Instructor Guide

AGRICULTURAL STRUCTURES

Writers:
Claude Busby, Brad King, and James C. Graham
Instructional Materials Laboratory
University of Missouri-Columbia

Consulting Editor:
Jim Riley
Agricultural Education
University of Missouri-Columbia

Sherry Mahnken, Editor
Instructional Materials Laboratory
University of Missouri-Columbia

Produced by:
Instructional Materials Laboratory
University of Missouri-Columbia
10 London Hall
Columbia, Missouri 65211

Volume 31
Number 1

Catalog Number 10-7103-I
June 1999

Available from:
Instructional Materials Laboratory
University of Missouri-Columbia
10 London Hall
Columbia, MO 65211
573-882-2883

The activity that is the subject of this report was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Vocational and Adult Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Vocational and Adult Education, and no official endorsement should be inferred.

ACKNOWLEDGMENTS

Recognition is given to advisory committee members for providing their valuable time and suggestions in developing this agricultural structures curriculum. The committee consisted of Gale Hodges, Doyle Justus, Keith Mueller, Mike Pollard, Alan Slayton, Kirk Lawson, Lance Massey, Joseph Zulovich, and Charles Parkes.

Information for this project was supplied by individuals at J&B Construction in Gallatin, Missouri; Weston Drilling and Pump Co. in New Franklin, Missouri; and Ballenger's Propane Service in Columbia, Missouri.

Appreciation is expressed to the following staff members of the Instructional Materials Laboratory for their efforts in producing this material: Dana Tannehill, Director; Dan Stapleton, Associate Director; Veronica Feilner, Project Coordinator; Bonnie Painter, Assistant Editor; Cheryl Unterschutz, Graphic Designer; Kevin Gamble, Graphic Artist; Chris Casey, Graphic Artist; and Jill Clark, Jamie Keith, and Allison Cadle, Editorial Assistants.

Sherry Mahnken, Editor
Instructional Materials Laboratory
University of Missouri-Columbia

Jim Riley, Instructor
Agricultural Education
University of Missouri-Columbia

FOREWORD

The development of the *Agricultural Structures* curriculum guide is the result of suggestions by the MVATA Teaching Aids Committee. The Agricultural Structures Advisory Committee suggested the topics to be included and reviewed the materials.

This curriculum contains seven units. The instructor guide includes: objectives, competencies, motivational techniques, teaching procedures, other activities, activity sheets, transparency masters, evaluations, answers to evaluations and activity sheets, references and teaching aids, and materials and equipment. Topics include working with plans, home and farmstead planning, building construction, concrete, electricity, plumbing, and fencing. One copy of the student reference is packaged with the instructor guide. Additional copies of the student reference can be purchased separately.

During the summer of 1981, the Missouri State Board of Education formally adopted the concept of “Instructional Management Systems” (IMS) as a priority for the 1981-82 school year. The Missouri Commissioner of Education described the IMS concept as a practical way of “organizing for excellence” in education. To meet the demand for greater productivity and accountability, the director of Vocational Education applied the elements of IMS to form the Vocational Instructional Management System (VIMS). The VIMS process provides a framework to use in planning and organizing to assure excellence in Missouri's vocational education system by focusing greater attention on the management of teaching and learning.

This guide incorporates the needed components to aid agriculture teachers in the implementation of VIMS. For ease of use, performance objectives and competencies have been included at the beginning of the guide as well as incorporated within each lesson. A competency profile has been provided in the front of the guide for convenient record keeping. A table is included to show how the competencies in *Agricultural Structures* relate to the Show-Me Standards and Curriculum Frameworks. *Agricultural Structures* is in the Natural Resources career path.

Jim Riley, Instructor
Agricultural Education
University of Missouri-Columbia

Terry Heiman, Director
Agricultural Education
Department of Elementary and
Secondary Education

AGRICULTURAL STRUCTURES

TABLE OF CONTENTS

UNIT V - ELECTRICITY

UNIT VI - PLUMBING

UNIT VII -FENCING

COMPETENCIES/OBJECTIVES

UNIT I - WORKING WITH PLANS
1. Read and create a simple construction drawing.
2. Develop a plan of procedure and a bill of materials for a construction project.

UNIT II - FARMSTEAD PLANNING
1. Evaluate a site for a home.
2. Arrange a farmstead.
3. Describe characteristics of disposal systems for managing livestock manure.

UNIT III - BUILDING CONSTRUCTION
1. Describe safety practices associated with building construction.
2. Identify types and designs of buildings and their methods of construction.
3. Identify and select building materials.
4. Identify the uses of different fasteners and fastening systems.
5. Describe how to construct a floor and subfloor.

6. Describe the purposes of walls, types of walls, supports, and siding used in agricultural buildings.
7. Select a roof support system.
8. Select roofing materials.
9. Identify factors affecting the heating, cooling, and ventilation of agricultural structures.

UNIT IV - CONCRETE
1. Discuss safety in working with concrete.
2. Identify factors that affect the quality of fresh concrete.
3. Identify site preparation requirements.
4. Describe the procedure for preparing to pour a concrete slab.
5. Explain the procedure for ordering, pouring, and finishing concrete.
6. Identify factors affecting the quality of cured concrete.
7. Describe the procedure for pouring a concrete wall.

UNIT V - ELECTRICITY
1. Identify the terms, dangers, and safety practices associated with electrical work.
2. Identify the terms associated with electrical work.
3. Match types and sizes of wire with their uses.
4. Identify the importance of grounding and GFCI protection.
5. Locate lights, outlets, and switches, and identify circuit protection needs.
6. Identify the symbols used in agricultural wiring plans.
7. Describe practices for running wire to an agricultural structure and wiring within the building safely.
8. Identify procedures for connecting the drop wires and branch circuit wires to the SEP.
9. Describe how to run wiring from the SEP to a junction box, lights, and receptacles.
10. Calculate cost and electrical power using Ohm’s Law.
11. Describe procedures for planning and installing lightning protection.
12. Identify problems in electrical systems.

UNIT VI - PLUMBING
1. Calculate how much water is needed for a farmstead.
2. Discuss safety practices for plumbing.
3. Identify pipe types and determine size requirements.
4. Measure, cut, and connect pipes and tubing.
5. Identify methods of protecting water pipes against freezing.

UNIT VII - FENCING
1. Discuss the terminology, dangers, and safety practices associated with building fences.
2. Describe how to set and brace wood and steel posts.
3. Describe techniques for building barbed and woven wire fences.
4. Describe techniques for building high tensile and electric fences.
5. Identify fence mending techniques.

EVALUATION

1. Give short, objective tests following each lesson and a more in-depth objective test at the conclusion of the unit.
2. Observe the changes in behavior as evidence of the improved ability of students to deal with problems in this unit using background information acquired from earlier units.
3. Observe students’ attempts to solve similar problems in their supervised agricultural experience programs.

REFERENCES AND MATERIALS

1. Student Reference

Agricultural Structures (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1999.

2. Teacher References

a. Books

1) Ahrens, Donald L. *Concrete and Concrete Masonry*. St. Paul, Minn.: Hobar Publications, 1976.

2) Annis, William H. *Basic Plumbing Skills*. Athens, Ga.: American Association for Vocational Instructional Materials (AAVIM), 1989.

3) Ball, John E. *Tools, Steel Square, and Joinery*. Vol. 1 of *Carpenters and Builders Library,* Revised by John Leeke. New York: Macmillan Publishing Co., Inc., 1991.

4) Boyd, James S. *Buildings for Small Acreages.* Revised by Carl L. Reynolds. Danville, Ill.: Interstate Publishers, Inc., 1996.

5) Boyd, James S. *Practical Farm Buildings.* 3rd ed. Revised by Joshua L. Reynolds. Danville, Ill.: Interstate Publishers, Inc., 1993.

6) Brunk, Art. *Building Maintenance.* Module III, *Plumbing.* University of Missouri--Columbia: Instructional Materials Laboratory, 1990.

7) Burch, Monte. *How to Build Small Barns and Outbuildings.* Pownal, Vt.: Garden Way Publishing, 1992.

8) Cooper, Elmer L. *Agricultural Mechanics: Fundamentals and Applications.* Albany, N.Y.: Delmar Publishers, 1997.

9) Duelm, Brian L. *Computer-Aided Drafting.* Holland, Ill.: Goodheart-Wilcox Company, Inc., 1989.

10) Ensminger, M.E. *The Stockman's Handbook.* 7th ed. Danville, Ill.: Interstate Publishers, 1992.

11) Hiatt, Richard S., ed. *Agricultural Wiring Handbook.* 11th ed. Columbia, Mo.: National Food And Energy Council. 1996.

12) Holzman, H.N. *Modern Residential Wiring.* South Holland, Ill.: Goodheart-Wilcox Company, Inc., 1996.

13) Huth, Mark W. *Construction Technology*. 2nd ed. Albany, N.Y.: Delmar Publishers, Inc., 1989.

14) Kicklighter, Clois E. et al. *Architecture: Residential Drawing and Design*. Tinley Park, Ill.: Goodheart-Willcox Company, 1995.

15) Jordan, Cora. *Neighbor Law: Fences, Trees, Boundaries, and Noise.* Berkeley, Calif.: Nolo Press, 1991.

16) Lindley, James A., and James H. Whitaker. *Agricultural Buildings and Structures.* Rev. ed. St. Joseph, Mich.: American Society of Agricultural Engineers. 1996.

17) McClain, Gerald R. *Basic Drafting*. 3rd ed. Stillwater, Okla.: MAVCC, 1997.

18) McConnell, Charles. *Plumbers and Pipe Fitters Library.* Vol 3, *Water Supply - Drainage - Calculations.* New York: Macmillan, 1989.

19) Mix, Floyd M. *House Wiring Simplified.* Tinley Park, Ill.: Goodheart-Willcox Company, Inc., 1996.

20) National Plan Service. *UCANDO Design #B2042.* 1994.

21) Phillips, Richard E. *Farm Buildings: From Planning to Completion.* St. Louis: Doane-Western, 1981.

22) Phipps, Lloyd J., and Carl L. Reynolds. *Mechanics in Agriculture.* 4th ed. Danville, Ill.: Interstate Publishers, 1990.

23) Ramsey, Dan. *The Complete Book of Fences.* Blue Ridge Summit, Pa.: TAB Books, Inc., 1983.

24) Richter, H.P., and W.C. Schwann. *Wiring Simplified.* 38th ed. Somerset, Wis.: Park Publishing, Inc., 1996.

25) Steele, Kenneth. *Animal Waste and Land Water Interface.* Boca Raton: Lewis Publishers, 1995.

26) Taylor, Robert L. *Builders Estimating Databook.* Blue Ridge Summit, Pa.: Tab Books, 1990.

27) Time-Life Editors. *Insulation & Weatherproofing.* Alexandria, Va.: Time-Live Books, 1996.

28) Wagner, Willis H. *Modern Carpentry*. South Holland, Ill.: Goodheart-Wilcox Co., Inc., 1987.

b. Extension publications

1) *Animal Waste Regulations for Livestock Producers in Missouri (WQ200).* University Extension Agricultural Publications, 1993.

2) *Constructing Electric Fences for Cattle (G1190).* University Extension Agricultural Publications, 1993.

3) Constructing Wire Fences (G1192). University Extension Agricultural Publications. University of Missouri-Columbia.

4) How to Size a Farm and Home Water System (G1801). University Extension Agricultural Publications. University of Missouri-Columbia.

5) *Lightning Protection for Missouri Farms and Homes (G1020).* University Extension Agricultural Publications, 1993.

6) Missouri Fencing and Boundary Laws (G810). University Extension Agricultural Publications, 1993.

7) *Selecting Wire Fencing Materials (G1191).* University Extension Agricultural Publications, 1993.

8) *Sources for Farm and Home Water Supply (G1800).* University Extension Agricultural Publications. University of Missouri-Columbia.

c. Internet resources

1) Bucklin, R. A., W. E. Kunkle, and R. S. Sand. "Construction of High Tensile Wire Fences." http://gnv.ifas.ufl.edu/~fairsweb/text/ae/ae017.html (9 September 1998).

2) Consumer Information Center. "A Home Electrical Safety Check." From the National Electrical Safety Foundation, 1995. http://www.pueblo.gsa.gov/cic_text/housing/home-elec/homeelec.txt (1 September 1998).

3) "Electrical Code." http://anna.texoma.net/Nonprofit/City/Code/Index.htm (22 January 1999).

4) Electricians Toolbox Etc."Lightning Protection." http://www.elec-toolbox.com/usefulinfo/ lightprot.htm (8 February 1999).

5) Environmental Protection Agency. "Office of Enforcement and Compliance Assurance." http://es.epa.gov/oeca/ (31 August 1998).

6) Granite Rock Company. "Concrete Surface Defects - Causes, Prevention and Repair." http://www.graniterock.com/tn.htm (12 December 1998).

7) Kardon, Redwood. "Code Check: Help with Building Codes." http://www.codecheck.com/
frame.htm (22 January 1999).

8) Kidwell, Boyd. "Choosing a Charger." *Progressive Farmer.com* http://progressivefarmer.
com/equipment/1098/fence/choose.html (20 May 1999).

8) Materials Science and Technology (MAST) Teacher's Workshop. "Concrete." Produced by the Department of Materials Science and Engineering at the University of Illinois, Urbana/Champaign. http://mach-pc66.mse.uiuc.edu/~tw/concrete/concrete.html (29 August 1998).

9) Mississippi State University Extension Service. *Frozen Pipes: Causes and Cures.* http://
www.ext.msstate.edu/pubs/is1438.htm (25 September 1998).

10) Missouri Department of Natural Resources. "Division of Energy." http://www.dnr.state.
mo.us/de (25 January 1999).

11) Missouri Department of Natural Resources. "Soil and Water Conservation Service Program." http://www.dnr.state.mo.us/deq/swcp/faqswcp/htm (17 August 1998).

12) State Farm Educational Materials. "Lightning Protection." http://www5.statefarm.com/
educate/lightnin.htm (8 Feb. 1999).

13) The Concrete Pages. "Control Joints for Concrete Slabs." http://www.concretepages.
com/tcjts.html (19 October 1998).

MATERIALS AND EQUIPMENT FOR ACTIVITIES

1. Unit 1, Lesson 1: Drawing a Plan

   Computer with CAD software and printer (if possible)
   Paper, either plain white copy paper or high rag content drawing paper (if professional hand drawing instruments are available)
   No. 2 lead pencil
   Ruler or architect's scale

2. Unit 3, Lesson 5: Joist Layout

   10 8-foot 2" × 8" boards
   2 10-foot 2" × 8" boards
   16d duplex head nails
   Circular or radial arm saw
   Hammer
   Tape measure

3. Unit 3, Lesson 7: Rafter Layout

   Pencil and paper

Carpenter's framing square
Boards, strips of construction paper, cardboard, or rolls of fax paper

4. Unit 3, Lesson 8: Applying Roofing Materials

   Classroom or shop tables
   Paper models of shingles

5. Unit 4, Lesson 3: Laying Out a Building

   4 stakes
   2 tape measures
   Twine

6. Unit 4, Lesson 4: Reinforcing Concrete

   1 8-foot 1" × 6" board
   20 16d duplex-head nails
   _" welding wire
   Wax paper or plastic wrap
   Latex gloves
   Eye protection
   Concrete mix

7. Unit 4, Lesson 5: Pouring a Concrete Curb

   Wood and duplex nails for forms
   Tape measure
   Concrete
   2 1" pipes, 1' long
   Wire
   Rebar
   Wire for rebar supports
   Shovel or spade
   Oil
   Hand trowel
   Board for screed
   Latex gloves
   Eye protection

8. Unit 4, Lesson 6: Curing Concrete

   Mixed concrete
   15 3" pieces of PVC pipe, 6" long
   Hydraulic press
   Oil (new motor oil)
   ¼" steel rod, 8" long
   4' × 4' piece of plywood or sheet metal
   Buckets
   Oven
   Freezer
   Sand

9. Unit 4, Lesson 7: Preparing Forms for a Concrete Wall

   Plywood

16d duplex-head nails
4 snap ties
8 snap tie holders
2 8-foot 2" × 4" boards for wales and braces
1 4-foot 1" × 4" board for ties
Wire for wire ties
2" × 4" scraps for spreaders
Electric drill and bits
Level

10. Unit 5, Lesson 9: Wiring a Three-Way Switch

Mock wall with two switch boxes and one light fixture already attached
1 12-2 NMC cable, 16 inches long
2 12-3 NMC cables, 30 inches long
2 three-way switches
Light fixture
Solderless connectors
Three-prong plug
Screw driver set
Wire strippers
Cable rippers

11. Unit 5, Lesson 12: Using Testing Devices

Neon tester
Voltage tester
VOM meter

12. Unit 6, Lesson 4: Cutting and Joining Plastic Pipe

1" PVC pipe, 4 feet in length
4 1-inch 90-degree PVC elbows
1 1-inch PVC T
1 1-inch PVC cap
Tape measure
Hacksaw
PVC primer and glue (optional)
Sandpaper

13. Unit 6, Lesson 4: Sweating Copper Pipe

1 1" copper pipe, 4 inches in length
1 1" cap
Flux
Brush
Propane torch
Stationary vise
Steel wool or sandpaper

14. Unit 7, Lesson 2: Constructing Model Brace Assemblies

1 8-foot 2" × 4"
1 4-foot ½" dowel
Hacksaw
½-inch drill bit
Drill

Wood glue
Wood chisel
1 12d nail
2 feet of thin wire (.035 MIG wire)

15. Unit 7, Lesson 3: Constructing Barbed Wire Fencing

    Barbed wire
    Fence stretchers
    Metal fence posts
    Metal post driver
    Wire clips
    Fencing pliers
    Standard screwdriver
    Claw hammer
    Fencing staples

16. Unit 7, Lesson 4: Tensioning Fences

    14-gauge soft wire
    Strainer
    Wire cutters

17. Unit 7, Lesson 5: Splicing Wire

    14-gauge soft electric wire, cut into four 2-foot pieces
    Compression sleeve
    Sleeve compressor or fencing pliers

Agricultural Structures - Competency Crosswalk

Duty Band and Task Statement	SHOW-ME STANDARDS		CURRICULUM FRAMEWORKS					
	Knowledge (Content)	Performance (Goals)	Math	Communication Arts	Science	Social Studies	Health/ Physical Education	Fine Arts
A-1	FA-4 CA-3 MA-2	1.4, 1.5, 1.6, 1.8, 2.1, 2.5, 4.1	MA/VI/9-12/3a, 3b	CA/I/9-12/3b CA/II/9-12/2c CA/II/9-12/3c CA/II/9-12/4i CA/III/9-12/1j				FA/IV-A/9-12/6a
A-2	MA-1 CA-1	1.4, 1.6, 2.1, 3.2	MA/V/9-12/1a MA/IV/9-12/3a, 3b, 3c, 3d	CA/II/9-12/1a, 1b				
B-1	SC-4, SC-8 SS-5, SS-6, SS-7 CA-3	1.1, 1.2, 1.4, 1.10, 2.3, 3.1, 3.8, 4.1, 4.2		CA/IV/9-12/1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h, 1i	SC/VIII-A/9-12/2a SC/VIII-B/9-12/2a	SS/IV-A/9-12/3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i SS/IV-B/9-12/1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h, 1i		
B-2	SC-1,SC-2, SC-5,SC-8 SS-5	1.2, 1.4, 2.3, 3.1, 3.2, 3.3, 3.5, 3.6, 3.7, 3.8			SC/II-A/9-12/2a SC/VIII-A/9-12/2b SC/VIII-B/9-12/2a, 2b, 2c	SS/IV-A/9-12/3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i SS/IV-B/9-12/1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h, 1i		
B-3	SC-8 CA-3	1.4, 1.5, 3.1, 3.2, 3.3, 3.5, 3.6, 3.7, 4.7		CA/I/9-12/1b, 1d CA/I/9-12/2a, 2b, 2c, 2d, 2e CA/1/9-12/3a, 3b, 3c, 3d, 3e	SC/VIII-B/9-12/1a			
C-1	HPE-6 CA-3	1.2, 1.10, 3.2, 3.3, 4.7	CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h				HPE/III-B/9-12/5a	
C-2	CA-3 MA-2	1.2, 1.7, 2.5 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8	MA/VI/9-12/2a	CA/I/9-12/1b CA/IV/9-12/1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h				

Duty Band and Task Statement	SHOW-ME STANDARDS		CURRICULUM FRAMEWORKS					
	Knowledge (Content)	Performance (Goals)	Math	Communication Arts	Science	Social Studies	Health/ Physical Education	Fine Arts
xviii C-3	CA-3	1.1, 1.4, 1.8, 1.10, 3.1, 3.5, 3.8		CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h				
C-4	SC-2	1.2			SC/IV-C/9-12/1a			
C-5	MA-1	1.3, 1.10, 2.5, 3.1, 3.2, 4.6, 4.7	MA/IV/9-12/3a, 3b, 3c, 3d, 3e					
C-6	MA-2	1.3, 1.5, 2.5, 3.5	MA/IV/9-12/3a, 3b, 3c, 3d, 3e MA/VI/9-12/1b, 1d, 1i, 1k, 1l, 2b, 2d, 2i, 2k, 2l, 3b, 3d, 3i, 3k, 3l					
C-7	MA-2	1.3, 1.5, 2.5, 3.5	MA/IV/9-12/3a, 3b, 3c, 3d, 3e MA/VI/9-12/1b, 1d, 1i, 1k, 1l, 2b, 2d, 2i, 2k, 2l, 3b, 3d, 3i, 3k, 3l					
C-8	CA-3 SC-1	1.2, 1.3, 1.5, 3.5, 4.1		CA/I/9-12/1b	SC/II-A/9-12/1c			
C-9	SC-8 CA-3	1.1, 1.2, 1.3, 1.4, 1.8, 2.5, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7		CA/I/9-12/1b CA/I/9-12/2c	SC/III-B/9-12/2a SC/III-C/9-12/4a			
D-1	CA-3 HPE-6	1.2, 1.4, 3.2, 3.3, 4.7		CA/I/9-12/1b CA/II/9-12/1c CA/IV/9-12/1c, 1d, 1e, 1h			HPE/III-B/9-12/5a	
D-2	SC-8 MA-1	1.2, 1.3, 1.4, 1.6, 1.8, 2.5, 3.1, 3.2, 3.3,	MA/IV/9-12/2b, 2c, 2d, 3b, 3c, 3d		SC/III-B/9-12/1a			

Duty Band and Task Statement	SHOW-ME STANDARDS		CURRICULUM FRAMEWORKS					
	Knowledge (Content)	Performance (Goals)	Math	Communication Arts	Science	Social Studies	Health/ Physical Education	Fine Arts
		3.4, 3.5, 3.6, 3.7, 3.8						
D-3	CA-3 MA-1, 2		MA/IV/9-12/2a, 2b, 2d, 3a, 3b, 3d	CA/I/9-12/1b CA/II/9-12/1c				
D-4	CA-3	1.2, 1.4, 1.5, 1.7, 1.8, 3.2, 3.3, 3.5, 3.7, 3.8		CA/1/9-12/Ib CA/II/9-12/1c CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h				
D-5	SC-8 CA-3 MA-1, 2	1.2, 1.3, 1.5, 1.8, 1.10, 2.5, 2.6, 3.2, 3.3, 3.7, 3.8	MA/I/9-12/4a, 4b, 4c, 4d, 4e MA/III/9-12/1a, 1b, 1c, 1d, 2a, 2b, 2c, 2d, 4a, 4b, 4c, 4d, 5a, 5b, 5c, 5d MA/IV/9-12/2a, 2b, 2c, 2d, 2e, 3a, 3b, 3c, 3d, 3e MA/VI/9-12/1a, 1b, 1c, 1d, 2a, 2b, 2c, 2d, 3a, 3b, 3c, 3d	CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h, 2c, 2d, 2e, 2f, 2g, 2h, 3c, 3d, 3e, 3f, 3g, 3h	SC/III-B/9-12/1a			
D-6	SC-8	1.2, 1.3, 1.5, 1.8, 1.10, 2.5, 2.6, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8			SC/III-B/9-12/1a			
D-7	SC-8 CA-3 MA-1, 2	1.2, 1.3, 1.5, 1.8, 1.10, 2.5, 2.6, 3.2, 3.3, 3.7, 3.8	MA/I/9-12/4a, 4b, 4c, 4d, 4e MA/III/9-12/1a, 1b, 1c, 1d, 2a, 2b, 2c, 2d, 4a, 4b, 4c, 4d, 5a, 5b, 5c, 5d MA/IV/9-12/2a, 2b, 2c, 2d, 2e, 3a, 3b, 3c, 3d, 3e MA/VI/9-12/1a, 1b,	CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h, 2c, 2d, 2e, 2f, 2g, 2h, 3c, 3d, 3e, 3f, 3g, 3h	SC/III-B/9-12/1a			

Duty Band and Task Statement	SHOW-ME STANDARDS		CURRICULUM FRAMEWORKS					
	Knowledge (Content)	Performance (Goals)	Math	Communication Arts	Science	Social Studies	Health/ Physical Education	Fine Arts
			1c, 1d, 2a, 2b, 2c, 2d, 3a, 3b, 3c, 3d					
E-1	HPE-6	1.1, 1.2, 1.3, 1.4, 1.5, 1.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7					HPE/III-D/9-12/1a, 1b	
E-2	CA-3			CA/I/9-12/1b CA/I/9-12/2c				
E-3	SC-8 CA-3	1.2, 1.3, 1.4, 1.8, 2.5, 2.6, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7		CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h	SC/III-B/9-12/1a			
E-4	HPE-6	1.2, 1.4, 1.8, 2.6, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 4.7					HPE/III-D/9-12/1a, 1b	
xx E-5	CA-3 HPE-6	1.2, 1.3, 1.4, 1.8, 2.5, 2.6, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 4.7		CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h CA/IV/9-12/2c			HPE/III-D/9-12/1a, 1b	
E-6	CA-3	1.2, 1.4, 1.8, 2.6, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7		CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h CA/IV/9-12/2c				
E-7	HPE-6 SC-8 CA-3	1.2, 1.3, 1.4, 1.7, 1.8, 2.6, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.7		CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h	SC/III-B/9-12/1a		HPE/III-D/9-12/1a, 1b	

Duty Band and Task Statement	SHOW-ME STANDARDS		CURRICULUM FRAMEWORKS					
	Knowledge (Content)	Performance (Goals)	Math	Communication Arts	Science	Social Studies	Health/ Physical Education	Fine Arts
E-8	HPE-6 SC-8 CA-3	1.2, 1.3, 1.4, 1.7, 1.8, 2.6, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.7		CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h	SC/III-B/1a		HPE/III-D/9-12/1a, 1b	
E-9	HPE-6 SC-8 CA-3	1.2, 1.3, 1.4, 1.7, 1.8, 2.6, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.7		CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h	SC/III-B/9-12/1a		HPE/III-D/9-12/1a, 1b	
E-10	MA-1,3 HPE-6 SC-8	1.1, 1.2, 1.4, 1.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.7	MA/IV/9-12/2a, 2b, 2c, 2d, 3a, 3b, 3c, 3d MA/V/9-12/1a, 1b, 1c, 2a, 2b, 2c		SC/III-B/9-12/1a		HPE/III-D/9-12/1a	
E-11	HPE-6 SC-8 CA-3	1.2, 1.3, 1.4, 1.7, 1.8, 2.6, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.7		CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h	SC/III-B/9-12/1a		HPE/III-D/9-12/1a, 1b	
E-12	CA-3 SC-1 HPE-6	1.1, 1.2, 1.4, 1.8, 1.10, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 4.7		CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h	SC/III-B/9-12/4a		HPE/III-D/9-12/1a	
F-1	MA-1 SC-8	1.2, 1.4, 1.8, 1.10, 3.2, 3.3, 3.5, 3.6, 3.7	MA/V/9-12/1a		SC/VIII-A/9-12/3b			
F-2	HPE-6 CA-3	1.2, 1.3, 1.7, 1.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7		CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h			HPE/III-D/9-12/1a, 1b	

Duty Band and Task Statement	SHOW-ME STANDARDS		CURRICULUM FRAMEWORKS					
	Knowledge (Content)	Performance (Goals)	Math	Communication Arts	Science	Social Studies	Health/ Physical Education	Fine Arts
F-3	CA-3 MA-1, 2	1.2, 1.4, 1.8, 2.5, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7	MA/V/9-12/1a MA/VI/9-12/1b, 1c, 1d, 2b, 2c, 2d, 3b, 3c, 3d	CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h				
F-4	HPE-6 CA-3 MA-1	1.2, 1.3, 1.4, 1.8, 2.5, 2.6, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.7	MA/I/9-12/1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 2d, 2e, 3a, 3b, 3c, 3d, 3e, 4a, 4b, 4c, 4d, 4e	CA/IV/9-12/1c, 1d, 1e, 1f, 1g, 1h			HPE/III-D/9-12/1a, 1b	
F-5	CA-3	1.2, 1.4, 1.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7	CA/I/9-12/1b CA/III/9-12/1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h, 1i,1j					
G-1	HPE-6 CA-3	1.2, 1.3, 1.7, 1.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7		CA/I/9-12/1b CA/III/9-12/1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h, 1i, 1j			HPE/III-D/9-12/1a, 1b	
G-2	MA-1	1.2, 1.3, 1.4, 1.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7	MA/IV/9-12/3a, 3b, 3c, 3d, 3e MA/I/9-12/1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 2d, 2e, 3a, 3b, 3c, 3d, 3e, 4a, 4b, 4c, 4d, 4e	CA/I/9-12/1b				
G-3	MA-1	1.2, 1.3, 1.4, 1.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7	MA/IV/9-12/3a, 3b, 3c, 3d, 3e MA/I/9-12/1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 2d, 2e, 3a, 3b, 3c, 3d, 3e, 4a, 4b, 4c, 4d, 4e	CA/I/9-12/1b				
G-4	MA-1	1.2, 1.3, 1.4, 1.8, 3.1, 3.2, 3.3, 3.4, 3.5,	MA/IV/9-12/ 3a, 3b, 3c, 3d, 3e MA/I/9-12/ 1a, 1b,	CA/I/9-12/1b				

Duty Band and Task Statement	SHOW-ME STANDARDS		CURRICULUM FRAMEWORKS					
	Knowledge (Content)	**Performance (Goals)**	**Math**	**Communication Arts**	**Science**	**Social Studies**	**Health/ Physical Education**	**Fine Arts**
		3.6, 3.7	1c, 1d, 1e, 2a, 2b, 2c, 2d, 2e, 3a, 3b, 3c, 3d, 3e, 4a, 4b, 4c, 4d, 4e					
G-5	CA-3	1.2, 1.3, 1.4, 1.5, 2.5, 2.6, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7		CA/I/9-12/1b CA/III/9-12/1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h, 1i, 1j				

AGRICULTURAL STRUCTURES

TEACHING CALENDAR

	Periods for Classroom Instruction/Activities	Length for Activity Sheets (AS)
Unit I, Lesson 1	6	AS 1.1 30 min.
		AS 1.2 1 class period
Unit I, Lesson 2	5	AS 2.1 30 min.
Unit II, Lesson 1	6	AS 1.1 1 class period
Unit II, Lesson 2	15	AS 2.1 1 class period
		AS 2.2 2 class periods
Unit II, Lesson 3	2	AS 3.1 1 class period
Unit III, Lesson 1	1	AS 1.1 30 min.
Unit III, Lesson 2	2	AS 2.1 1 class period
Unit III, Lesson 3	3	AS 3.1 1 class period
Unit III, Lesson 4	4	AS 4.1 1 class period
Unit III, Lesson 5	5	AS 5.1 30 min.
		AS 5.2 1 class period
Unit III, Lesson 6	5	AS 6.1 30 min.
Unit III, Lesson 7	6	AS 7.1 1 class period
Unit III, Lesson 8	4	AS 8.1 1 class period
Unit III, Lesson 9	2	AS 9.1 1 class period
Unit IV, Lesson 1	2	AS 1.1 1 class period
Unit IV, Lesson 2	3	AS 2.1 30 min.
Unit IV, Lesson 3	3	AS 3.1 1 class period
		AS 3.2 30 min.
Unit IV, Lesson 4	5	AS 4.1 2 class periods
Unit IV, Lesson 5	10	AS 5.1 2 class periods
Unit IV, Lesson 6	4	AS 6.1 1 class period
Unit IV, Lesson 7	5	AS 7.1 1 class period
Unit V, Lesson 1	2	AS 1.1 1 class period
Unit V, Lesson 2	2	AS 2.1 30 min.
Unit V, Lesson 3	5	AS 3.1 30 min.

	Periods for Classroom Instruction/Activities	Length for Activity Sheets (AS)
Unit V, Lesson 4	3	AS 4.1 30 min.
Unit V, Lesson 5	3	AS 5.1 1 class period
Unit V, Lesson 6	1	AS 6.1 30 min.
Unit V, Lesson 7	3	AS 7.1 30 min.
Unit V, Lesson 8	7	AS 8.1 30 min.
Unit V, Lesson 9	8	AS 9.1 1 class period
Unit V, Lesson 10	2	AS 10.1 30 min.
Unit V, Lesson 11	2	AS 11.1 30 min.
Unit V, Lesson 12	3	AS 12.1 30 min.
Unit VI, Lesson 1	3	AS 1.1 30 min.
Unit VI, Lesson 2	1	AS 2.1 15 min.
Unit VI, Lesson 3	3	AS 3.1 1 class period
Unit VI, Lesson 4	5	AS 4.1 1 class period
		AS 4.2 30 min.
Unit VI, Lesson 5	2	AS 5.1 30 min.
Unit VII, Lesson 1	2	AS 1.1 30 min.
Unit VII, Lesson 2	3	AS 2.1 1 class period
Unit VII, Lesson 3	5	AS 3.1 1 class period
Unit VII, Lesson 4	5	AS 4.1 30 min.
Unit VII, Lesson 5	2	AS 5.1 15 min.

AGRICULTURAL STRUCTURES
Competency Profile

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect **employability readiness** rather than the grades given in class.

Rating Scale:
3 Mastered - can work independently with no supervision
2 Requires Supervision - can perform job completely with limited supervision
1 Not Mastered - requires instruction and close supervision
N No Exposure - no experience or knowledge in this area

3	2	1	N	**A. Working With Plans**
				1. Read and create a simple construction drawing
				2. Develop a plan of procedure and a bill of materials for a construction project
				Other: ______________
				______________

3	2	1	N	**B. Farmstead Planning**
				1. Evaluate a site for a home
				2. Arrange a farmstead
				3. Describe characteristics of disposal systems for managing livestock manure
				Other: ______________
				______________

3	2	1	N	**C. Building Construction**
				1. Describe safety practices associated with building construction
				2. Identify types and designs of buildings and their methods of construction
				3. Identify and select building materials
				4. Identify the uses of different fasteners and fastening systems
				5. Describe how to construct a floor and subfloor
				6. Describe the purpose of walls, types of walls, supports, and siding used in agricultural buildings
				7. Select a roof support system
				8. Select roofing materials

3	2	1	N	**C. Building Construction (continued)**
				9. Identify factors affecting the heating,
				Other: ______________
				______________

3	2	1	N	**D. Concrete**
				1. Discuss safety in working with concrete
				2. Identify factors that affect the quality of

3. Identify site preparation requirements
4. Describe the procedure for preparing to
5. Explain the procedure for ordering, pouring,
6. Identify factors affecting the quality of cured
7. Describe the procedure for pouring a

Other: ______________________

____

3	2	1	N

E. Electricity

1. Identify the dangers and safety practices
2. Identify the terms associated with electrical
3. Match types and sizes of wire and their

3	2	1	N

E. Electricity (continued)

4. Identify the importance of grounding and
5. Locate lights, outlets, and switches, and

6. Identify the symbols used in agricultural

7. Describe practices for running wire to an

8. Identify procedures for connecting the drop

9. Describe how to run wiring from the SEP to

10. Calculate cost and electrical power using

11. Describe procedures for planning and

12. Identify problems in electrical systems

Other: ______________________

Other: ______________________

3	2	1	N

F. Plumbing

1. Calculate how much water is needed for a
2. Discuss safety practices for plumbing
3. Identify pipe types and determine size
4. Measure, cut, and connect pipes and tubing
5. Identify methods of protecting water pipes

3	2	1	N

G. Fencing

1. Discuss the terminology, dangers, and
2. Describe how to set and brace wood and
3. Describe techniques for building barbed
4. Describe techniques for building high
5. Identify fence mending techniques

Other: ______________________

AGRICULTURAL STRUCTURES

Student Names															
															UNIT I - WORKING WITH PLANS
															1. Read and create a simple construction drawing.
															2. Develop a plan of procedure and a bill of materials for a construction project.
															UNIT II - FARMSTEAD PLANNING
															1. Evaluate a site for a home.
															2. Arrange a farmstead.
															3. Describe characteristics of disposal systems for managing livestock manure.
															UNIT III - BUILDING CONSTRUCTION
															1. Describe safety practices associated with building construction.
															2. Identify types and designs of buildings and their methods of construction.
															3. Identify and select building materials.
															4. Identify the uses of different fasteners and fastening systems.
															5. Describe how to construct a floor and subfloor.
															6. Describe the purposes of walls, types of walls, supports, and siding used in agri- cultural buildings.
															7. Select a roof support system.
															8. Select roofing materials.
															9. Identify factors affecting the heating, cooling, and ventilation of agricultural structures.
															UNIT IV - CONCRETE
															1. Discuss safety in working with concrete.
															2. Identify factors that affect the quality of fresh concrete.
															3. Identify site preparation requirements.
															4. Describe the procedure for preparing to pour a concrete slab.

Student Names															
															5. Explain the procedure for ordering, pouring, and finishing concrete.
															6. Identify factors affecting the quality of cured concrete.
															7. Describe the procedure for pouring a concrete wall.
															UNIT V - ELECTRICITY
															1. Identify the dangers and safety practices associated with electrical work.
															2. Identify the terms associated with electrical work.
															3. Match types and sizes of wire with their uses.
															4. Identify the importance of grounding and GFCI protection.
															5. Locate lights, outlets, and switches, and identify circuit protection needs.
															6. Identify the symbols used in agricultural wiring plans.
															7. Describe practices for running wire to an agricultural structure and wiring within the building safely.
															8. Identify procedures for connecting the drop wires and branch circuit wires to the SEP.
															9. Describe how to run wiring from the SEP to a junction box, lights, and recep-tacles.
															10. Calculate cost and electrical power using Ohm's Law.
															11. Describe procedures for planning and installing lightning protection.
															12. Identify problems in electrical systems.
															UNIT VI - PLUMBING
															1. Calculate how much water is needed for a farmstead.
															2. Discuss safety practices for plumbing.
															3. Identify pipe types and determine size

Student Names															
															requirements.
															4. Measure, cut, and connect pipes and tubing.
															5. Identify methods of protecting water pipes against freezing.
															UNIT VII -FENCING
															1. Discuss the terminology, dangers, and safety practices associated with building fences.
															2. Describe how to set and brace wood and steel posts.
															3. Describe techniques for building barbed and woven wire fences.
															4. Describe techniques for building high tensile and electric fences.
															5. Identify fence mending techniques.

UNIT I - WORKING WITH PLANS

Lesson 1: Preparing a Plan

Competency/Objective: Read and create a simple construction drawing.

Study Questions

1. Why is having a good plan important?
2. What are the steps in making a good plan?
3. What is the definition of scale?
4. How is scale used in the drawing and interpreting of plans?
5. What are the common symbols and elements of a plan?
6. What is computer-aided drafting (CAD)?

References

1. Agricultural Structures *(Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit I.
2. Transparency Masters

   a) TM 1.1: Architect's Scale
   b) TM 1.2: Labeling
   c) TM 1.3: Symbols
   d) TM 1.4: Lines
   e) TM 1.5: Elevation Drawings

3. Activity Sheets

   a) AS 1.1: Reading a Plan
   b) AS 1.2: Drawing a Plan (Instructor)
   c) AS 1.2: Drawing a Plan (Student)

UNIT I - WORKING WITH PLANS

Lesson 1: Preparing a Plan

TEACHING PROCEDURES

B. ***Introduction***

A variety of structures are used in agriculture, and they all start with a plan. This lesson will increase understanding of plans by providing an opportunity to produce a simple construction drawing. Although professionally drawn plans for nearly any conceivable project are available at a reasonable cost, the production of a plan will give a much better understanding of the information plans convey.

C. ***Motivation***

Begin the lesson by writing the statement “Prior planning prevents poor performance” on the board. Ask the students for feedback about why planning is important and list their points on the board. To prompt discussion, suggest some elements to consider when planning, such as intended use, size, and style. Discuss with the students why prior planning is important, pointing out that changes to the plan can be easily accomplished, in comparison to changes made to a structure after it has been completed. Explain that a plan is a collection of information that builders use to know what a structure should look like and how to proceed.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students why planning is important. Reemphasize the points made in the motivation. Explain that in its final form the plan will contain all the information needed to complete the structure. Explain that the objective of a simple construction plan is to convey an overall understanding of the size and shape of the structure.

   Why is having a good plan important?

   a) Provides for a useable structure that serves its intended purpose
   b) Provides an opportunity to design the structure to meet specific needs
   c) Saves time and money
   d) Allows an individual to avoid the difficulties associated with situations caused by a lack of careful forethought

2. Ask students to list the steps in making a plan.

What are the steps in making a good plan?

a) Determine and define needs.
b) Determine the size of the structure.
c) Choose the style of the structure.
d) Consider other factors.
    1) Material resources available
    2) Cost factors and constraints
    3) Building and fire codes
    4) Zoning laws
    5) Insurance and/or financial stipulations
    6) Safety considerations for specific structures
    7) Utility and service access
    8) Cleaning requirements
    9) Heating and cooling requirements

3. Ask students to define scale.

What is the definition of scale?

a) Scale is a proportion between two sets of dimensions.
b) For plans, scale indicates an adjustment in the size of a drawing that reflects the size of the object being drawn.

4. Ask students to describe how they would choose a particular scale for a structure. Explain why different scales are used, pointing out that the larger the actual structure, the smaller the scale needs to be to fit on a standard page. Make sure the students understand that whatever size the scale is, it represents one foot of the actual structure. Show students the architect's scale pictured in TM 1.1.

How is scale used in the drawing and interpreting of plans?

a) For basic plan drawing, a picture sized to fit on drawing paper is done to scale to represent the actual size of the structure being built. A system for reducing the actual size mathematically has been devised to allow for easy drawing and interpretation.
b) Scale may be drawn by using a triangular architect's scale; it combines the eleven commonly used scales on one tool.
c) A regular ruler may also be used to draw a simple plan to scale.

5. Ask the class what the elements of a plan are. Use TM 1.2 to explain where and what information will be required on drawings. Show students TM 1.3. Explain that symbols are used in drawings as a convenience to represent different items contained in a drawing. Use TM 1.4 to illustrate the types of lines found on plans. Discuss

the use of elevation drawings, showing the class TM 1.5. Have students complete AS 1.1.

What are the common symbols and elements of a plan?

a) Elements are the different parts of the drawing that convey information or enhance the information provided.
   1) Information in the blocks provided in the title box
      (a) Name of the person drawing the plan
      (b) Title of the project
      (c) Date
      (d) Scale
   2) Symbols - pictorial representations of information that are included on the drawing
      (a) Symbols that may be subject to the same scale as the rest of the drawing and show the location of these parts of the structure
         (1) Doors
         (2) Windows
      (b) Symbols representative of where devices or appliances are to be located
         (1) Electrical fixtures
         (2) Plumbing fixtures
      (c) Symbols for the type or grade of materials used
         (1) Concrete
         (2) Steel
         (3) Wood
   3) Lines
      (a) Border line - dark line around the perimeter of the drawing paper
      (b) Object line - used to draw the object
      (c) Hidden line - represents material that is under other material
      (d) Extension line - used for placing dimensions on drawings
      (e) Dimension line - shows the size of an object
      (f) Break line - represents an area in the structure where a section has been removed
      (g) Cutting plane - shows where a section has been removed with arrows showing the direction from which it was taken
      (h) Center line - shows the centers of holes and round shapes

b) Elevation drawings are orthographic projections of a structure as viewed from different perspectives, most commonly the top, front, and one or both sides.

6. Ask students if they know what CAD (computer-aided drafting or design) means. Emphasize that plans drawn using CAD are only as good as the drafter’s skill and talent allow. CAD cannot replace the drafter’s creativity; it only makes it easier to express. Have students begin AS 1.2. Evaluate the school’s resources. If students have access to enough terminals with CAD capabilities and either are knowledgeable about CAD or can be taught the basics in the time allotted, using

CAD is an excellent choice. If CAD cannot be used, students may simply draw the structure described in the activity by hand.

What is computer-aided drafting (CAD)?

a) Computer-aided drafting or design, called CAD, is a system consisting of a computer and specially designed software that does the actual drawing of plans.

b) CAD is now the industry standard for drafting.
c) The four main benefits of CAD over conventional hand drafting are speed, quality, ease of making changes, and communication.

G. ***Other Activities***

Have each student produce a simple construction drawing for a structure of his or her choice.

H. ***Conclusion***

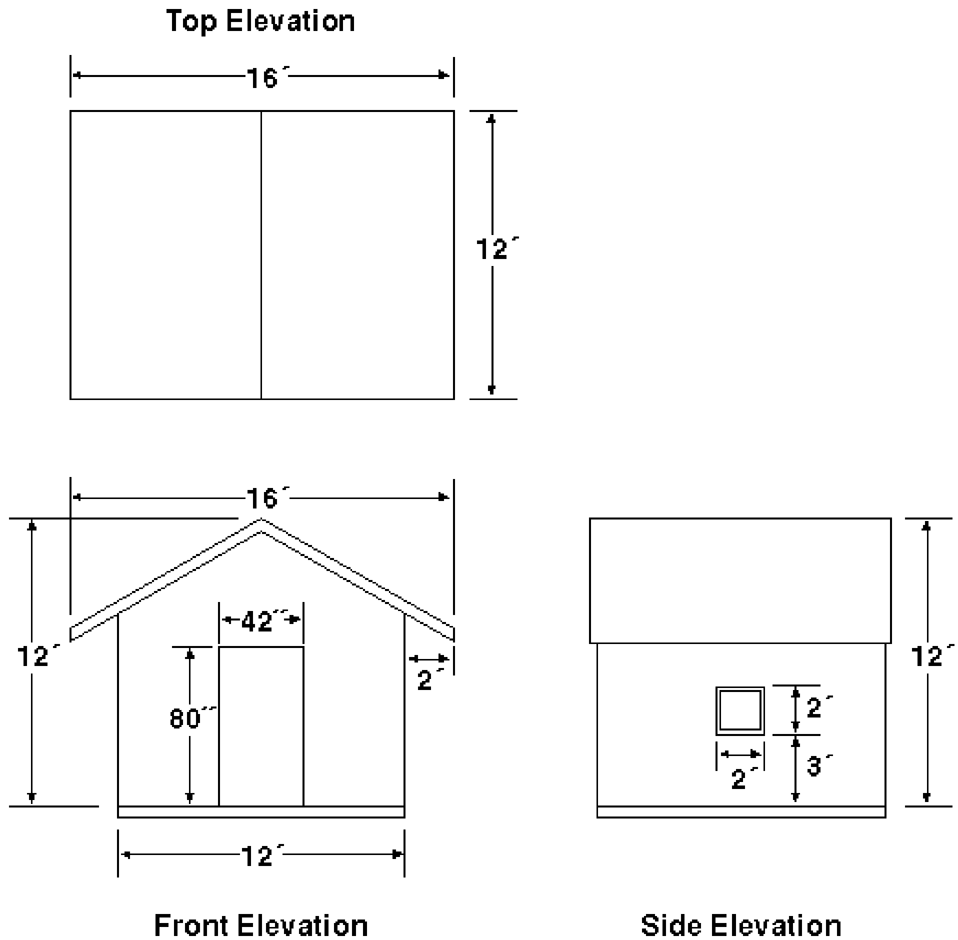
Having a good plan is essential to producing a good structure. Developing the plan involves considering the intended use, size, and style of the structure. After these decisions have been made, a simple construction drawing with at least three elevations is created either by hand or with CAD, using an appropriate scale and elements of the drawing to represent the structure on paper.

I. ***Answers to Activity Sheets***

AS 1.1

1. 33 feet
2. 4 posts
3. 4 feet
4. 6 posts
5. Three
6. Five
7. Four
8. Single pole and three way switches
9. Nine, including the overhead lighting for the bench
10. Door switch

AS 1.2


Top Elevation
16´
12´
16´
42´´
2´
12´
80´´
12´
Front Elevation
2´
2´
3´
12´
Side Elevation

J. ***Answers to Evaluation***

1. b
2. b
3. c

4. Scale can be defined as a proportion between two sets of dimensions.

5. Computer-aided drafting or design is a system consisting of a computer and specially designed software that does the actual drawing of plans.

6. Answers may include any two of the following: A good plan provides for a useable structure that serves its intended purpose, provides an opportunity to design the structure to meet specific needs, saves time and money, and allows an individual to avoid the difficulties associated with situations caused by a lack of careful forethought.

7. The four steps are as follows: determine and define needs, determine the size of the structure, choose the style of the structure, and consider other factors.

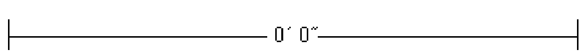
8. Border line

9. Dimension line

10. Object line

11. Answers will vary.

12. Students should draw a rectangle measuring



1¾ inches by 3¾ inches.

UNIT I - WORKING WITH PLANS Name _____

Lesson 1: Preparing a Plan Date ___________________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Symbols are:

   a. A plan of a structure.
   b. Pictorial representations of information placed on a plan.
   c. Three views drawn to represent a structure.
   d. Lines used to represent a structure.

2. Which of the following is not found on plan drawings?

   a. Dimension lines
   b. Tie lines
   c. Border lines
   d. Hidden lines

3. Elevation drawings are:

   a. The same as blueprints.
   b. Used to build models.
   c. Produced in more than one view.
   d. Drawings showing the height of a structure.

Complete the following short answer questions.

4. What is scale?

5. What does CAD mean? What is it?

6. What are two reasons why having a good plan is important when building a structure?

   a.

   b.

7. What are the four main steps in forming a good plan for a structure?

   a.

   b.

   c.

   d.

For each of the lines listed below, draw an example of the line beside its name.

8. Border line

9. Dimension line

10. Object line

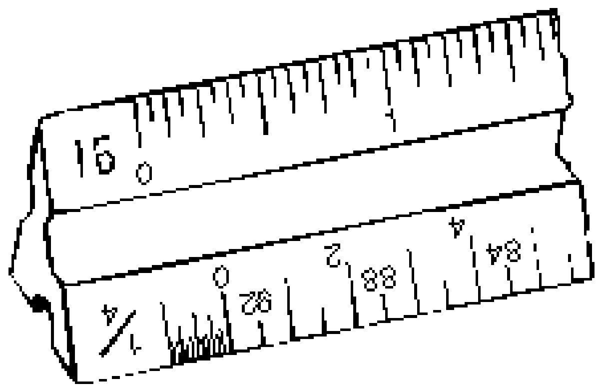
Sketch three elevation drawings (front, side, and top) for a dog house in the space below.

11.

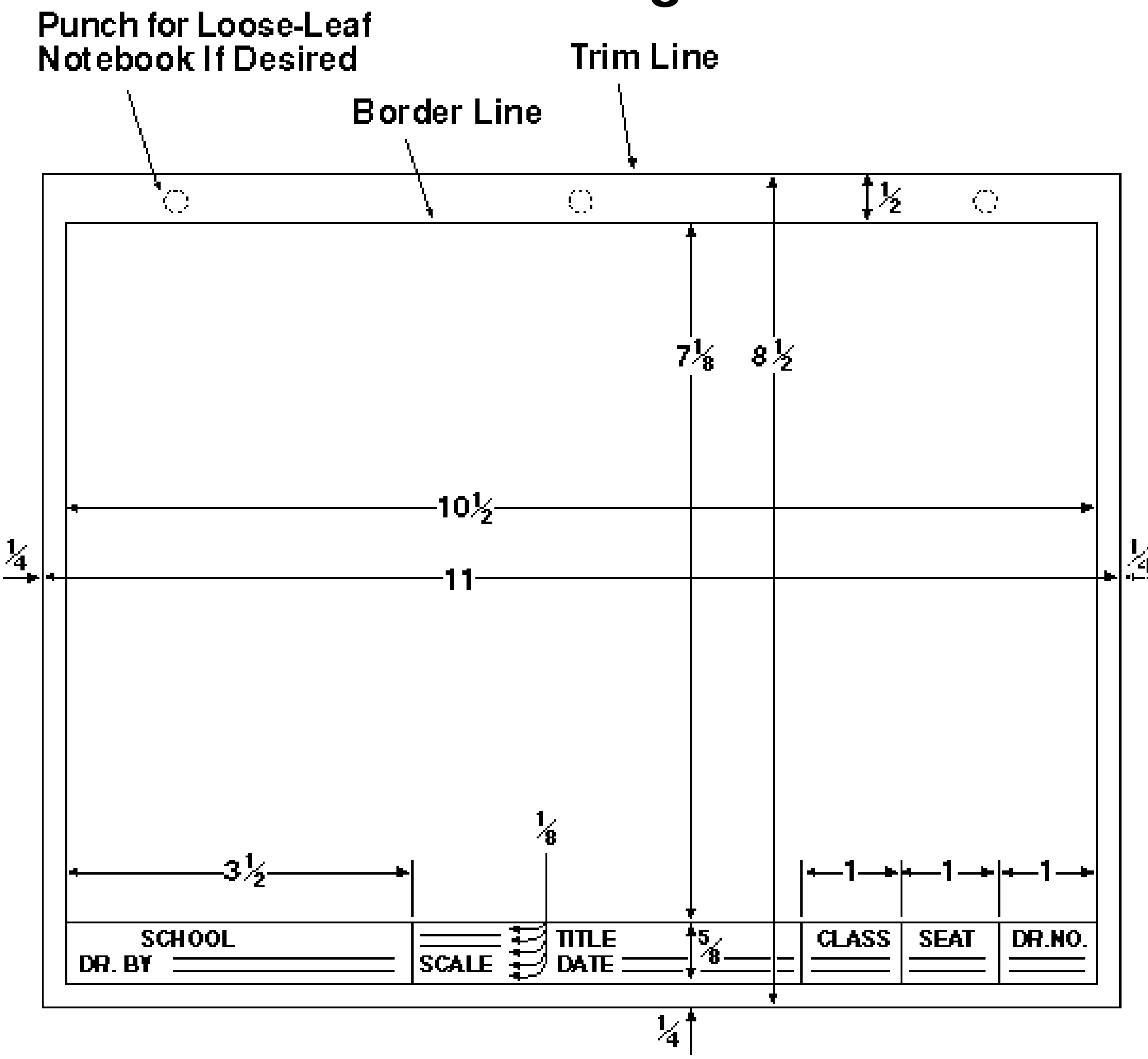
In the space provided below, use a ruler to draw a rectangle using the following scale: ¾ inch = 15 feet. The sides of the rectangle should equal 35 feet; the top and bottom of the rectangle should equal 75 feet.

12.

Architect's Scale



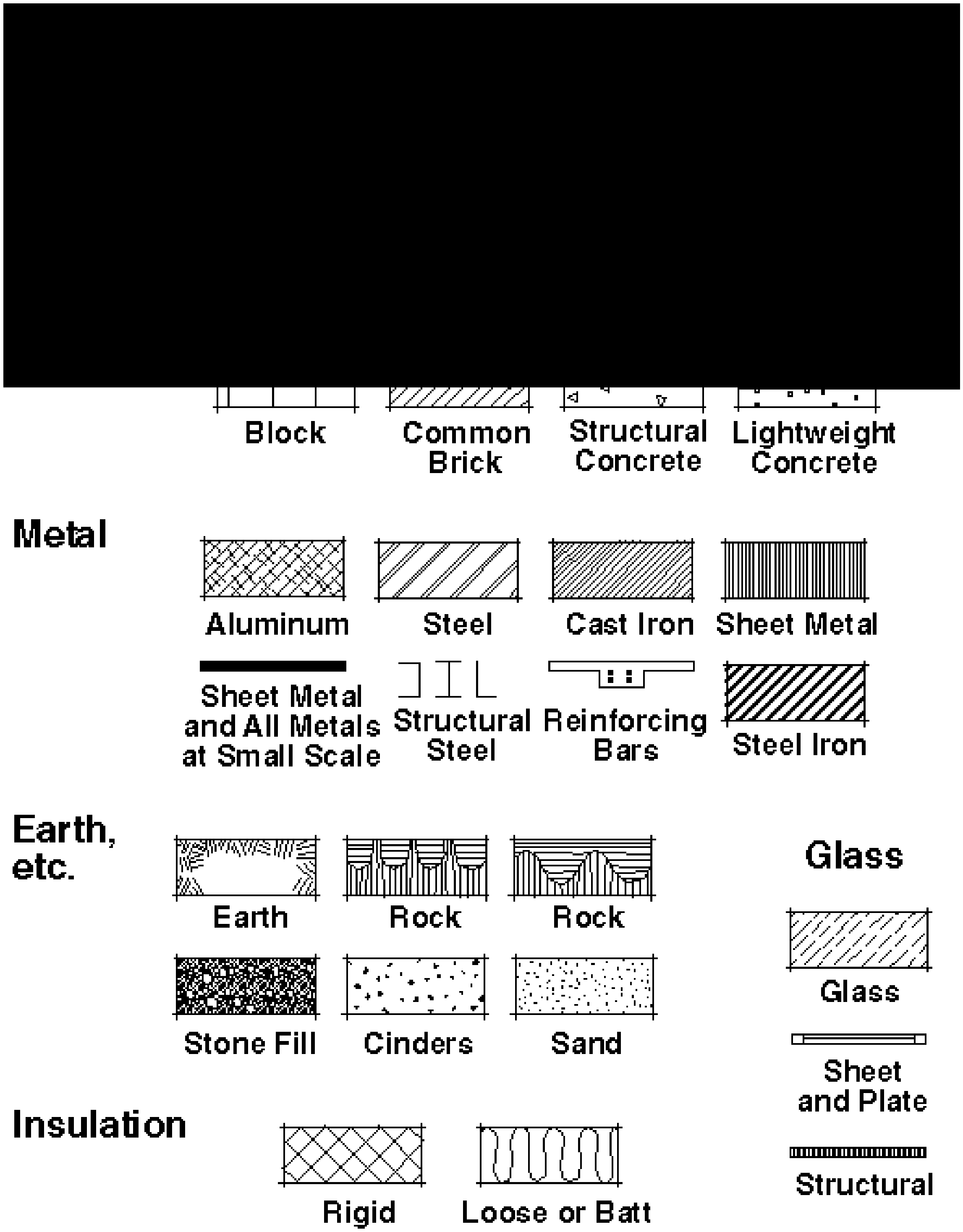
Labeling



Punch for Loose-Leaf Notebook If Desired
Trim Line
Border Line
½
7⅛
8 ½
10½
¼
11
¼
⅛
3½
1
1
1
SCHOOL
DR. BY
SCALE
TITLE
DATE
⅝
CLASS
SEAT
DR.NO.
¼

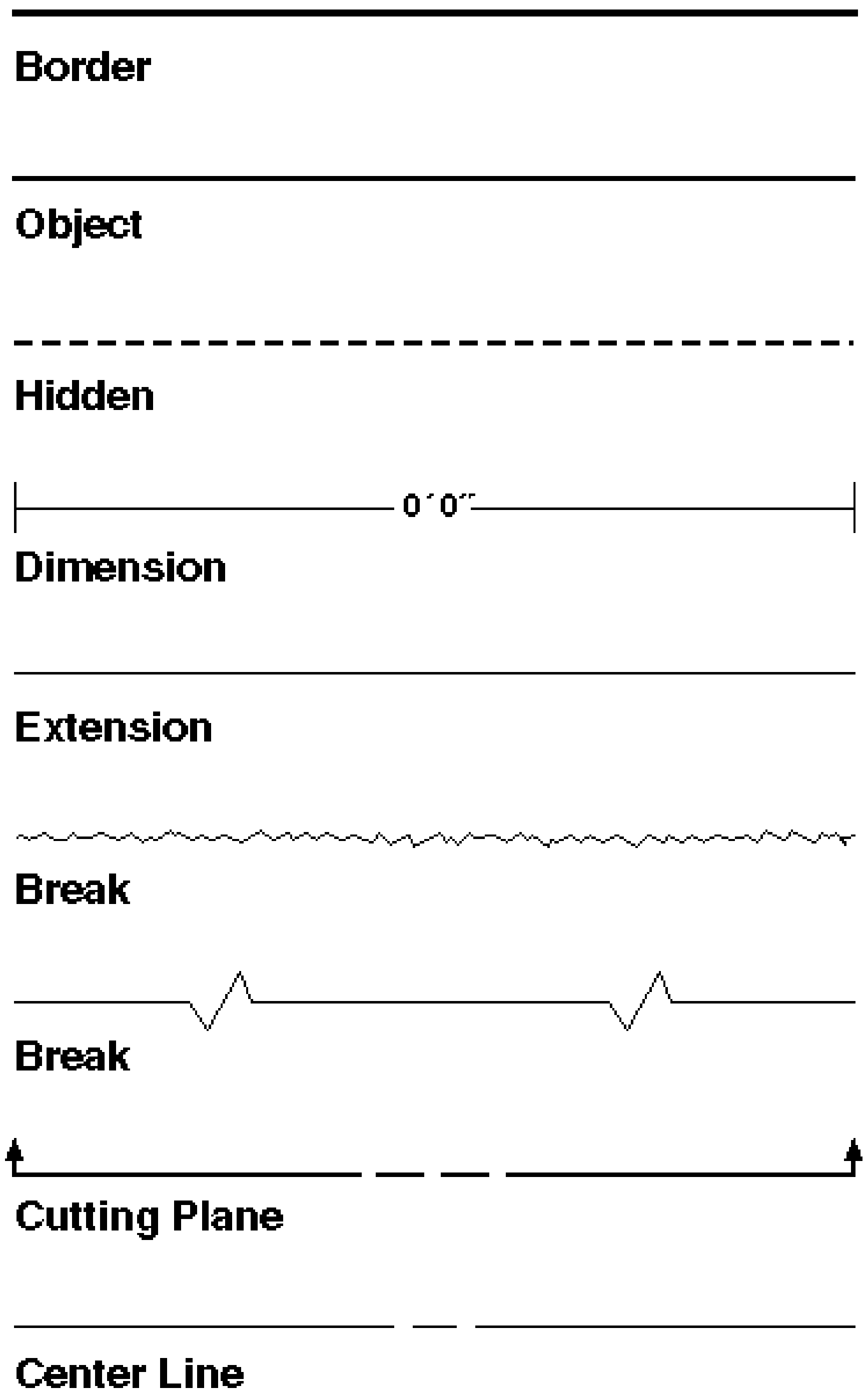
Symbols

[redacted]



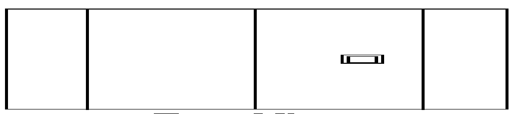

SHOWER DRAIN
FLOOR DRAIN
HOT WATER TANK
SINGLE SINK
18 X 24
DOUBLE SINK
21 X 32
DOUBLE HUNG
WINDOW
DOOR
LAVATORY
TOILET
BUILT-IN LAVATORY
BUILT-IN TUB WITH SHOWER
Electrical Symbols
SWITCH OUTLETS
S : SINGLE POLE SWITCH
S2 : DOUBLE POLE SWITCH
S3 : THREE WAY SWITCH
S4 : FOUR WAY SWITCH
SD : AUTOMATIC DOOR SWITCH
SCB : CIRCUIT BREAKER
CONVENIENCE OUTLETS
DUPLEX OUTLET
WEATHERPROOF
RANGE OUTLET
SPECIAL PURPOSE
LIGHTING PANEL
POWER PANEL
POWER TRANSFORMER
PUSH BUTTON
TELEPHONE
GENERAL OUTLETS
CEILING
WALL
OUTLET DROP CORD
PULL SWITCH
JUNCTION BOX

Lines

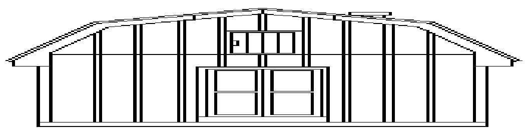

Border
Object
Hidden
0´0˝
Dimension
Extension
Break
Break
Cutting Plane
Center Line

TM 1.5

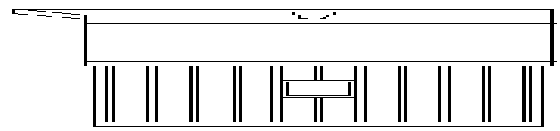
Elevation Drawings



Top View



Front View



Side View

Lesson 1: Preparing a Plan Name ____________________________

Reading a Plan

Objective: Read a simple construction plan.

Using the plan for a post frame repair shop, answer the questions.

1. What is the length of the unbroken wall along the side with only a personnel door?

2. How many posts form the wall with no doors?

3. How long is the wall between the 10-foot overhead door and the personnel door?

4. How many posts could be removed from the building if 8-foot on center post spacing is used for the entire building?

5. How many duplex outlets are found along the work bench?

6. How many duplex outlets are found in the rest of the building?

7. How many light switches are found in the building?

8. What different types of light switches are used?

9. How many ceiling lighting outlets are included in the structure?

10. What does the symbol S_D mean?

Drawing a Plan

Objective: Draw a simple construction plan.

Materials and Equipment:

Computer with CAD software and printer (if possible)
Paper, either plain white copy paper or high rag content drawing paper (if professional hand drawing instruments are available)
No. 2 lead pencil
Ruler or architect's scale

NOTE: Professionals use several pencils with lead in a variety of hardnesses to produce exact results. A regular No. 2 pencil can be used but must be utilized with care to produce acceptable results.

Procedure:

For this activity, draw a plan for a storage building with a gable roof having two sloping sides that meet at the ridge and a floor space of 12 feet by 12 feet. The walls will be 8 feet in height on the sides, and the height from the floor to ridge will be 12 feet. The overhang, the part of a roof that extends past the walls of a structure, is to be 2 feet from the walls. The right and left side of the building should each have a window that is 2 feet by 2 feet. The windows should be centered in the side of the building with the bottom of the window 3 feet from the floor of the structure. The door should be 42 inches wide by 80 inches tall and centered in the front of the building.

1. Before assigning the activity, determine what drafting experience the students possess. Knowledge will vary, but ideally the students will have had some involvement in previous classes such as industrial technology. If students do not have much experience, working through the activity with them may be necessary. Review the following information if needed:

    - How scale is used in drawing
    - Using a separate page for each elevation drawing
    - Using border lines around the edges of the paper
    - Centering the drawings on the page
    - Using dimension lines to show the overall dimensions of the structure

2. The whole process is much less involved for the students using CAD. They will complete a plan for the same structure, but using templates and automation. If using CAD is possible, your students will need access to a computer system with CAD capabilities and a suitable printer.

3. If the plans are to be hand drawn, students will need a suitable desktop or table, although drafting tables would be better. Triangular architect's scales may be used if they are available.

   Professional drawing instruments such as Bow pens, pencils and dividers, triangles, T-squares, and an assortment of pencils and inks may be available to some students. If so, excellent results may be achieved using professional quality high rag content drawing paper.

Lesson 1: Preparing a Plan Name ________________________

Drawing a Plan

Objective: Draw a simple construction plan.

Materials and Equipment:

Computer with CAD software and printer (if possible)
Paper
No. 2 lead pencil
Ruler or architect's scale

NOTE: Professionals use several pencils with lead in a variety of hardnesses to produce exact results. A regular No. 2 pencil can be used but must be utilized with care to produce acceptable results.

Procedure:

For this activity, draw a plan for a storage building with a gable roof having two sloping sides that meet at the ridge and a floor space of 12 feet by 12 feet. The walls will be 8 feet in height on the sides and the height from the floor to ridge will be 12 feet. The overhang, the part of a roof that extends past the walls of a structure, is to be 2 feet from the walls. The right and left side of the building should each have a window that is 2 feet by 2 feet. The windows should be centered in the side of the building with the bottom of the window 3 feet from the floor of the structure. The door should be 42 inches wide by 80 inches tall and centered in the front of the building.

1. If you are drawing by hand, prepare three sheets of paper, one for each of the different elevation drawings. Neatly include the following information on each sheet in a title box: your name, title of the project, date, and scale. A sample page showing labeling is included with this activity sheet.

2. Choose a scale for the drawing that will allow it to fit in the area provided by the paper.

3. Center your drawings in the area inside the border lines. Use object lines to draw the structure. Windows and doors are to be represented by the appropriate symbols where they are to be located.

4. Dimension lines are to be used to define the measurements of the structure and/or the exact size of elements in the structure. Use dimension lines to show width, length, and height as well as the dimensions of windows and doors and the amount of overhang. These lines are to be clean and precise.

5. Draw the front elevation.

6. Draw the side elevation.

7. Draw the top elevation.

UNIT I - WORKING WITH PLANS

Lesson 2: Understanding a Plan of Procedure

Competency/Objective: Develop a plan of procedure and a bill of materials for a construction project.

Study Questions

1. What are the steps in making a plan of procedure?

2. What is the importance of a bill of materials?

3. What is the difference between a cutting bill of materials and a purchasing bill of materials?

References

1. *Agriculture Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit I.

2. Activity Sheet

   a) AS 2.1: Preparing a Plan of Procedure

Lesson 2: Understanding a Plan of Procedure

TEACHING PROCEDURES

B. ***Review***

Having developed an understanding of basic construction plans in Lesson 1, it is now time to explore the planning process. A plan of procedure for a construction project involves determining the order in which to proceed as well as developing lists of the materials needed.

C. ***Motivation***

Discuss the advantages of having and following a good plan of procedure. Describe a scenario involving pouring concrete before plumbing lines have been installed. This example creates a very good visual image of a situation that could have been avoided with proper planning.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students to list the steps in forming a plan of procedure. Discuss the four steps in developing a plan.

   What are the steps in making a plan of procedure?

   a) A plan of procedure is the order in which everything concerning the eventual completion of a planned project is identified, listed, and then arranged in a logical order from the first step to the last step.
   b) Developing a plan of procedure involves four steps.
      1) The first step in developing a plan of procedure is identifying every factor that may affect the project and then arranging all the identified elements in a logical order.
      2) From the information thus far assembled, a decision is made about the type and grade of materials that is appropriate for the project.
      3) A list of materials required will need to be developed from the information assembled so far and by studying the plan drawings.
      4) Materials must be purchased, cut, and assembled in a logical order.

2. Discuss the description of a bill of materials. Ask students why developing a material list is important.

   What is the importance of a bill of materials?

   a) A bill of materials is a list of all the components needed to complete a proposed project, identifying the amount, size, and kind of materials needed. These lists are necessary for purchasing the correct amount of materials and for obtaining cost estimates.

3. Discuss a cutting bill of materials and a purchasing bill of materials, and explain the difference between the two. Have students complete AS 2.1.

   What is the difference between a cutting bill of materials and a purchasing bill of materials?

a) Many materials used in agricultural structures, such as plumbing supplies and lumber, are available for purchase in standard lengths and dimensions; as a result, more material will be purchased than used in the project, and the materials are then cut to the exact dimensions needed during construction.

b) Cutting bill of materials

1) This list is generally developed first to prevent waste when purchasing materials.

2) It is a list of the materials needed to assemble the project, in their required dimensions.

c) Purchasing bill of materials

1) This list is developed from the information accumulated to this point.

2) The list will include not just the materials identified from the cutting list in their standard sizes, but everything needed to construct the project, such as fasteners, hinges, wire, etc..

G. ***Other Activities***

Have students develop a project for an agricultural structure of their choice. They should produce a plan of procedure, including a cutting bill of materials and purchasing bill of materials.

H. ***Conclusion***

This lesson provides an understanding and appreciation of a plan of procedure. It also provides a working knowledge of how to apply the four-step procedure to develop a plan for an agricultural structure.

I. ***Answers to Activity Sheet***

1. Identify all the steps necessary to complete the project. Decide what materials should be used to construct the project. List the materials needed to complete the project, preparing a cutting and a purchasing bill of materials. Purchase the materials according to the purchasing bill of materials, make the cuts according to the cutting bill of materials, and assemble the project.

2. Top - Four 2" × 6" boards 4 feet in length and sixteen 3-inch wood screws
Side braces - Two 2" × 6" boards 18 inches in length, two 2" × 6" boards 39 inches in length, and 24 3-inch wood screws
Legs - Four 2" × 4" boards 2 feet in length

3. Eight 4-foot 2" × 6" boards
Two 18-inch 2" × 6" boards
Two 36-inch 2" × 6" boards
Four 2-foot 2" × 4" boards

4. Four 8-foot 2" × 6" boards
One 10-foot 2" × 6"
Forty 3-inch wood screws

J. ***Answers to Evaluation***

1. c
2. b
3. d

4. The steps are: identify every factor that may affect the project and then arrange all the identified elements in a logical order, decide what type and grade of materials will be used to construct the project, develop lists of materials required, and finally purchase, cut, and assemble materials.

5. A cutting bill of materials is a list of the materials needed to assemble the project in their required dimensions. A purchasing bill of materials is not just the materials identified from the cutting list in their standard sizes, but everything needed to construct the project.

6. Usually the cutting bill of materials needs to be developed first to prevent waste when purchasing materials.

7. The bill of materials is important because it is necessary for purchasing the correct amount of materials and for obtaining cost estimates.

UNIT I - WORKING WITH PLANS Name _

Lesson 2: Understanding a Plan of Procedure Date __

EVALUATION

Circle the letter that corresponds to the best answer.

1. A bill of materials consists of:

   a. The same information as the cutting bill of materials.
   b. The same information as a purchase order.
   c. A list of all materials needed for a project.
   d. A list of the materials that have been purchased.

2. The cutting bill of materials is:

   a. The same as the purchasing bill of materials.
   b. A list of the materials for the project in required dimensions.
   c. Not important until after materials have been purchased.
   d. Determined after project completion.

3. A purchasing bill of materials:

   a. Is the same as the cutting list.
   b. Cannot be determined until project completion.
   c. Is a list of lumber to be purchased.
   d. Is a list of all materials to be purchased.

Complete the following short answer questions.

4. What are the steps in forming a plan of procedure?

5. What is the difference between a purchasing and a cutting bill of materials?

6. Would the purchasing bill of materials be prepared before or after the cutting bill of materials? Explain your answer.

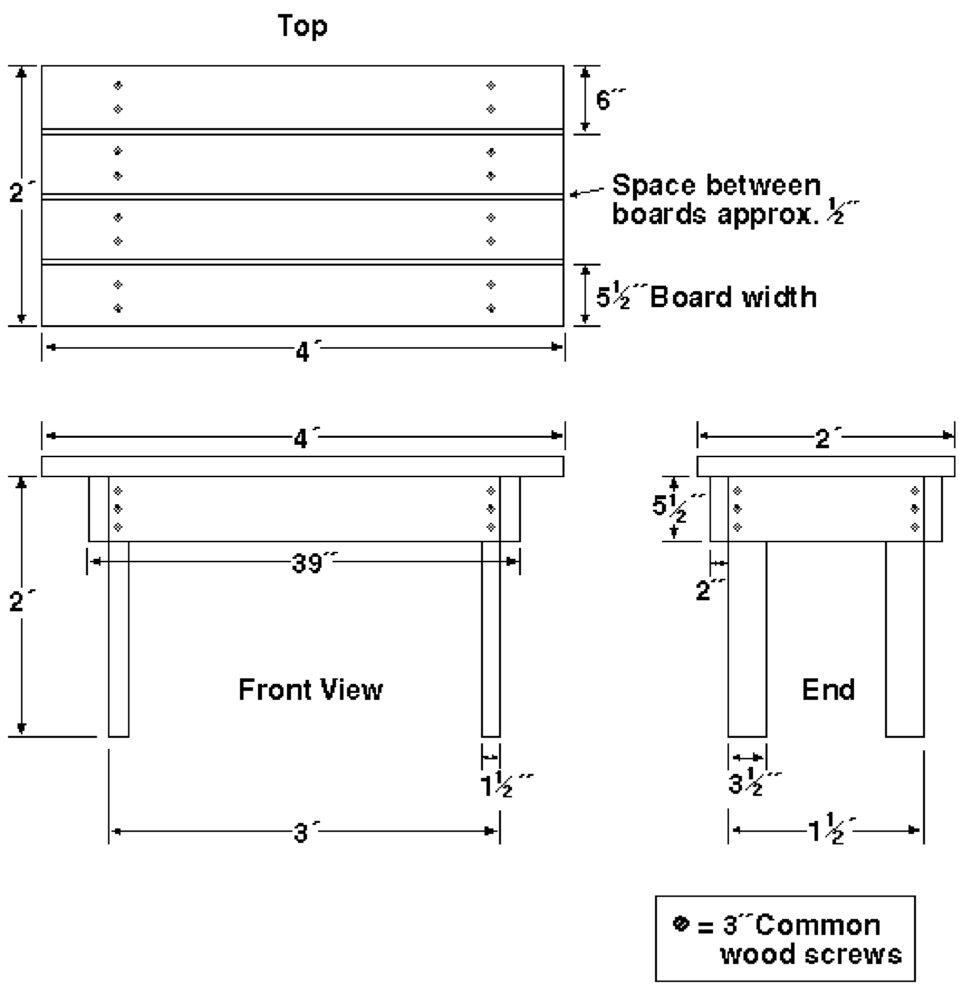
7. Why is making a bill of materials important?

Lesson 2: Understanding a Plan of Procedure Name _

Preparing a Plan of Procedure

Objective: Formulate a plan of procedure, including a cutting and a purchasing bill of materials.

Three elevation drawings of a pine workbench complete with dimension lines are shown below. Look at the three drawings of the workbench. Evaluate the drawings carefully. Then, answer the following questions.



1. What would be the steps in a plan of procedure for this project?

2. In the space below, list all the materials needed for the project.

3. Use the information from the list to develop a cutting bill of materials.

4. Develop a purchasing bill of materials. (Hint: Dimensional lumber from retailers most commonly starts at 8 feet and increases in length in 2-foot increments.)

UNIT II - HOME AND FARMSTEAD PLANNING

Lesson 1: Home Site Selection

Competency/Objective: Evaluate a site for a home.

Study Questions

1. How do soil and water conditions affect selection of a site?
2. How does topography affect planning for the home site?
3. How does wind affect planning?
4. How do services and utilities affect selection of the site?
5. What is the impact of regulatory agencies on planning for the home?
6. How do neighbors affect planning?
7. What are the implications of having the home and business on the same site?
8. What is the importance of conducting an environmental audit on a selected site?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit II.
2. Activity Sheet
    a) AS 1.1: Evaluating Home Sites

UNIT II - HOME AND FARMSTEAD PLANNING

Lesson 1: Home Site Selection

TEACHING PROCEDURES

B. ***Introduction***

Careful planning is involved in selecting a site for constructing a new home. Building in rural locations poses unique considerations. In order to have the best possible home when construction is completed, careful thought must be given to the selection of a home site.

C. ***Motivation***

Ask students to imagine that the class will be building a project on a particular piece of ground next to the school. Students should be asked if it will matter where the building is built on that land. The class discussion can be centered on those factors that might influence the location of the construction project.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Discuss what effect soil conditions and surface and subsurface water have on the selection of a site.

   How do soil and water conditions affect selection of a site?

   a) Soil conditions
      1) The bedrock depth and soil type will affect foundation design decisions.
      2) A test should be done to determine the depth of bedrock formations or the underlying soil conditions at possible sites.
   b) Surface and subsurface water
      1) Any site with surface and subsurface water for more than half the year should be avoided if possible.
      2) A building site will be easier to work with and on if the location selected does not have subsurface water.
         (a) Makes concrete work more difficult by increasing the moisture level in the concrete
         (b) Makes sealing the building difficult, which will lead to water in the basement or crawl space
         (c) Leads to mold, mildew, or rot in wood buildings.

3) If an entire plot has subsurface water, a drainage system may possibly be installed to remove the excess water.

2. Ask students to consider what the effect would be of building a home on top of a hill. Then ask them to consider what a home built in the bottom of a valley would be like. Would the homes have the same conditions?

How does topography affect planning for the home site?

a) Topography - the relative positions and elevations of the natural or man-made features of an area that determine the surface configuration of the land
b) Hillside construction
   1) Construction will have higher costs because the need for retaining walls, grading, fill material, and general site preparation is greater in comparison to a flat site.
   2) Considerable amounts of soil may need to be either removed or brought onto the site.
   3) This process will require additional advance planning in securing a place to deposit excavated dirt or finding a source for dirt or proper fill material.
c) Water runoff
   1) Building a house at the bottom of a hill means that water will run down toward the house, possibly causing flooding or sub-irrigation problems.
   2) A home site should generally be located on a higher elevation than livestock facilities or crop ground where many chemicals are used in order to allow the water runoff to flow away from the site.
d) Amount of wind that strikes the home
   1) Homes built on hilltops or knolls generally receive more wind than those built on hillsides or at the base of hills.
   2) Natural growing trees or man-made windrows can provide protection from wind, but the topography may limit natural growth or make new trees hard to establish.
   3) Additional construction costs may be incurred to insulate and strengthen roofs and walls that are exposed to heavy prevailing winds.
e) Possibility of expansion
   1) If an addition onto the building may some day be necessary, careful consideration should be given to the initial site chosen for the building.
   2) Room needs to be left around the building, especially on those sides where additions may be built.
f) Building perspective, or view
   1) Building perspective is the direction a building faces in relation to the external scenery.
   2) If a scenic view is desired and offered by a certain direction, the view must be considered in laying out the building.

3. Another consideration in selecting a building site for a house is wind. Discuss the effect of wind on planning for the construction of a house.

How does wind affect planning?

a) Main entrance - commonly located on a side of the house away from prevailing winds
b) If the door faces the direction of the prevailing winds
    1) Rain, dust, and debris may blow into the house.
    2) The wind may cause damage when the door is opened.
    3) Snow drifts can also accumulate around the door and may make it inaccessible.

4. Every new building requires certain services and utilities. Ask students to describe how services and utilities can impact the selection of a building site.

How do services and utilities affect selection of the site?

a) The distance to services and utilities should be considered because it will affect the cost of bringing them to the home.
    1) It is desirable to build as close to existing roads and utility lines as possible, especially electricity, telephone, and gas lines.
    2) If the closest access is found at one corner of the property, the home may be placed closer to that corner.
    3) The local electrical power, telephone service, and natural gas suppliers may be contacted to determine the cost.
b) If the location of the utilities is unknown, locator services can come to the property to determine the location.
    1) Using a locator service may reveal that some of the utilities already cross the property.
    2) By planning utility access, the builder can budget for the costs of bringing the utility to the building.
c) Many rural homes make use of propane gas for heating or cooking.
    1) Tanks should be located so as not to detract from the home's appearance.
    2) They should be easily accessible for the propane supplier to refill.
    3) Propane suppliers will provide tanks, meters, and trenched-in connecting lines for an initial lease fee for their customers.
    4) Suppliers may provide footing blocks, or the home builder can pour a level concrete pad to set the tank on.
    5) Home owners are required to provide a stubbed-up exterior line that is securely capped or connected to the heating system and/or appliances.
d) Drilling a well is often necessary for rural homes.
    1) State law requires all wells used for drinking water to be drilled to at least 80 feet to prevent groundwater runoff from directly entering the system.
    2) Knowing the average depth of drilling to reach quality water prior to selecting the site may influence selection.
    3) Drilling costs are based on the number of feet drilled and the soil structure where the drilling will be done.

        4) To determine approximate drilling depth, homeowners should contact the Missouri Department of Natural Resources, Division of Geology and Land Services.
    e) Several rural areas throughout the state have access to rural water districts.
        1) Water is purchased and piped from a nearby town or city's reservoir or well system.
        2) A homeowner can hook into this system for an initial fee and then purchase water based on usage on a monthly basis.
        3) Using a rural water district may be more cost efficient if the distance to the connection is fairly close and if the topography presents no major obstacles.
    f) If sewer service is not available, the builder will need to arrange for a private sewage disposal system to be constructed.
        1) A large area of land and suitable soil is necessary to prevent contamination of surface water and wells.
        2) Septic systems should be located away from home and building sites.
        3) Local or county sewer regulations should be consulted before building to determine if a site is acceptable.
        4) Many counties will not allow a septic tank or sewer field to be placed within a certain distance of rivers or ponds.
    g) Access to the site for concrete, lumber, and other material deliveries is important.
        1) Consideration should be given to where the roads currently are and where they will need to be built on the property.
        2) Roads and room for turning around should be provided.
        3) Time should be taken to consider where a lawn or any other landscaping will be prior to laying out the roads.
        4) Geomat is commonly placed on the ground to provide traction, if the site is wet and muddy.
        5) Bridges may need to be added to allow access.

5. Ask students what agencies may have control over where and how a house is built.

What is the impact of regulatory agencies on planning for the home?

    a) Fire codes and local building codes
        1) Fire codes may specify the distance from other buildings necessary to provide fire trucks and other emergency equipment access to the site.
        2) Common building codes include regulations for the reinforcement of concrete structures, service access, and utility access.
        3) An inspection is often required prior to beginning the project to make sure the building will be constructed according to code.
        4) For information about the codes for a particular area, the local building inspector or county commission can be contacted.
    b) Zoning laws

1) Many communities have zoning laws that prohibit the construction of private homes in areas that have been zoned for commercial development.

2) The local zoning commission, building inspector, or assessor can usually identify local zoning laws.

c) County board of commissioners

1) In a rural area, builders may only need to obtain permission for construction from a county board of commissioners.

2) The amount of regulation will depend on the local area.

(a) In some places, sewer fields must be approved prior to construction, generally by a local or county sanitation board.

(b) Zoning laws have also become much more common in many agricultural areas.

6. Ask students how close their own neighbors are, and if problems with neighbors have ever occurred. Discuss the effects of building more houses in rural areas.

