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ABSTRACT

This teachers guide to be used with the second-year student manual, "Stationary Engineering Science Manual--2," contains 140 lesson plans, corresponding to the lessons in the student manual. The lessons are brief and each involves concrete trade experiences where science is applied with 26 lessons also involving mathematical problems used in the respective trades. Lessons are organized into 16 units: (1) Introduction to Stationary Engineering, (2) Engineering Fundamentals (3) Steam Boilers, (4) Boiler Fittings, (5) Boilerroom Systems, (6) Feed-Water Accessories, (7) Steam Accessories, (8) Fuels, (9) Combustion Accessories, (10) Combustion, (11) Boiler Plant Instruments, (12) Boiler Water Conditioning, (13) Compressed Air System, (14) Electrical Systems, (15) Operation, and (16) Service and Maintenance. Each lesson plan lists objectives, aids, teaching procedures, notes on content, summary and testing, and appropriate assignment number in the student manual. (HD)

State of New Jersey
Department of Education
Division of Vocational Education

STATIONARY ENGINEERING

SCIENCE 2 - TEACHERS GUIDE

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Unit IV – Boiler Fittings

Unit V – Boilerroom Systems

Unit VI – Feed-Water Accessories

INTRODUCTION

These assignments relate science to the field of Stationary Engineering. The lessons are brief, but they include a wide range of activities in which science is applied to trade activities. A specific class or student may not be able to study all of the lessons; the instructor may wish to select only certain lessons from the wide range of lessons presented. Each lesson involves concrete trade experiences where science is applied.

Mathematics is also needed as science is applied. The following lessons involve mathematical problems used in the respective trade areas:

II-A-1-M1	Pressure Problems
II-A-1-M2	Pressure Conversion Problems
II-A-1-M3	Work and Power Problems
II-B-1-M1	Factor of Evaporation Problems
II-B-1-M2	Rated and Developed Horsepower Problems
II-C-1-M1	Temperature and Mechanical Equivalent Conversions
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VIII-C-2-M1	DuLong's Formula
X-D-1-M1	Excess Air Calculations
XI-B-1-M1	Draft Pressure Conversions
XIII-B-1-M1	Air Compressor Capacity

OBJECTIVE:

1. Be able to recognize industrial safety practices and procedures.

AIDS:

1. Any articles on OSHA
2. Any magazines on industrial safety.

PROCEDURE:

1. Discuss management's interest in safety.
2. Explain how accidents cost money.
3. Discuss OSHA and why it was formed.
4. Discuss some of the magazine articles on industrial safety.

SUMMARIZE:

1. OSHA and its objectives
2. Need for safety conscious workers

TESTING:

1. Was OSHA formed to protect management or labor?

ASSIGNMENT:

Complete Assignment 1-A-1 in Related Science Manual-2.

OBJECTIVES:

1. Be able to protect your job from fire.
2. Be able to organize a first aid fire brigade.

AIDS:

1. *Training Your Fire Brigade*, Walter Kidde Co.
2. Sample of quick-identification labels.

PROCEDURE:

1. Discuss how plant fire protection is also your own personal protection.
2. Discuss 3 classes of fires and new class D type of fire.
3. Explain dangers involved with using the wrong type of fire extinguisher.
4. Discuss importance of a plant fire brigade.
5. Discuss any plant experience you have had with fire prevention.

SUMMARIZE:

1. A little training can save lives.

TESTING:

1. Describe:
   a. Class A fires
   b. Class B fires
   c. Class C fires
   d. Class D fires

PROCEDURE:

Complete Assignment 1-A-2-1A Related Science Manual-2.

OBJECTIVE:

1. Be able to describe why good housekeeping is important to safety.

AIDS:

1. Any newspaper or magazine articles on industrial fires that were caused by poor housekeeping practices.

PROCEDURE:

1. Discuss what is meant by spontaneous combustion.
2. Discuss danger of oil spills.
3. Define:
   a. Flash point
   b. Fire point
   c. Volatile liquid

SUMMARIZE:

1. Good housekeeping requires good habits.

TESTING:

1. Which is higher in temperature – fire point or flash point.

ASSIGNMENT:

Complete Assignment 1-A-3-1A Related Science Manual-2.

OBJECTIVE:

1. Be able to describe the organization chart of an Engineering Department.

AIDS:

1. Organization chart
2. *Rules and Regulations,* Mechanical Inspection Bureau

PROCEDURE:

1. Discuss chain of command.
2. Discuss each man's responsibility
3. Discuss Mechanical Inspection Bureau requirement of the required license to be chief.
4. Stress importance of Engineering Department and how plant is dead if it goes down.

SUMMARIZE:

1. Engineering Department — heart of plant

TESTING:

1. Do you think it is necessary to require a higher grade license as chief in larger plants?

ASSIGNMENT:

Complete Assignment 1-B-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to define the term pressure and the units that are used to express it.
2. Be able to define the term work and the units that are used to express it.
3. Be able to define the term power and the units that are used to express it.

AIDS:

1. Blackboard

PROCEDURE:

1. Define force and explain that forces can act in any direction.
2. Define area and show how to find the area of a circle and rectangle.
3. Then combine force with area to give force per unit of area or pressure.
4. Show how the units of force (pounds) and the units of area (square inches) when combined to give pressure are pounds per square inch or P.S.I.
5. Explain gage and absolute pressures. Show how it is designated P.S.I.G. or P.S.I.A. Make a comparison of them.
6. With the use of the blackboard, show a force pulling an object. Explain that work will be done if the object is moved by the applied force.
7. Show how to calculate the amount of work done by finding the product of the force and the distance that the object was moved.
8. Explain how the product of units of force (pounds) and units of distance (feet) equals foot-pounds.
9. Define work and introduce a time factor. Build this into a rate of doing work or power.
10. Explain the units that are used for work (foot-pounds) and time (seconds or minutes).
11. Explain that power is a rate of doing work. Define horsepower and show that it is a definite amount of work per unit of time.

SUMMARIZE:

1. Force-area to pressure. Units of pressure (pounds per square inch).
2. Relationship of force, distance, and work and the units used to measure work (foot pounds).
3. Relationship of work, time, power, and horsepower, and also the units that express each.

TESTING:

1. What is force?
2. What is area?
3. How do force and area combine to give pressure?

4. Define gage and absolute pressure.
5. How is force and distance measured in relation to work?
6. How is work that is done measured?
7. Define work, time, power, and horsepower.
8. What does work per unit of time refer to?
9. How many foot-pounds per minute equal two horsepower?

ASSIGNMENT:

Complete Assignment 2-A-1- in Related Science Manual—2.

Pressure – Work – Power

OBJECTIVES:

1. Be able to use the pressure-force-area relationship in problem solving.
2. Be able to use the pressure conversion factors.
3. Be able to solve problems involving work.
4. Be able to solve problems involving power.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain the relationship of pressure - force and area.
   Explain the basic formula $P = \frac{F}{A}$ and show how to transpose for force and area. Use the examples from the student manual.
2. State the conversion factors:
   a. One vertical foot of water = .433 p.s.i.
   b. One inch of mercury = .491 p.s.i.
   c. Absolute pressure = gage +14.7 p.s.i.
3. Show and explain how to use the above in problem solving. Use examples from the student's manual.
4. Explain how work involves both force and distance. Explain how the units for work are foot pounds. Solve example problems from the student manual.
5. Explain that power is the rate of doing work. $P = \frac{W}{T} = \frac{Fxd}{T} = \frac{Ft.\ lbs.}{Min.}$
6. Explain how to solve for horsepower, and do sample problems from the student manual.

