons, pp. 162-171.

3. The Farm Shop, pp. 142-143.

X. To weld in the overhead position

Teacher Preparation

Subject Matter Content

Welding in the overhead position is difficult because the molten metal must be carefully controlled. Observe the following:

1. Use suitable electrodes (E-6010, E-6011, E-6012, E-6013).

2. Use small electrodes (1/8 inch) for most welding.

3. Use a short arc to make the metal hold. A long arc will cause molten metal to fall.

4. Take precautions to avoid injury from falling bits of hot metal and slag.

Suggested Teaching-Learning Activities

1. Have students read and study reading assignments.

2. Demonstrate overhead-welding.

3. Have students practice overhead-welding.

Suggested Instructional Materials and References

Instructional materials

1. Welder and equipment

2. Mild steel 3/16 inch thick

3. E-6010, E-6011, E-6012, E-6013 electrodes of 1/8 inch size

References

1. Modern Arc Welding, pp. 355-363.

2. Arc Welding Lessons, pp. 176-183.

XI. To operate and maintain a carbon-arc torch

Teacher Preparation

Subject Matter Content

The carbon arc torch is an accessory to the arc welder and is useful in applying heat through radiation rather than by an arc formed when an electrode is used. It is used for brazing, hardsurfacing, and soldering, and in jobs requiring bending and shaping.

Arc torches are commonly equipped with carbon centers coated with copper. The sizes most frequently used are those with 1/4, 5/16, and 3/8 inch diameters. Carbons burn slowly while in use, but a good supply of each size should be kept on hand.

The carbons are held in the torch so that the tips meet on an angle. The carbons may be moved laterally through the holder-clamp and should extend through the clamp 2 inches. A means of bringing the tips together to start the arc is provided, and the space between the tips can be varied to produce a desirable flame.

Carbon life expectancy can be as much as $1\frac{1}{2}$ hours on properly-adjusted carbons with correct amperage setting. Always refer to manufacturer's recommendations for amperage settings for the size of carbons being used.

Pointers for selecting and operating carbon-arc are

1. Follow recommended current settings for the size of carbons used.

2. Keep carbons in good condition by occasionally dressing the tips to the original shape.

3. Keep cables and other parts of the torch in good condition.

4. Do not use carbons less than 2 inches in length.

5. Make sure cable connections fit properly to the welder as recommended by the manufacturer.

Suggested Teaching-Learning Activities

1. Have students read and study reading assignments.

2. Explain how the carbon arc operates.

3. Use carbon with high heat setting to demonstrate effects of overheating.

4. Operate a torch, demonstrating the effects of narrow and wide tip settings.

5. Install a set of carbons in a holder, making the proper adjustments.

6. Demonstrate procedures of heating metal for bending.

7. Have students practice using and adjusting the carbon arc torch.

Suggested Instructional Materials and References

Instructional materials

1. Welder and equipment

2. Carbon arc torch

3. Carbons with 1/4, 5/16, and 3/8 diameters

4. Metal for bending

References

1. Arc Welding Lessons, pp. 57-62.

2. Modern Arc Welding, p. 435.

XII. To operate and maintain an oxyacetylene torch, and to fusion-weld

Teacher Preparation

Subject Matter Content

An oxyacetylene welder is a precision piece of equipment. Safe habits in handling and using it should be established to protect the weldor and the equipment.

1. Attach regulators to cylinders.

   a. Crack cylinder valves to blow out dirt.

   b. Wipe valves with a dry, clean cloth.

   c. Attach regulators and tighten them.

2. Connect hoses and turn on gases.

   a. Connect green hose to oxygen regulator and torch.

   b. Connect red hose to acetylene regulator and torch. (Oxygen has right-hand threads, acetylene has left-hand threads.)

   c. Open cylinder valves slowly (oxygen all the way; acetylene ½ turn).

3. Select the welding tip.

   a. Select a tip according to the manufacturer's recommendation for the job.

   b. Adjust tip on torch so that valves are on lower side of torch.

   c. Tighten tip with wrench.

4. Adjust working gas pressure according to manufacturer's recommendation for the tip used.

5. Locate all gas leaks.

   a. Locate gas leaks by using soap suds, or holding a finger over end of tip and submerging torch into water. Never use oil.

b. Tighten leaking connections.

c. Replace or repair any items which persist in leaking.