How do neighbors affect planning?

a) Some landowners choose to build the home as far as possible from other neighbors to obtain greater privacy.

b) If neighbors are also relatives, some home builders may select a site that is relatively close to allow for more family interaction and promote a greater sense of security.

7. Ask students who live on farms what they think are advantages and/or disadvantages of having a home on a farmstead. Discuss factors to consider when deciding whether to have a home as part of a farmstead.

What are the implications of having the home and business on the same site?

a) Possible sale of the home at a later time

1) Many owners choose to sell an existing home to finance the construction of a new one.

2) If the home is in the center of some type of business site, it may be difficult or impractical to sell.

3) If the home is located on the edge of the property separate from the business, selling the home will be easier but will require accepting new and closer neighbors.

4) Road access to the farming or business operation may have to be added, as well as connections to services and utilities.

b) Excessive noise, traffic, or pollution

c) Potential safety problems for the residents, especially children

1) Agricultural operations use numerous pieces of equipment that are dangerous.

2) Many people prefer to locate the home away from more hazardous activities to help ensure the safety of children and visitors.

8. Ask students to list possible environmental issues that may affect the selection of a building site. Discuss the need to conduct an environmental audit. Have students complete AS 1.1.

What is the importance of conducting an environmental audit on a selected site?

a) Environmental audit
   1) Examines the potential building site to determine if any environmental issues will need to be addressed prior to construction
   2) Can alert home builders to a number of potential hazards and what measures can be taken to eliminate any problems
b) Potential problems
   1) Abandoned wells, especially on old farmstead sites
      (a) Many old rock wells have been abandoned or even used to dispose of hazardous liquids.
      (b) Even modern wells have been abandoned for rural water connections.
      (c) A thorough environmental audit can help identify any abandoned wells through a study of county records of the property and a physical evaluation of the site.
   2) Identification of underground storage tanks, old landfills, or dump sites
      (a) Underground tanks may have held substances like gasoline or diesel fuel.
      (b) Landfills or dump sites could contain chemicals that are harmful to humans if they get into the drinking water.

G. ***Other Activities***

Obtain information from the local zoning or planning commission concerning legal issues affecting building homes in the local area. Allow students to evaluate the regulations and determine why they exist.

H. ***Conclusion***

When selecting a site for building a home, a number of issues should be considered prior to selecting the final site. These factors include topography, wind, services and utilities, regulatory agencies, neighbors, having the home and business on the same site, and environmental issues. By carefully considering these factors, prospective builders can select the ideal site that will eliminate or minimize problems later.

I. ***Answers to Activity Sheets***

J. ***Answers to Evaluation***

1. a
2. d
3. a
4. b

5. Answers may include any two of the following: future sale of the home; excessive noise, dust, or pollution; potential safety problems for residents, especially children, odors, fumes, dust, etc.

6. Underground tanks, abandoned wells, landfills or dump sites
7. To allow for more family interaction and promote a greater sense of security
8. Because the distance will affect the cost of bringing them to the home

9. Answers may include any two of the following: hillside construction, water runoff, amount of wind, possibility of expansion, and building perspective.

UNIT II - HOME AND FARMSTEAD PLANNING Name_

Lesson 1: Home Site Selection Date___________________________

EVALUATION

Select the letter that corresponds to the best answer.

1. Which part of the house is usually considered when designing for wind?

   a. Doors
   b. Windows
   c. Chimneys
   d. Eaves

2. Many counties have limitations on how close __________________ should be located to rivers or ponds.

   a. Electricity
   b. Telephone wires
   c. Gas lines
   d. Septic fields

3. An example of an agency that might be contacted prior to selecting a site is the:

   a. Zoning commission.
   b. County clerk.
   c. Treasurer.
   d. Weed control bureau.

4. What is one effect of subsurface water on a construction site?

   a. Affects the size of the foundation
   b. Makes sealing the building difficult
   c. Limits the size of the home
   d. Makes additional dirt necessary

Complete the following short answer questions.

5. What are two factors that should be considered when building the home on the site of the business?

   a.

   b.

6. What are three potential problems an environmental audit may discover about the land under consideration for building a home?

   a.

   b.

   c.

7. Why might a builder choose to locate a home close to a neighbor who is also a relative?

8. Why should the distance to services and utilities be considered when selecting a site for a home?

9. What are two factors related to topography that will affect the selection of a site?

   a.

   b.

Lesson 1: Home Site Selection Name ______________________

Evaluating Home Sites

Objective: Evaluate home sites according to the criteria discussed in this lesson.

For this activity, select a home site found in the country, using either your own home or the home of a friend or family member. Evaluate the home site according to the criteria discussed in the lesson, noting what impact, if any, each of these factors had on the selection of the site.

Location of home site: ____

Factors	Description of the Site
Topography	
Wind	
Services and utilities	
Neighbors	
Home on business site	

Environmental issues

In your opinion, why was the home constructed on that particular site?

UNIT II - HOME AND FARMSTEAD PLANNING

Lesson 2: Arranging a Farmstead

Competency/Objective: Arrange a farmstead.

Study Questions

1. How does the direction of the layout affect farmstead planning?
2. How does topography affect farmstead planning?
3. How does wind affect farmstead planning?
4. How does the potential of the natural resources base in comparison to environmental impact affect the farmstead plan?
5. What is the effect of the type and size of business on farmstead planning?
6. How do services and utilities affect farmstead planning?
7. How do neighborhoods affect farmstead planning?
8. What is the impact of regulatory agencies on farmstead planning?

References

1. *Agriculture Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit II.
2. Activity Sheet

   a) AS 2.1: Farmstead Planning
   b) AS 2.2: Planning a Farmstead

Agricultural Structures, II-14

Lesson 2: Arranging a Farmstead

TEACHING PROCEDURES

B. ***Review***

Lesson 1 addressed factors to consider when selecting a site for a home. Preparing a farmstead plan also takes care and forethought. The variety and complexities of modern farms make a good farmstead plan a requirement for successful operation. This lesson outlines many factors that must be considered to devise a good plan. Forming a good farmstead plan also requires research and expert help. Local University Extension offices are an excellent resource for information and referrals.

C. ***Motivation***

Discuss some key factors that affect the farmstead plan. Factors for possible discussion are service area, wind, water quality and quantity, surface and watershed drainage, current and future production volume requirements, and codes and regulations.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Question the class about factors affecting the direction of farm layout and list them on the board.

   How does the direction of the layout affect farmstead planning?

   a) Farmstead planning often involves orienting activities in relation to one another and the farm's effect on surrounding areas.
      1) Structures associated with related activities, such as feed storage facilities and feed lots, should be located near one another.
      2) Noise, dust, pollution potential, and insects associated with agricultural activities must be anticipated and directed away from residential areas.
   b) Orientation of structures according to the four directions is usually done to minimize the effects or take advantage of natural elements such as sun or a prevailing wind.
   c) Orientation of individual buildings is a function of the type of building, type of enterprise, and desired outcome of the structure's use.

2. A plastic display of an area of land (perhaps borrowed from a geography instructor) is a very good visual tool to use when teaching this topic. Taking the class outside and showing them local topographical features around the school also provides a good introduction to this topic. Ask students to describe features of the topography that may affect farmstead planning.

   How does topography affect farmstead planning?

   a) Drainage and pollution are of particular concern when considering topography.
      1) Drainage
         (a) Drainage of water from rain, snow, ice melt, or farm operations should be away from structures, with a slope of 3 to 5 percent.
         (b) This slope will allow for drainage without promoting erosion.

(c) Water can also damage structures if allowed to drain into them, which is why a slope away from structures is advisable.

2) Pollution

(a) Understanding a given area's topography will provide an understanding of the direction and routes of drainage.

(b) Structures such as dams, holding ponds, or routing channels are sometimes effective in controlling the effects of pollution in a given area.

b) Topography is also a significant factor in regard to accessibility for machinery, water retention, and soil components.

3. Show students pictures of the "dust bowl" of the 1930s. (Pictures may be available in history books in the school library or on the Internet). Ask them to define wind erosion. Discuss how wind affects farmstead planning.

How does wind affect farmstead planning?

a) A key to success in dealing with wind erosion is wind breaks, which are rows of trees strategically planted and spaced to interrupt a prevailing wind.

b) Wind must also be considered when planning for enterprises that involve odors or airborne contaminants.

1) Prevailing winds can be an advantage if they blow away from an area where windborne contaminants may cause problems.

2) If a prevailing wind is carrying contaminants into an inappropriate area, the most effective solution is to locate the source of the odors or contaminants at a distance from other activities.

c) Heating and cooling requirements are affected by wind.

1) Prevailing winter winds from the north are of considerable concern when evaluating heat requirements.

2) Orienting farm structures to take advantage of wind for ventilation can help in meeting cooling requirements as well as in enhancing livestock health.

4. Natural resources are often necessary for the success of a farmstead. Ask students to list some natural resources. After several have been named, ask students to list some effects farming can have on the resources listed.

How does the potential of the natural resources base in comparison to environmental impact affect the farmstead plan?

a) Natural resources are material sources of wealth that occur in a natural state, such as timber, water, or mineral deposits.

b) They must be used in compliance with the codes and regulations governing their use that are designed to protect the environment and its inhabitants.

c) This focus on regulations greatly affects farmstead planning.

1) Any fuel, waste products, or chemicals used in amounts considered to be at a commercial level will be regulated.

2) Of particular concern is any contaminant that can enter and be spread in the watershed, contaminating valuable natural resources.

5. Discuss different types of agricultural enterprises and how the size of the operations affects the farmstead plan. List key points on the chalkboard.

What is the effect of type and size of business on farmstead planning?

a) Farm acreage needs

1) Different enterprises require acreage suitable for their needs.

2) Careful consideration of future needs must take place during the first stages of planning if possible.

b) Number and type of structures

1) The number and type of structures on a farmstead also must be adapted to the specific operation's needs.

2) When planning a farmstead, an individual must do research to find information concerning the type of structures needed for a particular operation.

(a) Trade associations dealing with a particular type of enterprise

(b) University Extension Services

(c) Contract producers in the swine or poultry industries who work closely with the processors with whom they contract to develop plans for farmsteads and structures designed for efficient operation

c) Number and type of regulations

1) Research is required to determine what regulations might affect each aspect of the farmstead being planned.

(a) County planning and zoning office

(b) County Extension offices

2) As a rule, larger operations require more and larger structures and produce more waste. They are therefore subject to more regulations.

d) Financing options

1) Structures are expensive to construct and maintain, so careful planning is required when determining structural needs.

2) Obtaining professional advice concerning farm financing is recommended; in areas where agricultural enterprises are common, professional accountants experienced in financing should be available.

e) Sources and amount of water

1) Water needs should be anticipated and evaluated in the planning stage.

2) The types of water sources and amounts they can deliver must be considered as well.

3) Planning for structures should take into account convenient access to water supplies and drainage of wastes away from water sources.

4) Laws and regulations may affect the options for water for the operation.

f) Waste management

1) Waste management must be planned according to the codes and regulations governing the enterprise.

2) Waste management structures such as holding tanks or lagoons are critical for the environment and must be planned carefully.

6. Utilities and services take many forms. Discuss some of the more common ones with the class and list them on the chalkboard. Ask the students some of the ways utilities and services affect the farmstead.

How do services and utilities affect the farmstead plan?

a) Utilities of an acceptable level and dependability must be available at a cost that will allow profitable operation.

b) Services that affect the particular enterprise in question must be available and consistent enough to allow profitable operation.

1) Electricity

2) Passable roads

3) Fire protection

4) Ambulance services

5) Telephone services

c) Utilities and services must be considered when arranging the layout of structures.

1) Overhead electrical lines should be located away from trees if possible, since falling limbs may break lines.

2) Underground lines tend to be more dependable.

3) If water is supplied by a municipal source, structures must have suitable hookup access.

7. Discuss with students how a farming operation can affect neighbors or how a neighboring operation could affect the farmstead. After introducing this topic, ask students if they know of any situations where an operation affected a neighbor either positively or negatively.

How do neighbors affect farmstead planning?

a) Laws and regulations, particularly zoning laws, will dictate much of what is acceptable when planning in regard to the neighborhood surrounding the farmstead.

b) The potential for zoning changes and urban encroachment in the future should be taken into account.

c) Some concerns need to be considered, such as pollution and runoff that may affect neighbors, especially when planning structures that involve or alter watershed activity.

d) Fences that separate properties and are used by both parties are worthy of consideration when forming a farmstead plan.

8. Discuss the purposes and functions of the regulatory agencies discussed below. The main focus of the EPA and DNR--protecting the environment--should be emphasized. Have students complete AS 2.1 and AS 2.2.

What is the impact of regulatory agencies on farmstead planning?

a) Regulatory agencies designed to protect the environment, its inhabitants, and natural resources have a direct effect on most farm enterprises.

b) Compliance with regulations for such things as pollution control can be costly and involve considerable labor.

c) Regulations may limit the size an enterprise can operate at successfully.

d) Regulations also work to ensure that the environment is safe for everyone.

e) Two major regulatory agencies provide guidelines and answers to questions for farmstead planning.

   1) Environmental Protection Agency

   2) Department of Natural Resources

G. ***Other Activities***

Have students research a particular code or regulation that affects farmstead planning in their area. What is the regulation designed to protect? How does it affect farmstead planning?

H. ***Conclusion***

Developing a good farm plan is a large undertaking that requires a lot of thought and research into the particulars of the enterprise. Because of the variety and diversity of enterprises, every plan will be different. The information presented in this lesson outlines questions to be asked during the planning process so that the farmstead can operate successfully.

I. ***Answers to Activity Sheets***

J. ***Answers to Evaluation***

1. c
2. c
3. d
4. a
5. Department of Natural Resources and the Environmental Protection Agency
6. Wind breaks

7. Answers may include any two of the following: electricity, passable roads, fire protection, ambulance services, and communications services.

8. Answers may include any of the following: laws and regulations, particularly zoning laws, that dictate much of what is acceptable in regard to the neighborhood; the potential for zoning changes and urban encroachment; pollution and runoff that may affect neighbors; or fences that separate properties and are used by both parties.

UNIT II - HOME AND FARMSTEAD PLANNING Name _

Lesson 2: Arranging a Farmstead Date ______________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following are of particular concern when considering topography?

   a. Wind, natural resources
   b. Wind, drainage
   c. Drainage, pollution
   d. Natural resources, water retention

2. Structures associated with related activities should be located:

   a. Close to roads.
   b. Next to sources of water.
   c. Close to each other.
   d. Next to power lines.

3. When considering environmental impact on natural resources, what is of particular concern?

   a. Wind erosion
   b. Altering topographical features
   c. Airborne contaminants
   d. Contaminants in the watershed

4. When planning a farmstead, which of the following is <u>not</u> affected by the size and type of business?

   a. Prevailing winds
   b. Financing option
   c. Waste management
   d. Acreage needs

Complete the following short answer questions.

5. What are two major regulatory agencies that may affect a farmstead?

   a.

   b.

6. What is one way to deal with wind erosion?

7. What are two types of services that are important to consider during farmstead planning?

   a.

   b.

8. What is one thing to consider when planning a farmstead that takes neighbors into account?

Lesson 2: Arranging a Farmstead Name ____________________

Farmstead Planning

Objective: Understand a farmstead plan.

For each question, list two factors that would affect a farmstead plan for a beef cattle operation and a short explanation describing the effect of each of them.

1. How does the direction of the layout affect the farmstead planning?

2. How does topography affect the farmstead planning?

3. How does wind affect farmstead planning?

4. How does the potential of the natural resources base in comparison to environmental impact affect the farmstead plan?

5. What is the effect of the type and size of business on farmstead planning?

6. How do services and utilities affect farmstead planning?

7. How do neighborhoods affect farmstead planning?

8. What is the impact of regulatory agencies on farmstead planning?

Lesson 2: Arranging a Farmstead Name _

Planning a Farmstead

Objective: Prepare a farmstead plan.

Even the simplest of farmstead plans can be very complex. The goal of this activity is to understand the questions to be asked and how they may be answered, particularly by locating and identifying regulatory agencies that affect decisions.

Develop a farmstead plan of your ideal farm, using the study questions as a guide. Sketch the layout of your ideal farmstead, and then briefly explain how your farmstead addresses the discussion questions in paragraph form on an attached paper. Be sure to include how you designed your farmstead in relation to topography, wind, natural resources, type and size of business, service and utilities, the home, neighbors, and how government agencies would possibly view your plan. Be creative!!!

UNIT II - HOME AND FARMSTEAD PLANNING

Lesson 3: Livestock Manure Management Systems

Competency/Objective: Describe characteristics of disposal systems for managing livestock manure.

Study Questions

1. What are the principles of a manure management system?

2. What regulatory agencies are involved in manure management?

3. Where can help be obtained for planning a manure management system?

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit II.

2. Activity Sheet

   a) AS 3.1: Resources for Manure Management

Lesson 3: Livestock Manure Management Systems

TEACHING PROCEDURES

B. ***Review***

Lesson 1 of this unit discussed various aspects of farmstead planning. This lesson addresses the need for livestock manure management. Handling manure effectively is vital to prevent surface and ground water pollution.

C. ***Motivation***

Discuss the importance of manure management with the class. Explain that manure accumulates very quickly in confined areas such as feed lots and poultry houses. Point out that livestock manure contains nitrogen and phosphorous that, in large amounts, can seriously damage the environment. Manure, if not properly managed, can easily contaminate water supplies through runoff or leaching through the soil into the groundwater.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Discuss the principles of manure management systems with students.

What are the principles of a manure management system?

a) The main goal of manure management systems is to prevent surface and ground water pollution.
b) A manure management system generally consists of some form of manure storage and handling.
    1) For livestock operations in which the animals are kept on a well-maintained pasture, manure storage and handling is generally not an issue, because the manure is spread throughout the pasture.
    2) When animals are kept on lots or in some sort of confinement system, the manure that they produce must be handled efficiently.
        (a) To avoid pollution
        (b) To maintain sanitation
        (c) To make use of the nutrients in the manure for fertilizer
    3) Producers have a number of options for managing manure.
        (a) Depend on the conditions of the livestock operation
        (b) Common storage options
            (1) Pits underneath buildings with slotted floors
            (2) Storage tanks
            (3) Lagoons
        (c) Common methods for applying the manure
            (1) Pumping it through irrigation systems
            (2) Applying it using some type of mechanical spreader
    4) The exact type of manure disposal system needed will be dictated by many factors.
        (a) Size and type of enterprise
        (b) Location
        (c) Costs
        (d) Local zoning regulations

(e) Volume
(f) Odor considerations
(g) Proximity of neighbors
(h) Use of manure as fertilizer for crops

2. Ask students to name regulatory agencies involved in manure management. Discuss their activities.

What regulatory agencies are involved in manure management?

a) Department of Natural Resources (DNR)
   1) Monitors natural settings
      (a) Soil and water quality
      (b) Effect of pollution
   2) Enforces regulations
   3) Provides information about designing livestock manure systems
b) Environmental Protection Agency (EPA)
   1) Responsible for the enforcement of federal environmental policies and laws
   2) Provides information on the laws and rules governing the use of manure

3. A general discussion of the complexities of manure management is needed here to bring to light the fact that one design will not meet the needs of every operation. As a rule, individual systems must be designed to address specific conditions and needs of a given enterprise. Ask students where they would obtain help if they were trying to choose a manure management system for an operation. Discuss the various sources. Have students complete AS 3.1.

Where can help be obtained for planning a manure management system?

a) University Extension offices
b) Natural Resource Conservation Service (NRCS) offices
c) Associations for a particular species of livestock
   1) National Pork Producers Council
   2) National Cattlemen's Beef Association
d) Private agricultural engineering firms
e) For producers with contracts with large corporations, engineers who assist with design that are hired by the corporation

G. ***Other Activities***

Have the students do research and bring to class some recent news articles concerning livestock manure. Discuss the articles with the class.

H. ***Conclusion***

Livestock manure has the potential to be harmful to people and the environment, so proper management is critical to livestock enterprises. Manure management is an enterprise-specific process, and no one system is appropriate for every operation. Help and guidance is readily available from government agencies, livestock associations, and other sources. These resources should be utilized fully.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. b
2. a

3. Answers may include any two of the following: the local University Extension office, the NRCS office, the National Cattlemen's Beef Association, or a private agricultural engineering firm.

4. Answers may include any three of the following: size and type of enterprise, location, costs, local zoning regulations, volume, odor considerations, proximity of neighbors, and use of manure as fertilizer for crops.

5. Department of Natural Resources and Environmental Protection Agency

6. A manure management system generally consists of some form of manure storage and handling.

UNIT II - HOME AND FARMSTEAD PLANNING Name _

Lesson 3: Livestock Manure Management Systems Date __

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following is a resource for information concerning livestock manure management?

   a. American Society of Engineers
   b. University Extension services
   c. Department of Animal Health
   d. U.S. Society of Veterinary Practitioners

2. The greatest threat to the environment from manure is:

   a. Surface and ground water pollution.
   b. Air pollution.
   c. Chlorate toxicity.
   d. Insect population explosions.

Complete the following short answer questions.

3. What are two sources of information that would be helpful in the planning of a manure management system for an independent beef cattle operation consisting of feed lots supporting 500 head of cattle?

   a.

   b.

4. What are three factors that will affect the type of manure management system chosen?

   a.

   b.

   c.

5. What are two government agencies that are involved in regulating manure management?

   a.

   b.

6. What does a manure management system generally consist of?

Lesson 3: Livestock Manure Management Systems Name _

Resources for Manure Management

Objective: Develop research skills and locate sources of information concerning manure management.

Find addresses, telephone numbers, and web sites (if possible) for one of the following sources of information about manure management. These groups help define the regulations affecting manure management and the acceptable types of management systems.

- Department of Natural Resources ***or*** Environmental Protection Agency (national and state level)
- Natural Resource Conservation Service (NRCS)
- University Extension (state and local level)
- Professional associations, such as the Cattlemen's Association (national and state level)

Conduct research into one of these agencies or associations (obtaining materials from them if possible). Prepare a report discussing their duties and the type of information available from the source of information you have chosen.

UNIT III - BUILDING CONSTRUCTION

Lesson 1: Construction Safety

Competency/Objective: Describe safety practices associated with building construction.

Study Questions

1. What are safety factors to consider when working with heights?

2. What are safety factors to consider when working with construction equipment and tools?

3. What are safety factors to consider when working with structural elements?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit III.

2. Activity Sheet

   a) AS 1.1: Safety on the Construction Site

UNIT III - BUILDING CONSTRUCTION

Lesson 1: Construction Safety

TEACHING PROCEDURES

B. ***Introduction***

Accidents occur in the construction and agriculture industries all the time. In combining the activities of the two industries, a very dangerous array of work conditions exists. Taking precautions is necessary when participating in any construction project around the farm. While every possible hazard involved in agricultural construction cannot be addressed in a single lesson, this lesson outlines some specific recommendations for safety in constructing agricultural structures.

C. ***Motivation***

Discuss the Bureau of Labor statistics for 1997 given below. They indicate just how dangerous both the construction and agriculture industries can be. (Only the industry division for transportation and public utilities and the division for mining have a similarly high number of fatalities relative to the numbers for total employment.)

Percentage of total workforce involved in each industry division

Services	28%
Retail trade	17%
Manufacturing	16%
Government	15%
Construction	6%
Agriculture, forestry, and fishing	3%

Percentage of total fatalities for all workplace incidents

Services	12%
Retail trade	11%
Manufacturing	12%
Government	10%
Construction	18%
Agriculture, forestry, and fishing	13%

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students if they have ever worked on a roof or on top of a tall ladder. Did they take any measures to keep injuries and accidents from occurring? Discuss safety measures that could be taken to prevent injuries.

   What are safety factors to consider when working with heights?

   a) Equipment must be well maintained and in good working order.

b) The base of a ladder or the legs of a scaffold must be evenly set on a solid, non-slippery surface.
c) Any applicable safety equipment, such as safety belts and boots with non-skid soles, should be used.
d) Use extra caution when carrying roofing materials and carry small, manageable loads.
e) Move slowly and carefully because roofs can be slick.
f) Do not attempt to work at heights if experiencing any dizziness or disorientation.

2. Have students look at an assortment of simple tools (hammers, screwdrivers, saws, drills, etc.) that might be used in construction. Ask them to imagine the kinds of injuries that could occur when using these tools. Do they know anyone who has been seriously injured when building something? Discuss safety factors to consider to prevent similar accidents.

What are safety factors to consider when working with construction equipment and tools?

a) Keep tools well maintained and in proper working order.
b) Use tools and equipment for their intended purpose.
c) Follow the manufacturer's instructions for the use of equipment and tools and take heed of any safety recommendations.
d) Fatigue can lead to carelessness; take breaks as needed.

3. Ask students to list the different types of materials that may be used when constructing a building. What sorts of injuries might occur when working with these materials? Discuss the different factors that may prevent these injuries. Have students complete AS 1.1.

What are safety factors to consider when working with structural elements?

a) Care should be taken when loading and unloading; avoid standing where materials (or the equipment handling them) could be a hazard in the event of a mishap.

b) Care and good technique are necessary when lifting construction materials.

   1) They should be moved in some other way if possible, such as pushing, rolling, or sliding.

   2) If construction materials must be lifted, the best way to do so is to bend at the knees, keeping the back straight, and lift the object by straightening the legs; reverse the process when setting materials down.

   3) To turn, the feet should be moved to a new position; twisting at the waist should be avoided to prevent back injuries.

c) Some materials, such as concrete, may be caustic and should be handled wearing protective clothing and boots.

d) Electrical hook-ups should only be assembled by someone who is very knowledgeable and qualified to establish such service; sufficient grounding and circuit breaking devices must be in place.

e) Materials and waste materials should be kept organized and out of the way while working to prevent tripping.

G. ***Other Activities***

Have the students (possibly working in small groups) search news articles for examples of construction accidents and bring them to class. Discuss how these accidents might have been avoided.

H. ***Conclusion***

The safety tips about working with heights, tools and equipment, and structural elements that are given in this lesson address only a few of the areas of concern. Every worker needs to pay attention and use good judgement. Staying alert can help avoid injury when working on agricultural structures.

I. ***Answers to Activity Sheet***

Suggested answers are given below.

1. Tools should be well-maintained; manufacturer's instructions and safety recommendations should be followed; tools should be used for their intended purpose; use protective clothing such as gloves, long pants, ear protection, and safety glasses.

2. Set the base of the ladder securely; carry small, manageable loads; use good lifting technique; move slowly on the roof; wear boots with non-skid soles when working on the roof.

3. Take care when unloading materials and avoid standing in their path in case of an accident; lift materials safely; wear protective clothing such as gloves and work boots.

4. Keep waste materials out of the way; lift materials safely; wear protective clothing such as gloves and a hard hat.

J. ***Answers to Evaluation***

1. d
2. c
3. b

4. Answers may include any two of the following.
   - Keep tools well maintained and in proper working order.
   - Use tools and equipment for their intended purpose.
   - Follow the manufacturer's instructions for the use of equipment and tools and take heed of any safety recommendations.
   - Fatigue can lead to carelessness; take breaks as needed.

5. If you are experiencing dizziness or disorientation
6. To prevent tripping

UNIT III - BUILDING CONSTRUCTION Name _

Lesson 1: Construction Safety Date ______________________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. When lifting objects:

   a. Bend at the waist.
   b. Lift using only the arms.
   c. Lift with the back bent.
   d. Bend at the knees.

2. Which of the following is a safety factor to consider when working with heights?

   a. Carry large loads of materials to prevent making too many trips.
   b. Move quickly to avoid spending too much time moving around.
   c. Set the base of a ladder evenly on a solid, non-slippery surface.
   d. Wear tennis shoes to keep from slipping on the roof.

3. To turn when lifting materials:

   a. Twist at the waist.
   b. Reposition the feet.
   c. Turn at the knees.
   d. Reposition the arms.

Complete the following short answer questions.

4. What are two safety factors to consider when working with tools?

   a.

   b.

5. When should you not attempt to work on a height?

6. Why should materials and waste materials be kept organized and out of the way while working?

Lesson 1: Construction Safety Name ______________________

Safety on the Construction Site

Objective: Identify safety measures that should be taken in various construction situations.

Some common construction situations are described below. List three or four safety rules that would apply to each situation, including any protective clothing that would need to be worn.

1. You are beginning to construct wooden walls, using hammers, air nailers, saws, and other woodworking equipment.

2. You are roofing a new two-story house. Additional materials are on the ground and need to be moved onto the roof before you can continue roofing.

3. At the building site you are working on, they have just finished taking the forms off the concrete for the basement. You are ready to begin the flooring. The materials you need have just arrived on a truck from the lumber yard.

4. You are cleaning up the work site while other workers construct the roof. They throw the waste materials from the top of the building to the ground.

UNIT III - BUILDING CONSTRUCTION

Lesson 2: Building Designs

Competency/Objective: Identify types and designs of buildings and their methods of construction.

Study Questions

1. What are different designs and uses of agricultural structures?

2. What are advantages and disadvantages of different types of structures?

3. What factors should be considered when designing and constructing agricultural structures?

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit III.

2. Activity Sheet

   a) AS 2.1: Identifying Building Designs

Lesson 2: Building Designs

TEACHING PROCEDURES

B. ***Review***

Lesson 1 discussed safety factors to consider when constructing agricultural structures. The designs of these structures are as varied as the enterprises for which they may be used. A few types of designs and building materials are more commonly used than others. This lesson describes some of the different designs used in agriculture.

C. ***Motivation***

Discuss the diversity of agricultural structures in your area. They will most likely include pole barns, storage buildings, animal housing facilities, grain processing/storage structures, machinery sheds, workshops, etc.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students to describe the shapes and roof types of agricultural structures with which they are familiar and list them on the board for discussion. Discuss the different types of materials used in construction.

   What are different designs and uses of agricultural structures?

   a) Basic shapes of structures
      1) Square
      2) Rectangle
      3) Circle
      4) Oval
      5) Some combination of these shapes
   b) Seven roof styles
      1) Gable
      2) Hip
      3) Mansard
      4) Gambrel
      5) Shed
      6) Quonset
      7) Gothic/arched
   c) Methods of construction
      1) Wood frame - Weight-bearing upright wooden members are used for the walls of the building.
      2) Pole - Large wooden timbers are placed in the ground and serve as the weight-bearing skeleton of the building.
      3) Metal - Metal is used as a primary component of the building, which is constructed by welding and bolting the materials together.
      4) Masonry - Concrete or masonry blocks are the primary building material; buildings are constructed by pouring concrete in forms or laying blocks.

2. Ask students to list some advantages and disadvantages associated with each type of structure. Emphasize that each situation may be different, so advantages and disadvantages must be carefully evaluated in regard to the use of a specific structure. Have students complete AS 2.1.

What are advantages and disadvantages of different types of structures?

a) Wood frame
   1) Advantages
      (a) More economical than the other types of structures
      (b) Easy to partition or expand
   2) Disadvantages
      (a) Higher maintenance requirements
      (b) May not be durable under conditions of abusive use
      (c) Inherent fire hazard
b) Pole
   1) Advantages
      (a) Rapid and economical construction
      (b) Long life span
      (c) Partitioning or expansion usually easily accomplished
   2) Disadvantages
      (a) Inferior weather protection
      (b) Cannot be heated or cooled without modifications being made to the structure
c) Metal
   1) Advantages
      (a) Serviceable for a long time
      (b) Fire resistant
   2) Disadvantages
      (a) Expensive
      (b) Special equipment and considerable skill required for construction
      (c) Can be short-lived around manure
d) Masonry
   1) Advantages
      (a) Easily cleaned and disinfected
      (b) Fire resistant
      (c) Very long life span
      (d) Minimal maintenance requirements
   2) Disadvantages
      (a) Expensive
      (b) Extensive excavation required, depending on the topography
      (c) Requires a lot of labor to tear down masonry for expansion

3. Discuss the various factors that should be considered when designing and constructing a structure for use in an agricultural enterprise. Hand out AS 2.1.

What factors should be considered when designing and constructing agricultural structures?

a) Identify the intended uses of the structure.
b) Consider whether the cost of construction is reasonable enough to allow successful operation or use.
c) Determine whether the proposed structure is appropriate for local environmental conditions.
d) Consult codes and regulations for construction.
e) Consider whether materials are used efficiently.

G. ***Other Activities***

Have the students work in groups and build small models (birdhouse size) of some of the building styles mentioned in this lesson, such as a shed with a hip or gable roof. Small wood stock or even cardboard and glue would be suitable for materials.

H. ***Conclusion***

Selecting an appropriate design is very important when constructing an agricultural structure. Material selection, construction methods, costs, and codes all must be considered to produce a building with the desired advantages. Resources are readily available to assist in planning and producing a building that will serve its intended purpose.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. d
2. b
3. c

4. Poured concrete in forms or concrete blocks

5. Answers may include any three of the following.

   - Identify the intended uses of the structure.
   - Consider whether the cost of construction is reasonable enough to allow successful operation or use.
   - Determine whether the proposed structure is appropriate for local environmental conditions.
   - Consult codes and regulations for construction.
   - Consider whether materials are used efficiently.

6. Answers may include any two of the following: rectangle, square, circle, or oval.

7. In pole construction, large timbers are placed in the ground and serve as the weight-bearing skeleton of the building.

UNIT III - BUILDING CONSTRUCTION Name _

Lesson 2: Building Designs Date ______________________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following is a disadvantage of wood frame construction?

   a. Inferior weather protection
   b. Difficult to partition or expand if necessary
   c. Extensive excavation required for building
   d. Requires more maintenance

2. One of the advantages of metal designs is that structures are:

   a. Very easy to build.
   b. More fire resistant than others.
   c. Easily cleaned and disinfected.
   d. Very inexpensive to build.

3. An advantage of masonry construction is that:

   a. Structures can be rapidly constructed.
   b. Partitioning is usually easily accomplished.
   c. They have a very long life span.
   d. They do not have to be heated.

Complete the following short answer questions.

4. What are the materials used for masonry construction?

5. What are three factors that should be considered when choosing a design for an agricultural structure?

   a.

   b.

   c.

6. What are two basic shapes used in building designs?

   a.

   b.

7. What is pole construction?

Lesson 2: Building Designs Name ____________________

Identifying Building Designs

Objective: Identify different types of building designs.

Answer the questions below.

1. What types of enterprises are common in your area?

2. Choose one of the enterprises you listed above. What structures are used for that type of enterprise?

On a separate sheet of paper, paste pictures of each of the different structures listed above. Include at least ten pictures. They may be photographs you have taken yourself or pictures clipped from a magazine or some other source. Next to the picture, describe the design of the structure in terms of the shape, roof style, and type of materials used.

UNIT III - BUILDING CONSTRUCTION

Lesson 3: Building Materials

Competency/Objective: Identify and select building materials.

Study Questions

1. What are the different types of building materials?

2. What are the types and grades of dimension lumber?

3. What are the types and grades of sheathing materials?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999.

2. Transparency Master

   a) TM 3.1: Typical APA Plywood Grade-Trademark

3. Activity Sheet

   a) AS 3.1: Construction Materials

Lesson 3: Building Materials

TEACHING PROCEDURES

B. ***Review***

Lesson 2 discussed different types of building designs. Lesson 4 describes the types of building materials that may be used to build these designs, with an emphasis on wood products. This lesson discusses the types of materials available and how to determine the quality of the material by its grade.

C. ***Motivation***

Pass around a few samples of scrap dimensional lumber and small pieces of sheathing. Samples can be acquired from local lumber yards or possibly construction sites. Try to get a variety of common sizes in short lengths of a foot or so. Also, obtain a few small examples of plywood in different thickness and of nonveneered samples, such as particle board and oriented strand board. As these materials are being passed around, tell the class the focus of this lesson will be on identifying and understanding the grades of these types of materials.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Discuss the types of building materials available.

   What are the different types of building materials?

   a) Wood products, including boards and plywood
   b) Metals, such as steel and aluminum
   c) Concrete products
   d) Clay bricks and tiles
   e) Vinyl, plastics, glass, and fiberglass

2. Discuss the different types and grades of dimension lumber. Have the samples used for the motivation available to provide examples during the discussion.

   What are the types and grades of dimension lumber?

   a) Dimension lumber - Wooden building material sawn in lengths, usually starting at eight feet and increasing in increments of two feet, and uniform in thickness and width
   b) Types of dimension lumber
      1) Softwood is lumber from evergreen trees.
      2) Hardwood is from deciduous trees.
      3) Treated lumber is chemically treated for preservation.
      4) Green lumber is lumber with a high moisture content.
      5) Kiln-dried lumber is dried in a kiln, a sort of oven in which the lumber is heated to reduce moisture to a desired point.
   c) Grades of lumber

1) The American Lumber Standards Committee sets certain standards for grading lumber that are generally applied, and often expanded or detailed, by regional associations such as the Western Wood Products Association or Southern Forest Products Association.

2) Lumber is generally graded 1, 2, or 3 (1 being the highest number grade), possibly with an additional premium or select grade.

3) Grading is accomplished by evaluating the number and severity of defects.

   (a) Knots
   (b) Splits and checks
   (c) Shakes
   (d) Pitch pockets
   (e) Honeycombing
   (f) Wane
   (g) Blue stain
   (h) Decay
   (i) Holes
   (j) Warp

4) The designation "economy" generally is equivalent to grade three.

5) Some areas may have further designations involving letters or terms such as (S) or Select, (B) or Better, (C) or Common, Choice, or Supreme; these letters may or may not correspond to a number system.

6) Treated lumber usually does not have a number or letter grade; it is simply referred to as "treated."

3. Discuss common types and grades of sheathing materials available for construction uses. TM 3.1 will be of assistance in discussing the information stamped on sheathing material. Have students complete AS 3.1.

What are the types and grades of sheathing material?

a) Sheathing materials - generally wood or wood product panels that most commonly are four feet by eight feet in size, with a thickness of ¼ to 1 7/16 inches

b) Types of sheathing materials

   1) Plywood - made of thin sheets of wood laminated to a desired thickness.
   2) Composite plywood - has a veneer cover laminated to some form of wood core.
   3) Nonveneered panels, consisting of oriented strand board (OSB), particle board, and wafer board - made from wood flakes, chips, or fibers that are combined with suitable resins and glues and shaped into panels

c) Grades of sheathing materials

   1) Softwood plywood grades - assigned by associations such as the APA to sheathing materials manufactured to meet their specifications.

      (a) Generally, a rating of 1 indicates that the plywood is for exterior use, while a rating of 2 is for interior use.
      (b) Plywood with a rating of "Exposure 1" can withstand moisture but should be used indoors, while "Exposure 2" indicates plywood that should only be used indoors.
      (c) Letter system - used to rate the quality of the veneer used on the face and back
      (d) Plywood grade stamp from the APA

         (1) Span rating - Two numbers separated by a slash; the first number is the maximum span in inches that should be used for roof decking, while the second number is the recommended span for floor decking
         (2) Panel grade
         (3) Exposure durability
         (4) Thickness

   2) Hardwood Plywood Institute

      (a) Rating of 1 or 2 - good face and back with careful grain matching
      (b) Rating of 3 - structurally sound but has obvious defects and patching

   3) Softwood or hardwood plywood - may also be designated G1S, meaning "good one side," or G2S for "good two sides."

G. ***Other Activities***

1. Have the students add to your collection of sample materials.

2. Ask a knowledgeable representative from a local lumber retailer to come and speak to the class about the products and grades of lumber that the business carries.

H. ***Conclusion***

The selection of building materials should be made with a good understanding of what is available along with the advantages of different types of materials. Knowing the types and grades of materials will help control costs while allowing for the construction of a structure that will fulfill its intended purpose.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. b
2. c
3. c
4. b
5. a

6. Answers may include any two of the following: wood products, metals, concrete products, clay bricks and tiles, vinyl, plastics, glass, and fiberglass.

7. Softwood is lumber from evergreen trees, while hardwood is from deciduous trees.

8. Answers may include any three of the following: knots, splits and checks, shakes, pitch pockets, honeycombing, wane, blue stain, decay, holes, and warp.

9. A span rating consists of two numbers separated by a slash; the first number is the maximum span in inches that should be used for roof decking, while the other is the recommended span for floor decking.

UNIT III - BUILDING CONSTRUCTION Name _

Lesson 3: Building Materials Date ______________________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Kilns are for:

   a. Measuring lumber.
   b. Drying lumber.
   c. Surfacing lumber.
   d. Measuring moisture in lumber.

2. What is the regulatory agency that helps set lumber grading guidelines?

   a. American Lumber Agency.
   b. Wood Products Agency.
   c. Department of American Lumber Standards.
   d. Department of Natural Resources.

3. What is a veneer cover laminated to some form of wood core called?

   a. Plywood
   b. OSB
   c. Composite plywood
   d. Dimensional lumber

4. Lumber especially designed for outside use is:

   a. OSB.
   b. Treated lumber.
   c. Dimensional lumber.
   d. Kiln-dried lumber.

5. A material made from wood flakes, chips, or fibers that are combined with suitable resins and glues and shaped into panels is called:

   a. OSB.
   b. Composite plywood.
   c. Dimensional lumber.
   d. Kiln-dried lumber.

Complete the following short answer questions.

6. What are two common building materials?

   a.

   b.

7. What is the difference between hardwood and softwood?

8. What are three types of defects in a piece of lumber?

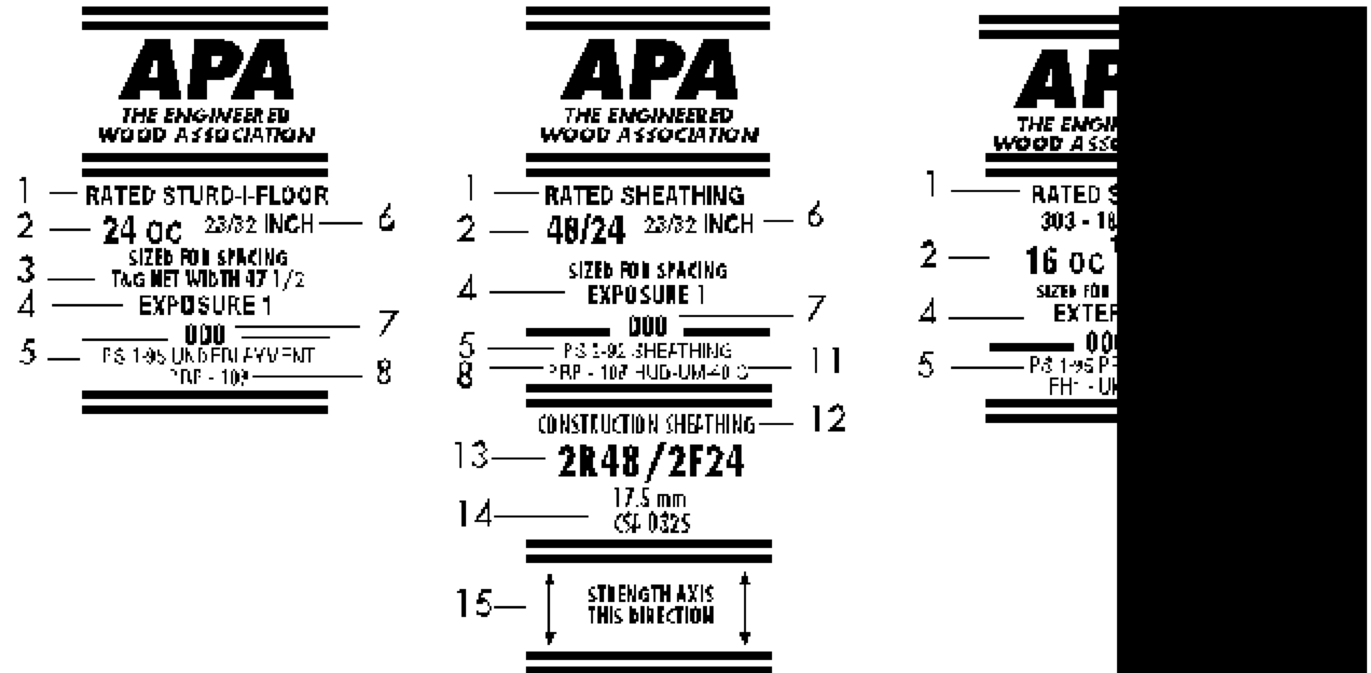
   a.

   b.

   c.

9. What does the span rating on a sheet of plywood indicate?

Typical APA Plywood Grade-Trademark



[redacted]

1 Panel grade
2 Span Rating
3 Tongue-and-groove
4 Exposure durability classification
5 Product Standard
6 Thickness
7 Mill number
8 APA's performance rated panel standard
9 Siding face grade
10 Species group number
11 HUD/FHA recognition
12 Panel grade, Canadian standard
13 Panel ma[redacted] end-use [redacted] Canadia[redacted]
14 Canadia[redacted] rated pa[redacted]
15 Panel fa[redacted] indicato[redacted]

Lesson 3: Building Materials Name ___________________________

Construction Materials

Objective: Compare and contrast different types of building materials.

Select one of the building materials listed below and research it to answer the following questions.

Wood products - dimension lumber
Metals - steel and aluminum
Concrete products
Clay bricks and tiles
Vinyl
Plastic
Fiberglass

1. What is this material commonly used for in building construction?

2. How is this material made or processed?

3. What safety factors should be remembered when working with this material?

4. How is this material sold, and how is it priced?

5. What are the advantages and disadvantages to using this material?

6. What finishes (paints, stains, etc.) can be used with this material?

7. What tools are needed to work with this material?

8. What fasteners can be used with this material?

UNIT III - BUILDING CONSTRUCTION

Lesson 4: Fasteners and Fastening Systems

Competency/Objective: Identify the uses of different fasteners and fastening systems.

Study Questions

1. What are the groups of fasteners and the uses of each group?
2. What are the factors to consider when selecting nails?
3. What are the types of screws and their uses in agricultural structures?
4. What are adhesives and their uses?
5. What are the types of construction anchors and their uses?
6. What are the types of framing anchors and their uses?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit III.
2. Transparency Masters
   a) TM 4.1: Nails
   b) TM 4.2: Nail Sizes
   c) TM 4.3: Screws
   d) TM 4.4: Sample Framing Anchors
3. Activity Sheet
   a) AS 4.1: Identifying Fasteners

Lesson 4: Fasteners and Fastening Systems

TEACHING PROCEDURES

B. ***Review***

The previous lesson, Lesson 3, described some of the materials used in construction. The following lesson explores the different fasteners and fastening systems as well as some of their uses. Nails, screws, adhesives, and construction anchors are all types of fasteners.

C. ***Motivation***

Show the class examples of different fasteners representing each of the groups discussed in this lesson.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students to list different kinds of fasteners. Discuss their uses.

   What are the groups of fasteners and the uses of each group?

   a) Nails - attach pieces of wood together
   b) Screws - attach pieces of wood as well as metals
   c) Adhesives - can bond many types of materials
   d) Construction anchors - devices used to attach walls to foundations
   e) Framing anchors - attach framing members together

2. Ask students to list some different types of nails. Use TM 4.1 to illustrate the different types. Discuss how different sizes of nails are designated. Discuss the factors to consider when choosing nails for use in construction. TM 4.2 shows different nail sizes.

   What are the factors to consider when selecting proper nails?

   a) Use
      1) Common nail - general purpose nails used anywhere a special purpose nail is not needed
      2) Box nail - have a thinner head and shank and are less likely to split wood and easier to cover with paint; often used in finish cabinet work
      3) Finish nail - useful for finishing because of their very small heads, which make them less noticeable; have less holding ability because of the small head
      4) Duplex-head nail - used when nails will have to be removed because the head extending above the surface makes their removal easier; commonly used for concrete forms
      5) Roofing nail - used for nailing shingles in place; have very wide, flat heads
      6) Ring-shank nail - used for applications where the nail will never be removed and the material needs to be held tightly; often used for stair treads
      7) Screw-shank nail - twisted shaft causes the nail to turn as it is driven in, making it difficult to remove; used where good holding ability is needed, such as on decks
      8) Staple - used mostly for wire, plastics, or vinyl
   b) Length

1) Designated by the term "penny" and the letter "d"
2) Should be long enough to pass entirely through one board and at least half the thickness of the board to which it will be attached

c) Exposure to weathering - Should choose nails made of materials such as zinc or aluminum that will resist corrosion or staining

3. Screws have better holding ability than nails. They are also used in combination with glues for even greater bonds. Discuss the different types of screws. Use TM 4.3 to illustrate as needed.

What are the types of screws and their uses in agricultural structures?

a) Head styles
1) Round head
2) Oval head
3) Flat head
4) Pan head

b) Slot types
1) Straight-slot
2) Phillips
3) Special slot styles (square, Allen, or star)

c) Wood screw - used to attach wood
d) Self-tapping metal screw - used with sheet metal or building siding
e) Drywall screw - used to secure drywall to walls and ceilings

4. Adhesives are used today in all phases of construction, and they are expected to play an even greater role in the future. Discuss the different adhesives and their uses. Emphasize that all manufacturer's recommendations should be followed carefully, because adhesives can be dangerous.

What are adhesives and their uses?

a) Wood glue - for joining woods
1) Polyvinyl (white wood glue) - for interior or furniture woodwork
2) Urea formaldehyde (plastic resin glue) - for repairing wood splits or reinforcing joints in a defective truss
3) Resorcinol resin - for wood where water exposure is likely

b) Epoxy - for extremely strong bonds; commonly used on fiberglass and plastics
c) Mastic - for materials with large surface areas, such as floor coverings; includes contact cements, which are used to attach laminates to counter tops or for vinyl floor coverings

5. Anchors include a wide range of devices, bolts, and cable systems. Discuss some of the different types of construction anchors that are used.

What are the types of construction anchors and their uses?

a) Generally used to attach walls to foundations; help protect the structure against damage from high winds by adding more strength and stability
b) Anchor bolt - large bolts set into the foundation to serve as anchors by securing the bottom of the wall to the concrete
c) Other types of anchor systems
1) Metal straps set in concrete and then attached to the wooden member in the wall
2) Anchors screwed into the ground with metal cables attaching them to the structure

6. Another type of anchor is a group of specially built brackets designed to attach framing pieces together. Show students examples of framing anchors using TM 4.4. Hand out AS 4.1, and assign students different groups of fasteners to research. If possible, discuss their research in class.

What are the types of framing anchors and their uses?

a) Differ from construction anchors in that they attach framing pieces together
   1) Setting joists in place
   2) Attaching the roof to the walls
   3) Attaching walls to each other
   4) Joining the parts of a truss

b) Have specific shapes for a particular purpose

G. ***Other Activities***

Have students compare sample fasteners to determine where each fastener would work best and where it would not be a good choice. If possible, have students collect different types of fasteners and add them to the school's collection.

H. ***Conclusion***

Five main groups of fasteners--nails, screws, adhesives, construction anchors, and framing anchors--are discussed in this lesson. Nails are the most commonly used type of fastener, while screws generally are stronger fasteners. Adhesives are now being used more frequently to join a variety of building materials. Anchors increase the strength and stability of the structure. For heavy construction, obtaining professional recommendations about the best types of fasteners to use is valuable.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. a
2. c
3. d
4. c
5. d
6. Self-tapping metal screws
7. To attach walls to foundations and help protect the structure against damage from high winds by adding more strength and stability
8. Use, length, and exposure to weathering
9. Answers may include any one of the following: attaching the roof to the walls, attaching walls to each other, and joining the parts of a truss together.

UNIT III - BUILDING CONSTRUCTION Name _

Lesson 4: Fasteners and Fastening Systems Date __

EVALUATION

Circle the letter that corresponds to the best answer.

1. A duplex-head nail is used for:

   a. Easy removal.
   b. Permanent installation.
   c. Attaching wire.
   d. Finishing.

2. White wood glue is a:

   a. Contact cement.
   b. Urea formaldehyde.
   c. Polyvinyl.
   d. Resorcinol resin.

3. The length of a nail is described by a number and the term:

   a. Weight.
   b. Inches.
   c. Dimes.
   d. Penny.

4. Which of the following nails has a twisted shaft that causes it to turn as it is driven?

   a. Ring-shank nail
   b. Finish nail
   c. Screw-shank nail
   d. Twister nail

5. Which of these adhesives is used for attaching vinyl floor coverings?

   a. Epoxy
   b. Urea formaldehyde
   c. Resorcinol resin
   d. Contact cement

Complete the following short answer questions.

6. What type of screw is used to attach sheet metal or metal siding?

7. What is the purpose of construction anchors?

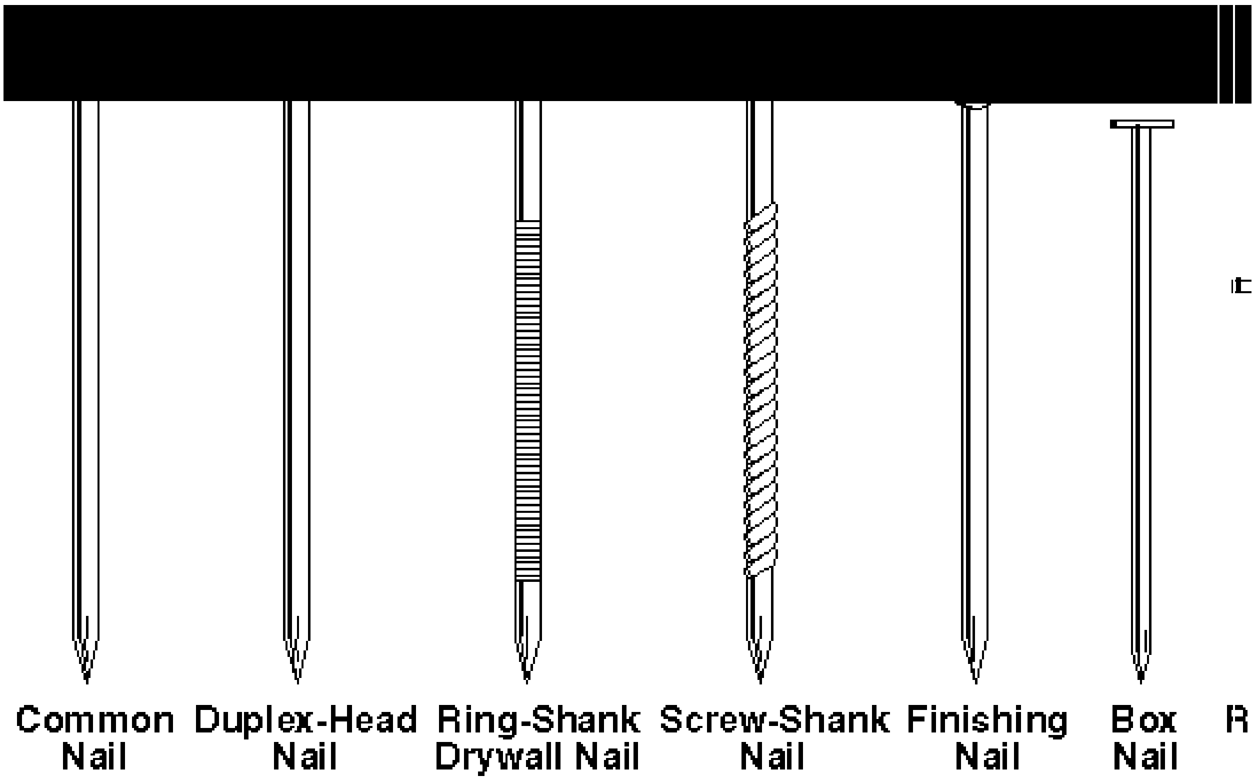
8. What are three factors that affect the selection of nails?

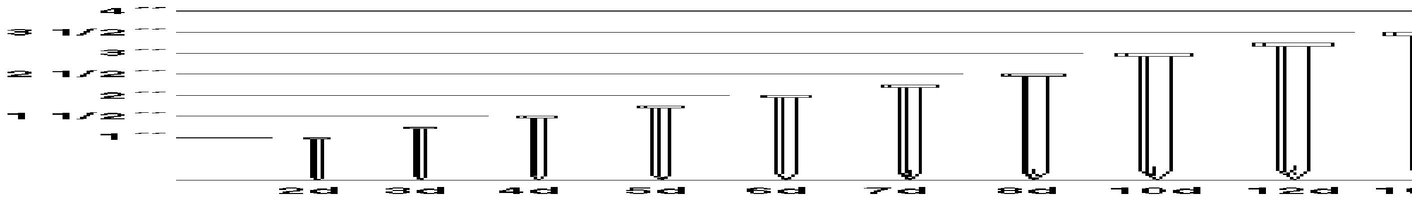
   a.

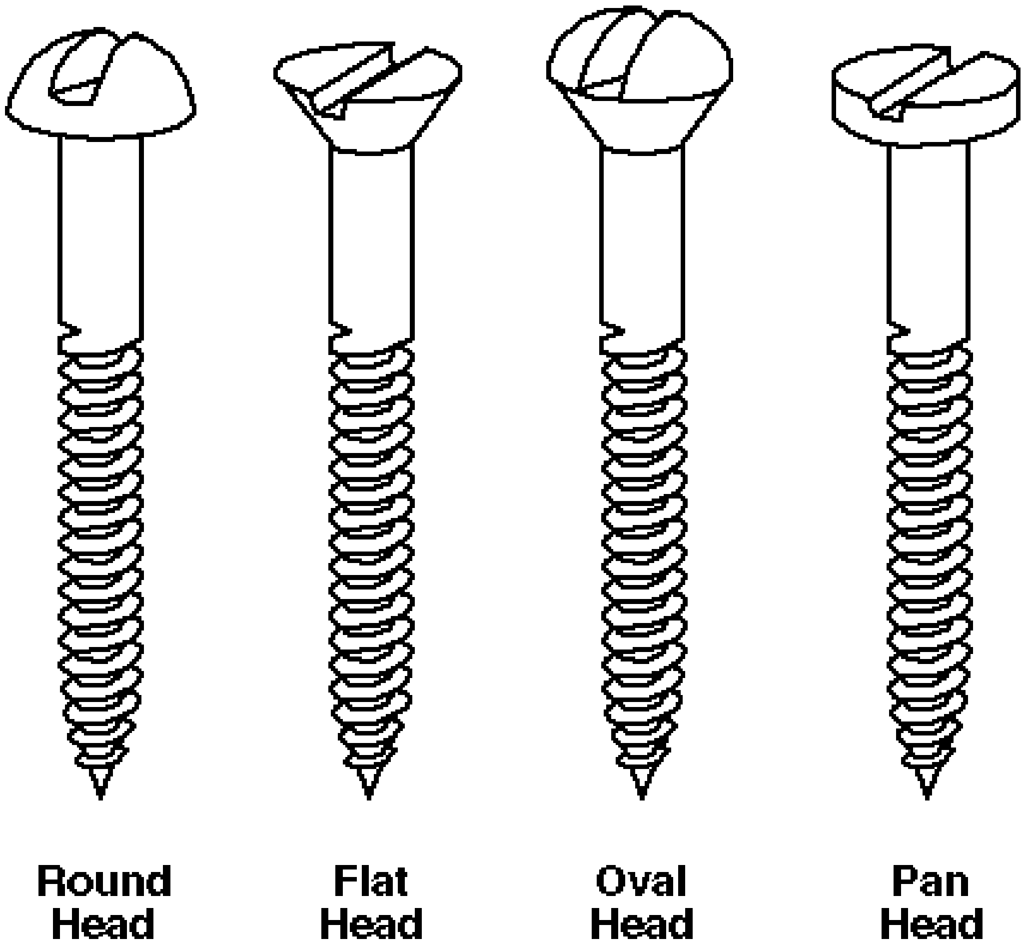
   b.

   c.

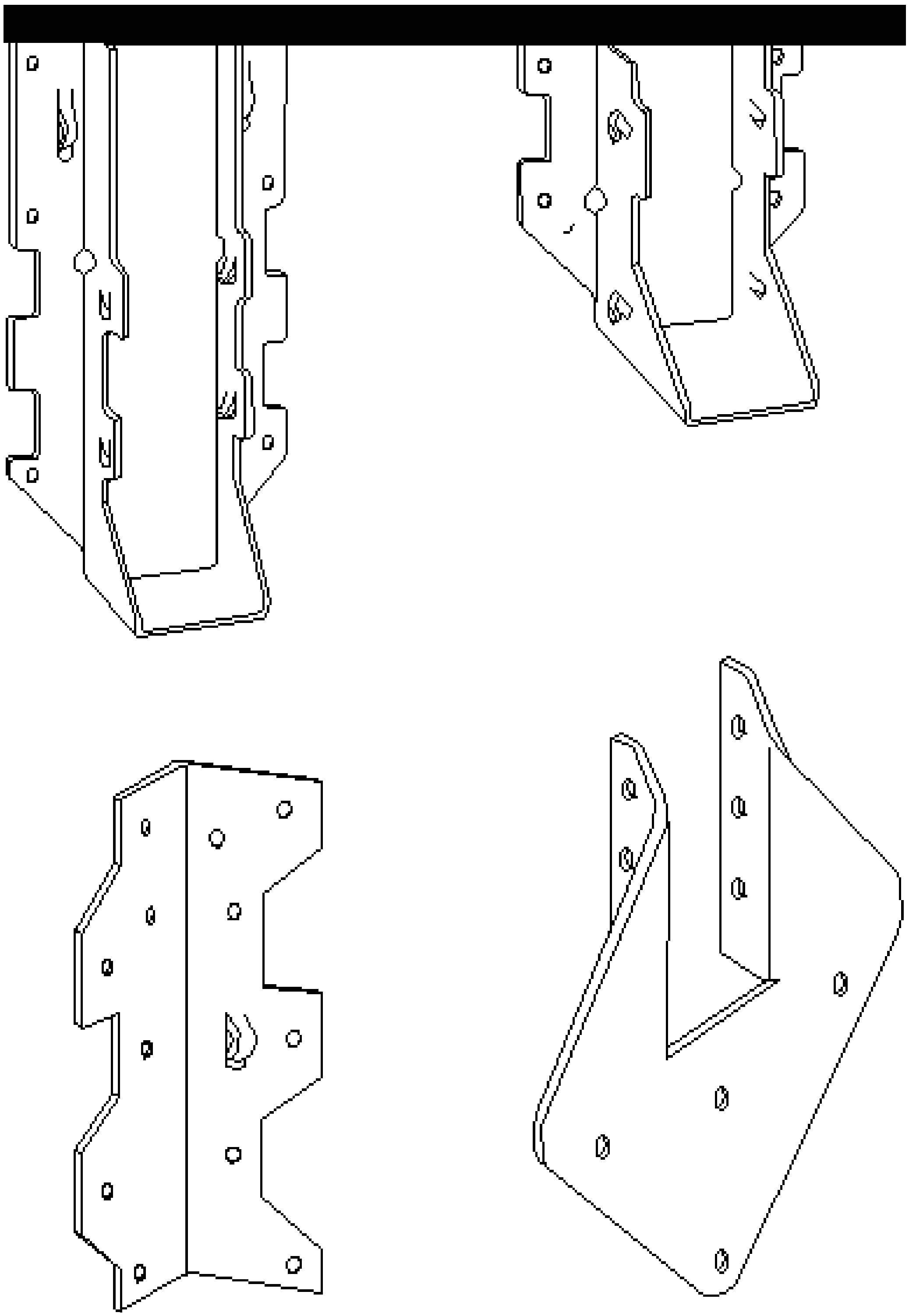
9. What is one use of framing anchors?


Common Nail
Duplex-Head Nail
Ring-Shank Drywall Nail
Screw-Shank Nail
Finishing Nail
Box Nail


4"
3 1/2"
3"
2 1/2"
2"
1 1/2"
1"
2d
3d
4d
5d
6d
7d
8d
10d
12d


Round
Head
Flat
Head
Oval
Head
Pan
Head

Sample Framing Anchors



Lesson 4: Fasteners and Fastening Systems Name ________________________

Identifying Fasteners

Objective: Identify the uses of different fasteners and fastening systems.

Research the group of fasteners assigned by your instructor then answer the questions below. Be prepared to discuss the information with the class.

1. What are five products available in the category selected?

2. How and when can each of them be used?

3. What are the advantages and disadvantages of each?

UNIT III - BUILDING CONSTRUCTION

Lesson 5: Floors and Subfloors

Competency/Objective: Describe how to construct a floor and subfloor.

Study Questions

1. What are the members used in floor framing?

2. How are the joists set in place?

3. How is the subflooring installed?

4. How does load determine the type of flooring and subflooring used?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit III.

2. Transparency Masters

   a) TM 5.1: Parts of a Floor
   b) TM 5.2: Bridging

3. Activity Sheet

   a) AS 5.1: Diagramming Flooring

4. Job Sheet

   a) JS 5.1: Joist Layout

Lesson 5: Floors and Subfloors

TEACHING PROCEDURES

B. ***Review***

Lesson 4 described the various types of fasteners and fastening systems used in construction. When building a structure, one of the first uses of fasteners is constructing a floor. This lesson concerns itself with wood or wood-metal combinations for the floor framework and subflooring. The basics of floor construction, including the members used and their assembly, will be explored.

C. ***Motivation***

Before the class period, construct a small model of a floor to display its basic components, including the sill, header joists, joists, bridging, and subflooring. The model can be made using balsa wood, small strips of pine, or Popsicle sticks. It should be small enough for the students to handle and pass around.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students if they can think of some terms associated with constructing floors. Discuss the following terms. Use TM 5.1 to show different floor members. TM 5.2 illustrates bridging.

   What are the members used in floor framing?

   a) Crawl space - space between the ground and the first floor in structures without a basement
   b) Sill plate
      1) Piece of material, usually made of wood or metal, that is attached to the foundation
      2) Usually a 2-inch thick board that is 4, 6, or 8 inches wide
      3) Place where the building frame attaches to the foundation
      4) Supports the floor joists
   c) Girder or beam
      1) Large piece of dimensional wood, a combination of dimensional wood and plywood, metal, or some fabricated combination of metal and wood
      2) Supports the weight of the structure at certain points along its length
      3) Supported by posts
   d) Post - wood, metal, or concrete support for girders
   e) Header joist
      1) Attaches to the sill to form a box sill
      2) Attaches to the ends of the joists
   f) Joist
      1) Wood or metal member that rests on the sill and supports the first layer of flooring and the weight of the structure
      2) Typically made of 2" × 8", 2" × 10", or 2" × 12" boards
   g) Bridging
      1) Small wooden or steel pieces fitted in pairs between the joists
      2) Crossed to reduce movement of the joist and help distribute weight

h) Subflooring
   1) First layer of material applied over the floor joists
   2) Commonly some type of sheathing material, usually plywood, particle board, or waferboard
   3) Typically has a thickness of at least ½ an inch and is usually _ or ¾ of an inch
   4) Lies under the finish floor
i) Underlayment
   1) Second layer of material attached to the subflooring to strengthen the floor
   2) Usually made of plywood

2. Explain the procedure used to set joists in place. Have students complete JS 5.1.

How are the joists set in place?

a) Attach a sill plate to the foundation or basement walls.
   1) The sill plate is most commonly attached to the foundation with anchor bolts.
   2) Once the sill plate is bolted down, marks can be made on it to indicate the placement of joists.
b) Cut the header joist to length and nail it in place along the outside perimeter of the sill plate; the header joists should be attached standing on the 2-inch edge of the board to form a box sill.
c) Set the stringer joists on edge and fasten them to the header joists using nails or screws.
   1) The joists are spaced an even distance apart, usually 16 inches measuring from the center of one joist to the center of the next.
   2) If a joist will be below a weight-bearing wall, another joist should be placed against it for added strength.
d) When joists meet at a beam, use a metal joist bracket and bolts to attach the ends of the two joists together.
e) Add bridging between joists.
   1) Metal bridging pieces may be used.
   2) Boards may be cut and nailed in place to join the bottom of one joist with the top of the adjacent joist, forming an "X" between the two joists.

3. Describe the procedure for installing subflooring. Hand out AS 5.1.

How is the subflooring installed?

a) Place the sheets of subflooring at 90-degree angle to the joists.
   1) The edge of the sheet should rest on a joist, covering half of the joist.
   2) Another sheet of subflooring can then be joined next to the first sheet, with both sheets attached to the joist.
   3) The sheets of subflooring should be placed with a gap of at least _ of an inch between them to allow for expansion and contraction of the sheets due to temperature changes.
b) Attach the sheets of subflooring to the joists with the fasteners about 8 to 12 inches apart.
   1) Using more fasteners will decrease later "squeaking" from subflooring that is loose.
   2) If extra holding strength is desired, glue may be placed on the tops of the joists before the subflooring is laid down.
c) When placing subflooring on a large floor, stagger or offset the place where the seams come together to give more strength to the floor; this may require cutting a smaller piece to start one strip of subflooring.

4. Emphasize that the floor must be able to support the load of the structure, so load will affect how the flooring is constructed.

How does load determine the type of flooring and subflooring used?

a) Load is the weight carried by any part of a structure.
   1) Dead load
      (a) Vertical weight of a structure

(b) Consists of the total weight of all the permanent parts of the structure, including the foundation, footings, lumber, and electrical and plumbing apparatuses

(c) Act constantly

2) Live load

(a) Temporary and intermittent

(b) Weight or pressure from static and dynamic loads

(c) Static load - from anything occupying the structure, such as livestock, equipment, or stored products

(d) Dynamic loads - from the operation of equipment like a tractor or handling equipment in the structure

3) Environmental load - caused by natural factors, such as wind, snow, and earthquakes, that result in weight or pressure

b) To determine what materials and spacing to use in the flooring, calculate dead load plus the maximum expected live load.

1) Average loads - joists placed 16 inches apart with ¾-inch subflooring

2) Heavy loads

(a) Joists spaced only 12 inches apart with 1-inch subflooring

(b) Often place two layers of subflooring on the joists for additional strength

(1) Increases the thickness of the subflooring to 1½ inches or more

(2) Placed at a 90-degree angle from the first layer

(c) Require wider joists; 2" × 12" joists can be used if the loads are very heavy

(d) Need metal members, large timbers, or combinations of metals, dimensional lumber, and possibly plywood

c) Several sources of information are available to help select the right materials and construction for different loads.

1) Tables in construction reference books

2) Manufacturer's recommendations that either are on the material or are made available by retailers

3) Commercially prepared plans

G. ***Other Activities***

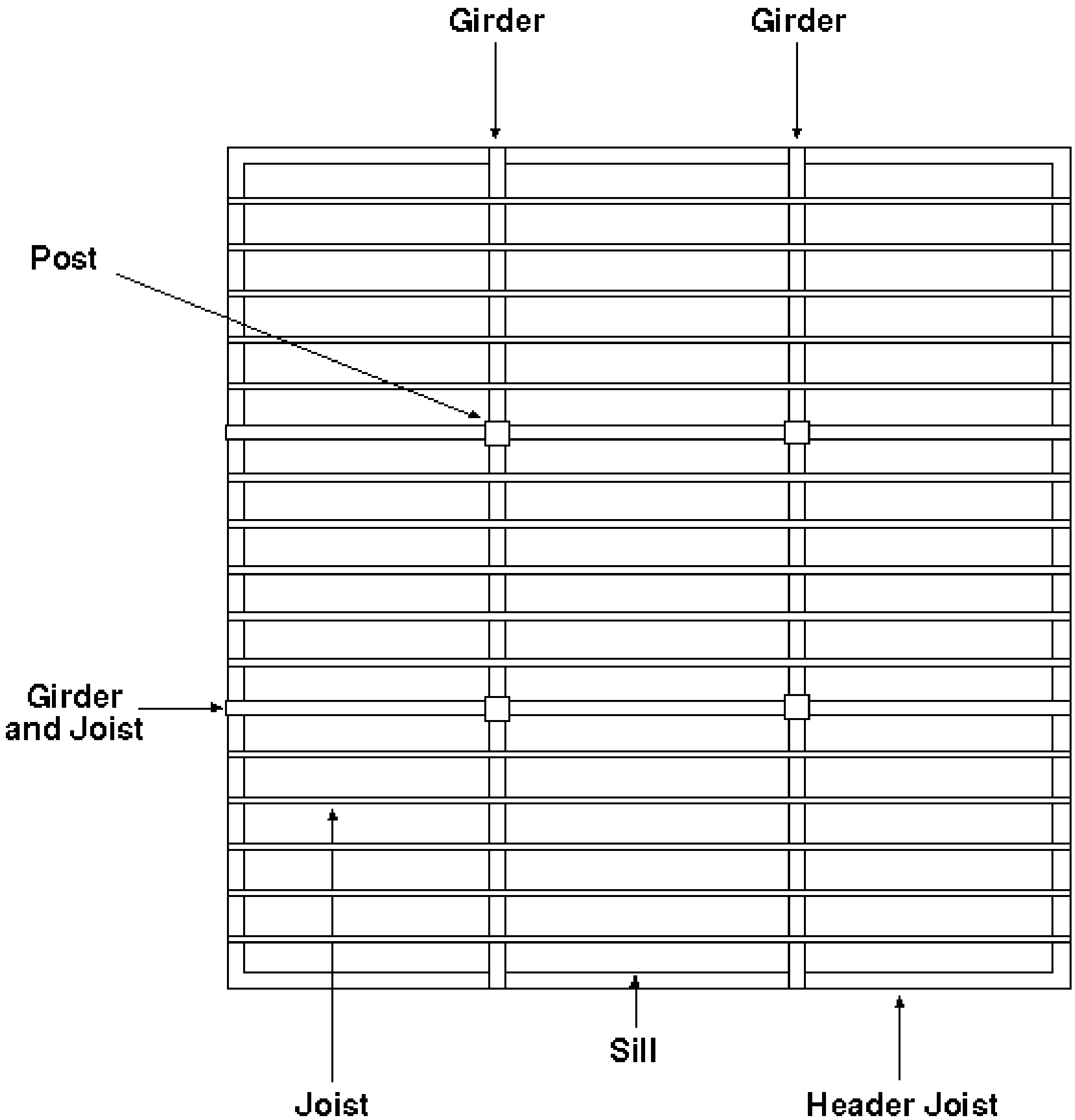
If possible, schedule a field trip to a construction site where a floor is under construction.

H. ***Conclusion***

Floor framing is the structural portion of the building that rests on the concrete foundation and attaches the building to it. Floors have a number of different parts that are constructed to support the building. An extremely important factor to consider when constructing floors is load. Load will determine the size and type of materials needed and their spacing.

I. ***Answers to Activity Sheets***

AS 5.1



J. ***Answers to Evaluation***

1. b
2. d
3. e
4. f
5. c
6. a
7. c
8. b
9. d
10. d

11. Another joist should be placed next to it for added strength.

12. To allow for expansion and contraction of the sheets due to temperature changes

UNIT III - BUILDING CONSTRUCTION Name _

Lesson 5: Floors and Subfloors Date __

EVALUATION

Match the word on the right with the description on the left.

1. ________ Member that rests on the sill and supports the first layer of flooring
2. Member attached to the foundation and the flooring system
3. Member that rests on the sill and attaches to the ends of the joists
4. Pieces placed between adjacent joists
5. Member that supports the joists across the span of the flooring
6. Layer of material placed on top of joists

a. Subflooring

b. Joist

c. Girder

d. Sill plate

e. Header joist

f. Bridging

Circle the letter that corresponds to the best answer.

8. Snow contributes to:

   a. Live loads.
   b. Dead loads.
   c. Environmental loads.
   d. Dynamic loads.

9. What is the typical spacing between joists?

   a. 15 inches
   b. 16 inches
   c. 17 inches
   d. 18 inches

10. Subflooring should be attached:

   a. Parallel to the joists.
   b. Between the joists.
   c. At the ends of the joists.
   d. At a 90-degree angle to the joists.

11. Which of the following might be done to help support heavy loads on a structure?

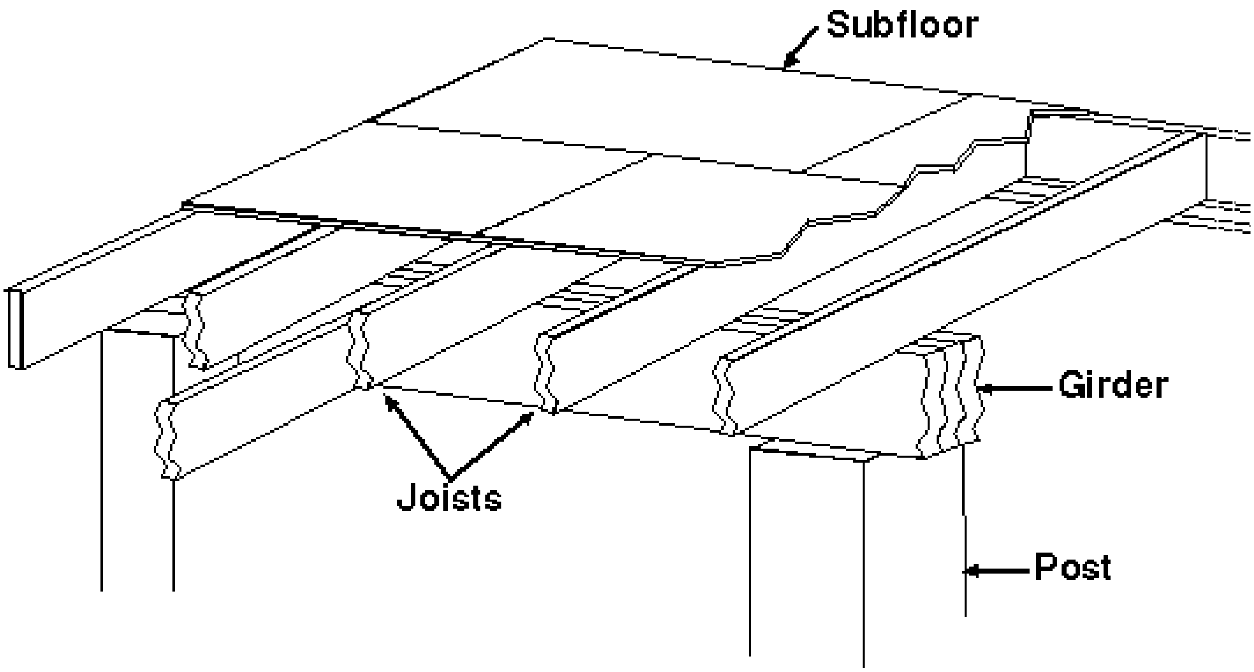
   a. Spacing joists 20 inches apart
   b. Using subflooring ½ an inch thick
   c. Using 2" × 6" boards for joists
   d. Adding a second layer of subflooring

Complete the following short answer questions.

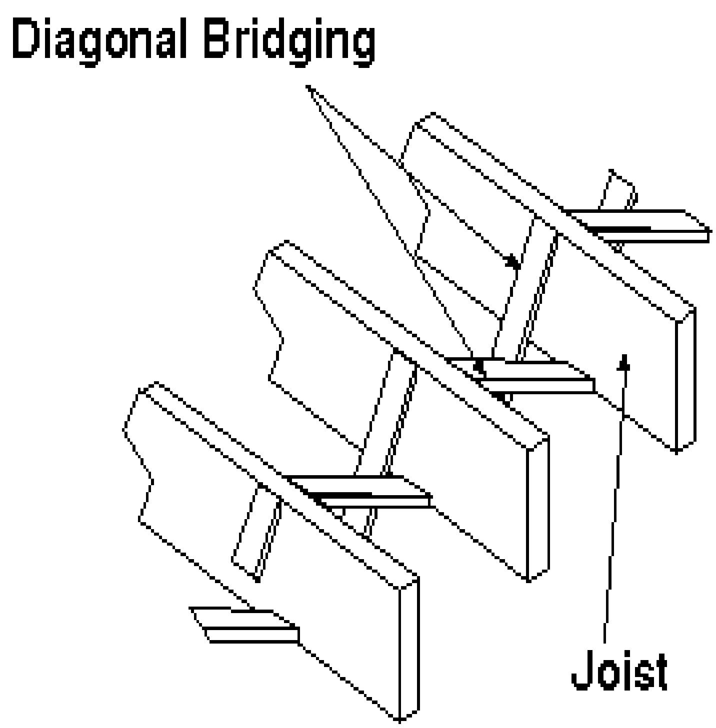
12. What should be done if a joist will be below a weight-bearing wall?

13. Why should sheets of subflooring be placed with a gap between them?

TM 5.1



Bridging



Lesson 5: Floors and Subfloors Name ____________________________

Diagramming Flooring

Objective: Diagram floor layout.

Using the information below, sketch the floor described showing an overhead view without decking. Use a scale of ¼” = 1’.

- The floor is to be 24 feet by 24 feet.
- The sill is a 2” × 6” that is anchor bolted to the foundation every four feet.
- The joists and joist headers are 2” × 10” material.
- Girders are positioned so that no span extends more than eight feet without support. Support posts for the girders are to be placed every eight feet.
- Bridging is not required for this project.

Lesson 5: Floors and Subfloors Name ____________________________

Joist Layout

Objective: Lay out joists for floor framing.

Materials and Equipment:

10 8-foot 2" × 8" boards
2 10-foot 2" × 8" boards
16d duplex head nails
Circular or radial arm saw
Hammer
Tape measure

Procedure:

For this activity, assume that the sill plate is in place and that the box sill would be connected to the sill plate.

1. Use the 10-foot boards for header joists.

2. Cut the joists to 7 feet, 9 inches in length.

3. Nail the two outside joists to the header joists, making a box.

4. Mark the header joist to indicate the placement of the remaining joists. The joists should be placed on 16-inch centers (16 inches from the center of one joist to the center of the next).

5. Nail the joists between the header joists on both ends, using two nails in each end.

UNIT III - BUILDING CONSTRUCTION

Lesson 6: Walls

Competency/Objective: Describe the purposes of walls, types of walls, supports, and siding used in agricultural buildings.

Study Questions

1. What are three purposes of walls?
2. What are different types of wall construction?
3. What are the components of stud frame walls?
4. How is a wood stud frame wall constructed?
5. What types of siding are used in agricultural structures?

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit III.
2. Transparency Masters
   a) TM 6.1: Pole Frame Construction
   b) TM 6.2: Stud Frame Construction
   c) TM 6.3: Components of a Frame Wall
3. Activity Sheet
   a) AS 6.1: Wall Construction

Lesson 6: Walls

TEACHING PROCEDURES

B. ***Review***

Lesson 5 discussed various aspects of constructing a floor for a structure. Walls are another important aspect of most construction projects. Lesson 6 describes the basic functions of walls as well as the different methods of construction and their components.

C. ***Motivation***

Make models of a post and beam wall and a wood frame wall using balsa wood, small strips of pine, or Popsicle sticks. These models should be small enough to handle easily. Pass them around and discuss the differences.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students if they can list three purposes of walls. Discuss these purposes with the students.

   What are three purposes of walls?

   a) Support vertical loads
   b) Resist lateral loads
   c) Provide protection from the weather

2. Use TM 6.1 and 6.2 to illustrate the differences between pole and stud frame construction. Discuss the differences between the two.

   What are different types of wall construction?

   a) Pole frame construction
      1) Poles or posts form the main structural members of the wall.
      2) Horizontal pieces of dimensional lumber called laths or girts are attached to the poles.
      3) Siding is placed vertically on the structure by attaching it to the laths.
   b) Stud frame construction - Walls are built using studs, which are the vertical wall members that provide the main support for the wall.

3. Show students TM 6.3. Discuss the different components of a frame wall.

   What are the components of stud frame walls?

   a) Top plate - horizontal member at the top of the wall on which the trusses or rafters rest
   b) Sole plate - structural member forming the bottom of the wall to which the studs are nailed
   c) Stud - vertical wall member that provides the main support for the wall
   d) Diagonal brace - member that adds to the rigidity of the wall, making it stronger; used in construction to keep the walls square and vertical
   e) Header - horizontal piece found above openings for doors and windows that provides support for loads over the opening

f) Jack stud or cripple stud - stud that is shorter than full length used below windows and above windows and doors

g) Trimmer stud - vertical framing member that forms the sides of door and window openings and supports the header

h) Rough sill - horizontal framing member attached to the top of the jack studs to form a rough base for a window

i) Blocking - wooden blocks that are used to fill in the space between framing members, providing support

j) Siding - material placed on the outside of a building to seal and enclose the building

k) Interior covering - material placed on the inside of the wall

4. Ask students to describe light wood construction. Hand out AS 6.1.

How is a wood stud frame wall constructed?

a) Walls are typically constructed one wall or section of a wall at a time, with the wall laying flat on the ground.

b) Determine the length of the wall and cut the top and bottom plates to that length.

c) Nail the studs between the top and bottom plate using two nails at each end of the stud.

  1) They are spaced an equal distance apart, usually 16 inches.

  2) Buildings with less weight on the walls are sometimes constructed with the studs 24 inches apart.

d) Nail double studs side by side at the corners of a building.

e) Diagonal braces and blocking attached between the studs add to the rigidity of the wall, making it stronger.

f) When the wall is finished, stand it upright and attach it to the foundation or subfloor using nails or bolts.

g) Nail walls together at the corners.

h) Remove diagonal braces.

i) If the wall has windows or doors, they require additional components.

  1) Window framing usually requires a header as well as extra support from trimmer boards at the sides of the opening.

  2) Window openings generally also use jack studs and a rough sill.

  3) Door framing involves the use of a header, extra supports on the sides, and sometimes jack studs.

5. Showing the class some samples or pictures clipped from sales literature will help when discussing this lesson’s content.

What types of siding are used in agricultural structures?

a) Dimensional lumber

  1) 1" × 12" boards or other similar sizes

  2) Accepts paint or stains readily, allowing customization

  3) Degrades due to weather, although it can be treated to be weather resistant, increasing the life of the lumber

b) Exterior plywood

  1) Sold in larger sheets, so fewer seams will exist, aiding in insulating

  2) Easier to apply than dimensional lumber

  3) Cheaper than other forms

  4) Not as attractive

c) Hardboard sheathing, or Masonite

  1) Sold in sheets that come in a number of colors

  2) Provides some insulation

  3) Relatively easy to apply

  4) Somewhat brittle and does not easily withstand stress

d) Metal siding

  1) Commonly made of galvanized steel or aluminum

  2) Sheets that are normally at least 3 feet wide and 8, 10, or 12 feet long

  3) Fewer seams, allowing for better insulation and weatherproofing

  4) Lasts for a very long time

  5) Can be painted but not stained

e) Vinyl siding

1) Consists of strips that overlap, sealing the building
2) Available in a variety of colors
3) Relatively long life
4) More expensive than other types of siding

f) Masonry products like bricks and cinder blocks
1) Decorative
2) Last for an extremely long time
3) Moderate cost
4) More difficult to apply

g) Fiberglass, glass, and plastics
1) Used in certain situations, such as a greenhouse
2) Purchased with varying levels of clarity, from totally clear to mostly opaque

G. ***Other Activities***

Ask students to identify which types of siding are commonly used in the community for different types of structures. Discuss why a particular type of siding would be used for certain applications.