SUMMARIZE:

1. Pressure – Force – Area relationship
2. Pressure conversion factors
3. Solving problems involving work
4. Solving problems involving power.

TESTING:

1. What is the formula for pressure, force, and area?
2. What are the pressure conversion factors?
3. Why is it necessary to move a weight a distance to do work?
4. How does power differ from work?

ASSIGNMENT:

Complete Assignments 2-A-1-M1, 2-A-1-M2, and 2-A-1-M3 in Related Science Manual–2.

OBJECTIVE:

1. Be able to calculate both the old and new methods of determining boiler horsepower.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain the necessity of having a method for rating steam boilers.
2. Explain the old method of 10, 12, and 14 square feet of heating surface per boiler horsepower.
3. Show and explain the new method of 34.5 pounds of water into steam from and at 212°F. per boiler horsepower.
4. Explain what the factor of evaporation is and how it can be used to find the developed boiler horsepower.
5. Set up and solve a boiler horsepower problem using the Factor of Evaporation.

SUMMARIZE:

1. Heating surface per boiler horsepower.
2. 34.5 pounds of water from and at 212°F.
3. Factor of Evaporation
4. Boiler horsepower problem solving

TESTING:

1. What is a boiler horsepower?
2. How many B.t.u.'s are needed to change one pound of water to steam at 212°F?
3. What is the Factor of Evaporation?

ASSIGNMENT:

Complete Assignment 2-B-1 in the Related Science Manual—2.

OBJECTIVE:

1. Be able to find the Factor of Evaporation of a boiler.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain why we need to know the Factor of Evaporation.
2. Show and explain the formula for finding the Factor of Evaporation.

$$\text{Factor of Evaporation} = \frac{Hs - (T_{FW} - 32)}{970.3}$$

3. Explain each term in the equation and how to determine each.
4. Set up and solve these two problems.

St. Press.	H_S B.t.u.'s	$Temp_{FW}$
350	1203.9	220°F
200	1189.4	160°F

SUMMARIZE:

1. Formula and terms
2. How to solve
3. Importance of a correct answer

TESTING:

1. What is the Factor of Evaporation?
2. How do you find it?
3. Where can we use it?

ASSIGNMENT:

Complete Assignment 2-B-1-M1 in the Related Science Manual-2.

OBJECTIVES:

1. Be able to find the rated horsepower of a boiler.
2. Be able to find the developed horsepower of a boiler.

AIDS:

1. Blackboard

PROCEDURE:

1. Define a boiler horsepower, and explain the difference between a rated and a developed boiler horsepower.
2. Show and explain the formula

$$B.H.P. = \frac{\text{Pounds of steam per hour}}{34.5}$$

3. Solve a sample problem using the above formula for rated horsepower.
4. Show and explain the formula

$$B.H.P. = \frac{W_S \times \text{Fact. of Evap.}}{34.5}$$

5. Solve two sample problems using the above formula for developed horsepower.
6. Show and explain the formula

$$B.H.P. = \frac{W_S (H_S - T_{FW} + 32)}{33{,}475}$$

Note: Show how it is derived from the Factor of Evaporation

7. Solve two sample problems using the above formula for developed boiler horsepower.

SUMMARIZE:

1. Explain each formula and how to substitute in them.

TESTING:

1. Define boiler horsepower.
2. What is the equation for finding rated horsepower?
3. What is the equation for finding developed horsepower?

ASSIGNMENT:

Complete Assignment 2-B-1-M2 in the Related Science Manual—2.

OBJECTIVES:

1. Be able to define heat.
2. Be able to define latent heat, sensible heat, latent heat of fusion, and latent heat of evaporation.
3. Be able to describe how heat is measured and transmitted.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain that heat is a form of kinetic energy due to the molecular motion within the substance.
2. Explain the three states of matter and the effect of heat being added or removed from a substance.
3. Explain that the intensity of heat can be measured with a thermometer, but that it does not tell you the amount of heat within a substance – only the intensity.
4. Define the British thermal unit and explain how it is used to measure the heat content of a substance.
5. Show and explain, with the use of a sketch, the meaning of sensible and latent heat.
6. Explain that heat flows from a high to low temperature area.
7. Explain the three methods of heat transmission. Give an example of each method.
8. Show and explain the mechanical equivalent of heat.
9. Show how to convert from B.t.u.'s to ft. lbs. and ft. lbs. to B.t.u.'s.

SUMMARIZE:

1. Heat
2. Types of heat
3. Measurement of heat
4. Transmission of heat

TESTING:

1. What form of energy is heat? Why?
2. What are the three states of matter?
3. Explain intensity of heat compared with quality of heat.
4. What is meant by latent heat, sensible heat, and latent heat of evaporation, and latent heat of fusion.
5. What are the three methods of transfer? Explain each method.

ASSIGNMENT:

Complete Assignment 2-C-1 in the Related Science Manual–2.

OBJECTIVES:

1. Be able to convert Fahrenheit, Centigrade, and Rankine temperatures from one scale to another.
2. Be able to convert B.t.u.'s to foot-pounds and foot-pounds to horsepower.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain the necessity of being able to convert from one temperature scale to another.
2. Show and explain how to use the formula to change °F to °C.

$$°C = \frac{°F - 32}{1.8}$$

Convert 140°F and 212°F to centigrade.

3. Show and explain how to change °C to °F

$$°F = (°C \times 1.8) + 32$$

Convert 60°C and 100°C to Fahrenheit.

4. Show and explain how to change °F to °Rankine.

$$°R = °F + 460$$

Convert 212°F and 120°F to Rankine

5. Show and explain how to change °R to °F.

$$°F = °R - 460$$

Convert 672°R and 580°R to Fahrenheit.

6. Explain that heat energy can be converted into other forms. Explain the mechanical equivalent of heat, and show how to convert from B.t.u.'s to foot-pounds and foot-pounds to B.t.u.'s.

$$\text{Foot pounds} = \text{B.t.u.'s} \times 778$$

Convert 100 B.t.u.'s and 1200 B.t.u.'s to foot-pounds

$$\text{B.t.u.'s} = \frac{\text{Foot-pounds}}{778}$$

Convert 10,000 ft. lbs. and 15,000 ft. lbs. to B.t.u.'s.

SUMMARIZE;

1. Converting from °F to °C.
2. Converting from °C to °F
3. Converting from °F to °R
4. Converting from °R to °F
5. Converting from B.t.u.'s to Ft. lbs.
6. Converting from Ft. lbs. to B.t.u.'s

TESTING:

1. Give a sample problem of each conversion.

ASSIGNMENT:

Complete Assignment 2-C-1-M1 in the Related Science Manual—2.

OBJECTIVES:

1. Be able to describe how steam forms in firetube and watertube boilers.
2. Be able to describe how the steam and water circulates in firetube and watertube boilers.

AIDS

1. Blackboard

PROCEDURE:

1. Show how the steam forms, and how steam and water circulates in a simple drum.
2. Explain the cycle:
   a. Flow of water to heated areas
   b. Flow of steam and heated water to upper areas
   c. Release of steam
3. Show and explain the effect of adding heating surface on steam formation and circulation in the simple drum.
4. Define heating surface.
5. Show and explain how the steam forms, and how circulation is established in a simple watertube circuit.
6. Show and explain the steam formation and the circulation in a Babcock and Wilcox boiler (straight tubes, front and rear header, cross drum).
7. Explain steam formation and circulation in a bent tube multi-drum boiler.