6. Light the torch.

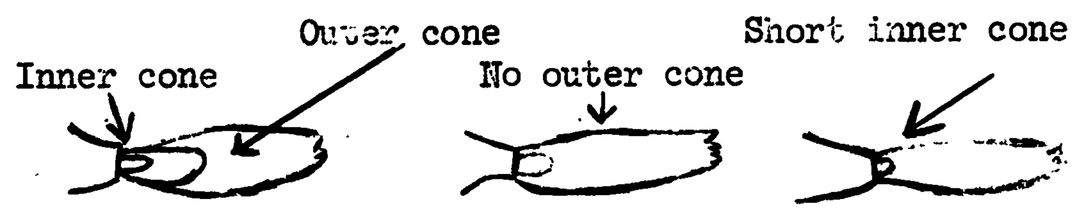
a. Follow manufacturer's recommendations.

b. Incorrect working pressures cause most difficulties in handling the torch.

7. Adjust the flame.

a. Adjust the flame by opening and adjusting the oxygen valve.

b. Too little oxygen gives a carbonizing flame; too much oxygen gives an oxidizing flame. A neutral flame is desired



Carbonizing flame   Neutral flame   Oxidizing flame

8. Avoid backfires and flashbacks.

a. Improper handling of the torch causes backfire (flame going out with a loud snap).

b. Ways to prevent backfires:

1) Operate torch at proper pressures.
2) Keep tip cool.
3) Keep tip clean.

c. Flashbacks is burning of the flame back into the torch. It may be followed by a hissing or squealing. Flashbacks are serious and endanger the safety of operators and equipment.

1) If continued, return torch to manufacturer for repair.
2) In case of flashback, turn off cylinders immediately to prevent an explosion.

Always shut down equipment when the job is completed. When equipment is left with gases turned on, leaks may develop and result in a fire or an explosion.

1. Shut off torch.

    a. Close acetylene valve first.

    b. Close oxygen valve last. This will extinguish any fire in torch.

2. Shut off gases.

    a. Close acetylene valve on cylinder.

    b. Close oxygen valve on cylinder.

    c. Open acetylene torch valve and drain pressure.

    d. Release acetylene regulator adjusting screw.

    e. Close acetylene torch valve.

    f. Open oxygen torch valve and drain pressure.

    g. Release oxygen regulator adjusting screw.

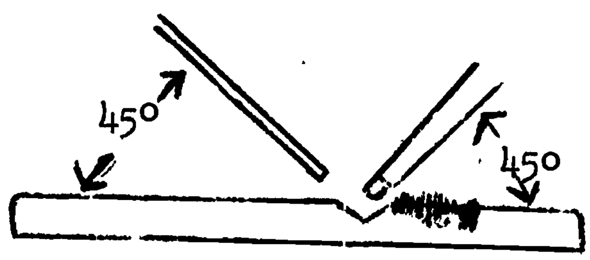
    h. Close oxygen torch valve.

Note: The above steps must be followed in the order listed to insure safety.

Fusion Welding with the Oxyacetylene Torch

In fusion welding, the metal edges are heated to the melting point and flowed together. A welding rod is used to add metal to the joint to strengthen it.

Forming and maintaining a molten pool is the first step in fusion welding. After this is mastered, the next step is to add metal from a welding rod. To carry a molten pool, one must first hold the torch at approximately 45 degrees with the surface of the work and inner cone about 1/8 inch from the metal and move the torch in a circular motion. The welding rod is added with the other hand and held at approximately 45 degrees to the surface of the metal and directed toward the flame.



After maintaining a molten pool and forming a bead by carrying the molten pool and adding the welding rod, the pieces of metal are ready to be welded together.

1. Butt welds

   a. Make plain butt joints in steel up to 1/8 inch thick; bevel edges on thicker pieces.

   b. Space pieces 1/2 thickness of metal apart to allow for heat expansion, and tack ends together.

   c. Arrange work so an air space is under the metal.

   d. Keep molten puddle running to both pieces and add rod to fill crack.

   e. Weld joints in metal thicker than 1/4 inch by two beads made progressively 1 inch at a time.

2. Fillet and lap welds

   a. The biggest errors in making these welds can be avoided by holding the torch at proper angles. The flame must be directed so that equal heat is applied on each piece of metal.

   b. Heat the lower plate almost to the melting point. Then weave torch to direct flame from one piece to the other, bringing both pieces to a molten pool at the same time.