H. ***Conclusion***

Wall construction is critical to a building's structural soundness and function. Walls serve three purposes: supporting vertical loads, resisting lateral loads, and providing protection from the weather. The two common types of wall construction for agricultural structures are pole frame construction and stud frame construction. Once a wall is constructed, a number of different types of siding can be used.

I. ***Answers to Activity Sheet***

1. Answers will vary, but should look something like the following image.

2. Two 2" X 4" boards, 7' long - door frame
Two 2" X 4" boards, 3' long - door frame
Twelve 2" X 4" boards, 7'9" long - studs

Two 2" x 4" boards, 12' long - top and bottom plate
Six 4" X 8" sheets of plywood - siding
Three 2" X 4" boards, 9" long - cripple studs

J. ***Answers to Evaluation***

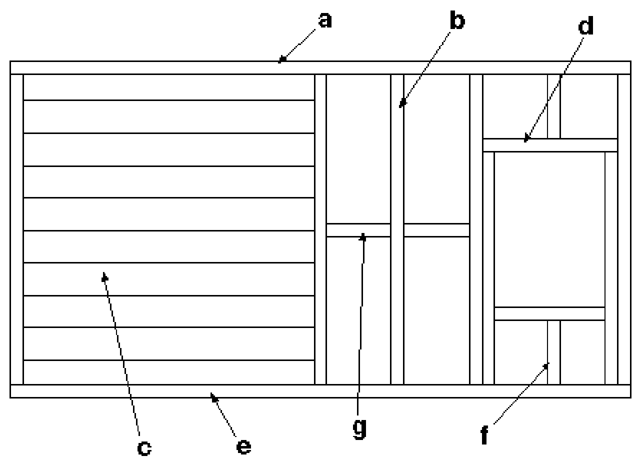
1. g
2. c
3. a
4. b
5. d
6. f
7. e
8. a
9. c
10. d
11. Pole frame and stud frame
12. To support vertical loads, resist lateral loads, and provide protection from the weather

UNIT III - BUILDING CONSTRUCTION Name _

Lesson 6: Walls Date ______________________________

EVALUATION

Write the letter in the blank next to the name of the structural member pictured.



1. Blocking piece
2. Siding
3. Top plate
4. Stud
5. Header
6. Jack stud
7. Sole plate

Complete the following short answer questions.

8. A piece of lumber nailed temporarily on a wall to stabilize it is called a:

   a. Diagonal brace.
   b. Stud.
   c. Siding.
   d. Top plate.

9. Studs are usually placed __________ inches apart.

   a. 14
   b. 15
   c. 16
   d. 17

10. A disadvantage of metal siding is that it:

    a. Is not fireproof.
    b. Is sold in large sheets.
    c. Has more seams when applied.
    d. Cannot be stained.

Complete the following short answer questions.

11. What are two different types of wall construction?

    a.

    b.

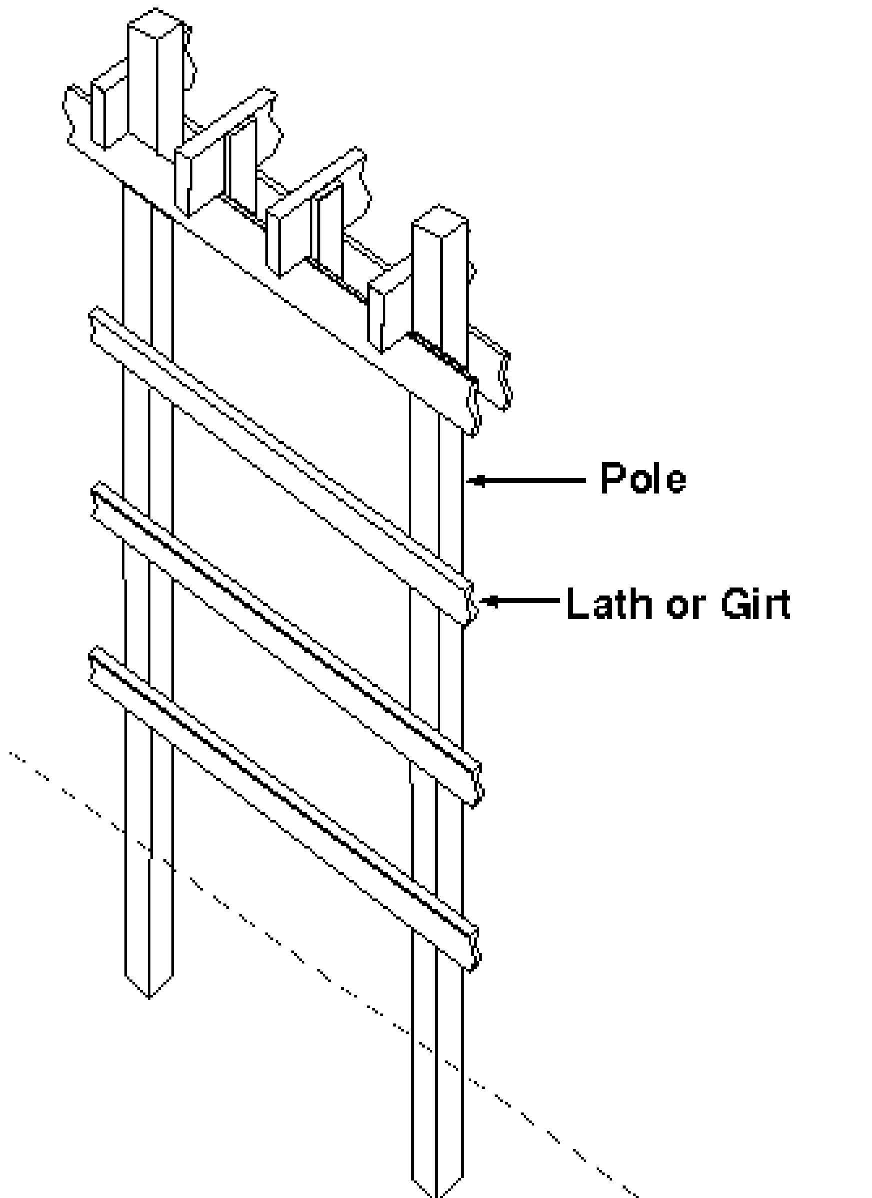
12. What are the three purposes of walls?

    a.

    b.

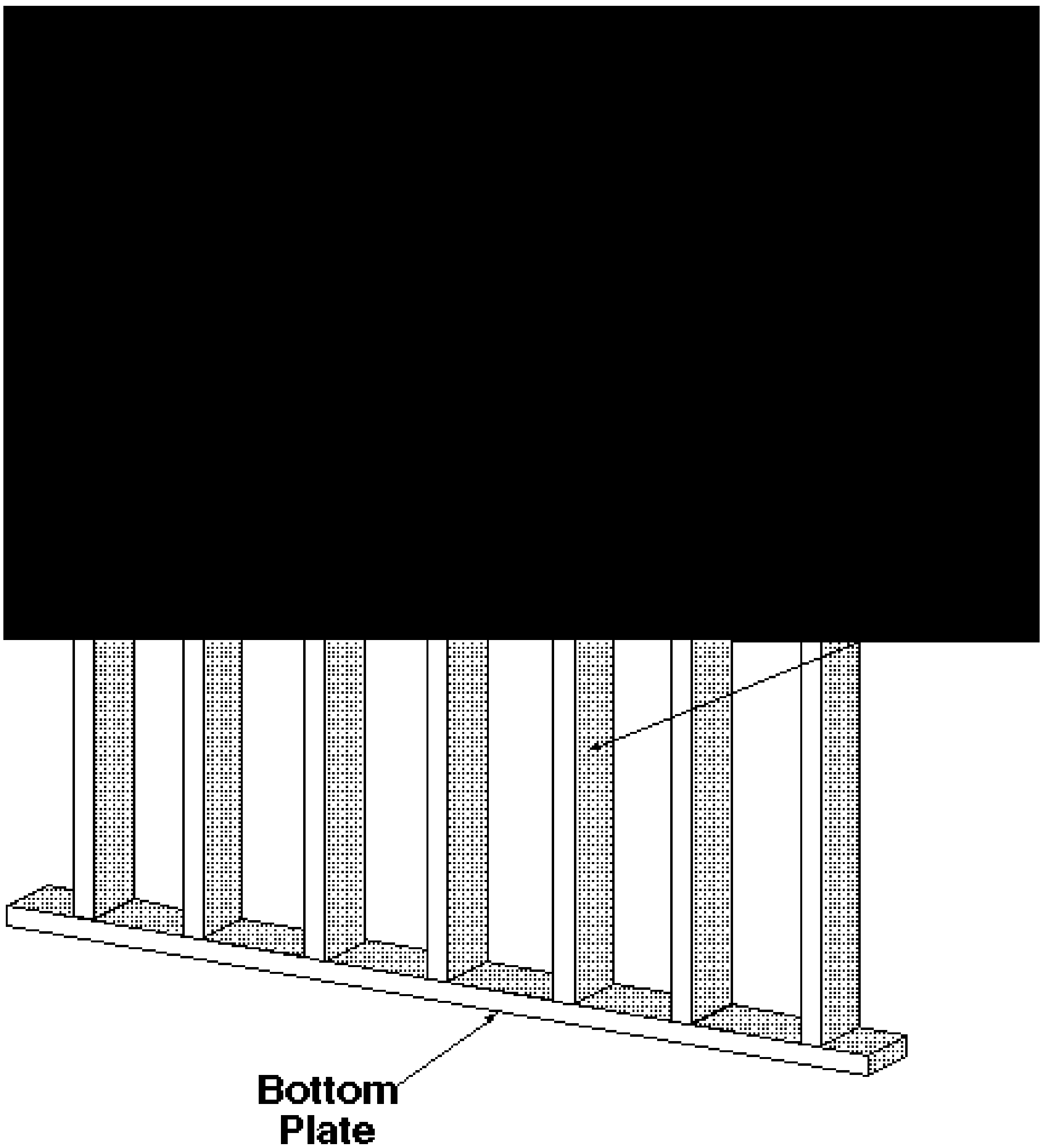
    c.

Pole Frame Construction

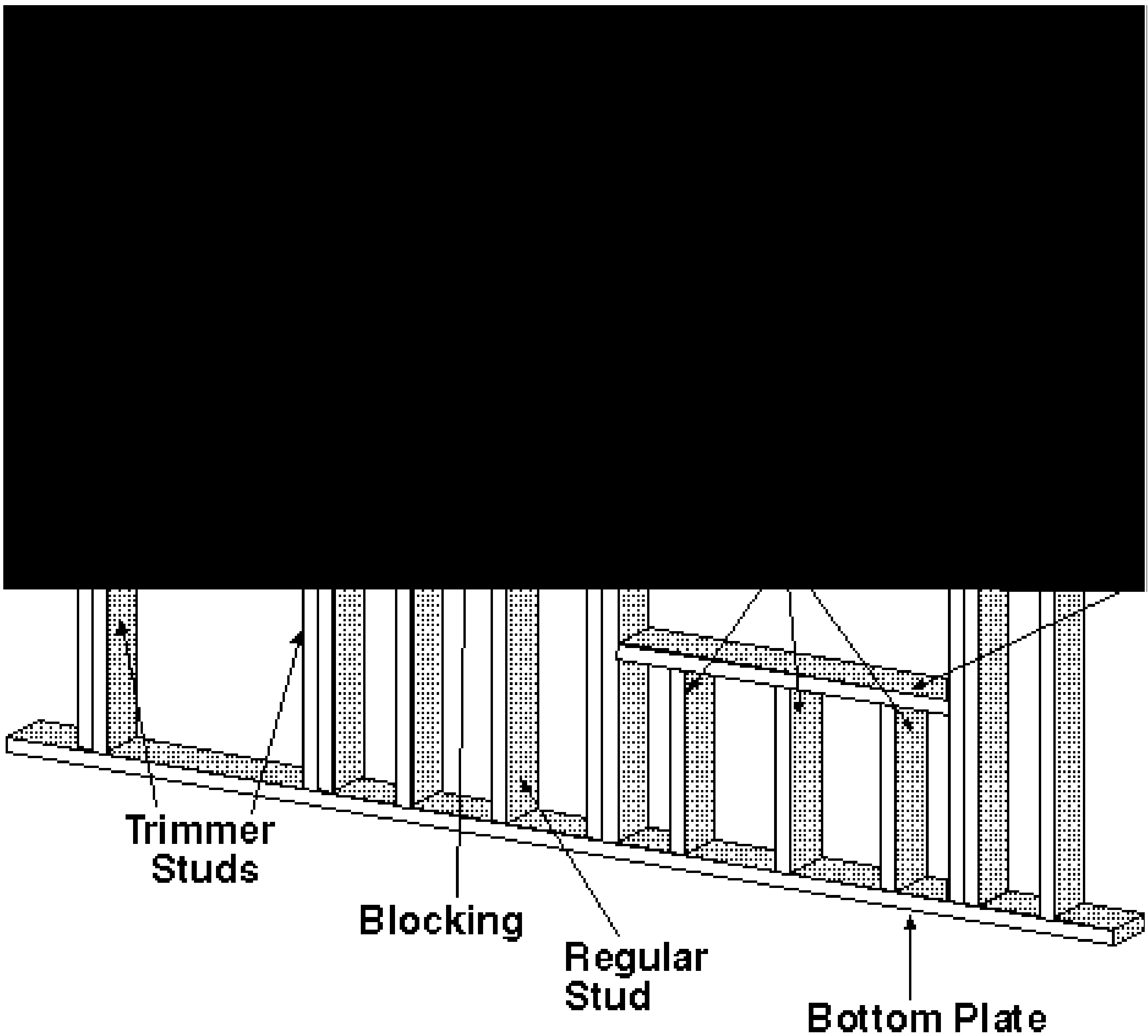


TM 6.2

Stud Frame Construction



Components of a Frame Wall



Lesson 6: Walls Name ___________________________

Wall Construction

Objective: Plan the construction of a wall.

Suppose you are constructing a wall that is 8 feet high and 12 feet long. Determine the materials required and the exact dimensions needed. The wall is to be sided on both sides with 4' × 8' plywood sheets and constructed of 2" × 4" boards. It will have a door consisting of a rough opening 3 feet by 7 feet in the exact middle of the wall. Put double studs at each end for strength.

1. First, sketch the wall as it would be constructed.

2. List the materials needed, indicating their uses.

UNIT III - BUILDING CONSTRUCTION

Lesson 7: Roof Support Systems

Competency/Objective: Select a roof support system.

Study Questions

1. What is the difference between a truss and a rafter?
2. How is a roof system selected?
3. What is pitch?
4. How is the pitch of a roof figured?
5. What are the parts of a rafter?
6. How is a rafter laid out?
7. What is a top plate?
8. How is a top plate constructed?
9. How is a truss ordered?
10. What are the types of roof styles?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit III.
2. Transparency Masters

    a) TM 7.1: Sample Truss
    b) TM 7.2: Rafters
    c) TM 7.3: Pitch
    d) TM 7.4: Parts of a Rafter
    e) TM 7.5: Rafter Table
    f) TM 7.6: Rafter Cuts
    g) TM 7.7: Roof Styles

3. Job Sheet

    a) JS 7.1: Rafter Layout

Lesson 7: Roof Support Systems

TEACHING PROCEDURES

B. ***Review***

Lesson 6 discussed the functions of walls, their different methods of construction, and their components. Most agricultural structures will also require a roof. A vital part of a roof is its support system. This lesson explores aspects of roof support systems and various options available as well. The process of laying out a rafter is also described.

C. ***Motivation***

Prepare a model of a truss made of 2" × 4" boards, balsa, thin strips of pine, etc. Discuss the parts of the model with the class.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. If the model prepared for the motivation is available, use it to illustrate what a truss looks like. TMs 7.1 and 7.2 can also be used to show the differences between a truss and a rafter. Discuss these differences.

   What is the difference between a truss and a rafter?

   a) Truss
      1) Structural assembly of lightweight material consisting of connected triangles used to create a system designed to support heavy loads over a considerable span
      2) Made of wood, wood products, metal, or a combination of any or all of these materials
      3) Vary in design depending on the needs of the structure
      4) Nearly always prefabricated units designed for a specific structure that are transported to the construction site and mechanically placed in position
   b) Rafter
      1) Structural member that spans from a wall's top plate to the ridge board of the roof
      2) Generally describes a site-built truss-type system

2. Discuss load as an aspect of selecting a roof system. Point out that due to liability, more and more people are turning to professionals for information about load and roof support systems. Discuss the economics of labor and time involved in building a roof system.

   How is a roof system selected?

   a) Ability to safely support roof loads
      1) The choice of a roof system will vary depending on the weather of the geographical area, which determines wind and snow loads.
      2) Different materials and roof designs have varying load capacities.
   b) Economics of cost and labor
      1) Truss companies will build to order and generally provide this service at a cost equal to or less than the cost of manufacturing a system on site.

2) Roof support systems of smaller structures may be built on site at a savings.
3) The labor involved in cutting and assembling systems must be considered.

3. Ask students to define pitch. Use TM 7.3 to illustrate pitch. Again, the model suggested in the motivation section could be used as a tool for initiating this discussion.

What is pitch?

a) Pitch is the steepness of a roof.
b) To calculate pitch, the rise and run for the roof must be known.
   1) Rise - vertical distance from the top plate to the ridge
   2) Run - horizontal distance covered by one rafter from the outside edge of the top plate to the exact center of the ridge
   3) Span - Total distance from the outside edge of one wall to the outside edge of the other wall; equal to twice the run
c) Pitch may be defined as a fraction that is a ratio of the rise to the span.
d) Pitch may also be expressed as slope in a ratio of the number of inches of rise per foot of run.
   1) Example: 6:12, meaning six inches of elevation for every twelve inches of length
   2) Shown using an inverted right triangle and the accompanying rise and run numbers

4. Write these formulas on the blackboard and discuss them. Have students work some sample problems to understand how pitch is calculated.

How is the pitch of a roof figured?

$$Pitch = \frac{Rise}{2 \times Run}$$

5. Use TM 7.4 to illustrate the parts of a rafter. Discuss the different parts with the class.

What are the parts of a rafter?

a) Tail (overhang) - part of the rafter that forms the part of the roof from the side of the building to the end of the roof
b) Tail cut - cut made at the end of the rafter, parallel with the wall
c) Seat cut (bird's mouth) - notch cut out of a rafter that allows the rafter to be seated on the top plate
d) Ridge cut (plumb cut) - cut made at the end of the rafter that fits against the ridge board and allows the rafter to fit flush against the ridge

6. A carpenter's framing square is almost essential to teach this part of the lesson. Show the class the rafter table on the framing square and discuss how it is used. Obtain three or four feet of 2″ × 8″ material and make the tail, ridge, and seat cuts. Have all the students observe how the numbers on the square were used to determine the exact places to cut. TMs 7.5 and 7.6 can also be used to illustrate the rafter table and how to make the cuts on the rafter. Hand out JS 7.1.

How is a rafter laid out?

a) Determine the length of the rafter.
   1) Locate the number that indicates the rise per foot of run on the blade of the framing square.
   2) In the rafter table beneath this number is a number indicating the length of a common rafter per foot of run.
   3) Multiply this second number by the number of feet of run.
   4) Add the length of the tail and subtract one-half the thickness of the ridge board; round as needed to the nearest 1/4 inch.
   5) Divide by 12 to find the length in feet and inches.
b) Make the tail cut at the end of the board that overhangs the structure.

1) Mark the measuring line in the center of the rafter material and then measure and mark the correct length of the rafter along the line.
2) Place the square on the material and align the body's number 12 with the top of the board.
3) Pivot the framing square until the number indicating the rise on the tongue aligns to the top edge of the board; the outside edge of the tongue must be even with the mark made along the measuring line.
4) Mark the tail cut along the outside edge of the tongue and cut the rafter.

c) Make the ridge cut at the opposite end of the material.
1) The ridge cut is made in the same manner as the tail cut.
2) Take care to align the outside edge of the tongue with the mark indicating the length of the rafter found at this end of the measuring line.

d) Make the seat cut.
1) Measure the length of the tail and mark this point on the measuring line.
2) Lay the material with the edge to be cut facing the opposite direction.
3) Place the framing square on the material with the body pointing to the right and the tongue pointing up.
4) Align the inside edge of the tongue to the mark indicating the length of the tail; adjust the tongue until the rise corresponds with the edge of the board and the number 12 is on the inside edge of the body on the edge of the board.
5) Mark and cut out the wedge-shaped section.

7. Use TM 7.2 to show what a top plate looks like. Discuss the function and location of this structural member.

What is a top plate?

a) A top plate is a wall member that is usually made of the same material as a wall's studs.
b) It is attached to the top of the studs.
c) Rafter seat cuts fit over the top plate, connecting the wall to the roof support system.

8. Discuss how to construct a top plate.

How is a top plate constructed?

a) Dimensional lumber of the same size used for the wall studs is attached to the tops of the studs.
b) Often a second piece of the same material is attached to increase strength and stability; the joints of the layers should not overlap.

9. Ask students to list information a truss manufacturer would need to know if trusses were ordered from the company. Discuss the information given below.

How is a truss ordered?

a) Supply the truss manufacturer with a copy of the building's plans, which will provide all the technical information needed.
b) Tell the builder the type of roofing material that will be used.
c) Provide the desired delivery date, time, and exact directions to building site.

10. Ask students to list some roof styles used for agricultural structures. Use TM 7.7 while describing the characteristics of the different styles.

What are the types of roof styles?

a) Shed
1) Only a single pitch
2) Usually found on smaller structures of 2,000 square feet or less

3) Inexpensive to construct
4) Simple to frame and install
5) Able to resist winds well because the slope of the roof is relatively shallow

b) Hip
1) Attractive appearance
2) Difficult to frame and install
3) Poor ventilation of attic areas

c) Gable
1) Often used for agricultural structures
2) Relatively inexpensive and easy to frame
3) May be extremely wind resistant if the pitch of the roof is not too steep

d) Gambrel
1) Two different pitches, with the top pitch being approximately 30 degrees and the bottom pitch around 60 degrees
2) Used for barns, because the design provides the advantage of spacious overhead room for storage
3) Expensive
4) More difficult to construct
5) Less resistant to damage from winds

e) Mansard
1) Attractive appearance
2) Leaks more easily because of the shallow pitch of the roof

f) Quonset
1) No flat surfaces
2) Forms a semicircle with an arching roof
3) Usually sold as a package and are therefore easy to construct

g) Gothic/arched
1) Two curving arches meeting at a point
2) Structures
(a) Similar to Quonset buildings in that they have no walls
(b) Other types of buildings, such as barns, that do have distinct walls
3) Strong roof
4) Large storage volume.

G. ***Other Activities***

Have students research and prepare reports on truss systems. They should describe (and diagram, if possible) some of the different styles and configurations available.

H. ***Conclusion***

Roof support systems consisting of trusses or rafters are vital parts of agricultural structures. Truss systems are generally prefabricated and brought to the building site; rafter systems are commonly built on site. Either system may work well if loads are carefully considered, and the choice of which system to use is often based on the economics of cost and labor.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. d
2. b
3. c
4. a
5. c

6. Answers may include any two of the following: shed, hip, gable, gambrel, mansard, Quonset, and Gothic/arched.

7. To increase strength and stability

8. Answers may include any of the following: supply the truss manufacturer with a copy of the building's plans, tell the builder the type of roofing material that will be used, and provide the desired delivery date, time, and exact directions to building site.

9. The ability to safely support roof loads and the economics of cost and labor

10. _

UNIT III - BUILDING CONSTRUCTION Name _

Lesson 7: Roof Support Systems Date __

EVALUATION

Circle the letter that corresponds to the best answer.

1. The structural member that connects the wall to the roof support system is the:

   a. Ridge board.
   b. Rafter.
   c. Tail.
   d. Top plate.

2. Which of the following is the part of the rafter that allows the rafter to be attached to the wall?

   a. Ridge cut
   b. Seat cut
   c. Tail cut
   d. Bird's tail

3. Pitch may be expressed as:

   a. The ratio of the number of inches of run per foot of rise.
   b. The rise divided by the run.
   c. The ratio of the number of inches of rise per foot of run.
   d. The run divided by the rise.

4. The structural member that spans from the wall to the ridge board of the roof is the:

   a. Rafter
   b. Tail
   c. Seat
   d. Truss

5. What is the first step in determining the length of the rafter?

   a. Find the number on the rafter table indicating the length of a common rafter per foot of run.
   b. Locate the number that indicates the run per foot of rise on the blade of the framing square.
   c. Locate the number that indicates the rise per foot of run on the blade of the framing square.
   d. Find the number on the rafter table indicating the length of a common rafter per foot of rise.

Complete the following short answer questions.

6. What are two types of roofs commonly used for agricultural structures?

   a.

   b.

7. What is one thing that must be done when ordering a truss?

8. When constructing a top plate, why would it be doubled?

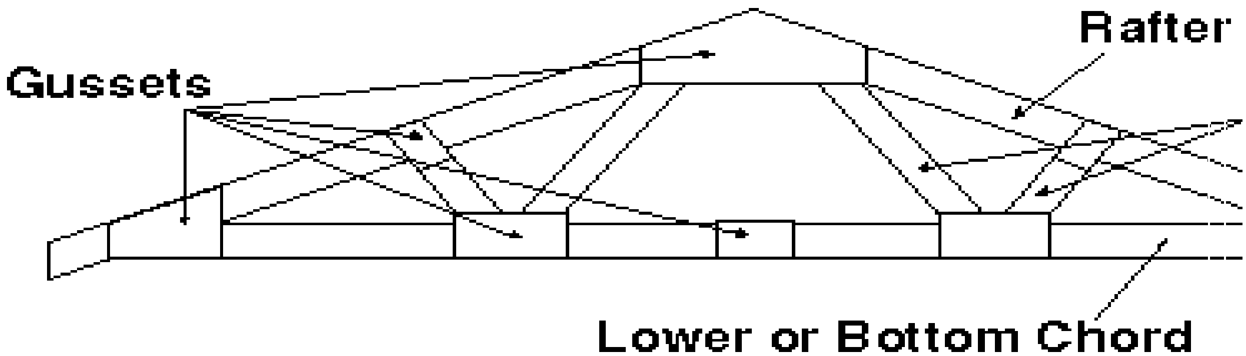
9. What are two things that must be considered when selecting a roof system?

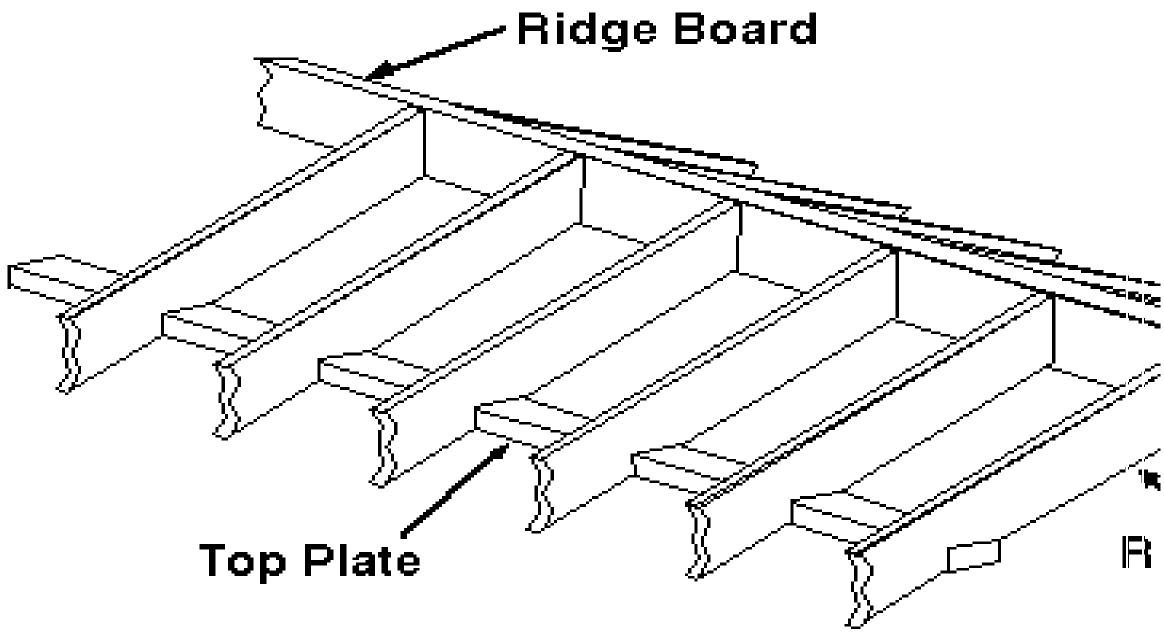
   a.

   b.

10. What is the pitch of a roof with a rise of 8 feet and a run of 12 feet?

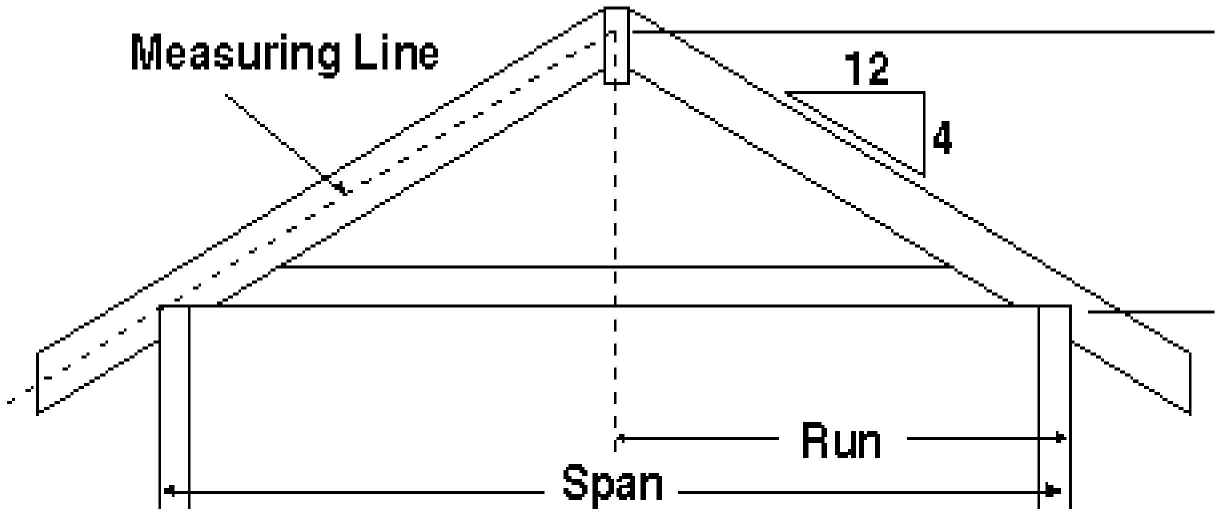
TM 7.1





Ridge Board
Top Plate

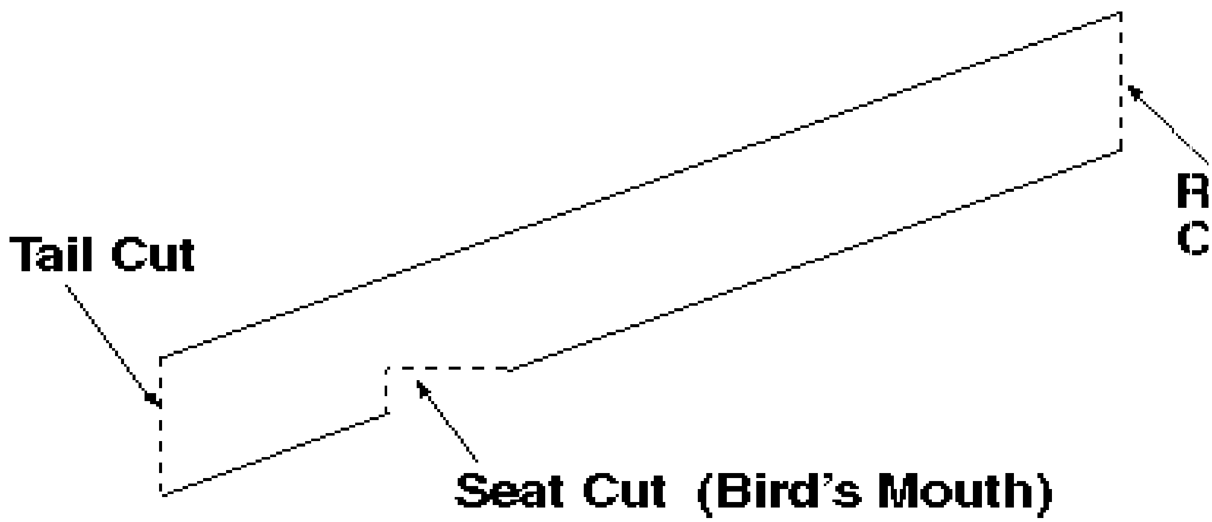
Pitch



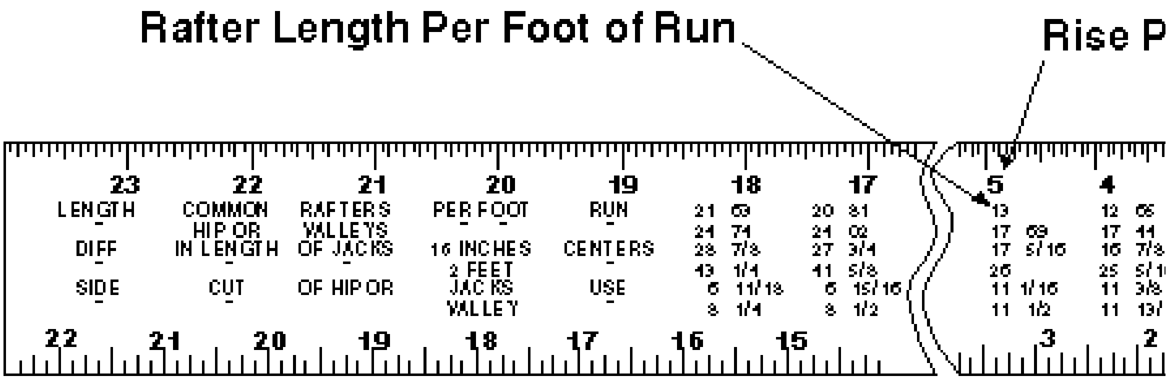
Span = 24 feet
Rise = 4 feet
Run = 12 feet

$$\text{Pitch} = \frac{\text{Rise}}{2 \times \text{Run}}$$

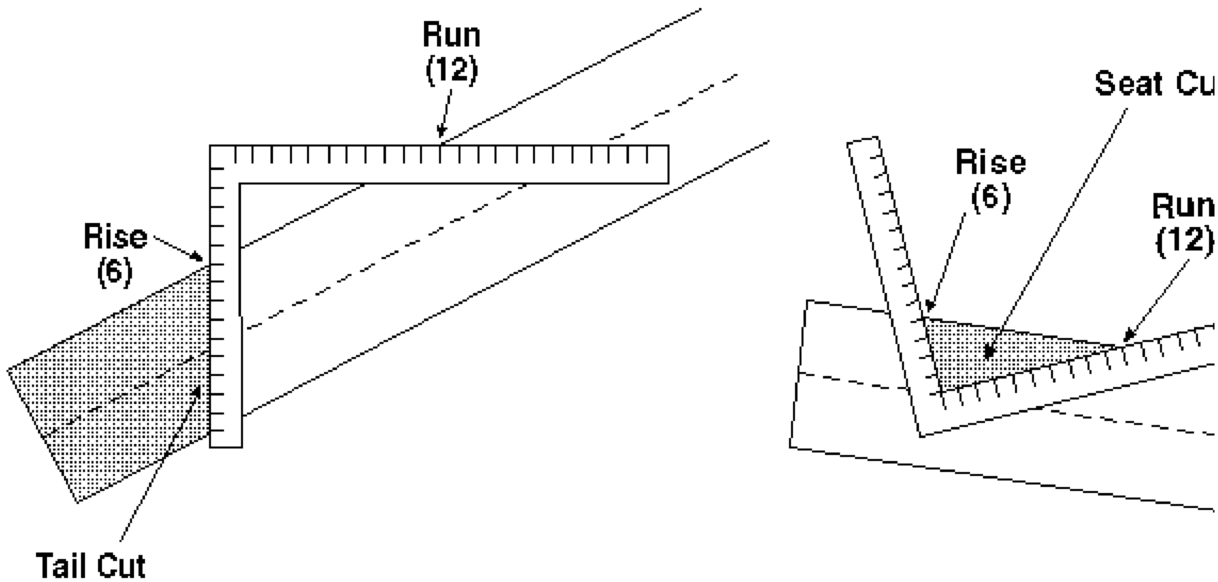
What is the pitch? What is the slope?


Tail Cut
R
C
Seat Cut (Bird's Mouth)

Rafter Table

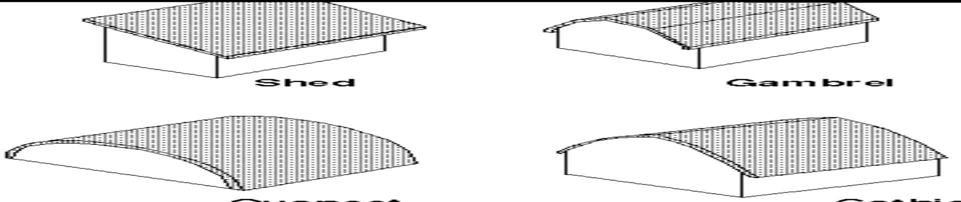


Rafter Cuts



TM 7.7

Roof Styles



Lesson 7: Roof Support Systems Name ______________________________

Rafter Layout

Objective: Lay out a rafter.

Materials and Equipment:

Pencil and paper
Carpenter’s framing square
Boards, strips of construction paper, cardboard, or rolls of fax paper

Procedure:

For this problem, lay out a rafter for a building that has a span of 10 feet and a rise of 5 feet. Using rafter material provided, lay out the ridge cut, seat cut, and tail cut. Assume that the overhang is 12 inches long. The slope is 6:12, because the rafter will have 6 inches of rise for every foot of run.

1. Using the rafter material, begin at one end by marking the ridge cut. For this exercise, you will use the step method of using a framing square.
2. Place the square so that the 6-inch mark on the tongue is on the edge of the square and the same side of the tongue crosses at the corner of the board.
3. Align the 12-inch mark on the body with the edge of the board to form the correct angle for the ridge cut.
4. Mark a line along the edge of the tongue of the square.
5. Where the 12-inch mark rests on the edge of the board, make a small mark. This mark will be used in the next step.
6. Line up the 6-inch mark on the tongue with the mark you just made.
7. Line up the square so the 12-inch mark on the body is at the edge of the board.
8. Make another small mark where the 12-inch mark meets the edge.
9. Repeat steps 6 to 8 four more times.
10. Draw a line across the board next to the tongue of the square to mark the seat cut.
11. From this line, measure another 12 inches down the board and mark the location for the overhang.
12. At this mark, repeat steps 6 to 8 again to indicate the tail cut.
13. On the seat cut line, measure 1½ inches up from the bottom and make a mark on the line to indicate the depth of a seat cut (commonly the thickness of a 2" board).
14. At the mark, use the framing square to make a 90-degree angle to the edge of the board. Mark the line to form the seat cut.
15. If a ridge board is used, ¾ of an inch needs to be cut off the ridge cut (half the thickness of a 2" board) at the same angle as the ridge cut.

UNIT III - BUILDING CONSTRUCTION

Lesson 8: Roofing Materials

Competency/Objective: Select roofing materials.

Study Questions

1. What different types of roofing materials are available?

2. What are the advantages and disadvantages of different types of roofing materials?

3. What are the structural components of a roof?

4. How are different types of roofs attached?

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit III.

2. Transparency Master

   a) TM 8.1: Structural Components of Roofs
   b) TM 8.2: Applying the Starter Course
   c) TM 8.3: Three-Tab Shingle Application
   d) TM 8.4: Applying Cap Shingles

3. Activity Sheet

   a) AS 8.1: Applying Roofing Materials

UNIT III - BUILDING CONSTRUCTION

Lesson 8: Roofing Materials

TEACHING PROCEDURES

B. ***Review***

Lesson 7 discussed the roof support systems found in agricultural structures. The support system is only part of the roof, however. Lesson 9 explores the roofing materials that are commonly used, their advantages or disadvantages, and how roofing materials are used in roof construction.

C. ***Motivation***

Display a few different types of shingles, a piece of roll roofing, and a few sections of metal roofing (both galvanized and painted). Identify the different materials and ask students to name places they have seen these materials in use.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Discuss the different materials listed below with the class. If the samples suggested in the motivation section are available, use them to illustrate the various types. If not, use clippings from magazines as examples of these products.

What different types of roofing products are available?

a) Asphalt - roll or shingle form
b) Fiberglass - shingles
c) Metal - galvanized or painted

2. Discuss the advantages or disadvantages of these materials in comparison to each other.

What are the advantages and disadvantages of different types of roofing materials?

a) Asphalt
   1) Advantages
      (a) Lower in cost than either metal roofing or fiberglass shingles
      (b) Roll asphalt - simple installation
   2) Disadvantages
      (a) Roll asphalt - least attractive roofing material
      (b) Relatively brief life span of 15 to 25 years under normal conditions
      (c) Burns readily
b) Fiberglass shingles
   1) Advantage
      (a) Moderate in cost
      (b) Long life span, around 30 years
   2) Disadvantage - flammable
c) Galvanized metal
   1) Advantages

(a) Relatively inexpensive

(b) Very fire resistant

(c) Very long life span of 50 years or longer

(d) Very durable material

2) Disadvantage

(a) Plain silver appearance, which may not make it suitable for all uses

(b) Noise caused by rain or hail striking the roof

d) Painted metal

1) Advantages

(a) Fire resistant

(b) Long life span of 30 or more years

2) Disadvantages - generally more expensive than asphalt shingles, galvanized metal, or fiberglass roofing

3. Use TM 8.1 as an aid in explaining the structural parts of a roof system. Discuss the structural components of roofs.

What are the structural components of a roof?

a) Rafters or trusses

b) For roll or shingle asphalt or fiberglass shingles, a solid decking system to which the roofing material is attached

1) The decking may be either some form of sheathing material, such as plywood or oriented-strand board, or dimensional lumber (usually 3/4" thick).

2) The decking is nailed or screwed over the top of the roof support system.

c) For metal roofing, a purlin system to which the roofing material is attached

1) Purlins are pieces of dimensional lumber, commonly 1" × 4", in varying lengths.

2) They are nailed perpendicular to the rafters.

3) The spacing of the purlins is dependent on many variables, such as the roof span, the strength of the material used for the purlins, and pitch.

4. Collect some examples of common roofing materials to display while discussing this part of the lesson. Describe how different types of roofs are attached, using TMs 8.2, 8.3, and 8.4 to illustrate shingling. Have students work on AS 8.1. Enough of the model shingles to complete the activity should be photocopied and given to the students before beginning the activity.

How are different types of roofs attached?

a) Roofing materials in roll or shingle form

1) They are fastened with galvanized or aluminum nails.

(a) The nails are usually 1¾ inches long.

(b) They have a large, flat head to hold the material securely and resist tearing the shingle.

2) Shingles may also come with an adhesive on them to help secure them to the decking.

3) The first step in attaching shingles is to nail or staple a layer of building felt, or underlayment, in place.

(a) Building felt is a tar-soaked fabric that will repel water.

(b) Place the felt across the length of the roof horizontally starting at the bottom, with successive layers overlapping about 4 inches.

(c) Apply a drip edge to the bottom and sides of the roof over the underlayment to prevent moisture from seeping under the underlayment.

4) Apply the shingles to the roof, starting at the bottom with each successive layer or course of shingles overlapping the layers below.

5) The first layer of shingles is made of half shingles.

(a) For three-tab shingles, cut the shingle lengthwise at the top of the tabs.

(b) Cut the first shingle in the starter course to a length of 30 inches to offset the end with the first course of full shingles.

(c) Place the long edge of the shingle along the edge of the roof.

(d) Attach the shingles as square to the edge as possible; use a hand level to make sure the first layer is level.

(e) Apply nails in the sealer strip, with one nail on each end of the shingle and above each weep.

6) Lay the remaining courses.

(a) The starter course will be completely covered by the next course of shingles.

(b) The shingles in each remaining course overlap the previous course halfway, or just above the top of the weeps.

(c) Stagger the weeps of each course equally from the previous course to form a brick-type pattern.

(d) Cut the first shingle in each course at six-inch increments, producing shingles that are 30, 24, 18, 12, and 6 inches long.

(e) Lay out these shingles at the edge of the roof in sequence.

(1) Start with a full shingle and continue across the roof with full shingles.

(2) Cut the last shingle in the course even with the side of the roof.

(3) Start the second course with a 30-inch shingle, the third with a 24-inch shingle, etc., creating a pattern that is repeated every six rows.

(f) The cut-off material may be used at the other end of a course.

(g) Any pieces over 12 inches long may be used on the peak of the roof.

7) At the peak of the roof, finish the cap.

(a) One method is to cut three-tab shingles into three sections and lay them over the top courses on each side of the ridge.

(b) Another method involves using special cap shingles at the peak of the roof.

(c) Overlap the shingles to prevent rain from getting under them.

(d) The direction of overlap depends on the normal wind direction.

b) Metal roofing

1) Metal roofing materials are attached with ring shank screws or nails with an attached neoprene or lead washer.

(a) They are generally 2½ inches in length.

(b) Overlap the ribbing running the length of the material.

(c) Place the nails or screws through the ridges of the roofing material, not in the flat areas.

(d) The placement of fasteners will vary depending on the type of ribbing; the manufacturer's recommendations should always be followed.

2) Aluminum and galvanized metal materials should not be used together, since the combination will result in an electrolyte reaction that causes corrosion.

G. ***Other Activities***

1. Have students collect pictures of the roofs of different agricultural structures. Have the class assemble these into a scrapbook that can be used as a reference in the future.

2. Divide the class into groups; have each group prepare a report about one of the basic types of roofing materials covered in this lesson. They could provide information on variations in quality, life span warranties among similar products, and manufacturer's recommendations for their use. The groups should be prepared to present their findings to the class.

3. Have students watch "Application of Three-Tab Composition Shingles" (15 min.), available from MVRC.

H. ***Conclusion***

Roofing materials are made from asphalt, fiberglass, or metal. Each of these materials has advantages and disadvantages. The structural components of the roof and how the roofing material is attached will vary depending on the materials used.

I. Answers to Activity Sheet

1. To allow the water to drain off without leaking

2. By determining how many square feet needed to be covered. Shingles are sold in squares, and one square is enough to cover 100 square feet.

3. The starter course determines how straight and square each course above will be.

J. ***Answers to Evaluation***

1. b
2. c
3. a
4. d
5. b
6. Shingles and roll roofing
7. Galvanized metals
8. Shingles or roll roofing
9. To nail or staple a layer of building felt in place

 Name _

Lesson 8: Roofing Materials Date __

EVALUATION

Circle the letter that corresponds to the best answer.

1. The roofing material that generally has the longest life span is:

   a. Painted metal.
   b. Galvanized metal.
   c. Asphalt.
   d. Fiberglass.

2. Which roofing material costs the least?

   a. Painted metal
   b. Galvanized metal
   c. Asphalt
   d. Fiberglass

3. Purlins are nailed:

   a. Perpendicular to the rafters.
   b. Diagonal to the ridge board.
   c. Parallel to the rafters.
   d. Perpendicular to the ridge board.

4. The roofing material that generally has the shortest life span is:

   a. Painted metal.
   b. Galvanized metal.
   c. Asphalt.
   d. Fiberglass.

5. Where should the first row of shingles be laid?

   a. At the top of the roof
   b. At the bottom of the roof
   c. At the left edge of the roof
   d. At the right edge of the roof

Complete the following short answer questions.

6. What two forms does asphalt roofing material come in?

   a.

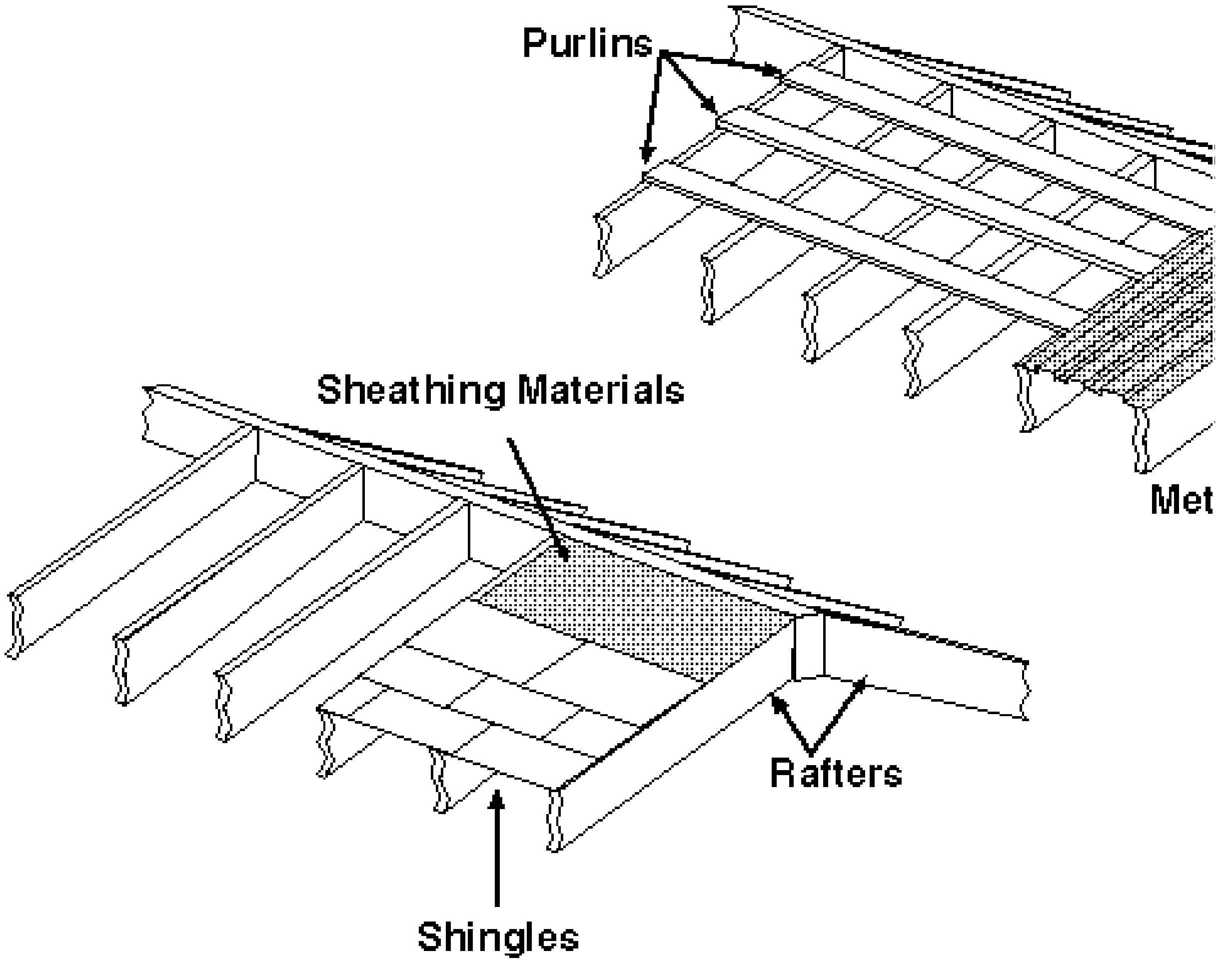
   b.

7. What type of roofing material cannot be attached with aluminum fasteners?

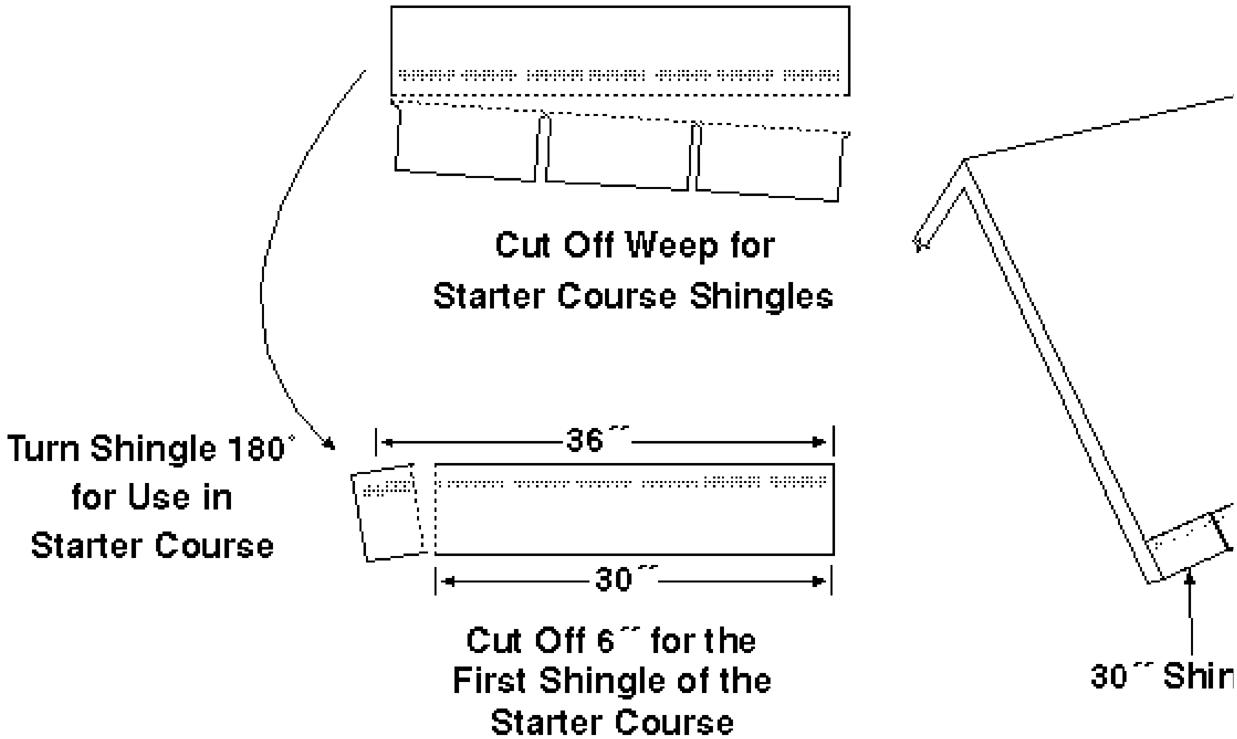
8. What types of roofing material must be applied over a solid decking?

9. What is the first step in attaching roofing shingles?

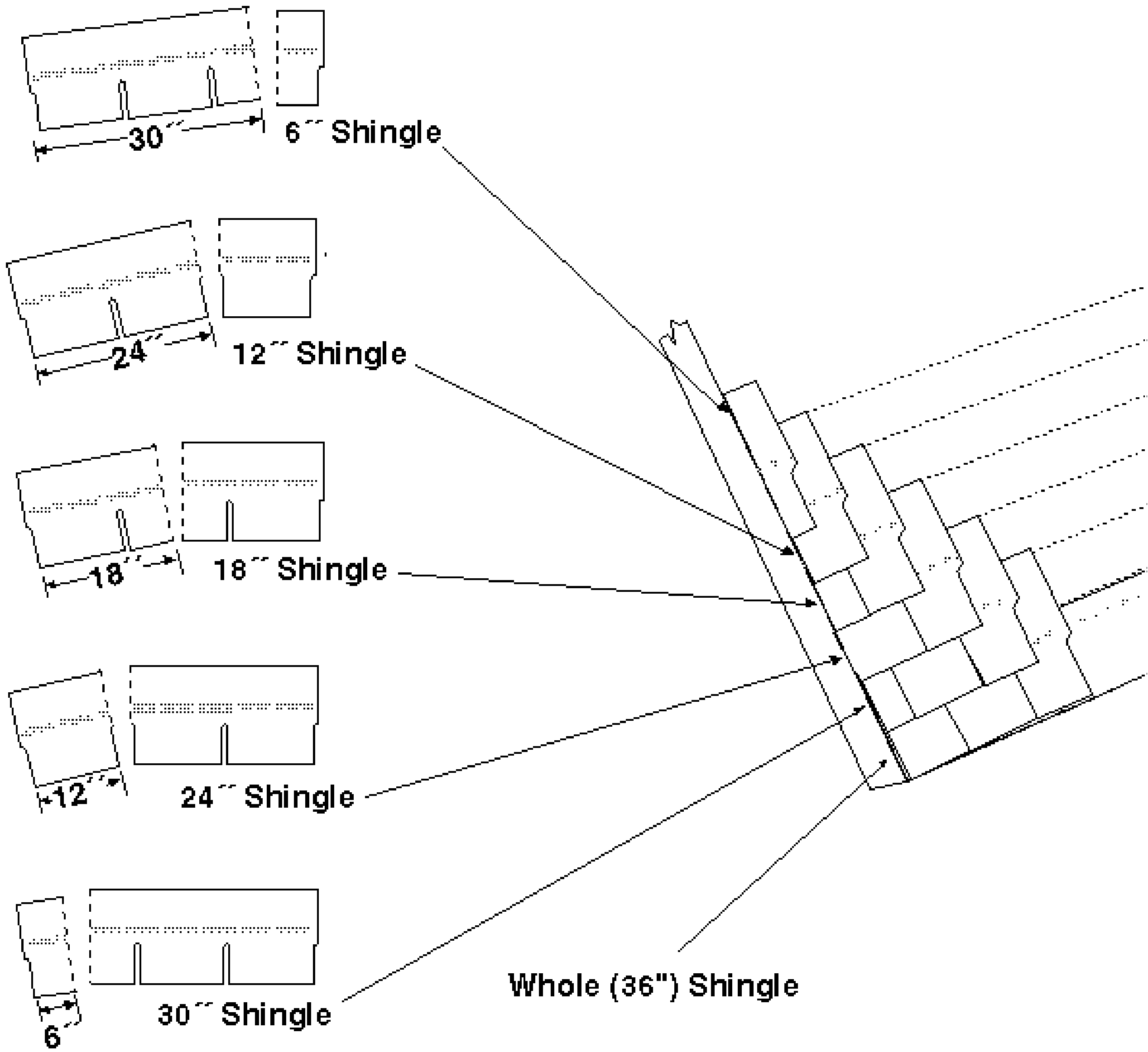
Structural Components of Roofs



Applying the Starter Course

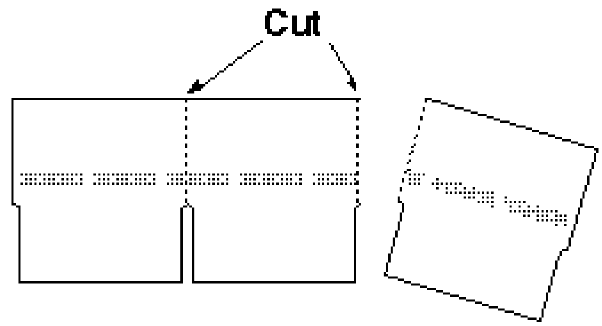


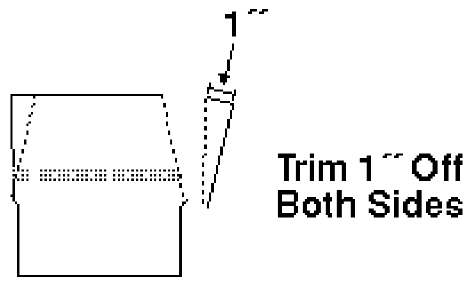
Three-Tab Shingle Application

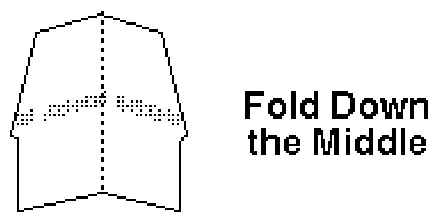


TM 8.4

Applying Cap Shingles







Lesson 8: Roofing Materials Name ________________________________

Applying Roofing Materials

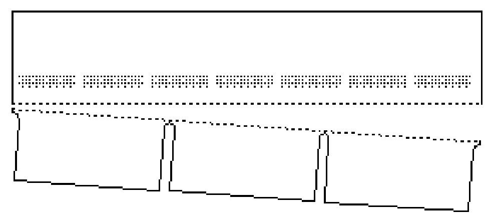
Objective: Apply different types of roofing materials.

Materials and Equipment:

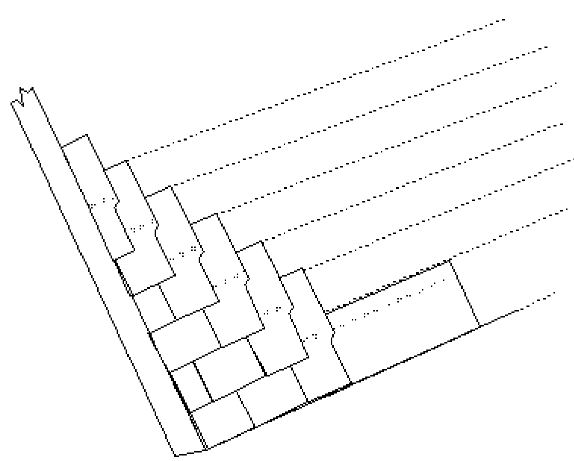
Classroom or shop tables
Paper models of shingles

Procedure:

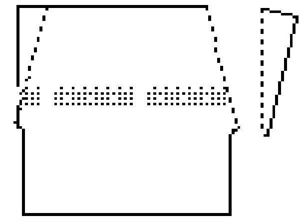
For this activity, assume that one edge of the table is the bottom of a roof. Place the model shingles on the "roof's" surface, starting at the bottom. The paper shingles are 9 inches long, ¼ the size of a real shingle. All cuts in the shingle must be scaled to the appropriate length.



1. Make half shingles by cutting the shingle at the top of the tabs (Figure 1.1). Cut first shingle to 7½ inches in length and place the long, uncut side of the shingle along the bottom edge.
3. Apply the starter course to the table using tape at the top of the shingle. Make sure the shingles are as square to the edge as possible.
4. Make partial shingles at the end of each course by cutting the last shingle as appropriate.
5. Lay the first full course over the starter course. Apply the entire course with tape, making sure the shingles are square.
6. For the next course, cut 1½ inches off the first shingle.
7. Apply the course, laying the shingles halfway over the first course (just above the weeps).
8. Lay the rest of the courses across the table surface, staggering the shingles in a brick-type pattern (Figure 1.2). Keep the shingles as square to the edge as possible.



10. At the peak, apply the cap. Cut three-tab shingles into three sections at the weeps to use as cap shingles. Angle trim each cap shingle from the top of the shingle to the top of the weep (Figure 1.3).



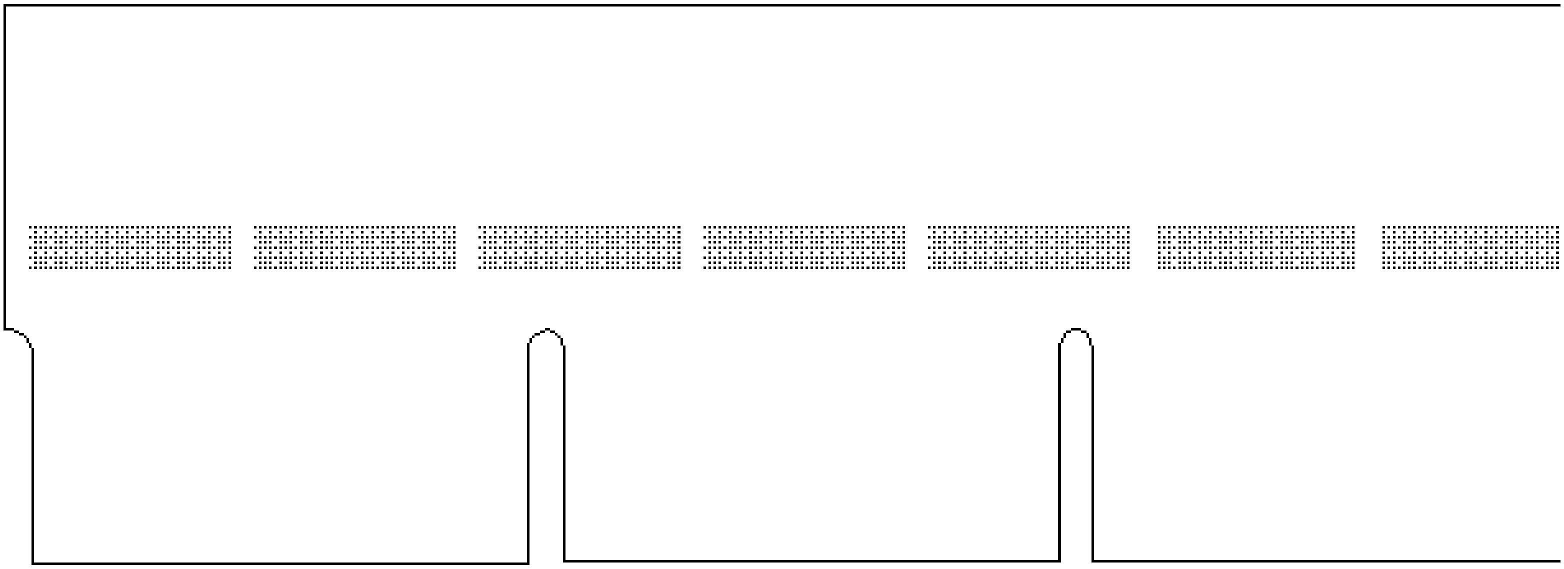
11. Place the cap shingles over the top course. They should overlap each other as if the wind is coming from the left side of the table.

Key Questions:

1. Why are the layers of shingles overlapped?

2. How would you determine how many shingles to buy for a construction project?

3. Why is it important to make sure the starter course is straight and square?



UNIT III - BUILDING CONSTRUCTION

Lesson 9: Heating, Cooling, and Ventilation

Competency/Objective: Identify factors affecting the heating, cooling, and ventilation of agricultural structures.

Study Questions

1. Why insulate buildings?
2. What are the different types and methods of insulation?
3. Why is ventilation important?
4. What type of heating systems are available?
5. When is passive solar heating feasible?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit III.
2. Activity Sheet
   a) AS 9.1: Heating, Cooling, and Ventilation Needs

Lesson 9: Heating, Cooling, and Ventilation

TEACHING PROCEDURES

B. ***Review***

Lesson 8 discussed roofing materials and how they are used for agricultural structures. Lesson 9 introduces the basics of heating, cooling, and ventilation. While not all agricultural buildings will require elaborate insulation, heating, or ventilation, these factors are important to consider, because they may affect the design and construction of a structure.

C. ***Motivation***

Discuss how temperature and weather conditions affect agricultural structures and their uses. Topics for discussion include how heat or cold can affect the livestock being housed in a structure and the effect of freezing on plumbing.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students why insulation is used in buildings. Discuss the purposes of insulation with students.

   Why insulate buildings?

   a) Insulation enhances a structure's ability to regulate temperature.
   b) A particular insulation's ability to resist the transfer of heat is expressed mathematically as an R-value.

2. Have students list some types of insulation they have seen. Discuss the materials and the methods of insulation used. If possible, bring in some samples of insulating material and show them to the class.

   What are the different types and methods of insulation?

   a) Types of materials
      1) Natural/organic - generally cheaper but do not insulate as well
         (a) Cotton
         (b) Cellulose
         (c) Shredded Bark
         (d) Shavings
         (e) Sawdust
         (f) Straw
      2) Manufactured - higher R-value per inch of thickness
         (a) Fiberglass
         (b) Rockwool
         (c) Expanded mica
         (d) Fiber board
         (e) Cellular glass
         (f) Expanded polystyrene
         (g) Expanded polyurethane

(h) Urea formaldehyde
(i) Polyisocyanurate

b) Methods of insulation
1) Blanket
(a) Consists of wide rolls of material, often with foil covering on one or both sides and an insulating material like fiberglass in the middle
(b) Used for insulating metal buildings and covering large sections of walls
(c) Usually stapled to the inside walls of the structure on wide, flat surfaces
2) Batt
(a) Provided in rolls of material in precut sections, usually 8 feet in length and 16 inches wide with a thickness of 4 to 6 inches, although the exact size of this material varies with the intended application
(b) Fits between the studs in the walls or other framework in structures
(c) Fastened in place with staples
3) Rigid
(a) Available in the form of sheathing (usually 4′ × 8′) in varying thicknesses
(b) May be made of a number of materials but is most commonly Styrofoam
(c) Often covered with foil on one or both sides
(d) Usually nailed in place on the outside walls of a structure before siding is applied
4) Fill
(a) Comes in a loose form
(b) Generally made of fiberglass or expanded mica
(c) May be emptied from bags where needed or mechanically blown in place through a large hose that feeds the material to the desired place
(d) Sometimes mixed with chemicals to make it adhere to a horizontal or overhead surface and then blown into place

3. Discuss the importance of ventilation with the class.

Why is ventilation important?

a) Controls temperature
b) Controls inside moisture levels
c) Reduces the growth of microorganisms
d) Diminishes odor problems
e) Prevents the accumulation of dangerous gases

4. Ask student to list some types of heating systems they have seen. Discuss the types of systems commonly used in agricultural structures.

What types of heating systems are available?

a) Radiant
1) Heat passes through the air until it comes into contact with an object and passes on its energy as heat.
2) The system will not heat objects out of its path.
3) Gas or electricity may be used to power these systems.

b) Floor
1) The systems are usually designed to heat specific areas.
2) Hot water pipes or electric elements are buried just below the surface of the floor.
3) These systems may be powered by electricity, natural gas, or ground-source heat pumps.

c) Unit
1) These heaters are used to heat the air in a general area of a structure.

2) They often use fans to circulate the air after heating it.

3) Unit heaters may be powered by a variety of fuels, such as propane, natural gas, or electricity.

d) Boilers and furnaces

1) Boilers and furnaces are large commercial appliances utilizing a system of pipes, ducts, or vents to transfer heat to where it is needed.

(a) Boilers - hot water pumped to radiators

(b) Furnaces - heat air and blow it through ductwork to the rest of the building

2) They may be powered by fuels such as propane, natural gas, electricity, or wood.

5. Discuss when passive solar heating might be used. Have students complete AS 9.1.

When is passive solar heating feasible?

a) Passive solar heating is feasible if a building has a consistent solar exposure not obstructed by trees, other buildings, clouds, or other items that block the sun's rays.

b) Positioning a structure so that its south wall has windows and an unrestricted plane will allow solar energy to enter the structure naturally.

c) Covering the windows with an insulating material at sundown will help the structure to retain the heat.

d) Strategically placing large water containers or building with stone or masonry where they can be warmed by the sun allows them to act as storage units that collect and hold the sun's heat.

G. ***Other Activities***

If possible, have a local HVAC contractor speak to the class.

H. ***Conclusion***

Heating, cooling, and ventilation are important factors to consider when building an agricultural structure. Insulating structures creates a slower heat transfer rate. Many different materials and methods of insulation are used to insulate buildings. Adequate ventilation is often imperative for a structure to function safely. Structures may also need to be heated, and several different types of heating systems may be used. The sun can be a good supplemental heat source. A well-designed building may be able to use a passive solar heating system to provide all the heat necessary.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. b
2. b
3. a
4. d
5. a

6. Answers may include any two of the following: controls temperature, controls moisture levels, reduces the growth of microorganisms, diminishes odor problems, and prevents the accumulation of dangerous gases.

7. Hot water pipes or electric elements are buried just below the surface of the floor.

8. If a building has a consistent solar exposure not obstructed by trees, other buildings, clouds, or other items that block the sun's rays.

9. Insulation enhances a structure's ability to regulate temperature.

UNIT III - BUILDING CONSTRUCTION Name _

Lesson 9: Heating, Cooling, and Ventilation Date __

EVALUATION

Circle the letter that corresponds to the best answer.

1. R-value indicates:

   a. Residual heat.
   b. Heat-transfer rating.
   c. Thermal units.
   d. The amount of heat available.

2. ______________________ insulation comes in rolls of material in precut sections.

   a. Adhesive
   b. Batt
   c. Rigid
   d. Fill

3. Which type of insulation consists of wide rolls of material and is used for insulating metal buildings?

   a. Blanket
   b. Batt
   c. Adhesive
   d. Fill

4. Which of the following types of insulation is loose in form?

   a. Blanket
   b. Batt
   c. Rigid
   d. Fill

5. Which type of heating system will only heat objects in its path?

   a. Radiant
   b. Floor
   c. Unit
   d. Furnace

Complete the following short answer questions.

6. What are two reasons that ventilation is important?

   a.

   b.

7. What is a floor heating system?

8. When is passive solar heating feasible?

9. What is the purpose of insulation?

Lesson 9: Heating, Cooling, and Ventilation Name _

Heating, Cooling, and Ventilation Needs

Objective: Assess the heating, cooling, and ventilation needs for a farm building.

Select one of the following buildings: greenhouse, calving barn, broiler house, machinery shop, crop storage building, or any others suggested by your instructor. Prepare a short report on the heating, cooling, and ventilation needs for that building. Be sure to address the following questions.

1. What are the specific temperature requirements for this type of building?

2. Why and when will this building need to be ventilated?

3. What are the optimal temperatures for this building?

4. What are the various heating, cooling, and ventilation systems that could be used in this type of building?

5. Are there any types of heating, cooling, and ventilation systems that should not be used? Why not?

UNIT IV - CONCRETE

Lesson 1: Safety in Working with Concrete

Competency/Objective: Discuss safety in working with concrete.

Study Questions

1. What is concrete?
2. How can concrete be dangerous to people?
3. What is the proper personal protective clothing to use when working with concrete?

References

1. Agricultural Structures *(Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit IV.
2. Activity Sheet
   a) AS 1.1: Concrete Safety

UNIT IV - CONCRETE

Lesson 1: Safety in Working with Concrete

TEACHING PROCEDURES

B. ***Introduction***

Concrete is a durable, versatile material of choice for many applications in agricultural structures. However, working with concrete does require some safety measures. Understanding and taking advantage of the suggestions provided in the lesson will help to ensure safety while working with concrete.

C. ***Motivation***

Discuss how common concrete is used in construction. Ask if anyone knows of any injuries associated with concrete. If so, have them explain the injury. If not, tell the students that a few specific hazards will be outlined in this lesson.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students to explain what concrete is. Discuss the characteristics of concrete.

What is concrete?

a) Concrete is an artificial stone-like material consisting chiefly of sand, gravel, cement, and water.
b) These materials are mixed together and harden and set due to a process called hydration, in which the cement combines with water and bonds to the different components.
c) It is a versatile construction material that can be adapted to almost any application and molded into many different shapes.
d) Concrete has a relatively low maintenance cost, is easily repaired and poured, and is easy to work.

2. Discuss the following information on the possible hazards of construction with concrete.

How can concrete be dangerous to people?

a) Tripping and falling over rebar and wire
b) Working with different kinds of potentially dangerous equipment
c) Chemical burns from concrete
   1) Perhaps the most common injury
   2) Consist of ulcerated areas where skin and flesh have been eroded away
   3) Caused by prolonged skin contact with some of the ingredients used to make cement; exposure of one hour or more will usually cause significant skin damage
   4) Prevent injury by using protective clothing and gear and immediately flushing with water and washing an exposed area
d) Airborne powdered cement getting in the eyes or being inhaled, producing the same caustic results as exposure to wet cement

3. Discuss protective clothing and gear with students. Show the class samples of as many of these items as possible. Hand out AS 1.1.

What is the proper personal protective clothing to use when working with concrete?

a) Protective eye gear, either goggles, which provide the best protection, or safety glasses, when working with cement in wet or powdered form
b) Disposable face masks to reduce the amount inhaled when working with powdered cement
c) Long-sleeved shirt
d) Heavy work pants
e) Waterproof or heavy work gloves; waterproof gloves are preferable
f) Rubber boots

G. ***Other Activities***

Ask your local EMS service, hospital, or nursing school if they would be willing to have someone come and talk to the class about concrete burns.

H. ***Conclusion***

The hazards of working with concrete are greatly minimized by staying alert and using protective clothing or gear. In most cases, avoiding a problem is the best way to deal with it.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. a
2. c
3. To reduce the amount inhaled when working with powdered cement
4. Immediately flushing with water and washing an exposed area
5. One hour or more
6. An ulcerated area where skin and flesh have been eroded away
7. An artificial stone-like material consisting chiefly of sand, gravel, cement, and water

UNIT IV - CONCRETE Name______________________________

Lesson 1: Safety in Working with Concrete Date___

EVALUATION

Circle the letter that corresponds to the best answer.

1. Eye protection is recommended:

   a. When working with wet or powdered cement.
   b. When working with wet cement.
   c. For exposure to cement in powdered form.
   d. For non-professionals working with wet cement.

2. What is the most common type of injury when working with concrete?

   a. Injuries from tripping and falling over rebar and wire
   b. Injuries from working with equipment
   c. Burns caused by the chemicals in wet concrete
   d. Reactions from getting powdered concrete in the eyes

Complete the following short answer questions.

3. Why should disposable face masks be worn?

4. In addition to wearing personal protective clothing, what can be done to protect against injuries from concrete burns?

5. While the length of time before damage occurs may vary, how much exposure to wet concrete usually causes significant skin damage?

6. What does a concrete burn look like?

7. What is concrete?

Lesson 1: Safety in Working with Concrete Name _

Concrete Safety

Objective: Observe concrete safety practices in use at a construction site.

Travel to a local construction site where concrete is being poured. Observe their activities, recording in the areas listed below the proper safety practices being used, as well as any others you think are appropriate. Also, record any improvements that could be made. Be prepared to discuss what you observed after returning to the classroom.

Clothing

Eye protection

Skin protection

How concrete is moved/handled

Ventilation requirements

Teamwork/working together

UNIT IV - CONCRETE

Lesson 2: Factors Affecting the Quality of Fresh Concrete

Competency/Objective: Identify factors that affect the quality of fresh concrete.

Study Questions

1. What are the raw materials of concrete?

2. What are the different mixes of concrete and their uses?

3. What are the different concrete additives and their uses?

4. What is a slump test, and why is it important?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit IV.

2. Transparency Master

    a) TM 2.1: Slump Test

3. Activity Sheet

    a) AS 2.1: Mixing Concrete

UNIT IV - CONCRETE

Lesson 2: Factors Affecting the Quality of Fresh Concrete

TEACHING PROCEDURES

B. ***Review***

The agricultural industry utilizes concrete as a construction material in many different applications. As discussed in Lesson 1, being able to work with concrete safely is important because it is so common. Lesson 2 will describe important factors that influence the quality of concrete. These factors include the raw materials used, the types of mixes, concrete additives, and the importance of slump tests in pouring quality concrete.

C. ***Motivation***

1. Show students examples of concrete construction around the agriculture facility. Ask them to determine if the final product is an example of quality concrete. If the example does not appear to be of good quality, ask the students why the concrete shows faults. Then ask the students if they think different types of concrete are used for different applications.

2. Ask if any of the students have ever poured concrete. For those answering yes, ask them to list the ingredients of the concrete and to explain how they were mixed. Then ask the students what the consistency and color of the concrete mixture resembled.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. For the finished concrete to have the proper strength and finish, the correct ingredients must be mixed together. Ask students what materials are found in a concrete mix. List the ingredients on the board or a transparency. What does each ingredient add to the mixture?

What are the raw materials of concrete?

a) Aggregates (sand and gravel)
   1) Makes up 60 to 80 percent of the volume of the concrete mixture
   2) Classified into two main categories
      (a) Fine aggregates are those particles that are smaller than a quarter inch in size.

(1) Typically called sand
(2) Should be clean and relatively dry
(b) Coarse aggregates are particles larger than one quarter inch in size.
(1) Called gravel
(2) Should be clean and uniform in size
3) Functions of aggregates
(a) They provide a cheap filler material.
(b) They are stable materials that resist forces on the concrete.
(c) They help to maintain the volume of concrete while it sets and hardens.
4) Can use other compounds for specialty applications
(a) Vermiculite and pearlite are used in lightweight concrete that can be sawed.
(b) Clay, shale, and crushed brick act as insulation.
(c) Steel or iron shot may be used for high density concrete for radiation shielding, as in a nuclear reactor or in the walls surrounding an x-ray laboratory.

b) Water
1) Purposes
(a) Water allows the concrete to be molded or shaped.
(b) It aids in mixing.
(c) Water plays an important role in hydration, the chemical reaction between water and cement that bonds the mixture together.
2) Should be clean
(a) Water generally can be used if it is potable, or drinkable.
(b) It should have less than 2,000 ppm of total dissolved solids.
3) Abram's Law
(a) This rule describes the relationship between water and concrete.
(b) "For given materials and conditions of handling, the strength of concrete is determined primarily by the ratio of the weight of mixing water to the weight of cement as long as the mixture is plastic and workable."
(c) Less water is generally better in mixing concrete, as long as the mixture is workable.

c) Cement
1) With water, forms the glue that holds concrete together
2) Portland cement - most common cement used today; first patented in 1824 by Joseph Aspdin
3) Steps in manufacturing portland cement
(a) Limestone, the base material, is taken from a quarry and crushed into a fine powder.
(b) The powdered limestone is then mixed with clay or shale and ground again.
(c) This mixture is then sent to a kiln to dry; the dried product is clinker.

(d) Gypsum is then added, and the mixture is ground a final time to form portland cement.

4) Five types of portland cement

(a) Type I is for normal applications.

(b) Type II is used where heat buildup is a concern.

(c) Type III, or high early strength cement, is used where the concrete needs strength in the first two to three days after pouring.

(d) Type IV, or low heat cement, reduces the heat generated by hydration.

(e) Type V, sulfate resistant cement, is poured over alkaline soils.

5) Regulated by two agencies that determine the requirements for the different categories of portland cement and work to maintain concrete quality

(a) American Society for Testing and Materials (ASTM)

(b) Canadian Standards Association (CSA)

d) Air

1) Air entraining - trapping small pockets of air in the concrete

2) Benefits of air entraining

(a) Air-entraining improves concrete's workability.

(b) It improves watertightness.

(c) It improves finish qualities.

(d) It increases the concrete's resistance to freezing and thawing.

(e) It increases concrete's resistance to salt and sulfates.

2. Just as concrete has many applications, it may consist of many different mixes. What is being built affects the mixture of ingredients in the concrete. Discuss the different mixes. Have students complete AS 2.1.

NOTE: Several weights are important when calculating a concrete mixture. A review of common weight conversions may be helpful to fully understand the calculations needed for the mixture.

What are the different mixes of concrete and their uses?

a) The first method of describing concrete mixes refers to the number of bags of cement in each yard of concrete, which is equal to 27 cubic feet of volume.

1) Ready-mix concrete ordered through a supplier is usually ordered using this method.

2) Three common ready mixes are used.

(a) Five bags of cement/yard; used for foundation walls and footings

(b) Six bags of cement/yard; used for house floors, dairy floors, driveways, and septic tanks

(c) Seven bags of cement/yard; used for concrete under severe conditions and concrete exposed to acids or severe weather

b) A second method of referring to concrete mixes uses a ratio that shows the relative amounts of the different components of the concrete.

1) A common mixture is 1:2:3:6, which is one part cement, two parts sand, three parts gravel, and six parts water.
2) Each part consists of a particular volume, such as one cubic foot.

c) The third method used to describe concrete mixes indicates the gallons of water mixed with each sack of cement.
1) Common mixes described in this manner are 5.0, 6.0, and 7.0, which correspond in their uses to the various ready-mixes already discussed.
(a) Five gallons of water/sack of cement; used for concrete under severe conditions and concrete exposed to acids or severe weather
(b) Six gallons of water/sack of cement; used for house floors, dairy floors, driveways, and septic tanks
(c) Seven gallons of water/sack of cement; used for foundation walls and footings
2) To learn the amounts of other components needed to make the cement, specific charts must be consulted to find the volume of each ingredient in a cubic yard.

3. For many applications and instances, changing the concrete that is poured or being able to pour concrete in less than ideal circumstances is desirable. Various additives can be used to change the properties of the concrete. List the different additives.

What are the different concrete additives and their uses?

a) Also called admixtures
b) Seven main categories
1) Air entraining
(a) Force small air pockets in the concrete
(b) Air entraining - process of trapping air in the concrete
(c) Improves workability, watertightness, and finish
(d) Increases resistance to freezing and thawing
(e) Increases resistance to salt and sulfates
2) Superplasticizers - increase the strength of the concrete by altering it to need less water to be workable
3) Retarding
(a) Slow down the setting process
(b) Result in greater long-term strength
4) Accelerating
(a) Speed up setting
(b) Result in more early strength
(c) Makes the concrete less vulnerable to temperature changes during setting
(d) Frequently used in cold weather to force the concrete to set more quickly
(e) Common additive - calcium chloride
5) Mineral - increase strength
6) Fibers

(a) Reduce the tendency of the concrete to break along seams or at the edges
(b) Helps to bind the concrete together.

7) Pigment
   (a) Change the color of the concrete
   (b) May be added to the whole batch of concrete or only to the final layer

4. Mixing concrete does not involve following a cookbook recipe, since some of the materials may already contain a certain moisture content, especially the sand. Ask students how they would determine whether the concrete has the proper consistency. Describe how to perform a slump test. Show the students TM 2.1.