SUMMARIZE:

1. Steam formation and the circulation in:
   a. Simple drum.
   b. With addition of heating surface
   c. Simple water tube circuit.
   d. B. & W. boiler (straight tube)
   e. Bent tube – Multi-drum

TESTING:

1. How is steam formed and circulation established in the following:
   a. Simple drum boiler
   b. Simple drum boiler with more heating surface
   c. Simple watertube circuit.
   d. B. & W. straight tube boiler
   e. Bent tube, multi-drum

ASSIGNMENT:

Complete Assignment 2-C-2 in the Related Science Manual–2.

OBJECTIVE:

1. Be able to describe the properties of saturated and superheated steam.

AIDS:

1. Blackboard
2. Chart of steam tables

PROCEDURE:

1. Explain boiling point and the effect that pressure has on the boiling point.
2. Define saturated steam.
3. Explain the terms, dry saturated and wet saturated.
4. Define quality of steam, or the dryness factor.
5. Explain how to find the total heat in one pound of saturated steam.
6. Define superheated steam.
7. Show how to find the degree of superheat.
8. Show how to find the total heat in one pound of superheated steam.

SUMMARIZE:

1. Boiling point
2. Saturated steam (quality)
3. Superheated steam
4. Total heat

TESTING:

1. Define boiling point of a liquid.
2. What is saturated steam?
3. What is superheated steam?
4. How can we determine the quality of saturated steam?
5. How can we find the total heat in a pound of steam?

ASSIGNMENT:

Complete Assignment 2-C-3 in the Related Science Manual—2.

OBJECTIVES:

1. Be able to apply Charles' Laws.
2. Be able to apply Boyle's Law.

AIDS:

1. Blackboard

PROCEDURE:

1. Show and explain, with the use of a sketch, how the volume of a gas changes with temperature when the pressure is held constant.
2. Show and explain, with the use of a sketch, how the pressure of a gas changes with temperature when the volume is held constant.
3. Show and explain the following equations:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad \text{Constant pressure}$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \qquad \text{Constant volume}$$

4. Explain the units that are used to express pressure, temperature, and volume.

   Pressure — p.s.i.a.
   Volume — cu. ft.
   Temperature — °R - (°F+460)

5. Show and explain, with the use of a sketch, how the volume will change with pressure when the temperature is held constant.
6. Show and explain the following equations:

$$P_1 = \frac{1}{V_1} \qquad P_2 = \frac{1}{V_2}$$

$$P_1 V_1 = P_2 V_2$$

7. Show that by combining the above laws you can derive the following equation.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

The pressure is in pounds per square inch absolute.
The volume is in cubic feet.
The temperature is in degrees Rankine or (degrees Fahrenheit plus 460).

SUMMARIZE:

1. Pressure-Temperature-Volume relationship of gases.
2. How to use each equation:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad \text{Constant pressure}$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \qquad \text{Constant volume}$$

$$P_1 \propto \frac{1}{V_1} \qquad P_2 \propto \frac{1}{V_2}$$

$$P_1V_1 = P_2V_2$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

TESTING:

1. If the pressure on a gas is held constant, how does the volume change with temperature?
2. With a constant volume process, how would the pressure change with temperature?
3. If the temperature is held constant, how will the volume change if the pressure is changed?
4. Explain the following equations:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad \frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

5. What units are used for the above equations?

ASSIGNMENT:

Complete Assignment 2-D-1 in Related Science Manual–2.

OBJECTIVE:

1. Be able to solve pressure-temperature-volume problems using the General Gas Law.

AIDS:

1. Blackboard
2. Charts

PROCEDURE:

1. Explain that if the pressure on a gas is kept constant, its volume will change proportionally with its temperature.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

2. Show how to use the above equation. Use:

$V_1 = 10$ cu. ft. $V_2 = 12$ cu. ft.
$T_1 = 90°F$ $T_2 = 200°F$

3. Explain that if the volume on a gas is kept constant, its pressure would change proportionally with its temperature.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

4. Show how to use the above equation. Use:

$P_1 = 100$ p.s.i.a. $T_1 = 90°F$
$P_2 = 120$ p.s.i.a. $T_2 = 200$ F

5. Explain that if the temperature of a gas is held constant, its volume will vary inversely with its pressure.

$$P_1 = \frac{1}{V_1} \qquad P_2 = \frac{1}{V_2}$$

$$P_1 V_2 = P_2 V_2.$$

6. Show how to use the above equations. Use:

$P_1 = 50$ p.s.i.a. $V_1 = 210$ cu. ft.
$P_2 = 150$ p.s.i.a. $V_2 = 70$ cu. ft.

7. Show that by combining all the above equations, we will derive the following new equation:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

8. Show how to transpose for any unknown quantity in the above equations.
9. Using the following values, set up problems and show how to solve for the unknown value.

P_1 = 50 p.s.i.a.	P_2 = 100 p.s.i.a.
V_1 = 10 cu. ft.	V_2 = 2.5 cu. ft.
T_1 = 1000°R	T_2 500°R

SUMMARIZE:

1. Stress that all units are in absolute values.
2. Transposing in the equations
3. Solving for an unknown value

TESTING:

1. Transpose each formula to solve for each unknown value:

$$V_1 = \frac{V_2 \times T_1}{T_2} \text{ etc.}$$

2. Transpose to solve for each unknown in the formula:

$$P_1 V_1 = P_2 V_2$$

3. Transpose to solve for each unknown in the formula:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

ASSIGNMENT:

Complete Assignment 2-D-1-M1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to describe the relationship that exists between steam pressure and its temperature.

AIDS:

1. Steam Tables

PROCEDURE:

1. Define steam.
2. Explain that the boiling point of water changes with pressure. Give examples from the Steam Tables.
3. Explain the meaning of critical pressure (3206 p.s.i.a.) and critical temperature (705°F.).
4. Define superheated steam.
5. Explain that water vapor tends not to follow the gas laws.

SUMMARIZE:

1. Pressure-temperature relationship
2. Critical pressure and critical temperature

TESTING:

1. What is steam (saturated and superheated)?
2. Why does the boiling point of water change with pressure?
3. What is the critical pressure and critical temperature of water?

ASSIGNMENT:

Complete Assignment 2-D-2 in Related Science Manual—2.

OBJECTIVE:

1. Be able to plot a pressure-temperature steam chart.

AIDS:

1. Steam Tables
2. Blackboard

PROCEDURE:

1. Explain how to set up a graph. Use the "X" axis for pressure and the "Y" axis for temperature.
2. Show how to plot the points for the curve. Take all values from the dry saturated steam tables.
3. Show how to plot a graph for superheated steam. Explain how to obtain the final temperatures.

SUMMARIZE:

1. How to set up graph
2. How to plot a curve
3. Values to use

TESTING:

1. What axis is used to represent pressure? Temperature?
2. How do you plot a curve?
3. How do you obtain the values?

ASSIGNMENT:

Complete Assignment 2-D-2-M1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to use the Steam Tables for dry saturated steam.

AIDS:

1. Steam Tables
2. Blackboard

PROCEDURE:

1. Review the following terminology:
   a. Absolute pressure and gage pressure
   b. Latent heat
   c. Latent heat of fusion
   d. Sensible heat
   e. Latent heat of evaporation
   f. Enthalpy
2. Explain how to use the Steam Tables to find the following information.
   a. Temperature of steam
   b. Enthalpy of saturated liquid
   c. Enthalpy of evaporated steam
   d. Total heat in the steam
3. Explain the effect that increasing pressure has on the heat content of liquid and vapor.
4. Explain critical temperature and critical pressure.

SUMMARIZE:

1. How to use Steam Tables
2. Effect of heat changes on pressure.

TESTING:

1. What is meant by the terms critical pressure and critical temperature?
2. What values can be found in a Steam Table?
3. What is the enthalpy of saturated liquid, vapor, and steam?