3. Welding in the vertical and overhead position

   a. Start at bottom and weld upward for a vertical weld.

b. Use a shallow puddle and lift flame at regular intervals to allow lower edge of puddle to solidify.

c. Use less heat in overhead position than for similar job in the flat position.

d. Always use correct angles of torch and rod, both always at 45 degrees with the surface of the work.

Suggested Teaching-Learning Activities

1. Have students study reading assignments.

2. Demonstrate proper setting-up of oxyacetylene equipment.

3. Demonstrate tip sizes and their uses.

4. Demonstrate proper setting of gas pressures.

5. Demonstrate proper flame adjustments.

6. Demonstrate various welding exercises.

   a. Carry a molten puddle.

   b. Add a rod to puddle.

   c. Show various welds in various positions.

7. Demonstrate shutting down equipment.

8. Have students demonstrate some of the above exercises in class.

9. Have students practice all the above exercises.

Suggested Instructional Materials and References

Instructional materials

1. Oxyacetylene welder complete with all equipment

2. Mild steel rods 3/32 inch thick

3. Metal 1/8 inch thick

References

1. The Oxyacetylene Handbook, pp. 75-91, 187-210.

2. Smith's Short Course for Gas Cutting, Welding, Brazing.

3. The Farm Shop, pp. 168-174.

XIII. To hardsurface metals (ferrous)

Teacher Preparation

Subject Matter Content

Hard surfacing is overlaying a softer base metal with another metal of a high hardness characteristic to give the softer metal a longer usable life. Hardsurfacing metal provides durability of the base metal because of its hardness, abrasion resistance, impact resistance and decreased friction.

Using hardsurface powder is recommended for hardsurfacing of very thin edges, such as cultivator sweeps, where heat from electrode or flame using a rod might burn through.

1. The edge to be surfaced must be ground bright.

2. Apply surfacing powder.

3. Use a carbon arc torch, carbon in the electrode holder, or an oxyacetylene flame with a carbonizing flame (outer cone twice the length of the inner cone).

4. Melt the powder and sweat it to the metal. This is not a fusion process.

5. Be careful not to warp the metal.

Using Hardsurfacing Rods and Electrodes

Select the proper hardsurfacing rod or electrode; clean the metal to be surfaced, and apply surface with a long arc so that penetration will be shallow and the bead will be wide and thin. Deep penetration will reduce hardness of deposit.

Suggested Teaching-Learning Activities

1. Have students study reading assignments.

2. Demonstrate hardsurfacing with powder.

3. Demonstrate hardsurfacing with electrodes.

4. Have students practice hardsurfacing.

Suggested Instructional Materials and References

Instructional materials

1. Oxyacetylene welder and equipment
2. Arc welder and equipment
3. Hardsurfacing powder
4. Hardsurfacing electrodes
5. Metal to be hardsurfaced

References

1. The Oxyacetylene Handbook, pp. 355-372.
2. Modern Arc Welding, pp. 459-460.
3. Hobart Vest Pocket Guide, pp. 56-59.
4. Arc Welding Lessons, pp. 258-275.
5. Smith's Short Course for Gas Cutting, Welding, Brazing, p. 17.
6. The Farm Shop, pp. 157-158, 184-185.

XIV. To cut metal with an arc welder and an oxyacetylene welder

Teacher Preparation

Subject Matter Content

It is often necessary to cut metal. The hack saw, arc welder, or oxyacetylene torch is used for this job. The arc welder does not do a smooth job of cutting, but it is satisfactory in many cases since the rough areas may be ground off by a grinder. Cutting may be used also as a means of beveling a piece of iron for welding, gouging, chamfering, or piercing a hole.

Cutting with the Arc Welder

Usually an amperage setting of 140 and a 1/8 inch mild steel electrode will cut 1/4 inch plate. A 5/32 inch electrode and an amperage setting of 180 will cut steel over 1/4 inch thick. The electric arc actually burns away the metal.

Cutting is usually accomplished in the vertical or flat position. The arc is struck and the molten metal is raked away with the electrode.

To pierce a hole, hold a long arc with the electrode perpendicular over the spot where the hole is to be. When the metal is molten, push the electrode through the puddle. Give the molten metal a chance to fall through the hole, then circle around the edge of the hole until the desired diameter is reached. To pierce a hole through a heavy piece, place the metal in the vertical position to allow the metal to drip away freely while the electrode is bored through the metal.