What is a slump test, and why is it important?

a) Determines if the concrete is of the proper consistency
b) Indicates if more or less moisture is needed
c) Makes it possible to prepare a concrete mixture with the optimal combination of strength and workability
d) Procedure
   1) The slump test involves the use of a metal cone that is 12 inches tall, with a diameter of 4 inches at the top and 8 inches at the bottom, and open at both ends.
   2) The cone is placed on a flat surface with the wide end down.
   3) Prior to being filled with concrete, the cone may be moistened with oil to make cleanup easier.
   4) The cone is filled one-third full with concrete.
   5) The concrete is tamped down with a 12-inch metal rod 25 times to make it settle and remove any air pockets.
   6) Concrete is added until the cone is two-thirds full, and the concrete is tamped again.
   7) The cone is filled, and the concrete is tamped for the third time.
   8) The cone is carefully removed, and the concrete “slumps,” or drops in height due to gravity.
   9) A straight edge is placed across the top of the cone, and a measurement is taken from the straight edge down to the average level of the top of the concrete.
   10) In most instances, the slump should be between 1 and 3 inches.
   11) Too much slump indicates too much water, while not enough slump indicates a lack of water.
   12) If too much water is present, adding aggregates or cement will thicken the mixture.
      (a) Adding ingredients should be the last resort in mixing concrete because it will result in weaker concrete.
      (b) Most state or federal construction contracts prohibit adding ingredients after the initial mix.

G. ***Other Activities***

1. Using concrete mixing charts, prepare several trial mixtures and perform slump tests.

2. Visit the local ready-mix concrete plant to observe the mixing of different types of concrete.

H. ***Conclusion***

Concrete has many applications. How concrete is mixed depends upon the final use of the concrete. Good concrete does not result from a random mixing of ingredients. It involves using the right raw materials in the proper proportions and any necessary additives to get the desired quality of concrete.

I. ***Answers to Activity Sheet***

AS 2.1

1. 545 lbs./yd. × 11.74 yds. = 6,398 pounds
2. 1,140 lbs./yd. × 11.74 yds. = 13,384 pounds
3. 1,800 lbs./yd. × 11.74 yds. = 21,132 pounds
4. 300 lbs./yd. × 11.74 yds. = 3,522 pounds
5. 3,522 lbs. ÷ 8.3 lbs./gal. = 424 gallons

J. ***Answers to Evaluation***

1. a
2. d
3. a
4. c
5. b

6. 1 part cement, 2 parts sand, 3 parts gravel, 6 parts water

7. Aggregates, cement, water

8. To determine if the concrete is of the proper consistency and indicate if more or less moisture is needed

9. Calcium chloride

10. Answers may include any four of the following: air entraining additives, superplasticizers, retarding additives, accelerating additives, mineral additives, fibers, and pigments.

UNIT IV - CONCRETE Name _____

Lesson 2: Factors Affecting the Quality of Fresh Concrete Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. The type of portland cement that should be used for normal applications is:

   a. Type I.
   b. Type II.
   c. Type III.
   d. Type IV.

2. Aggregates compose __________ percent of the total volume of concrete.

   a. 10 to 30
   b. 20 to 40
   c. 40 to 60
   d. 60 to 80

3. In making portland cement, what is the name of the mixture before the gypsum is added?

   a. Clinker
   b. Paste
   c. Concrete
   d. Masonry

4. Air entraining improves concrete's:

   a. Color.
   b. Texture.
   c. Workability.
   d. Flexibility.

5. An acceptable slump on general use concrete would be __________ inches.

   a. 0
   b. 1-3
   c. 3-5
   d. 5-7

Complete the following short answer questions.

6. What do the numbers mean in a 1:2:3-6 concrete mixture?

7. What are the three main ingredients used in concrete?

    a.

    b.

    c.

8. Why is it necessary to perform a slump test?

9. What additive is commonly used to allow concrete to be poured in cold weather?

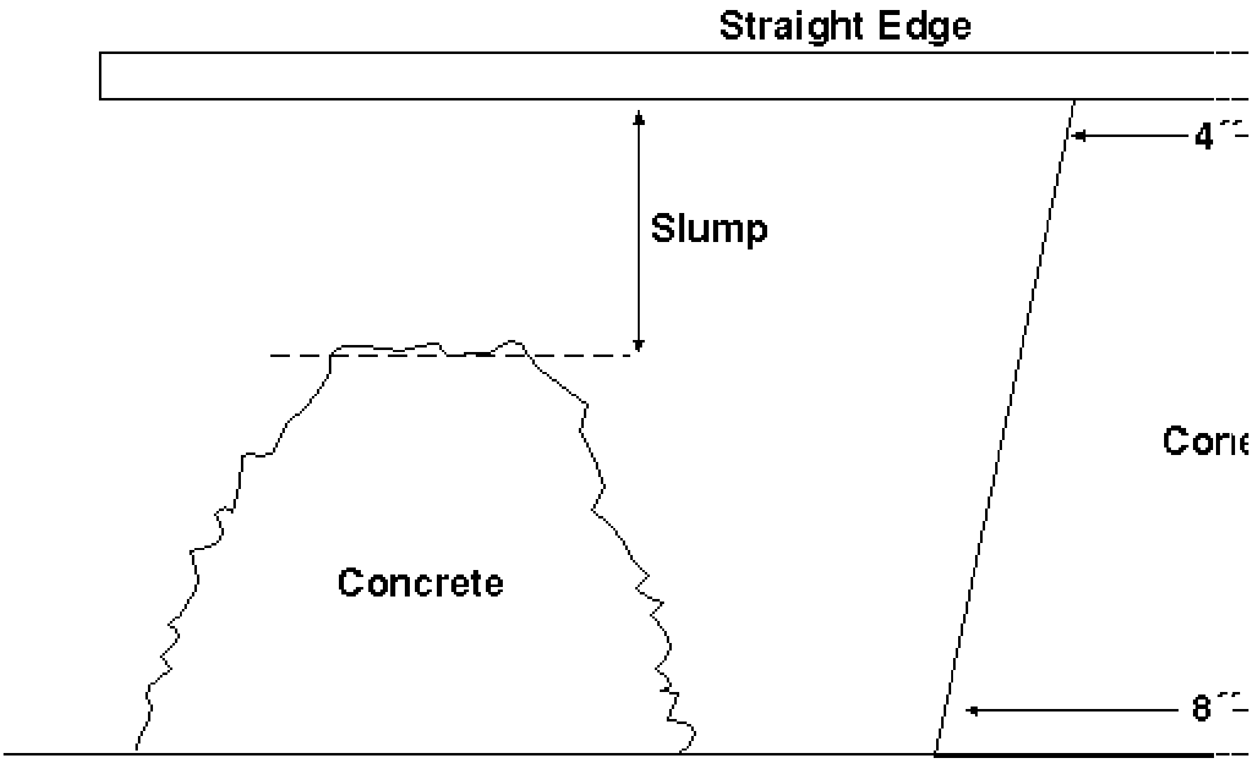
10. What are four of the common types of concrete additives, or admixtures?

    a.

    b.

    c.

    d.


Straight Edge
Slump
4"
Cone
Concrete
8"

Lesson 2: Factors Affecting the Quality of Fresh Concrete Name ___________________________

Mixing Concrete

Objective: Calculate the volume of ingredients required for a specific concrete job.

Perform the necessary calculations to figure out the volume of the raw materials needed for the concrete slab described in the problem.

Assume you are going to pour a slab that will require 11.74 cubic yards of concrete. The concrete will include ¾" aggregate, fine dry sand, and air-entrained cement. You will use a mixture of .55 gallons of water per pound. Looking at a chart, you discover that you need:

Pounds of cement per cubic yard	545
Pounds of sand per cubic yard	1,140
Pounds of gravel per cubic yard	1,800
Pounds of water per cubic yard	300

Figure the total amount of materials needed for the concrete slab. (Round to the nearest pound or gallon.)

1. Total pounds of cement __________

2. Total pounds of sand __________

3. Total pounds of gravel __________

4. Total pounds of water __________

5. Gallons of water (8.3 lbs./gal.) __________

Lesson 3: Site Preparation

Competency/Objective: Identify site preparation requirements.

Study Questions

1. What are factors in preparing a subgrade?
2. What are footings, and why are they needed?
3. How is the foundation of an agricultural structure laid out?
4. What are factors in preparing the final grade?
5. What tools are needed for site preparation?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, Unit IV, 1999.
2. Transparency Masters
   a) TM 3.1: Footing
   b) TM 3.2: Equal and Unequal Diagonals
   c) TM 3.3: Batter Boards
3. Activity Sheets
   a) AS 3.1: Site Preparation
   b) AS 3.2: Laying Out a Building

UNIT IV - CONCRETE

Lesson 3: Site Preparation

TEACHING PROCEDURES

B. ***Review***

Lesson 2 described the components of concrete and some of the factors that affect the quality of fresh concrete. To use concrete at a specific site, various steps must be taken to prepare the site for pouring concrete. Lesson 3 will discuss the various factors that influence site preparation.

C. ***Motivation***

Locate pictures of the Leaning Tower of Pisa, and show them to the students. Ask the students why the structure is leaning and what could have been done to prevent it.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Subgrade preparation can be a detailed process due to the conditions of the site. The considerations discussed in the previous question can affect the factors in preparing a subgrade. Ask the students to think about factors that should be considered when choosing a location and how they might affect the preparation of the subgrade. Have students complete AS 3.1.

   What are factors in preparing a subgrade?

   a) Drainage - If the construction site does not drain well, installing a drainage system below the site may be necessary.
   b) Removal of topsoil
      1) In some cases, the topsoil is scraped off the site with a tractor and blade prior to other excavation.
      2) The topsoil may be saved for later use, especially for landscaping the property, or sold.
   c) Removal of organic material
      1) Organic material is matter produced by plants and animals that is found in or on the soil.
      2) The organic material on the building site needs to be removed as much as possible.

        (a) Organic material does not readily mix with concrete and can even have a slightly oily surface, which further prevents mixing.
        (b) The particles in the concrete cause inclusions, or holes created when the matter eventually decays, that weaken the overall strength of the concrete.
        (c) Organic material will keep the ground from being packed tightly to support the weight of the structure, and as the material decays, settling will occur.
    3) Organic material is typically removed with a tractor and blade.

d) Removal of rocks and stones
    1) Larger rocks and stones should be removed, since they may cause major differences in the slope of the land.
    2) They can be removed using a tractor and blade.
    3) These rocks can be placed in lower areas, as well as areas with poor drainage.

e) Subgrade slope
    1) The site should be graded using a tractor and blade to create a desired slope for drainage.
    2) A 3 percent slope away from the building is considered minimal.

f) Packing or compacting
    1) Driving a tractor back and forth across the site so that the tires form a pattern across the previous tire tracks will pack the soil down.
    2) Portable, hand-operated packers are also available.
    3) Packing is commonly done using a sheep foot roller.
    4) Packing prevents differential settling of the soil.

g) Sand or aggregate fill
    1) Most construction sites use fill consisting of added sand or aggregates to create a level site and leave a more uniform surface under the concrete foundation.
    2) If the soil texture and structure do not permit proper soil drainage, placing 4 to 6 inches of sand or aggregate on the site will enhance drainage by allowing water to flow downward more readily.
    3) If fill is added, the site should be packed again after the fill is in place.

h) Vapor retarder and insulation
    1) If a drainage system cannot be used or if excessive soil moisture is a continual problem, a vapor barrier or retarder should be used under the concrete.
    2) The vapor barrier, typically polyethylene sheeting, prevents moisture from being absorbed into the concrete.
    3) In cold climates, insulation is also commonly placed under the concrete to maintain heat in the building and keep the floor warmer.

i) Dampening the site
    1) If a vapor barrier is not used and the ground is dry, the site should be sprayed with water to dampen the fill.
    2) This practice will prevent excessively dry fill from pulling water out of the concrete during the curing process.

2. Ask students what the lowest part of a building is called. How are footings prepared? Show the class TM 3.1.

What are footings, and why are they needed?

a) Footings are large supporting blocks of concrete between the foundation and the soil that are placed around the exterior edge of the building and under walls that will support the structure's weight.
b) They spread the weight of the building across a larger area and make the structure more stable.
c) Footings are necessary for several different reasons, including temperature, moisture, and soil structure.
    1) Temperature
        (a) The frost line is the deepest point in the soil where frost is normally found during the winter.
        (b) Footings located below the frost line will decrease or eliminate movement of the building due to expansion and contraction of the soil because of temperature changes.
        (c) To place the footings below the frost line, the building site must be excavated to the proper depth.
    2) Moisture
        (a) Variable levels of moisture during the year will cause the soil to expand and contract.
        (b) The building can be stabilized by placing large footings on a sand or aggregate base.
    3) Soil structure
        (a) Soils with a very loose soil structure tend to allow more settling of the building over time, which can be diminished by integrating larger than normal footings.
        (b) Certain clay soils expand and contract dramatically when wet; placing footings on a layer of sand and aggregate can reduce the movement of the building.

3. Ask students how they would determine where to place the footings. Discuss how the foundation of a structure is laid out. TM 3.2 can be used to demonstrate diagonals, and TM 3.3 shows batter boards. Have students complete AS 3.2.

How is the foundation of an agricultural structure laid out?

a) The first step in laying out a building is driving stakes into the ground where the corners of the structure are to be located.
    1) For an addition to an existing building, place the two corner stakes in relation to the building by measuring the desired distance from the building and the distance between the stakes.

2) For a new structure, drive a stake to mark the location of a corner and make measurements to the adjacent corners; after stakes are placed at these corners, make measurements from them to determine the placement of the final stake.
3) After all the corner stakes are in place, strong twine or rope is tied between them to represent the sides of the building.

b) To determine if the stakes are square on all four corners of the building, diagonal measurements should be made from the corner stakes.
1) When the measurements are identical, the building is square.
2) If the building's diagonals are not equal, the stakes must be carefully moved until the diagonal measurements are identical.
3) Because of the twine connecting the stakes, the building's dimensions remain correct.

c) The procedure for marking the corners so the stakes can be removed involves the use of batter boards.
1) Batter boards are typically either 1" × 4" or 1" × 6" boards nailed to three 2" × 4" stakes at least four feet from the corner of the building.
2) If the twine connecting the stakes is extended to the batter boards, the corner stakes can be removed because the intersection of the strings still marks the location of the corner of the building.
3) Suspending a weight like a plumb bob from where the strings intersect at the corners will ensure that the strings cross exactly at the corner of the building.
4) After the lines are in place, the position of the lines is marked, and a saw kerf about ¼ deep is sawn into the board to indicate the proper placement.
5) When the position of the lines is marked, the stakes can be safely removed.

4. Ask students to explain how to prepare the final grade.

What are factors in preparing the final grade?

a) Slope
1) The final slope of the building site can greatly influence the amount of concrete needed and the degree to which the forms will need to be leveled.

2) To determine the slope of the building site, several different methods can be used.
(a) Hand-held level
(b) Tripod-mounted transit or level, for increased accuracy

b) Fill
1) Fill needs to be added across the site to maintain the desired slope.
2) Fill is especially important if major depressions or high spots are found on the building site.
3) Low wet spots can be filled with aggregate or rocks.

5. Specific tools are used for all jobs, and site preparation for pouring concrete is no different. Although the tools are not specialized or complex, they are necessary for site preparation. Have students list tools needed.

   What tools are needed for site preparation?

   a) Tractor with a blade
   b) Compactor or packer
   c) Shovel
   d) Transit or surveyor's level with tripod and surveying rod

G. ***Other Activities***

1. Have students prepare the subgrade for a concrete project like a sidewalk or a building, such as a new greenhouse.

2. Using resources from the local assessor or county zoning commission, discuss the zoning regulations of different areas around the community. Discuss any zoning regulations that might apply to the areas around where students live and what measures need to be considered for construction in that zone.

H. ***Conclusion***

Taking the time to plan and prepare the construction site will make the rest of the building project run more smoothly and efficiently. Subgrade preparation is crucial to the construction process, since all the following steps and procedures rely upon the quality of the subgrade.

I. ***Answers to Activity Sheets***

AS 3.1

Answers will vary.

AS 3.2

1. The building will not be square unless the stakes are set at 90 degree angles.
2. Two tape measures are needed to measure the four diagonals and to place the four corner stakes.
3. The building will be crooked.

J. ***Answers to Evaluation***

1. b
2. a
3. c

4. To mark the corners of a building so stakes can be removed
5. For drainage
6. Temperature, moisture, and soil structure

7. The particles of organic matter in the concrete cause inclusions that weaken the overall strength of the concrete.

8. Answers may include any three of the following: tractor with a blade, compactor or packer, shovel, and transit or surveyor's level with tripod and surveying rod.

UNIT IV - CONCRETE Name _____

Lesson 3: Site Preparation Date ___________________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. The large support blocks under the foundation of a structure are the:

   a. Bases
   b. Footings
   c. Sills
   d. Underlayments

2. The layer of polyethylene sheeting over the subgrade is called a:

   a. Vapor barrier
   b. Sub-seal
   c. Floor wrap
   d. Soil seal

3. Which of the following factors should be focused on when preparing the final grade?

   a. Removal of rocks and stones
   b. Subsurface water
   c. Slope
   d. Removal of topsoil

Complete the following short answer questions.

4. Why are batter boards used?

5. Why is subgrade slope important?

6. What are three reasons that footings need to be used?

   a.

   b.

   c.

7. Why is organic material removed from a site?

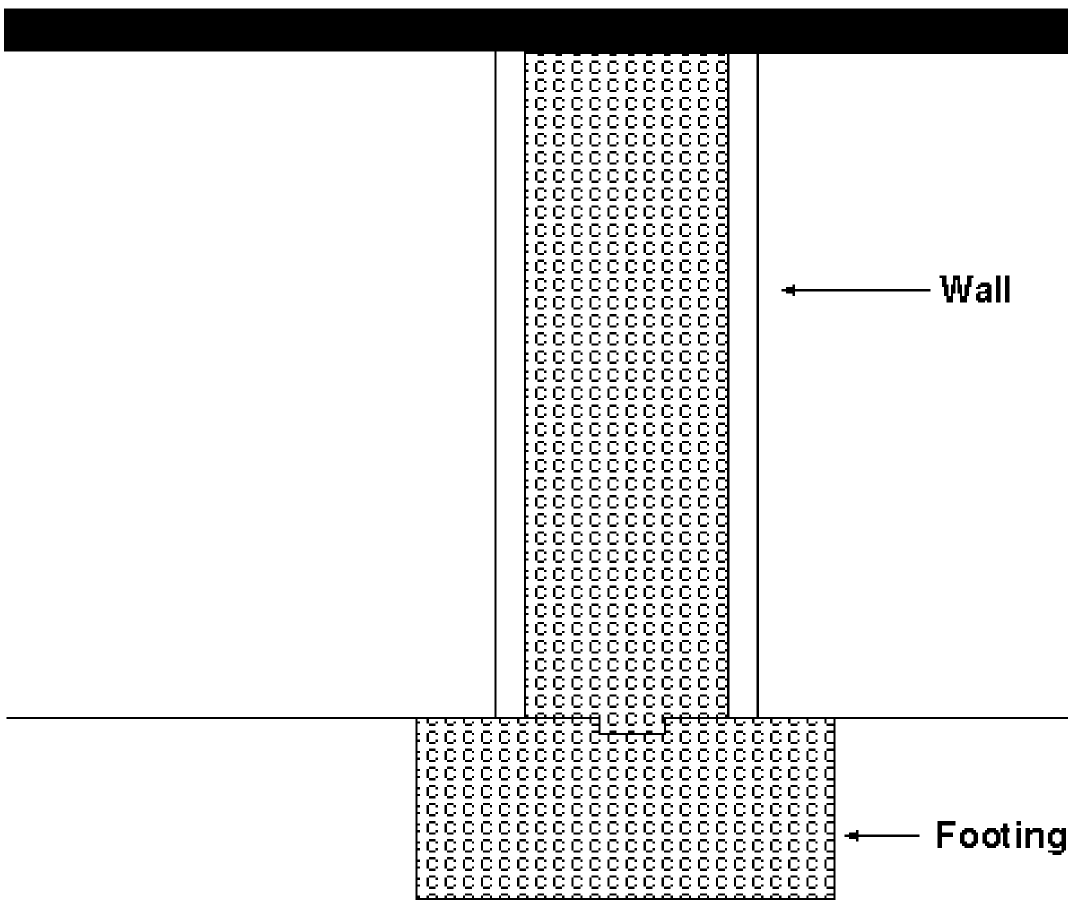
8. What are three tools used in site preparation?

   a.

   b.

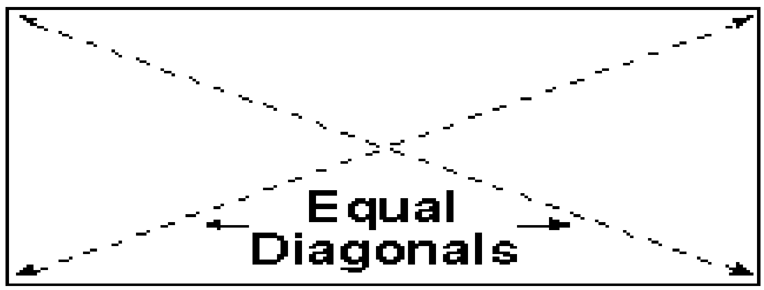
   c.

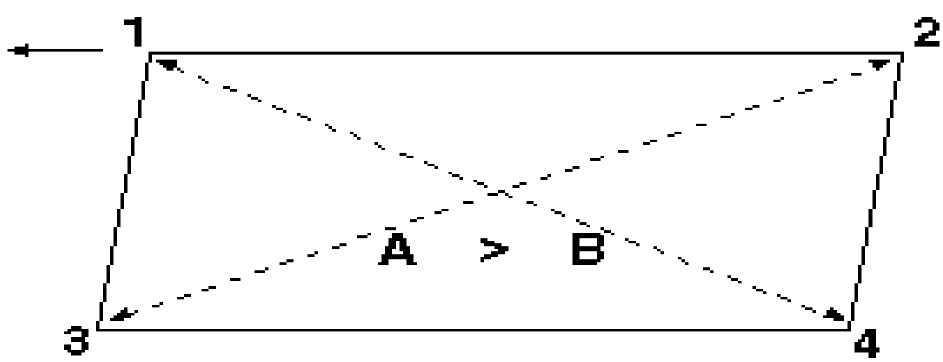
Footing

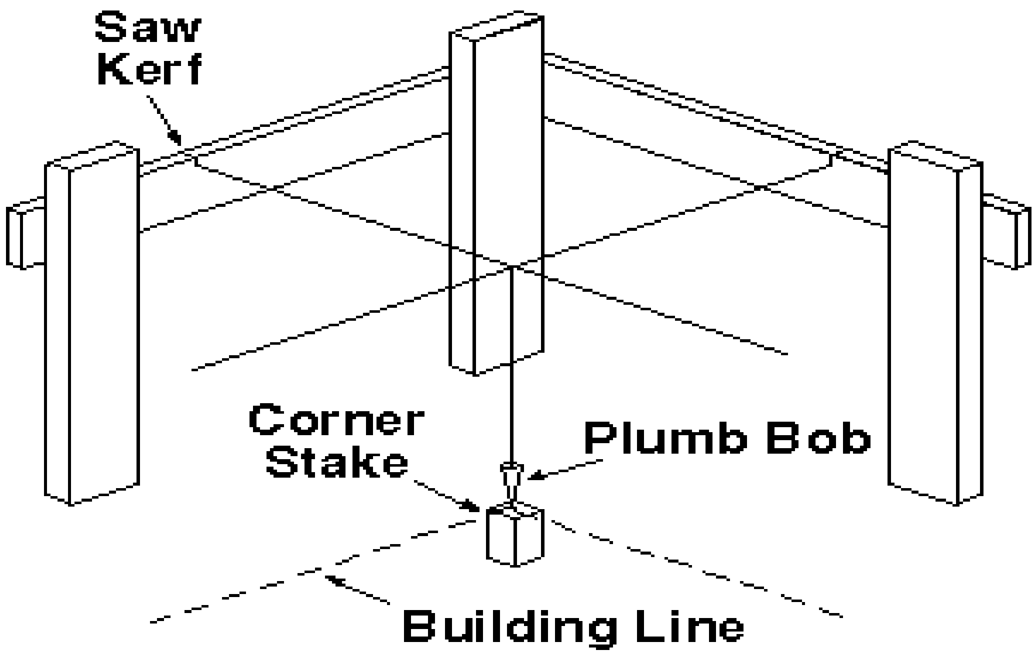


TM 3.2

Equal and Unequal Diagonals






Saw
Kerf
Corner
Stake
Plumb Bob
Building Line

Lesson 3: Site Preparation Name ____________________________

Subgrade Preparation

Objective: Explain factors that are important in the preparation of a subgrade.

Using a sample plot of land identified by your instructor, determine what work needs to be done to prepare the subgrade for construction. Based on the factors listed below, describe the steps needed to prepare the land for the type of building suggested by your instructor.

Factor/Category	Preparation
1. Drainage	
2. Removal of topsoil	
3. Removal of organic material	
4. Removal of rocks and stones	
5. Subgrade slope	
6. Packing/Compacting	

7. Sand or aggregate fill

8. Vapor retarder/insulation

9. Dampening the site

10. Removal of rocks

11. Fill

12. Frost level

13. Soil texture/structure

Lesson 3: Site Preparation Name ______________________________

Laying Out a Building

Objective: Lay out the corner stakes of an 8' × 10' building.

Materials and Equipment:

4 stakes
2 tape measures
Twine

Procedure:

1. On a spot away from other groups of students, place the first stake for a corner of your building.

2. Using the tape measure to determine the correct distance, place the second stake 8 feet away from the first stake.

3. Measuring from the first stake along a line forming a 90 degree angle to the other two stakes, place a stake 10 feet away from the first stake.

4. Using the two tape measures, measure from the second and third stakes and place the fourth corner stake the correct distance from them.

5. Join the stakes with twine.

6. Using one of the tape measures, measure both the diagonals from opposite corners. Record your measurements below.

   Diagonal 1: _________
   Diagonal 2: _________

7. If the two diagonals are equal, the building is perfectly square. If the two diagonals are not square, move the stakes.

8. Once the four stakes are in place, measure the diagonals again and record your answers above in Trial 2.

   Diagonal 1: _________
   Diagonal 2: _________

9. If the diagonals are not square, repeat steps 6 and 7 until the diagonals are equal.

Key Questions:

1. If the stakes are placed at the correct distance apart, why is the building not necessarily square?

2. Why are two tape measures needed to perform this activity?

3. If one diagonal measurement is longer than the other, how will the difference affect the later construction of the building?

UNIT IV - CONCRETE

Lesson 4: Pouring a Concrete Slab

Competency/Objectives: Describe the procedure for preparing to pour a concrete slab.

Study Questions

1. What tools are needed for pouring concrete?
2. What are forms for concrete pouring?
3. How are forms constructed for slabs?
4. What is the purpose of reinforcement in concrete?
5. What are the types of reinforcement for concrete?
6. How should reinforcement be installed?
7. What are expansion and control joints, and when are they needed?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, Unit IV, 1999.
2. Activity Sheet
    a) AS 4.1: Reinforcing Concrete

UNIT IV - CONCRETE

Lesson 4: Pouring a Concrete Slab

TEACHING PROCEDURES

B. ***Review***

Lesson 3 discussed the various factors that influence site selection and preparation. One of the most common tasks involving concrete is pouring a slab, like that found in sidewalks and driveways. This lesson will explore the equipment, procedures, and materials used in pouring a concrete slab.

C. ***Motivation***

1. Ask students if any of them have poured concrete. If so, what was the concrete used for? Ask the class if concrete poured in a slab will always be formed and constructed in the same manner.

2. Examine the concrete in the floor of the agricultural facility and the sidewalks outside the facility. Look for any cracks or breaks. Ask the students to determine what may have caused the faults in the concrete.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask the students to list the tools and equipment needed to pour concrete.

   What tools are needed for pouring concrete?

   a) Sledge and claw hammers
   b) Carpenter's level
   c) Shovel
   d) Hose and water source
   e) Tape measure
   f) Transit or surveyor's level with surveying tripod and surveyor's rod
   g) Calculator
   h) Circular saw
   i) Carpenter's or framing square
   j) Lumber
   k) 16d duplex-head nails

2. Once the equipment has been obtained, construction of the forms can begin. Ask the students to explain what forms are in relation to concrete. What is the purpose of concrete forms? Discuss the different types of forms used.

   What are forms for concrete pouring?

   a) Forms are structures designed to hold the concrete in proper shape and location until it sets and hardens.
   b) Forms can be constructed of different materials.
      1) Wood forms
         (a) Wood forms for pouring a sidewalk or slab are usually made of 2" × 4" or 2" × 6" boards.
         (b) If plywood is used, SP plywood, or plyform, should be utilized; it is a special plywood made with a waterproof glue that repels the moisture in the concrete so the concrete will not be dried out by the forms.
         (c) Hardboard is sometimes used when forming curves because of its strength and flexibility.
         (d) Wood forms are typically less expensive and easier to construct.
      2) Aluminum or metal alloy forms
         (a) Aluminum or metal alloy forms will give a smoother, more uniform finish to the concrete.
         (b) They are structurally stronger than wood forms.
         (c) They will yield extremely straight, square concrete, since the forms do not bend or sway like wood forms will.
         (d) Aluminum or metal alloy forms are easy to construct and relatively inexpensive
      3) Earthen forms
         (a) Earthen forms can be constructed by shoveling soil in a pile in the desired location.
         (b) The earth is covered with a plastic lining to prevent soil from mixing with the concrete and to keep moisture from bleeding out of the concrete into the soil.
         (c) Earthen forms are rarely used and result in a poor quality slab.

3. Ask students how they would construct wooden forms. How are the forms braced?

   How are forms constructed for slabs?

   a) Determine the desired height of the forms.
      1) If a 4-inch slab is to be poured, 2" × 4" boards are used, but if the board has been planed or smoothed, the end product is only 1½" × 3½".
      2) This board size can be used for forming a 4-inch slab if soil has been placed on the outside of the form to strengthen it and close the opening at the bottom.

3) If thicker slabs are desirable, wider boards, such as 6-inch or 8-inch boards, are required.

b) Using the strings placed in laying out the corner stakes of the slab, put the edge of the boards directly underneath the string.
   1) Small stakes should be driven at least 6 inches into the ground with a hammer every 4 feet along the outside of the boards.
   2) The top of the stakes must be below the edge of the form to allow the slab to be worked as the concrete dries.
   3) The stakes are nailed to the boards using duplex-head nails attached on the outside of the forms.

c) Double check the forms to see if they are square by measuring the diagonals with a tape measure; if they are not, the forms should be adjusted.

d) Once the forms are square, determine if the forms are level by using the transit or level, tripod, and rod.
   1) If they are not level, the hammer can be used on the higher spots of the form to decrease its height.
   2) At this point, whether the slab should slope or be level should be considered.
      (a) If water or manure drainage is a concern, the slab should have at least a 4 percent slope in the direction that the excess water or manure should run off.
      (b) This slope should be figured into the final placement of the forms.

e) If the slab is to curve, plywood can be used in place of boards to make the forms.
   1) The plywood should be cut so the grain of the plywood runs vertically, because the stress from the concrete would crack or break the form if the grain ran horizontally.
   2) The stakes should be placed only 1 to 2 feet apart on curves instead of every 4 feet.

f) Forms should be secured tightly at the corners to prevent them from separating; sometimes they are attached using bolts or screws.

4. Often concrete by itself is not strong enough to handle the stress of the forces acting on it. Discuss the purposes of reinforcement. Ask students to list examples of concrete slabs that would be under great stress.

What is the purpose of reinforcement in concrete?

a) Reinforcement can strengthen the concrete and help it to resist the forces acting on it.
   1) Concrete has great compressive strength, which is the strength to resist forces pressing downward on the concrete.
   2) Concrete does not have good tensile strength, which is the ability to withstand tension or pull.

3) Reinforcing the concrete will increase its tensile strength, especially at the edge of the slab.

b) Reinforcement will also reduce the tendency of the concrete to crack due to changes in temperature.

5. Have students list materials they think would work as reinforcement in concrete. Discuss the methods of reinforcing concrete.

What are the types of reinforcement for concrete?

a) The most common types of reinforcement are made of steel.
b) Steel has high tensile strength, which helps resist the forces acting on the concrete.
c) The steel used in concrete for reinforcement must be clean and free of rust and organic debris like leaves.
d) In some cases, specially manufactured fibers can be added to the concrete as reinforcement in place of structural steel.
e) Steel rods are also commonly known as reinforcing bars, or rebar.
    1) Can be purchased in a variety of sizes, from ¼ inch up to 2 inches in diameter
    2) Typically sold in lengths of 20 feet and cut to fit
    3) Identified by a number, like 2, 3, 4, 5, or 6, that refer to the diameter of the rod, expressed in eighths of an inch
f) The other common type of reinforcement is steel wire mesh.
    1) Consists of rods of steel wire joined in a criss-cross pattern to form a mesh
    2) Comes in a number of different diameters, ranging from 0000 (small) up to 16 gauge
    3) Differ in the spacing between the wire rods in the mesh; common spacings are 2, 3, 4, 6, 8, 10, 12, and 16 inches
    4) Sold in rolls with common widths of 36, 42, 48, and 60 inches and in common lengths of 150, 200, and 300 feet

6. Ask students how they would install the different types of reinforcement.

How should reinforcement be installed?

a) Steel reinforcement
    1) Steel reinforcement should be placed in the bottom half of the slab, where the tensile forces on the concrete are the greatest; the reinforcement is placed approximately 1 inch above the soil or fill by wiring it to 12-inch rebar stakes that have been driven into the ground.
    2) Both rods and wire mesh need to be joined where they meet.
        (a) Rebar should overlap by a length that is equal to 24 times the diameter of the rod and not less than 12 inches, while mesh should be overlapped one full square spacing plus 2 inches.

(b) The reinforcement should be tied with thin wire where the bars or wire mesh meet.

3) When installing steel reinforcement, be sure to place the rebar or mesh around the outside edges of the slab.

4) The ends of the reinforcement should be placed at least 3 inches from the very edge of the slab, so that it does not eventually stick out of the edge of the concrete and pose a hazard.

b) Thickened edges

1) Thickened edges involve placing a thicker, deeper layer of concrete at the edges of a concrete slab as a type of footing.

(a) The edge should be 4 to 6 inches thicker than the slab itself.

(b) The base of the thickened area should be 12 inches wide, with a 45-degree slope from the bottom of the main slab to the bottom of the thickened edge.

2) This type of reinforcement is used on the perimeter of feeding floors and driveway edges where livestock or vehicles enter the paved area.

7. When placing larger slabs of concrete like a concrete pad or sidewalk, the slab will sometimes move. Ask students to examine the sidewalks outside the agricultural facility or school. What is the purpose of the lines in the concrete? Have students complete AS 4.1.

What are expansion and control joints, and when are they needed?

a) Expansion and control joints may either be grooves made in the concrete or material placed in the concrete to prevent breaks or control where the concrete breaks.

1) Joints can often prevent breakage, but if the concrete does break, these devices will also limit the location and force the break to form a straight line.

2) The straight grooves commonly seen across sidewalks and driveways are expansion and control joints.

b) Expansion and control joints can be made using several different methods.

1) For joints consisting of grooves in the concrete, a piece of angle iron or a v-shaped piece of wood can be pushed in a straight line through the drying concrete.

2) A mason’s trowel can also be used to inscribe a groove into the drying concrete.

3) Another method is to saw grooves in the concrete, cutting the joints into the dried concrete with a masonry saw 4 to 12 hours after the concrete is poured.

4) An alternative method of installing expansion and control joints is to place small strips of IKO board on edge in the form before the concrete is poured.

(a) Expansion and control joints should always be placed in straight lines perpendicular to each other.

(b) For slabs 4 inches thick or less, joints should be made in the concrete every 10 feet; for slabs 6 inches thick, joints should be included every 15 feet.

G. ***Other Activities***

Have the students form and pour a sidewalk or small concrete slab at the agricultural facility or school. Be sure to include reinforcement and control joints.

H. ***Conclusion***

One of the most common tasks when working with concrete is pouring a slab. This lesson outlined the tools used in pouring a concrete slab, the procedure for laying out and forming concrete slabs, the methods of reinforcing concrete, and the use of expansion and control joints. Through careful attention to the procedures described, a concrete slab can be placed with minimal concrete defects.

I. ***Answers to Activity Sheets***

AS 4.1

1. Answers will vary.
2. Answers will vary.
3. Sidewalks and edges of driveways, etc.

J. ***Answers to Evaluation***

1. b
2. d
3. a
4. b

5. Rods and wire mesh

6. Rebar should overlap by a length that is equal to 24 times the diameter of the rod and not less than 12 inches, while mesh should be overlapped one full square spacing plus 2 inches. Both should be tied together with thin wire.

7. Expansion and control joints may either be grooves made in the concrete or material placed in the concrete to prevent or control where the concrete breaks.

8. Answers may include any three of the following: sledge and claw hammers, carpenter’s level, shovel, hose and water source, tape measure, transit or surveyor’s level with a surveying tripod and surveyor’s rod, calculator, circular saw, carpenter’s or framing square, lumber, and 16d duplex-head nails.

9. Reinforcement can increase the tensile strength of concrete and help it to resist the forces acting on it; it will also reduce the tendency of the concrete to crack due to changes in temperature.

10. Determining the desired height of the forms

UNIT IV - CONCRETE Name _____

Lesson 4: Pouring a Concrete Slab Date ___________________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. The plywood used for concrete forms should:

   a. Be a special color.
   b. Be made with waterproof glue.
   c. Have lots of knots.
   d. Have a special type of grain.

2. Aluminum or alloy forms are _______________________ than wood.

   a. Easier to build
   b. Poorer in quality
   c. Weaker
   d. More expensive

3. Earthen forms should be lined with:

   a. Plastic.
   b. Clay.
   c. Organic material.
   d. Oil.

4. What is the minimal amount of slope on a slab for drainage?

   a. 3 percent
   b. 4 percent
   c. 8 percent
   d. 15 percent

Complete the following short answer questions.

5. What are the two most common steel reinforcement materials used in concrete?

   a.

   b.

6. How should reinforcement materials be overlapped during installation?

7. What are expansion and control joints?

8. What are three tools needed for pouring concrete?

   a.

   b.

   c.

9. What are two purposes of reinforcement?

   a.

   b.

10. What is the first step in constructing wooden forms?

Lesson 4: Pouring a Concrete Slab Name ________________________

Reinforcing Concrete

Objective: Compare the strength of reinforced and non-reinforced concrete.

Materials and Equipment:

1 8-foot 1" × 6" board
20 16d duplex-head nails
_” welding wire
Wax paper or plastic wrap
Latex gloves
Eye protection
Concrete mix

Procedure:

NOTE: Safety glasses and gloves should be worn whenever working with concrete to protect your eyes from splashing concrete and your skin from chemical burns from the reaction of the cement and water.

1. Construct two forms from the materials provided. The forms should have inside measurements of 2" × 3" × 24". The forms will basically be open-topped boxes into which the concrete will be poured.

2. Line the forms with wax paper or plastic wrap to prevent the concrete from sticking to the wood in the forms.

3. In one of the forms, place two pieces of rebar 3/4 of an inch from the bottom. Do not place rebar in the second box. Support the rebar with small supports made from welding or other stiff wire. These supports are made in the shape of a capital letter M, with the rebar resting in the valley on top of the M.

4. Pour concrete into both of the boxes. Be sure to not displace the rebar.

5. As the concrete is drying, write your name in the concrete in both forms. This will identify your samples and indicate which side of the concrete was up when it was poured.

6. Allow the concrete to cure for seven days.

7. After seven days, remove the forms and place the concrete on top of two sturdy supports with your name facing upwards.

8. Using a large hammer, strike both beams of concrete as close to the middle as possible.

Key Questions:

1. What happened to each of the samples when they were struck with a hammer?

2. What effect did the rebar have on the strength of the concrete?

3. What are two examples of locations where additional strength would be needed for concrete?

   a.

   b.

UNIT IV- CONCRETE

Lesson 5: Ordering, Pouring, and Finishing Concrete

Competency/Objective: Explain the procedure for ordering, pouring, and finishing concrete.

Study Questions

1. How is the necessary quantity of concrete calculated?

2. What are factors to consider when ordering concrete?

3. What are the procedures for pouring a slab?

4. What are the different types of concrete finishes and their applications?

5. What are the procedures for different finishes?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, Unit IV, 1999.

2. Job Sheet

   a) JS 5.1: Pouring a Concrete Curb

TEACHING PROCEDURES

B. ***Review***

Lesson 4 discussed the procedures for constructing forms and reinforcing a concrete slab. This lesson will examine the calculations needed for ordering concrete, the procedures for pouring and finishing concrete slabs, and the different types of finishes that can be used.

C. ***Motivation***

Ask students to compare the differences between the concrete in sidewalks around the school and the concrete that forms the floor of the laboratory. Why are the two concrete slabs different?

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. When large quantities of concrete are needed, people often order the concrete from a ready-mix business. Ask students how they would order the concrete for a slab the size of the classroom.

   How is the necessary quantity of concrete calculated?

   a) Concrete is ordered in cubic yards.
   b) One cubic yard is equal to 27 cubic feet.
   c) For a rectangular slab, multiply the length, width, and depth in feet of the slab, and divide this number by 27.

$$\text{Length (ft.)} \times \textit{Width}\,(\textit{ft.}) \times \textit{Depth}\,(\textit{ft.}) \times \frac{\textit{yd.}^3}{27\ \textit{ft.}^3} = \textit{Cubic yards of concrete}$$

   d) If the slab to be poured is circular, the formula for the volume of a circle is used to calculate the amount of concrete needed.

$$\pi\,(3.14) \times \textit{Radius}^2\ (\textit{ft.}^2) \times \textit{Depth}\,(\textit{ft.}) \times \frac{\textit{yd.}^3}{27\ \textit{ft.}^3} = \textit{Cubic yards of concrete}$$

   e) When ordering concrete, the amount ordered will usually be more than the amount calculated by a factor of 10 to 25 percent.
      1) Multiply the amount needed by 1.1 or 1.25 to provide the extra concrete.
      2) The additional material will make up for any spilled concrete and differences in soil or fill level, especially for low spots.

2. When deciding to order concrete, a number of issues should be addressed. Ask the students if the same type of concrete would be ordered for all situations. What other factors should be considered when placing an order for concrete?

   What are factors to consider when ordering concrete?

   a) Weather

1) Concrete should preferably not be poured in a rain storm or when temperatures are below 40 degrees or above 85 degrees.

2) These weather conditions will affect the rate of curing, or hardening, of the concrete as well as the overall final strength of the concrete.

3) Calcium chloride has to be added to the mix for pouring concrete in cold weather.

b) Conditions affecting the type of cement needed - The concrete mix may include different types of Portland cement, depending on factors such as whether the concrete is to be poured on alkaline soils or in areas where heat may build up, whether the concrete needs strength in the first two to three days, or whether the heat generated by the concrete needs to be reduced.

c) Labor needs and availability - The arrival of the delivery truck should be timed to occur when sufficient labor will be available.

d) Access to the area by truck

1) Most ready-mix businesses offer trucks with extension slides to allow the concrete to be poured over greater distances and avoid hauling the concrete in wheelbarrows.

2) Companies generally also have a few trucks that can pump the concrete to a location higher than the tires of the truck.

e) Water needs

1) The site needs to be sprayed with water if the fill is dry.

2) The concrete is sprinkled with water as it cures to increase the moisture content and improve the strength of the finished concrete.

3) Water will be used to clean equipment.

3. After the concrete has been ordered and delivered, it is time to pour the concrete. Ask the students what procedure they would follow in pouring a slab.

What are the procedures for pouring a slab?

a) The site needs to be moistened while the concrete is being delivered or mixed on site.

b) The concrete should be poured as soon as possible after its arrival at the site or after being mixed.

1) Maximizes the amount of moisture in the concrete, increasing its strength

2) Aids in maintaining the proper slump

c) An important point to remember is that concrete will begin to set 30 to 60 minutes after pouring.

1) Results in reduced strength if the concrete is moved in any way during the first hour after pouring

2) Should move the truck or mixer as close as possible to the final location of the concrete to avoid having to move it in wheelbarrows

d) The chute, or discharge tube, should be placed as close to the ground as possible when unloading the concrete; if the chute is too high, the impact will partially separate the aggregate from the cement mixture.

e) As the concrete fills the forms, a shovel or spade should be pushed through it, especially at the edges.

1) Will mix the aggregate well and move it away from the edge somewhat, resulting in a smoother finish at the edges

2) Removes any air bubbles that may have resulted from pouring, giving the concrete more strength

f) If the slab to be poured is wider than 10 feet, pouring the slab in two or more sections should be considered because slabs wider than 10 feet will be more difficult to finish.

4. The surface of the concrete can be worked to create finishes with several different textures. Ask the students to describe the different finishes they have seen and where they were used. Why was that particular type of surface chosen for that area?

What are the different types of concrete finishes and their applications?

a) Smooth - used where ease of cleaning is desired, as for floors in a shop, house, or grain bin

b) Rough - for traction on sidewalks, livestock walkways, inclined walks, and steps

c) Aggregate - consists of exposed rocks on the surface of the concrete; used for traction and decorative purposes anywhere a decorative surface is desired, such as sidewalks

5. The processes for creating each of these different types of finishes are somewhat different. However, they all must be done carefully to produce the desired surface. Have students describe the process they would follow for each of the finishes. Have students complete JS 5.1.

What are the procedures for the different finishes?

a) Smooth
   1) Screed the concrete.
      (a) Screeding the concrete involves moving a board across the concrete along the top of the forms.
      (b) This process will move concrete into lower spots inside the form and remove excess concrete.
      (c) Screeding is typically done by moving a straight 2" × 4" board back and forth at a 90-degree angle to the edge of the form.
   2) Use a bull float to work the aggregate below the surface.
      (a) A bull float is a wide board or flat piece of aluminum that is held level with the surface and tipped up slightly along the front edge as it moves across the concrete.
      (b) The float will force the aggregate below the surface, leaving the concrete relatively smooth.
   3) Remove the ridges left by the bull float using a power trowel, steel hand trowel, or magnesium hand float.
      (a) If the person pouring the concrete has access to a power trowel, it should be used; the power trowel works in a circular pattern to smooth away any edges, leaving a very smooth surface overall.
      (b) If a power trowel is not available, a steel hand trowel can be used to achieve the same effect.
      (c) The hand trowel or magnesium float should be worked in curving motions, with the front edge sloped slightly upward to help compact the surface.
   4) An edger should be used along the forms as the concrete begins to set to separate it from the forms and leave a slightly rounded edge.
   5) At the same time, control or expansion joints should be applied if they are needed.

b) Rough
   1) Screed the surface.
   2) Use a bull float to force the aggregate down.
   3) Remove the ridges using a power trowel or hand trowel.
   4) Pull a push broom across the surface of the curing concrete to leave small, even grooves in the concrete that will reduce slippage and increase traction, especially if water freezes on the surface.
   5) An edger is used along the forms.
   6) Expansion and control joints are then applied.

c) Exposed aggregate
   1) Screed the concrete.
   2) Work it with a bull float.
   3) Lightly work the concrete with a power or hand trowel, with less concern for creating a smooth surface.
   4) To add the aggregate to the finish, evenly apply a layer consisting only of aggregate over the surface.
      (a) This layer of aggregate is embedded using a board similar to the screed to force the aggregate into the concrete to a depth of about one half of its diameter.
      (b) The aggregate should not be forced too far into the concrete, because the desired finish will be reduced
   5) Allow the concrete to dry until surface water disappears.
   6) After the water has evaporated and the mixture can support a person’s weight, use a hose and bristle broom to remove any film of concrete on the surface of the exposed aggregate.

G. ***Other Activities***

Tour a local ready-mix facility to learn the steps involved in mixing, delivering, and pouring concrete.

H. ***Conclusion***

Ordering the concrete required for a specific job is the first step in preparing to pour a concrete slab. Once the concrete arrives, it is carefully poured and finished to meet the needs of the construction project. If the procedures described in this lesson are followed, the slab poured will consist of high quality, lasting concrete.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. a
2. c
3. d
4. b
5. c
6. d
7. b
8. $(120 \times 4 \times .33) / 27 = 5.87$ cubic yards
9. $5.87 \times 1.1 = 6.46$ cubic yards
10. Answers may include any three of the following: weather, conditions affecting the type of cement needed, labor needs and availability, access to the area by truck, and water needs.

UNIT IV: CONCRETE Name______

Lesson 5: Ordering, Pouring, and Finishing Concrete Date___

EVALUATION

Circle the letter that corresponds to the best answer.

1. The process of leveling the concrete with the top of the forms is called:

   a. Screeding.
   b. Floating.
   c. Finishing.
   d. Smoothing.

2. What is the preferred maximum width of forms for a slab?

   a. None
   b. 5 feet
   c. 10 feet
   d. 15 feet

3. The type of concrete finish where the rocks are exposed is called:

   a. Smooth.
   b. Rough.
   c. Hard.
   d. Aggregate.

4. The concrete finish that should be used on ramps leading into livestock barns is:

   a. Smooth.
   b. Rough.
   c. Rocky.
   d. Aggregate.

5. Which tool is used to work the aggregate below the surface of the concrete during finishing?

   a. Trowel
   b. Screed
   c. Bull float
   d. Shovels

6. Which tool would be used for the final step on a smooth finish?

   a. Bull float
   b. Darby
   c. Screed
   d. Magnesium hand float

7. Control joints can be made in newly formed concrete:

a. Immediately after the concrete is poured.

b. At the end of the finishing process.

c. Between screeding and floating.

d. At any time.

Complete the following short answer questions.

8. How much concrete would be needed for a sidewalk that is 120 feet long, 4 feet wide, and 4 inches thick?

9. Overestimating the amount needed for question 8 by 10 percent, how much concrete should be ordered?

10. What are three factors that are important to consider when ordering concrete?

    a.

    b.

    c.

Lesson 5: Ordering, Pouring, and Finishing Concrete Name__

Pouring a Concrete Curb

Objective: Pour concrete to make a curb.

Materials and Equipment:

Wood and duplex nails for forms
Tape measure
Concrete
2 1" pipes, 1' long
Wire
Rebar
Wire for rebar supports
Shovel or spade
Oil
Hand trowel
Board for screed
Latex gloves
Eye protection

Procedure:

1. The purpose of this exercise is to build curbs like those found in a parking lot. Since the size of concrete curbs varies, measurements should be taken of the curbs already in place to duplicate their size.

2. Construct a form using the materials provided by your instructor. Build the form so that the curb is upside down, leaving a larger opening for pouring the concrete. Be sure to use duplex nails so the form can be removed more easily after the concrete has set.

3. Once the form is finished, insert rebar reinforcement into it using wire supports to hold it in place. Since the form is upside down, the rebar will now be at the top of the form.

4. Approximately two feet from each end of the form, insert an oil-covered pipe vertically into the form. The pipes will be removed after the concrete has set, leaving anchor holes through the curb. Support the pipe with wire wrapped around the form.

5. If the concrete is being mixed by the class, mix the concrete. If the concrete is being ordered, the next step depends on the arrival of the truck.

6. When the concrete is ready, begin pouring the concrete into the forms. Pour until the form is filled halfway and then use a spade or shovel to work up and down through the concrete, especially around the edges. This will remove air bubbles and move the aggregate away from the edges, creating a smoother finish.

7. Pour the concrete to the top of the form. Using a spade or shovel, work the concrete that was added to the form to remove air pockets.

8. Using a straight board as a screed, work the top until the entire surface is level and even.

9. Allow the concrete to begin to set.

10. Once the surface of the concrete starts to dry and no water is standing on top of the poured concrete, take a small hand trowel and smooth the surface of the curb.

11. Allow the curb to cure for at least three to four days or preferably up to one week for maximum strength. If the curing is done outside, sprinkle water on the surface of the concrete once or twice a day for the first two to three days.

12. After the concrete has set completely, remove the pipes and turn the form over to remove the curb. If necessary, remove the ends of the form to separate the curb from the form.

UNIT IV - CONCRETE

Lesson 6: Curing Concrete

Competency/Objective: Identify factors affecting the quality of cured concrete.

Study Questions

1. What is the process of concrete curing?

2. Why is curing important?

3. What are the methods of curing concrete?

4. What are the different types of concrete defects?

5. When and how should forms be removed?

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit IV.

2. Activity Sheet

   a) AS 6.1: Curing Concrete

UNIT IV - CONCRETE

Lesson 6: Curing Concrete

TEACHING PROCEDURES

A. ***Review***

Lesson 5 discussed the processes of pouring and finishing concrete. Perhaps the most important stage in working with concrete is the actual curing of the concrete. This lesson will explore the process of curing and the causes of common defects in concrete.

B. ***Motivation***

Ask students to explain how concrete hardens. One common answer will be that the concrete dries out as water evaporates. If they give this answer, have students explain why the concrete remains in a particular shape after drying and does not crumble away into the dry ingredients.

C. ***Assignment***

D. ***Supervised Study***

E. ***Discussion***

1. After the concrete is poured into the molds and finished, the concrete needs to harden. Ask the students why the concrete hardens.

   What is the process of concrete curing?

   a) Curing is the hardening of concrete.
   b) Curing is the result of hydration, which is the mixing of a compound with water.
   c) The curing process involves a chemical reaction between water and the elements in Portland cement.
   d) As the cement starts to react with the water, a substance called a gel is formed from the chemicals in the cement and water.
   e) Eventually the gel becomes a solid mass, thickening and hardening the concrete.
   f) The rate of curing for pure concrete without additives is affected by temperature.
      1) Between 65 and 75 degrees Fahrenheit - ideal temperatures for curing
      2) Higher than 75 degrees - will cause the concrete to cure too quickly
      3) Between 32 and 65 degrees Fahrenheit - concrete will cure, but more slowly
      4) Below 32 degrees - will not cure
   g) The length of time that pure concrete is allowed to cure depends on the outside temperature.
      1) Above 70 degrees Fahrenheit - at least five days
      2) 50 to 70 degrees Fahrenheit - at least seven days
      3) Less than 50 degrees Fahrenheit - at least seven to ten days and preferably longer
      4) Ideal curing time - 28 days

2. Ask students what would happen if the concrete did not cure completely. What effect would it have on the concrete?

   Why is curing important?

   a) Causes the concrete to harden and determines its strength

1) To a point, the more water the concrete can retain, the greater its strength will be.

2) For maximum strength, the concrete must have adequate water to continue the chemical reaction until it has completely hardened.

b) Gives concrete the ability to hold water in or out

3. Have the students list conditions that might affect curing concrete. What changes may be made to the curing process to counteract these conditions? Hand out AS 6.1.

What are the methods of curing concrete?

a) Cold weather curing
   1) Do not pour concrete onto frozen soil, because the ground will cause the water in the concrete to freeze; heat the ground using propane torches.
   2) When pouring concrete in temperatures below 50 degrees Fahrenheit, heat the concrete so that it is between 60 and 80 degrees Fahrenheit by heating the water added to the mixture.
   3) Provide protection for the forms in order to retain the heat.
      (a) Consists of straw, plastic, or paper spread directly on the surface of the concrete
      (b) Should remain over the concrete for at least 48 hours, and preferably for four to five days
   4) Another option for heating the concrete is to build an enclosure around the forms and heat the entire area with fuel-burning heaters.
      (a) Should be used with caution because of the carbon dioxide they give off, which sometimes reacts with the concrete to form a thin layer of calcium carbonate over its surface
      (b) Requires adequate ventilation for the exhaust fumes
   5) Leave the forms around the concrete for as long as possible to act as insulation.
   6) One way to test whether the concrete froze during curing is to pour hot water on it.

b) Hot weather curing
   1) If outside temperatures are above 80 degrees Fahrenheit, more water will be needed in the concrete mixture to maintain the optimal slump of 1 to 3 inches.
   2) High temperatures will also shorten the time that the concrete can be worked or finished; reduce the time needed for pouring by having plenty of labor available.
   3) Hot weather can cause incomplete curing due to the rapid curing of the outside layer of the concrete.
   4) Several methods can be used to keep the concrete cool.
      (a) Adding cold water
      (b) Dampening the subgrade
      (c) Placing wet burlap over the concrete
      (d) Lightly spraying cold water on the concrete

c) Moist curing
   1) Retaining the moisture on the surface of the concrete is called moist curing.
   2) Moist curing can be accomplished using a variety of methods.
      (a) Placing moist burlap sacks over the surface of the concrete
      (b) Spraying the surface with water
      (c) Covering it with waterproof paper
      (d) Covering the surface with plastic sheets
      (e) Spraying the concrete with a curing compound, which places a chemical membrane over the concrete to seal in the moisture

4. After curing, different types of defects may become apparent. Ask students to describe concrete defects that they have seen. Discuss the sources of various types of faults.

What are the different types of concrete defects?

a) Honeycomb surface
   1) Results from the use of a concrete mixture that was too dry and needed more water to mix completely
   2) Causes air pockets around the unmixed dry materials, resulting in a honeycomb structure
   3) Prevention
      (a) Moist enough mix
      (b) Spading the edges of the forms to avoid dry spots
b) Air pocket
   1) A hole left in the concrete after curing due to the presence of a confined body of air
   2) Prevention
      (a) Spading the edge of the forms
      (b) Wiping oil on the surface of the forms
c) Rock pocket or gravel streak - caused by cracks or knotholes in the forms that allow the mortar to flow out, leaving pockets and veins of coarse aggregate
d) Sand streaking
   1) Involves small ribbons of sand running across the surface of the concrete
   2) Caused by a mixture that was too wet, which allows the coarse aggregates to sink and separate out from the rest of the mixture, leaving the fine aggregate to work to the top
e) Red to pink stain
   1) The result of the resin in the plywood forms reacting with the concrete
   2) Will generally happen with forms used for the first time and will diminish with continued use
   3) Can be reduced by using older forms
   4) Difficult to remove but will fade and disappear in time
f) Rust stain
   1) Caused by steel reinforcement that has worked to the edge or surface of the concrete
   2) Can be cleaned from the concrete using a chemical solution of diluted oxalic acid but will reappear as long as the exposed metal is present
g) Dusting
   1) The appearance of a powdery material on the surface of newly hardened concrete
   2) Causes
      (a) Excess clay or silt in the concrete
      (b) Premature floating and troweling
      (c) Addition of carbon dioxide from heating systems
      (d) Condensation of water on the surface before floating and troweling have been completed
      (e) Dry-heat heaters that lower the humidity too quickly and cause incomplete curing
      (f) Inadequate or no curing due to insufficient water in the mixture
h) Scaling
   1) Occurs when the surface of hardened concrete slabs breaks away to a depth of 1/16 to 3/16 of an inch
   2) Causes
      (a) Freezing and thawing of newly placed concrete
      (b) Freezing and thawing of concrete that is not air-entrained
      (c) Application of deicing salts on concrete that is not air-entrained
      (d) Faulty workmanship caused by finishing the concrete while it was still “bleeding” or giving off water
i) Crazing

1) The presence of numerous fine hairline cracks in the surface of a newly hardened slab due to shrinkage
2) Causes
   (a) Rapid surface drying by the sun or wind
   (b) Premature floating and troweling on a moist surface along with the rapid loss of moisture
   (c) Overuse of tools such as a power screed or bull float, which works too much mortar to the surface of the concrete

5. After the concrete has cured, it is time to remove the forms. Ask students to describe how and when the forms should be removed.

When and how should forms be removed?

a) Remove the forms when the concrete has cured sufficiently to support its own weight.
   1) In summer or warm weather conditions - two days after pouring
   2) In winter or cold weather conditions - at least four to seven days
   3) Can be removed in less time if accelerating additives are used; can cut the curing time in half
b) Any reinforcement around the forms should be loosened prior to their removal, including all the duplex nails holding the forms together.
c) If the forms were properly coated with oil, they should come away easily, without the use of force.
d) The forms should then be cleaned to remove any concrete residue before storing them away for future use.
e) The slab can be cleaned with water once the forms have been removed.

F. ***Other Activities***

Observe the concrete around the school. Have students look for defects. Discuss what could have been done to avoid these problems.

G. ***Conclusion***

Concrete curing is caused by the reaction of water and cement; it allows the concrete to harden and gain strength. The process of curing concrete may vary depending on weather and temperature conditions. When the concrete is cured to the point that it can support its own weight, the forms may be removed. Various types of defects may become apparent after curing if the concrete was not mixed or worked properly.

H. ***Answers to Activity Sheet***

1. The concrete cured at room temperature should be the strongest for each test. The other environments are too wet, too cold, too hot, or too dry.
2. The concrete should get stronger as the length of time increases.
3. Concrete should be cured at room temperature and for longer periods of time, up to 28 days.

I. ***Answers to Evaluation***

1. d
2. d
3. a
4. c
5. c
6. d

7. Answers may include any three of the following: excess clay or silt in the concrete, premature floating and troweling, addition of carbon dioxide from heating systems, condensation of water on the surface before floating and troweling have been completed, dry-heat heaters that lower the humidity too quickly and cause incomplete curing, and inadequate or no curing due to insufficient water in the mixture.

8. Adding cold water to the concrete mix
9. Curing is important because it causes the concrete to harden and strengthen and because it gives concrete the ability to hold water in or out.

10. Answers may include any two of the following: placing moist burlap sacks over the surface of the concrete, spraying the surface with water, covering it with waterproof paper, covering the surface with plastic sheets, and spraying the concrete with a curing compound, which places a chemical membrane over the concrete to seal in the moisture.

UNIT IV - CONCRETE　　　　　　　　　　Name ______________________________

Lesson 6: Curing Concrete　　　　　　　　　　Date ______________________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. The curing process is the result of:

    a. Evaporation.
    b. Drying.
    c. Stiffening.
    d. Hydration.

2. Which defect is caused by a knothole in the form that allows the mortar to flow out?

    a. Sand streaking
    b. Crazing
    c. Honeycomb surfaces
    d. Rock pockets

3. In summer, forms can be removed ____________ days after pouring pure concrete.

    a. Two
    b. Three
    c. Four
    d. Five

4. When temperatures are below 50 degrees Fahrenheit, heat the concrete mix to:

    a. 40° to 60° F
    b. 50° to 70° F
    c. 60° to 80° F
    d. 70° to 90° F

5. What is the name of the defect that results in small cracks on the surface of newly hardened concrete?

    a. Dusting
    b. Honeycomb
    c. Crazing
    d. Scaling

6. The ideal temperature for curing pure concrete is:

    a. 50° to 60° F
    b. 55° to 65° F
    c. 60° to 70° F
    d. 65° to 75° F

Complete the following short answer questions.

7. What are three possible causes of dusting on concrete?

   a.

   b.

   c.

8. How can concrete be cooled?

9. What are two reasons that curing is important?

   a.

   b.

10. What are two ways to keep concrete moist for moist curing?

    a.

    b.

Lesson 6: Curing Concrete Name ___________________________

Curing Concrete

Objective: Compare the strength of concrete that is cured in different environmental conditions.

Materials and Equipment:

Mixed concrete
15 3" pieces of PVC pipe, 6" long
Hydraulic press
Oil (new motor oil)
¼" steel rod, 8" long
4' × 4' piece of plywood or sheet metal
Buckets
Oven
Freezer
Sand

Procedure:

1. Cover the inside of the PVC pipes with a light coating of oil to prevent the concrete from sticking to the pipes.

2. Prior to filling the pipes with concrete, label and number them to identify the type of curing: freezer, room, water, oven, and sand. Three pieces of pipe should be used for each type of curing. For instance, the pipes to be placed in the freezer may be labeled “Freezer 1”, “Freezer 2”, “Freezer 3”, etc.
3. Fill each of the pipes with concrete. Stand the pipes on a piece of plywood or sheet metal.

4. After filling each pipe, work the steel rod through the concrete to remove any air pockets.

5. Place the pipes in the appropriate environments: in a freezer, at room temperature in the laboratory, submerged in water, in an oven at 150 degrees Fahrenheit, and submerged in a bucket of dry sand.

6. After three days, remove the pipes labeled with the number 1 from each location.

7. Remove the cement from each pipe using a hydraulic press.

8. Once the column of cement has been removed, test its strength by placing it horizontally on the hydraulic press and forcing the press downward until it breaks. If possible, use a hydraulic press that measures the force exerted, and record the measurements.

9. Compare the six columns to determine which has the most strength.

10. After seven days, repeat the tests with concrete from the pipes labeled with a 2, and determine which has the most strength.

11. After 14 days, repeat with the process with the concrete from the last set of pipes. Determine which column of concrete has the most strength.

Key Questions:

1. Which cylinder from each test had the most strength, and why?

2. What difference did time have on the strength of concrete?

3. Considering the information from this test, how should concrete ideally be cured?

Lesson 7: Pouring Concrete Walls

Competency/Objective: Describe the procedure for pouring a concrete wall.

Study Questions

1. What tools are needed for pouring walls?

2. What are the form types available for walls?

3. How are forms constructed for walls?

4. How should reinforcement be installed in walls?

5. What are the procedures for pouring a wall?

6. What are methods of preventing water from entering a structure?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit IV.

2. Transparency Masters

   a) TM 7.1: Plywood Forms
   b) TM 7.2: Parts of a Form

3. Job Sheet

   a) JS 7.1: Preparing Forms for a Concrete Wall

UNIT IV - CONCRETE

Lesson 7: Pouring Concrete Walls

TEACHING PROCEDURES

B. Review

Lesson 6 described procedures for curing concrete. So far in this unit, the focus has been on working with concrete slabs. Lesson 7, however, describes the construction of concrete walls. In particular, the construction of forms and the procedures used for pouring a concrete wall are discussed.

C. ***Motivation***

Ask students how pouring a concrete wall would be similar to pouring a slab and how it would be different. Then ask them what problems might occur when pouring a wall that would not happen with a slab.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. When pouring a concrete wall, a number of tools are needed to do the job correctly. Have students list these tools.

   What tools are needed for pouring walls?

   a) Trowel
   b) Steel tamp rod
   c) Shovel
   d) Hand level
   e) Tape measure
   f) Circular saw
   g) Hammer

2. Several types of forms can be used to construct a wall. Discuss the different types of forms. Use TM 7.1 to illustrate plywood forms.

   What are the form types available for walls?

   a) Wood
      1) Most commonly used material
      2) Constructed of plywood made with an exterior glue

b) Aluminum or metal
    1) Produce straighter walls because the metal does not bend from the weight of the concrete as much as wood does
    2) More expensive than plywood forms
c) Styrofoam
    1) Made of Styrofoam with steel mesh embedded in it to add strength to the form
    2) Is not removed after the concrete is poured; becomes a permanent part of the wall
    3) Have several advantages and disadvantages
        (a) Advantages
            (1) Less labor required
            (2) Allows for construction in all types of weather
            (3) Lightweight and snap together for easy construction
            (4) Less bracing required
            (5) Can run wiring and pipes through the forms easily
            (6) Energy efficient
            (7) Can be finished or painted with exterior paint
        (b) Disadvantages
            (1) Not reusable
            (2) Much more expensive than wooden forms and slightly more expensive than the metal forms

3. Ask students how they would build forms to pour a concrete wall. TM 7.2 shows the different parts of a form. If possible, show them a sample snap tie and holder. Hand out JS 7.1.

How are forms constructed for walls?

a) Wood forms have several parts.
    1) Stake
        (a) Typically made from a 2" × 4" board
        (b) Placed 4 feet apart or less for strength
    2) Brace - Nailed to the stake and the form to help keep the forms vertical
    3) 1" x 4" tie - Keeps the two sides of the form apart to give the wall the desired thickness
    4) Sheathing
        (a) Forms the sides of the form
        (b) Typically made of plywood
    5) Wale
        (a) 2" × 4" board that prevents the wall from bulging outward from the weight of the concrete
        (b) Nailed to the form with the wide side down
    6) Holder
        (a) Holds wales and snap ties in place
        (b) Placed over the snap ties, and then wales are placed in the holder

(c) Holds the entire form together

7) Snap tie
   (a) Specially constructed pieces of wire that run through the wall
   (b) Helps hold the forms the correct width apart
   (c) Has a wider spot that allows the holder to clamp tight on it without slippage

8) Spreader
   (a) Typically consists of a 2" × 4" board cut to a length that is equal to the thickness of the wall
   (b) Placed inside the form to keep its sides apart while the concrete is poured

9) Wire tie
   (a) Hold the forms the correct width apart
   (b) Used on the ends of a form
   (c) Constructed of twisted wire

10) Key - Groove made in a footing that allows the concrete from the walls to bond to the concrete in the footing

11) Marker nails - Driven through the form from the outside to mark the desired height of the concrete if it will not be poured to the top of the form

b) Start by standing the sheathing upright where the wall will be poured.

c) The holders, snap ties, and wales should be put on to hold the two sides together.

d) Spreaders can be added on the inside of the form.

e) Stakes are placed in the ground about 5 to 8 feet away from the form.

f) The braces are cut to the correct distance to reach the stakes.

g) The form should be checked using a level to make sure it is level and plumb.

h) The braces are nailed to the forms and the stakes to hold the forms in the correct position.

i) The wire ties are placed on the ends of the forms

j) The 1" x 4" ties are secured to the ends of the forms with duplex-head nails.

k) The forms must be square, because if they are not the building will not be square; the diagonal method is used to check whether they are square.

l) All of the pieces on the form must fit tightly together, and the forms must be strong, so they should be checked for weak spots prior to pouring the concrete.
   1) Usually occur at corners or where two forms meet
   2) Can be braced using additional 1" x 4" ties and duplex-head nails attached diagonally across the corners, or across the joint where the forms meet

m) High quality lumber must be used in constructing forms because weak spots from cracks, knot holes, or other problems will reduce the strength of the form.

4. Once forms have been constructed, reinforcement should be added in the walls to make them stronger. Ask students how they would reinforce the walls. How should the rebar be inserted?

How should reinforcement be installed in walls?

a) Walls are typically reinforced with rebar.
b) The rebar should be placed in the middle of the wall at an equal distance from each side of the form.
c) It should not stick out the top.
d) Rods are placed length-wise through the walls, spaced 8 to 12 inches apart.
e) Rods are driven vertically in the ground every 4 feet to support the horizontal rods.
f) The vertical and horizontal rods are tied together using thin wire.

5. Once the reinforcement is in place, it is time to pour the concrete. Ask students how they would fill the forms. Where would they start? How would they level the concrete? How is a structure connected to the concrete used in a foundation?

What are the procedures for pouring a wall?

a) Before filling the forms with concrete, they should be lightly oiled to prevent the concrete from sticking.
b) The concrete is then poured from one end or corner, working along the wall, with the corner being filled before moving on.
c) Enough concrete should be poured in one spot to fill the form before moving so that the concrete does not have to be shoveled backward to fill low spots.
d) Spreaders must be removed as the form is filled.
e) When the form is filled to the desired level, the steel tamp rod is run up and down through the concrete to help work out air bubbles.
f) After each of the walls has been poured, the top surface of the concrete must be smoothed and leveled using a small trowel or a board cut the width of the wall; the tool is worked along the top of the forms in a process similar to screeding.
g) After the first wall has been leveled and smoothed and the surface starts to dry, anchor bolts can be inserted into the concrete.
    1) Standard bolts placed with the head of the bolt in the moist concrete to anchor the wooden portion of the structure
    2) At least _ of an inch in diameter and typically 4½ to 5 inches long
    3) Generally set at least 2 inches into the concrete
    4) Straight when placed in the concrete
    5) Spaced 4 to 6 inches apart along each side of the building, with one bolt set in from the corner near each end of a wall; the distance between them depends on wind loads
    6) Placed where they will not interfere with the upright studs in the walls
h) Before the forms are removed, concrete walls should cure for at least one week, preferably longer.
i) When the concrete has cured enough, the forms are removed.
    1) Loosen all holders and wales
    2) Remove braces and stakes
    3) Remove sheathing
    4) Twist snap ties back and forth until they break or snap off
    5) Fill holes left in the concrete by wire ties with cement paste

6. Ask students what can be done to prevent water from entering a structure.

   What are methods of preventing water from entering a structure?

   a) Vapor barrier - specially constructed protective material attached to the inside of the underground portion of a concrete wall to eliminate condensation
   b) Waterproofing materials
      1) Painted on the outside of a wall
      2) Typically made of polyurethane, rubber, tar, or other waterproofing compounds
      3) May also consist of a layer of polyethylene plastic glued to the outside of the wall that will repel water from the soil
   c) Waterstop - synthetic material placed between concrete construction joints to stop water from entering through the joints
   d) Drainage pipes - placed around the structure to move excess water away

G. ***Other Activities***

Observe a concrete wall being poured at a construction site. Discuss the construction of the forms and the techniques used when pouring the concrete.

H. ***Conclusion***

Pouring concrete walls is a common task in constructing buildings, especially for houses with basements or crawl spaces. Constructing the forms correctly will make for straighter, stronger walls that will make building the structure much easier. Pouring the concrete in the forms is a relatively easy task, although it is necessary to carefully work out all air bubbles and smooth the top surface. After one week, the forms can be removed, and other construction can continue.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. a
2. c
3. b
4. d
5. Wood, metal, or Styrofoam
6. To keep the concrete from sticking to the form
7. At corners or where two forms meet

8. Students should give answers similar to the following.
   a) Prevents the wall from bulging outward from the weight of the concrete
   b) Helps hold the forms the correct width apart

c) Marks the desired height of the concrete if it will not be poured to the top of the form

9. Answers may include any two of the following: trowel, steel tamp rod, shovel, hand level, tape measure, circular saw, or hammer.

10. Standing the sheathing upright where the wall will be poured

UNIT IV - CONCRETE Name______

Lesson 7: Pouring Concrete Walls Date______

EVALUATION

Circle the letter that corresponds to the best answer.

1. The protective material attached to the inside of the underground portion of a concrete wall to eliminate condensation is called:

   a. Vapor barrier.
   b. Water stop.
   c. Water repellant.
   d. Moisture barrier.

2. What connects the wooden portion of a house or building to the concrete?

   a. Metal straps
   b. Weight
   c. Anchor bolts
   d. Wood screws

3. How far apart should the rebar be placed inside the wall to reinforce it properly?

   a. 4 to 8 inches
   b. 8 to 12 inches
   c. 12 to 16 inches
   d. 16 to 20 inches

4. Concrete in walls should be allowed to cure for a minimum of:

   a. 1 day.
   b. 3 days.
   c. 5 days.
   d. 1 week.

Complete the following short answer questions.

5. What are the three main types of wall forms?

   a.

   b.

   c.

6. Why should forms be lightly oiled before the concrete is poured?

7. Where do weak spots usually occur on forms?

8. What is the purpose of each of these parts of a wall form?

   a. Wale -

   b. Snap tie -

   c. Marker nail -

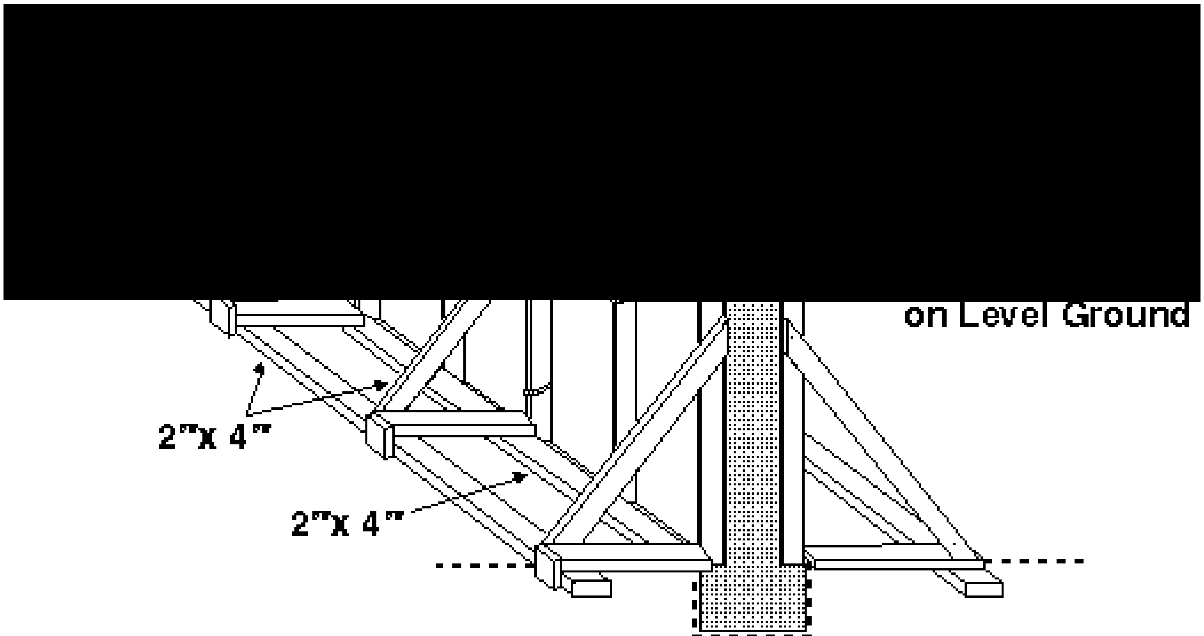
9. What are two tools needed for pouring concrete walls?

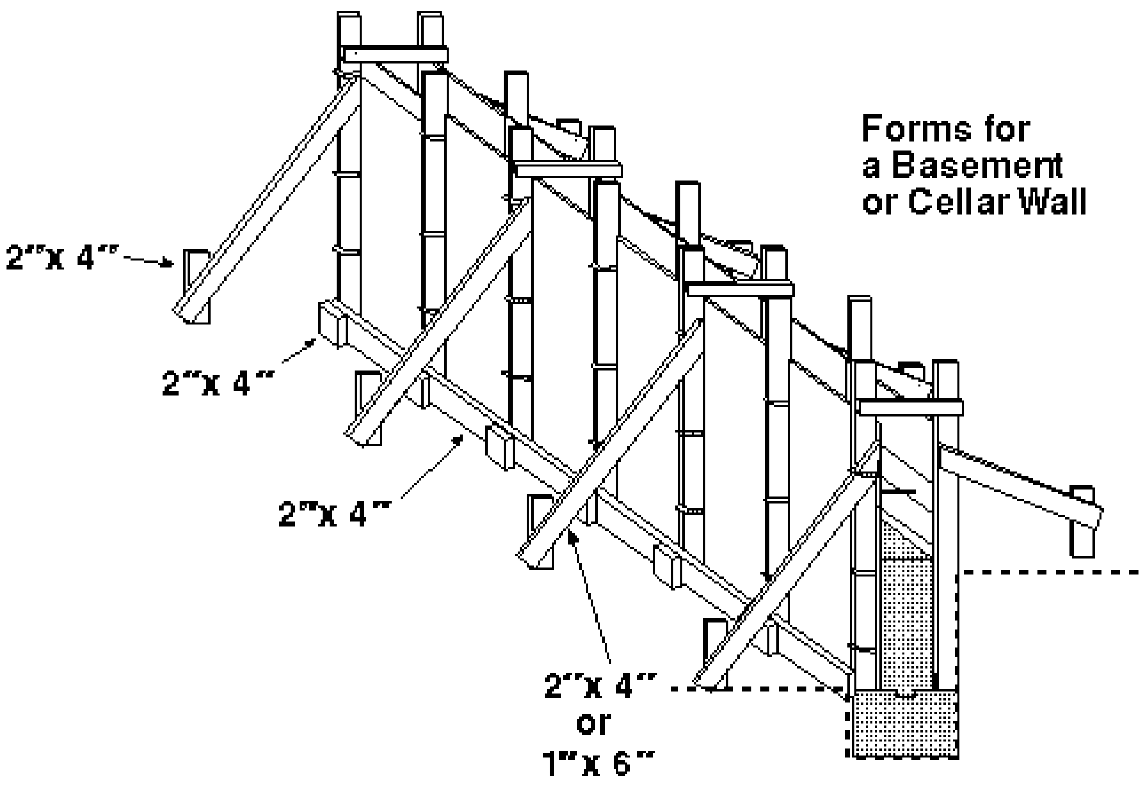
   a.

   b.

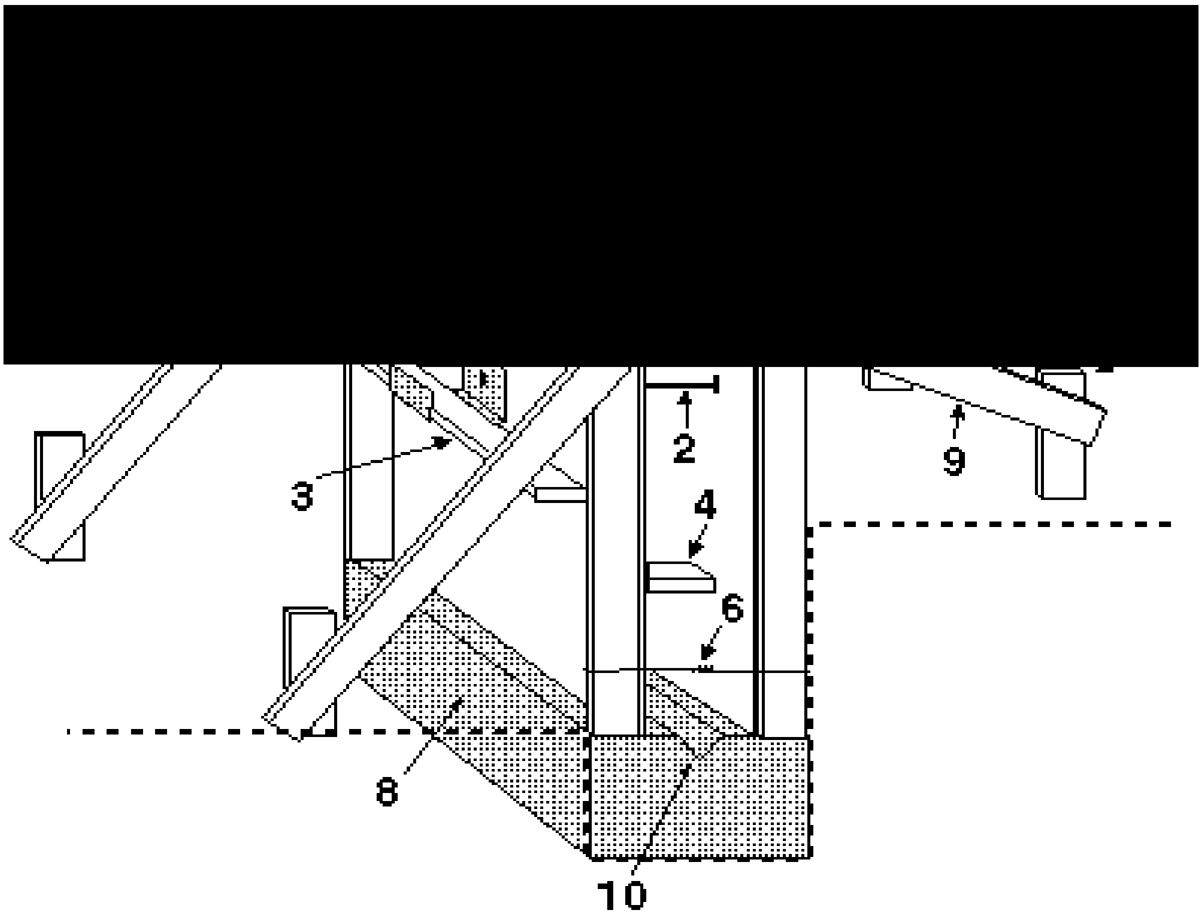
10. What is the first step in assembling forms?

Plywood Forms





Parts of a Form



1. Holder
2. Tie Snap
3. Wale
4. Spreader
5. Sheathing
6. Tie Wire
7. 1"x 4" Tie
8. Footing
9. Brace
10. Key
11. Stake
12. Marker Nail

Lesson 7: Pouring Concrete Walls Name_______________________________

Preparing Forms for a Concrete Wall

Objective: Construct and set up the forms to pour a concrete wall.

Materials and Equipment:

Plywood
16d duplex-head nails
4 snap ties
8 snap tie holders
2 8-foot 2" × 4" boards for wales and braces
1 4-foot 1" × 4" board for ties
Wire for wire ties
2" × 4" scraps for spreaders
Electric drill and bits
Level

Procedure:

1. Using the plywood provided, cut the sheathing for the two sides of the form. The wall should be 4 feet by 4 feet.

2. Using the drill, drill holes for the snap ties in the sheathing. Drill the holes to provide maximum strength by using only four snap ties.

3. Place the snap ties through the holes, and place the holders over the ends of the snap ties.

4. Add spreaders inside the form.

5. Add wales to the outside of the form.

6. Nail the 1" × 4" ties to the end of the form.

7. After setting the forms in the location indicated by your instructor, drive stakes in the ground about 4 feet from the bottom of the form.

8. Cut four braces to run from the top and bottom of the form to the stakes at each corner.

9. Using the level to check that the forms are straight, nail the braces to the form and stakes.

10. Double check to make sure that everything fits tightly and is square.

11. If your instructor permits, as an additional challenge, construct forms in cooperation with another group to form a 90-degree corner from the two forms.

UNIT V - ELECTRICITY

Lesson 10 : Cost and Electrical Power Use

Competency/Objective: Calculate cost and electrical power using Ohm's Law.

Study Questions

1. What is the power equation, Ohm's Law, and their applications?

2. How is electricity measured?

3. How is the cost of electricity determined for each plan?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.

2. Transparency Masters

   a) TM 10.1: Formulas
   b) TM 10.2: Measuring Electricity

3. Activity Sheet

   a) AS 10.1: Calculating Electrical Costs

UNIT V - ELECTRICITY

Lesson 10: Cost and Electrical Power Use

TEACHING PROCEDURES

A. ***Review***

Lesson 9 described how branch circuits are run to the individual outlets and light fixtures within agricultural structures. After the circuits are in place and electricity is available, calculating the power used in those systems becomes important. This lesson introduces the mathematical formulas needed to determine the amount of power used and explains how to calculate the cost of electricity.

B. ***Motivation***

Ask students if they know how to read an electric meter. If possible, show them a meter, and have them try to read it.

C. ***Assignment***

D. ***Supervised Study***

E. ***Discussion***

1. When calculating power usage, four factors are important: wattage, voltage, amperage, and resistance. They are needed to find values for both the power equation and Ohm’s Law, which is the basic mathematical formula for electrical power. Discuss the formulas and their use. Show students TM 10.1 to demonstrate how to multiply and divide to calculate the different values.