ASSIGNMENT:

Complete Assignment 2-D-3 in Related Science Manual–2.

OBJECTIVE:

1. Be able to solve problems using the steam tables.

AIDS:

1. Steam Tables
2. Blackboard

PROCEDURE:

1. Explain how to find the value of the following for any given pressure:
   a. Temperature (t) in °F.
   b. Enthalpy liquid (h_f) in B.t.u./lb.
   c. Enthalpy evaporated (h_{fg}) in B.t.u./lb.
   d. Enthalpy of saturated vapor (h_g) in B.t.u./lb.
2. Explain how to interpolate for the intermediate values in the Steam Tables.
3. Show an example of each problem in No. 1 using 115 p.s.i.a. as the pressure.

SUMMARIZE:

1. Finding values in the Steam Tables
2. Examples of interpolation problems.

TESTING:

1. How can you find how much heat is in the liquid, vapor, and steam of a boiler?
2. Using 62 p.s.i.a. as the pressure, find:
   a. Temperature of steam
   b. Heat in liquid
   c. Heat in vapor
   d. Total heat in steam.

ASSIGNMENT:

Complete Assignment 2-D-3-M1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to describe how the firetube boiler was developed.

AIDS:

1. Overheat projector
2. Transparencies 3-A-1-1 to 3-A-1-8

PROCEDURE:

1. Use transparencies and show how boiler developed.
2. Discuss how increasing heating surface was beneficial.
3. Discuss the requirements of an ideal boiler.
4. Discuss advantages and limitations of firetube boilers. Explain that it was because of these limitations that the watertube boiler was developed.
5. Explain why a firetube boiler may explode more than a watertube boiler.

SUMMARIZE:

1. Advantages and limitations
2. Different types

TESTING:

1. If you had to select a boiler for a plant that needed 500 p.s.i. and 20,000 pounds of steam per hour, what type of boiler would you choose?

ASSIGNMENT:

Complete Assignment 3-A-1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to identify a firetube boiler as to its type and classification.

AIDS:

1. Overhead projector
2. Transparencies 3-A-2-1 to 3-A-2-4

PROCEDURE:

1. Discuss various types of firetube boilers; use transparencies.
2. Discuss how to recognize the various types of firetube boilers.
3. Explain how firetube boilers are classified.

SUMMARIZE:

1. How to identify firetube boilers

TESTING:

1. You have a choice of a vertical firetube boiler or an H.R.T. boiler. Both have equal pressure and capacity. Which would you select? Why?

ASSIGNMENT:

Complete Assignment 3-A-2 in Related Science Manual—2.

OBJECTIVE:

1. Be able to describe the basic construction of a firetube boiler.

AIDS:

1. Overhead projector
2. Transparencies of various types of firetube boilers.

PROCEDURE:

1. Using transparencies, point out locations of the various stays.
2. Discuss why stays and braces are not needed in watertube boilers.
3. Explain why firetube boilers are limited in size and pressure because of their construction.

SUMMARIZE:

1. Need for stays
2. Reason for limiting size

TESTING:

1. Do you feel that firetube boiler still has a place in industry, or should they be replaced with watertube boilers?

ASSIGNMENT:

Complete Assignment 3-A-3 in Related Science Manual—2.

OBJECTIVE:

1. Be able to describe how the watertube boiler was developed.

AIDS:

1. Overhead projector
2. Transparencies of watertube boilers 3-B-1-1 to 3-B-1-14

PROCEDURE:

1. Discuss how firetube explosions were instrumental in the development of watertube boilers.
2. Using transparencies, point out how each change was brought about for safety and economy.
3. Discuss why there is less chance of a boiler explosion when using a watertube boiler.

SUMMARIZE:

1. Watertube boiler development due to safety

TESTING:

1. Why are firetube boilers considered more dangerous than watertube boilers.

ASSIGNMENT:

Complete Assignment 3-B-1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to identify a watertube boiler according to its type and classification.

AIDS:

1. Overhead projector
2. Transparencies of various types of watertube boilers.

PROCEDURE:

1. Show vertical and inclined tube boilers with overhead projector. Discuss tube arrangement.
2. Show a single-drum, three-pass boiler. Point out the parts. Briefly show the path of water and the flow of gases.
3. Show a multi-drum boiler. Point out the parts. Briefly show the path of the water and the flow of gases.

SUMMARIZE:

1. Difference between straight tube and bent tube boiler.
2. Difference between single- and multi-drum boiler.

TESTING:

1. Why do we have so many different types of watertube boilers?
2. Why not just perfect one watertube boiler?

ASSIGNMENT:

Complete Assignment 3-B-1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to describe the basic construction of a watertube boiler.

AIDS:

1. A.S.M.E. Code, Section I and Section V

PROCEDURE:

1. Discuss A.S.M.E. Code, Section I on general requirements of power boilers.
2. Explain purpose of the A.S.M.E. Code on Safety.
3. Discuss A.S.M.E. Code, Section V on low-pressure boilers.
4. Compare the two codes to show how requirements will vary with temperature and pressures.
5. Discuss stress in boiler construction and how expansion and contraction is taken care of.

SUMMARIZE:

1. Reasons for Code
2. Reasons for Section I and Section V

TESTING:

1. Why can't one section of the code be used for both high- and low-pressure boilers?

ASSIGNMENT:

Complete Assignment 3-B-3 in Related Science Manual—2.

OBJECTIVE:

1. Be able to apply to the New Jersey Mechanical Inspection Bureau's Rules and Regulations as they apply to boilers.

AIDS:

1. N.J. Mechanical Inspection Bureau's Rules and Regulations

PROCEDURE:

1. Discuss reason for N.J. Mechanical Inspection Bureau. Stress safety.
2. Discuss type of equipment requiring a licensed operator.
3. Discuss boiler inspection, boiler numbers, boiler stampings, and boiler certificates.

SUMMARIZE:

1. Need for the N. J. Mechanical Inspection Bureau

TESTING:

1. Where is the state registration number found, and how is it displayed?

ASSIGNMENT:

Complete Assignment 3-C-1 in Related Science Manual-2.

OBJECTIVE:

1. Be able to apply rules covered in A.S.M.E. Code, Section I on power boilers.

AIDS:

1. A.S.M.E. Code, Sections I, IV, VI, VII

PROCEDURE:

1. Discuss and name the 11 sections covered in the Code.
2. Stress importance of being familiar with Sections I, IV, VI, and VII.
3. Demonstrate how to use Section I of Code to find the type of material for boilers with specific pressures.

SUMMARIZE:

1. Need for being familiar with Code and its jurisdictional limits.

TESTING:

1. Why do material specifications change as pressures increase?

ASSIGNMENT:

Complete Assignment 3-D-1 in Related Science Manual–2.

OBJECTIVE:

1. Be able to describe the types, purpose, and location of safety valves.

AIDS:

1. Blackboard

PROCEDURE:

1. Using blackboard, show where safety valve would be found on boiler.
2. Discuss why safety valve should be connected as close as possible with no intervening valves.
3. Explain why the safety valve is considered the most important valve on the boiler.
4. Explain what causes a boiler explosion and how the safety valve protects the boiler.
5. Discuss blowback or blowdown of a safety valve, and why it is necessary.

SUMMARIZE:

1. Why safety valve is most important valve on boiler
2. Location of safety valve

TESTING:

1. What type of valve is allowed between the safety valve and the boiler?

PROCEDURE:

Complete Assignment 4-A-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe how a safety valve is constructed.
2. Be able to test some of the Code requirements for safety valves.