Cutting with the Oxyacetylene Torch

Cutting is severing of metal with a torch through heating and the rapid oxidation of the metal with pure oxygen. This is a chemical process involving the chemical affinity of oxygen-heated metals. In addition, there is a noticeable mechanical eroding produced by the energy of the oxygen stream which washes away metal in the form of slag.

Adjust the oxygen and acetylene pressures according to the manufacturer's recommendations. Start the cutting torch like any other torch, but adjust it to a neutral flame by using the preheat oxygen valve. Heat the metal to a bright orange, then open the oxygen lever, and travel the torch in the direction or angle desired. To pierce a hole, heat metal to a bright orange, lift the torch slightly to prevent clogging the tip and open the oxygen lever, thus piercing a hole.

Suggested Teaching-Learning Activities

1. Have students study reading assignments.

2. Demonstrate cutting and piercing with the arc welder.

3. Have a student demonstrate hooking up a torch and lighting and adjusting the flame.

4. Demonstrate cutting with the torch.

5. Have students practice cutting and piercing with both welders.

Suggested Instructional Materials and References

Instructional materials

1. Arc welder and equipment
2. Mild steel electrodes
3. Oxyacetylene welder and equipment
4. Cutting torch
5. Metal to cut

References

1. Arc Welding Lessons, pp. 215-221.
2. Modern Arc Welding, pp. 403-406.
3. The Oxyacetylene Handbook, pp. 411-444.
4. Smith's Short Course for Gas Cutting, Welding, Brazing, p. 8.
5. The Farm Shop, pp. 186-188.

XV. To weld nonferrous metals and braze ferrous metals

Teacher Preparation

Subject Matter Content

Working and welding nonferrous metals with the arc welder is limited to brazing with the equipment studies in this module. Nonferrous arc welding is best accomplished with TIG arc welding equipment.

Aluminum, copper, and brass may be welded by the oxyacetylene process.

Welding Aluminum

Aluminum may be fusion-welded by using aluminum rods and flux. The metal must be clean and bright with no grease or oil present. Chemical cleaning or a 5% caustic soda cleaning may be necessary. Then rinse the metal in hot water, and dip it into a 10% solution of nitric acid and then a hot water bath.

Use a slightly carbonizing flame since oxygen is not wanted on aluminum because it interferes with the fusion process. Flux is used on the rod and the welding process is similar to that of ferrous metals. After the weld cools, remove flux with hot water.

Welding Copper and Brass

Copper and brass are most easily fastened by the soldering or brazing process. The fusion process is best used in TIG welding. The silver alloy and soldering methods are accomplished by using only enough heat to melt the silver alloy and flux or solder onto the joints to be fastened.

Brazing Ferrous Metals

Brazing is a process of joining metal by using a filler of nonferrous metal (brass), which has a lower melting point. Flux or a flux-coated rod is necessary for this process. The first step in brazing is to heat the base metal to a temperature which expands the pores, freeing impurities. The joint is then tinned by using the flux and rod, and the two pieces may be joined by bridging them together with the rod used for tinning. Heat for this process may be furnished by the carbon arc torch, a carbon in the electrode-holder, or the oxyacetylene flame. The important fact is not to overheat the metal; a bright orange to cherry-red color is enough heat.

Welding cast iron is discussed in <u>The Farm Shop</u>, pp. 153-155, 182-184.

<u>Suggested Teaching-Learning Activities</u>

1. Have students study reading assignments.

2. Review identification of

3. Demonstrate aluminum fusion process.

4. Demonstrate silver alloy brazing process of copper and brass.

5. Demonstrate soldering of brass and copper.

6. Demonstrate brazing of ferrous metals.

7. Have students practice the above exercises.

Suggested Instructional Materials and References

Instructional materials

1. Arc welder and equipment

2. Oxyacetylene welder and equipment

3. Copper, brass, aluminum, cast iron, and mild steel

4. Brazing rods, solder, and silver alloy rods

5. Proper fluxes for rods

References

1. Arc Welding Lessons, pp. 237-243.

2. The Oxyacetylene Handbook, pp. 246-253.

3. Smith's Short Course for Gas Cutting, Welding, Brazing, pp. 11-15.

4. The Farm Shop, pp. 153-155, 180-184.

XVI. To weld with inert gas

Teacher Preparation

Subject Matter Content

The inert-gas-shielded arc welding process is one of the newest methods of fusion welding. In it a shield of an inert gas protects the electrode and the weld puddle.