   What is the power equation, Ohm’s Law, and their applications?

   a) Power equation
      1) Mathematical formula that expresses the amount of power used in an electrical circuit or system
      2) Indicates the relationship between wattage (P), amperage (I), and voltage (E)

$$P = I \times E$$

      3) Primarily used to calculate power usage in watts but can also be used to determine the amperage or voltage of a system
      4) Important when testing an electrical system for efficient operation and for calculating the power use of individual branch circuits or the total system
   b) Ohm’s Law
      1) Mathematical formula that expresses the relationship between electromotive force (E), electric current (I), and resistance (R).

        (a) Electromotive force, measured in volts, is the pressure created by the movement of electrons.
        (b) Electric current is measured in amps.
        (c) Resistance is measured in ohms.

$$E = I \times R$$

    2) AC circuits - impedance (Z) rather than resistance
        (a) Impedance describes the counter electromotive force created by the directional change in the AC circuit.
        (b) The strength of the resistance depends on the rapidity of the directional change.
    3) Determines the energy efficiency of an electrical circuit, looking at factors such as voltage drop.
        (a) It helps electricians determine if changes need to be made in a system.
        (b) The equation can also help in determining if it would be feasible to expand an existing system.

2. Obtaining accurate measurements of electrical consumption is necessary to calculate the cost of the electricity used. Explain how meters are used to monitor usage. TM 10.2 provides examples showing how to read one type of meter.

How is electricity measured?

a) Measured by power companies using a watt-hour meter, which measures and instantly records electrical consumption in watts or kilowatts
    1) Attached to the electrical system at the meter base
    2) Located at or near the service entrance panel in homes and on individual structures or at the power pole when a number of structures will be operating on the electrical service
b) Commonly use two types of meters
    1) Newer type - uses a rotating meter similar to the mileage indicator on a car
    2) Older type - has several rotating pointers that turn as electricity is used
        (a) The first dial is read counterclockwise.
        (b) The second dial is read clockwise.
        (c) The third dial is read counterclockwise.
        (d) The fourth dial is read clockwise.
        (e) The numbers are written down from left to right.
        (f) If the pointer is between numbers, the smaller number is read.

3. Discuss how the cost of electricity is calculated. Bring in information on local rates and have students practice calculating the cost of electrical power. Hand out AS 10.1.

How is the cost of electricity determined?

a) Calculating the cost of electricity requires the rate scale from the electric company and the total kilowatt-hours consumed.
b) To calculate the total use over a period of time, the previous meter reading is subtracted from the current one.
c) The basic calculation involves multiplying the rates charged by the amount of electricity used.

F. ***Other Activities***

As students complete AS 10.1, ask them to track the daily usage of electrical power. Have them describe any fluctuations in daily usage and explain the cause of those fluctuations.

G. ***Conclusion***

The power equation and Ohm's Law measure the flow of electricity through the electrical system of agricultural structures. These formulas make it possible to calculate loads for each structure, check electrical costs, and plan for future expansion to meet electrical needs.

H. ***Answers to Activity Sheet***

I. ***Answers to Evaluation***

1. .91 amps, .73 amps
2. 83.33 volts, 1.33 volts
3. 720 watts, 4,800 watts
4. $E = I \times R$, where E = electromotive force, I = electric current, and R = resistance
5. To describe the counter electromotive force created by the directional change in the AC circuit
6. Watt-hour meter
7. 1,111 watts used
   100 × $ .055 = $5.50
   200 × $ .045 = $9.00
   500 × $ .035 = $17.50
   311 × $ .025 = $7.78
   TOTAL = $39.78

UNIT V - ELECTRICITY Name _____

Lesson 10: Cost and Electrical Power Use Date ___________________________

EVALUATION

Using the power equation, determine the missing values.

1. Find the amperes:

   a. Volts - 11 Watts - 100 _______________

   b. Volts - 240 Watts - 175 _______________

2. Find the volts:

   a. Watts - 500 Amps - 6 _______________

   b. Watts - 12 Amps - 9 _______________

3. Find the watts:

   a. Volts - 120 Amps - 6 _______________

   b. Volts - 240 Amps - 20 _______________

Complete the following short answer questions.

4. What is the formula for Ohm's Law for DC circuits? What does each of the variables represent?

5. Why is impedance (Z) used in the formula for Ohm's Law for AC circuits?

6. What device is used by power companies to measure the amount of electricity used?

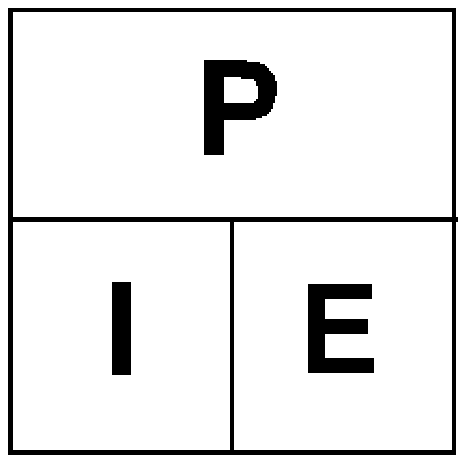
Calculate the cost of electricity for the problem below. Show your work.

7. Meter readings: Previous - 1,222 kWh Current - 2,333 kWh

   Sliding rate scale:

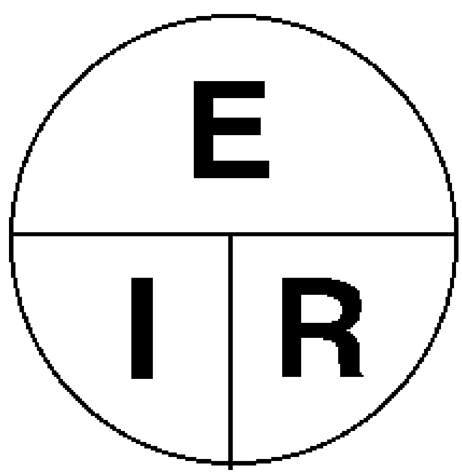
   $ .055 for the first 100 kWh
   $ .045 for the next 200 kWh
   $ .035 for the next 500 kWh
   $ .025 for the next 700 kWh
   $ .01 for over 1500 kWh

Formulas



P = Wattage
I = Amperage
E = Voltage

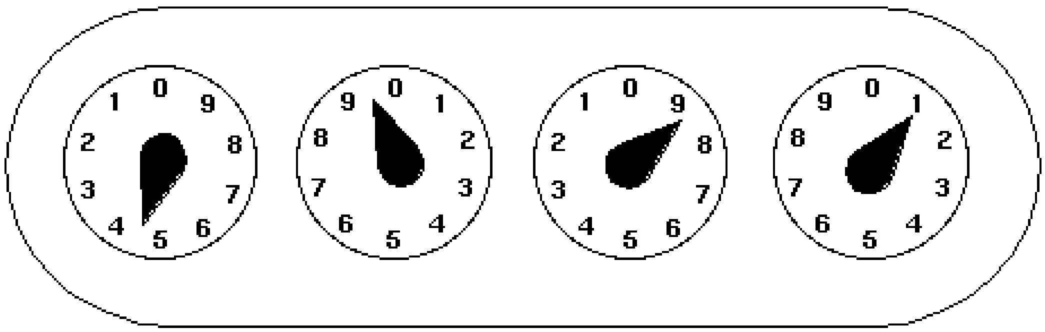
Note: Cover the letter of the value you wish to find to discover the method.



E = Voltage
I = Amperage
R = Resistance

Note: Cover the letter of the value you wish to find to discover the method.

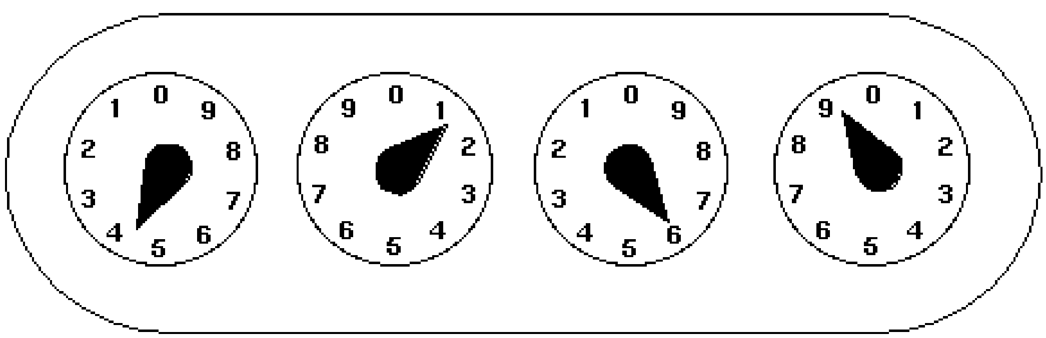
Measuring Electricity



July 15

First dial - number passed 4---
Next dial - number passed -9--
Next dial - number passed --8-
Right dial closest number ---1

Reading = 4981 kwh



June 16

First dial - number passed 4---
Next dial - number passed -1--
Next dial - number passed --6-
Right dial closest number ---9

Reading = 4169 kwh

4981- 4169 = 812 kwh used

Lesson 10: Cost and Electrical Power Use Name ______________________________

Calculating Electrical Costs

Objective: Calculate the cost of the electricity used in the home based on current local utility rates.

Keep a record of the power used at your home over a five-day period. Find out the local utility rates for your area from your parents or the utility company. At the end of the week, calculate the cost of electricity used. Show your work.

Meter reading:

Start - ____________________ kWh End - ____________________ kWh

Utility rate:

Weekly usage:

Cost:

Agricultural Structures, V-160

Lesson 11: Lightning Protection

Competency/Objective: Describe procedures for planning and installing lightning protection.

Study Questions

1. What is lightning, and why does it strike structures?
2. What lightning protection is necessary for the operation?
3. What constitutes a good system of protection?
4. How is the lightning protection system installed?
5. How is equipment protected from lightning?
6. How is lightning grounded off a structure?

References

1. *Agriculture Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.
2. Transparency Masters
   a) TM 11.1: When Lightning Strikes
   b) TM 11.2: Components of a Lightning Protection System
   c) TM 11.3: Grounding Practices
3. Activity Sheet
   a) AS 11.1: Assessing Lightning Protection

B. ***Review***

Lesson 10 described the formulas used to measure the consumption of electricity and the cost of electricity. Lesson 11 discusses efficient lightning protection systems. Lightning protection is important because lightning strikes can overload electrical systems, damage structures, and injure or kill people and animals.

C. ***Motivation***

Use a 6-volt battery to demonstrate how electricity jumps from a negative to a positive pole to demonstrate how electrons jump between the clouds and earth to create lightning. Attach a short wire to the positive electrode of the battery and another to the negative electrode. Move the wires together until a spark appears. Use a capacitor attached to the positive wire to increase the voltage for a longer arc.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students to explain what lightning is and why it occurs. Discuss their answers, explaining why lightning strikes structures. TM 11.1 can be used to help illustrate the conditions that produce lightning. Emphasize that more than 125 people are killed by lightning each year.

   What is lightning, and why does it strike structures?

   a) Lightning
      1) It is the visible discharge of static electricity within a cloud, between clouds, or between the earth and a cloud.
      2) It is basically a large electric spark caused when current jumps a gap in the air.
   b) Strikes
      1) Strikes occur when hot and cold air masses meet, causing atoms to lose electrons.
      2) Negatively charged electrons gather at the cloud base.
      3) Positive ions converge at high locations on the earth's surface.
      4) The ions and electrons are attracted to each other, creating a stepped leader, an unseen conduit through which negative charges move from the cloud to the earth.

5) From the earth, ion streamers called leaders travel upward.
6) If the two puncture the air gap insulator and converge, a channel is created for electrical energy to move between the earth and the cloud as the charges rapidly equalize themselves.

2. Lightning protection is necessary not only to prevent injuries and fatalities but also to provide protection against fires and damage from electrical surges. Discuss the factors to consider when determining what lightning protection is needed by an agricultural operation.

What lightning protection is necessary for the operation?

a) Before installing lightning protection, the need for such protection should be assessed.
   1) Frequency of lightning
   2) Type of structure and its construction
   3) Location of the structure
   4) Topography of the surrounding area
   5) Contents of the structure
b) Tall structures such as silos should be grounded not only to protect them but because they can provide a cone of protection with a diameter that is two times the height of the object.
c) Electric fences should be grounded.

3. Ask students what components make up a lightning protection system. Show them TM 11.2 and describe the purpose of the different components pictured.

What constitutes a good system of protection?

a) Air terminals or lightning rods
   1) The points where lightning strikes
   2) Installed on high points on structures, such as roof ridges or ventilators
b) Main conductors - cables that connect the air terminals to the grounding electrodes, or ground terminations
c) Ground terminations - copper or copper-clad rods driven into the earth, preferably to a minimum of ten feet in depth
d) Lightning arresters - protect wiring from lightning-induced damage
e) Surge suppressors - used to further protect electrical equipment, such as computers

4. Proper installation of a lightning protection system is crucial to its efficiency. Describe the guidelines for installing lightning protection. Emphasize that having a professional install the system will provide the best protection by ensuring that it has been done properly.

How is the lightning protection system installed?

a) Number of grounding electrodes
   1) All buildings with a perimeter of 250 feet or less must have two grounding electrodes, preferably diagonally at opposite corners of the structure.
   2) If the perimeter is between 250 and 350 feet, three electrodes are required.
   3) At perimeters of 350 to 450 feet, four electrodes are necessary.
   4) Another grounding electrode is added for every 100 feet of perimeter.
b) Grounding conductors
   1) They should follow a straight horizontal or vertical path to the grounding electrode.
   2) The cables need to be free of sharp turns and "U" or "V" pockets.
   3) Turns in conductors should not exceed 90 degrees.
   4) Bends should not have a radius of less than eight inches.
c) Air terminals - should be properly sized, spaced, and installed
d) Conductors
   1) The down conductors should carry the discharge directly to the ground.
   2) Entrance conduits, gutters, drain pipes, pipe vents, metal water pipes, radio and T.V. antennas, metal roofing, fences, and other metal objects should be bonded to the down conductors and ground rods.
   3) The main bonding conductors must be at least AWG 6 copper wire or its equivalent.
   4) Down conductors should be enclosed in a conduit or metal tubing extending from a point at least five feet above ground level to one foot below the ground's surface.
e) Ground rods
   1) Ground rods of adequate size must be located properly throughout the system.
   2) Lightning system ground rods must be driven to a minimum depth of 10 feet where soil conditions permit.
   3) Other acceptable options are to dig a trench 3 to 4 feet deep by 10 feet long and bury a grounding rod or to bury a grounding plate at least 18 inches deep.
   4) Another method involves connecting down conductors to a metal water system, as long as the pipes are a minimum of three feet deep and ten feet long and are in direct contact with the earth.
   5) If ground rods used for the electrical or telephone system are within 6 feet of a grounding electrode, they must be bonded together to prevent side flashes.

5. Providing protection to equipment is another important function of lightning protection systems. Discuss the methods used to prevent damage to equipment.

How is equipment protected from lightning?

a) Power supply system
   1) Stepping down
      (a) Power from the source passed through several transformers and other devices
      (b) Reduce and convert the electricity into forms the consumer can use
   2) Offers lightning protection at each level
b) Surge suppressor
   1) Used to protect electronic equipment, particularly computers, from surges
   2) Provide a receptacle or a bank of receptacles with a breaker that automatically trips when the electricity spikes
   3) Prevent damage from lightning if computer equipment is plugged into telephone lines
      (a) Telephone companies - lightning suppression devices in the lines
      (b) Special surge suppressors - connections for telephone lines
c) Lightning or surge arrester
   1) Used to remove high voltage charges from the system by breaking the circuit and then diverting the electricity to the ground
   2) Installed where service wires enter the building at the service entrance panel or prior to the connection of specialized electrical loads or other equipment away from protected buildings
d) Controller
   1) Normally used for starting and stopping motors
      (a) For small motors of _ hp or less - overcurrent device at the service entrance panel
      (b) For larger motors - separate switch with a current capacity at least twice the full load rating of the motor
   2) Should have overload devices installed that stop the current to the motor during electrical surges and power overloads
   3) Should also have a manual reset so the motor does not restart automatically when normal power is restored

6. The grounding of the lightning protection system will determine the extent of protection available. Discuss how lightning is grounded off a structure. TM 11.3 shows grounding practices for a building. Have students complete AS 11.1.

How is lightning grounded off a structure?

a) Electrical grounding - connecting one end of a properly sized copper conductor to the air terminals and the other end to a metal conductor that is in direct and permanent contact with the earth
b) Grounding
   1) ½-inch copper rod
   2) _-inch copper-clad rod
   3) ¾-inch galvanized iron pipe
   4) Metallic water system
   5) Metal plate if a ground rod cannot be used due to rock beneath the soil

c) Size of the grounding wire determined by the size of the wire supplying power to the service entrance panel

d) Wire clamped to the grounding electrode using lugs or clamps

G. ***Other Activities***

Invite a certified electrician or a professional who installs lightning protection systems to give a presentation to the class about his or her work.

H. ***Conclusion***

Lightning can be dangerous to humans and animals and destructive to structures and equipment. An efficient lightning protection system is necessary to help prevent damage and loss of life. For the best possible protection, a qualified and certified professional should install systems for the home and farm.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. d
2. d
3. c

4. Answers may include any two of the following: frequency of lightning, type of structure and its construction, location of the structure, topography of the surrounding area, and contents of the structure.

5. They are the points where the lightning strikes.

6. A channel is created for electrical energy to move between the earth and the cloud.

7. To dig a trench 3 to 4 feet deep by 10 feet long and bury a grounding rod or to bury a grounding plate
8. The size of the wire supplying power to the service entrance panel
9. Used to protect electronic equipment, particularly computers

UNIT V - ELECTRICITY Name _____

Lesson 11: Lightning Protection Date ____________________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. How many ground rods are required for a structure with a perimeter of 410 feet?

   a. 1
   b. 2
   c. 3
   d. 4

2. Before lighting strikes, ________________________ travel(s) upward from the earth.

   a. Electrons
   b. Ions and electrons
   c. A stepped leader
   d. An ion streamer

3. What size copper wire should be used for the main bonding conductors?

   a. AWG 2
   b. AWG 4
   c. AWG 6
   d. AWG 8

Complete the following short answer questions.

4. What are two factors to consider when assessing the need for lighting protection?

   a.

   b.

5. What is the function of air terminals?

6. What happens when the air gap insulator is punctured?

7. What are two alternative methods of establishing a grounding electrode if one cannot be driven to the proper depth?

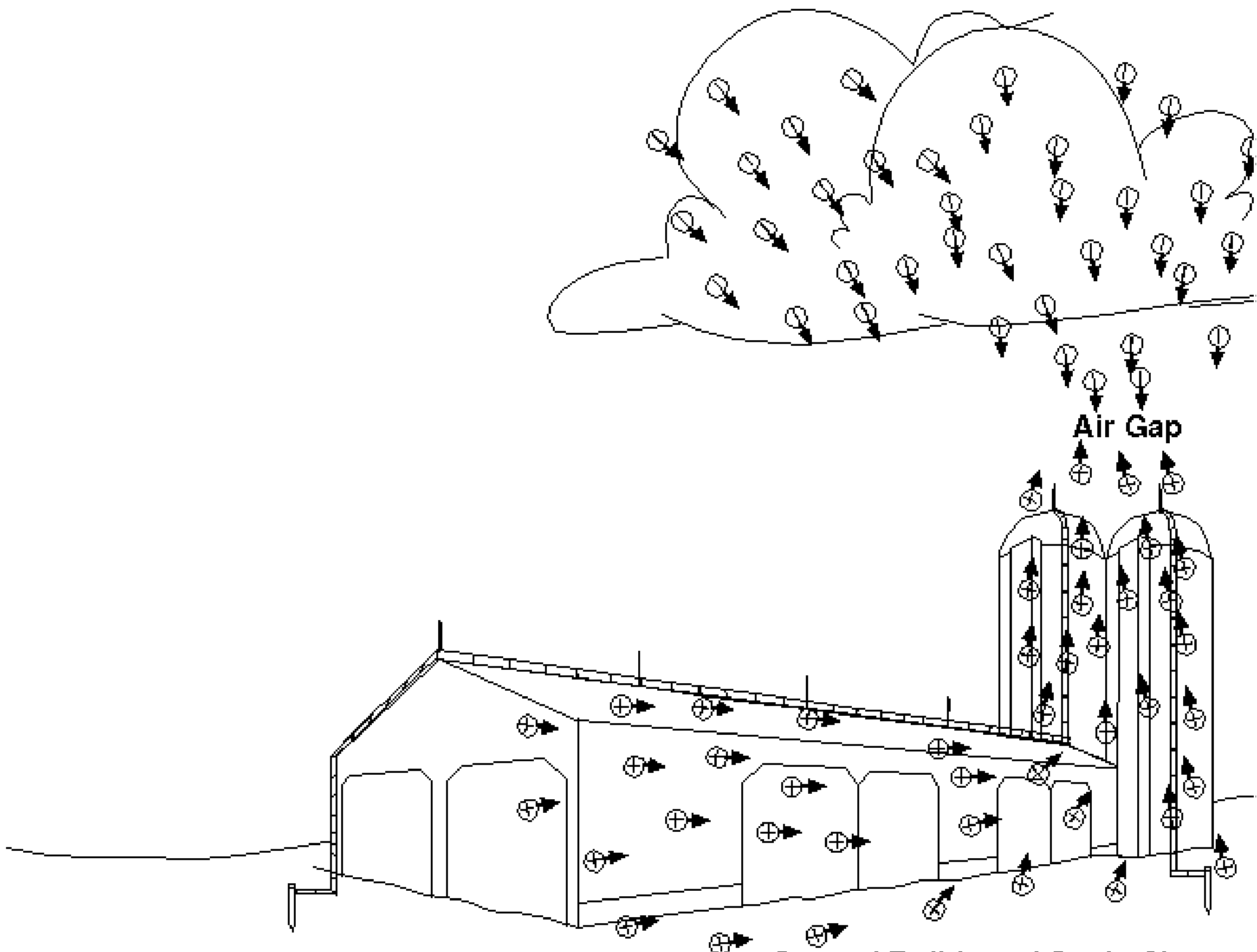
   a.

   b.

8. What determines the size of the grounding wire?

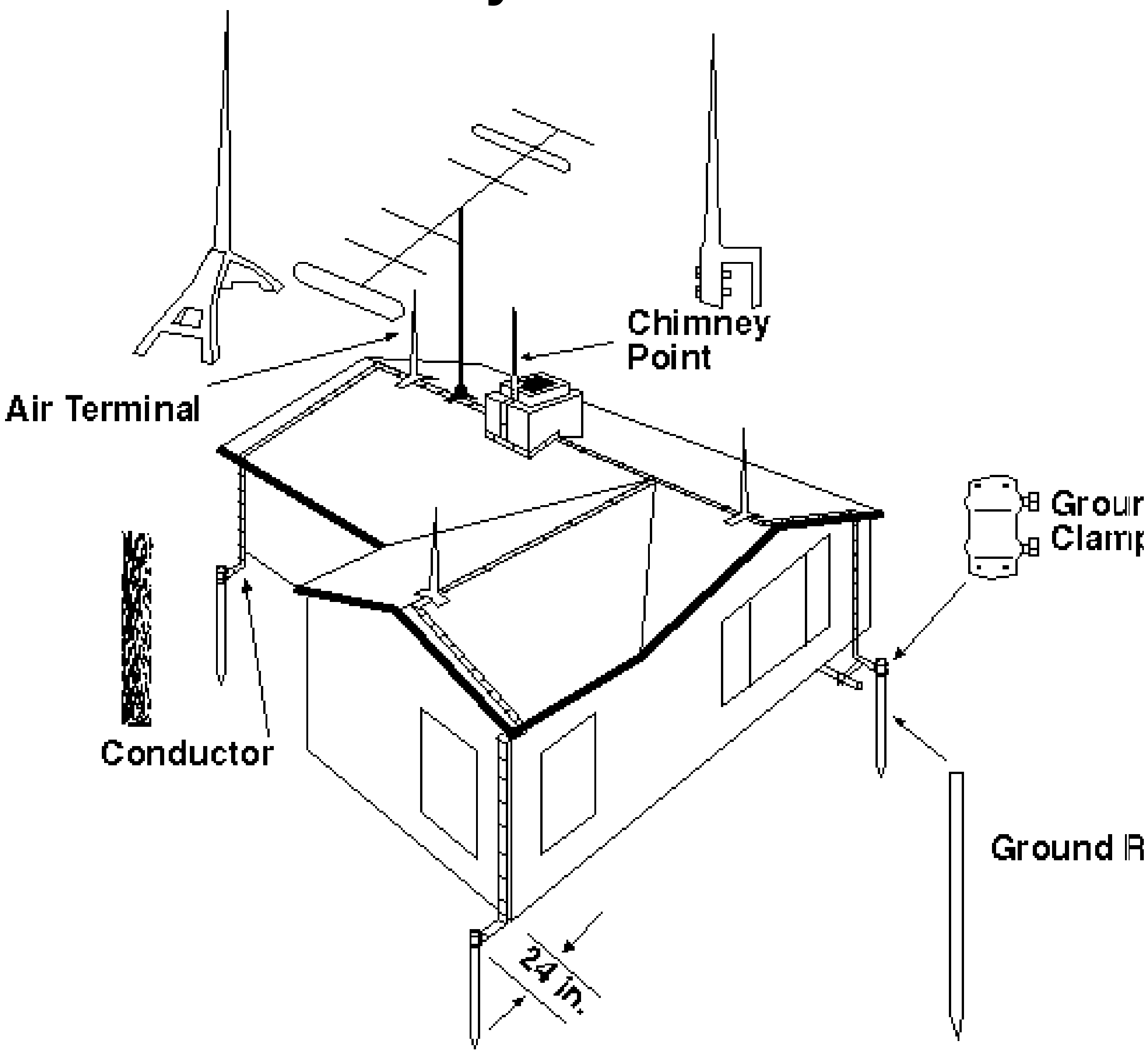
9. What is the function of surge suppressors?

When Lightning Strikes

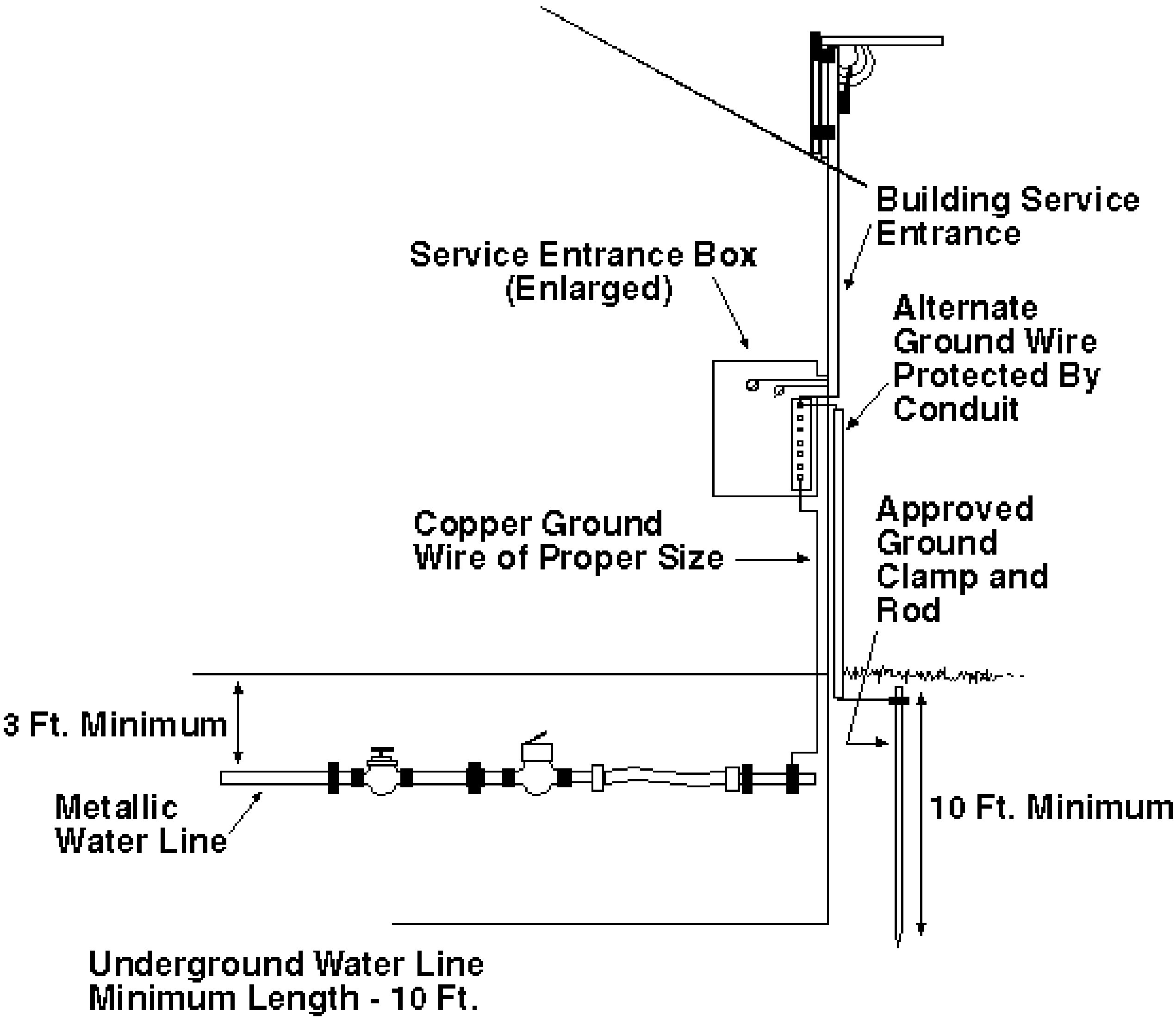


When the force is great enough to puncture the air gap, the charge follows the path of least resistance to the ground.

Components of a Lightning Protection System



Grounding Practices



Lesson 11: Lightning Protection Name ______________________________

Assessing Lightning Protection

Objective: Identify the components of the lightning protection system in a structure.

Investigate the lightning protection system installed in your home or an agricultural structure. Identify the components of the system and fill out the chart. If no lightning protection is present, indicate what components would be needed and where they would be installed.

Components	Number	Location
Air terminals		
Down conductors		
Ground terminations		
Lightning arresters		
Surge suppressors (telephone/electrical)		

UNIT V - ELECTRICITY

Lesson 12: Detecting Problems

Competency/Objective: Identify problems in electrical systems.

Study Questions

1. **What types of testers are used in troubleshooting?**

2. **How are the testing devices used?**

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.

2. Transparency Master

    a) TM 12.1: Types of Electrical Testers

3. Activity Sheet

    a) AS 12.1: Using Testing Devices

TEACHING PROCEDURES

A. ***Review***

Lesson 11 described how to protect electrical systems from lightning. Lightning is not the only potential cause of problems, however. After an electrical system is installed, problems caused by poor wiring practices, misuse, or wear can occur. This lesson will focus on troubleshooting electrical problems, particularly the use of electrical testers.

B. ***Motivation***

Ask students the following questions. Discuss their answers, pointing out that the problems described are all common and must be addressed to safely and efficiently provide electrical power.

- Have any of you experienced breakers tripping on a repeated basis?
- Are there any electrical outlets in your home that do not function properly?
- Have you ever felt a tingle when plugging or unplugging a cord in an outlet?

C. ***Assignment***

D. ***Supervised Study***

E. ***Discussion***

1. Identifying and correcting electrical problems involves the use of different testing devices that make it possible to safely and easily detect problems. Discuss these devices, using TM 12.1 to illustrate them.

   What types of testers are used in troubleshooting?

   a) Neon tester
      1) Simplest device used by electricians
      2) Used on either a 120-volt or 240-volt system
      3) Glowing light - indicates that voltage is present; the greater the voltage, the brighter the light
   b) Voltage tester
      1) Used to indicate the voltage and polarity, or direction of electrical flow, in a circuit
      2) Uses a series of neon lights to indicate the approximate voltage moving through the circuit
   c) VOM (volt-ohm-milliammeter) meter

1) Displays the voltage and polarity of the circuit; also provides accurate measurements of circuit resistance and amperage
2) Combines a voltmeter, ohmmeter, and ammeter in one casing
    (a) Voltmeter - measures voltage across two points in an electrical circuit
    (b) Ohmmeter - measures resistance
    (c) Ammeter - measures the electrical flow or amperage
3) Provides information on a calibrated numerical scale

2. Explain how to use the testing devices listed. Emphasize that the manufacturer's directions for the proper use of these testing devices should be understood prior to their use. Have students complete AS 12.1. It may be appropriate to create a malfunction in the receptacle tested. Students could also add an outlet receptacle to the electrical board described in AS 9.1 that could be made to malfunction for testing.

How are the testing devices used?

a) Neon tester for testing outlet receptacles
    1) Place the ends of the leads into the parallel slot openings; if the tester lights up, no problem exists.
    2) If the tester does not light up, insert the end of one of the leads into the ground opening, with the other lead in one of the other slots.
    3) If the tester lights up, the problem is with the neutral connection or the neutral wire.
    4) If the tester still does not glow, remove the outlet cover plate and receptacle.
    5) Touch the leads to the opposite terminal screws.
    6) If the tester lights up, the receptacle does not function and should be replaced.
b) Voltage tester for outlets, switches, fixtures, and other electrical devices
    1) It works in a similar way as the neon tester.
    2) The tester also indicates whether an electrical system carries 120 volts or 240 volts as well as its polarity.
c) VOM meter
    1) The leads are color coded, with red used for the power side and black for return or neutral side of the circuit during testing.
    2) The leads are used as they are with the other testers.
    3) The ohmmeter contains its own power source, so all power to the electrical system should be disconnected before testing for circuit resistance.

F. ***Other Activities***

Using a VOM meter, test a switch.

G. ***Conclusion***

To troubleshoot electrical systems, it is important to be competent in the use of various testing devices. A problem can only be fixed if it can be identified.

H. ***Answers to Activity Sheet***

I. ***Answers to Evaluation***

1. d
2. b
3. c
4. Volt-ohm-milliammeter
5. Faulty receptacle
6. Using a series of neon lights

UNIT V - ELECTRICITY Name _____

Lesson 12: Detecting Problems Date ____________________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. The power should be disconnected when using the __________________.

   a. Neon tester
   b. Voltage tester
   c. Voltmeter
   d. Ohmmeter

2. On a voltmeter, what is the color of the lead that is used for the power side of the circuit?

   a. White
   b. Red
   c. Black
   d. Green

3. What does the glowing light on a neon tester indicate?

   a. Resistance
   b. Amperage
   c. Voltage
   d. Polarity

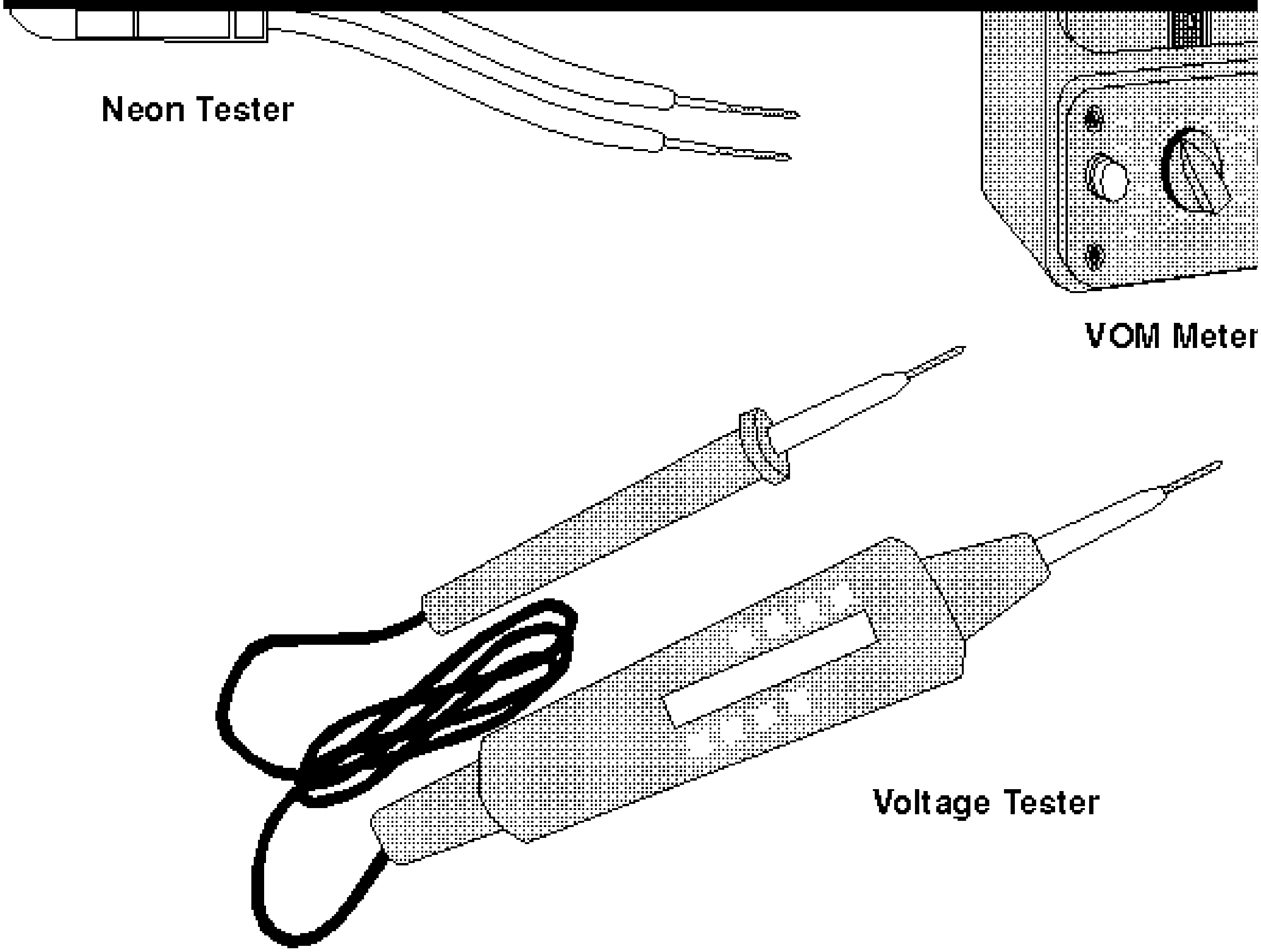
Complete the following short answer questions.

4. What does VOM mean?

5. When testing an outlet receptacle with the neon tester, you find that the tester lights up only when you touch the leads directly to the terminal screws of the outlet. What is the problem?

6. How does the voltage tester indicate the approximate voltage moving through the circuit?

[redacted]



Lesson 12: Detecting Problems Name ____________________________

Using Testing Devices

Objective: Use an electrical testing device to test an outlet receptacle for power.

Use the different testing instruments described in this lesson to test an electrical outlet chosen by your instructor. Fill in the table, describing the types of information provided by the different testers, the procedures followed to conduct the test, and the results of the test.

Type of Tester	Information Provided	Test Procedure and Results
Neon tester		
Voltage tester		
VOM meter		

UNIT V - ELECTRICITY

Lesson 1: Electrical Safety

Competency/Objective: Identify the dangers and safety practices associated with electrical work.

Study Questions

1. What are the basic rules of electrical safety?

2. What are the sources of electrical defects in equipment?

3. What should be done if someone gets shocked?

4. What are the types of circuit protection?

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.

2. Activity Sheet

   a) AS 1.1: Electricity on the Internet

UNIT V - ELECTRICITY

Lesson 1: Electrical Safety

TEACHING PROCEDURES

B. ***Introduction***

Everyone uses electricity in many different ways every day. Electricity is also a major energy source in agriculture. However, it can be dangerous if used improperly. To work with electricity safely, understanding the basic safety practices, and hazards is important. This lesson will provide information that will help you work safely with electricity.

C. ***Motivation***

1. Take students on a tour around the shop or school. Point out possible electrical hazards. Make note of warning signs around electrical equipment. Discuss the importance of these warnings.

2. Bring a damaged and/or burned out electrical fixture to class. They can usually be obtained from a local electrician or electrical company. Explain the hazards of faulty wiring and the misuse of electrical equipment.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students what they believe to be the major hazards associated with electricity. Discuss the various aspects of electrical safety.

   What are the basic rules of electrical safety?

   a) Two major safety concerns with electricity
      1) Shock is the passing of an electric current through the body and the body's reaction to it; it affects the rhythm of the heart,
      2) Electrical fires have two main causes.
         (a) Wires overheat, generally due either to a restriction in the flow of electricity through the conductor or an overloaded system.
         (b) An electrical current jumps a gap, creating sparks; the gap may be produced by broken wires or improper electrical connections.
   b) Precautions to minimize these hazards
      1) During the installation and repair of electrical systems, always disconnect the main power source before working with the system.

2) Follow state and local electrical codes when installing new systems.
3) Manufacturers' instructions for the installation and use of electrical equipment are another important source of information about the proper procedures to use.

c) Sources of electrical hazards
1) The use of extension cords is another factor that can create electrical hazards.
(a) Do not place extension cords under items, such as rugs or other things that put weight directly onto the cord.
(b) Avoid placing cords in high traffic areas, which can also lead to insulation damage and a restriction of electrical flow.
(c) Always uncoil a long extension cord before plugging it in.
(d) If an extension cord becomes warm or smells of burning rubber, discontinue its use immediately.
2) Fuses and breakers, safety devices designed to shut off electrical flow, can be a source of electrical hazards.
(a) Check out the system and correct the problem before replacing a fuse or resetting a breaker.
(b) Never use a higher capacity fuse or circuit breaker for a repair; electrical systems are designed to carry a certain load, and an attempt to increase this load will burn out the system.
3) A situation that can be extremely hazardous is performing an installation near wet areas.
(a) While working with electrical systems or appliances in areas that are wet or damp, make sure that the power is disconnected.
(b) Utilize cabinets, shelves, and stands to keep tools and appliances dry.
(c) Install GFCI outlets in noncorrosive plastic device boxes in wet or damp areas.
4) As with most hazardous situations, misuse due to the human factor tends to be the single greatest cause of electrical mishaps.
(a) Remember that safety devices put in place by manufacturers have a purpose; do not damage or disable them.
(b) Do not use any electrical product that is damaged in any way.
(c) Do not remove a plug from an outlet by pulling on a cord.
(d) Never carry a power tool by its cord.
5) Joining two wires that are composed of different metals can pose an electrical hazard; a special type of connector should be used.

2. Ask students if they have ever seen or used electrical equipment that had a defect and what that defect was. Then discuss the common sources of defects.

What are the sources of electrical defects in equipment?

a) Ground wire

1) Occurs when the ground, or neutral, wire is missing, broken, improperly connected, or not connected at all
2) Can lead to shorts in the system and a possible shock hazard to anyone using equipment connected to the line

b) Open conduit
1) Conduit - metal or plastic tube that encloses electrical wires
2) Leads to wire damage from water entering the open conduit
3) Allows for wear and deterioration of the insulation
4) Can create a short circuit

c) Damage to insulation
1) Occurs when the insulation becomes worn, wet, or oily
2) Can lead to short circuits, shocks, and fire hazards

d) Damage to equipment
1) Occurs during manufacturing or installation and use
2) Normally occurs in switches, receptacles, and extension and appliance cords
3) Can lead to shock and fire hazards

e) Lack of maintenance
1) Can cause dirty, improperly adjusted electrical equipment to overheat, throw sparks, and short out
2) Can create a fire hazard

f) Misuse through carelessness
1) Most common source of defects
2) May result in the misuse of equipment, improper wiring practices, limited knowledge of electrical systems, and working around electricity in wet environments without proper precautions

3. Ask students if they have ever been shocked (by either an electric fence or by electrical equipment). Discuss what it felt like. Then describe what should be done if someone receives a serious shock.

What should be done if someone gets shocked?

a) For someone receiving an electric shock of 120 to 240 volts
1) Disconnect the source of the electric current, if possible.
2) If it cannot be disconnected, a long pole or other item of nonconductive material, such as wood or fiberglass is needed.
3) Insulate oneself by making sure to avoid any liquids or wet areas.
4) Use the pole to move the person or the conductor, depending on which is easier and safer to move.

b) For a power source over 240 volts
1) Assume that the downed wire is live and can kill.
2) Keep everyone at least 200 feet away because the static electricity in the air can arc to individuals wearing any type of metal.
3) Contact emergency personnel immediately.
4) Call the power company to give them the exact location of the incident.

c) In either case
    1) Never attempt to grab a person in direct contact with a live wire.
    2) The electrical current will “freeze” muscles, thus compounding the situation and putting a rescuer at risk of electrocution and death.

d) First aid given once the victim is moved from the electrical source
    1) Check to see if the victim is conscious.
    2) Check for signs of breathing and a pulse.
    3) Perform CPR if trained.
    4) If burns are present, cover them with a dry, sterile dressing; do not attempt to cool electrical burns since efforts to soothe them may only make the situation worse and can lead to further damage.
    5) Never move the victim unless an immediate threat to his or her safety exists; due to the nature of an electrical injury, the victim may experience damage to the spine that would be worsened by being moved.

4. Ask students what they would do if they walked into a room, turned on some sort of appliance, and the power shut off. What is the likely reason the electricity shut off? Discuss the different circuit protection devices. Hand out AS 1.1.

What are the types of circuit protection?

a) Overcurrent devices
    1) Devices that limit the amperage in any wire to the maximum permitted
    2) Consist of fuses and circuit breakers
    3) Both rated by the number of amps that will travel through the overcurrent device without triggering it; the size of the wire used in the system will determine the amperage rating of the overcurrent device used

b) Fuse
    1) Short piece of metal that has been experimentally tested to melt at a predetermined flow of amps
    2) Housed in a nonconductive material for protection and removal

c) Circuit breaker
    1) Semi-permanent device positioned in the service panel during wire circuit installation
    2) Does not require replacement when a break occurs in the circuit
    3) Resembles a toggle switch with a handle
    4) Has four switch positions
        (a) On
        (b) Tripped
        (c) Off
        (d) Reset
    5) Has a mechanism inside that “trips” the breaker and disconnects the load in an overload situation
    6) Most commonly used type of overcurrent device because of the ease of resetting it

d) Ground fault circuit interrupter (GFCI) - interrupts the flow of electricity in order to prevent electrical shock if a fault exists in the circuit that will not affect a fuse or circuit breaker

G. ***Other Activities***

Schedule a guest speaker from a local power company to discuss electrical safety.

H. ***Conclusion***

Because electricity affects the lives of every person, electrical safety should be a concern for everyone. For people working with electricity in particular, being aware of the electrical hazards that may affect them will help enable them to work safely. They must be familiar with safety devices and know what to do if someone is injured by electricity.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. b
2. c
3. d

4. Answers may include any three of the following: problems with the ground wire, open conduits, damage to insulation, damage to equipment, lack of maintenance, and misuse through carelessness.

5. Answers may include any one of the following.

   - Do not place extension cords under items, such as rugs or other things that put weight directly onto the cord.
   - Avoid placing cords in high traffic areas, which can also lead to insulation damage and a restriction of electrical flow.
   - Always uncoil a long extension cord before plugging it in.
   - If an extension cord becomes warm or smells of burning rubber, discontinue its use immediately.

6. Fuse and circuit breaker

7. Disconnect the source of the electric current, if possible. If it cannot be disconnected, a long pole or other item of nonconductive material, such as wood or fiberglass, is needed to move the person or the conductor.

UNIT V - ELECTRICITY Name _____

Lesson 1: Electrical Safety Date __________________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. The part of the body affected by electricity when a person is shocked is the:

   a. Bones.
   b. Heart.
   c. Lungs.
   d. Liver.

2. GFCI outlets should be placed in ________________________ in wet areas.

   a. Metal boxes
   b. Aluminum boxes
   c. Plastic boxes
   d. Bare walls

3. A device that limits the amperage in any wire to the maximum permitted is called a:

   a. Outlet.
   b. Limiter.
   c. Undercurrent device.
   d. Overcurrent device.

Complete the following short answer questions.

4. What are three of the six sources of electrical defects in equipment?

   a.

   b.

   c.

5. What is one thing that can be done to minimize electrical hazards with electrical extension cords?

6. What are the two types of overcurrent devices for circuit protection?

   a.

   b.

7. What is the first thing you should do if someone receives a shock of 120 to 240 volts?

Lesson 1: Electrical Safety Name__________________________

Electricity on the Internet

Objective: Explore the various sources of information on electricity and electrical safety available on the Internet.

Using the following web sites or others approved by your instructor, investigate one web site and use the information found to answer the questions. Include a print out of the web site's home page. Then use the links from one of these sites or a search engine to find another source of electrical information.

<u>Web Resources</u>

National Electrical Safety Foundation	http://www.nesf.org/
National Fire Protection Association	http://roproc.nfpa.org/home.html
Electric Links	http://www.codecheck.com/

1. What is the name of the site?

2. What is its purpose (educational, marketing, regulatory, etc.)?

3. What is the internet address of this site?

4. What types of information are available on this site?

5. Who sponsors this site?

6. Who would use this site the most and why?

7. What is the most interesting thing about electricity you learned from this site?

UNIT V - ELECTRICITY

Lesson 2: Electrical Terminology

Competency/Objective: Identify the terms associated with electrical work.

Study Questions

1. What are the terms and definitions of electricity?

2. What is the NEC?

3. How are NEC guidelines enforced?

4. What does a UL listing mean?

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.

2. Activity Sheet

   a) AS 2.1: Electrical Terms

UNIT V - ELECTRICITY

Lesson 2: Electrical Terminology

TEACHING PROCEDURES

B. ***Review***

Lesson 1 addressed electrical safety, electrical defects, and types of circuit protection. To work with electricity safely, a knowledge of the basic terminology is important in order to understand it properly. The NEC and Underwriters Laboratories play an important role in electrical work as well.

C. ***Motivation***

Point out to the class that electricity has its own set of terms and definitions. Ask students if they know what volts, ohm, amps, and watts are. Discuss why it is important to understand this terminology.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. To become proficient in working with electricity, an individual needs to become familiar with the terminology used. Have students list electrical terms they have heard and discuss their definitions.

   What are electrical terms and definitions?

   a) Conductor - wire through which electrical current is carried through a circuit; typically made from copper, aluminum, or copper-clad aluminum
   b) Circuit - complete, uninterrupted path of electricity
   c) Positive, or hot, wire - wire that acts as a conductor of electrical power; typically color-coded red or black
   d) Neutral wire - wire that conducts electricity from the appliance back to the source, completing the circuit; color-coded white or gray
   e) Insulation - protective covering on the wires; usually made of plastic or rubber
   f) Grounding - electrical connection from the piece of equipment or appliance to the earth
   g) Fuse - safety device that prevents the overload of an electrical circuit by “burning out” and interrupting the electrical flow
   h) Circuit breaker - automatic flip switch located on an electrical circuit that breaks, or shuts off, the current when overloaded

i) Alternating current (AC) - electrical current that alternates, or changes its direction of flow at regular intervals, usually 60 times per second
j) Direct current (DC) - electrical current that flows steadily in the one direction through a conductor; produced by a generator or battery
k) Amperage - measurement of the flow of current through an electrical system; measured in amperes, or amps (A)
l) Voltage - measurement of the pressure created by electricity moving through a conductor; measured in volts (V)
m) Wattage - measurement of the total electrical power within a system; calculated by multiplying amperage and voltage and measured in watts (W)
n) Kilowatt (kW) - 1,000 watts
o) Resistance - opposition to the flow of current as it moves through a conductor; measured in ohms
p) Voltage drop - loss of electrical pressure from the source to the point of use
q) Short circuit - wires in the same circuit come into contact, causing the flow of electrical current to move from its desired path

2. Ask students what the acronym NEC stands for. Discuss the purposes of the NEC.

What is the NEC?

a) In 1911, the National Fire Protection Association sponsored the development of the National Electrical Code (NEC).
b) The goal of the NEC is to address four issues.
   1) Changing power needs in the United States
   2) Safe user practices of new technology
   3) Minimum standards for electric wiring practices and materials used nationwide
   4) Increased energy use in the home, workplace, and community
c) Printed periodically in book form.
d) Topics covered in the 1996 edition
   1) Wiring and protection
   2) Wiring methods and materials
   3) Equipment for general use
   4) Special occupancies (buildings for particular purposes)
   5) Special equipment
   6) Special conditions
   7) Communication systems

3. Ask students if they think that they are required to follow NEC guidelines in every structure they build. Why might it be a good idea to do so?

How are NEC guidelines enforced?

a) The NEC is basically a reference and resource for state and local governments and for insurance companies.

b) Government agencies utilizing the NEC include the Occupational Safety and Health Administration (OSHA) and state and local building inspectors.

c) Insurance companies may require the use of NEC guidelines in buildings they insure, primarily for those structures being built for rental or resale.

4. Show students the UL listing on some type of electrical equipment. Ask them if they know what it means. Discuss the purpose of a UL listing. Have students complete AS 2.1.

What does a UL listing mean?

a) Underwriters Laboratories, Inc. (UL) - independent, not-for-profit testing and certification organization that evaluates products, materials, and systems in the interest of public safety

b) UL listing
   1) Means that representative samples of the product have been tested and evaluated with reference to nationally recognized safety standards for electric shock, fire, and related safety hazards
   2) Important because it provides a degree of product quality assurance

G. ***Other Activities***

Have students work in groups to list everyday items (for example, a 40-watt light bulb) or situations in which many of the terms discussed in this lesson are used.

H. ***Conclusion***

To fully understand how to work with electricity, knowing the basic terms associated with it is vitally important. The terms addressed in this lesson are fundamental to the entire industry. Understanding each of them is imperative to learning how electricity works and how to wire circuits.

I. ***Answers to Activity Sheet***

1. Conductor
2. Circuit breaker
3. Wire that acts as a conductor of electrical power; typically color-coded red or black
4. Voltage
5. Covering on the wires; usually made of plastic or rubber
6. Neutral wire
7. Fuse
8. Complete, uninterrupted path of electricity
9. Alternating current (AC)
10. National Electrical Code (NEC)
11. Measurement of the flow of current through an electrical system; measured in amperes, or amps
12. Electrical connection from the piece of equipment or appliance to the earth
13. Short circuit

14. Measurement of the total electrical power within a system; calculated by multiplying amperage and voltage and measured in watts
15. Underwriters Laboratories, Inc. (UL)
16. Loss of electrical pressure from the source to the point of use
17. 1,000 watts
18. Direct current (DC)
19. Opposition to the flow of current as it moves through a conductor; measured in ohms
20. UL listing

J. ***Answers to Evaluation***

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

8. Answers may include any one of the following.

   - Changing power needs in the United States
   - Safe user practices of new technology
   - Minimum standards for electric wiring practices and materials used nationwide
   - Increased energy use in the home, workplace, and community

9. A UL listing means that representative samples of the product have been tested and evaluated with reference to nationally recognized safety standards for electric shock, fire, and related safety hazards.

10. Government agencies, including the Occupational Safety and Health Administration (OSHA) and state and local building inspectors, and insurance companies

UNIT V - ELECTRICITY Name _____

Lesson 2: Electrical Terminology Date _____

EVALUATION

Match the term on the right with the description on the left.

1. ____ Electrical current flowing steadily in the same direction through a conductor
2. ____ The loss of electrical pressure from the source to the point of use
3. ____ The opposition to flow of current as it moves through the conductor; measured in ohms
4. ____ A unit of measurement for the flow of current through an electrical circuit
5. ____ The actual wire through which electricity is carried through a circuit
6. ____ Electrical current that changes its direction of flow at regular intervals
7. ____ Amperage multiplied by voltage

a. Ampere

b. Wattage

c. Direct current

d. Alternating current

e. Voltage drop

f. Resistance

g. Conductor

Complete the following short answer questions.

8. What is one of the four issues addressed by the National Electrical Code?

9. What does a UL listing mean?

10. Who enforces NEC guidelines?

Lesson 2: Electrical Terminology Name _____

Electrical Terms

Objective: Define important terms used in the electrical industry.

Fill in the term or the definition for each of the blanks below.

Term

1. ______________
2. ______________
3. Positive, or hot, wire
4. ______________
5. Insulation
6. ______________
7. ______________
8. Circuit
9. ______________
10. ______________
11. Amperage
12. Grounding
13. ______________
14. Wattage

Definition

Wire through which electrical current is carried through a circuit; typically made from copper, aluminum, or copper-clad aluminum

Automatic flip switch located on an electrical circuit that breaks, or shuts off, the current when overloaded

Measurement of the pressure created by electricity moving through a conductor

Wire that conducts electricity from the appliance back to the source, completing the circuit; color-coded white or gray

Safety device that prevents the overload of an electrical circuit by “burning out” and interrupting the electrical flow

Electrical current that changes its direction of flow at regular intervals, usually 60 times per second

Code sponsored by the National Fire Protection Association

Wires in the same circuit come into contact, causing the flow of electrical current to move from its desired path

16.	______________	Independent, not-for-profit testing and certification organization that evaluates products, materials, and systems in the interest of public safety
17.	Voltage drop	
18.	Kilowatt (kW)	
19.	______________	Electrical current that flows steadily in the one direction through a conductor; produced by a generator or battery
20.	Resistance	
21.	______________	Mark indicating that representative samples of a product have been tested and evaluated with reference to nationally recognized safety standards

Lesson 3: Wire Types and Uses

Competency/Objective: Match types and sizes of wire with their uses.

Study Questions

1. What are the different types of wire?

2. Which wires are best adapted for agricultural wiring?

3. Why is wire size important?

4. How is the right wire size selected?

5. What are feeder wires?

6. How does demand load affect the feeder wire?

7. How does length and voltage drop affect feeder wire size?

8. What are some rules of thumb to apply when calculating the circuit needs of a structure?

9. What is the procedure for calculating the load in an agricultural building?

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.

2. Transparency Masters

   a) TM 3.1: Service Wire
   b) TM 3.2: Cable
   c) TM 3.3: Wire Sizes
   d) TM 3.4: Wiring Tables
   e) TM 3.5: Feeder Wires

3. Activity Sheet

   a) AS 3.1: Calculating Feeder Wire Size

UNIT V - ELECTRICITY

Lesson 3: Wire Types and Uses

TEACHING PROCEDURES

B. ***Review***

In the previous lesson, the importance of safety when working with electricity and electrical terminology were stressed. This information will now be applied to actual wiring procedures. When planning electrical systems in construction, determining the types of wires to be used is a priority. To choose the proper type of wire and wire size, it is important to be familiar with the types of wire available and the uses of each, the NEC recommendations for agriculture structures, and the electrical load to be placed on the wire.

C. ***Motivation***

1. Buy different sizes of tubing (_", ¼", ½", ¾") from a hardware store and bring them to class. Have students answer the following questions.

   - Which tube will allow the least amount of water through?
   - Which will allow the greatest?
   - What will happen if the same amount of water carried through the ¾" tube is forced through the ¼" tube? (Increased pressure!)
   - What does this pressure create? (Friction)

2. The same principles apply to electricity and electrical wiring. Think of the tubing as the wire and the water as electricity. Just like the tubing, the goal when selecting electrical wire is to have the appropriate size to allow the needed amount of electricity to flow through it without experiencing losses in power, or voltage drop, due to excess friction throughout the path, which causes resistance to electrical flow.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. For a building or structure to receive electricity, power must flow through a series of different sizes and types of wire. Each type of wire is identifiable by its components and a lettering scheme. Ask the class why it is important to have different types of wires available for conducting electricity. TMs 3.1 and 3.2 can be used to illustrate cables and emphasize the different components.

   What are the different types of wire?

a) Wire material
   1) Copper wire
      (a) Best conductor for most purposes
      (b) Most widely used
   2) Aluminum wire
      (a) Relatively poor conductor
      (b) Copper clad aluminum slightly better
      (c) Must be two sizes bigger than copper wire to produce similar results
b) Service wires - carry power into the home or building to the service entrance panel
   1) SE - overhead installations
   2) USE - underground service
   3) Consist of a bundle of wires, with fine strands of uninsulated wire wrapped around the insulated wires; the uninsulated wire is the grounded neutral
c) Interior wires - must be protected from the elements
   1) Type T
      (a) Most commonly used interior wire type
      (b) Has thermoplastic insulation, which is a single layer of plastic compound that covers the individual wire
      (c) Can strip insulation off easily and cleanly, making the wire easy to use
      (d) Divided into four categories based on the wire's ability to withstand environmental and temperature conditions
         (1) TW - moisture resistant; may not be buried directly in the ground; maximum temperature of 140 degrees Fahrenheit
         (2) THW - moisture and heat resistant, with a heat rating of 194 degrees Fahrenheit; may not be buried in the ground
         (3) THHN - dry conditions; maximum temperature of 194 degrees Fahrenheit
         (4) THHW - wet and dry conditions; maximum temperature of 194 degrees Fahrenheit in dry conditions and 167 degrees Fahrenheit in wet conditions
   2) Type R
      (a) Previously rubber coated for insulation but now uses synthetic polymers
      (b) May have moisture-resistant, flame-retardant outer covering
      (c) Rarely used in modern construction, although still found in older structures
      (d) Has three categories of wire
         (1) RH - dry conditions; maximum temperature of 167 degrees Fahrenheit
         (2) RHH - dry conditions; temperature rating of 194 degrees Fahrenheit

(3) RHW - wet or dry conditions; temperature rating of 167 degrees Fahrenheit

d) Cables - individual wires assembled and covered with a protective element; predominant form of structural wiring used in the modern construction industry

1) Nonmetallic sheathed cable
   (a) Most common type of cable used in building construction
   (b) Contains two or three THHN or THHW wires with an additional bare ground wire
   (c) Easy to install, clean in appearance, and highly economical
   (d) Comes in three forms
      (1) NM - used in dry conditions, not in barns or other damp locations on agricultural operations
      (2) NMC - designed for damp or corrosive locations but cannot be buried underground
      (3) UF - identical to NMC but can be buried directly underground

2) Armored cable
   (a) Used in dry locations only
   (b) Contains TW, THW, or THHN wires
   (c) Wires enclosed in tough paper overwrap and spiral steel armor

3) Flexible cord
   (a) Type SPT-2
      (1) Wires imbedded in plastic
      (2) Used for small appliances, such as floor lamps, radios, etc.
   (b) Type S
      (1) Heavier
      (2) Used for applications where heavy use and abuse is possible, such as for power tools
      (3) Wires bundled into a round assembly insulated with plastic or rubber
   (c) Type HPN
      (1) Heater cord
      (2) Used for heating appliances, such as toasters and irons

2. Agriculture structures pose slightly different requirements than homes or businesses in terms of electrical work. Why?

Which wires are best adapted for agricultural wiring?

a) NEC categories of agricultural buildings

1) Buildings where excessive dust and dust with water may accumulate
   (a) Totally enclosed and environmentally controlled poultry and livestock structures
   (b) Confinement systems where litter, dust, and feed dust may accumulate
   (c) Feed mills

2) Buildings where a corrosive atmosphere exists - totally enclosed and environmentally controlled areas where:
   (a) Poultry and animal excrement may cause corrosive vapors in the confinement area
   (b) Corrosive particles may combine with water
   (c) The area is damp and wet because of periodic washing and sanitizing with water and cleansing agents, as is the case in milk parlors

b) Approved wires for agricultural buildings
   1) UF, NMC, and other cables or raceways that are highly resistant to corrosion
   2) In buildings with excessive dust, must have “dust-ignition-proof” wires and fixtures that do not produce a

rcs, sparks, or heat sufficient to cause dust to

i
g
n
i
t
e

3. The size of the wire is as important as selecting the proper wire type for a job. Ask students why wire size matters. Refer back to the demonstration of the tubes in the motivation section. Show students TM 3.2 to illustrate wire size.

Why is wire size important?

a) Wire size is measured using the American Wire Gauge (AWG).
  1) Smaller AWG numbers represent larger wire sizes.
  2) Number 14 is the smallest size allowed in most structures, although the wire size used in agricultural structures should not be smaller than number 12.
  3) Wire sizes range from 4/0 (about ½ inch in diameter) to 20+.

b) Wire size is important for two reasons.
  1) Ampacity is defined as the safe carrying capacity of the wire.
    (a) The greater the amount of amperes flowing through a conductor, the greater the amount of heat produced.
    (b) Doubling the amperes without changing the wire size will increase heat output by four times.
    (c) If the amperage becomes too high for a prolonged period, it may damage the insulation and start a fire.
  2) Voltage drop is the loss of electrical pressure over a length of wire.
    (a) Some voltage drop is expected, and a 2 percent drop is acceptable, but excessive voltage drop is wasted power.
    (b) Machinery and equipment that run at lower than rated voltages work inefficiently.
    (c) Wire size affects voltage drop; a larger conductor provides a larger surface for more complete electrical flow.
    (d) If more amperes are pushed through a conductor than its size allows, increased friction results, causing heat buildup and voltage drop.

4. After electrical loads are established for each circuit, the proper wire size must be determined. Discuss how to select the proper wire size. Show the students the table on TM 3.3 and explain its use.

How is the right wire size selected?

a) Some key information is needed before the appropriate wire size can be determined.
   1) Amperage load
   2) Voltage
   3) Wattage
   4) Length of run
   5) Type of wire installation used, such as open air or buried wire, since larger wires are needed overhead for support and because of voltage leaks
b) Wire size can be determined by using amperage, voltage, wattage, and the length of the run.

   NOTE: Show the class the tables on TM 3.3 and explain how they are used to choose a wire size for a particular situation. As an example, use 30 amperes at 240 volts with a one-way distance of 120 feet, requiring a number 8 wire. Explain that different tables would be used with underground wires.

   1) Always round up calculated wattage in consideration of future growth and increased power conditions.
   2) If the distance the wire is to span falls between the distances given on the table, use the longer distance and the larger wire.
c) Beyond the basic considerations, overhead wires pose other requirements.
   1) The wires need to be large enough to support themselves without sagging and to maintain some rigidity under heavy snow loads.
   2) To carry 600 volts or less, AWG 10 is recommended for spans up to 50 feet in length; number 8 wire is needed for longer spans.
   3) To carry over 600 volts, AWG 6 is needed where individual conductors are used, and number 8 where conductors are in the form of a cable.

5. For agricultural facilities, power is brought in and distributed differently than in most homes and businesses. Ask students to explain the differences. Show students TM 3.4 to illustrate power distribution from a yard pole through feeder wires.

   What are feeder wires?

   a) The feeder wires span the distance from the electrical service equipment at the pole to the service panel at each individual structure.
   b) They are either SE or USE wire, depending upon whether the service will be installed overhead or underground.

6. When planning to supply electrical power to outlying agriculture structures, the demand load of those structures needs to be taken into account. Ask the class to define demand load. What is the connection between demand load and feeder wire size?

   How does demand load affect the feeder wire?

a) The size of the feeder wire depends on the demand load for a structure.
b) Demand load is considered to be the amount of power that will likely be needed at any given time.
c) The minimal calculated demand load is normally about 35 percent of the actual connected load.
d) Depending on the type and use of the electrical system within an agriculture structure, this percentage may be higher.
e) The approximate amperage that will be in use will determine the necessary feeder wire size.

7. Discuss the effect of wire length and voltage drop on feeder size. Have students complete AS 3.1.

How does length and voltage drop affect feeder wire size?

a) Because length tends to be a fixed factor once the yard pole is in place, the size of the feeder wire must then be increased to avoid voltage drop if demand loads or amperage requirements increase.
b) A good rule of thumb is to place the pole or power source as close as possible to the building or buildings that will have the highest electrical use.

8. Discuss the guidelines that should be applied when planning the circuit requirements of a structure.

What are some rules of thumb to apply when calculating the circuit needs of a structure?

a) Lighting and/or convenience outlets - at least one for every 150 square feet of floor space
b) Minimum of 3 watts of lighting for each square foot of floor space
c) Convenience outlets installed every 12 linear feet along walls
d) Branch circuit with a 20-amp minimum for 500 square feet of floor space
e) Minimum of a 15-amp branch circuit for every 375 square feet of floor space
f) Water heater - branch circuit of 30 amps, carrying 220 volts
g) Fan - branch circuit of 20 amps, carrying 110 volts
h) Water pump - branch circuit of 20 amps, carrying 110 or 220 volts
i) Workshop bench - branch circuit of 20 amps, carrying 110 or 220 volts

9. Ask students what they would do to calculate the electrical load for a building. Explain the steps of the procedure for calculating load.

What is the procedure for calculating the load in an agricultural building?

a) List the number of circuits, special appliances, motors, etc. to be used.

b) Determine the total volt-amperes (VA), or watts (W), for each by multiplying their amperage and voltage requirements and then multiply each one by the number of power outlets of that type.
c) Add the numbers to determine total wattage of the structure.
d) Multiply by the demand load factor; if in doubt about the size of the demand load, use a higher percentage.

EXAMPLE: Use this example to demonstrate how to calculate feeder wire size. The problem given is also included in the *Agricultural Structures* student reference.

Circuits and appliances:

10 lighting circuits, generally calculated at 400 W
5 outlets, generally calculated at 200 W
3 motors, at 1200 W, 2000 W, and 3000 W
1 heater, stamped with a rating of 5000 W

W requirements:

10 × 400 W = 4000 W
5 × 200 W = 1000 W
(1200 W + 2000 W + 3000 W) × 0.50 = 3100 W (Use .5 as a multiplier if all the motors do not run at the same time.)
Heater = 5000 W

Total W: 4000 W + 1000 W + 3100 W + 5000 W = 13,100 W or 13.1 kW

Demand load: 13.1 kW × 0.50 = 6.55 kW, or 6550 watts

G. *Other Activities*

Using the classroom or shop, have the students determine the number and electrical requirements of lights, outlets, and equipment. Use this information to determine the volt-ampere/watt requirements of the area and the size of the feeder wire needed to connect the meter base to the service panel.

H. *Conclusion*

Choosing the correct wire type for agricultural structures is important, since certain hazards may be present if inappropriate wires are used. The size of these wires is also critical, since the electrical system may operate inefficiently if conductors are not large enough. Feeder wires are especially important, since they carry electricity from the service equipment at the yard pole to the individual structures of the farmstead. Determining the correct feeder wire size involves calculating the amount of electrical usage and the demand load of the structure.

I. ***Answers to Activity Sheet***

1. TOTAL CONNECTED LOAD = 29500 W
2. DEMAND LOAD = 29500 W × .45 = 13275 W
3. WIRE SIZE = No. 6 AWG

J. ***Answers to Evaluation***

1. d
2. c
3. e
4. a
5. b
6. b
7. c
8. a
9. Amperage load, voltage, wattage, length of run, and type of wire installation used
10. NMC and UF
11. Ampacity and voltage drop

12. List the number of circuits, special appliances, motors, etc. to be used.

13. Place the yard pole as close as possible to the building or buildings that will have the highest electrical use to reduce wire costs and the effects of voltage drop.

14. Demand load is typically considered to be the amount of power which will likely be needed at any given time.

UNIT V - ELECTRICITY Name _____

Lesson 3: Wire Types and Uses Date ___________________________

EVALUATION

Match the term on the right with the description on the left.

1. ____	Heater cord	a.	THW
2. ____	Nonmetallic cable; corrosive areas	b.	RH
3. ____	Underground service cables	c.	NMC
4. ____	Heat and moisture resistant	d.	HPN
5. ____	Dry conditions	e.	USE

Circle the letter that corresponds to the best answer.

6. For 500 square feet of floor space, a minimum _____________ branch circuit is required.

   a. 15-amp
   b. 20-amp
   c. 25-amp
   d. 30-amp

7. The wires that span the distance from the electrical service equipment at the pole to the service panel at each individual structure are:

   a. Cords.
   b. Demand cables.
   c. Feeder wires.
   d. Copper wires.

8. What is the minimum wattage for lighting per square foot of floor space?

   a. 3
   b. 4
   c. 5
   d. 6

Complete the following short answer questions.

9. What are the five pieces of information required to determine the wire size?

a.

b.

c.

d.

e.

10. What are two examples of approved wires for agricultural buildings?

    a.

    b.

11. What are two reasons that using the proper wire size is important?

    a.

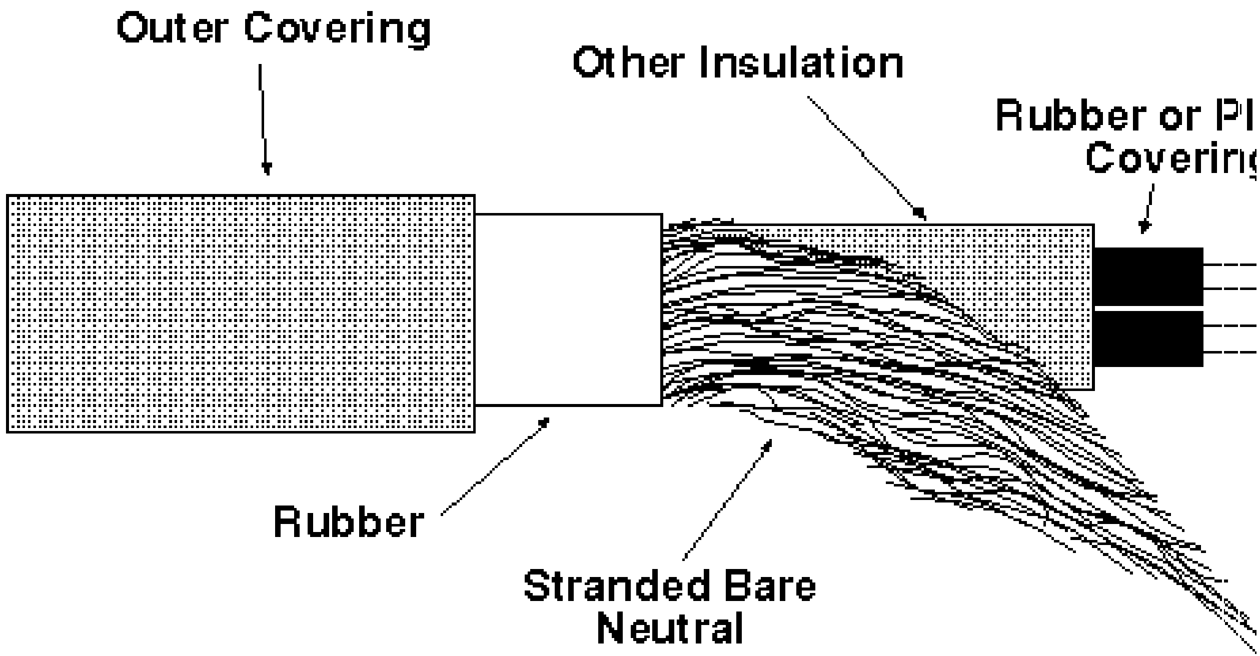
    b.

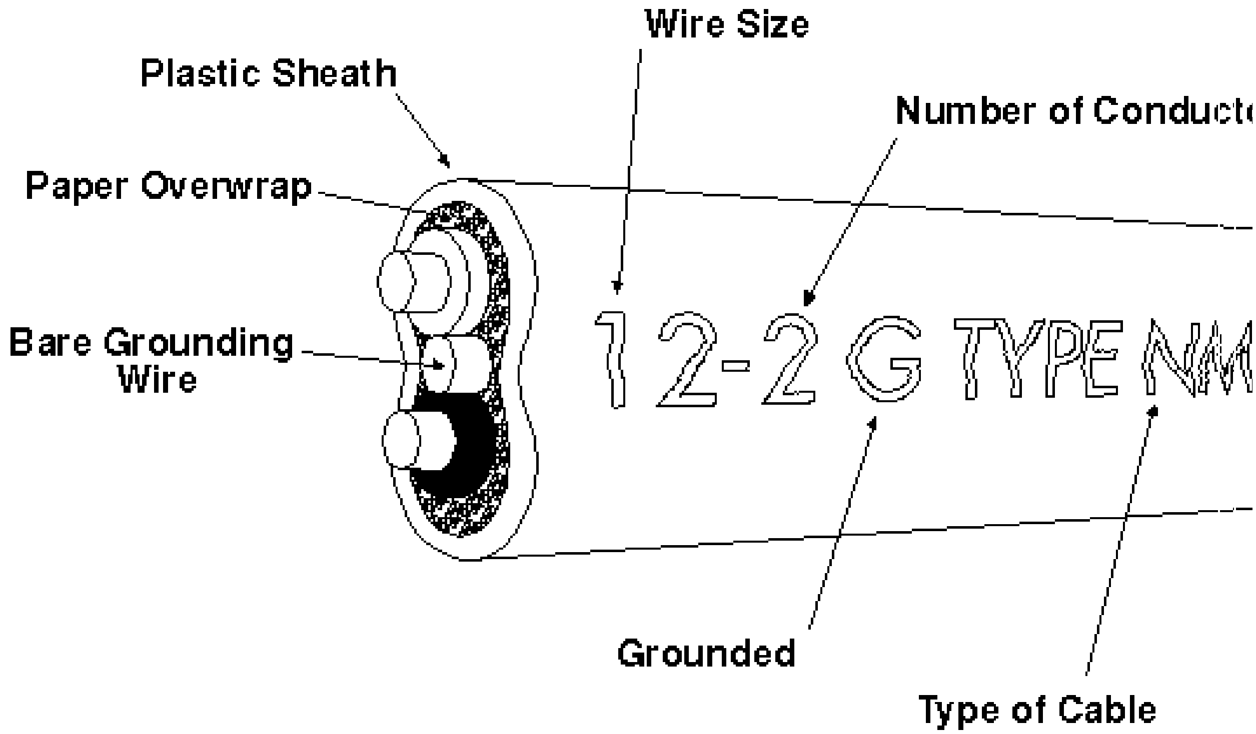
12. What is the first step in calculating load for an agricultural structure?

13. Where would the electrical service pole best be located, and why?

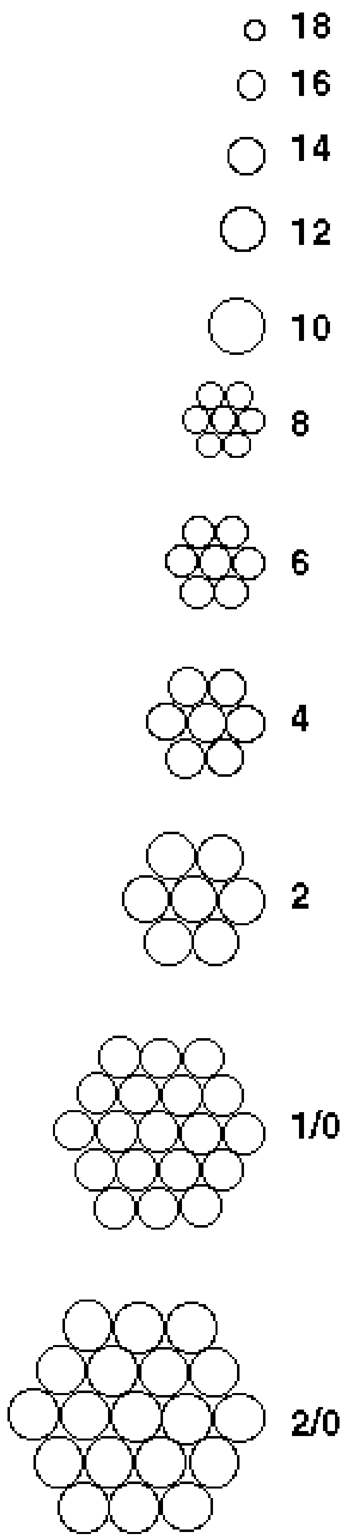
14. What is demand load?

Service Wire


Outer Covering
Other Insulation
Rubber or Pl
Coverin
Rubber
Stranded Bare
Neutral


Wire Size
Plastic Sheath
Number of Conduct
Paper Overwrap
Bare Grounding Wire
12-2 G TYPE NM
Grounded
Type of Cable

Wire Sizes

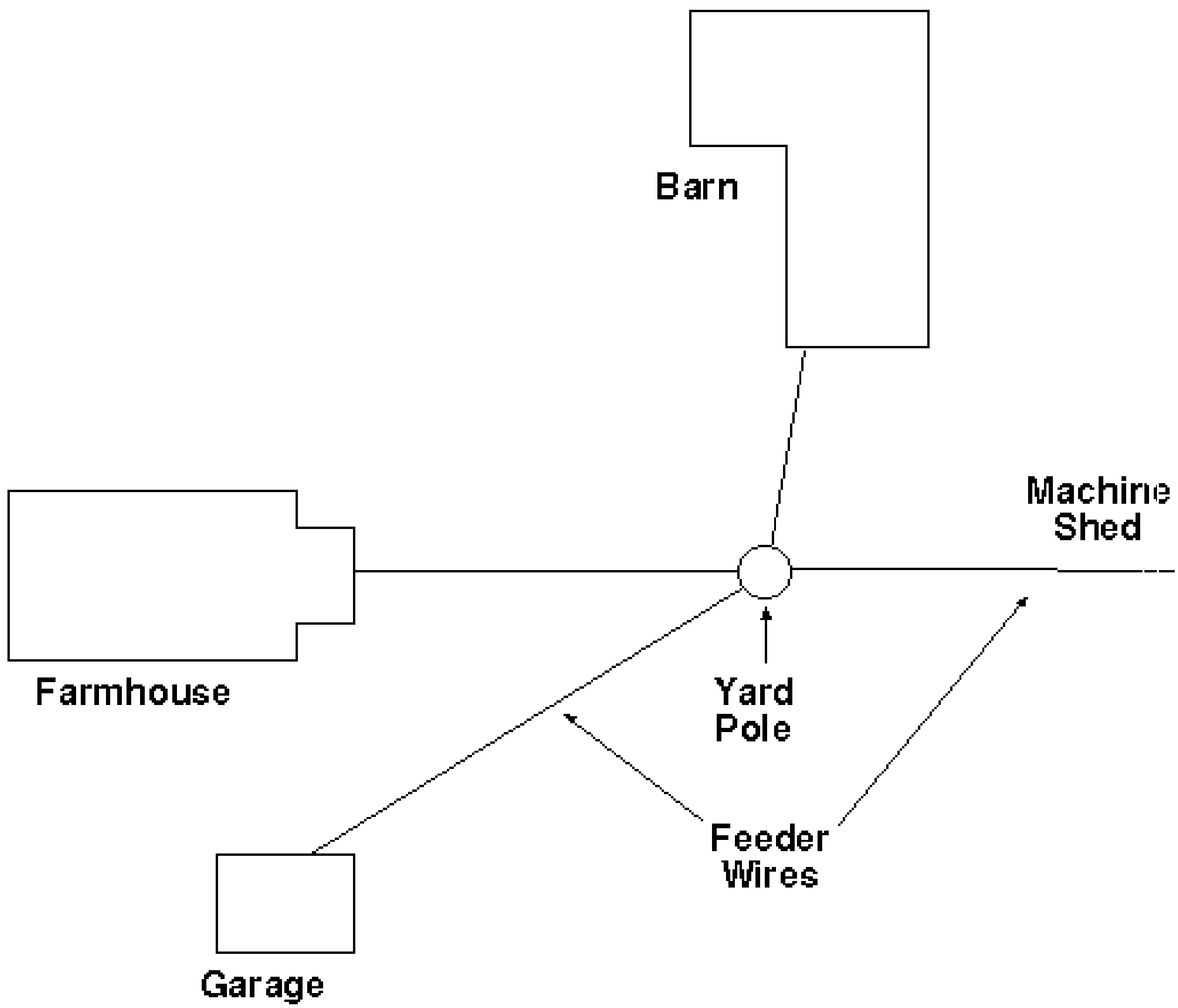


Wiring Tables

One-Way Distances (in Feet) at 120 Volts, Single-Phase, with 2% Voltage Drop											
		AWG Wire Sizes									
Amps	Watts	14	12	10	8	6	4	2	1/0	2/0	3/0
5	600	90	140	225	360	570	910				
10	1200	45	70	115	180	285	455	725			
15	1800	30	45	70	120	190	300	480	765	960	
20	2400	20	35	55	90	145	225	360	575	725	915
25	3000	18	28	45	70	115	180	290	460	580	730
30	3600	15	24	35	60	95	150	240	385	485	610
40	4800			28	45	70	115	180	290	360	455
50	6000			23	36	55	90	145	230	290	365

One-Way Distances (in Feet) at 240 Volts, Single-Phase, with 2% Voltage Drop											
		AWG Wire Sizes									
Amps	Watts	14	12	10	8	6	4	2	1/0	2/0	3/0
5	1200	180	285	455	720	1145					
10	2400	90	140	225	360	570	910	1445			
15	3600	60	95	150	240	380	610	970	1530		
20	4800	45	70	115	180	285	455	725	1150	1450	
25	6000	35	55	90	140	230	365	580	920	1160	1450
30	7200	30	48	75	120	190	300	480	770	970	1220
40	9600		36	56	90	140	230	360	575	725	915
50	12000			45	70	115	185	285	460	580	725
60	14400				60	95	150	240	385	485	610
70	16800				50	80	130	205	330	410	520
80	19200					70	115	180	285	360	460
90	21000					60	100	160	260	320	405
100	24000					55	90	145	230	290	365
125	30000						75	120	190	240	300
150	36000							95	150	195	245

200	48000		70	115	145	185


Barn
Machine Shed
Farmhouse
Yard Pole
Feeder Wires
Garage

Lesson 3: Wire Types and Uses Name ___________________________

Calculating Feeder Wire Size

Objective: Calculate the total connected load, the demand load, and the feeder wire size.

Using the information provided and the necessary tables from the student reference, calculate the total connected load, the demand load, and the AWG wire size for the feeder wire. Show your work.

Circuits and appliances at 240 volts:

15 lighting circuits at 400 W each
12 receptacle outlets at 200 W each
5 motors, ½, 1, 2, 2, and 4 hp
1 heater at 7000 W
2 ventilation fans at 4500 W each

Motor data:

½ hp	500 W
1 hp	1200 W
2 hp	2000 W
4 hp	4500 W

Other information:

Use 0.50 factor for electrical motors.
Use a demand load factor of 45%.
The length of the run from service pole to service panel is 75 feet.

1. TOTAL CONNECTED LOAD = _________

2. DEMAND LOAD = ______

3. WIRE SIZE = ______

UNIT V - ELECTRICITY

Lesson 4: Grounding and GFCI Protection

Competency/Objective: Identify the importance of grounding and GFCI protection.