AIDS:

1. Overhead projector.
2. Transparencies 4-A-2-1, 4-A-2-2, and 4-A-2-3

PROCEDURE:

1. Use transparency 4-A-2-2 to explain parts of safety valve.
2. Use transparency 4-A-2-1 to explain why safety valve will pop open.
3. Discuss why a safety valve should pop open.
4. Discuss Code requirements on number and capacity of safety valves.
5. Discuss who can adjust and who can repair safety valves.

SUMMARIZE:

1. Why safeties pop.
2. Why restrictions are made on adjustment and repair of safety valves.

TESTING:

1. When is more than one safety valve required on a steam boiler?

ASSIGNMENT:

Complete Assignment 4-A-2 in Related Science Manual—2,

OBJECTIVES:

1. Be able to find total upward force on a safety valve.
2. Be able to transpose and find either the diameter of the safety valve or the popping pressure.

AIDS:

1. Blackboard

PROCEDURE:

1. Solve problem on blackboard finding total upward force on safety valve.
2. Using formula for total force, show how to transpose and develop formula for diameter and popping pressure.
3. Solve sample problems.
4. Review square root problems if necessary.

SUMMARIZE:

1. Basic formula
2. How to transpose

TESTING:

1. Have class use basic formula and develop the formula for popping pressure and diameter.

ASSIGNMENT:

Complete Assignment 4-A-2-M1 in Related Science Manual—2.

OBJECTIVES:

1. Be able to describe the types of blowdown valves.
2. Be able to locate and describe the purpose of blowdown valves.
3. Be able to blow down a boiler using the bottom blowdown valves.

AIDS:

1. Blackboard

PROCEDURE:

1. Show with a sketch where the blowdown lines are located on firetube and watertube boilers.
2. Discuss four reasons for blowing down a boiler.
3. Discuss location of quick-closing and screw-type valves.
4. Discuss how to blowdown a boiler and the precautions to take.

SUMMARIZE:

1. Why blowdown valves are needed.
2. Reason for proper handling

TESTING:

1. Why should you never walk away from an open blowdown valve?

ASSIGNMENT:

Complete Assignment 4-B-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain why there are construction requirements for blowdown valves.
2. Be able to list some of the Code requirements for bottom blowdown valves.

AIDS:

1. Blackboard
2. A.S.M.E. Code, Sections I and VII

PROCEDURE:

1. Explain how blowoff lines and valves are subjected to full boiler temperature and pressure without a warmup period.
2. Discuss why lines must be protected against heat, corrosion, or freezing.
3. Explain why maximum and minimum sizes for lines are stipulated.
4. Discuss when extra heavy piping is needed.
5. Discuss maintenance and safety requirements in handling blowoff valves.

SUMMARIZE:

1. Care in handling
2. Safety requirements

TESTING:

1. Why is it important to close and tag out blowdown valves before entering the steam and water drum of a boiler?

ASSIGNMENT:

Complete Assignment 4-B-2 in Related Science Manual–2.

OBJECTIVE:

1. Be able to describe the construction of a water column and how it works.

AIDS:

1. Overhead projector
2. Transparency 4-C-1-1

PROCEDURE:

1. Using transparency, discuss the construction of the water column, and purpose of the gage glass and try cocks.
2. Purpose of high-low water alarm.
3. Reason for sediment chamber.
4. Need for frequent blowing down of water column
5. Reading on gage glass with top line closed or clogged; with bottom line closed or clogged.
6. How to renew a broken gage glass with boiler under pressure.
7. What size to cut glass.
8. Reason for keeping gage glass nuts from clearing.
9. Cautions to follow while working on glass under pressure.

SUMMARIZE:

1. Reading on glass with top or bottom lines closed or clogged.

TESTING:

1. How to replace a broken gage glass boiler under pressure.

ASSIGNMENT:

Complete Assignment 4-C-1 in Related Science Manual-2.

OBJECTIVES:

1. Be able to locate the water column.
2. Be able to describe Code requirements on water column.

AIDS:

1. Overhead projector
2. Transparencies 4-C-2-1, 4-C-2-2, and 4-C-2-3

PROCEDURE:

1. Using transparencies, point out the location of the water column and the gage glass.
2. Stress importance of knowing that column is at its proper location and how to check it to make sure.
3. Discuss danger of too high or too low a setting.
4. Discuss reason for minimum pipe size connecting column to boiler.
5. Briefly discuss material specifications re: different pressures.
6. Discuss Code requirements re: valves on lines connecting column to boiler.
7. Explain why cross fittings are used.

SUMMARIZE:

1. Proper location of water column
2. How to check water column

TESTING:

1. What is the danger of an improperly located water column?

ASSIGNMENT:

Complete Assignment 4-C-2 in Related Science Manual—2.

OBJECTIVES:

1. Be able to identify the various types of steam gages.
2. Be able to locate and to describe the purpose of steam gages.

AIDS:

1. Overhead projector
2. Transparencies of steam gages and gage faces showing possible ranges.

PROCEDURE:

1. Using transparencies, point out ranges and graduations.
2. Explain range requirements
3. Discuss compound gage.
4. Explain need for siphon and why gage must be tested if live steam enters Bourdon tube.

SUMMARIZE:

1. Purpose, location, and calibration of steam pressure gage.

TESTING:

1. What does p.s.i.g. and p.s.i.a. mean?

ASSIGNMENT:

Complete Assignment 4-D-1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to describe the Code requirements for steam pressure gages.

AIDS:

1. Overhead projector
2. Transparency showing internal parts of pressure gage
3. Transparency showing suggested piping.

PROCEDURE:

1. Using transparency, briefly discuss working parts of pressure gage.
2. Discuss why and how Bourdon tube is protected.
3. Using transparency of suggested pressure gage hookup, explain why lever type valves are used.
4. Discuss reason for inspector test cock connection.
5. Discuss why minimum sizes are required for gage corrections.
6. Reason for pressure gage range

SUMMARIZE:

1. Location of gage
2. Protection of gage
3. Range requirements

TESTING:

1. Why must gage range be twice, but not less than 1½ times the safety popping pressure?

ASSIGNMENT:

Complete Assignment 4-D-2 in Related Science Manual—2.

OBJECTIVES:

1. Be able to explain why steam gages have to be corrected.
2. Be able to correct a steam gage.

AIDS:

1. Blackboard

PROCEDURE:

1. Review Code requirements on gage location.
2. Discuss .433 pounds pressure per vertical foot of water.
3. Explain how to obtain the .433.
4. Discuss how to find the reciprocal of a number.
5. Do sample problem.

SUMMARIZE:

1. .433 pounds pressure per vertical foot

TESTING:

1. Solve sample problem

ASSIGNMENT:

Complete Assignment 4-D-2-M1 in Related Science Manual—2.

OBJECTIVES:

1. Be able to describe what an internal feed line is.
2. Be able to explain why internal feed lines are necessary.

AIDS:

1. Overhead projector
2. Transparency 4-E-1-1
3. Transparency of firetube and watertube boilers that show internal feed line

PROCEDURE:

1. Using overhead projector, show location of internal feed lines in both firetube and watertube boilers.
2. Explain reason for needing internal feed.
3. Discuss what is meant by thermal shock.

SUMMARIZE:

1. Location and need

TESTING:

1. What do you think would happen if incoming feedwater were allowed to impinge on boiler heating surface?

ASSIGNMENT:

Complete Assignment 4-E-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain the function of soot blowers.
2. Be able to use soot blowers.