The gas shield is obtained by feeding an inert gas, such as argon or helium, around a single tungsten electrode through a confining cup. The arc is drawn between the work and the tungsten electrode. This electrode is run at a current density which causes it to be white-hot at the end, but not so hot as to melt and fall off. When the tungsten electrode is running at the proper current density, a small ball forms at the end. This ball is steady and does not oscillate unless the current is too high; then it oscillates and falls off.

The tungsten electrode must be kept from oxidizing. Tungsten is ordinarily considered non-consumable, but about one-half thousandth of an inch of tungsten is used each time the arc is started. If the end of the tungsten is allowed to come in contact with air while it is hot, it may oxidize as much as 1/16 inch.

The welding torch and tungsten electrode are handled in somewhat the same manner as a gas welding torch. In many cases, filler metal may be added. Weld quality is high because the inert gas shield prevents oxidation and inclusion of gases or formation of water vapor in weld. The efficiency of the gas in shielding the molten metal makes possible welding virtually all of the commerically nonferrous materials.

The following table should be consulted when selecting current for inert-gas-shielded arc welding:

MATERIAL	ALTERNATING CURRENT	DIRECT CURRENT	
	With High Frequency Stabilization	STRAIGHT Polarity	REVERSE Polarity
Magnesium up to 1/8-in. thick	1	N.R.	1
Magnesium above 3/16-in. thick	1	N.R.	N.R.
Magnesium castings	1	N.R.	2
Aluminum	1	N.R.	N.R.
Aluminum castings	1	N.R.	N.R.
Stainless steel up to 0.050 in.	1	2	N.R.
Stainless steel 0.050 in. and thicker	2	1	N.R.
Brass alloys	1	1	N.R.
Everdur *	2	1	N.R.
Monel **	2	2	N.R.
Silver	2	1	N.R.
Hastellay alloys	1	2	N.R.

MATERIAL	ALTERNATING CURRENT With High Frequency Stabilization	DIRECT CURRENT STRAIGHT Polarity	DIRECT CURRENT REVERSE Polarity
Silver cladding	1	N.R.	N.R.
Hard-facing	1	2	N.R.
Cast iron	2	1	N.R.
Low carbon steel 0.015 to 0.050 in. (Killed Steel only)	1	2	N.R.
Low carbon steel 0.050 in. and thicker (Killed Steel only)	2	2	N.R.
High carbon steel 0.015 to 0.050 in.	1	N.R.	N.R.
High carbon steel 0.050 in. and thicker	2	1	N.R.
Deoxidized copper up to 0.090 in.	2	1	N.R.

Key:
1. Excellent operation---best recommendation
2. Good operation---2nd recommendation

N.R.: Not recommended

* Use d.c.s.p. for 3/8 in. and thicker

** Inert-Gas process not always satisfactory for Monel

Suggested Teaching-Learning Activities

1. Have students practice striking an arc with an inert-gas-shielder welder.

2. Have students practice running beads and fusing together the following metals:

   a. Magnesium

   b. Aluminum

   c. Stainless steel

   d. Hard-facing

   e. Silver

   f. Brass alloys

Suggested Instructional Materials and References

Instructional materials

1. A welder with an inert-gas-shielded torch

2. Metal pieces of the above-named kinds

Reference

Modern Arc Welding, pp. 473-482.

Suggestions for Evaluating Educati nal Outcomes of the Module

The educational outcomes of the module should be evaluated according to attitudes and manipulative skills developed.

1. Manipulative skills

   Each student should be required to perform suggested learning activities in each competency of the module. Welding is basically a skill developed by practice and experience. The teacher should observe the student closely in order to correct bad practices and to evaluate the student's accomplishments.

2. Attitudes

   Attitudes should be evaluated according to student participation in class discussion, response to assignments, and performance of jobs.

Sources of Suggested Instructional Materials and References

Printed texts

1. Arc Welding Lessons for School and Farm Shop. Cleveland, Ohio: The James F. Lincoln Arc Welding Foundation, 1964. Price: $1.

2. Hobart Vest Pocket Guide, (EW-332). Troy, Ohio: Hobart Technical School, 1964. Free. (Quantities availabe for school use.)