Study Questions

1. What is grounding, and why is it important?

2. What are the NEC requirements for grounding?

3. What are GFCIs?

4. What are the NEC requirements for GFCI use?

5. What are the types of GFCI units used in agriculture structures?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.

2. Transparency Masters

   a) TM 4.1: A GFCI at Work
   b) TM 4.2: Types of GFCIs

3. Activity Sheet

   a) AS 4.1: Grounding and GFCIs

TEACHING PROCEDURES

A. ***Review***

The last lesson discussed the importance of properly selecting wire types and sizes for agricultural structures. This lesson, Lesson 4, focuses on the importance of grounding the electrical system. The grounding of a building's electrical system is a safety feature that helps to protect people and animals from receiving a shock by redirecting the electrical current. Ground fault circuit interrupters, or GCFIs, also provide a safety feature that helps protect against electrical shock.

B. ***Motivation***

Ask students to think of electricity as a living entity that is continually searching for a means of completing its path. Electricity will always seek the path of least resistance to complete its circuit. What would happen if a person came in contact with a wire or piece of equipment that has a short? What can protect individuals from being shocked?

C. ***Assignment***

D. ***Supervised Study***

E. ***Discussion***

1. Ask students to describe ways to prevent shock hazards, and list them on the board. How many are related to grounding? Ask students to define grounding. Why is it important?

   What is grounding, and why is it important?

   a) Grounding
      1) Forms the connection between a piece of equipment or electrical appliance and the earth
      2) Provides electricity an alternate path back to its source
      3) Grounding point
         (a) Typically established at or near the service entrance panel
         (b) May consist of a metal rod driven into the ground that is connected directly to the service panel with a ground wire
         (c) May also consist of a grounding wire attached to an established galvanized metal water pipe
      4) Connected to appliances and electrical equipment through a dedicated ground wire

(a) Connected either to the equipment directly or to the electrical outlet receptacle
(b) Leads back to the ground connection at the service panel

b) Importance - prevention of electrical shock
   1) Provides a safety measure for channeling an electrical current that is out of the electrical circuit back to the earth at the source
   2) Directs the charge away from humans and livestock

2. The NEC has set forth guidelines related to correct procedures for safely installing a grounding system. Discuss NEC requirements for grounding.

What are the NEC requirements for grounding?

a) Three main purposes
   1) Grounding limits voltages in an electrical system due to lightning, line surges, or unintentional contact with higher voltage lines.
   2) It helps stabilize voltages within the system.
   3) It provides a path to facilitate the operation of overcurrent devices.
b) Regulations
   1) Proper grounding rods must be in place and connected to the electrical system prior to making the electrical connection to the power source.
   2) The ground rod conductor is to be connected at the point where the electrical service enters the service panel.
   3) All connections to the ground rod must be made at the service panel and the entrance point to the service panel, not on the individual circuits.
   4) The grounding electrode should be as near as practical to the service entrance.

3. Ask students whether a ground wire can provide all the protection needed for an electrical system. What would happen if the ground wire was faulty? Describe the uses of GFCIs. Show students TM 4.1 to illustrate how GFCIs work.

What are GFCIs?

a) GFCI (ground fault circuit interrupter) - device that interrupts the circuit to any electrical device when a fault current exceeds a predetermined level less than that required to operate the overcurrent protection device
b) Primary function - to interrupt the flow of the current to prevent people and animals from being shocked
c) Monitors the magnitude and time of electrical flow; interrupts abnormal electrical flows of 5/1000 amperes in 25/1000 of a second
d) Work by sensing imbalances in electrical circuits caused by shorts or other faults
   1) When an imbalance occurs between the black “hot” wire and white “neutral” conductors, an uneven electrical load exists in the system.

2) A ground fault current is present and seeking a return conductor to the source.
3) A person or animal coming in contact with the fault current can provide this path.
4) The GFCI prevents shocks by stopping the electrical flow.

4. The NEC has developed a set of guidelines that apply to the installation and use of GFCIs. Discuss the requirements of the NEC.

What are the NEC requirements for GFCI use?

Required for all outlet receptacles or any devices permanently wired into the electrical system that are installed in the locations listed

a) Bathrooms
b) Garages and grade level portions of unfinished accessory buildings used for storage and work areas
c) Outdoors
d) Crawl spaces, where the crawl space is at or below ground level
e) Unfinished basements and areas not intended as habitable rooms and limited to storage areas, work areas, and the like
f) Kitchens, where the receptacles are installed to serve counter top surfaces
g) Indoor or outdoor swimming pools
h) Hot tubs
i) Portable signs
j) Any location using temporary power

5. Ask students to describe any GFCIs they have seen. Describe the four types of GFCIs available for homes and farms. TM 4.2 illustrates the different types. Point out that the use of a particular type of GFCI will be determined by the conditions of the structure. Have students complete AS 4.1.

What are the types of GFCI units used in agriculture structures?

a) Circuit breaker
    1) Fixed, permanently installed
    2) Substitutes for a standard circuit breaker
    3) Controls the outlets within an entire circuit
b) Plug-in
    1) Designed for use in existing electrical systems that do not have GFCI devices
    2) Plugs into a regular receptacle
    3) Protects only those appliances plugged into it
c) Portable
    1) Has an extension cord and is portable
    2) Plugs into standard outlets
    3) Generally used for construction and short term circuit protection needs

d) Outlet-type
    1) Permanently mounted in an outlet box
    2) Protects all the items plugged into it
    3) Widely used in the construction of new buildings

F. ***Other Activities***

Have students identify various locations of GFCIs in the school. In class discuss their findings. Discuss the reasons for having GFCIs in those locations. Were there any locations where GFCIs should have been installed but were not?

G. ***Conclusion***

Grounding and GFCIs are an important safety feature for electrical systems in agricultural structures. Because they are so important, the NEC requires their use to help protect humans and livestock from shocks from faulty or damaged wiring. They also work to protect the electrical system from hazardous overloads.

H. ***Answers to Evaluation***

1. d
2. c
3. a
4. a
5. b
6. Ground fault circuit interrupter

7. It provides a safety measure for channeling an electrical current that is out of the electrical circuit back to the earth at the source, directing the charge away from humans and livestock.

8. Answers may include any one of the following: grounding limits voltages in an electrical system due to lightning, line surges, or unintentional contact with higher voltage lines; it helps stabilize voltages within the system; and it provides a path to facilitate the operation of overcurrent devices.

9. At the point where the electrical service enters the service panel

10. Answers may include any three of the following: bathrooms; garages and grade level portions of unfinished accessory buildings used for storage and work areas; outdoors; crawl spaces, where the crawl space is at or below ground level; unfinished basements and areas not intended as habitable rooms and limited to storage areas, work areas, and the like; kitchens, where the receptacles are installed to serve counter top surfaces; swimming pools; hot tubs; portable signs; and any location using temporary power.

UNIT V - ELECTRICITY Name _____

Lesson 4: Grounding and GFCI Protection Date ___________________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. The outlet-type GFCI:

   a. Controls the outlets within an entire circuit.
   b. Has an extension cord.
   c. Plugs into standard outlets.
   d. Is permanently mounted in an outlet box.

2. The grounding electrode should be:

   a. Close to all of the major appliances.
   b. Connected to each of the individual circuits.
   c. As near as practical to the service entrance.
   d. Outside of the agricultural structure.

3. How does a GFCI work to prevent shocks?

   a. By interrupting the flow of the current.
   b. By serving as a path between electricity and its source.
   c. By directing a charge into the ground.
   d. By allowing electricity to escape out of the outlet.

4. The _______________ ground fault has an extension cord attached to it.

   a. Portable
   b. Plug-in
   c. Outlet-type
   d. Circuit breaker

5. The _______________ ground fault controls the outlets in an entire circuit.

   a. Outlet-type
   b. Circuit breaker
   c. Plug-in
   d. Portable

Complete the following short answer questions.

6. What does GFCI mean?

7. Why is grounding important in the prevention of electrical shock hazards?

8. What is one of the purposes of grounding, according to the NEC?

9. According to NEC regulations, where should the ground rod conductor be connected?

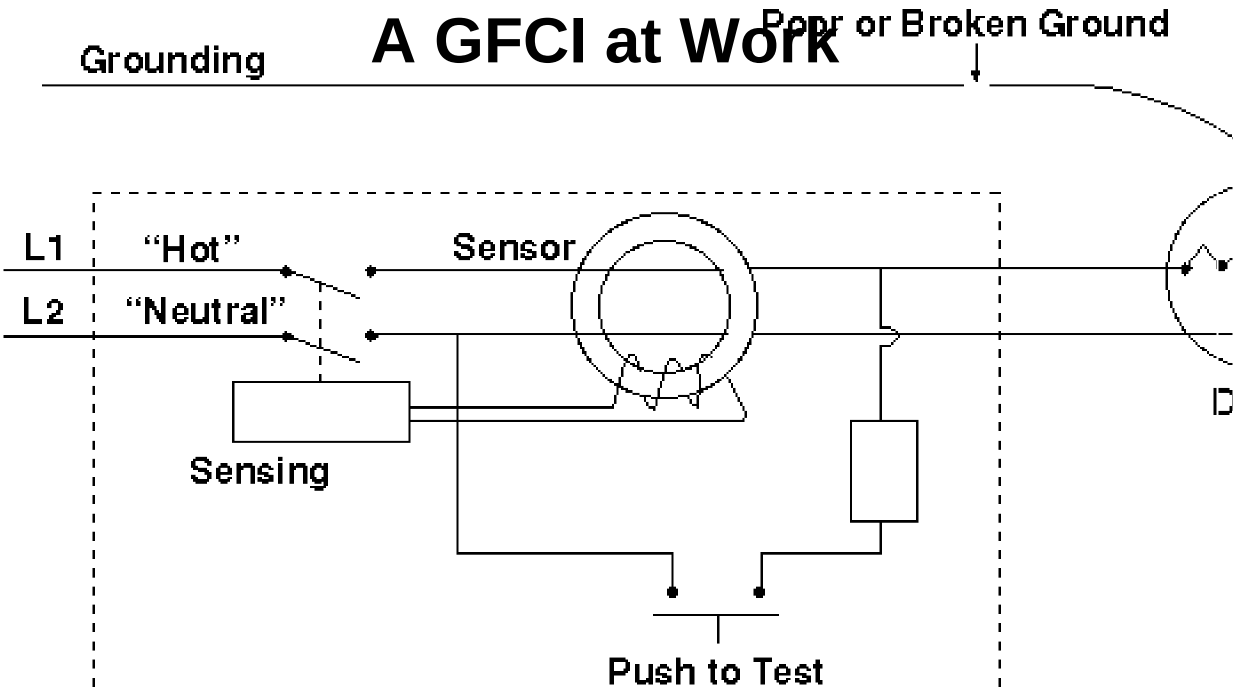
10. Where are three places the NEC requires that GFCIs be used?

    a.

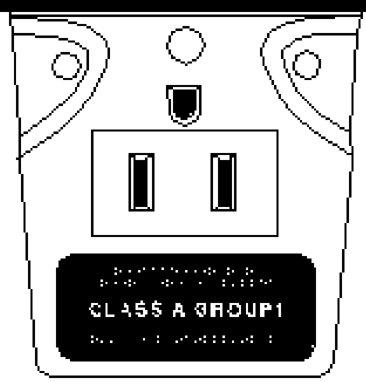
    b.

    c.

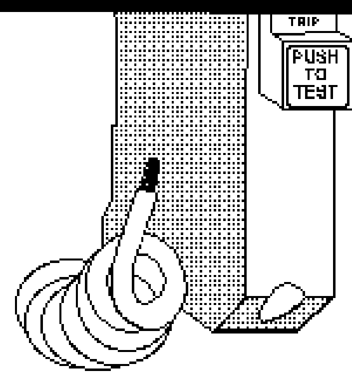
A GFCI at Work



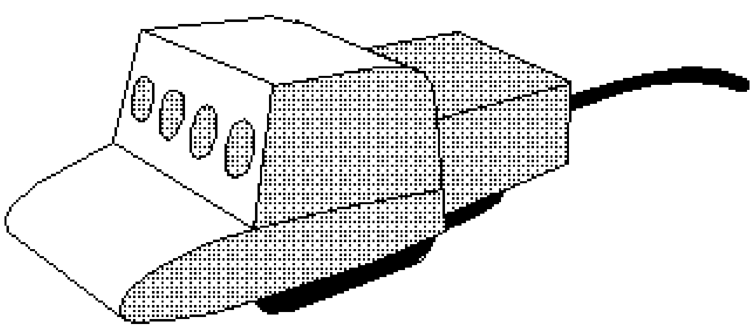
Types of GFCIs



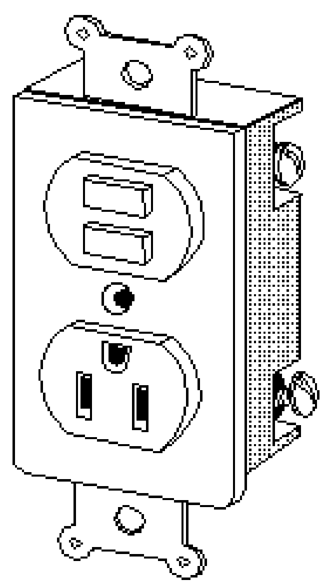
Plug-In Ground Fault



Circuit Breaker Ground Fault



Portable Ground Fault



GFCI Outlet

Lesson 4: Grounding and GFCI Protection Name ___________________________

Grounding and GFCIs

Objective: Identify sources of electrical grounding and the location of GCFIs around the home and farm.

In the space below is a diagram of a simple machine shop. On the diagram, identify the ideal position for the electrical service panel (ESP), ground rods (GR), and installed GFCIs, using the abbreviations given.

UNIT V - ELECTRICITY

Lesson 5: Lights, Outlets, Switches, and Circuit Protection

Competency/Objective: Locate lights, outlets, and switches, and identify circuit protection needs.

Study Questions

1. **What are the rules for lighting outlets located in an agriculture structure?**
2. **What are the types of lighting and their uses?**
3. **What are the rules for convenience outlets located in an agriculture structure?**
4. **What are the rules for switches located in an agriculture structure?**
5. **What electrical protection is needed in an agricultural structure?**
6. **What are the general recommendations for branch circuits?**

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.
2. Activity Sheet
   a) AS 5.1: Evaluating Lights, Outlets, Switches, and Circuit Protection

TEACHING PROCEDURES

A. ***Review***

In Lesson 4, proper grounding practices and GFCI use was discussed. Another important aspect of the installation of electrical wiring in an agricultural structure is planning the number and type of lights, outlets, and switches.

B. ***Motivation***

Ask students if they know what a dust explosion is. What leads to dust explosions in agriculture structures? Discuss ways to avoid these problems, focusing particularly on items such as lights, switches, and outlets.

C. ***Assignment***

D. ***Supervised Study***

E. ***Discussion***

1. When planning the wiring of an agricultural structure, it is important to follow safety standards from the NEC and local regulatory agencies. Discuss the general guidelines for lighting outlets.

   What are the rules for lighting outlets located in an agriculture structure?

   a) Wet areas - nonmetallic light fixture made of nonconductive materials, such as porcelain, plastic, or rubber
   b) Areas where dust is a problem - dust-tight light fixtures that prevent combustible materials from coming into contact with electrical connections

2. Another important consideration is the type of lighting to be used in the structure. In order to choose the most appropriate type, it is necessary to be familiar with the different types of lighting. Ask students to list the types of lighting they have seen. Discuss the different types and their uses.

   What are the types of lighting and their uses?

   a) Incandescent lamp - produces light when electricity moves through a wire filament that then glows at a white heat
   b) Gaseous discharge lamps - pass an electric current through a gas enclosed under pressure in a tube or bulb, producing light when the current moves through the gas particles

1) Low pressure gaseous discharge lamps
    (a) Fluorescent lamps
        (1) Made up of a glass tube that contains mercury vapor and argon gas
        (2) Ultraviolet energy produced by electricity flowing through the mercury vapor; turns to visible light after striking the fluorescent coating of phosphors on the inside of the tube
        (3) Used indoors
        (4) Used effectively for supplementary lighting in greenhouses
    (b) Low pressure sodium lamps
        (1) Consist of two glass tubes, one inside the other
        (2) Inner tube - contains solid sodium and a mixture of argon and neon gas
        (3) Outer tube - protective barrier for the lamp
        (4) Gives off a yellow light
        (5) Commonly used for street lights
2) High pressure gaseous discharge lamps
    (a) Mercury vapor lamps
        (1) Two-bulb configuration
        (2) Inner bulb - quartz arc tube containing mercury vapor at a high pressure, which allows it to produce visible light without phosphors
        (3) Produces greenish-blue light
        (4) Longer life than other lamps of similar wattage
        (5) May take 5 to 7 minutes for vapor pressure to build up and reach full brightness
        (6) Primarily used outdoors around farms and homes
    (b) Metal halide lamps
        (1) Contain compounds of metal and halogen with the same basic two-bulb design
        (2) Produce more naturally colored light
        (3) Long life and high light output
        (4) Excellent outdoor light source
        (5) Some indoor applications as well, such as supplementary lighting for greenhouses
    (c) High pressure sodium lamps
        (1) Similar to mercury vapor lamps
        (2) Arc tube made of aluminum oxide containing a solid mixture of sodium and mercury
        (3) Produce an orange-white light
        (4) Long life and very high light output
        (5) Used outside around homes and farms

3. A sufficient number of convenience outlets must be included in an agricultural structure. Have students observe the number of convenience outlets in the

classroom and the spacing between them. Discuss the guidelines for their installation.

What are the rules for convenience outlets located in an agriculture structure?

a) Location
   1) Installed where animals will not readily bump into them; should be at least 5 feet above ground level anywhere livestock may be present
   2) Must be easily accessible
   3) Mounted between the studding or flush with the wall
b) Type
   1) 20-amp duplex receptacles with a safety ground
   2) GFCI receptacle preferable, especially in damp areas
   3) Nonmetallic outlet boxes
c) Number
   1) Depends on the amount of use the outlet will receive and the building type
      (a) Livestock buildings - 12 to 15 feet between outlets
      (b) Other structures - 8 to 10 feet
   2) Rule of thumb - to install enough outlets so that extension cords will not have to be used on a regular basis

4. Switches control everything from lighting to motorized equipment. Discuss the use of switches in agricultural structures.

What are the rules for switches located in an agriculture structure?

a) Location based on convenience and ease of access
b) Installed at elbow height in protected spots
c) On the latch side of doors and on the traffic side of arches
d) Need multiple switches when multiple doors provide access to a single room or bay, if the doors are farther than 10 feet apart

5. Because of the damp and corrosive environments found in agricultural structures, electrical protection is a priority in these buildings. Describe the types of electrical protection needed.

What electrical protection is needed in an agricultural structure?

a) Branch circuits - need adequate amperage-rated fuses or circuit breakers, which is calculated based on the anticipated use of the circuit
b) Grounding
   1) Needed for all noncurrent carrying devices
   2) System ground wire - same size as the wires carrying electrical current

6. Branch circuits are the primary electrical connections within agricultural structures. Therefore, it is very important to carefully plan these circuits. Discuss the

recommendations for branch circuits. Have students complete AS 5.1. Point out that older structures may not meet the current standards described in this lesson, although they may not be unsafe.

What are the general recommendations for branch circuits?

a) Must have enough circuits to carry out business efficiently
   1) General purpose circuits must be considered in planning.
      (a) Permanent lighting circuits
      (b) Convenience outlets
      (c) Special lighting circuits like automatic on/off outdoor lights
      (d) Portable heater units
   2) The service entrance panel should have open circuit spaces for anticipated electrical expansion.

b) Limitations
   1) Branch circuits should not operate at more than 2 percent voltage drop or use wire smaller than AWG 12.
   2) The electrical load is not to exceed 80 percent of the branch circuit rating.
   3) Fixed appliances must not be over 50 percent of the load if lighting is also included on the circuit.

F. ***Other Activities***

Have students identify the branch circuits and the outlets they control in the agriculture building by examining the labeling on the service entrance panel.

G. ***Summary***

When planning the electrical system of an agriculture structure, identifying the lighting, outlet, and switch requirements for that building is crucial. The materials installed should be designed for the typical uses and environmental conditions of the structure. Careful planning is required to design a system that will meet current and future demands.

H. ***Answers to Activity Sheets***

I. ***Answers to Evaluation***

1. d
2. e
3. a
4. b
5. c
6. f
7. To prevent combustible materials from coming into contact with electrical connections
8. 12 to 15 feet in livestock buildings, 8 to 10 feet in others

9. The same size as the wires carrying electrical current
10. Answers may include any two of the following: permanent lighting circuits, convenience outlets, special lighting circuits, and portable heater units.

UNIT V - ELECTRICITY Name _____

Lesson 5: Lights, Outlets, Switches, and Circuit Protection Date _____

EVALUATION

Match the lamp types on the right with the descriptions on the left.

1. ____ Contains compounds of metal and halogen
2. ____ Produces an orange-white light
3. ____ Uses a filament that produces light under high heat
4. ____ Converts ultraviolet light into visible light
5. ____ Produces greenish-blue light
6. ____ Contains sodium, argon, and neon

a. Incandescent
b. Fluorescent
c. Mercury vapor
d. Metal halide
e. High pressure sodium
f. Low pressure sodium

Complete the following short answer questions.

7. Why should dust-tight light fixtures be used in areas where dust is a problem?

8. How far apart should convenience outlets be placed in livestock buildings? In other structures?

9. What size wire should be used to ground the system in agricultural structures?

10. What are three general purpose circuits to be considered when planning branch circuits?

a.

b.

c.

Lesson 5: Lights, Outlets, Switches, and Circuit Protection Name ________________________

Evaluating Lights, Outlets, Switches, and Circuit Protection

Objective: Observe the existing lights, outlet, switches, and circuit protection in an agricultural structure and determine if they meet the recommendations presented in class.

Observe the electrical system of an agricultural structure, such as a barn, machine shed, etc., looking at the lighting, outlets, and switches. Answer the following questions to determine if the electrical system meets NEC recommendations.

Type of Structure: ____

1. Are the lighting fixtures appropriate for the type of structure?

2. Is there adequate lighting for this structure, based on light type?

3. How many convenience outlets are present?

4. Are the convenience outlets in the recommended positions?

5. Are switches provided in convenient locations? Are multiple switch systems set up?

6. How many outlets, both light and convenience, are found on each branch circuit? (Hint: Look at the labels found on the inside cover of the SEP panel.)

7. Using the information from Lesson 2 of this unit, calculate the branch circuit loads (lights, outlets, other equipment, and motors). Is the circuit protection for these branch circuits adequate?

UNIT V - ELECTRICITY

Lesson 6: Electrical Symbols in Wiring Plans

Competency/Objective: Identify the symbols used in agricultural wiring plans.

Study Questions

1. Which symbols are used to indicate lighting, receptacle, and switch outlets?

2. Which symbols are used to indicate power, fusing, and grounding?

3. Which symbols are used to indicate panelboards, switchboards, and related equipment?

4. Which symbols are used to indicate remote control stations for motors or other equipment?

5. Which symbols are used to indicate miscellaneous connections?

References

1. *Agriculture Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.

2. Transparency Master

   a) TM 6.1: Electrical Wiring Symbols

3. Activity Sheet

   a) AS 6.1: Diagramming Electrical Wiring

TEACHING PROCEDURES

A. ***Review***

Lesson 5 discussed guidelines for lights, outlets, switches, and circuit protection in agricultural structures. Before one can begin to install these items, a wiring plan must be developed. A set of symbols is used to stand for the different aspects of electrical systems shown on these plans.

B. ***Motivation***

Ask students what electrical items in the classroom would be identified in a wiring schematic. Discuss the importance of planning the placement of those devices in the overall wiring process.

C. ***Assignment***

D. ***Supervised Study***

E. ***Discussion***

1. The use of symbols is a standardized method of identifying the location of electrical components. Familiarity with the symbols is necessary for being able to read plans and correctly install electrical components. Discuss the symbols commonly used for lighting, receptacle, and switch outlets. TM 6.1 can be used throughout the lesson to illustrate the symbols used on plans.

   Which symbols are used to indicated lighting, receptacle, and switch outlets?

   a) Lighting outlets
      1) Ceiling
         (a) Surface or pendant incandescent or similar lamp fixture
         (b) Surface or pendant individual fluorescent fixture
         (c) Surface or pendant continuous row fluorescent fixture
         (d) Blanked outlet
         (e) Junction box
      2) Wall
   b) Receptacle outlets
      1) Single
      2) Duplex
      3) Triplex
      4) Duplex - split wired
      5) Single special purpose

6) Double special purpose
7) Range outlet
8) Clock hanger

c) Switch Outlets
1) Single-pole (SPST)
2) Double-pole (DPST)
3) Three-way (SPDT)
4) Four-way (DPDT)
5) Switch and pilot lamp
6) Switch and single receptacle
7) Switch and double receptacle
8) Door switch
9) Time switch
10) Ceiling pull switch

2. In wiring diagrams, it is also necessary to identify the power source and fusing and grounding locations.

Which symbols are used to indicate power, fusing, and grounding?

a) Electric motor
b) Electric generator
c) Power transformer
d) Electric watt-hour meter
e) Circuit breaker
f) Fusible element
g) Ground

3. When planning for agricultural wiring, identifying the location of the service entrance panel and any specialized switches is also necessary. Point out the different symbols used for these components.

Which symbols are used to indicate panelboards, switchboards, and related equipment?

a) Surface-mounted panelboard and cabinet
b) Motor or other power controller
c) Externally operated disconnection switch
d) Combination controller and disconnection means

4. Agricultural structures tend to utilize more motorized equipment than the home or other types of businesses. Therefore, symbols are frequently used to indicate specialized wiring and switches for motors.

Which symbols are used to indicate remote control stations for motors or other equipment?

a) Push-button station
b) Float switch - mechanical
c) Limit switch - mechanical
d) Pneumatic switch - mechanical
e) Thermostat

5. Because of the environmental and physical considerations of agricultural structures, it is necessary to identify electrical devices designed to provide protection. TM 6.1 shows some of these symbols. Have students complete AS 6.1.

Which symbols are used to indicate miscellaneous connections?

a) Weather proof
b) Water tight
c) Dust tight
d) Grounded
e) Vapor tight
f) Rain tight
g) Explosion proof
h) Recessed

F. ***Other Activities***

Show students an actual wiring diagram of the classroom or mechanics laboratory discussed in the motivation. Discuss how their previous observations matched, or did not match, what is identified on the diagram.

G. ***Conclusion***

To successfully wire a structure, reading electrical wiring diagrams is required. The key to using these diagrams is identifying electrical symbols for the different components of the electrical system.

H. ***Answers to Activity Sheet***

I. ***Answers to Evaluation***

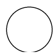
1. g
2. I
3. e
4. c
5. j
6. a
7. b
8. d
9. h
10. f

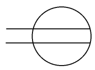
UNIT V - ELECTRICITY Name _____

Lesson 6: Electrical Symbols in Wiring Plans Date _____

EVALUATION

Match the symbol on the left with the terms on the right.



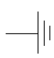
 1. ____ 10. _____

S 2. ____

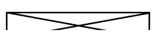
Sp 3. ____

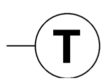
MOT

4. ____



5. ____



 6. ____

VT 7. ____

8. _____

9. _____

a. Ground

b. Power controller

c. Switch with pilot lamp

d. Thermostat

e. Single-pole switch

f. Fusible element

g. Surface lighting element

h. Vapor tight

I. Duplex receptacle

j. Motor connection

[redacted]

Similar Lamp Fixture

Surface or Pendant Individual Fluorescent Fixture

Surface or Pendant Continuous Row Fluorescent Fixture

Blanked Outlet

Junction Box

Wall

To indicate wall installation of above outlets, place circle near wall and connect with line as shown.

Duplex

Triplex

Duplex
Split Wi

Single S
Recepta

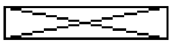
Duplex
Recepta

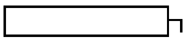
Range

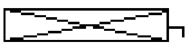
Clock H

Panelboards, Switchboards, and Related Equipment

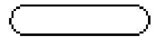

Surface-Mounted Panelboard and Cabinet

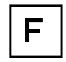

Motor or Other Power Controller


Externally Operated Disconnection Switch

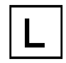

Combination Controller and Disconnection Means

Remote Control Stations for Motors or Other Equipment

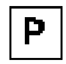

Push-Button Station



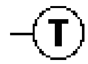
Float Switch - Mechanical



Limit Switch - Mechanical



Pneumatic Switch - Mechani



Thermostat

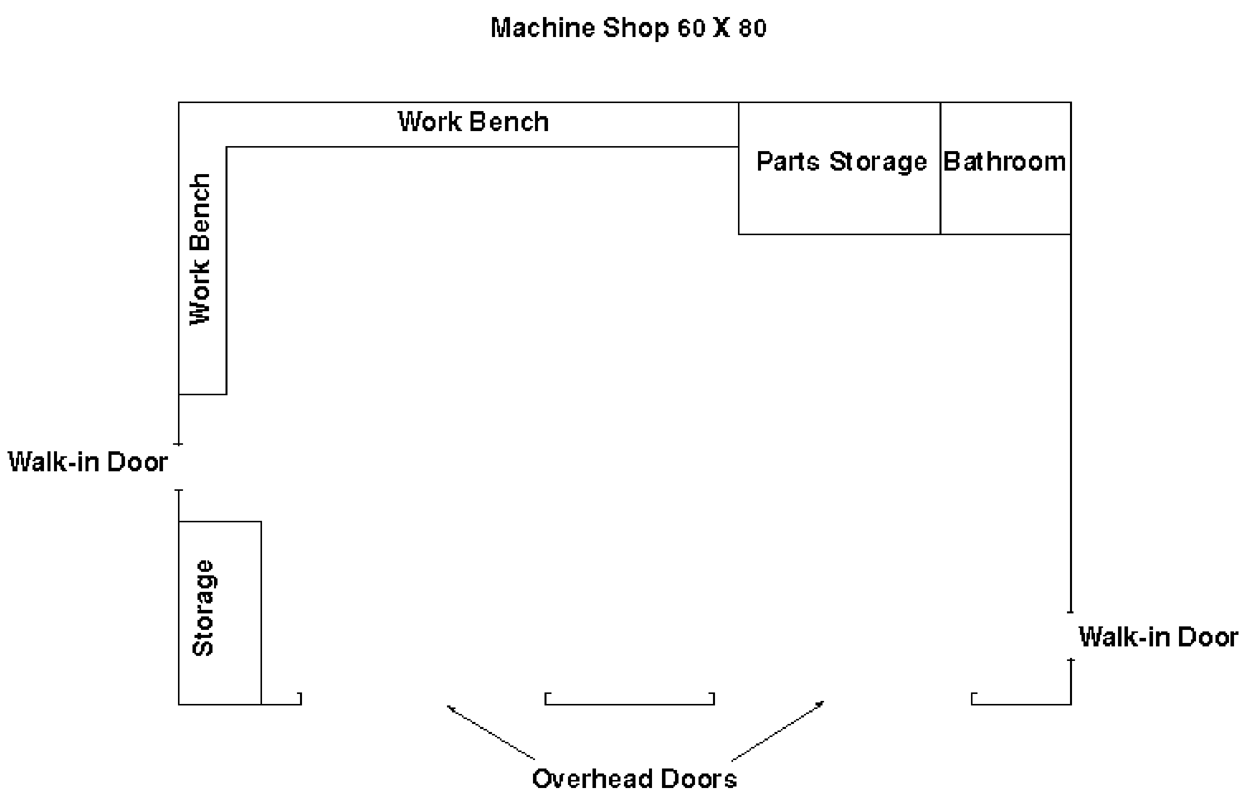
Lesson 6: Electrical Symbols in Wiring Plans Name ____________________________

Diagramming Electrical Wiring

Objective: Diagram a wiring plan for an agricultural structure.

Draw the symbols for the fixtures listed below in the appropriate area of the machine shop diagram. You will choose where the entrances are located. Draw a line from the switches used to the fixtures controlled.

- 4 ceiling light fixtures
- 6 wall mount light fixtures
- 4 duplex receptacles (GFCI)
- Wall switches (you decide how many)



UNIT V - ELECTRICITY

Lesson 7: Running Electrical Wiring

Competency/Objective: Describe practices for running wire to an agricultural structure and wiring within the building safely.

Study Questions

1. What is the configuration at the pole?

2. How is the service entrance installed?

3. When would branch circuits be used on agricultural structures?

4. What must be considered when wiring a barn?

5. What must be considered when wiring a hay barn?

6. How are switches and receptacles selected?

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.

2. Transparency Masters

   a) TM 7.1: Wire Stacking at the Pole
   b) TM 7.2: Installation of the Service Entrance

3. Activity Sheet

   a) AS 7.1: Diagramming the Service Stack

UNIT V - ELECTRICITY

Lesson 7: Running Electrical Wiring

TEACHING PROCEDURES

B. ***Review***

Planning is an important step in correctly installing an electrical system. As discussed in Lesson 6, prior to installing a single wire, a written diagram should be drawn utilizing the proper wiring symbols to identify electrical components. Wiring can take place when the diagram is complete. Wiring begins with bringing the electrical service in at the yard pole and then installing wiring from the yard pole to the service entrance of a structure. The wire can then be run within the structure to branch circuits and electrical fixtures.

C. ***Motivation***

Show students how service wires enter the agricultural education building at school. Discuss the method of attaching service wires to the SEP.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. The electrical service pole is the central hub for power distribution on agricultural operations. The installations made at the yard pole, main service entrance, and the meter should be done by an electrical contractor or the power company to be sure that they are done properly. However, understanding the configuration at the pole is important. Discuss the configuration, using TM 7.1 to illustrate the various components.

   What is the configuration at the pole?

   a) Three wires bring electricity in from the power company, including two hot wires and one neutral wire.
   b) The grouping of the wires at the pole is called the stack.
      1) Single stack - Wires that travel into the meter from the power company and those wires traveling out to individual structures are both contained within a single conduit.
      2) Double stack
         (a) Supply wires coming in from the power company use a separate conduit from the wires that lead out to the individual structures.

(b) Double stacking is utilized when a large number of structures are being served by one meter.

c) A separate ground wire connected to the neutral wires runs along the outside of the conduit to a ground rod.

d) All of the wires carrying power in to or out from the pole are connected directly to the pole with insulators.
   1) Requires two racks of insulators with three insulators per rack, one rack for incoming wires and the other for outgoing wires
   2) Anchored with heavy lag screws and at least one through bolt inserted through the pole for added strength

e) Feeder wires are used to carry power to the meter base.
   1) Attached to supply wires with solderless connectors
   2) Enter the conduit through the service head
   3) Run down the conduit and then attach directly to meter base

f) Short feeder wires are attached from the meter base to the main power disconnect switches at the pole.

g) The size of the feeder and supply wires traveling from the disconnect switches to the structures will be determined by each structure's demand load.

2. Once the wires are in place at the yard pole, the service entrance needs to be installed. Discuss the installation of the service entrance, using TM 7.2 as an illustration. Hand out AS 7.1.

How is the service entrance installed?

a) Size and type of wire
   1) According to the NEC, AWG 8 wire is allowed if up to two two-wire circuits are being installed.
   2) AWG 6 is allowed if up to five two-wire circuits are being installed.
   3) For bigger systems, amperage calculations and wire size tables are needed to determine the proper wire size.

b) Two-wire or three-wire type service
   1) A two-wire system has 110 volts available for use, which is acceptable for small sheds or buildings that will have only lights or outlet receptacles in use.
   2) A three-wire system has both 110 and 220 volts available for use within the structure to provide electricity for equipment requiring 220 volts.

c) Location of the service entrance
   1) The location of the SEP should be determined prior to running wires from the power pole.
   2) NEC guidelines indicate that the SEP should be as close as practical to the point where wires enter the building.
   3) If possible, the service box should be near equipment that requires higher 220-volt electrical loads.
   4) The SEP should be installed in a location that is easily accessible.

d) Wire connections at the building
  1) Insulators are connected to the structure for overhead runs of wire.
  2) The feeder wires connect to main wires and then run into the service head, through the conduit, and into the service entrance panel (SEP).

3. Ask students what branch circuits are used for. Discuss when they are used in agricultural structures.

When would branch circuits be used on agricultural structures?

a) The type of structure and its use will determine the number of circuits needed.
  1) Small sheds with lighting
    (a) Need only two branch circuits
    (b) Allows for backup lights if one circuit blows
  2) Larger structures, such as shops and barns
    (a) Typically need 110/220-volt service
    (b) 220-volt outlet - requires a separate circuit made by combining two 110-volt circuits at the service entrance panel
    (c) Varying number of circuits depending on the number of electrical systems and the number and type of appliances used
b) When determining the number of circuits needed, careful calculations of the wattage used by all electrical components are necessary.
c) A good rule of thumb is to add additional circuits and break up the system to avoid overload problems.
d) Planning for expansion is also important when installing the SEP and calculating the need for branch circuits.

4. Most agricultural structures have uses that must be taken into account when planning electrical wiring. Ask students what might be considered when wiring a barn.

What must be considered when wiring a barn?

a) Environmental conditions
  1) Barns naturally have damp and corrosive environments and tend to lack proper ventilation.
  2) NCM or UF cable is required along with nonmetallic junction boxes that resist moisture.
b) Mechanical damage
  1) Running wires along the sides of beams and joists to where fixtures are located provides protection.
  2) Wires are also run in protective conduits.
c) Lighting, switches, and receptacles
  1) Plenty of lighting should be included throughout the barn.
  2) Switches should be easily accessible and mounted at elbow height.
  3) Receptacles should be dust tight, watertight, and corrosion resistant.
  4) Installing GFCI outlets is a good idea.

d) Livestock considerations
   1) Lights, outlets, and switches should be out of the reach of livestock.
   2) This practice will prevent damage to equipment, fire hazards, and shock hazards.

5. Discuss the considerations that affect wiring in hay barns.

What must be considered when wiring a hay barn?

a) The dust produced by hay is highly flammable, so precautions must be taken to prevent electrical sparks from coming in contact with the dust.
b) Wires must be enclosed in conduits or within a wall covered with sheathing.
c) Vapor proof fixtures seal out dust from electrical connections.
d) Lighting fixtures should minimize the entrance of dust as well as foreign matter, moisture, and corrosive materials into the exposed wiring areas.
   1) Fixtures exposed to physical damage must be protected by a guard.
   2) Fixtures exposed to water must have watertight protective coverings.

6. Proper switches and receptacles must be used when wiring agricultural structures. Ask students what characteristics these fixtures should have.

How are switches and receptacles selected?

a) The NEC requires that switches, circuit breakers, motor controllers, fuses, push buttons, relays, and similar devices be protected from environmental and physical damage.
b) These components should have weatherproof, corrosion resistant enclosures designed to minimize the entrance of dust, water, and corrosive elements.
c) Switches and receptacles designed for outdoor use may be useful because these components tend to be durable and provide protection from environmental conditions.

G. **Other Activities**

Invite a certified electrician to discuss the selection and installation of electrical devices in agricultural structures.

H. ***Conclusion***

The connections at the yard pole and service entrance panel must be made correctly, so they should be installed only by trained professionals. Other wiring within agricultural structures can be done by nonprofessionals. However, in order to install wiring properly, they must take into account the number of branch circuits needed, the conditions in the structures that will affect wiring, and the measures needed to protect wiring.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. b
2. a
3. c
4. To prevent damage to equipment, fire hazards, and shock hazards
5. Because it is highly flammable
6. Because they are durable and provide protection from environmental conditions
7. As close as practical to the point where wires enter the building

8. Wires in to the meter and out to the structures run through a single conduit in a single stack and through different conduits in a double stack.

UNIT V - ELECTRICITY Name _____

Lesson 7: Running Electrical Wiring Date ___________________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. What wire size can be used if up to five two-wire circuits are being installed?

   a. AWG 8
   b. AWG 6
   c. AWG 4
   d. AWG 2

2. How many branch circuits are needed for small sheds with lighting?

   a. 2
   b. 3
   c. 4
   d. 5

3. At the yard pole, feeder wires carry power to the:

   a. Stack.
   b. Ground rod.
   c. Meter base.
   d. Neutral wire.

Complete the following short answer questions.

4. Why should lights, outlets, and switches be out of the reach of livestock in barns?

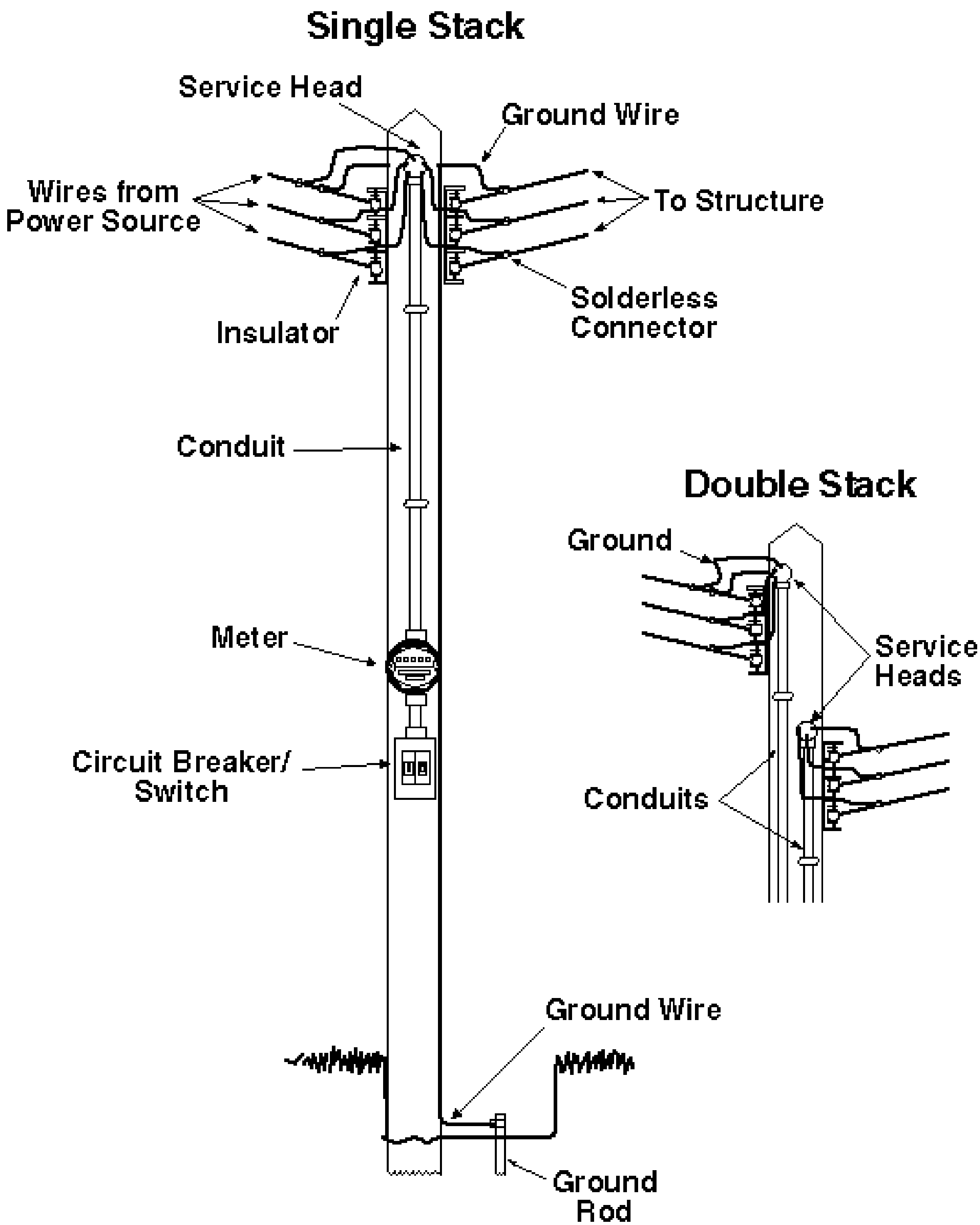
5. Why should hay dust be prevented from coming in contact with electrical sparks in hay barns?

6. Why are switches and receptacles designed for outdoor use useful in agricultural structures?

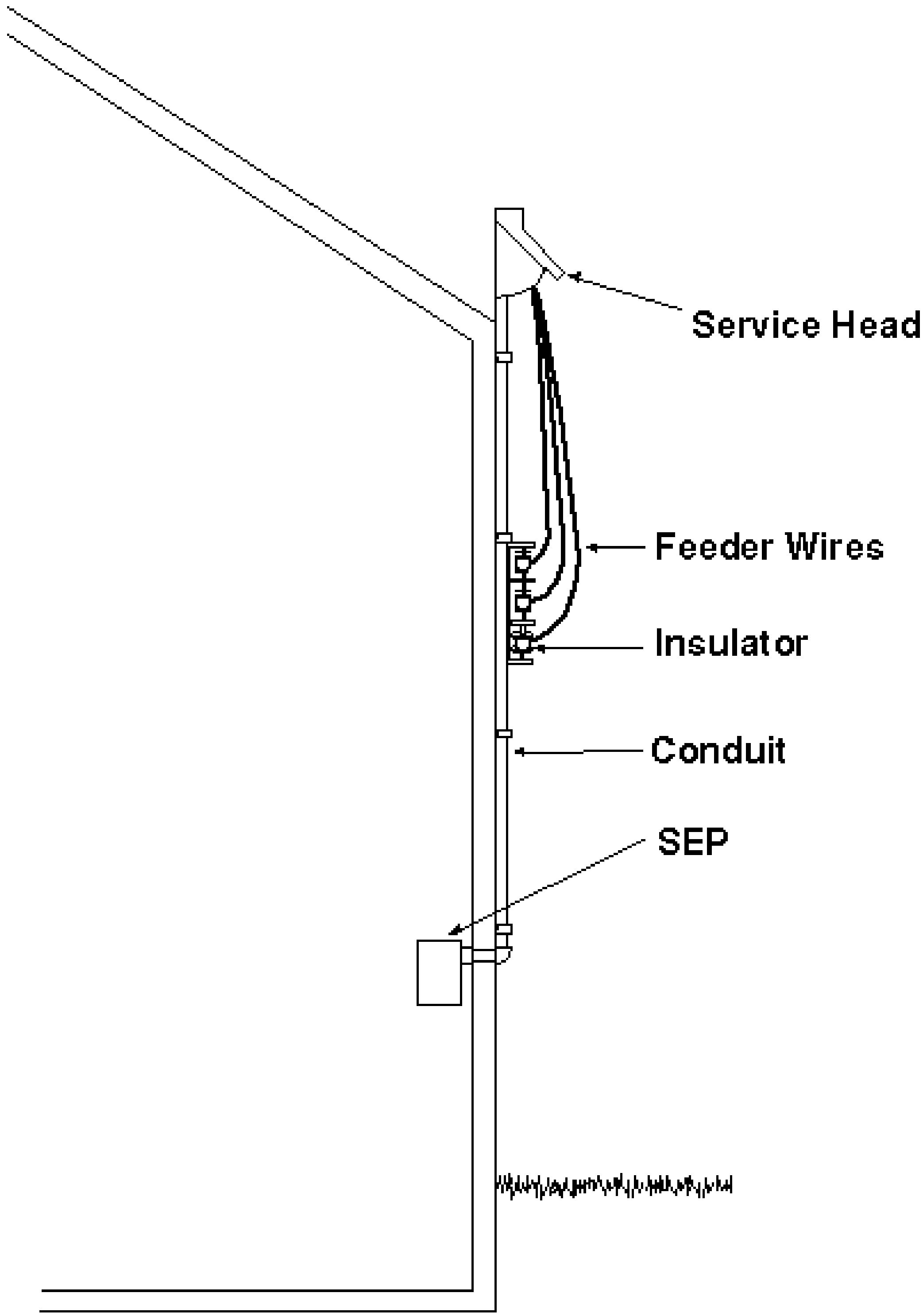
7. Where should the service entrance be installed?

8. What is the difference between a single stack and a double stack?

Wire Stacking at the Pole



Installation of the Service Entrance



Lesson 7: Running Electrical Wiring Name ____________________________

Diagramming the Service Stack

Objective: Identify the stack configuration at the service pole or service entrance.

Identify the stack configuration found at either the electrical service pole or the service entrance at your home. In the space below, diagram the configuration. In the diagram, include the stack configuration, the meter base, the main disconnect switch (if present), and the wires. Color code the wires, using black or red for hot wires, grey for neutral wires, and green for ground wires.

UNIT V - ELECTRICITY

Lesson 8: Connecting to the SEP

Competency/Objective: Identify procedures for connecting the drop wires and branch circuit wires to the SEP.

Study Questions

1. **What are the parts of the SEP?**
2. **What are some good wiring practices to follow when wiring the panel?**
3. **What is the procedure for connecting the service entrance conductors to the SEP?**
4. **How is the ground system installed for the SEP?**
5. **How are circuit protectors selected and sized?**
6. **How are the 120-volt branch circuits connected to the SEP?**
7. **How are the 240-volt individual circuits connected to the SEP?**
8. **What is three-phase power, and when should its use be considered?**

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.
2. Transparency Masters
   a) TM 8.1: SEP Parts
   b) TM 8.2: Ground System
   c) TM 8.3: Wired 120/240 V Panel
3. Activity Sheet
   a) AS 8.1: Identifying SEP Components

TEACHING PROCEDURES

A. ***Review***

Lesson 7 described bringing electrical power in at the yard pole and then installing wiring from the yard pole to the service entrance, after which wire can be run to branch circuits and electrical fixtures. The next step is making the connections at the service entrance panel. Within the SEP, circuits are linked to the power source, providing electrical power to the entire system.

B. ***Motivation***

Remove the cover from the SEP in the agriculture shop or building. Have students examine how the connections are made. Ask students if they can determine which circuits are 120 volts and which are 240 volts.

C. ***Assignment***

D. ***Supervised Study***

E. ***Discussion***

1. The SEP distributes power throughout a structure. Ask students to list the components of an SEP. Use the SEP in the agriculture building to illustrate the different parts, or show students TM 8.1.

   What are the parts of the SEP?

   a) Cabinet - houses the parts of the SEP
   b) Main disconnect switch - large amperage breaker used to disconnect the power coming into the structure from the individual circuits
   c) Panel with banks, or rows, of sockets designed to accept either circuit breakers or fuses
   d) Circuit breakers or fuses - provide overcurrent protection for the circuits
   e) Neutral bar - specialized bar with terminal screws placed in it to make connections between neutral wires and ground wires
   f) Grounding screw - the point where the ground wire connects to the neutral bar
   g) Bonding strap - ground the cabinet

2. Describe proper wiring procedures at the SEP.

   What are some good wiring practices to follow when wiring the panel?

a) Reducing overheating
    1) One way to reduce heat buildup is by wiring neatly and keeping wiring orderly within the cabinet.
    2) Keep wire runs in the SEP as straight and direct as possible.
    3) Wires should not be bent during wiring, because the constriction of wires can cause insulation damage as well as overheating.

b) Other good practices
    1) Make tight connections without excessive bare wire showing at the terminal screws.
    2) Place the neutral bar in a convenient location in the SEP box to make direct wire runs easier.
    3) Cut wires to the exact length necessary, removing any excess wire from the box.

3. Typically, three wires enter the SEP from the service drop, including two 120-volt hot conductors and one neutral conductor. Discuss the procedure for connecting the wires. Emphasize the importance of making secure connections.

What is the procedure for connecting the service entrance conductors to the SEP?

a) Check to make sure that the power is shut off.

b) Connect the two hot conductors to the main disconnect switch.
    1) Cut the conductors to the proper length.
    2) Strip off enough insulation to make a good connection.
    3) Insert the bare ends of the wire into the connectors on the main disconnect.
    4) Tighten the holding screws securely onto the wires.

c) Using the same procedures, attach the neutral wire to the neutral bar.

d) Ground the SEP cabinet by attaching either the flexible bonding strap or the ground wire to the grounding screw.

4. Discuss the installation of ground systems and grounding electrodes. TM 8.2 illustrates one type of ground system.

How is the ground system installed for the SEP?

a) Involves connecting a ground wire from the neutral bar in the SEP to a grounding electrode or a ground system
    1) Several different types of electrodes may make up ground systems.
        (a) Buried metal water pipe 10 feet or more in length, which must be supplemented by at least one other electrode
        (b) Grounded metal frame of the structure
        (c) Concrete-enclosed electrode

(1) Composed of either 20 or more feet of ½-inch reinforced steel or AWG 4 copper wire
(2) Placed inside at least 2 inches of concrete located near the bottom of the foundation and in direct contact with the earth
(d) Buried AWG 2 or bigger wire that encircles the entire structure
2) If none of these options for the ground system are available, a grounding electrode is used.
(a) Underground metal piping or buried metal tanks
(b) ½-inch copper rod or _-inch metal or copper-clad rod
(c) ¾-inch galvanized steel pipe
(d) Buried metal plate at least 2 square feet in diameter
b) Size of the ground wire
1) If the service entrance conductor is AWG 2 or smaller, AWG 6 or 8 wire should be used.
2) If the service entrance conductor is AWG 1 or 0, AWG 6 is the minimum size permitted.
3) If the service entrance conductor is AWG 2/0 or 3/0, the ground wire should be a minimum of AWG 4.
4) If wire larger than AWG 3/0 is used at the service entrance, AWG 2 must be used for the ground connection.
c) Installation of the ground wire
1) Fasten the wire to the surface over which it runs using special staples.
2) Install the wire in a location that will minimize physical damage.
3) Protection is typically provided by either tucking the grounding wire behind the service conduit entering the structure or running the wire along wall studs.
4) If AWG 8 or smaller wire is used for grounding, protect it with a conduit.

5. Either circuit breakers or fuses are needed for overcurrent protection. Most structures being built have circuit breakers because they are easier to use. Discuss how circuit protectors are selected and sized.

How are circuit protectors selected and sized?

a) Determining whether fuses or circuit breakers will be used is important.
b) Other factors considered when selecting overcurrent devices are the wire size and amperage ratings, the electrical devices operated on the circuit, and the demand load of the circuit.
c) Correctly sized circuit protection devices must be installed.
1) Main disconnect breaker
(a) Determines the total electrical capacity of the SEP
(b) Rated at 30, 40, 50, 60, 70, 90, 100, 125, 175, and 200 amps, with larger breakers available for industry purposes
2) Fuses and circuit breakers
(a) Begin at 15 amps and increase by 5-amp increments up to 50 amps.

    (b) Must have an amperage rating equal to or less than the rating for the conductor

6. Once the service wires have been connected into the SEP, the branch circuits can be connected. Describe the process of connecting 120-volt branch circuits. TM 8.3 can be used to illustrate the wiring.

   How are the 120-volt branch circuits connected to the SEP?

   a) Planning the location of each circuit before beginning the installation is important.
   b) Connect the neutral and ground circuit wires from the branch circuit to the neutral bar.
      1) Strip off enough insulation from the wires to make good contact with the neutral bar.
      2) Place each wire under a different screw on the neutral bar.
      3) Tighten the screws firmly.
   c) Attach the hot wire.
      1) Strip off the insulation of the black wire.
      2) Insert the wire under the terminal screw of the circuit breaker, which should be screwed tight.
   d) Insert the circuit breaker into the slot in the SEP panel.

7. Larger circuits that carry 240 volts use a double-pole circuit breaker for the connections at the SEP. Discuss how the circuits are connected, using TM 8.3 as an illustration. Hand out AS 8.1. To complete the activity sheet, contact a local electrician and obtain a SEP with breakers to use as a model. Wire the SEP as if it were actually in use. If possible, give the circuits sample labels, and ask students to identify their purpose.

   How are the 240-volt individual circuits connected to the SEP?

   a) Connect the black circuit wire to one terminal screw of the double-pole breaker.

   b) Connect the white circuit wire to the other terminal screw.
   c) Attach the ground wire to the neutral bar.

8. Another type of power that can be supplied to agricultural structures is three-phase power, which is a form of alternating current. Describe three-phase power and its uses.

   What is three-phase power, and when should its use be considered?

   a) Three-phase power
      1) Three-phase AC power utilizes three hot wires, each carrying electrical current at different stages of alternation.

2) Each wire peaks in amperage at a slightly different point in time.
3) By synchronizing the wave patterns of the three hot wires, a more consistent amperage is achieved.

b) Uses
1) Three-phase motors may be less expensive than single phase motors with the same horsepower.
2) Three-phase power can also operate larger motors than standard single-phase power and will power those motors more efficiently.

c) Limiting factors
1) The cost of three-phase power is higher than that for single-phase power.
2) The power company must install additional transformers.
3) A more expensive meter is needed to monitor power usage.

F. ***Other Activities***

G. ***Conclusion***

The service entrance panel provides power to all the circuits in an agricultural structure. The SEP houses individual circuit protection in the form of overcurrent devices and provides a centralized location for power control for the entire electrical system.

H. ***Answers to Activity Sheet***

I. ***Answers to Evaluation***

1. c
2. a
3. d
4. e
5. b
6. 30 amps or less
7. In a location that will minimize physical damage
8. To remove any excess wire from the box

9. Three-phase motors may be less expensive than single phase motors with the same horsepower, and three-phase power can also operate larger motors and will power those motors more efficiently.

10. Answers will vary, but the wires should be drawn and labeled appropriately.

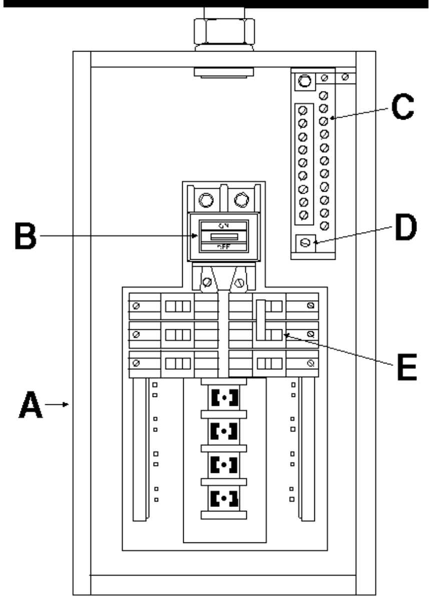
UNIT V - ELECTRICITY Name _____

Lesson 8: Connecting to the SEP Date ____________________________

EVALUATION

Write the letter in the blank next to the [redacted] **name of the SEP part pictured.**

1. Main disconnect switch
2. Circuit breaker
3. Neutral bar
4. Grounding screw
5. Cabinet



Complete the following short answer questions.

6. If AWG 12 wire with a rating of 30 amps is used for a circuit, what size circuit breaker should be used?

7. Where should the ground wire be installed?

8. When wiring the SEP panel, why should wires be cut to the exact length necessary?

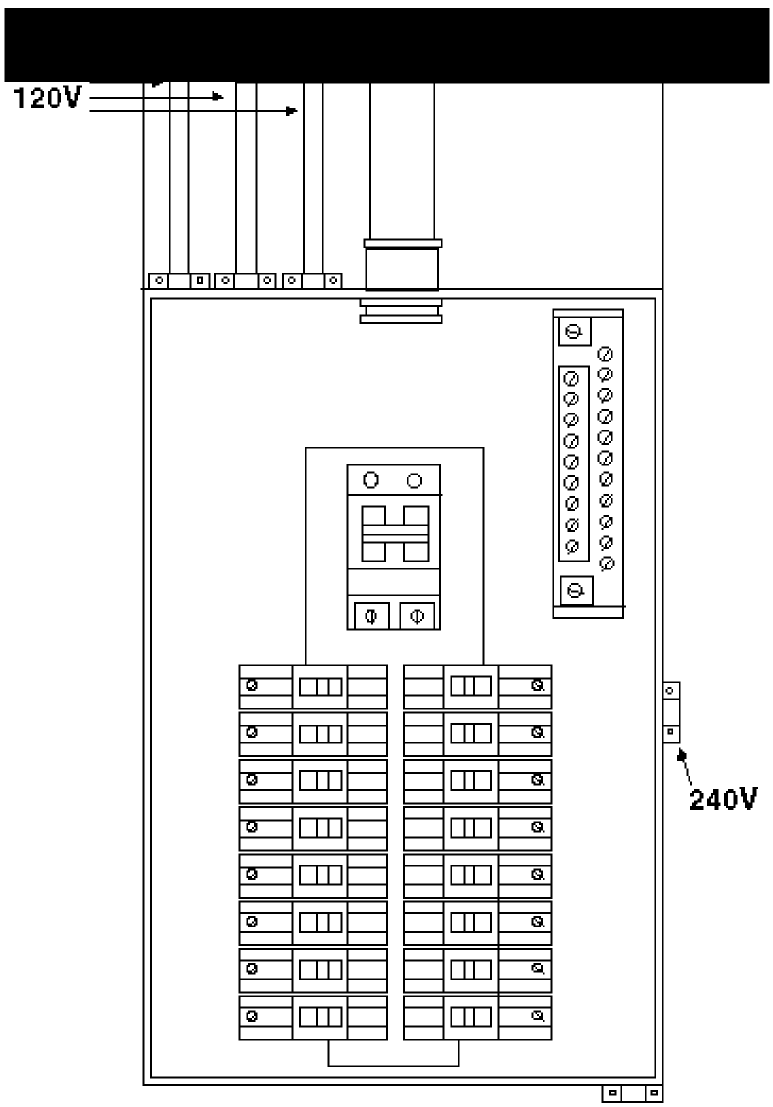
9. What are two reasons three-phase power might be used?

   a.

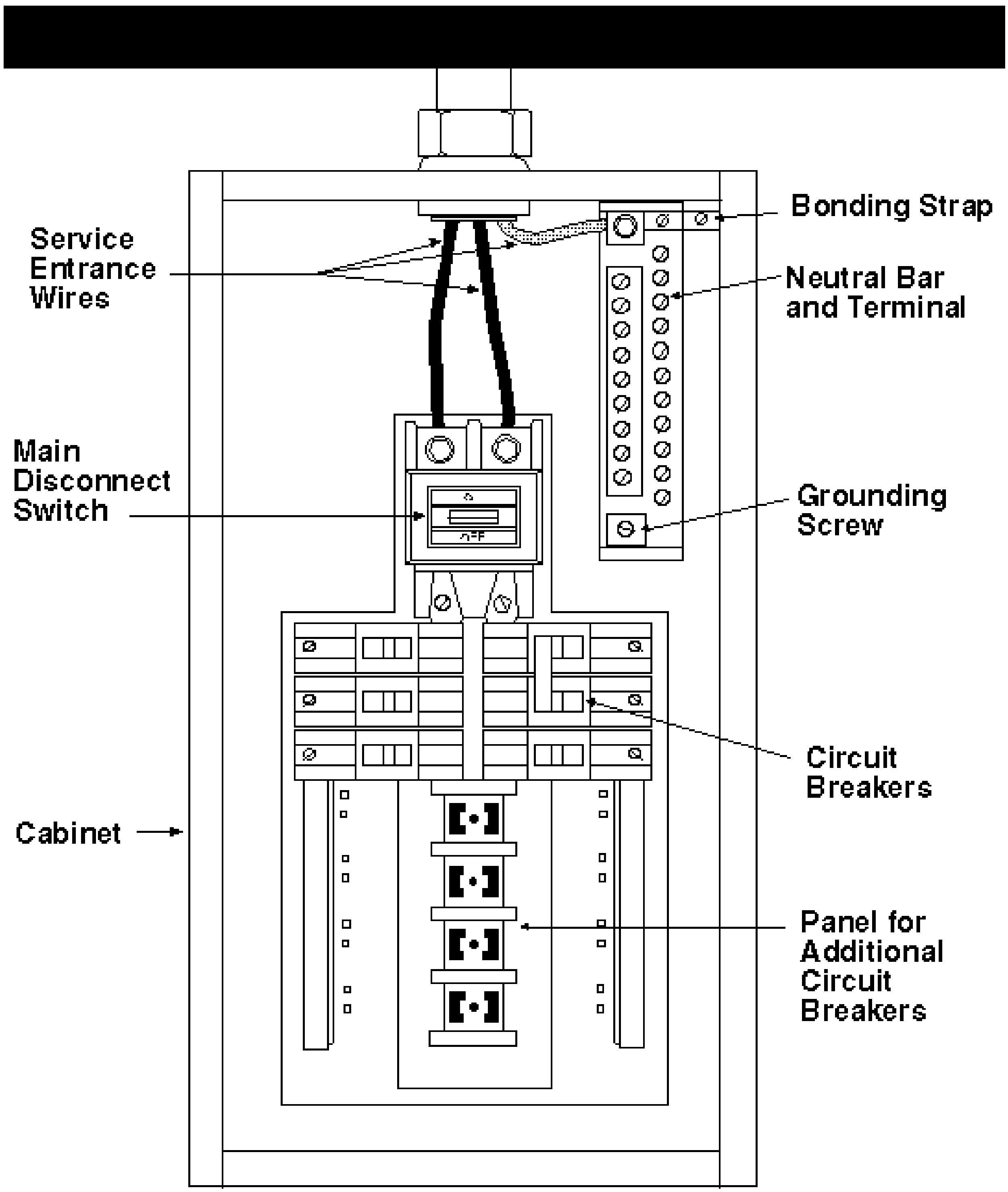
   b.

On the diagram of the SEP, draw the wiring for the connections listed and label the conductors (hot, neutral, ground, etc.).

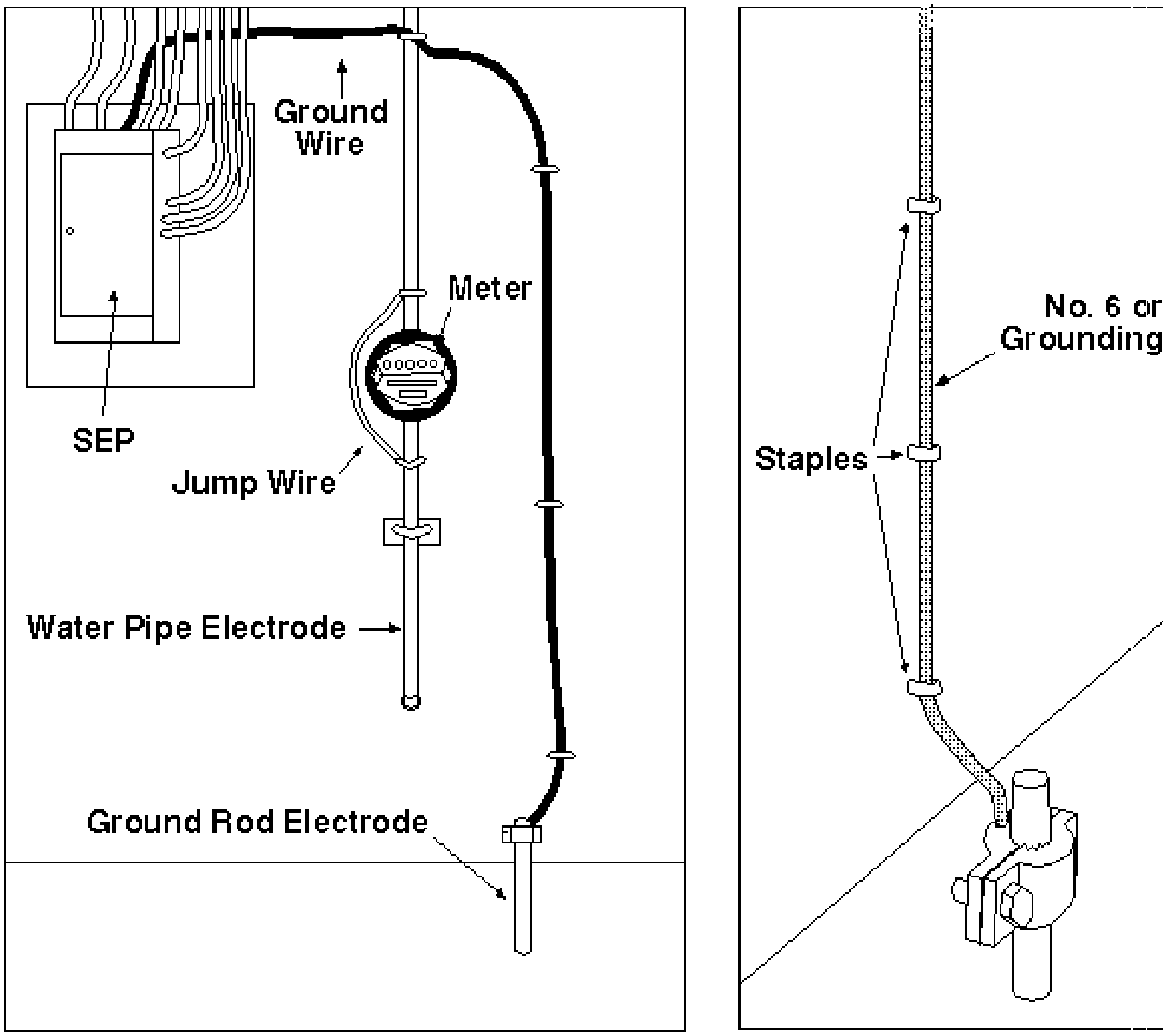
10. • Service entrance conductors
    - 120-volt branch circuit
    - 240-volt branch circuit


120V
240V

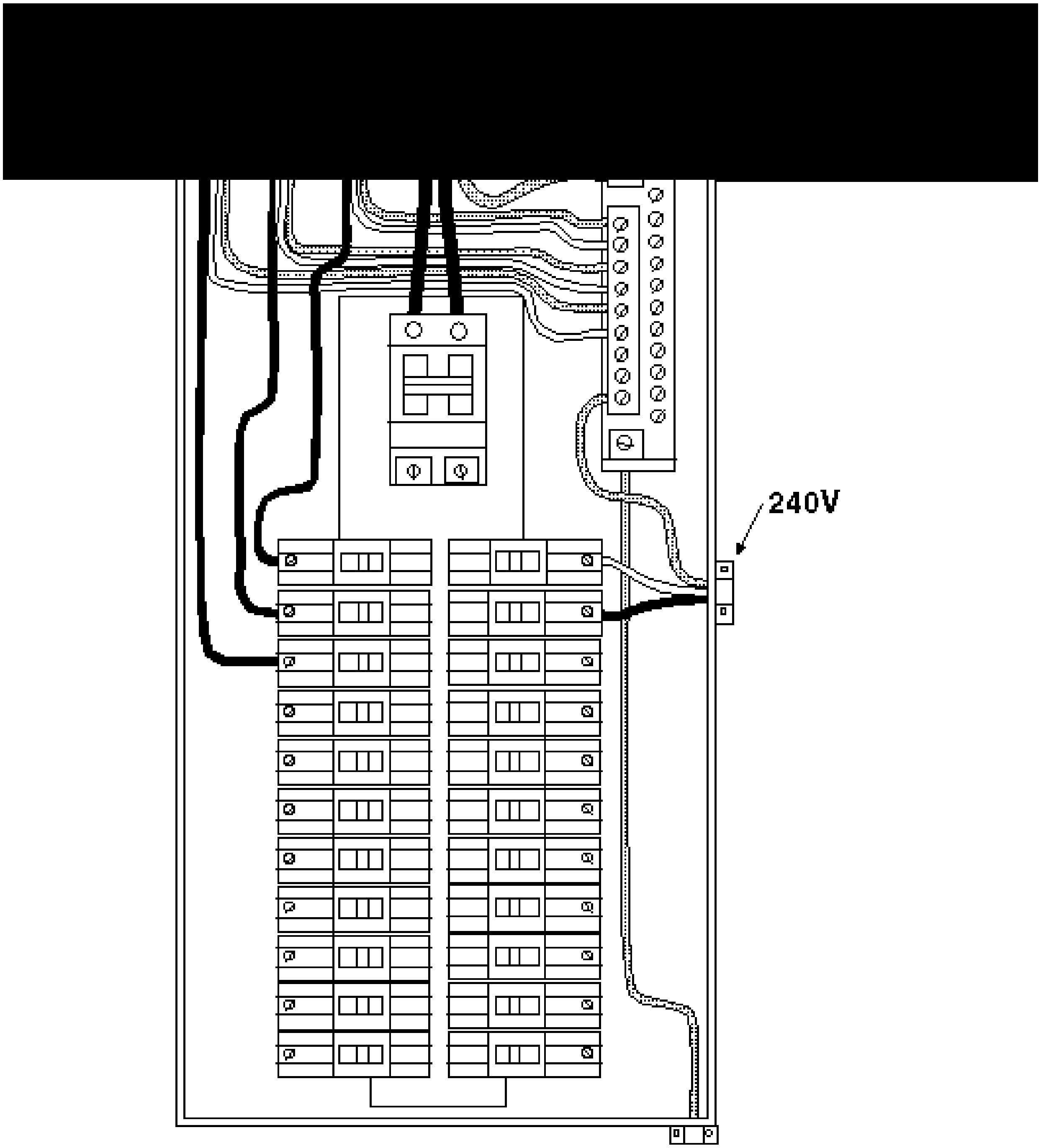
SEP Parts


Service
Entrance
Wires
Main
Disconnect
Switch
Cabinet
Bonding Strap
Neutral Bar
and Terminal
Grounding
Screw
Circuit
Breakers
Panel for
Additional
Circuit
Breakers

Ground System



Wired 120/240 V Panel

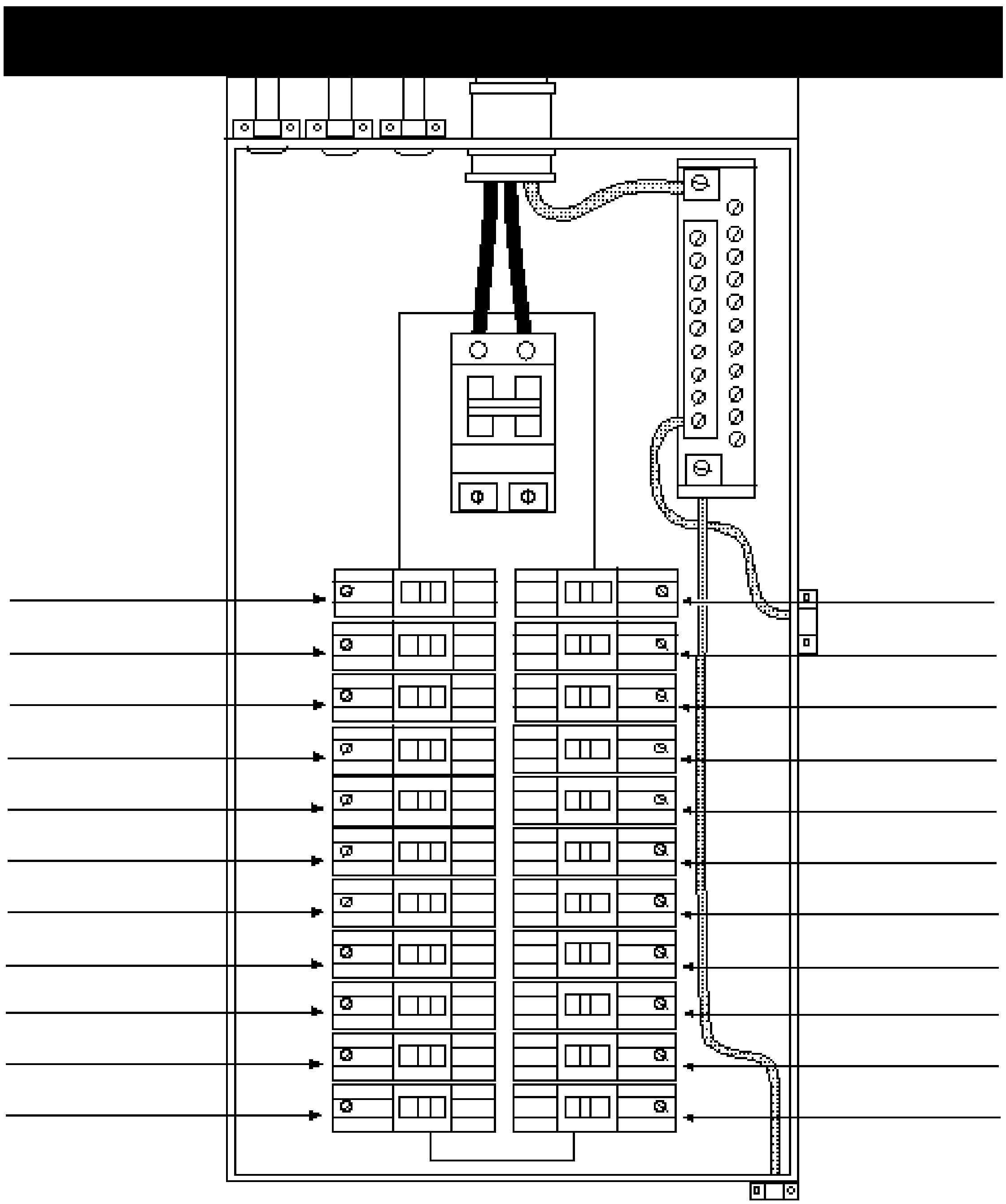


Lesson 8: Connecting to the SEP Name ___________________________

Identifying SEP Components

Objective: Identify the components of a service entrance panel.

Using the model SEP provided by your instructor, label the wires and breakers installed within the panel. List the amperage ratings of each breaker and whether the circuit is 120 volts or 240 volts.



UNIT V - ELECTRICITY

Lesson 9: Running Wire from the SEP

Competency/Objective: Describe how to run wiring from the SEP to a junction box, lights, and receptacles.

Study Questions

1. **Where should the service entrance panel be located?**
2. **How is the route of each circuit determined?**
3. **How are the wires run through the building?**
4. **What tools are needed to wire a receptacle or light?**
5. **What is the function of a junction box?**
6. **What techniques are used when splicing wires?**
7. **How is a light circuit wired?**
8. **How are convenience outlet circuits wired?**

References

1. *Agricultural Structures* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.

3. Transparency Masters

   a) TM 9.1: Wiring Diagram
   c) TM 9.2: Labeling Receptacles
   d) TM 9.3: Ceiling Runs
   e) TM 9.4: Wall Runs
   f) TM 9.5: Junction Box
   g) TM 9.6: Connectors
   h) TM 9.7: Wiring a Switch and Light
   I) TM 9.8: Wiring a Switch Loop
   j) TM 9.9: Wiring a Three-Way Switch and Light
   j) TM 9.10: Series and Parallel Wiring
   k) TM 9.11: Wiring a Convenience Outlet

3. Job Sheet

   a) JS 9.1: Wiring a Three-Way Switch

TEACHING PROCEDURES

A. ***Review***

Lesson 8 described the proper methods for making connections at the service entrance panel. Lesson 9 will examine how branch circuits are planned and how wire is run through a structure. Switches, lights, and convenience outlets can then be installed.

B. ***Motivation***

Show the students examples of light fixtures and convenience outlets so they can see the terminals used in wiring. Display the tools used in installing the different devices.

C. ***Assignment***

D. ***Supervised Study***

E. ***Discussion***

1. Ask students where the SEP should be located within an agricultural structure. Discuss the factors that affect its location.

Where should the service entrance panel be located?

a) As close as practical to the point where the wires enter the building
b) Near equipment that has a high electrical draw, such as water heaters or large motorized equipment
c) In an easily accessible location
   1) In an emergency, someone must be able to shut off power immediately.
   2) Ease of access to the panel is necessary if fuses blow or breakers are tripped.
   3) An easily accessible panel makes it easier to add circuits to the system.

2. Because a number of different circuits may control different outlets, lights, and equipment, the path of each electrical circuit should be carefully planned. Discuss the use of wiring diagrams; a sample diagram is provided in TM 9.1. Describe how circuits

and electrical devices can be labeled to distinguish between them, as shown in TM 9.2.

How is the route of each circuit determined?

a) Two types of electrical circuits are considered when making a wiring plan.
   1) General circuits - circuits carrying 110-volt current and normally containing more than one electrical device
   2) Individual circuits - circuits carrying 220 volts of current and typically operate a single piece of equipment
b) The next consideration is which outlets will be connected to which circuit at the service entrance panel.
   1) A good rule of thumb is to avoid placing all the light fixtures in the same room or building on one circuit.
   2) The amount of electrical load placed on convenience outlets will determine their circuit needs.
      (a) On a single circuit if the outlets in a room or building will have low usage, with one to two outlets used at any given time
      (b) On different circuits if more than two outlets will be used at once or equipment with a high electrical draw will be used on a regular basis
c) A wiring diagram is useful when planning where branch circuits will run and what electrical devices will be connected to them.
   1) Mark the entry point.
   2) Add up the number of devices on the circuit and make sure sufficient amperage can be supplied.
   3) Repeat this process for each circuit.
d) Physically mount outlet boxes for lights and receptacles at each location, and label them on the diagram and within the structure for easy reference.
   1) Use Roman numerals for the individual circuit line.
   2) Letters designate the different outlet boxes.
   3) Switches are labeled with an S.
   4) Three-way switches are labeled S1 and S2.

3. Describe the techniques used when running wires through a structure. TMs 9.3 and 9.4 illustrate ceiling and wall wire runs.

How are the wires run through the building?

a) Wire protection
   1) Avoid excessive bending of electrical conductors to prevent the insulation from cracking.
   2) Run wire inside of walls and ceilings to prevent physical damage.

3) Exposed wire runs or runs where damage may be a concern should have the conductor placed inside of a conduit.

b) General practices

1) Conductors should run as straight as possible from the SEP to the individual outlets.
2) As few splices as possible should be used.
3) Wire runs should be as high and dry as possible.

c) Ceiling runs

1) Ceiling runs are best because damage from traffic is minimized.
2) They reduce wire damage because the wires are not located where water may collect or flow.

d) Floor runs - Noncorrosive conduits should enclose the wires.

e) Wall runs

1) Drill a hole in the center of the wall studs that is large enough to accept the conduit or to allow the cable to slide through easily without friction and binding.
2) Staple the wire along the side of a stud.
3) Cut a notch in the side of the wall studs, and install a steel cover plate over the notch after the wire is in place.
4) In structures where moisture will not be a factor, notch the bottom of the studs and run the wires along the bottom plate of the wall.

4. The use of the proper tools is essential to installing wiring efficiently and safely. Ask students to list the tools that they would use in wiring a light fixture or convenience outlet.

What tools are needed to wire a receptacle or light?

a) Essential tools

1) Wire cutters, either lineman’s pliers, side cutting pliers, or needlenose pliers
2) Cable rippers, which is used to remove the cable covering from the conductors housed in the cable sheathing
3) Wire strippers for removing insulation from conductors
4) Complete set of screw drivers
5) Hammer
6) Slip-joint pliers
7) Level
8) Tubing cutter for cutting conduit
9) Conduit bender, which is used to bend or form conduit to turn corners

b) Other tools

1) Socket wrenches
2) Drill motor and drill bits
3) Adjustable open-end wrench
4) Hand saw
5) Electrical testing equipment

5. Sometimes branching a circuit is necessary. Discuss the use of junction boxes. TM 9.5 shows wiring within a junction box.

What is the function of a junction box?

a) Used to protect the wires that are spliced together to branch circuits - Junctions are sometimes needed if a long electrical run is required or if no convenient outlets are available from which to branch power to different outlets on the same circuit.
b) Basically an outlet box with a solid cover
   1) The NEC states that all boxes must be dust tight and watertight.
   2) The NEC also requires that they be made of corrosion-resistant material.
   3) Junction boxes should be located where they are permanently accessible for repairs.
c) Connections in a junction box
   1) Insert the ends of the wires into the junction box through the knockouts.
   2) About 6 inches of each wire should pass through the knockouts.
   3) Connect black wires to black wires, white wires to white wires, and ground wires to ground wires.
   4) If the outlet box is metal, connect a separate piece of wire to the box and the ground wires.
   5) Clamp the wires securely to the box to prevent the splices from pulling apart.

6. Splices should be as sound as an unbroken conductor. Describe the different types of connectors that may be used. Different types of solderless connectors are shown in TM 9.6.

What techniques are used when splicing wires?

a) Insulated solderless connectors (wire nuts)
   1) Strip back the wire insulation just enough for the wires to fit inside the connector.
   2) Lay the wires together.
   3) The method for connecting the wires depends on the connector selected.
      (a) Threaded metal insert - Screw the connector onto the wires to be joined.
      (b) Removable metal insert
         (1) Remove the insert from the insulating shell.
         (2) Slip the insert over the wires.
         (3) Tighten the set screw in the insert to lock the wires in place.
         (4) Screw the insulating shell back on over the insert.
      (c) Spring-loaded - Screw the connector onto the wires to be spliced.
   4) Tape the conductors if necessary.
b) Metal connectors for wires that are AWG 8 and larger

1) They have a collar with a set screw.
2) Insert the wires into the connector.
3) Tighten the screw.
4) Wrap the connector and wires with electrician's tape.

7. Because most structures have some form of lighting, understanding how to wire lights and switches is important. Describe how different types of circuits should be wired. TMs 9.7, 9.8, and 9.9 show the wiring for a switched circuit, switch loop, and three-way switch. TM 9.10 can be used to illustrate series and parallel wiring. Hand out JS 9.1. The mock walls that students will use for wiring should be prepared before class period. They are made using 2" × 4" boards and should measure 2 feet by 2 feet.