AIDS:

1. Overhead Projector
2. Transparencies of boilers showing soot blower locations

PROCEDURE:

1. Using overhead transparencies, discuss location of soot blowers.
2. Explain how soot is formed and where it is found in firetube or watertube boilers.
3. Discuss how efficiency is improved 2% to 10%.
4. Discuss how stack temperature increases as much as 75° after a day's run to 175° after several days of not blowing tubes.
5. Explain importance of proper alignment.
6. Show how tubes can be cut by impingement of steam.
7. Explain procedure to follow when using soot blowers.
8. Discuss dangers involved by improper use.

SUMMARIZE:

1. Need for soot blowers
2. Proper procedure when using soot blowers

TESTING:

1. What will happen if soot blower elements move out of proper alignment?

ASSIGNMENT:

Complete Assignment 4-F-1 in Related Science Manual–2.

OBJECTIVE:

Be able to locate and to explain the purpose of all the equipment found in a feed-water system.

AIDS:

1. Sketch of a complete F.W. System
2. Transparency of an F.W. System
3. Blackboard

PROCEDURE:

1. Explain why a feed-water system is so important.
2. Explain why you need one pound of water for each pound of steam generated.
3. Explain the danger of low water and why a boiler explodes – drop in pressure without a corresponsing drop in temperature.
4. Using a transparency or sketch of a complete feed-water system, trace water from the open feed-water heater to each boiler.
5. Explain the function of all equipment in the system.
6. Explain why the open heater must be vented and the dangers of using an open F.W. heater.

SUMMARIZE:

1. Importance of knowing every possible way of getting water to a boiler.
2. Danger of high and low water
3. Dangers of an open F. W. heater.

TESTING

1. Why are one steam and one electric pump recommended?
2. How could you get water to a boiler if the regulator failed?
3. Name the parts and the function of each part in a feed-water system.

ASSIGNMENT:

Complete Assignment 5-A-1 in the Related Science Manual–2.

OBJECTIVE:

1. Be able to locate and to explain the purpose of all the equipment found in a No. 6 fuel oil system.

AIDS:

1. Blackboard
2. Transparency of fuel oil system (5-B-1-1)

PROCEDURE:

1. Using transparency 5-B-1-1, show the fuel oil system.
2. Explain the purpose and the location of all of the parts in the fuel oil system.
3. Trace the flow through the system.
4. Explain why duplication is needed for tanks, pumps, strainers, and heaters.
5. Explain how the system functions during normal operation.

SUMMARIZE:

1. Discuss the fuel oil system showing the flow of oil through the system. Stress the function of each part in the system.

TESTING:

1. What equipment is found in a No. 6 fuel oil system?
2. What is the function of each part?
3. Can you operate a fuel oil system without pressure gages and thermometers?
4. What is it important to be able to isolate some equipment in the system?

ASSIGNMENT

Complete Assignment 5-B-1 in Related Science Manual—2.

OBJECTIVES:

1. Be able to calibrate a fuel oil tank.
2. Be able to compute fuel oil readings.
3. Be able to compute fuel oil consumption.

AIDS:

1. Blackboard
2. Fuel oil chart

PROCEDURE:

1. Explain how fuel oil tanks are calibrated.
2. Explain that all soundings must be converted to inches.
3. Explain how to read the fuel oil chart to get gallons.
4. Explain how to interpolate between values to find half inch readings.
5. Explain how to make up a chart for half inch readings.

SUMMARIZE:

1. How to interpolate
2. How to make a chart for half inch readings

TESTING:

1. Solve several interpolation problems
2. How will your charts for half inch readings be made up?

ASSIGNMENT:

Complete Assignment 5-B-1-M1 in Related Science Manual–2.

OBJECTIVE:

1. Be able to correct No.6 fuel oil to the standard 60°F.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain that No. 6 fuel oil is the major fuel used in industry.
2. State its B.t.u. content, and make a comparison with coal.
3. Explain the necessity of heating No. 6 fuel oil to move it through pipelines.
4. Explain that normally No. 6 fuel oil is delivered to a plant at 120°F to 140°F, but you are charged for the number of gallons at 60°F. Therefore, it is necessary to use a correction factor.
5. Show and explain the following equation:

$$\text{Corr. Gals} = \text{Gals Rec.} \left[1.0000 - (.000345[\text{Temp} - 60°\text{F}])\right]$$

6. Explain how to solve a problem using the above equation in four simple steps.
7. Show an example using 5415 gals delivered at 130°F.

SUMMARIZE:

1. Correction factor equation.
2. How to use the equation to find the correction factor

TESTING:

1. Have students do a sample problem.

ASSIGNMENT:

Complete Assignment 5-B-1-M2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe the various gas burner systems.
2. Be able to identify the parts and to explain the function of each part in the different gas systems.

AIDS:

1. Transparencies of each system

PROCEDURE:

1. Using the overhead projector, show the low-pressure gas burner system. Identify the parts and explain the function of each part.
2. Using the overhead projector, show the high-pressure gas burner system. Identify the parts and explain the function of each part.
3. Explain where gas and air mix in each burner.
4. Explain the function of the venturi tube.
5. Explain the purpose of the safety devices – vent lines, automatic shutoff valves, and slow opening valves.
6. Explain the advantages and disadvantages of combination burners.

SUMMARIZE:

1. Discuss operation of each gas burner system.
2. Review each transparency.

TESTING:

1. How does a low-pressure gas system function?
2. How does a high-pressure gas system function?

ASSIGNMENT:

Complete Assignment 5-B-2 in Related Science Manual–2.

OBJECTIVES:

1. Define draft.
2. Be able to explain why it is necessary to control draft in a boiler.
3. Be able to control draft in a boiler.

AIDS:

1. Transparencies of all sketches from Related Science Manual–2.

PROCEDURE:

1. Define draft. Explain why it is necessary in a boiler.
2. Using the transparencies, show:
   a. Flow through the boiler
   b. Points at which draft is controlled.
   c. Pressure at various points through the boiler.
3. Explain the reasons mechanical draft is used.
4. Explain the importance of proper draft control in a boiler (fuel-air ratio).

SUMMARIZE:

1. Natural and mechanical draft
2. Why it is necessary to control draft
3. How to control draft in a boiler

TESTING:

1. What is natural draft?
2. What is mechanical draft?
3. How is draft controlled in a boiler?
4. What purpose does a draft system serve?

ASSIGNMENT:

Complete Assignment 5-C-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to write the formula that is used to determine the theoretical amount of draft produced by a chimney.
2. Be able to calculate the theoretical amount of draft produced by a chimney.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain how draft is produced in a chimney.
2. Show and explain each term in the equation:

$$D = .52 \text{ H.P. } \left(\frac{1}{T_A} - \frac{1}{T_S}\right)$$

3. Show two examples of how to find the theoretical draft produced by a chimney.

Use:		
H =	250 ft.	350 ft.
P =	14.7 p.s.i.a.	14.7 p.s.i.a.
T_A =	90°F	75°F
T_S =	600°F	350°F

SUMMARIZE:

1. Each term in the equation
2. How to set up each problem
3. Use of absolute values

TESTING

1. Solve a sample problem.

ASSIGNMENT

Complete Assignment 5-C-1-M1 in Related Science Manual—2.

OBJECTIVES:

1. Be able to trace every possible way of getting water into a boiler.
2. Be able to explain what to do in the event of low water in a boiler.

AIDS:

1. Transparency of feed-water lines.

PROCEDURE:

1. Explain the necessity of maintaining a normal water level at all times.
2. Stress the danger of not knowing how to supply a steaming boiler with water in an emergency.
3. Explain the possible damage to a steam boiler as the water level drops.
4. Using the transparency, explain each way of getting water to the steam boiler.
5. Explain the makeup water systems and the reasons why they are needed.
6. Explain the A.S.M.E. Code on feed-water lines.