3. Linde. The Oxyacetylene Handbook. New York: Union Carbide Corporation, Linde Division, 270 Park Avenue. Price: $3.

4. Modern Arc Welding Procedures and Practices, (EW-200). Troy, Ohio: Hobart Technical School. Price: $3.50.

5. Phipps, Cook, Scranton, and McCalley. Farm Mechanics Text and Handbook. Danville, Illinois: Interstate Publishers, Inc., 1959.

6. Smith's Short Course for Gas Cutting, Welding, Brazing (form 242). Minneapolis: Educational Department of Smith Welding Equipment, Division of Tescom Corporation, 27th Avenue and 4th Street, S.E. Free

7. Wakeman, T. F. and McCoy, V. L. The Farm Shop. New York: The MacMillan Company, 1960.

Films, film strips, and slides

1. Arc Welding at Work, (16 mm.). Schenectady, New York: General Electric Company. Free.

2. Arc Welding Electrode Selection, (16 mm., 20 minutes). Troy, Ohio: Hobart Technical School, Free.

3. Causes and Cures of Common Welding Troubles, (35 mm. slides (12)). Troy, Ohio: Hobart Technical School, Price: $1.25.

4. Learning Arc Welding Skills, (35 mm., 3 strips, 136 frames). Troy, Ohio: Hobart Technical School, Price: $1.25.

5. Magic Wand of Industry, (16 mm., 25 minutes). Cleveland, Ohio: Lincoln Electric Company. Free

Teaching aids

"Factors to Consider in Selecting Electrodes". (chart 35" x 28"). Troy, Ohio: Hobart Technical School. Price: $1.25.

"Good and Bad Weld Plastic Replicas". (set of 10) Troy, Ohio: Hobart Technic School. Price: $6.00.

THE CENTER FOR RESEARCH AND LEADERSHIP DEVELOPMENT
IN VOCATIONAL AND TECHNICAL EDUCATION
THE OHIO STATE UNIVERSITY
980 KINNEAR ROAD
COLUMBUS, OHIO, 43212

INSTRUCTOR NOTE: As soon as you have completed teaching each module, please record your reaction on this form and return to the above address.

1. Instructor's Name ______________________________

2. Name of school ______________________ State ____________

3. Course outline used: _____ Agriculture Supply--Sales and Service Occupations
   _____ Ornamental Horticulture--Service Occupations
   _____ Agricultural Machinery--Service Occupations

4. Name of module evaluated in this report ______________________

5. To what group (age and/or class description) was this material presented? ____
____

6. How many students:
   a) Were enrolled in class (total) _______
   b) Participated in studying this module _______
   c) Participated in a related occupational work experience program while you taught this module _______

7. Actual time spent teaching module: / Recommended time if you were to teach the module again:

Actual time		Recommended time
_____ hours	Classroom Instruction	_____ hours
_____ hours	Laboratory Experience	_____ hours
_____ hours	Occupational Experience (Average time for each student participating)	_____ hours
_____ hours	Total time	_____ hours

(RESPOND TO THE FOLLOWING STATEMENTS WITH A CHECK (✓) ALONG THE LINE TO INDICATE YOUR BEST ESTIMATE.)

	VERY APPROPRIATE	NOT APPROPRIATE
8. The suggested time allotments given with this module were:	└ . . . . ┘	
9. The suggestions for introducing this module were:	└ . . . . ┘	
10. The suggested competencies to be developed were:	└ . . . . ┘	
11. For your particular class situation, the level of subject matter content was:	└ . . . . ┘	
12. The Suggested Teaching-Learning Activities were:	└ . . . . ┘	
13. The Suggested Instructional Materials and References were:	└ . . . . ┘	
14. The Suggested Occupational Experiences were:	└ . . . . ┘	

(OVER)

15. Was the subject matter content sufficiently detailed to enable you to develop the desired degree of competency in the student? Yes____No____
Comments:

16. Was the subject matter content directly related to the type of occupational experience the student received? Yes____No____
Comments:

17. List any subject matter items which should be added or deleted:

18. List any additional instructiona. materials and references which you used or think appropriate:

19. List any additional Teaching-Learning Activities which you feel were particularly successful:

20. List any additional Occupaticnal Work Experiences you used or feel appropriate:

21. What d- ·ou see as the major strength of this module?

22. What do you see as the major weakness of this module?

23. Other comments concerning this module:

______________________ ______________________________________
(Date) (Instructor's Signature)

____
(School Address)