How is a light circuit wired?

a) Simple circuit
   1) Connect the black hot wire to a brass screw on the light fixture.
   2) Connect the white neutral wire to a silver screw.
   3) This system is impractical because the light cannot be turned on and off.
b) Switched circuit
   1) A switch breaks the electrical circuit of the light fixture.
   2) White, black, and ground wires enter the switch box from the power source.
      (a) Connect the white source wire to a white wire with a connector.
      (b) Connect the black source wire to a brass screw on the switch.
      (c) Attach a black wire to the other screw on the switch.
      (d) At the light fixture, connect the black wire to a brass screw and the white wire to a silver screw.
      (e) Connect a green ground wire from the light fixture to the ground wire from the source using a solderless connector.
      (f) If the boxes are metallic, the ground wires are attached to the boxes with a piece of wire.
   3) In a switch loop, a pair of black wires brings the power to the switch from the lighting box and carries it back to the light.
      (a) Connect the black source wire to a length of black wire with a connector.
      (b) Connect this wire to a brass screw on the switch.
      (c) Connect another black wire to the other brass screw on the switch.
      (d) This second black wire runs back to the lighting box.
      (e) Attach it using a connector to a black wire from the brass screw on the fixture.
      (f) Connect the white source wire to a white wire from the light fixture using a connector.
      (g) Attach the white wire to a silver screw at the light fixture.
c) Three-way switch

1) Using a three-way switch, a light can be turned off and on from two different locations.
2) Wiring a three-way switch begins at one of the switches.
   (a) Connect the black wire from the power source to the common terminal on the switch.
   (b) Connect a black wire to the switch on the opposite side from the black source wire.
   (c) Connect a red wire to the other terminal on that side.
   (d) Splice the white wire from the source to another white wire with a solderless connector.
   (e) Make the appropriate ground connections at the switch.
3) Next, the other wires are connected at the second switch.
   (a) Connect a black wire to the common terminal of the switch.
   (b) Attach a red wire to the terminal opposite the black wire.
   (c) Connect a white wire to the other terminal.
   (d) Make the ground connections in the box.
4) The wires from the two switches meet at the light fixture.
   (a) Connect the black wire from the first switch to the white wire from the second switch using a solderless connector.
   (b) Splice the red wires together using a connector.
   (c) Attach the black wire from the second switch to the brass screw on the fixture.
   (d) Connect the spliced white wire from the power source to the silver screw.

d) Series and parallel wiring - Used when more than one light fixture is on a circuit
   1) Series wiring is an impractical system because the way the outlets are connected, if one light goes out, they all go out.
      (a) The black wire from the source is attached to a terminal on the first fixture.
      (b) A white wire then runs directly from the second terminal to the next lighting fixture and attaches to a terminal there.
      (c) Another black wire runs from the second terminal on that fixture directly to the next fixture.
      (d) This pattern continues through the series.
   2) Parallel wiring is the most common method of wiring multiple light fixtures.
      (a) Jumper wires attached to each light fixture are spliced to the white and black wires from the power source.
      (b) This system allows power to flow separately to each individual lamp on the same circuit.

8. Describe the process for wiring a circuit with one receptacle or several receptacles. TM 9.11 can be used to illustrate the wiring.

How are convenience outlet circuits wired?

a) One receptacle

1) Attach the black source wire to the side of the receptacle with the brass screw.
2) Attach the white wire to the silver screw on the opposite side of the receptacle.
3) Join the ground wires using a connector.

b) Two or more receptacles on a circuit

1) Connect the first receptacle as described.
2) Connect another black wire to the other brass screw on the first outlet and to the brass screw on the second receptacle.
3) Connect a white wire to the second silver screw on the first receptacle and the silver screw on the second.
4) Follow the same procedure for any other receptacles on the same circuit.
5) Make the appropriate ground connections.

F. ***Other Activities***

Have students draw a diagram on a piece of paper showing how to hook a series of outlet receptacles to an on/off switch at the source. They should color code the different wires used.

G. ***Conclusion***

The location of the circuits within an agricultural structure should be planned before running any wire to make sure that it is installed correctly. Once the wire is in place, light fixtures and convenience outlets can be installed.

H. ***Answers to Activity Sheets***

I. ***Answers to Evaluation***

1. c
2. a
3. e
4. d
5. b
6. b
7. d
8. d
9. a

10. Jumper wires attached to each light fixture are spliced to the white and black wires from the power source.

11. Threaded metal insert connector, removable metal insert connector, and spring-loaded connector
12. A wiring diagram
13. Answers may include any two of the following: drilling a hole in the center of the wall studs, stapling the wire along the side of a stud, cutting a notch in the wall studs and covering it with a steel plate, and cutting a notch in the bottom of the studs and running the wires along the bottom plate of the wall.
14. To protect the wires that are spliced together to branch circuits

UNIT V - ELECTRICITY Name _____

Lesson 9: Running Wire from the SEP Date ___________________________

EVALUATION

Match the tools on the right with the description on the left.

1. ____ Used to cut conduit a. Wire cutters

2. ____ May use lineman's pliers b. Cable ripper

3. ____ Used to form conduit c. Tubing cutter

4. ____ Used to remove insulation d. Wire stripper

5. ____ Used to remove cable covering e. Conduit bender

Circle the letter that corresponds to the best answer.

6. Which of the following is used to indicate the circuit line in a label?

   a. Arabic numerals (1, 2, 3, etc.)
   b. Roman numerals (I, II, III, etc.)
   c. Letters (A, B, C, etc.)
   d. Special symbols (S1, S2, S3, etc.)

7. Where should the service entrance panel be located?

   a. In the basement of a structure
   b. Near the point where the circuits come together
   c. In a corner of the building
   d. Near where the wires enter the building

8. When wiring a single receptacle, the ___________________ is attached to the brass screw.

   a. White source wire
   b. Green ground wire
   c. Red hot wire
   d. Black source wire

9. At a light fixture, the ______________________ is attached to the silver screw.

   a. White wire
   b. Green wire
   c. Red wire

d. Black wire

Complete the following short answer questions.

10. How are light fixtures wired in parallel wiring?

11. What are three types of solderless connectors?

    a.

    b.

    c.

12. What can be used to help plan the path of branch circuits?

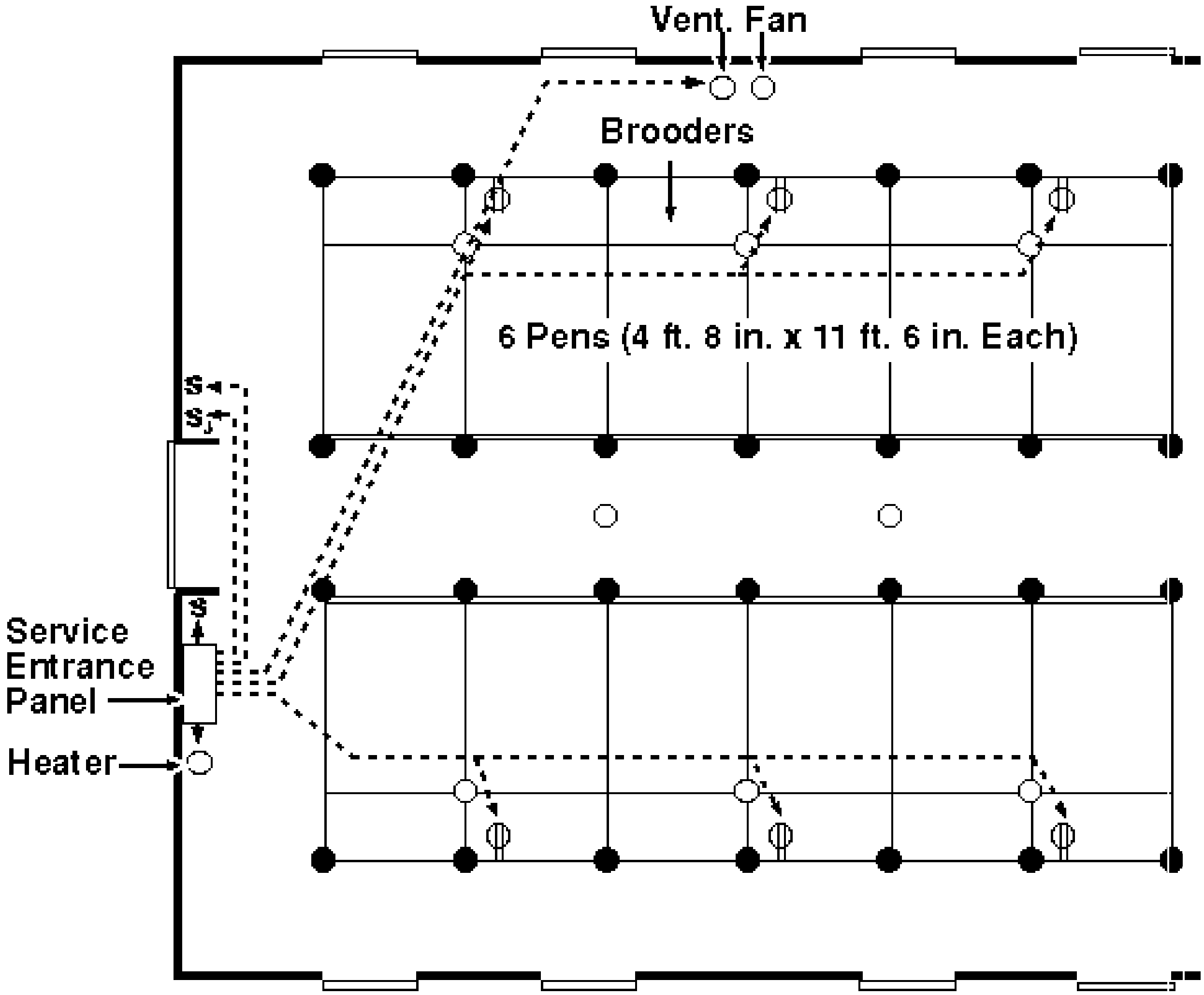
13. What are two ways wire may be run in walls?

    a.

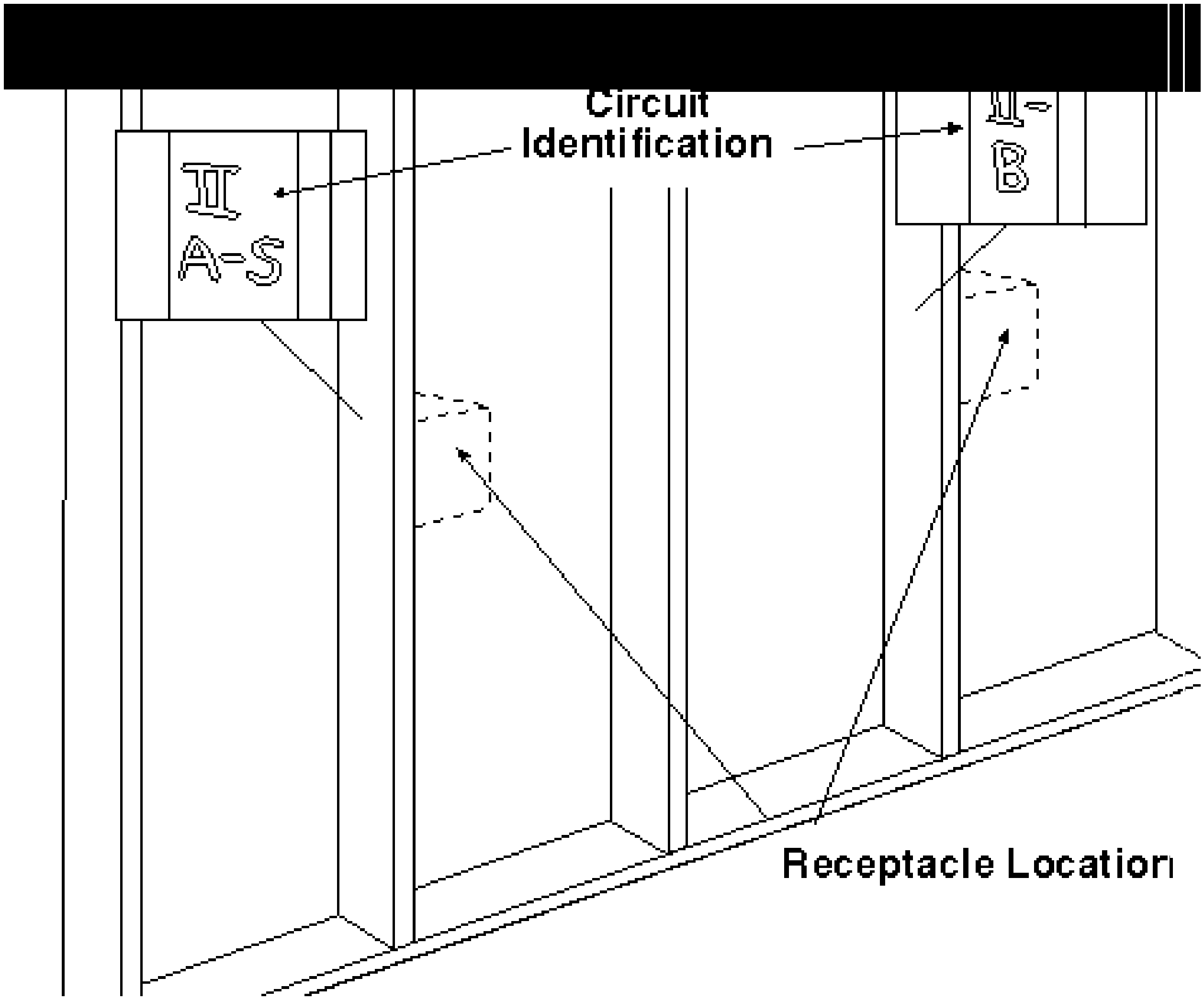
    b.

14. What is a junction box used for?

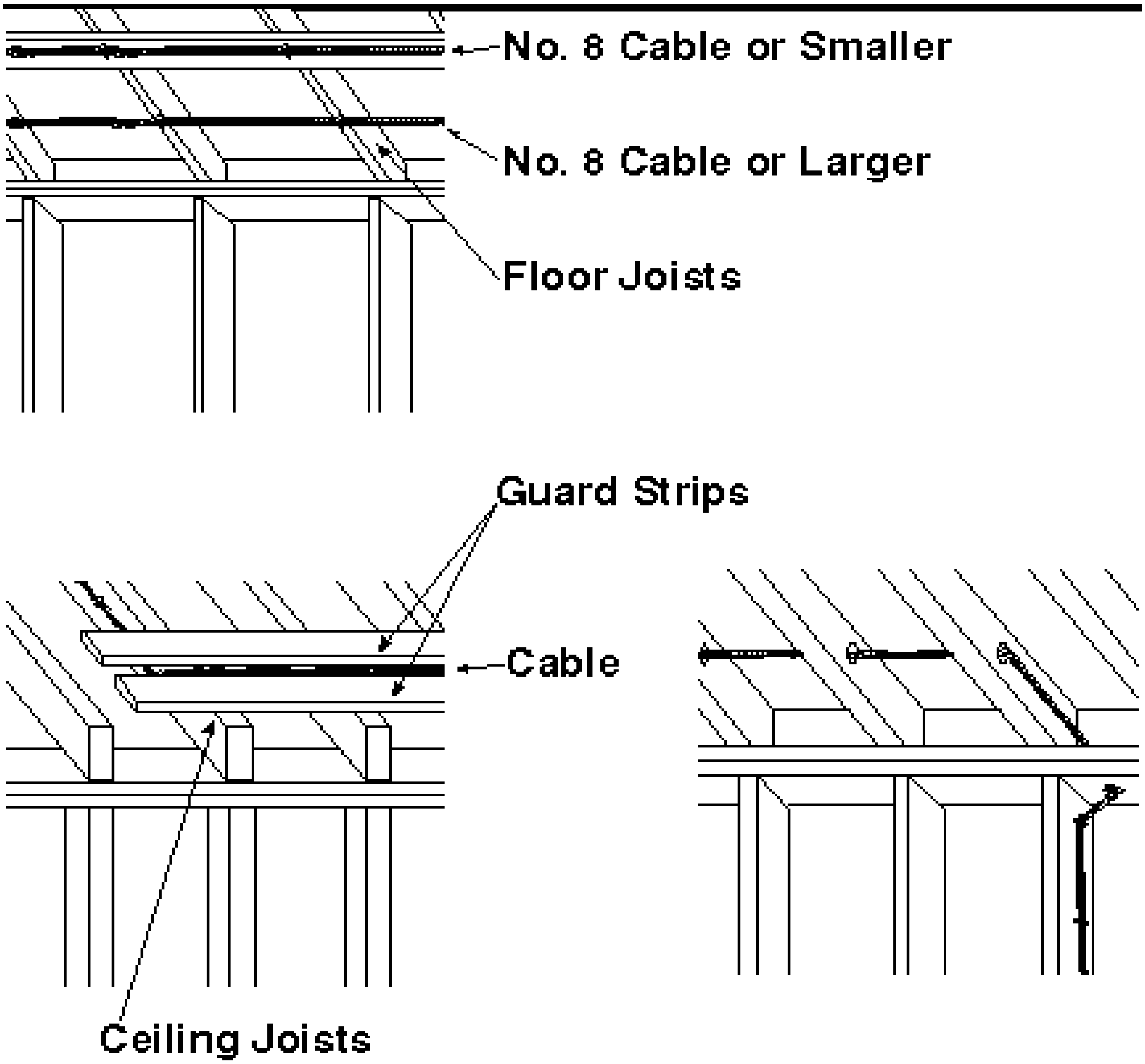
Wiring Diagram

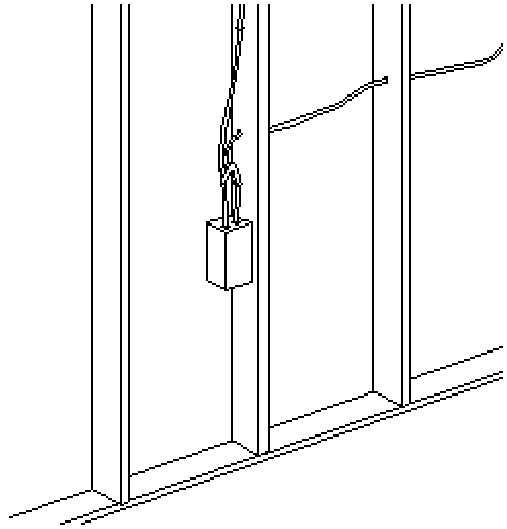


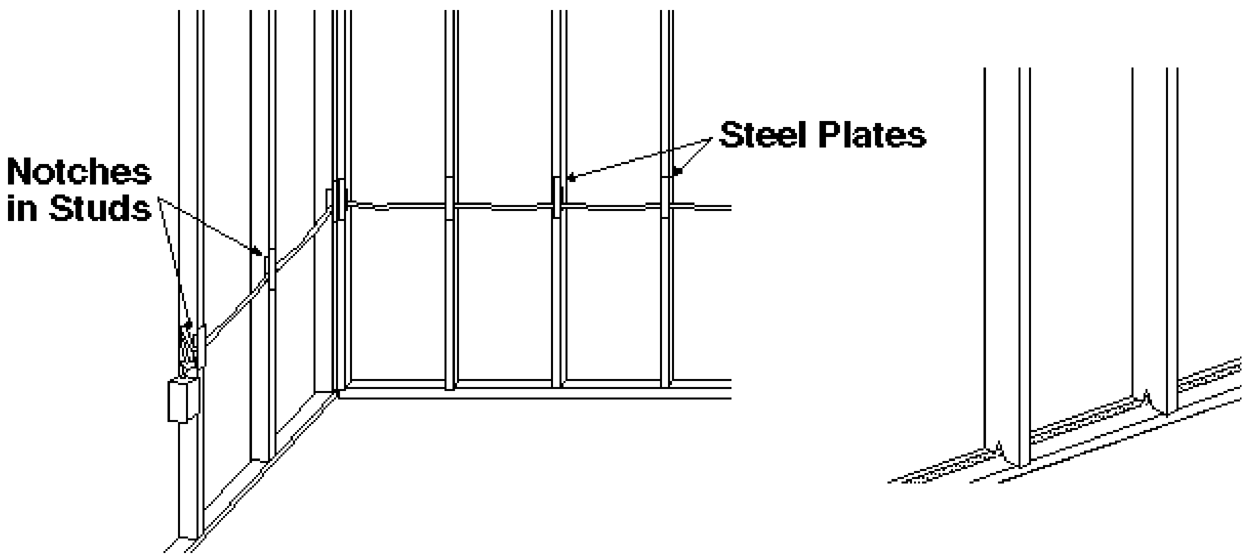
12-Pen Hog Farrowing House


Circuit
Identification
II
A-S
II-
B
Receptacle Location

Ceiling Runs

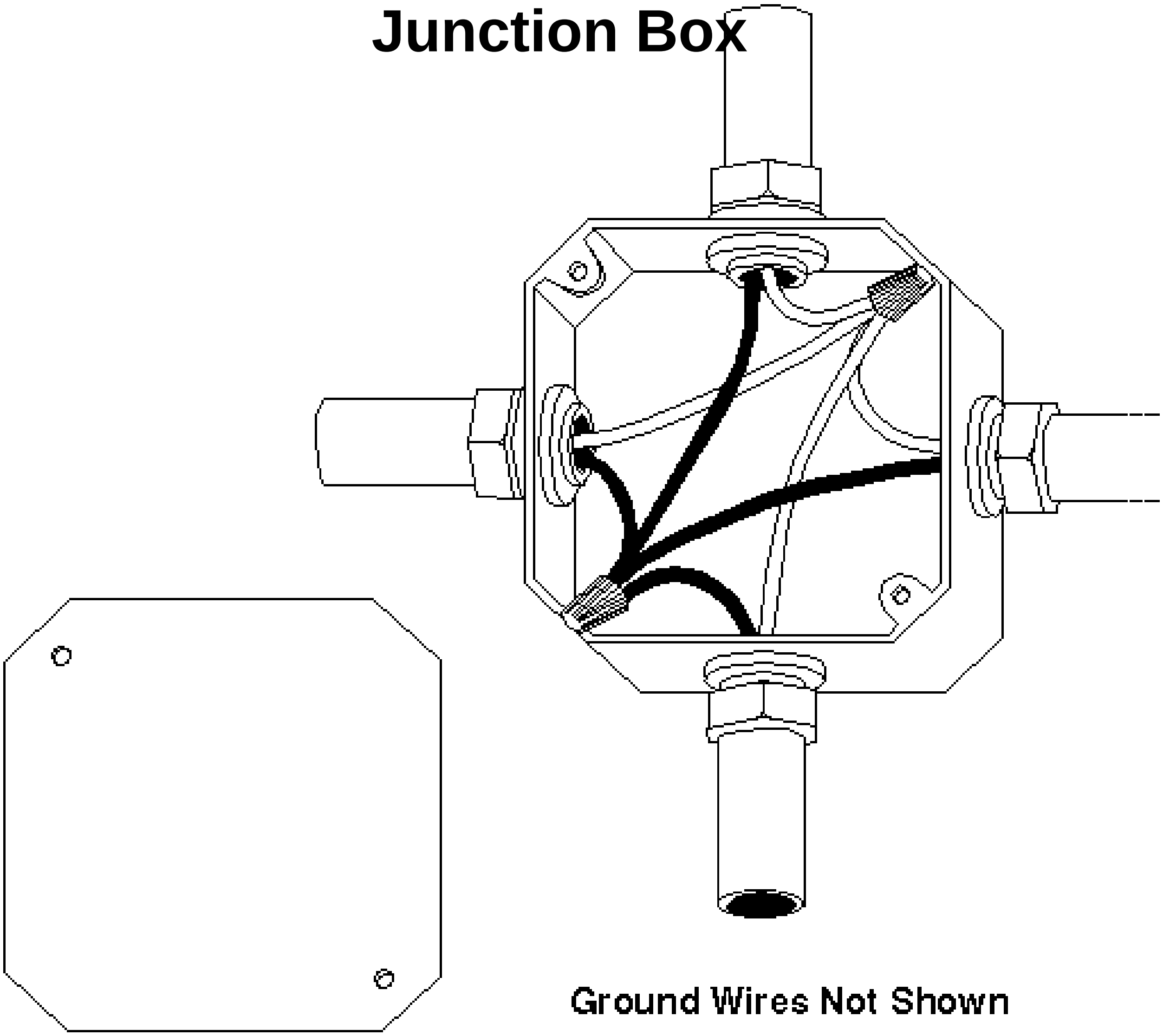






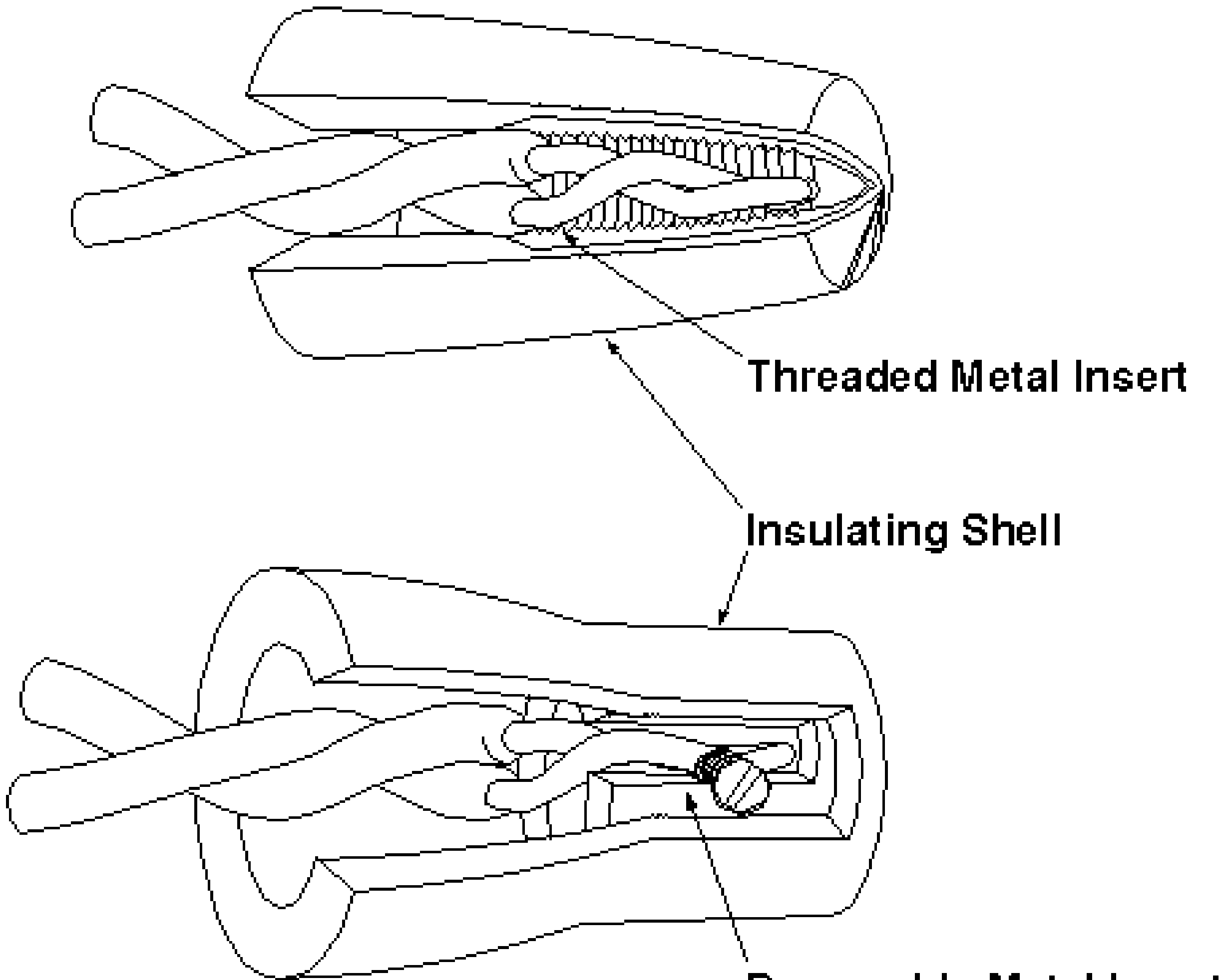
Wall Runs

Junction Box

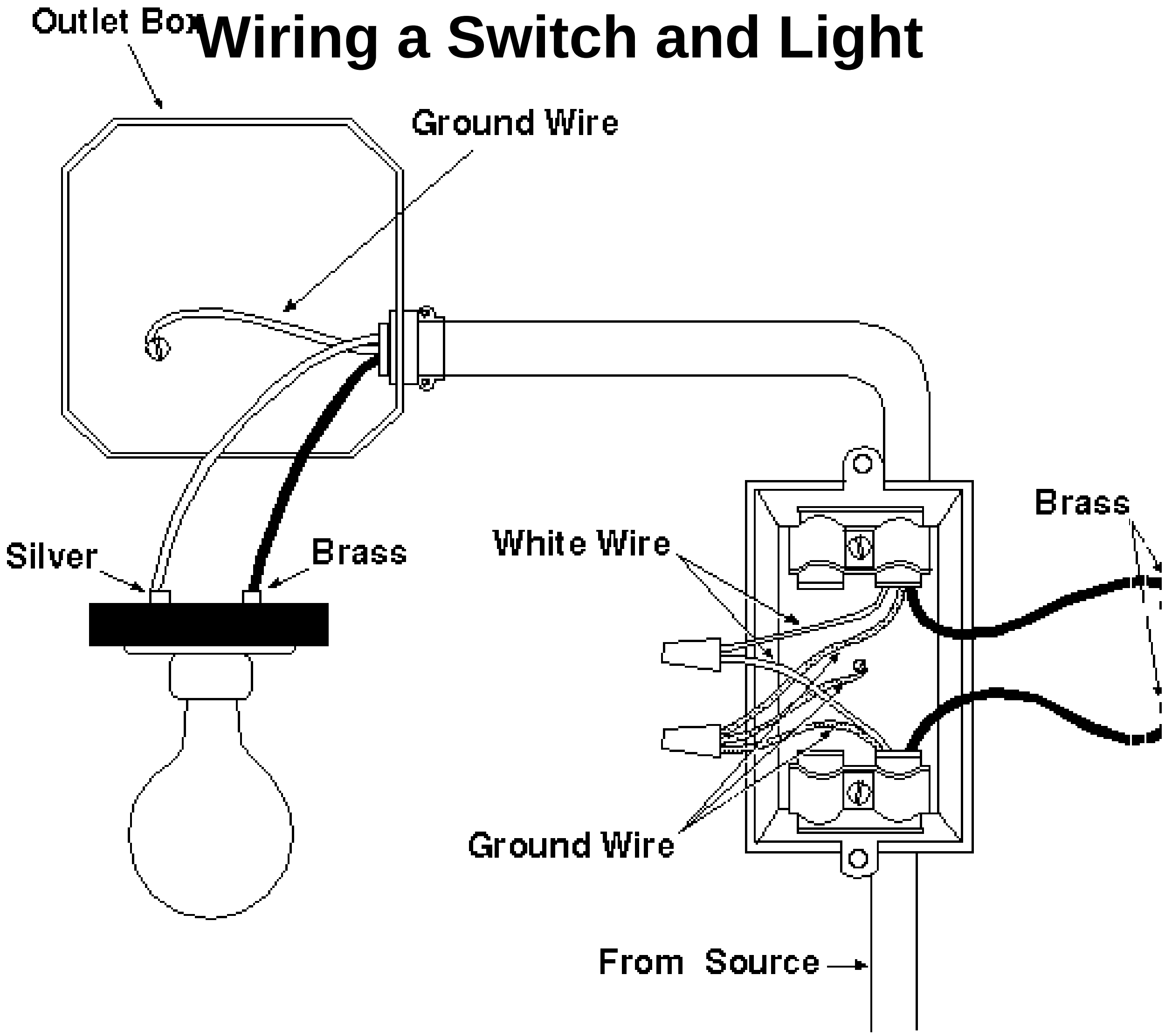


Ground Wires Not Shown

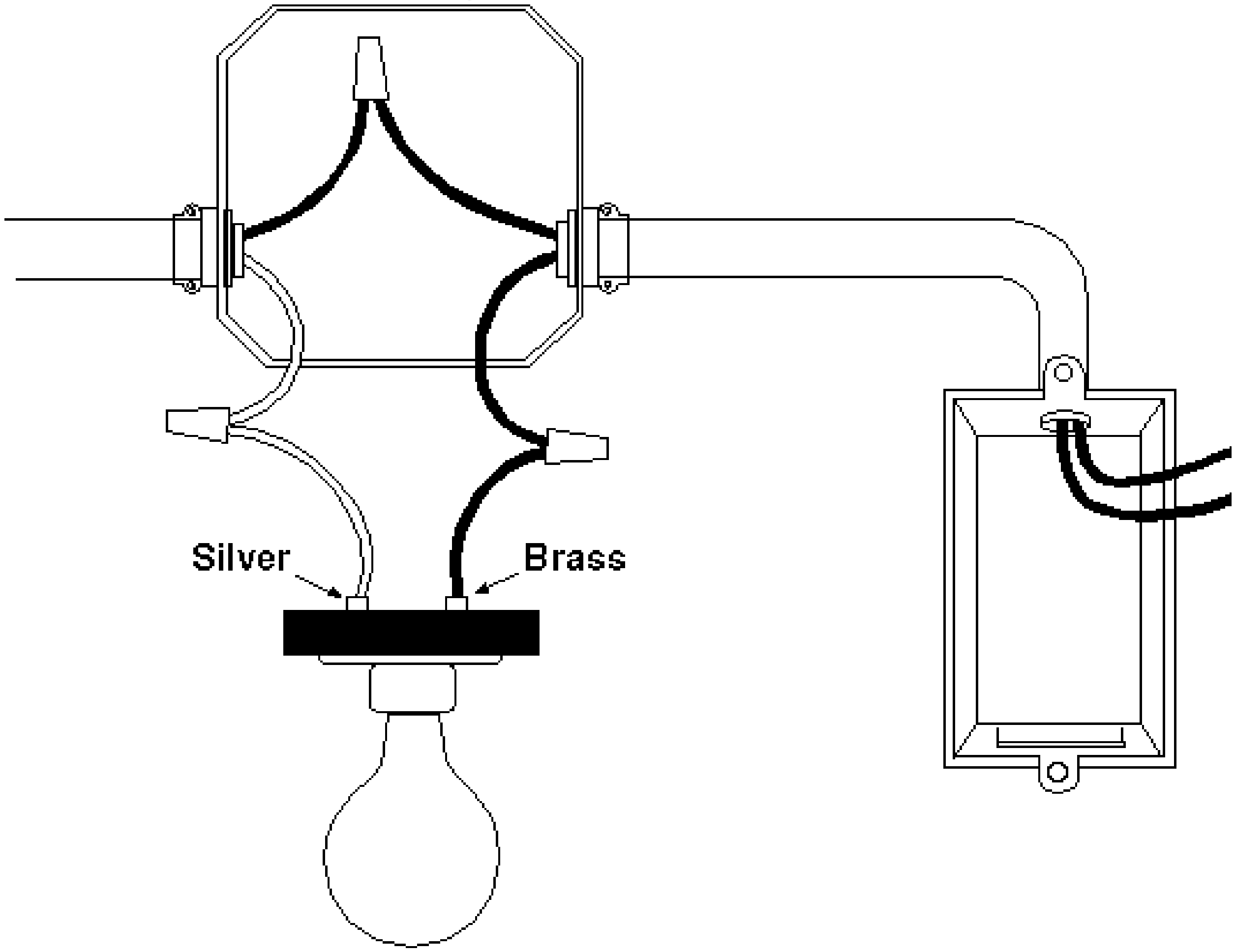
Connectors


Threaded Metal Insert
Insulating Shell
Removable Metal Insert

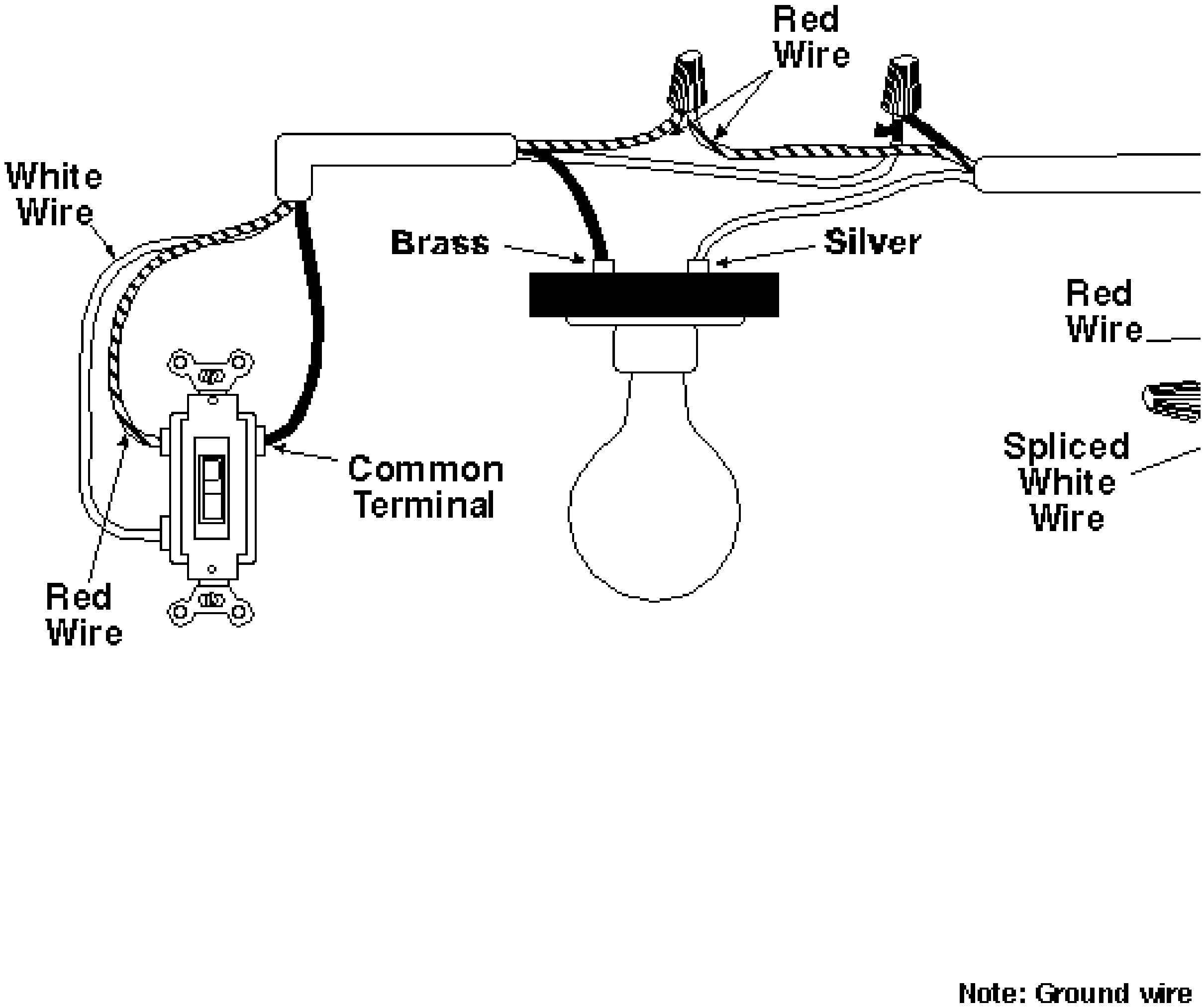
Wiring a Switch and Light



Wiring a Switch Loop

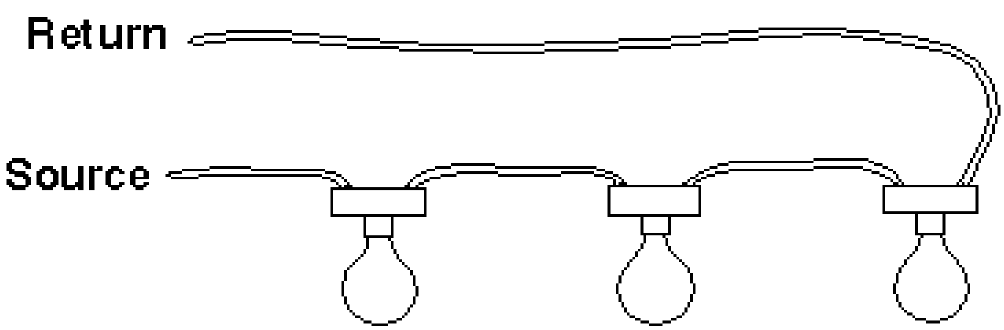


Wiring a Three-Way Switch and Light

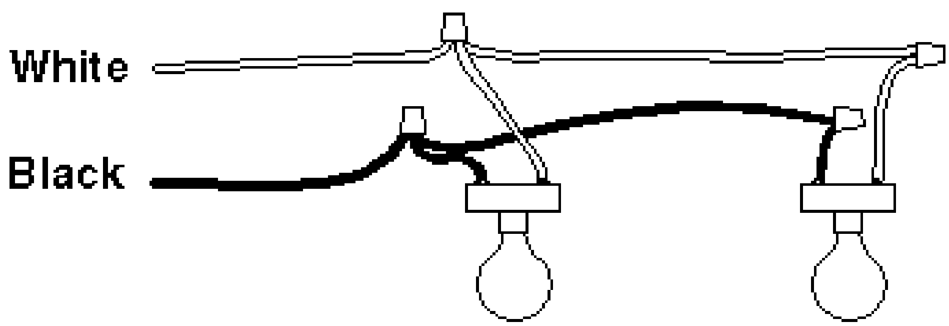


Series and Parallel Wiring

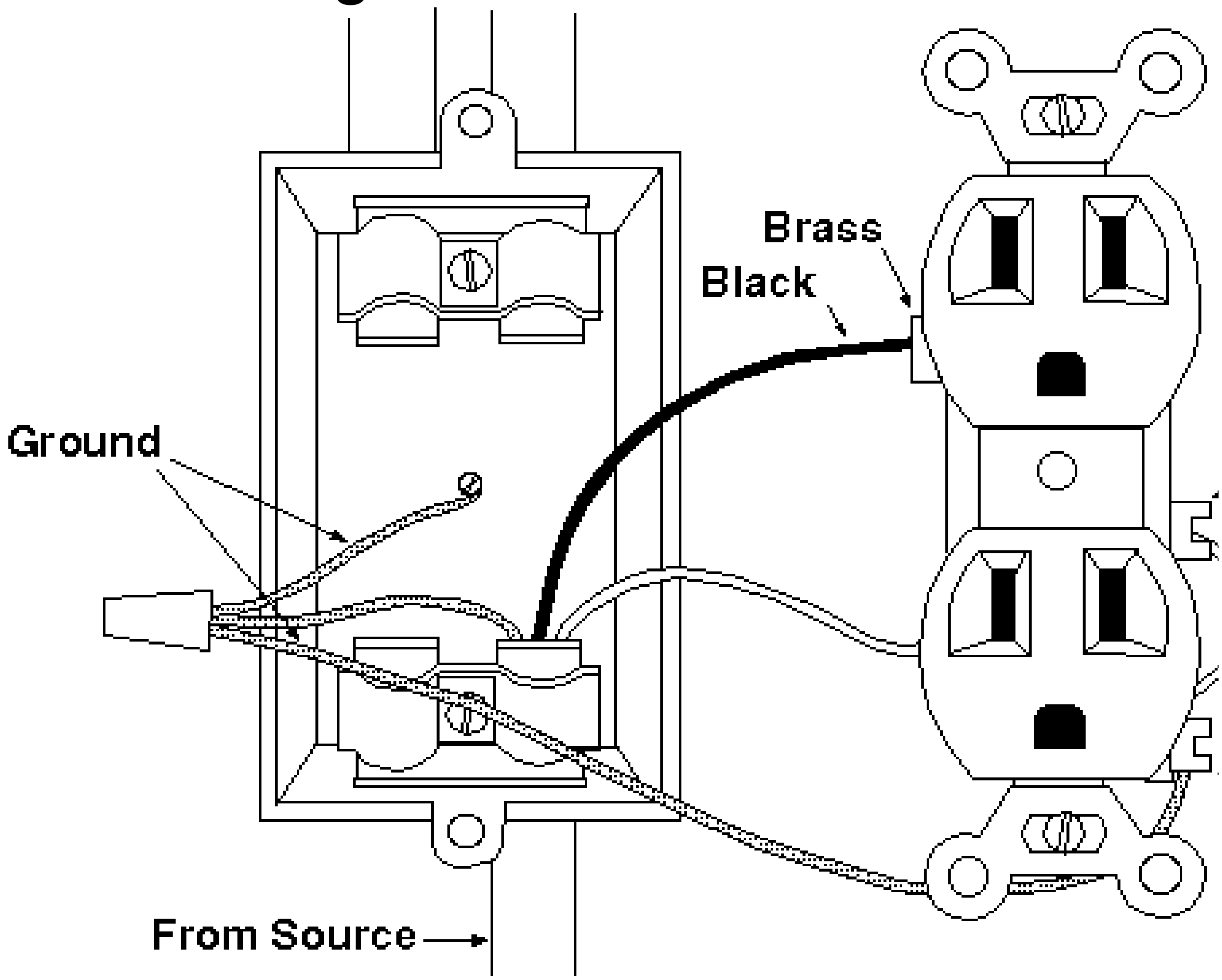
Series Electrical Connection



Parallel Electrical Connection



Wiring a Convenience Outlet



Lesson 9: Running Wire from the SEP Name ___________________________

Wiring a Three-Way Switch

Objective: Wire a three-way switch to a light.

Materials and Equipment:

Mock wall with two switch boxes and one light fixture already attached
1 12-2 NMC cable, 16 inches long
2 12-3 NMC cables, 30 inches long
2 three-way switches
Light fixture
Solderless connectors
Three-prong plug
Screw driver set
Wire strippers
Cable rippers

Procedure:

1. Strip off six inches of the cable sheathing on one end of the 12-2 wire and both ends of the 12-3 wires.

2. Strip back 1 inch of insulation on all exposed wires. Bend hooks in the wires that will be connected to the switches or light fixture.

3. The 12-2 wire will be the power source. Attach the bared end of the 12-2 wire to one switch box with a box connector. Hot, neutral, and ground wires without sheathing should be in the box.

4. Using box connectors, attach one end of each of the 12-3 wires to a switch box and the other ends to the light fixture box.

5. At the first switch box

    a. Attach the black wire from the 12-2 cable to the common terminal of the switch.

    b. Attach the black wire from the 12-3 cable to the terminal opposite the black source wire.

    c. Connect a red wire to the third terminal.

    d. Connect the white source wire to another white wire with a connector.

    e. Connect the ground wires with a connector. With metal outlet boxes, run a 6-inch jumper wire from the ground wires to the box and attach it with a ground clip.

6. At the second switch box

    a. Connect the black wire from the 12-3 cable to the common terminal of the switch.

    b. Connect a red wire to the terminal opposite the black wire.

    c. Connect the white wire to the other terminal.

    d. Make the appropriate ground connections.

7. At the light fixture box

    a. Using a connector, connect the black wire from the first switch with the white wire from the second.

    b. Connect the red wires with a connector.

    c. Connect the black wire from the second switch to the brass screw on the light fixture.

    d. Connect the white wire from the first switch to the silver screw on the light fixture.

    e. Make the appropriate ground connections.

8. Remove 1 inch of the sheathing from the unconnected end of the 12-2 wire.

9. Open the three-prong plug casing and attach the 12-2 wire to the mounting screws, connecting the black wire to the brass terminal, the white wire to the silver terminal, and the green to the green.

10. Close the plug casing.

11. Have your instructor inspect all the connections.

12. Attach the switches and light fixtures to the boxes.

13. Place the cover plates on the switches.

14. Obtain a light bulb from your instructor and insert it into the light fixture.

15. Plug in the cord. Test the workings of the three-way switch.

UNIT VI - PLUMBING

Lesson 1: Water Needs

Competency/Objective: Calculate how much water is needed for a farmstead.

Study Questions

1. What are the sources of water on a farmstead?

2. What are the uses of water on a farmstead?

3. How is the total daily water need determined?

4. How is peak water need determined?

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit VI.

2. Transparency Master

    a) TM 1.1: Water Needs Table

3. Activity Sheet

    a) AS 1.1: Determining Water Needs

UNIT VI - PLUMBING

Lesson 1: Water Needs

TEACHING PROCEDURE

B. ***Introduction***

Agricultural operations depend on their water supply for production. Determining which water sources are suitable for an operation and the volume of water required are essential to the success of the producer.

C. ***Motivation***

Ask students if they know how much water each of them consumes (total water use) on a daily basis (approximately 50 to 100 gallons per day). Then ask them to list as many different uses of water in agricultural operations as they can. Can any operations exist without water?

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students to list different sources of water with which they are familiar. Discuss the sources of water for agricultural operations.

   What are the sources of water on a farmstead?

   a) Public water supply
      1) Provides a safe, dependable water supply
      2) Not available in all areas, making private water sources necessary
   b) Well
      1) Provides a large quantity of safe water with relatively little maintenance
      2) Either shallow or deep
         (a) Shallow wells - sufficient water but poorer in quality
         (b) Deep wells - cleaner water and usually a larger volume of water; more expensive to drill
   c) Cistern - stores rainwater for domestic use but may not supply enough for livestock
   d) Pond
      1) Natural or man made
      2) Supplies livestock with water
      3) Can be used for humans with the proper construction and purification
      4) Problem - protection from pollution
   e) Natural sources of water, such as creeks, streams, and springs
      1) May not be able to provide enough water to meet the needs of the operation
      2) Can be unreliable for most irrigation and animal needs because of flooding, droughts, and changing topography of water courses

2. Refer back to the motivation and discuss the uses of water that predominate at their homes or operations. Discuss the different uses.

   What are the uses of water on a farmstead?

   a) Drinking water for livestock
   b) Irrigating crops

c) Sanitation

d) Cooling systems in some types of facilities, such as greenhouses or hog facilities

e) As a delivery system, by adding fertilizer to water while irrigating or medication to animals' drinking water

f) Human use for various domestic purposes, if a home is located on the farmstead

3. Ask students how they would go about determining how much water an agricultural operation needs on a daily basis. Using TM 1.1, discuss the use of tables showing water needs for different applications. Point out that overestimating daily water needs is usually better than underestimating the amount.

How is the total daily water need determined?

a) Find information on water needs.
   1) Charts that show the water needs for different types of animals and crops or special circumstances
   2) Local University Extension offices
   3) Trade associations

b) Multiply the recommended amount of water for a particular use by the amount of usage.

c) Add the different water uses together to find the total daily need of the operation.

4. Ask students how peak water need is determined. Have students complete AS 1.1.

How is peak water need determined?

a) The volume of water a water source can deliver is usually measured in gallons per hour.

b) Compare the total daily needs with the hourly output, which should be greater than the daily needs of the operation in order to meet peak water needs.

G. ***Other Activities***

Have students determine their water needs at home. Have them find out whether their water source is sufficient.

H. ***Conclusion***

Water, which may come from a variety of different sources, is a necessity for agricultural production. With a bit of calculating, a producer can estimates the amount that will be needed for his or her operation. This information can be useful when planning water systems.

I. ***Answers to Activity Sheet***

Category	Water Needs
Humans - 4 adults	400
25 beef cows	300
15 calves	150
4 horses	48
Lawn watered weekly - 1 inch (2,000 square feet)	1200
100 sows	800
Flushing the floor of the barn (400 square feet)	40
Total water needs	2938

1. No

2. 402 gallons

3. Drill another well, or reduce the number of hogs raised.

J. ***Answers to Evaluation***

1. c
2. a
3. Local University Extension offices and trade associations

4. Answers may include any three of the following: drinking water for livestock; irrigating crops; sanitation; cooling systems in some types of facilities; as a delivery system, by adding fertilizer to water while irrigating or medication to animals' drinking water; and use by humans for various domestic purposes, if a home is located on the farmstead.

5. By multiplying the recommended amount of water for a particular use by the amount of usage and adding the different water uses together to find the total daily need of the operation

6. By comparing the total daily needs with the hourly output

UNIT VI - PLUMBING Name ______________________

Lesson 1: Water Needs Date ______________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following sources of water holds rainwater for domestic use?

   a. Public water supplies
   b. Wells
   c. Cisterns
   d. Springs

2. What is a potential problem in using a pond as a water source?

   a. Pollution
   b. Flooding
   c. Maintenance
   d. Water storage

Complete the following short answer questions.

3. What are two potential sources of information about water needs?

   a.

   b.

4. What are three uses of water by agricultural operations?

   a.

   b.

   c.

5. How is the total daily water need calculated for an agricultural operation?

6. How is peak water need determined?

Water Needs Table

Use	Water Needs
Adult human	50 to 100 gallons per day
Beef animal	8 to 12 gallons per day
Milk cow	35 to 45 gallons per day
Dry cow	20 to 30 gallons per day
Calf	6 to 10 gallons per day
Swine (finishing)	3 to 5 gallons per day
Sow and litter	8 gallons per day
Horse	12 gallons per day
100 chickens (laying)	9 gallons per day
Lawn and garden	600 gallons to apply 1 inch of water on 1,000 square feet of area
Flushing floors	Minimum of 10 gallons per 100 square feet of floor

*Adapted from *How to Size a Farm and Home Water System (G1801)*, a University of Missouri Extension agricultural publication.

Lesson 1: Water Needs Name ___________________________

Determining Water Needs

Objective: Determine if the water supply is sufficient to supply this farm's water needs.

You are considering adding a 100-sow hog enterprise to your farm. One of your main concerns is whether the single well on the farm will be enough to supply the entire farm's needs, including the new hog operation. You will use water for the hogs and for flushing the floor of the barn. Your well provides 2,500 gallons. Using the information from the chart in the student reference, determine the total daily water needs for the farm. Use the maximum numbers for each category when determining your water needs. Then answer the questions below.

Category	Water Needs
Humans - 4 adults	__________
25 beef cows	__________
15 calves	__________
4 horses	__________
Lawn watered weekly - 1 inch (2,000 square feet)	__________
100 sows	__________
Flushing the floor of the barn (400 square feet)	__________
Total water needs	__________

1. Will your well supply enough water to add 100 sows?

2. How much extra water do you have without the hogs?

3. What are your alternatives for dealing with this water shortage?

UNIT VI - PLUMBING

Lesson 2: Plumbing Safety

Competency/Objective: Discuss safety practices for plumbing.

Study Questions

1. What are the different hazards associated with plumbing?

2. What are the tools needed for safe plumbing practices?

3. What are the proper methods for using tools and supplies associated with plumbing?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit VI.

2. Transparency Masters

    a) TM 2.1: Cutting Tools for Copper Pipe
    b) TM 2.2: Flaring and Bending Tools

3. Activity Sheet

    a) AS 2.1: Working with Plumbing Safely

Lesson 2: Plumbing Safety

TEACHING PROCEDURES

B. ***Review***

Many agricultural structures require some plumbing construction or repairs. Much of this work may be performed without outside help. A basic understanding of possible hazards and basic plumbing tools and their use is therefore desirable to perform these activities safely.

C. ***Motivation***

Ask students if they have heard of or seen any accidents associated with working with plumbing. If possible, bring in newspaper clippings about serious accidents, such as trench cave-ins. Discuss the importance of safety.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Referring back to the motivation, ask students to list some of the hazards associated with plumbing activities.

   What are the different hazards associated with plumbing?

   a) Open trenches
      1) People can suffocate if the sides cave in and bury them.
      2) The sides should be carefully observed for signs of instability, such as loose and collapsing areas.
      3) These areas should be avoided until they have been excavated to a safe point.
      4) Heavy excavating equipment close to the sides of a trench can cause the earth to cave in.
      5) The equipment should be removed before anyone enters the area.
   b) Plastic pipes cleaners and glues containing strong chemicals
      1) They may produce very strong, sometimes toxic, fumes.
      2) They may also irritate the skin.
      3) They can be flammable.
   c) Fire
      1) In areas where septic or waste lines are present, methane gas may accumulate; it is flammable and can explode.
      2) A potential fire hazard occurs when using a propane torch, because the flame can cause a fire if it comes into contact with combustible materials.
   d) Disorganized, untidy work sites
      1) Tripping and falling are common causes of injuries.
      2) Small sections of pipe left lying around can be particularly hazardous, since they tend to roll when stepped on.
      3) Ladders can tip over if they are not set on a level, solid surface.

2. Display examples or pictures of the tools with which students may not be familiar. Discuss other tools that are needed when working with plumbing. TMs 2.1 and 2.2 show different tools for working with copper pipe.

   What are the tools needed for safe plumbing practices?

   a) General tools for plumbing practices

1) Shovel for digging shallow trenches for pipe
2) Heavy earth-moving equipment for deeper trenches
3) Level
4) Claw hammer
5) Ladder
6) Tape measure
7) Drill

b) Plastic pipe
1) Adjustable wrench
2) Hacksaw to cut pipes
3) Sandpaper, a knife, or a scraping tool for smoothing the rough edges of pipe that has been cut
4) Pipe cleaner to remove residue from cutting
5) Pipe glue to join pipes

c) Copper pipes
1) Propane torch and soldering material to join pipes together
2) Pipe cutter
3) Pipe bender
4) Reamer to remove sharp edges after cutting the pipe
5) Flaring tool to widen the end of the pipe

3. Describe the practices that should be followed to use plumbing tools safely. If possible, demonstrate the safe use of some of the tools brought in as examples for the previous question.

What are the proper methods for using tools and supplies associated with plumbing?

a) Use protective clothing and gear.
1) Heavy work pants
2) Boots
3) Gloves
4) Eye protection
5) Safety helmet, if injury from above is possible

b) All tools should only be used according to the manufacturer's recommendations.

c) When utilizing plastic pipe cleaners and cements, special attention should be given to any safety recommendations concerning ventilation, skin contact, or fire hazards.

d) Extreme caution should be used when working with a propane torch; proper ventilation and the use of the protective clothing and gear listed above are a must.

G. ***Other Activities***

Ask a local plumber or a representative from a plumbers' union to come and speak to the class about plumbing safety.

H. ***Conclusion***

Being aware of the potential hazards and safety practices outlined above can reduce the chance of accidents while performing plumbing work. Safety should always be considered first to avoid accidents whenever possible.

I. ***Answers to Activity Sheet***

For each of the questions, examples given as answers may vary.

1. Fire
2. Ventilation

3. Cave-in
4. To avoid tripping

J. ***Answers to Evaluation***

1. d
2. e
3. a
4. b
5. c
6. g
7. f
8. Answers may include any two of the following: heavy work pants, boots, gloves, eye protection, and safety helmet.
9. People can suffocate if the sides cave in and bury them.
10. Methane gas
11. Safety recommendations concerning ventilation, skin contact, or fire hazards
12. Because they can be particularly hazardous in terms of causing falls, as they tend to roll when stepped on

UNIT VI - PLUMBING Name ______________________

Lesson 2: Plumbing Safety Date ______________________

EVALUATION

Match the description in the column on the left with the tool in the column on the right.

1.	Used for digging shallow trenches	a.	Knife
2.	Tool for cutting pipes	b.	Propane torch
3.	Tool used to smooth rough edges on cut pipe	c.	Pipe cleaner
4.	Used to join copper pipes together	d.	Shovel
5.	Removes residue from cutting	e.	Hacksaw
6.	Used to widen the end of copper pipe	f.	Pipe glue
7.	Joins plastic pipe together	g.	Flaring tool

Complete the following short answer questions.

8. What are two items of protective clothing that can be worn to prevent injury?

   a.

   b.

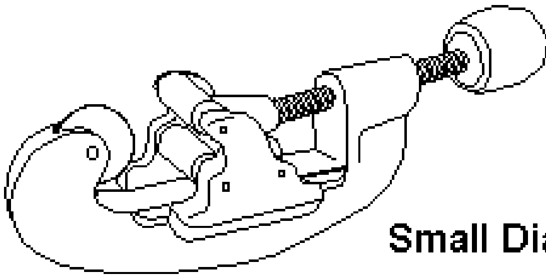
9. Why can open trenches be dangerous?

10. What is the name of the flammable gas that can accumulate around septic lines?

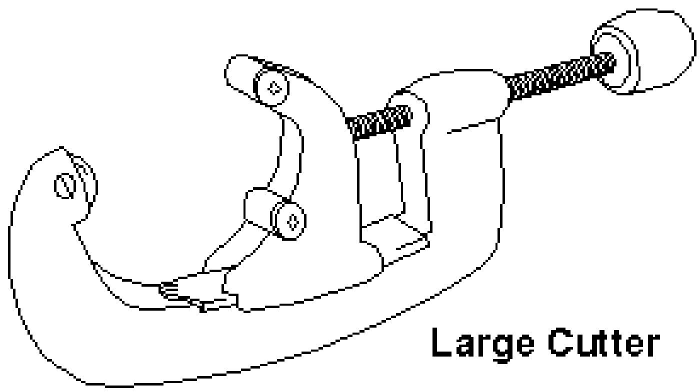
11. When utilizing pipe cleaners and cements, what types of safety recommendations are important?

12. Why should small sections of pipe always be picked up immediately?

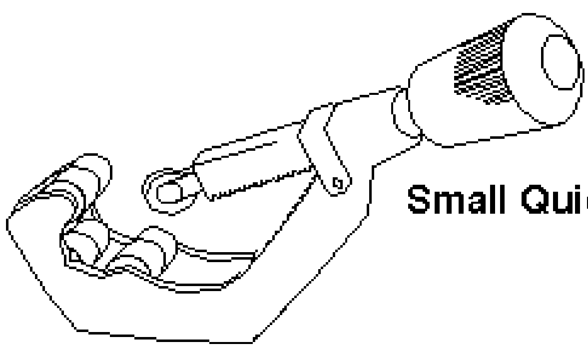
Cutting Tools for Copper Pipe



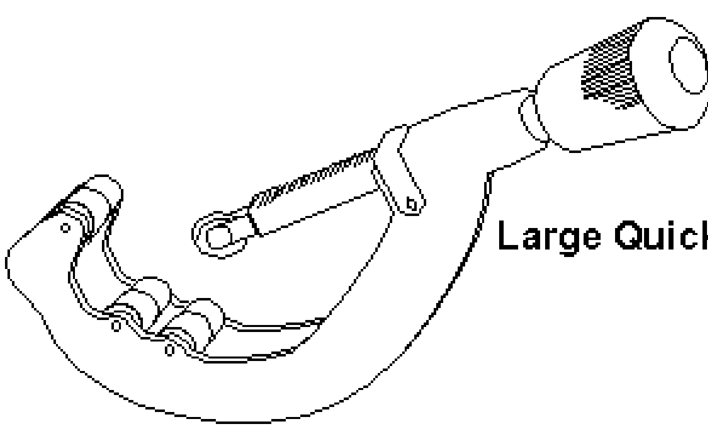
Small Diameter Cutter



Large Cutter

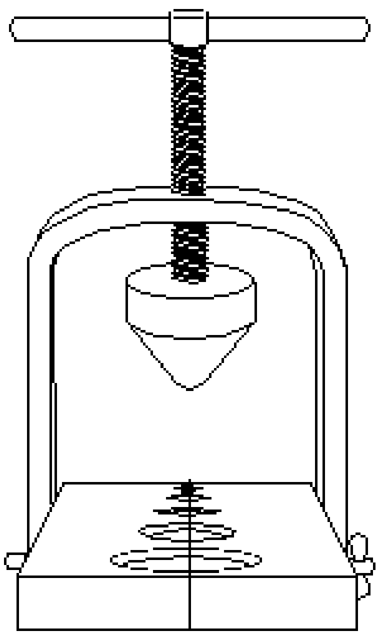


Small Quick-Opening Cutter

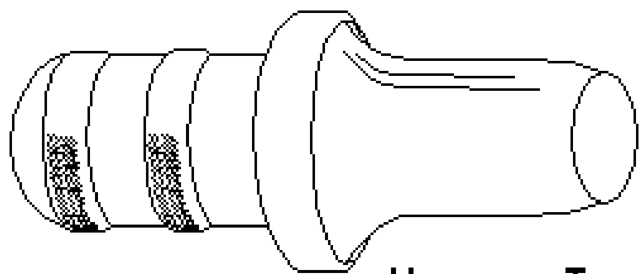


Large Quick-Opening Cutter

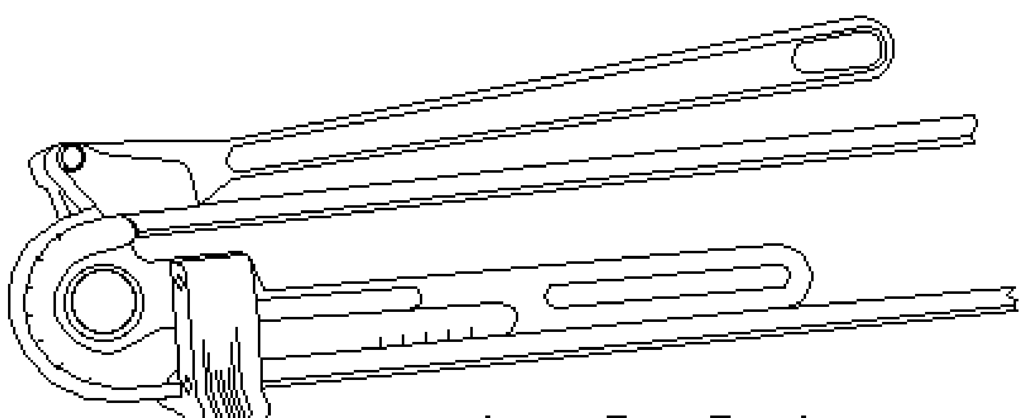
Flaring and Bending Tools



Yoke and Screw
Flaring Tool



Hammer-Type
Flaring Tool



Lever-Type Bender

Lesson 2: Plumbing Safety Name ____________________________

Working with Plumbing Safely

Objective: Describe safety concerns associated with plumbing.

Answer the following questions concerning plumbing safety. Describe a situation in which each hazard might become a danger.

1. What is a serious hazard associated with propane torches used for soldering?

2. What is an essential precaution when working with plastic pipe cement?

3. What is the major concern when working in deep trenches?

4. Why should small sections of scrap pipe be picked up immediately?

UNIT VI - PLUMBING

Lesson 3: Pipe Types and Size Requirements

Competency/Objective: Identify pipe types and determine size requirements.

Study Questions

1. What are the types of pipes and the characteristics of each?

2. How are pipes sized?

3. How is the pipe size needed to deliver a desired flow rate determined?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit VI.

2. Transparency Masters

   a) TM 3.1: Plastic Pipe Fittings
   b) TM 3.2: Copper Pipe Fittings
   c) TM 3.3: PVC Pipe Size Table

3. Activity Sheets

   a) AS 3.1: Pipe Usage

Lesson 3: Pipe Types and Size Requirements

TEACHING PROCEDURES

B. ***Review***

Lesson 2 described safety practices for working with plumbing. They are important because all agricultural operations require some plumbing. A variety of pipe materials that are easy enough for non-professionals to install exist for use in plumbing systems. This lesson explores the basics of pipe types and sizes.

C. ***Motivation***

1. Collect and display samples of different types and sizes of pipe. Hardware stores or plumbers may have short sections of pipe available that they would be willing to donate.

2. Take a field trip to a local hardware store to observe the different types of pipe available. If possible, have a clerk discuss the different types of pipe.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Discuss the different types of pipe and their characteristics. Use the pipe samples from the motivation or pictures as examples. TMs 3.1 and 3.2 can be used to illustrate some common types of pipe fittings that will be used with these plastic and copper pipes. Hand out AS 3.1 to the class. Point out that as they investigate the types of pipe used, they may see galvanized metal pipe in older structures.

What are the types of pipe and the characteristics of each?

a) Plastic pipe
   1) Most popular plumbing material for agricultural structures
   2) Durable and readily available in various forms and diameters
   3) Less expensive than copper pipe
   4) Easier to work with; requires few specialized tools or skills
   5) Brittle and more easily broken at low temperatures
   6) Crushed more easily
   7) Five basic types
      (a) Polyvinyl Chloride (PVC)
         (1) Common rigid white plastic pipe seen around construction sites
         (2) Generally is either 1 inch or ¾ inch in diameter
         (3) Comes in lengths of 10 to 20 feet
         (4) Used for cold water supply and waste disposal lines
         (5) Not recommended for hot water because of its chemical composition
      (b) Chlorinated Polyvinyl Chloride (CPVC)
         (1) Off-white or cream in color
         (2) Recommended for temperatures up to 180 degrees Fahrenheit
         (3) Most commonly found in ½- to ¾-inch diameters and 10 foot lengths

(4) Common choice for hot water lines

(c) Acrylonitrile-Butadiene-Styrene (ABS)

(1) Hard black plastic pipe used mostly for drain and sewer lines

(2) Commonly available in sizes ranging from 1¼ inches to 6 inches in diameter and in lengths of 10 to 20 feet

(d) Polyethylene (PE)

(1) Flexible black plastic tubing

(2) Comes in coils from 100 to 300 foot in length

(3) Available in diameters of ¾ inch to 2 inches

(4) Cannot withstand heat and so is only useful for handling cold water

(5) Primarily used for installing underground water service lines

(e) Polybutylene (PB)

(1) Flexible plastic pipe, usually gray in color

(2) Uses with cold or hot water

(3) Most commonly _ inch or ¼ inch in diameter

(4) Flexible enough to go around corners or objects without having to be cut and joined

(5) Have been prone to leaks, especially around fittings

b) Copper pipe

1) Very durable

2) Not difficult to work with, but does require more skill and specialized equipment

3) More expensive than plastic pipe

4) Available in two forms, hard and soft copper

(a) Rigid hard copper pipe

(b) Flexible soft tubing

5) Available in sizes of ¼ inch to 12 inches in diameter

6) Generally comes in 20-foot lengths for hard copper and coils varying in lengths from 45 to 100 feet for soft copper

7) Four weights

(a) K

(1) Thickest walls of the four types

(2) Available in hard and soft copper forms

(3) Color coded green

(4) Used for underground supply lines

(b) L

(1) Slightly thinner than K

(2) Available in hard or soft forms

(3) Color coded blue

(4) Used above ground, for general interior work

(c) M

(1) Slightly thinner than L

(2) Available in hard form only

(3) Color coded red

(4) Commonly used for above ground interior water supply, waste, or drainage lines

(d) DWV

(1) Thinnest of the four types of copper pipe

(2) Available only in the hard form

(3) Color coded yellow

(4) Used above ground for drainage, waste, or vent pipes

2. Discuss pipe sizes with the class.

How are pipes sized?

a) All types of pipe are referred to by their diameter.

b) Standard pipe sizes are ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 4, 5, 6, and 8 inches.

c) Pipe sizes are measured to the nearest fraction of an inch.

d) The measurement most often approximates the inside diameter (ID) of small pipes of less than six inches and the outside diameter (OD) on large pipes.

3. Ask students what factors concerning pipes might affect the flow rate. Discuss how to determine the proper pipe size. TM 3.3 can be used to demonstrate the use of pipe size tables.

How is the pipe size needed to deliver a desired flow rate determined?

a) For complex construction projects where the pipes must be sized exactly to deliver the desired flow rate

1) Two pieces of information are required.

(a) Desired flow rate in gallons per minute

(b) Amount of resistance due to friction between the water and the surface of the pipe.

2) Determine the desired flow rate by adding the typical flow rates for different water outlets that will be operating at the same time.

3) Select a pipe size that will allow the desired flow rate while limiting losses in pressure due to friction to 5 pounds per square inch or less.

b) A less exact method for less complex structures like homes and agricultural buildings

1) Use pipe size tables to choose the correct pipe size given the pipe system length and the desired flow rate.

2) Add ten percent to the measured length of the system to make up for losses due to fittings when using the table.

G. ***Other Activities***

Ask a plumber or plumbing sales representative to come and speak to the class concerning pipe materials and sizing considerations.

H. ***Conclusion***

Plastic and copper pipes are commonly used because they are relatively easy to work with. These materials are available in a variety of forms and sizes that serve many different functions. Many factors can affect the size of the pipes used in a plumbing system. One way that the necessary pipe size can be determined is by looking at the amount of water needed and the amount of friction between the water and the surface of the pipe.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. c
2. b
3. d
4. a
5. b
6. b
7. d
8. c

9. Answers may include any two of the following: ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 4, 5, 6, and 8 inches.

10. 1½ inch pipe

UNIT VI - PLUMBING Name ____________________

Lesson 3: Pipe Types and Size Requirements Date __

EVALUATION

Circle the letter that corresponds to the best answer.

1. How many common forms of plastic pipe are available for plumbing?

   a. Three
   b. Four
   c. Five
   d. Six

2. The plastic pipe suitable for hot water is called:

   a. CPV.
   b. CPVC.
   c. PVC.
   d. ABS.

3. When sizing pipe, a size must be selected that will allow the desired flow rate while limiting losses to:

   a. 2 pounds per square inch or less.
   b. 3 pounds per square inch or less.
   c. 4 pounds per square inch or less.
   d. 5 pounds per square inch or less.

4. Which is the thinnest form of commercial copper pipe?

   a. DWV
   b. M
   c. L
   d. K

5. Pipe sizes are referred to by their:

   a. Radius.
   b. Diameter.
   c. Length.
   d. Volume.

6. Which type of copper pipe is used for general interior work?

   a. K
   b. L
   c. M
   d. DWV

7. The hard black plastic pipe mostly used for drain lines is:

a. PVC.
b. PE.
c. CPVC.
d. ABS.

8. What is the plastic tubing used for underground water service lines?

a. CPVC
b. PVC
c. PE
d. ABS

Complete the following short answer questions.

9. What are two standard pipe sizes?

a.

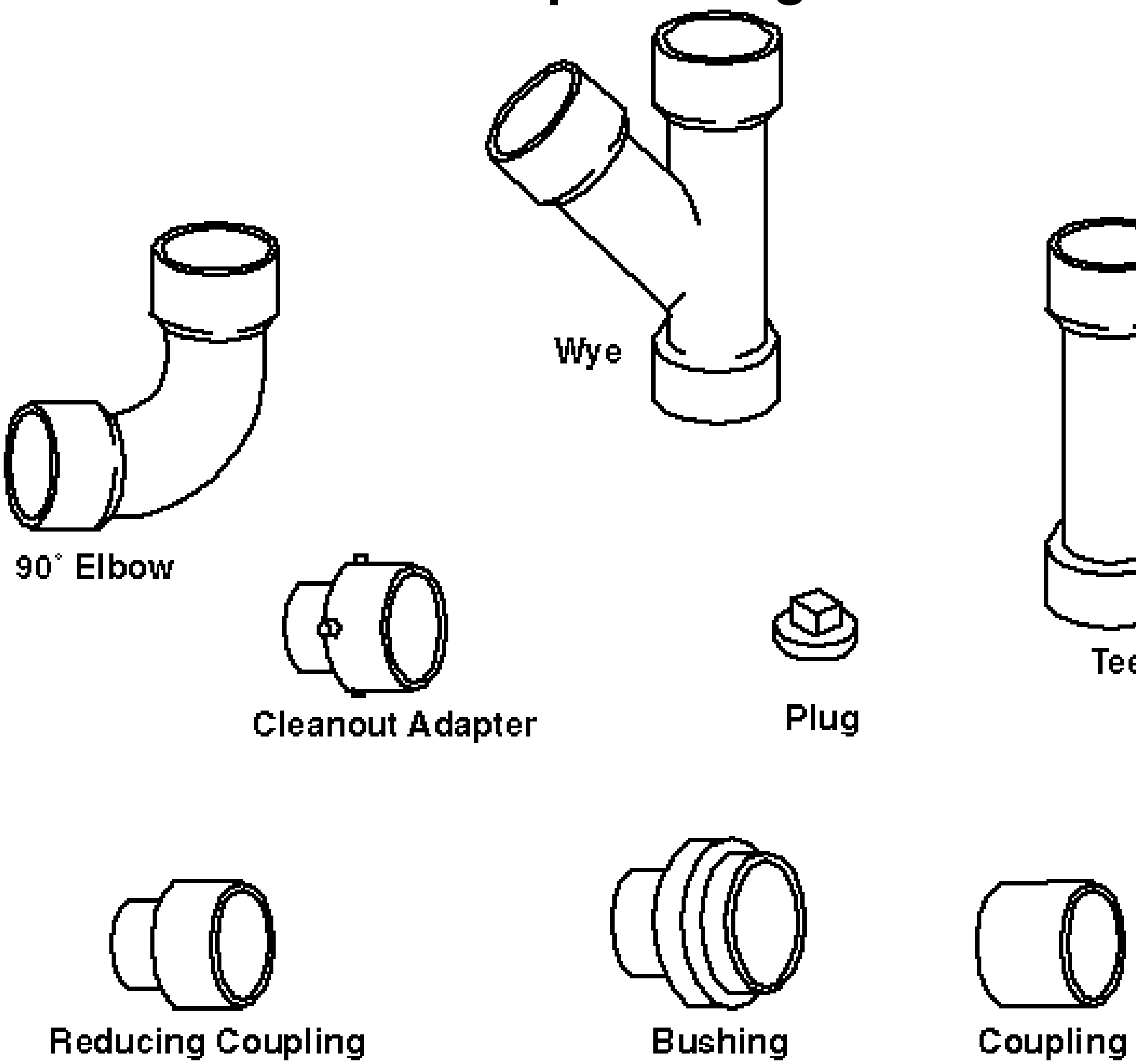
b.

10. What size of PVC pipe should be used for a pipe system that is 250 feet in length with a flow rate of 10 gallons per minute?

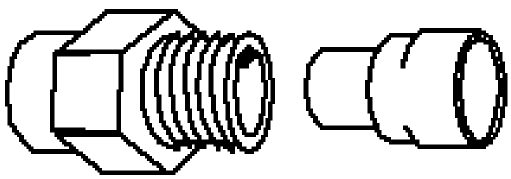
Distance in Feet*	Flow Rate (Gallons Per Minute)						
	2	3	5	7.5	10	15	20
Up to 25	½	½	¾	¾	1	1	1
50	¾	¾	¾	1	1	1¼	1¼
75	¾	¾	1	1	1	1¼	1½
100	¾	¾	1	1	1	1¼	1½
150	¾	¾	1	1	1¼	1½	1½
200	¾	1	1	1¼	1½	1½	2
300	¾	1	1	1¼	1½	2	2
400	1	1	1¼	1½	1½	2	2
500	1	1	1¼	1½	2	2	2

*Add 10 percent to the measured length to account for losses due to pipe fittings.

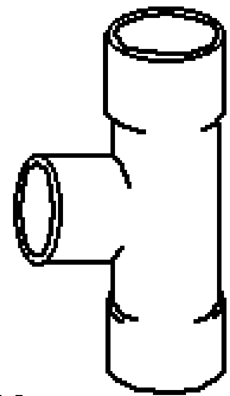
Plastic Pipe Fittings



Copper Pipe Fittings



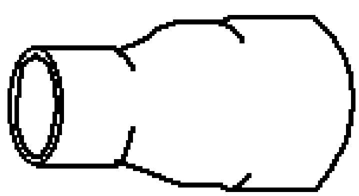
Adapters



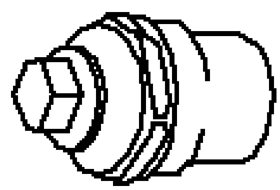
Tee

90

Coupling



Reducing
Coupling



Cleanout
with Plug

PVC Pipe Size Table

Distance in Feet*	Flow Rate (Gallons Per Minute)						
	2	3	5	7.5	10	15	20
Up to 25	½	½	¾	¾	1	1	1
50	¾	¾	¾	1	1	1¼	1¼
75	¾	¾	1	1	1	1¼	1½
100	¾	¾	1	1	1	1¼	1½
150	¾	¾	1	1	1¼	1½	1½
200	¾	1	1	1¼	1½	1½	2
300	¾	1	1	1¼	1½	2	2
400	1	1	1¼	1½	1½	2	2
500	1	1	1¼	1½	2	2	2
600	1	1	1¼	1½	2	2	2
700	1	1¼	1¼	1½	2	2	2½
800	1	1¼	1½	1½	2	2	2½
900	1	1¼	1½	2	2	2½	2½
1,000	1	1¼	1½	2	2	2½	2½
1,500	1¼	1¼	1½	2	2	2½	2½
2,000	1¼	1½	2	2	2½	2½	3
3,000	1¼	1½	2	2	2½	3	3

*Add 10 percent to the measured length to account for losses due to pipe fittings.

Lesson 3: Pipe Types and Size Requirements Name ___________________________

Pipe Usage

Objective: Identify where different types of pipes are used.

Look at the pipes in various structures, including your house, agricultural buildings, and school, as well as any other buildings to which you have access. Fill out the chart below, indicating the location of the pipes, what type of pipe was used, and why that type of pipe was chosen for that location. Then answer the questions about your observations.

Location	Type of Pipe	Reasons for Use

UNIT VI - PLUMBING

Lesson 4: Measuring, Cutting, and Connecting Pipes

Competency/Objective: Measure, cut, and connect pipes and tubing.

Study Questions

1. What factors must be considered before proper measurement of a pipe system can be accomplished?

2. How are different types of pipe cut properly?

3. What methods are available to join different types of pipe?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit VI.

2. Activity Sheet

   a) AS 4.1: Cutting and Joining Plastic Pipe

3. Job Sheet

   a) JS 4.1: Sweating Copper Pipe

Lesson 4: Measuring, Cutting, and Connecting Pipes

Teaching Procedures

B. ***Review***

Lesson 3 described the types and sizes of pipe and fittings used for plumbing and how they are sized to deliver a certain flow rate. After a particular type and size of pipe is chosen, it must be installed. Measuring, cutting, and joining pipe is an essential part of installing plumbing lines.

C. ***Motivation***

Have students observe the pipes located in the agriculture facility or elsewhere in the school. Ask them how they would cut and join the pipes for that particular application.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. With a metal tape measure or folding ruler, demonstrate how to measure by measuring around a room to find the total distance. Lay out pipes to fit a certain distance and then show how much attaching fittings to the pipes increases the length.

   What factors must be considered before proper measurement of a pipe system can be accomplished?

   a) Distance from the water source to the desired outlet along the exact path that the pipe will take
   b) Length of the pipe being installed
   c) Fittings used to join the sections of pipe, since they increase the length of the system
      1) The amount of increase is dependent on the size of the fittings as well as any angles made by the fittings.
      2) The length of the pipes may have to be adjusted to account for the fittings.

2. If possible, demonstrate how to cut pipe using a hacksaw or pipe cutter. Let the class examine the cut before and after smoothing it with sandpaper or some other tool, such as a knife or file. Cut some copper pipe and or tubing for the class and let them examine the joint before and after smoothing the cut with a file. Describe the process for using the different cutting tools.

   How are different types of pipe cut properly?

   a) Carefully measure the pipes with a tape measure or folding ruler.
      1) Make an allowance for the fittings; add the length to which the pipe will slide or screw into the fitting to the length that will run between fittings.
      2) With a pencil, mark the point where the pipe should be cut.
      3) The marking should extend all the way around the pipe.
      4) Measurements should be made to the nearest 1/32 of an inch.
   b) Cut the pipe.
      1) Use a wheel-type cutter for copper pipe.
         (a) Open the cutter by turning the handle until the pipe will fit between the wheel and roller.
         (b) Place the pipe in the base of the cutter and turn the handle until the pipe touches the cutter wheel.
         (c) Position the wheel on the point where the pipe is to be cut.
         (d) Turn the handle to press the wheel into the pipe.
         (e) Rotate the tool around the pipe once.

(f) Tighten the handle and rotate the tool again.

(g) Repeat this process until the pipe is cut.

2) Use a hacksaw for plastic pipe.

(a) If possible, place the pipe in a vise to hold it still.

(b) Position the hacksaw blade on the mark for cutting.

(c) Pull the hacksaw backwards, placing no pressure on the pipe.

(d) Bring the blade forward with pressure exerted to cut into the pipe.

(e) Hold the saw at a 90-degree angle to the pipe, resulting in a square cut.

(f) Repeat this process until the pipe is sawn through completely.

c) Smooth any burrs and ridges left on the inside or outside of the pipe from cutting.

1) With copper pipe, use a small file, sandpaper, or a special reaming tool.

2) Use sandpaper or a knife for plastic pipe.

3. Discuss the different methods of joining pipe. If time and materials are available, demonstrate joining plastic pipes and fittings with cement. Let the students try to pull the joint apart to show how solid they can be. Have students complete AS 4.1 and JS 4.1.

What methods are available to join different types of pipe?

a) Cements for plastic pipe

1) The end of the pipe and the fitting must be smooth and clean; a chemical cleaner is the best way to clean this material.

2) Once the fitting and pipe end are clean, they are covered with an even coating of cement on the pipe and fitting socket.

3) The cement usually acts quickly, so the pieces need to be joined together immediately and firmly.

4) The pipe should be given a quarter turn to make sure it is seated securely.

5) A solid and permanent joint will be created after the pipe and fitting are held together ten seconds to a minute.

6) A line of cement should appear all the way around the joint, indicating that enough cement was used.

7) The directions and recommendations for cements should always be read before they are used.

b) Soldering for copper pipe

1) The end of the pipe and the fitting must be clean; very fine sandpaper or emery cloth works well.

2) The use of soldering material, which looks like heavy wire, is enhanced by flux; flux may need to be placed on the joint before soldering.

3) Since different kinds of solder have different compositions and recommended uses, the manufacturer's instructions should be read before the material is used.

4) The fitting is placed on the pipe or tubing.

5) A propane torch is used to heat first the pipe and then the fitting until the solder melts when touching the joint.

6) The solder is held to the rim of the fitting and is drawn into the joint.

7) The solder is applied around the joint until it is found around the entire rim of the fitting.

8) The excess solder is wiped away while the pipe and fitting are still hot.

c) Flare joints for copper tubing

1) A flare nut is placed on the tubing.

2) The pipe is flared using some type of flaring tool; one common type of flaring tool is a yoke and screw flaring tool.

3) The tubing is placed in the correctly sized opening of a flaring block and secured in position, with the end of the tubing extending above the block about _ the depth of the block chamfer.

4) The yoke of the flaring tool is placed over the block, with the compression cone centered over the tubing.

5) The screw is tightened to form the flare between the block and the cone.

6) The screw should not be turned too far, since the tubing may split.

7) When the flare is finished, the fit of the flare is checked to the seat of the flare nut.

8) The fitting is then placed against the flare.

9) The nut is tightened to hold it in place.

G. ***Other Activities***

1. Have the class figure how much plumbing material would be needed to span a given area. Specify the length of the pipes used and the types of fittings required.