SUMMARIZE:

1. Ways to get water to a boiler
2. How to handle low water.

TESTING:

1. How many ways are there of getting water to a boiler?
2. If you were operating a boiler and the water in the gage glass dropped below the bottom of the glass, what would you do? Explain in detail.

ASSIGNMENT:

Complete Assignment 6-A-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to identify the types and describe the purpose of the valves found on a feed-water line.
2. Be able to explain the A.S.M.E. Code requirements for feed-water line valves.

AIDS:

1. Transparency 6-A-2-1

PROCEDURE:

1. Using the transparency, locate the positions of all valves in the feed-water line.
2. Explain the type and purpose of each valve.
3. Explain the A.S.M.E. Code requirements.

SUMMARIZE:

1. Position and purpose of all valves
2. A.S.M.E. Code

TESTING:

1. Name the valves found on the feed-water line.
2. State the purpose of each valve.
3. What does the Code say about feed-water lines and fittings.

ASSIGNMENT:

Complete Assignment 6-A-2 in Related Science Manual-2.

OBJECTIVES:

1. Be able to explain the purpose of an open feed-water heater.
2. Be able to describe how an open feed-water heater functions.
3. Be able to describe how an open feed-water heater is constructed.

AIDS:

1. Overhead projector
2. Transparencies of types of open feed-water heaters.

PROCEDURE:

1. Using transparencies, discuss how open feed-water heater works.
2. Discuss functions of a feed-water heater.
3. Discuss basic construction.
4. Discuss dangers involved to boiler using open heater.
5. Discuss reasons for internal overflow.
6. Explain purpose of the vent condenser.

SUMMARIZE:

1. Function of heater
2. Danger to boiler

TESTING:

1. What will happen if the temperature of open feed-water gets too high? Too low?

ASSIGNMENT:

Complete Assignment 6-B-1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to calculate the percent fuel saving from heating feed water.

PROCEDURE:

1. Explain that if exhaust steam is not used for heating purposes, it is usually wasted except in plants that use it to heat the feed water.
2. Explain that this preheating of feed water with exhaust steam is done in the open feed-water heater.
3. Explain that the fuel saving can be quite large when feed water is preheated.
4. Show and explain the following formula:

$$\% \text{ Fuel saving} = \frac{T_L - T_E}{H_E - (T_E - 32)} \times 100$$

5. Show two examples using the following values:

T_L	T_E	H_E
180°F	80°F	1060
208°F	100°F	1190

SUMMARIZE:

1. How to set up the equations for finding the % fuel saving.
2. How to solve the equation.
3. Stress the need for efficient use of fuel.

TESTING:

1. What are the main reasons for preheating feed water?
2. How can we determine how much fuel is saved by preheating feed water with exhaust steam?
3. Solve sample problem:

T_L = 230°F, T_E = 120°F, and B.t.u. = 1176

ASSIGNMENT:

Complete Assignment 6-B-1-M1 in Related Science Manual—2.

OBJECTIVES:

1. Be able to explain the purpose of a closed feed-water heater.
2. Be able to locate the closed feed-water heater.
3. Be able to describe the basic construction of a closed feed-water heater.

AIDS:

1. Transparencies 6-B-2-1, 6-B-2-2

PROCEDURE:

1. Explain the purpose of the closed heater in respect to thermal shock and efficiency.
2. Explain the types of closed heaters and how they are constructed.
3. Using the transparencies, trace the flow of water and steam. Explain the purpose of the inlet, outlet, and by-pass valves. Show the safety and relief valves that protect the heater from excessive pressure. Point out the shell, tubes, and tube sheets.

SUMMARIZE:

1. Construction
2. Flow – water and steam
3. Purpose and location

TESTING:

1. What is the basic purpose of a closed feed-water heater?
2. Describe a closed heater.
3. What protects the heater from pressure?

ASSIGNMENT:

Complete Assignment 6-B-2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain the purpose of the fuel economizer.
2. Be able to locate the fuel economizer.

AIDS:

1. Sketches or transparencies showing location of economizers

PROCEDURE:

1. Explain how economizers provide a way to increase boiler efficiency by extracting heat from flue gas.
2. Using transparencies, discuss location of economizers.
3. Discuss material used and reasons for selecting these materials.
4. Discuss need for bypass dampers and valves.
5. Explain why induced draft fans are needed with economizers.

SUMMARIZE:

1. Why economizers are used.
2. Where they are found.
3. Need for bypasses.
4. Need for induced draft

TESTING:

1. Could an economizer be installed in the school plant? Explain.
2. What would you do if economizer tubes started to leak?

ASSIGNMENT:

Complete Assignment 6-B-3 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe the purpose and to locate the feed-water regulators.
2. Be able to identify the types of feed-water regulators.
3. Be able to operate a feed-water regulator.

AIDS:

1. Overhead projector
2. Transparencies of different types of regulators
3. Sketches showing location of various types of regulators

PROCEDURE:

1. Discuss purpose of all feed-water regulators.
2. Using transparencies, explain how regulators are connected to the boiler and how each regulator works.
3. Explain why certain boilers need a certain type of regulator.
4. Discuss fireman's duties and responsibilities towards feed-water regulators.
5. Discuss functional failures and how to handle each.

SUMMARIZE:

1. Types, purpose and location of feed-water regulators.
2. Discuss operation of electric type of regulator.
3. Discuss operation of mechanical type of regulator.

TESTING:

1. If a Copes regulator stuck in an open position, what would you do?
2. If a McDonnell Miller 150 regulator failed to shut off the boiler, what would you do?
3. How does the Copes regulator shut boiler off due to low water?

ASSIGNMENT:

Complete Assignment 6-C-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe the purpose and to locate automatic city water makeup valves.
2. Be able to describe the fireman's responsibility regarding automatic city water makeup valves.

AIDS:

1. Overhead projector
2. Transparencies of automatic city water makeup valves
3. Cutaway model of automatic city water makeup

PROCEDURE:

1. Discuss the purpose of an automatic city water makeup.
2. Explain how returns can be lost or contaminated.
3. Using overhead transparencies, point out the location in the high-pressure and low-pressure plant.
4. Explain why the locations are necessary.
5. Discuss importance of blowdown and cleaning strainer.
6. Explain why 100% returns are important in a low-pressure plant.
7. Discuss reason for bypass.

SUMMARIZE:

1. Need for automatic feed-water regulator.
2. 1 pound of water for pound of steam
3. Various locations of regulators and why.

TESTING:

1. What would happen if automatic city water makeup failed to shut off?
2. Why is a bypass needed.

ASSIGNMENT:

Complete Assignment 6-C-2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe the purpose and to locate a low water cutoff.
2. Be able to describe the fireman's responsibility regarding low water cutoffs.

AIDS:

1. Overhead projector
2. Transparencies showing location of low water cutoff
3. Cutaway models of low water cutoffs

PROCEDURE:

1. Discuss purpose and location of low water cutoff.
2. Explain reasons for blowing down low water cutoff.
3. Discuss evaporation test – purpose and how to do it.
4. Using overhead projector, point out location of low water cutoffs.
5. Use models to show how the cutoffs work.

SUMMARIZE:

1. Purpose and location of cutoffs
2. Two ways to test cutoff

TESTING:

1. What could happen if the low water cutoff were not tested?
2. Why should the evaporation test be made periodically?

ASSIGNMENT:

Complete Assignment 6-C-3 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe the purpose and to locate the condensate tank.
2. Be able to describe the fireman's responsibility regarding condensate tanks.