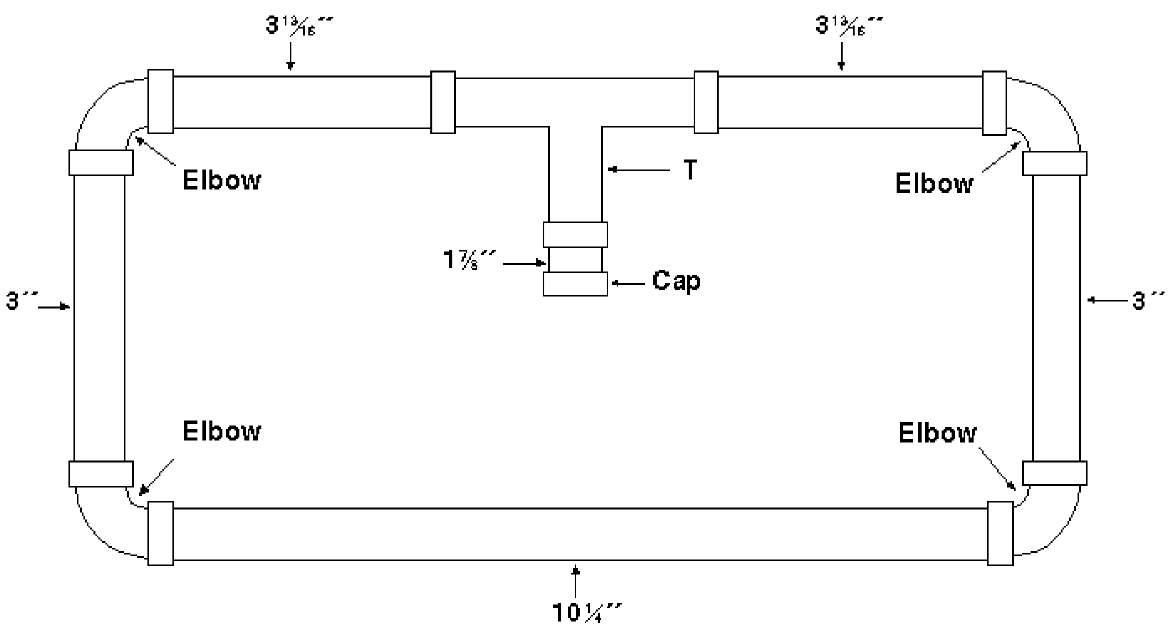
2. Have the students measure and cut some pipe material. Check the length of the pipe for accuracy.

H. ***Conclusion***

Precise measurements are necessary to determine the lengths of the materials in a plumbing system. Pipes are then cut to the appropriate length. When pipe has been cut, the pipes and fittings are joined. The goal is to produce a solid, watertight joint using pipes and fittings that have been cut to provide plumbing that is the proper length for installation.

I. ***Answers to Activity Sheet***

To achieve the correct dimensions, students will have to cut the pipe accurately. The correct lengths for the different pieces of pipe are shown below.



1. Answers will vary.
2. Answers will vary.
3. The same skills are used in preparing and constructing PVC pipe projects in structures.

J. ***Answers to Evaluation***

1. c
2. b
3. d
4. The distance from the water source to the desired outlet along the exact path that the pipe will take, the length of the pipe being installed, and the fittings used to join the sections of pipe
5. That enough cement was used
6. Because different kinds of solder have different compositions and recommended uses

UNIT VI - PLUMBING Name _

Lesson 4: Measuring, Cutting, and Connecting Pipes Date __

EVALUATION

Circle the letter that corresponds to the best answer.

1. Because accurate measurements are very important, measurements should be made to the nearest ______________ of an inch.

   a. 1/8 of an inch
   b. 1/16 of an inch
   c. 1/32 of an inch
   d. 1/64 of an inch

2. A plastic pipe and fitting should be held together for at least ____________________ seconds to be sure the joint will hold.

   a. 5
   b. 10
   c. 15
   d. 20

3. When cutting pipe with a hacksaw, the saw should be held at a _____________________ angle to the pipe to produce a square cut.

   a. 30-degree
   b. 45-degree
   c. 60-degree
   d. 90-degree

Complete the following short answer questions.

4. What three factors should be considered when measuring pipe?

   a.

   b.

   c.

5. What does a ring of cement around a joint indicate?

6. Why should the manufacturer's instructions be read before soldering material is used to join pipes?

Lesson 4: Measuring, Cutting, and Connecting Pipes Name _

Cutting and Joining Plastic Pipe

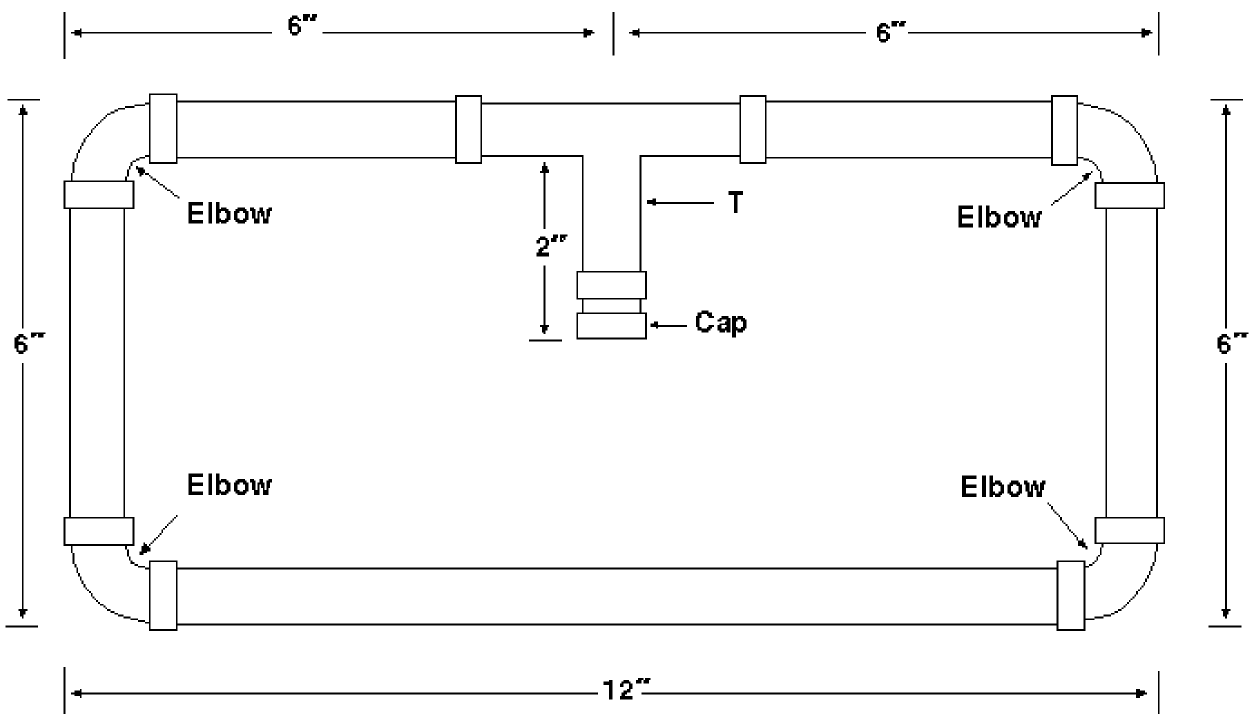
Objective: Cut and join plastic pipe.

Materials and Equipment:

1" PVC pipe, 4 feet in length
4 1-inch 90-degree PVC elbows
1 1-inch PVC T
1 1-inch PVC cap
Tape measure
Hacksaw
PVC primer and glue (optional)
Sandpaper

Procedure:

Using the diagram below, construct the PVC apparatus shown. Measure each piece carefully because you do not have much extra material. Once you have the pieces of pipe cut, either glue or stick the



pieces together, depending on your instructor's directions.

Key Questions:

1. Does your project have the correct dimensions? If not, why not?

2. What changes would you make in your procedure in constructing this project?

3. How could these skills be used in real world applications?

Lesson 4: Measuring, Cutting, and Connecting Pipes Name _

Sweating Copper Pipe

Objective: Join a copper pipe and fitting.

Materials and Equipment:

1 1" copper pipe, 4 inches in length
1 1" cap
Flux
Brush
Propane torch
Stationary vise
Steel wool or sandpaper

Procedure:

1. Place the pipe in the stationary vise.

2. Apply flux to the inside of the cap and the outside of the pipe using the brush.

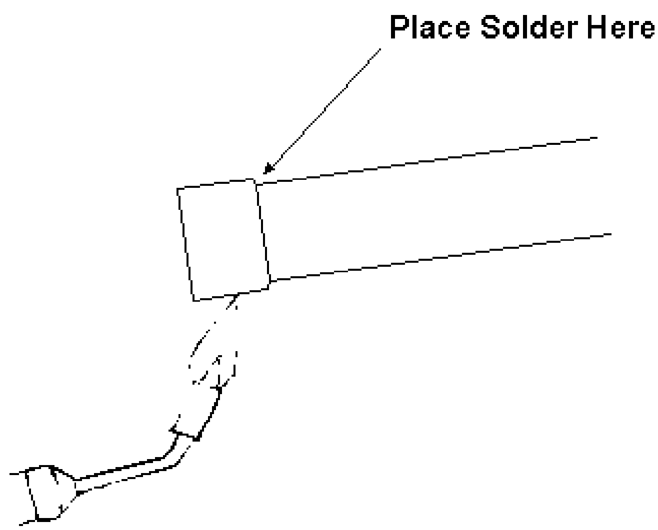
3. Join the cap and pipe.

4. Begin heating the cap as shown in Figure 1.1.

5. When the flux starts to bubble, add a small amount of solder to the rim of the fitting on the opposite side of the fitting from the heat source.

6. After the solder is drawn into and around the joint and seals the cap, use the steel wool or sandpaper to clean off the excess solder.

7. Allow the pipe to cool.



UNIT VI - PLUMBING

Lesson 5: Protecting Water Pipes from Freezing

Competency/Objective: Identify methods of protecting water pipes against freezing.

Study Questions

1. In respect to pipe freezing, what factors must be considered before installing pipe?

2. What different methods are available to prevent pipes from freezing?

3. What methods are available to thaw frozen pipes?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit VI.

2. Transparency Master

   a) TM 5.1: Electric Heat Tape

3. Activity Sheet

   a) AS 5.1: Water Pipes and Freezing Temperatures

UNIT VI - PLUMBING

Lesson 5: Protecting Water Pipes From Freezing

TEACHING PROCEDURES

B. ***Review***

Lesson 4 described methods of measuring, cutting, and joining pipe for installation. An important factor to consider when installing pipes is protecting them from freezing. Designing a plumbing system to prevent freezing and providing sufficient protection for pipes are necessary because of the potential cost of damage from pipes that have split and burst. If pipes do freeze, several methods are available to heat and thaw the frozen sections of pipe.

C. ***Motivation***

Cap one end of a short section of plastic pipe, fill it with water, and cap the other end. Place this in a very cold freezer or on dry ice for a few hours. When the water in the pipe has frozen, show it to the class. It likely will have bulged and split from the expansion of the water as it turned to ice. (If time allows, students may perform this experiment themselves.)

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Discuss the consequences of frozen pipes, referring back to the pipe used for the motivation. Explain that sections of pipe damaged due to freezing must be replaced even if water lines have to be dug up. Discuss factors to consider when installing pipe.

   In respect to pipe freezing, what factors must be considered before installing pipe?

   a) Running water lines underground below the frost line
      1) The average frost line in Missouri ranges is 3 feet.
      2) Pipes should be below the frost line.
      3) Most people install their pipes a foot below the frost line to help prevent freezing.
   b) Design of the plumbing system
      1) Designing the system so that pipes are placed in interior rather than outside walls can protect them.
      2) Insulation should be used around pipes placed near exterior walls.
         (a) R factor of 6.5 to 8
         (b) Carefully wrapped, with the ends butted together tightly and joined with tape
      3) Frost-free faucets should be used outdoors.
      4) If pipe is installed in an area subject to freezing, a drain valve should be added.

2. Discuss effective practices for preventing pipes from freezing. If possible, show a sample of electric tape and pipe insulation to the class.

   What different methods are available to prevent pipes from freezing?

   a) Wrapping exposed pipe in waterproof insulation
   b) Protecting exposed pipe from direct winds
   c) Supplying at least minimal heat to the inside of the structure using any appropriate heating system
   d) Using electric heat tape

1) The heat tape is placed along the pipe, which is then wrapped in insulation to hold the heat close to the pipe.
2) The tape carries an electrical current through it to supply heat.
3) Heat tape can be wired either with a timer set to turn it on and off at certain times or with a thermostat that activates the tape at a designated temperature.

e) Allowing water to run continuously
1) If water pressure begins to drop, the line should be opened a little so that the water runs continuously.
2) If the pressure returns to normal, the water should be allowed to drip or trickle from the faucet until the temperature rises to a safe point.

3. Ask students how they would thaw a pipe once it had frozen. Discuss the following different methods of thawing the pipe. Have students complete AS 5.1.

What methods are available to thaw frozen pipes?

a) Torches used by professional plumbers
1) If the flame comes in contact with combustible material, a fire can result.
2) Heating the pipes in one spot too quickly can cause the water to boil, creating enough pressure to cause the pipes to explode.
3) A flame should never be applied directly to a plastic pipe.

b) Electric heaters, hair dryers, heating pads, and electric blankets - should only be used after evaluating if any danger of electrical shock exists

c) Placing embers or charcoal briquettes in an appropriate container near frozen pipes for exterior pipes

G. ***Other Activities***

Ask a plumber to come and speak to the class about methods they have found effective for preventing pipes from freezing and thawing frozen pipes.

H. ***Conclusion***

Every attempt should be made to protect pipes from freezing. Placing lines below the frost line and providing insulation or other protection for any pipe that is not buried will greatly increase the odds of avoiding frozen pipes. If all efforts to prevent freezing have failed, the solution to frozen pipes is to raise the temperature enough for them to thaw by whatever safe and practical means are available.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

1. a
2. b
3. The heat tape is placed along the pipe, which is then wrapped in insulation to hold the heat close to the pipe.
4. Fire and exploding pipes caused by the pressure from boiling water
5. Answers may include any two of the following: electric heater, hair dryer, heating pad, and electric blanket.
6. Drain valve

UNIT VI - PLUMBING Name ____________________

Lesson 5: Protecting Water Pipes from Freezing Date __

EVALUATION

Circle the letter that corresponds to the best answer.

1. Exposed pipe should be:

   a. Wrapped with waterproof insulation.
   b. Covered with an electric blanket.
   c. Buried in dirt.
   d. Wrapped in duct tape.

2. If the water pressure begins to drop, what should be done to prevent the pipe from freezing?

   a. The outlet should be turned off.
   b. The water should be allowed to run continuously.
   c. Water to the entire plumbing system should be shut off.
   d. The pipe should be heated using a propane torch.

Complete the following short answer questions.

3. How is electric heat tape used to keep pipes from freezing?

4. What are two problems that may occur when using a torch to thaw copper pipes?

   a.

   b.

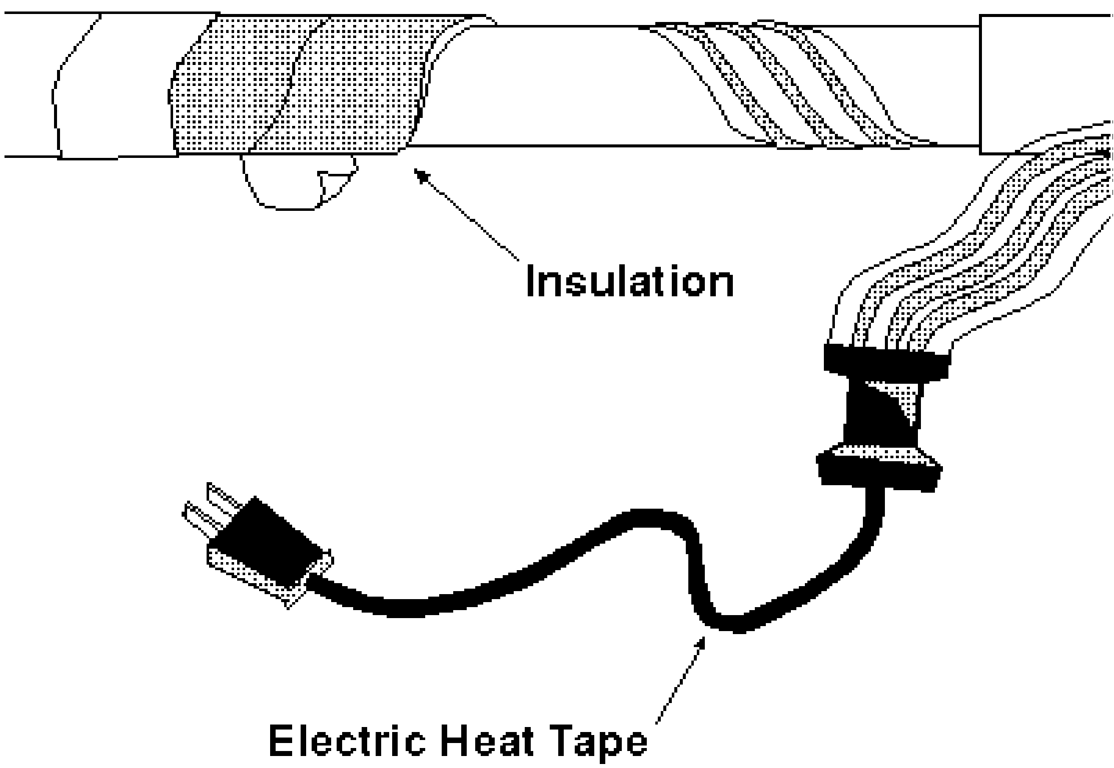
5. What are two electric devices that can be used to thaw frozen pipes?

   a.

   b.

6. What special fixture should be added if pipe is installed in an area subject to freezing?

Electric Heat Tape



Lesson 5: Protecting Water Pipes from Freezing Name ______________________________

Water Pipes and Freezing Temperatures

Objective: Describe common methods for preventing freezing in water lines and for thawing pipes.

Using the questions below, interview three different homeowners or owners of agricultural operations about their experiences with frozen water lines. Record their answers here or on another sheet of paper if more space is needed. Be prepared to discuss the answers with the class.

1. Have any of your water lines ever frozen?

2. If not, what measures were taken that prevented freezing?

3. If so, where and why did the lines freeze?

4. Did any damage occur to the plumbing system? If so, what was done to repair the damage?

5. What action was taken to thaw the pipe?

UNIT VII - FENCING

Lesson 1: Fencing Basics

Competency/Objective: Discuss the terminology, dangers, and safety practices associated with building fences.

Study Questions

1. What is a legal fence?

2. What are the common tools used in building fences and safety measures for their uses?

3. What are the safety measures used in putting up a fence?

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit VII.

2. Activity Sheet

   a) AS 1.1: Building Legal Fences

UNIT VII - FENCING

Lesson 1: Fencing Basics

TEACHING PROCEDURES

B. ***Introduction***

Suitable fencing is necessary for many types of agricultural enterprises. In this unit, a discussion of some of the fencing options available and how they may be erected will be presented. This lesson describes some fencing basics. Before constructing a fence, an understanding of what constitutes a legal fence is required to avoid being liable for damages if livestock do get out. Also, because working with fences can be dangerous, taking precautions is important for safety's sake.

C. ***Motivation***

Discuss the fence types and their uses in your area. If possible, show some pictures of well-built fences and fences that would not meet the definition of a legal fence.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students to provide examples of what kind of damage can occur if livestock get out of a pasture or lot. Discuss the legal definitions of a fence. Have students complete AS 1.1.

   NOTE: Because fencing laws vary, check the local regulations to find out the definition of a legal fence in a particular area. Reviewing the laws concerning fencing each time this lesson is taught may also be helpful to make sure that the regulations have not changed.

   What is a legal fence?

   a) General law
      1) Hedges are at least 4 feet high.
      2) Fences composed of posts and rails, post and palings, posts and wire, posts and boards, or palisades are at least 4½ feet high with posts firmly in the ground not more than 8 feet apart.
      3) Fences consisting of woven wire, wire netting, or wire mesh are at least 4½ feet high with posts not more than 16 feet apart.
      4) Other fence structures satisfying the definition of a lawful fence are described, including worm (rail) fences, turf fences, and stone or brick fences.
      5) All fences should be constructed to resist horses, cattle, swine, and similar stock.
   b) Fence and Enclosure Act of 1963
      1) A fence with not fewer than four boards per 4 feet of height, each board to be spaced no farther apart than twice their width and to be fastened to posts not more than 12 feet apart with one stay.
      2) A fence of four barbed wires supported by posts not more than 15 feet apart with one stay or 12 feet apart with no stays.
      3) Any fence that is at least equivalent to the types of fences in the other categories.

2. Ask students to list some tools that might be used for fencing. Describe the safety practices associated with their use.

What are the common tools used in building fences and safety measures for their use?

a) Basic tools
   1) Hand-operated post hole digger
   2) Power-driven post hole digger (sometimes called an auger)
   3) Metal rod for packing earth around posts
   4) Hammer
   5) Tape measure
   6) Fencing pliers
   7) Fence stretchers
   8) Hand ax
   9) Chain saw
   10) Metal post driver
   11) Post maul for driving wooden posts
   12) Roll of nylon string to help lay out straight lines
   13) Level to help assure that posts are set straight
b) Protective clothing
   1) Steel-toed boots
   2) Heavy pants
   3) Gloves
   4) Eye protection
c) Safety measures
   1) Hand-operated post hole diggers
      (a) The target area for digging should be clear and free of large rocks.
      (b) Maintaining good posture while operating this tool will help reduce back strain or injury.
   2) Power-driven post hole diggers
      (a) Follow the manufacturer's recommendations.
      (b) Keeping any loose clothing away from the auger can help prevent serious injury, because it can easily mangle a person's arms or legs if clothing gets caught in the auger as it twists.
      (c) Hearing and eye protection should be used.
   3) Metal rods
      (a) Protective glasses can prevent injury to the eyes.
      (b) Gloves and steel-toed boots can help avoid injury to the hands and feet.
   4) Metal post drivers
      (a) Good posture and control while lifting the post driver can help avoid back injury.
      (b) Gloves will help prevent blisters.
   5) Post maul
      (a) Make sure that everyone working in the same area is out of striking distance.
      (b) Gloves should be worn to protect the hands.
      (c) Eye protection should be worn to prevent injuries from stray flying material.
   6) Hand ax - Safety glasses, gloves, and steel-toed boots are needed for safety.
   7) Chain saw - Hearing protection, eye protection, gloves, and steel-toed boots will increase safety.
   8) Fence stretchers - The tool should be used with caution, because wire that has been stretched too tightly may break.

3. Discuss other safety measures that can be taken when constructing a fence.

What are the safety measures used in putting up a fence?

a) Protective clothing and safety accessories should be used; a hat and a shirt with long sleeves may provide additional protection.

b) If possible, fence construction should not involve working alone in an isolated area, since help may be necessary if an injury occurs.

c) The tools used for construction of the fence should only be used as designed and recommended by the manufacturer.

d) Fence construction may involve heavy lifting, so proper lifting techniques should be used.
   1) Keep the back straight and use the leg muscles to help move the weight.
   2) Hold heavy loads close to the body to help reduce strain.
e) Unexpected hazards such as wasps, bees, snakes, and plants such as poison ivy are also to be considered and avoided if possible.
f) Caution should be used when working with wire, which commonly causes cuts.
g) Overstretching may occur, causing the wire to break and whip back against or around the person stretching it or someone else; wearing gloves and eye protection is a must.

G. ***Other Activities***

Have students collect pictures of good and bad fences to add to the collection displayed in the motivation.

H. ***Conclusion***

A good fence is required for livestock, to ensure their safety and to prevent property damage. Fences should meet the definition of a legal fence to avoid liability if livestock do cause damage. Using basic fencing tools safely, wearing protective clothing, and taking precautions can help make building a fence safer.

I. ***Answers to Activity Sheet***

Barbed wire:

Number of posts - 220
Length of barbed wire - 10,560 feet

Woven wire:

Number of posts - 168
Length of woven wire - 2,640 feet

Boards:

Number of posts - 332
Number of 2" × 6" boards - 1,328 boards

1. Posts and boards
2. Posts and boards
3. Barbed wire, because it is cheaper and easier to construct

J. ***Answers to Evaluation***

1. b
2. c
3. a
4. d
5. b

6. Answers may include any two of the following: steel-toed boots, heavy pants, gloves, and eye protection.

7. Because the augur can mangle a person’s arms or legs if clothing gets caught in it as it twists.

UNIT VII - FENCING	Name ______________________

Lesson 1:	Fencing Basics	Date ______________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following is a provision of the general statute defining a legal fence?

   a. A fence has four boards per 4 feet of height.
   b. Fences consisting of woven wire are 4½ feet high.
   c. Barbed wire fences are 3 feet high.
   d. A wire mesh fence has posts 18 feet apart.

2. An important safety consideration when using a post maul is:

   a. The number of swings needed.
   b. The weight of the tool.
   c. The position of anyone else in the area.
   d. The material of the handle.

3. Overstretching fence wire can cause the wire to:

   a. Break.
   b. Weaken.
   c. Knot.
   d. Tighten.

4. Under the Fence and Enclosure Act of 1963, a barbed wire fence should have:

   a. 1 wire.
   b. 2 wires.
   c. 3 wires.
   d. 4 wires.

5. Caution should be used when working with wire, because it commonly produces what type of injury?

   a. Bruises
   b. Cuts
   c. Scrapes
   d. Wire burns

Complete the following short answer questions.

6. What are two items of protective clothing that should be worn when building fences?

   a.

   b.

7. Why is keeping loose clothing away from an auger important?

Lesson 1: Fencing Basics Name ______________________________

Building Legal Fences

Objective: Understand fencing laws that affect agricultural enterprises.

For this activity, imagine that you are a local fencing contractor. A customer has contacted you, asking for a list of the materials needed to build a fence around a small square field. The total length of the fence will be ½ mile. The fence must comply with the state laws for legal fences, which in your county consists of the Fence and Enclosure Act. The customer has not decided whether to use barbed wire, woven wire, or posts and 2" × 6" boards. Develop a list of the materials needed to build each type of fence. The posts will be the same diameter and length for each type of fence. Then answer the questions below.

Barbed wire:

Number of posts, 12 feet apart ______________

Total length of the barbed wire ______________

Woven wire:

Number of posts, 16 feet apart ______________

Total length of the woven wire ______________

Boards:

Number of posts, 8 feet apart ______________

Number of 2" × 6" boards, 8 feet in length ______________

1. Which type of fence will require the largest number of posts?

2. Which fence would probably be the most expensive?

3. Considering the three types of fences discussed, which type of fence do you think is most commonly used on agricultural operations? Why?

UNIT VII - FENCING

Lesson 2: Setting and Bracing Posts

Competency/Objective: Describe how to set and brace wood and steel posts.

Study Questions

1. What are the materials and tools needed for installing wood posts and braces?
2. Where are wood and steel anchor-and-brace assemblies located?
3. How are assemblies and brace wire installed?
4. How are the wood line posts installed?
5. What tools are needed for installing steel posts and braces?
6. How are steel post-and-brace assemblies installed?
7. How are steel line posts installed?
8. What are the factors to consider when installing a gate?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit VII.
2. Transparency Masters
   a) TM 2.1: Anchor-and-Brace Assemblies
   b) TM 2.2: H-Brace
   c) TM 2.3: Metal Corner Post and Braces
3. Activity Sheet
   a) AS 2.1: Constructing Model Brace Assemblies

Lesson 2: Setting and Bracing Posts

TEACHING PROCEDURES

B. ***Review***

Lesson 1 discussed the tools used to build fences and how to build them safely. Building fences is a labor intensive process. Constructing a fence correctly is better than doing a poor job and having to perform excessive maintenance and repairs. This lesson describes how to install anchor-and-brace assemblies and line posts for wood and steel posts.

C. ***Motivation***

Ask students whether the fences they are familiar with use wood or steel posts or some combination of the two. Ask students why they think the different kinds of posts are used for those fences.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask students to describe the tools needed to install braces and wood posts. Discuss the different tools. If possible, show students a sample wood post and brace.

What are the materials and tools needed for installing wood posts and braces?

a) Materials
  1) Wood corner posts
    (a) Chemically treated to resist rotting
    (b) 6 or more inches in diameter
    (c) 8 feet or more in length
  2) Wood line posts
    (a) Chemically treated
    (b) 2½ inches to 6 inches in diameter, with a diameter of 5 inches preferred
    (c) 5½ to 8 feet in length
  3) Wood brace poles
  4) Large nails, such as 16d tempered ring shank pole barn nails
  5) 12½ gauge high tensile smooth wire for wire braces
  6) Staples
b) Tools
  1) Axe
  2) Wheelbarrow
  3) Chain saw
  4) Heavy equipment
  5) Post hole digger
  6) Shovel
  7) Hoe
  8) Tape measure 100 feet or more in length
  9) Level

2. Discuss where anchor-and-brace assemblies are located along the fence line.

Where are wood and steel anchor-and-brace assemblies located?

a) Fence corners

b) At points along the fence line to compensate for the effect of stresses exerted on the fence

  1) Type of fence

  2) Topography of the ground

  3) Type of ground

  4) Length of the fence run

  5) Bends in the fence line

3. Describe the process for installing the most common type of assembly, the H-brace. TM 2.1 can be used to illustrate other types of assemblies. TM 2.2 shows a finished H-brace. Hand out AS 2.1.

How are assemblies and brace wire installed?

a) Set the posts in place.

  1) Place the end or corner post first.

  2) Put the second brace post in place in line with the first at the desired distance.

    (a) A longer brace pole will provide more structural strength.

    (b) The industry standard is 8 feet in length, but when a single H-brace is needed, using a 10- to 12-foot brace is preferable.

b) Form a notch for the brace pole in each post.

  1) The notches should be perpendicular to the fence line.

  2) A good height for the bottom edge of the brace pole is 36 to 42 inches.

  3) The height should be determined by the spacing of the fence wires, so the brace does not interfere with wire placement.

c) Install the twist wire.

  1) Wrap the wire twice completely around each of the posts.

  2) The direction of the fence pull will determine the placement of the twist wire.

  3) Loosely staple the twist wire low on the brace post farthest from the longer stretch of fence and just above the brace on the post next to the length of fence being braced.

  4) Remove as much slack as possible from the twist wire by pulling on both ends.

  5) Splice the wires together.

d) Nail the ends of the brace pole to the posts using the 16d nails ring shank nails; four nails are used at each end, one on top, one on each side, and one on the bottom.

e) Insert a twist stick between the wires.

  1) The stick may be a 1-inch wood dowel, fiberglass rod, or a short section of 2" × 4" or 2" × 2".

  2) It should be a minimum of 20 inches in length.

f) Twist the wires so that when the assembly is finished the stick will be pulled against the brace pole on the opposite side from where the wire is attached.

  1) The structure should begin to move in the opposite direction from the pull of the fence.

  2) A good rule of thumb is to move the end post approximately ½ to ¾ of an inch out of plumb away from the direction of pull.

g) Attach the twist stick to the brace pole by drilling a ¼-inch hole through the twist stick in line with the brace and then driving a 16d galvanized nail through the stick and into the pole.

4. Discuss the procedures used to install wood line posts.

How are wood line posts installed?

a) Lay out the fence line.

1) One person stands behind a corner post and another person moves down the fence line toward the next corner post holding a movable post, or sighting pole.

2) The person at the corner post directs him or her to a position that lines up the corner post, the post being held, and the next reference point.

3) The spot is marked for reference in aligning the posts.

b) Measure off the line post spacing.

1) The placement is determined by the type of fence, the amount of pressure that will be placed on the fence by livestock, dips and rises in the ground, and whether steel, fiberglass, or other types of posts are also placed in the fence line.

2) For field fencing, line posts are commonly 14 to 20 feet apart, while 8 to 16 feet is typical for more confined lots.

3) A tape measure may be used to measure out the exact spot for each post, or the distance between them may simply be estimated by pacing out the distance.

c) Mark the ground line on the posts; line posts are usually set 30 inches into the ground.

d) Dig the holes to the proper depth and set the posts in packed dirt.

e) A level may be used to check the posts' plumbness.

f) An alternative method of placing wood posts is sharpening and driving them into the ground with a post maul or a hydraulic post driver mounted on a tractor.

g) Special considerations for setting any line posts are topography and ground conditions.

1) Wet areas will typically require a longer post driven deeper into the ground to provide stability for the fence.

2) Posts set in low areas may need special bracing to keep them from lifting out of the ground.

5. Ask students to list the tools needed to install steel posts and braces.

What tools are needed for installing steel posts and braces?

a) Chain saw

b) Ax

c) Heavy equipment

d) Metal post driver

e) Set of wrenches or a socket set for bolts

f) Portable arc welder

g) Fencing pliers or special tool for fasteners

h) Portable cement mixer or a wheelbarrow

i) Shovel

j) Buckets or a hose to supply water for concrete

6. Discuss how to install steel post-and-brace assemblies at a corner or along a fence line. Use TM 2.3 to illustrate the installation of a corner post.

How are steel post-and-brace assemblies installed?

a) Dig the anchor post hole.

1) Should be 3 feet deep

2) Provides more stability if it is approximately 20 inches in diameter at the bottom and 18 inches in diameter at the top

b) Mark the ground line on the post.

c) Bolt or weld the braces to the anchor post.

d) Dig holes where the braces touch the ground.

1) Must extend 6 inches below the frost line

2) Should be a minimum of 18 inches deep and preferably deeper, usually 2 to 3 feet

e) Place the concrete around the post and braces.

f) Mold the top of the concrete to slope away from them.

g) Use a level to make sure the post is plumb.

7. Discuss the procedures for installing a steel line post.

How are steel line posts installed?

a) Measure the line post spacing and align the posts.
b) Mark the ground line on the posts, which are set 2 to 3 feet deep.
c) Drive the posts to the proper depth using a steel post driver.

8. Collecting some pictures of gates and displaying them will help stimulate interest in this topic. Discuss the following factors with the class.

What are the factors to consider when installing a gate?

a) A heavy gate will provide a counter force to the pull of the fence, so the weight of the gate should be taken into account when tensioning the brace structure.
b) Gates should not be hung from lone posts.
c) A larger post, 7 inches in diameter or more, should be used for the gate post.
d) Gates should be hung in line with the fence structure, providing maximum support.
e) If double gates are hung, a brace assembly must be installed on both sides of the opening.

G. ***Other Activities***

1. Examine fences around the school or community to investigate methods of bracing.

2. Ask a local fencing contractor to speak to the class about new types of fencing and fence bracing.

H. ***Conclusion***

Installing wood or steel posts is the first step in building a fence. Careful installation of both anchor-and-brace assemblies and line posts is necessary to construct a sturdy fence. Gates should also be installed with care, because their size and weight can have an effect on the fence.

I. ***Answers to Activity Sheet***

1. They add strength to the fence, keep wires tight, and allow line wires to be tightened.

2. The fence would have little overall strength, and all wires would become very loose.

3. The twist wire pulls the posts toward each other.

J. ***Answers to Evaluation***

1. d
2. c
3. c
4. b
5. d
6. a
7. Twist stick

8. Answers may include any two of the following: type of fence, topography of the ground, type of ground, length of the fence run, and bends in the fence line.

9. They must be driven deeper into the ground.

10. Answers may include any two of the following: a set of wrenches or a socket set for bolts, a portable arc welder, and fencing pliers or a special tool for fasteners.

UNIT VII - FENCING　　　　Name ____________________

Lesson 2:　Setting and Bracing Posts　　　　Date __

EVALUATION

Circle the letter that corresponds to the best answer.

1. The recommended size for wood line posts is:

   a. 2 inches in diameter.
   b. 3½ inches in diameter.
   c. 4½ inches in diameter.
   d. 5 inches in diameter.

2. How deep are steel line posts generally set?

   a. 1 to 2 feet deep
   b. 1½ to 2½ feet deep
   c. 2 to 3 feet deep
   d. 2½ to 3½ feet deep

3. How deep are wood line posts usually set?

   a. At least 10 inches
   b. At least 20 inches
   c. At least 30 inches
   d. At least 40 inches

4. What is the first step in installing steel post-and-brace assemblies?

   a. Mark the ground line on the post.
   b. Dig the anchor post hole.
   c. Bolt the braces to the post.
   d. Dig holes for the braces.

5. How large should a gate post be?

   a. At least 4 inches in diameter
   b. At least 5 inches in diameter
   c. At least 6 inches in diameter
   d. At least 7 inches in diameter

6. What type of wire is preferred for wire braces?

   a. 12½ gauge high tensile smooth wire
   b. 12 gauge barbed wire
   c. 10½ gauge smooth wire
   d. 10 gauge high tensile smooth wire

Complete the following short answer questions.

7. What is used to tighten a brace wire?

8. What are two factors that may affect the placement of an anchor-and-brace assembly along a fence line?

   a.

   b.

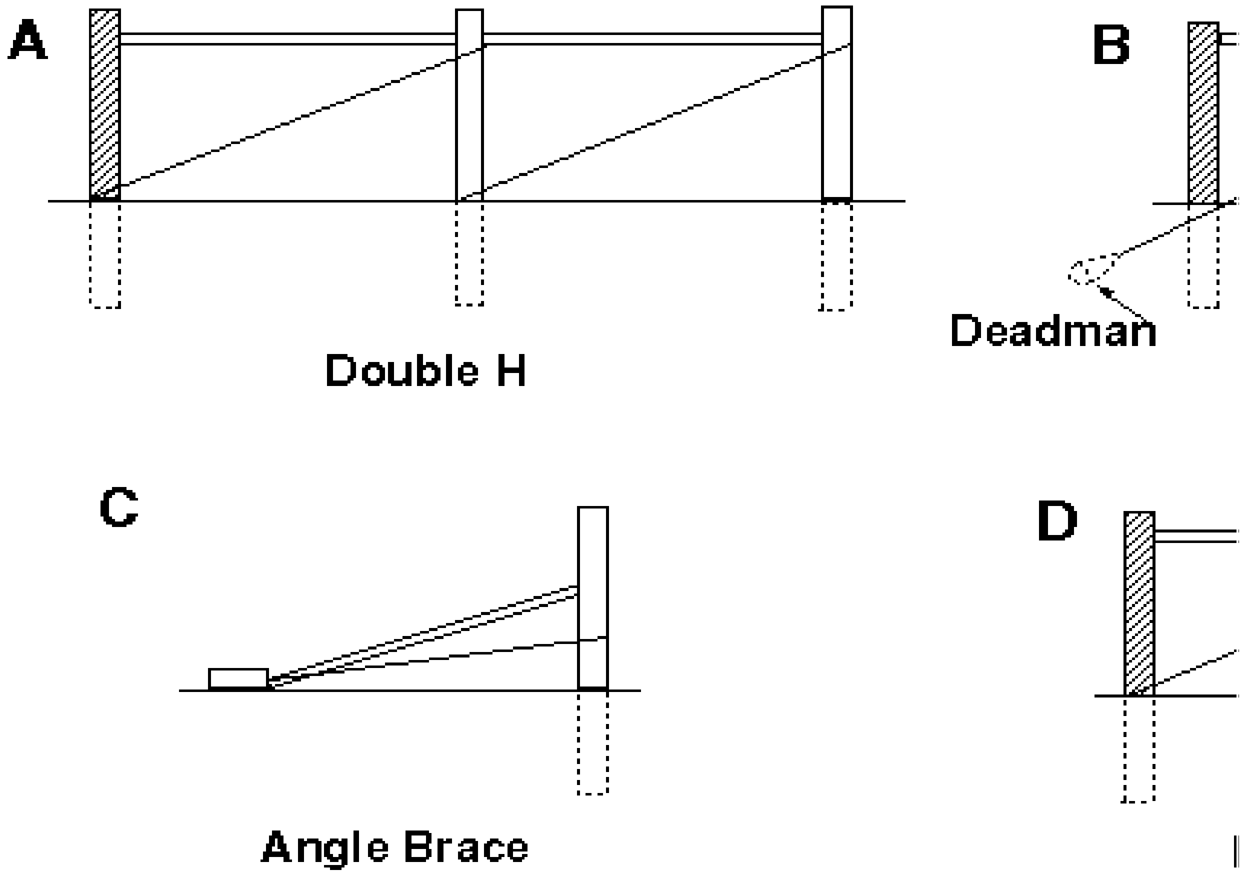
9. What must be done to provide more stability for line posts set in wet areas?

10. What are two tools used to attach braces to steel posts?

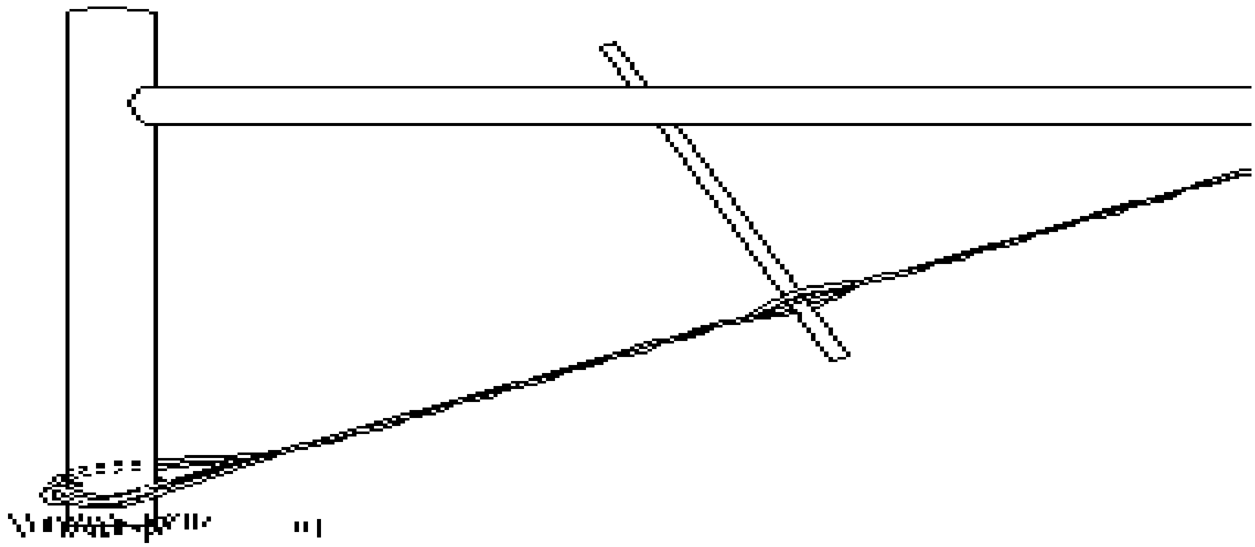
   a.

   b.

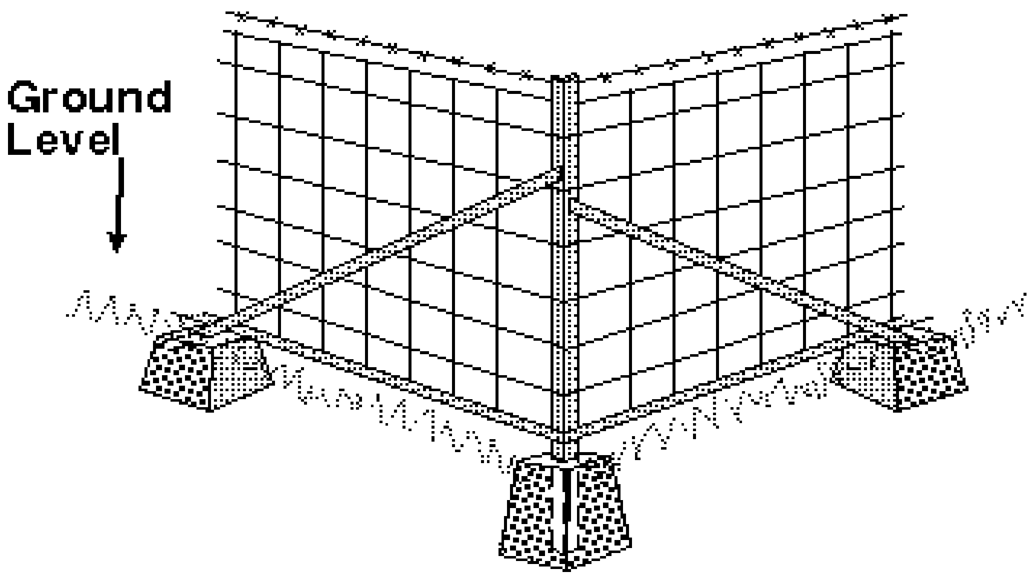
Anchor-and-Brace Assemblies



H-Brace



Metal Corner Post and Braces



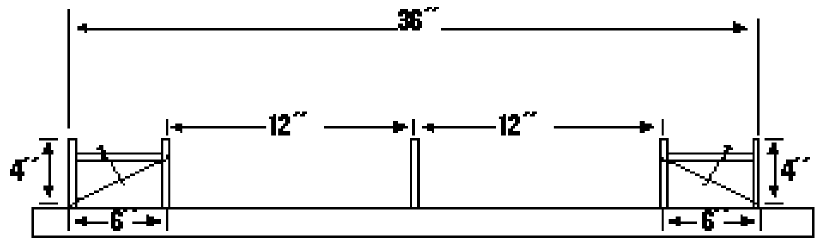
Lesson 2: Setting and Bracing Posts Name ___________________________

Constructing Model Brace Assemblies

Objective: Construct model brace assemblies similar to those used in fencing.

Materials and Equipment:

1 8-foot 2" × 4"
1 4-foot ½" dowel
Hacksaw
½-inch drill bit
Drill
Wood glue
Wood chisel
1 12d nail
2 feet of thin wire (.035 MIG wire)



Procedure:

In this activity, you will construct a model (Figure 1.1) of a wood post fence that is 36 feet long, including the corner bracing. The model will be on the scale of 1" = 1'.

1. On your 2" × 4", mark on the board where the end posts will be placed. Drill holes 1 inch in depth into the board for the dowel posts.
2. At each end of the fence, brace posts will be placed 6 inches from the end post. Mark their location on the board and drill these holes.
3. The line posts in the middle will be 12 inches from the brace posts, with 12 inches between them. Mark their location and drill the holes.
4. Cut the dowel in 6-inch lengths to make six fence posts
5. Before inserting any dowels into the holes, notch the brace posts for the brace pole. The top of the brace will be placed 4 inches above the surface. Mark the position on four of the posts, and cut a notch into the post that is ½ inch in diameter and only about ¼ inch into the post. Using the wood chisel, chip out the material between the cuts where the brace will be inserted.
6. Place a small amount of glue in the brace assembly holes at each end of the fence. Insert the four posts in the base so that the notches in the end and brace posts face each other.
7. Once these posts are in place, measure and cut the braces to the correct length.
8. Using wood glue, insert the brace in the notches of the brace assembly at one end of the model.
9. Wrap the wire around the posts forming the brace assembly. The wire should wrap around the bottom of the end post and the top of the other post.
10. Pull the wire as tight as possible. Tie the ends together tightly.
11. Insert a nail between the two wires in the middle of the brace span and begin twisting. Twist until the wire is tight and begins to cut into the dowel.
12. When the wire is tight, let the nail rest against the brace.

13. Wrap more wire around the nail and brace to hold the nail in place.

14. Repeat steps 8-13 for the brace assembly at the other end of the board.

15. Using a small amount of glue, insert the other two posts.

16. Optional - Using more of the wire, finish the model as if it were a 4-wire barbed wire fence. Fasten your wire to the posts using a hand staple gun.

Key Questions:

1. Why are fences braced in this manner?

2. How would the strength of the fence be affected if the brace assemblies broke?

3. What does the twist wire do?

UNIT VII - FENCING

Lesson 3: Barbed and Woven Wire Fences

Competency/Objective: Describe techniques for building barbed and woven wire fences.

Study Questions

1. What materials and tools are needed to install barbed wire fencing?
2. How is barbed wire laid out on the fence line?
3. How is barbed wire stretched?
4. How is barbed wire attached?
5. What materials and tools are needed for woven wire?
6. How is woven wire laid out?
7. How is woven wire stretched?
8. How is woven wire attached?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit VII.
2. Transparency Masters
   a) TM 3.1: Staple Positioning
3. Activity Sheet
   a) JS 3.1: Constructing Barbed Wire Fencing

Lesson 3: Barbed and Woven Wire Fences

TEACHING PROCEDURES

B. ***Review***

Lesson 2 described how wood and steel posts should be set when building fences for agricultural operations. Barbed and woven wire fences are two common types of fences in agriculture. In this lesson, the materials, tools, and wire installation techniques for these types of fences are outlined.

C. ***Motivation***

Display some basic fencing materials and tools, such as staples, fencing pliers, and fence stretchers. Ask students to explain how they are used for fencing.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Some samples of barbed wire (consisting of a few inches of 12½ and 14 gauge wire with 2 or 4 points) will be of help in presenting this lesson. Discuss the following materials and tools with the class.

What materials and tools are needed to install barbed wire fencing?

a) Materials
   1) Barbed wire - fencing material made of wire strands twisted together with wire barbs placed at various intervals
      (a) Gauge
         (1) Number representing the diameter of the wire, with a lower number corresponding to a larger diameter
         (2) 12½ and 14 gauge - most common in Missouri
      (b) Number of barbs - most commonly two and four points
      (c) Wire coating
         (1) Zinc
         (2) Aluminum
      (d) Made of soft wire or high tensile wire
   2) Staples or metal clips
b) Tools
   1) Claw hammer
   2) Fencing pliers
   3) Fence stretcher

2. Discuss how a barbed wire fence is laid out.

How is barbed wire laid out on the fence line?

a) Wrap the bottom strand of the wire around a corner post two or three times and staple it securely.
b) Twist the end of the wire tightly around the wire strand.

c) The number of strands of wire used determines the height of the bottom strand.

d) Unroll the wire along the fence line on the stock side of the posts.

  1) The length unrolled depends on the topography, fence layout, and the position of fence brace structures.

  2) Barbed wire comes in rolls of wire a quarter mile long; the entire length of the wire can be laid out at once under the proper conditions.

  3) Using short stretches of wire is more costly.

e) Use the same procedure for each strand, from the bottom to the top.

f) Place the wire as close as possible to the fence line.

g) Walking the fence line and moving the wire into place may be necessary to help remove excess slack prior to stretching the wire.

3. Show students a wire stretcher. If possible, demonstrate how hand-operated fence stretchers work. Discuss how wire is stretched.

How is barbed wire stretched?

a) Attach the stretcher to the wire being stretched.

  1) The stretcher can be attached to a solid object in line with the wire, usually the post of a brace structure or a piece of equipment.

  2) For longer stretches, the wire can be stretched and spliced in the middle to distribute the pull more evenly; the stretcher then connects to the wire only.

b) The length of wire to be stretched at a time depends on the topography of the area and the stretching tools.

  1) Hilly areas require stretching short sections at a time to keep the wire level.

  2) A rule of thumb is to stretch from 5 to 20 rods at a time.

  3) Stretching longer sections of wire will take less time.

c) Slowly stretch the wire just to the point of being relatively tight and straight.

d) Depending on the length of the stretch, it may be necessary to walk along the fence line and untangle the wire.

4. Show the class some examples of fence staples and metal post clips and discuss how they are used to attach barbed wire. Use TM 3.1 to illustrate how staples should be set in a wood post. If possible, demonstrate how wire clips work with a steel post. Hand out JS 3.1. In order for students to practice constructing a barbed wire fence, solid posts should already be in place to complete this activity.

How is barbed wire attached?

a) Attach the wire to the post while the stretchers are still in place.

b) The end of the wire should be long enough to wrap completely around the post twice and then be tied off back onto the wire.

c) Staple the wire to the post.

d) Use staples to attach wire to wood posts.

  1) Set the staples at a slight downward angle diagonal to the side of the post.

  2) Drive the staple into the post.

  3) Staples should not be driven in so tightly that they and the wire become embedded in the post.

e) If steel posts are used, attach the wire using metal clips.

5. Show the class pictures of different types of woven wire. Discuss the tools needed to install it.

What materials and tools are needed for woven wire?

a) Materials

  1) Woven wire

    (a) Fencing material in which wires are connected together to form a mesh

      (1) Hinge lock - has short pieces of wire wrapped into a knot at each horizontal wire, so the stay is not one piece of wire

(2) Stiff stay - has a continuous stay with short sections of wire forming the knots that attach the stay to the horizontal wire

(b) Either soft wire or high tensile wire

(c) System of labeling - a three-number designation identifying the number of horizontal wires, the height of the fence, and the distance between vertical stay wires

b) Tools

1) Claw hammer

2) Fencing pliers

3) Fence stretcher

6. Discuss how woven wire is laid out along the fence line.

How is woven wire laid out?

a) Unroll the wire past the corner post on the side of the post to which the wire will be attached.

b) Lay out enough wire to wrap around the post once.

c) Remove three or four stays to wrap around the post cleanly.

1) Hinge lock fencing

(a) Cut the stay in the middle of each block.

(b) While using pliers to hold the knot, grab and twist the ends of the cut wire in the opposite direction from the knot.

(c) The sections of the stay wire should slide off the horizontal wire.

2) Stiff stay wire - Cut the small knot wire that holds the vertical stay in place.

d) Set the wire to the desired height against the anchor post.

e) Wrap the wires around the post.

f) Tie them off by splicing the end of each wire onto itself.

g) Roll out the wire either to the brace structure that it is to be attached to or to the point where it will be spliced onto another roll.

1) Rolls of woven wire are 330 feet long.

2) The maximum length that can be stretched at one time is a quarter mile, or four rolls of wire.

3) For short stretches of wire, the wire will be rolled out past the brace structure to be stretched.

4) If two or more rolls are required, one roll is fastened to a post at each end, and then the wire rolls are stretched and spliced in the middle.

5) An alternative method is to attach one end of the first roll to a post and then tie the other end to the next roll to tighten the entire length at the same time; the wire will not be as tight.

7. Explain how woven wire is stretched.

How is woven wire stretched?

a) Woven wire can be stretched using stretcher boards.

1) Wood stretcher boards are made of 2" × 4" boards that are bolted together to hold the woven wire.

2) Metal stretcher boards can be purchased from retailers that carry fencing supplies.

b) Attach the stretcher boards to the wire a few feet past the post to which the wire will be tied off.

c) Attach the stretcher board in line with one vertical stay.

d) Wrap the ends of a heavy chain around the top and bottom of the boards.

e) Attach the cable winch-puller to the chain and to a secure point, such as a truck, tractor, or another anchor post.

f) Tension the fence slowly.

1) Remove ½ to _ of the tension bump.

2) The wire is too tight if the tension bump is completely straightened.

g) The fence may need to be shaken to free it from snags.

8. Discuss how staples and metal clips are used.

How is woven wire attached?

a) Tie off each wire, one at a time.
   1) Cut the wire at a point far enough past the post for the wire to wrap the post.
   2) Any stays that might interfere with the post should be removed.
   3) Wrap the wire around the post, tie it off, and staple it tightly to the post.

b) Remove the stretcher boards.

c) Attach the horizontal wires to the line posts.
   1) With wood posts, staple each wire tightly.
      (a) Set the staple and wire into the post.
      (b) Place the staples crosswise with a slight downward angle.
   2) If metal posts are used, fasten wire clips according to the manufacturer's recommendations.
   3) For fences up to 4 feet tall, only five staples or clips are needed per post.
   4) Taller fences may require a few more fasteners.
   5) Attach the top and bottom wires at every post.
   6) Stagger the other fasteners on different wires at each post.

G. ***Other Activities***

Observe a local fencing contractor constructing new fencing using barbed and woven wire. Have students observe techniques for stretching and attaching wires.

H. ***Conclusion***

Fencing is essential for many agricultural operations. Barbed wire and woven wire fences are two common fence types. Similar materials and tools are needed to build these types of fences: barbed or woven wire, fasteners, a claw hammer, fencing pliers, and fence stretcher. In each case, the wire is laid out along the fence line, stretched properly, and then attached to the posts.

I. ***Answers to Activity Sheet***

1. Tightening the wire could pull the post over.

2. The bumps on the post hold the wires in place.

3. The number of wires used will depend on the type of livestock for which the fence will be used.

J. ***Answers to Evaluation***

1. a
2. d
3. b
4. d
5. a
6. At a slight downward angle diagonal to the side of the post
7. Hinge lock and straight stay
8. Claw hammer, fencing pliers, and fence stretchers
9. Stretcher boards
10. Top and bottom wires

UNIT VII - FENCING Name ____________________

Lesson 3: Barbed and Woven Wire Fences Date __

EVALUATION

Circle the letter that corresponds to the best answer.

1. When installing barbed wire, which strand is attached first?

   a. Bottom
   b. Middle
   c. Top
   d. Any

2. Barbed wire can be attached to steel post with:

   a. Staples.
   b. Metal tape.
   c. Wire.
   d. Clips.

3. How many points does barbed wire commonly have?

   a. One or three points
   b. Two or four points
   c. Three or five points
   d. Four or six points

4. What is the rule of thumb for the length of wire to be stretched at one time?

   a. 2 to 5 rods
   b. 3 to 10 rods
   c. 4 to 15 rods
   d. 5 to 20 rods

5. When laying out woven wire, unroll enough to wrap the wires ____________ around the post.

   a. Once
   b. Twice
   c. Three times
   d. Four times

Complete the following short answer questions.

6. How should staples be set in a wood post?

7. What are two types of woven wire?

   a.

   b.

8. What are three tools needed to install woven wire fences?

   a.

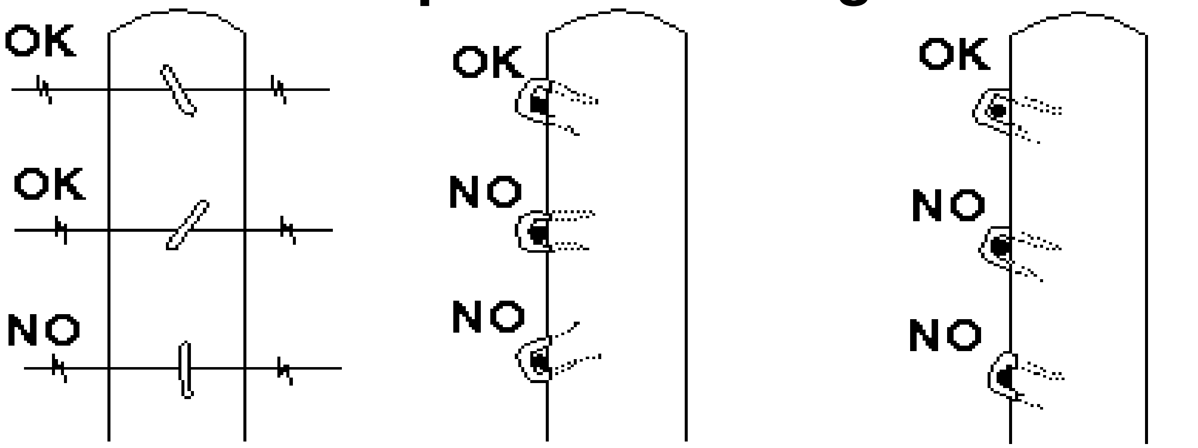
   b.

   c.

9. What special tool is used to stretch woven wire?

10. When attaching woven wire to posts, which wires should be attached at every post?

Staple Positioning



Staples at an Angle to Post's Side

Staples at Proper Angle

Wire Loose in Staple

Lesson 3: Barbed and Woven Wire Fence Name ___________________________

Constructing Barbed Wire Fencing

Objective: Practice the skills used in constructing barbed wire fencing.

Materials and Equipment:

Barbed wire
Fence stretchers
Metal fence posts
Metal post driver
Wire clips
Fencing pliers
Standard screwdriver
Claw hammer
Fencing staples

Procedure:

In this activity, you will be constructing a small sample barbed wire fence by stretching and applying the wire to posts to wood and metal posts.

1. Using the wood posts identified by your instructor as the end posts, lay out the steel posts where they will be driven into the ground. Steel posts should be placed about 15 feet apart.

2. Stand one of the posts upright in line with the two brace posts. Have another person help you align the post by looking to see whether line posts line up with the two end posts.

3. Turn the post so the ridges on the side of the post are at a 90-degree angle to the line of the post. The ridges help to keep the wire in line vertically on the post. It is important to make sure all the line posts are turned the same way.

4. Using the post driver, pound the post in until the metal clip towards the bottom of the post is completely underground, a distance of about 18 inches.

5. Repeat steps 2 through 4 until all the line posts are set.

6. Starting at one brace post, unroll enough wire to wrap around the post at least twice with another 2 feet to spare on the end.

7. Wrap the wire twice around the post 8 inches above the ground. Wrap the tail of the wire around the fence line wire at least three or four times.

8. Staple the wire to the wood post, pounding the staple in tightly enough to prevent slippage.

9. Unroll enough wire to reach the other brace post, cutting the wire so that there is enough to wrap around the post at least twice and an additional 2 feet.

10. Pull the wire as tight as possible by hand. Attach the fence stretchers to the wire.

11. Tighten the wire using the stretchers.

12. Repeat steps 7 and 8 at the other end post.

13. Attach the wire to the line posts at the desired height using wire clips.

14. For each additional wire, repeat steps 7 to 13. The top wire should be about 4 feet above the ground, and the two middle wires should be evenly spaced between the top and bottom wires.

UNIT VII - BUILDING FENCES

Lesson 4: High Tensile and Electric Fences

Competency/Objective: Describe techniques for building high tensile and electric fences.

Study Questions

1. What are the advantages of high tensile fencing?
2. What are the components of high tensile fencing?
3. How are high tensile fences constructed?
4. What are the advantages of electric fences?
5. What are the components of electric fences?
6. How should electric fence chargers be selected?
7. How are electric fences constructed?

References

1. *Agricultural Structures (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit VII.
2. Transparency Master
   a) TM 4.1: Electric Fencing Components
3. Activity Sheet
   a) AS 4.1: Tensioning Fences

Lesson 4: High Tensile and Electric Fences

TEACHING PROCEDURES

B. ***Review***

Lesson 3 discussed barbed and woven wire fencing, which are commonly used for agricultural purposes. Other types of fences frequently used in agriculture are high tensile and electric. This lesson outlines some basics for both types of fencing.

C. ***Motivation***

Ask the students if they have come in contact with an electric fence. Have them describe the sensation they experienced. Describe how the shock is transmitted from the fence to people or livestock that come into contact with it.

D. ***Assignment***

E. ***Supervised Study***

F. ***Discussion***

1. Ask the students to list some advantages of high tensile fencing. Discuss the properties of high tensile wire.

   What are the advantages of high tensile fencing?

   a) Chief advantage - high tensile strength, which allows the wire to take a large amount of stress before breaking
   b) Longer life span
   c) Lower maintenance requirements
   d) Versatile, coming in a variety of forms
   e) Easier to handle than barbed or woven wire
   f) Easily electrified
   g) Good choice to replace barbed wire when the animals being fenced need protection from the barbs, as in the case of show animals

2. Describe the components of high tensile fences and discuss them with the class.

   What are the components of high tensile fencing?

   a) High tensile wire
   b) Wood or steel posts
      1) Either rounded or square wood posts
      2) Wood corner posts at least 5 inches in diameter
      3) Brace posts at least 4 inches in diameter
      4) Line posts at least 3½ inches in diameter
   c) Fasteners
      1) Staples that are 1¾ to 2 inches long
      2) Wire clips
   d) Spacers called battens, stays, or droppers
      1) Replace some of the line posts in holding the wire in place
      2) Made of wood, steel, or fiberglass

e) Permanent in-line strainers or tension springs

3. Ask students to review the steps in constructing barbed and woven wire fences. Discuss their similarity to the steps in high tensile fence construction.

How are high tensile fences constructed?

a) Set the anchor post and brace structure; double brace structures should be used because they can hold more tension.
b) Set the line posts, spacers, and line brace structures.
   1) Include line brace structures at appropriate intervals and at the top and bottom of slopes.
   2) Set the line posts 2½ feet into the ground for stability.
   3) The distance between line posts will vary with the purpose of the fence; 16 feet apart is a good rule of thumb for large pastures with little pressure on the fence.
   4) The use of spacers allows them to be set further apart.
c) Attach the wires working from the bottom to the top.
d) Place a spinning jenny somewhere in the middle of the span.
e) Pull the first wire from the spinner to one brace structure.
f) Wrap it around the post twice and tie it off.
g) Cut the wire at the spinner.
h) Attach the strainer to the end of the wire.
i) Pull the wire from the spinner to the other brace structure and tie it off.
j) At the spinner, run about 3 feet of wire past the strainer and cut the wire.
k) Place the end of this wire in the strainer, and take up tension by turning its drum.
l) After applying some tension, loosely staple the wire in place.
m) Once all the wires are in place, tighten the wires to the proper tension and staple them to the posts, with the wire left slightly loose in the staples.
n) Attach the wires to the spacers.

4. Have students list all the advantages they can think of concerning electric fences. Could they be considered low maintenance? Why or why not?

What are the advantages of electric fences?

a) Low in cost
b) Quick and easy to construct
c) Versatile - used for all types of animals
d) Long life span because the animals generally leave the fence alone
e) No physical damage to animals from shock

5. Ask students to list the components of an electric fence. If possible, show the class a charger, ground rod, and sample insulators. Show students TM 4.1.

What are the components of electric fences?

a) Wire
   1) 12½-gauge or 14-gauge high tensile or soft wire
   2) Poly-wire
      (a) Useful alternative for temporary fences
      (b) Stranded polyethylene wire that has smaller wire conductors embedded in it
b) Fence charger
c) Ground rod
d) Posts

1) Wood posts that are at least 5 or 6 inches in diameter
2) Steel posts
3) Small fiberglass rods 3 to 5 feet in length for constructing a temporary fence

e) Insulators

6. Discuss considerations that affect the selection of a fence charger.

How should electric fence chargers be selected?

a) Location of the fence
    1) Determines if electricity is available
    2) Battery types
        (a) Useful for remote areas
        (b) Solar-powered battery charger built into the charger in some units
    3) Plug-in chargers - used to take advantage of main line power where electricity is available
b) Voltage put out by the charger
c) Length of the fence
d) Amount of vegetation
    1) Grass and weeds - rob the fence of some of its power
    2) Low impedence fence chargers
        (a) Useful when vegetation is high
        (b) Increases its energy output as power is drained off by plants touching the fence
e) Species of livestock
    1) Less voltage needed for animals that have thin coats
        (a) Horses
        (b) Short-haired cattle
    2) Higher voltages required for animals with thicker coats
        (a) Sheep
        (b) Goats
f) Safety - approved by the Underwriters Laboratories or another reputable agency

7. Describe the process for constructing an electric fence.

How are electric fences constructed?

a) Install the charger in a dry, protected area.
b) Set the ground rod in place and attach it to the charger.
    1) The ground rod must be in solid contact with moist earth, which may mean driving it to a depth of up to 6 feet.
    2) Drier conditions may require the use of more than one rod.
c) Clamp a heavy wire to the top of the rod and attach the other end to the charger's ground terminal.
d) When the posts and wire for the fence are in place, run another wire from the positive terminal of the charger to the electric fence or to a lead wire.
e) If permanent posts are in place, they should be used; if not, set the posts in place.
    1) The posts should be set to a depth of 3 to 3½ feet.
    2) The distance between the posts may vary between 20 and 50 feet.
    3) For a temporary fence, the corner and line posts are set to a depth that feels solid.
f) Place the insulators on the posts at two-thirds of the height of the livestock being fenced.
g) Attach the wire to the posts.
    1) One or two strands of wire are sufficient for an electric fence.
    2) Attach the end of the wire to the insulator on the anchor post, and unroll the wire along the fence line.
    3) Stretch soft wire using fence stretchers.
    4) Attach it to the insulators.

5) If high tensile fencing is used, the wire should be laid out and stretched as appropriate.

G. ***Other Activities***

1. Have the students collect some electric fence insulators to use as examples when teaching this lesson.

2. Allow students to observe a local fencing contractor building a high tensile fence.

H. ***Conclusion***

High tensile and electric fencing have many advantages for agricultural operations. High tensile wire is useful where strong wire that does not break easily is needed. Among the advantages of electric fencing are low cost and ease of construction. High tensile fencing is often electrified to provide the advantages of both types of fencing.

I. ***Answers to Activity Sheet***

1. To tension or tighten the wire

2. Wires should not be stretched tightly on hot days because the wire will contract as it cools and possibly break. Wires should not be left loose on cold days, as the wire will expand as temperatures increase, leaving too much slack in the wire.

3. Putting the strainer in the middle will provide more even tension through the span.

J. ***Answers to Evaluation***

1. d
2. c
3. b
4. d
5. Two-thirds of the height of the livestock being fenced
6. The location of the fence, the voltage put out by the charger, and safety
7. Because they can hold more tension

8. Answers may include any two of the following: low cost, quicker and easier construction, versatile, long life span, and no physical damage to animals from shock.

9. To maintain the tension on the wire

10. A component of high tensile fences that can replace some of the line posts holding the wire.

UNIT VII - BUILDING FENCES Name _

Lesson 4: High Tensile and Electric Fences Date __

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following is a component of an electric fence?

   a. Spacers
   b. Stays
   c. Staples
   d. Ground rod

2. What is the main advantage of high tensile fencing?

   a. It is low in cost to construct.
   b. It does not need to be electrified.
   c. It can take a large amount of stress.
   d. It requires only small rods for posts.

3. In pastures with little pressure on the fence, how far apart can the posts of a high tensile fence be spaced?

   a. 14 feet
   b. 16 feet
   c. 18 feet
   d. 20 feet

4. How far apart are the posts in an electric fence generally set?

   a. 5 to 15 feet
   b. 10 to 30 feet
   c. 15 to 45 feet
   d. 20 to 50 feet

Complete the following short answer questions.

5. At what height should insulators be placed on a fence post?

6. What are three factors to consider when choosing a charger for an electric fence?

   a.

   b.

   c.

7. Why are double brace assemblies useful with high tensile fencing?

8. What are two advantages of electric fences?

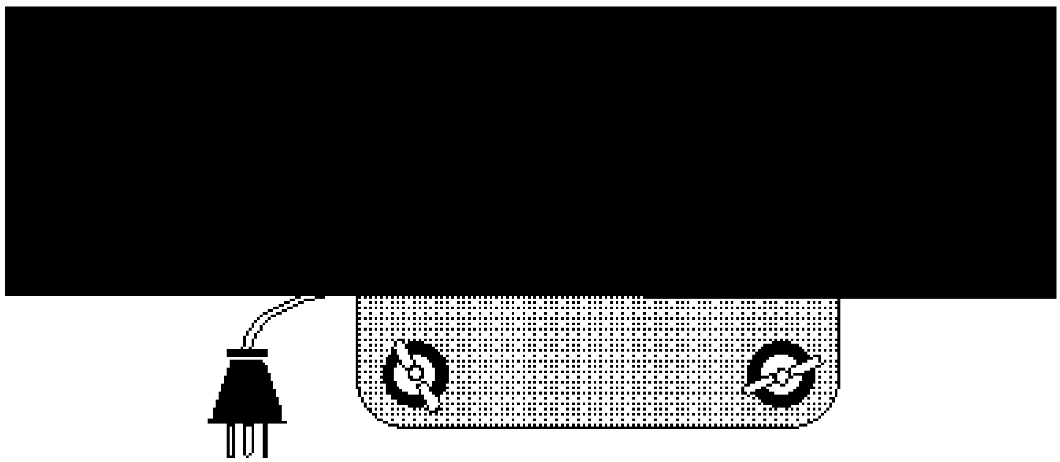
   a.

   b.

9. What is the purpose of adding a permanent in-line strainer when building a high tensile fence?

10. What are stays?

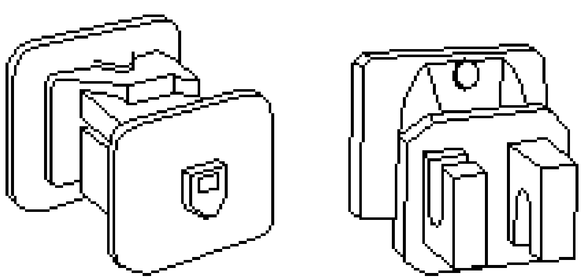
Components of Electric Fences

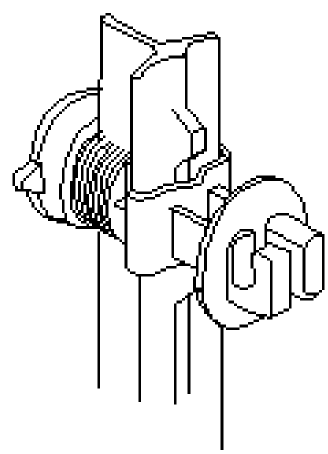


Insulators

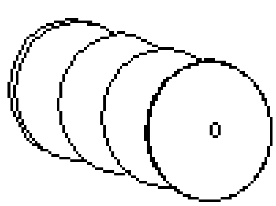
Wood Post Insulators

T-Post Insulator





Square Insulator



Nob Insulator

Lesson 4: High Tensile and Electric Fences Name ___________________________

Tensioning Fences

Objective: Tension an electric fence.

Materials and Equipment:

14-gauge soft wire
Strainer
Wire cutters

Procedure:

In this activity, you will practice tensioning soft wire using the process described for high tensile wire in your student reference.

1. Wrap the wire at least twice around a post selected by your instructor. Wrap the tail of the wire around the fence line wire at least three or four times.
2. Unroll enough wire to span approximately half the length of the fence, and cut the wire.
3. At the opposite post, repeat step 2.
4. From the second post, unroll enough wire to reach the first wire and extend 2 to 3 feet beyond it.
5. Run one wire through the hole on the body of the strainer and tie or crimp the wire to the strainer.
6. Run the other wire into the hole on the drum of the strainer.
7. Turn the drum until the wire is relatively tight.

Key Questions:

1. What is the purpose of the strainer?

2. Suppose that you are going to tighten the wire in more extreme weather conditions, when it is 35 or 90 degrees Fahrenheit. How would these temperature extremes affect how much you would tighten the wire?

3. Why is putting the strainer close to the middle of the span recommended?

UNIT VII - FENCING

Lesson 5: Fence Mending Techniques

Competency/Objective: Identify fence mending techniques.

Study Questions

1. **What are the methods of tightening fence wires?**

2. **What are the tools available for mending broken wires?**

3. **What are the different methods of splicing?**

4. **How are posts replaced in an existing fence line?**

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit VII.

2. Transparency Master

   a) TM 5.1: Using a Compression Sleeve
   b) TM 5.2: Splicing Woven Wire

3. Activity Sheet

   a) AS 5.1: Splicing Wire

Lesson 5: Fence Mending Techniques

TEACHING PROCEDURES

A. ***Review***

Lesson 4 described the advantages of high tensile and electric fencing and how these types of fences are built. All fences require maintenance and repair, because use and age causes fences to deteriorate and break. Repairs are generally simple and are effective in extending the life of the fence. This lesson, Lesson 5, outlines the practices for keeping a fence in good order.

B. ***Motivation***

Discuss some of the problems that occur that make fence repairs necessary. Examples are breaks in a wire or post, vegetation growing into the wire, rot or fire damage to wood posts, fasteners coming loose, etc.

C. ***Assignment***

D. ***Supervised Study***

E. ***Discussion***

1. Discuss procedures for tightening wire with students. Refer back to Lessons 3 and 4 for information on stretching different types of wire.

   What are the methods of tightening fence wires?

   a) Stretching the wire at a post
      1) Detach the wire from an anchor post and loosen it at the line posts.
      2) Stretch the wire at the anchor post.
      3) Reattach the wire to the posts.
   b) Stretching the wire in the middle of the fence line
      1) Cut the wire in the middle of the fence.
      2) Attach the fence stretchers at this point.
      3) Stretch the wire.
      4) Splice the ends of the wire together.

2. Display the tools used to mend wires while discussing them with students. Mention that fencing pliers can perform the task of hammering, splicing, and compressing sleeves, though usually not as efficiently as specialized tools.

   What are the tools available for mending broken wires?

   a) Claw hammer
   b) Fencing pliers
   c) Fence stretchers
   d) Splicing tools
      1) Sleeve compressor
      2) Woven wire splicing tool

3. Using some smooth wire, demonstrate how to splice wire to the class. TMs 5.1 and 5.2 can also be used to illustrate the use of a compression sleeve and a woven wire splicing tool. Have students complete AS 5.1.

What are the different methods of splicing?

a) Barbed or smooth wire
   1) Preferred method - crimp splice using a metal compression sleeve
      (a) Thread both ends of the wire through the sleeve.
      (b) Press the sleeve together tightly using the fencing pliers.
   2) Wrap splice
      (a) This type of repair seldom produces as tight a bond.
      (b) Lacerations to the hands are more likely.

b) Woven wire
   1) Twist the wires together tightly using a splicing tool or pliers.
   2) These splices may cause lacerations to the hands, so heavy gloves should be worn.

4. Discuss the process for replacing fence posts if the existing posts can no longer support the fence effectively.

How are posts replaced in an existing fence line?

a) Detach the wire from the post and remove the post from the ground.
   1) Sometimes posts can be loosened by rocking them back and forth and then pulled out by hand.
   2) Posts may also be removed using post pullers or a jack.
   3) Sometimes a post breaks off at ground level.
      (a) If possible, the new post is set to one side of the old post.
      (b) If it is not possible, digging up the old post is necessary.

b) Set the new post in place.

F. ***Other Activities***

Using smooth wire, have students practice making splices with compression sleeves. They may also practice wrap splices.

G. ***Conclusion***

For agricultural operations, fence repairs are frequently a necessity. Mending fences may require tightening wires, splicing broken wires, or installing new posts. These repairs are generally fairly simple and require relatively few tools.

H. ***Answers to Activity Sheet***

1. Crimp splice

2. Crimp splice

3. Older wires generally will not splice well and could break.

I. ***Answers to Evaluation***

1. d
2. b
3. c
4. A sleeve compressor and woven wire splicing tool
5. Post pullers or a jack

6. The wires are twisted together tightly using a splicing tool or pliers.

 Name ______________________

Lesson 5: Fence Mending Techniques Date ______________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. What is the preferred method of splicing barbed or smooth wire?

    a. Using a smooth wire splicing tool
    b. Twisting the wire with fencing pliers
    c. Tying the wire by hand
    d. Using a compression sleeve

2. Which of these steps would be done first when tightening fence wires?

    a. Fasten the wire tightly to the posts.
    b. Detach the wire from the anchor post.
    c. Attach the fence stretchers at the post.
    d. Remove the fasteners along the length of the wire.

3. What should be done if a post breaks off at ground level?

    a. The broken post should be driven deeper into the ground.
    b. The broken post should be pulled out of the ground with a chain.
    c. The new post should be set to one side of the broken post.
    d. The new post should be set on top of the broken post.

Complete the following short answer questions.

4. What are two specialized tools for mending broken wires?

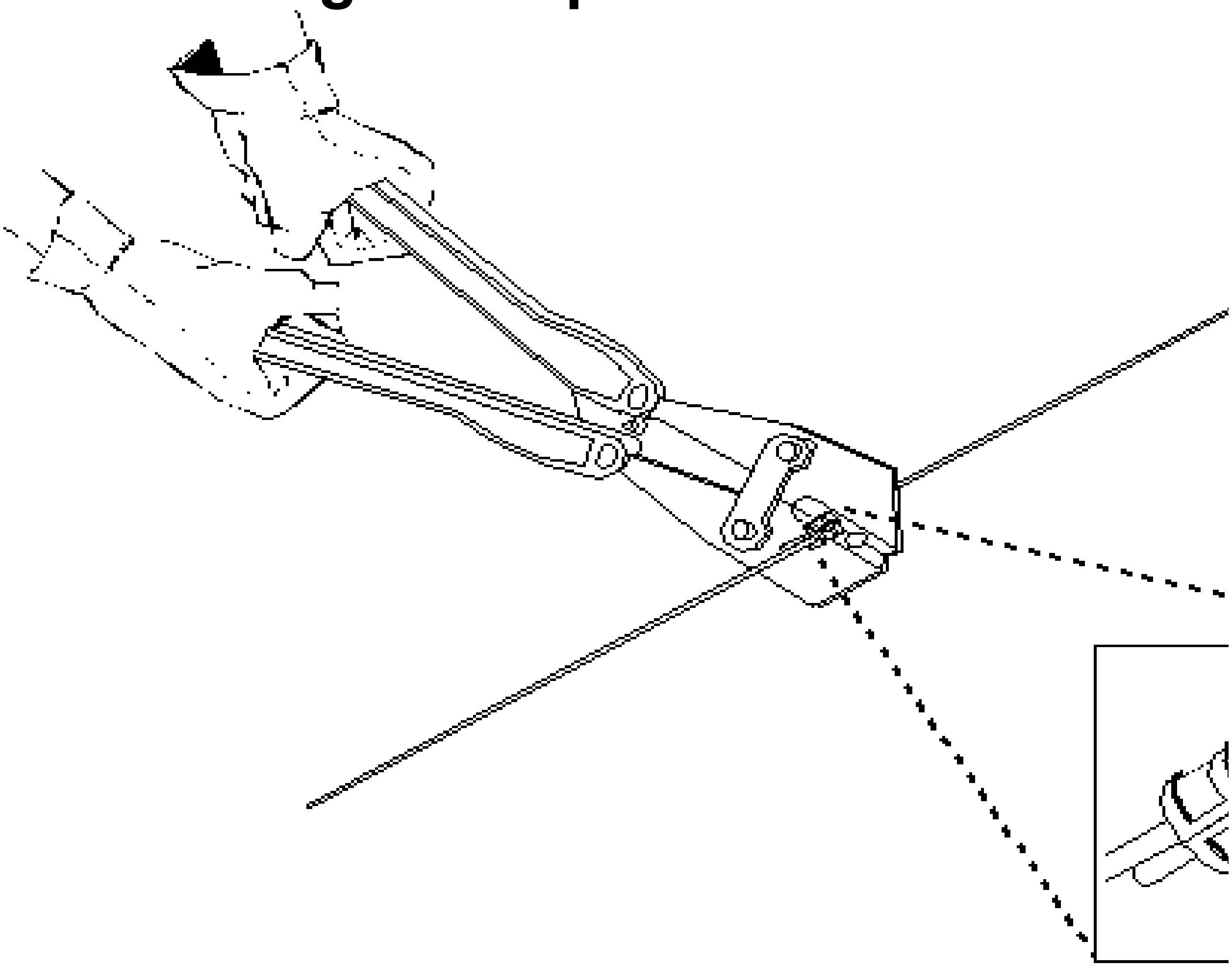
    a.

    b.

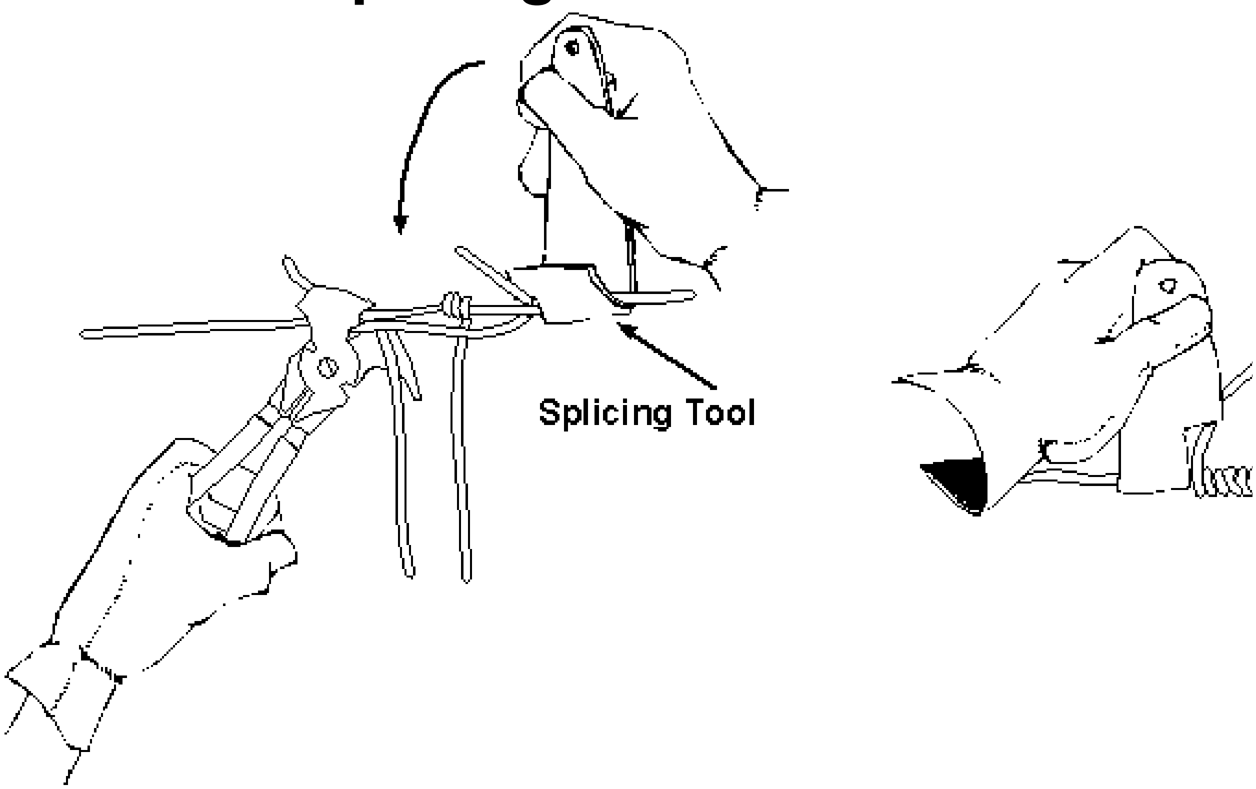
5. If a post is difficult to remove by hand, what can be used to move the post?

6. How are the wires of a woven wire fence spliced together?

Using a Compression Sleeve



Splicing Woven Wire



Lesson 5: Fence Mending Techniques Name ___________________________

Splicing Wire

Objective: Practice wire splicing techniques.

Materials and Equipment:

14-gauge soft electric wire, cut into four 2-foot pieces
Compression sleeve
Sleeve compressor or fencing pliers

Procedure:

Crimp splice

1. Insert the ends of two sections of wire into the compression sleeve.

2. Crimp the sleeve down using the sleeve compressor or fencing pliers.

Wrap splice

1. On one of the other pieces of wire, form a 2-inch loop. Wrap the tail of the wire around the main wire three or four times.

2. Holding the looped wire in your left hand, run the other wire about 8 inches through the loop with your right hand.

3. Bend the wire in your right hand back over to the right. Wrap this wire around the wire in your right hand at least three or four times.

Key Questions:

1. Which splice would be quicker to apply?

2. Which splice uses tools?

3. What effect would the general condition of the wire (age, rust, etc) have on the second type of splice?