AIDS:

1. Blackboard
2. Overhead projector
3. Transparencies showing tank and fittings

PROCEDURE:

1. Discuss reasons for saving condensate.
2. Explain results and causes of increase and decrease of condensate temperature.
3. Using blackboard show the location of condensate tanks and how they could be piped up in a large plant.
4. Using transparencies, explain the purpose of all fittings and accessories found on tank.
5. Discuss procedure to follow in event of oil contamination of returns and the effect on plant operation.

SUMMARIZE:

1. Fireman's responsibility on temperature and contamination

TESTING:

1. Why is it important to prevent contaminated water from entering the boiler?

ASSIGNMENT:

Complete Assignment 6-D-1 in Related Science Manual—2.

OBJECTIVES:

1. Be able to describe the purpose and to locate the vacuum condensate tank.
2. Be able to describe how a vacuum pump works.
3. Be able to describe the fireman's responsibility regarding vacuum pumps and tanks.

AIDS:

1. Blackboard
2. Overhead projector
3. Transparencies on vacuum tank and pumps

PROCEDURE:

1. Discuss purpose of a vacuum tank and pump.
2. Explain where air and non-condensable gases come from, and discuss how air and gases are removed from system.
3. Using blackboard, show location of vacuum tank and pumps in the system.
4. Using the overhead projector, explain the parts and the purpose of fittings found on the vacuum tank.
5. Explain the reason for having thermometer, and the cause and effects of an increase in return condensate temperature.
6. Discuss procedure for correcting this situation.
7. Explain the three-way selector switch and how to use it.
8. Discuss vacuum setting and range.
9. Discuss causes of water discharging from the air vent.
10. Explain the purpose of dual pumps.
11. Discuss the maintenance requirements of vacuum tanks and pumps.

SUMMARIZE:

1. Purpose and location of vacuum condensate tanks system
2. Selector switch
3. Cause and remedy of increase in condensate return temperature.

TESTING:

1. If you saw water coming out of the air vent, what would you do?
2. If the vacuum tank started making loud knocking noises, what would you look for?

ASSIGNMENT:

Complete Assignment 6-D-2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe how a reciprocating pump works.
2. Be able to explain the meaning of the name plate data.
3. Be able to explain the reasons a reciprocating pump will fail to deliver water to a boiler.

AIDS:

1. Blackboard
2. Sketch of boiler showing steam line to pump and discharge line to boiler. (Include steam pressure and water pressure.)

PROCEDURE:

1. Put sketch on board and ask if anyone can explain how a pump using 100 p.s.i. of steam can deliver 400 p.s.i. of water pressure.
2. Explain the design of pump steam piston, which is 2–2½ times larger in area than the water piston.
3. Explain what is meant by total force (area X pressure).
4. Explain what is meant by: total force on steam side of pump = total force on water side of pump.
5. Use pump data: 4 X 2 X 8 steam pressure 100 p.s.i. Show how to find the water pressure developed by the steam pressure.

$$\text{Total Force Steam Side} = \text{Total Force Water Side}$$
$$\text{Area Steam Side} \times \text{Steam Pressure} = \text{Area Water Side} \times \text{Water Pressure}$$
$$(d_{ss})^2 \times .7854 \times \text{Steam Pressure} = (d_{sw})^2 \times .7854 \times \text{Water Pressure}$$
$$4 \times 4 \times .7854 \times 100 = 2 \times 2 \times .7854 \times \text{Water Pressure}$$
$$12.5664 \times 100 = 3.1416 \times \text{Water Pressure}$$
$$\frac{12.5664 \times 100}{3.1416} = \text{Water Pressure}$$
$$\frac{1256.64}{3.1416} = \text{Water Pressure}$$
$$400 = \text{Water Pressure}$$

6. Explain again why steam piston of feed pump must be 2–2½ times larger in area than water piston.
7. Explain the purposes of the reciprocating pump other than as a feed-water pump.
8. Explain the reason for various locations.
9. Explain cover name plate data and what it means.
10. Explain the reasons why a pump would fail to discharge enough water to a boiler.

SUMMARIZE:

1. How pump works
2. Name plate data
3. Reasons for failure

TESTING:

1. What do figures on the name plate indicate?
2. How do you find the total force developed on a pump?
3. What name plate data would you expect to find on a boiler feed-water pump?
4. How many reasons can you think of that would cause a reciprocating pump to fail to furnish water to a boiler?

ASSIGNMENT:

Complete Assignment 6-E-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain what is meant by *total force = total force.*
2. Be able to find the steam pressure needed knowing the water pressure developed when using *total force = total force.*
3. Be able to find the water pressure developed knowing the steam pressure on hand when using *total force = total force.*

PROCEDURE:

1. Explain that force is push or pull. Pressure is force acting on a body per unit of area; this can be pounds per square inch or pounds per square foot.
2. Area of circle = $D^2 \times .7854$ or πR^2. Explain why we usually use $D^2 \times .7854$.
3. Explain pounds per square inch. (p.s.i.).
4. Explain what is meant by an equation.
5. Explain what is meant by total force = total force. (Use figures to prove it.)
6. Explain how to solve for steam pressure.
7. Explain how to solve for water pressure.
8. Solve sample problems:

   Pump 4 X 2 X 6 steam pressure 150 p.s.i. Find water pressure.
   Pump 4 X 1.5 X 4 water pressure 150 p.s.i. Find steam pressure.

SUMMARIZE:

1. Total force = total force
2. Show how to transpose and solve for unknowns.
3. Show how to prove answer testing.

TESTING:

1. Using the formula, *total force = total force,* have students develop formula for finding
   a. steam pressure
   b. water pressure.

ASSIGNMENT:

Complete Assignment 6-E-1-M1 in Related Science Manual–2.

OBJECTIVE:

1. Be able to calculate the pumping capacity of a reciprocating pump.

AIDS:

1. Blackboard

PROCEDURE:

1. Using a diagram explain how the waterside of a reciprocating pump operates.
2. Explain volume and how it relates to this type of pump.
3. Discuss leakage and how it can affect the efficiency.
4. Explain that 231 cubic inches of water is equal to one gallon.
5. Define "stroke of a pump".
6. Explain the meaning of the terms simplex, duplex, single acting, and double acting.
7. Show and explain the formula

$$G.P.M. = \frac{LANE}{231}$$

8. Set up and solve two problems using the following values:

L	Dia.	N	E
12	10	100	75%
16	14	120	80%

SUMMARIZE:

1. Formula and terms
2. How to solve
3. How to determine number of strokes

TESTING:

1. Explain each term in the formula for finding the capacity of a reciprocating pump.
2. Have students do the following test problem and discuss the results:

   A pump with the following data 4 X 6 X 8 operates at 80 strokes per minute. It is 80% efficient. How many gallons will it discharge in a minute?

ASSIGNMENT:

Complete Assignment 6-E-1-M2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe how a centrifugal pump works.
2. Be able to list the advantages and disadvantages of centrifugal pumps for boiler feed-water service.
3. Be able to select a centrifugal pump for boiler feed-water service.

AIDS:

1. Transparency of centrifugal pump
2. Overhead projector
3. Cutaway model of centrifugal pump

PROCEDURE:

1. Explain centrifugal force, kinetic energy, and potential energy.
2. Using overhead projector, show transparency of centrifugal pump.
3. Explain the operation of a centrifugal pump and how it pumps liquid.
4. Explain the advantages and disadvantages of the centrifugal pump.
5. Explain how to select a centrifugal pump for boiler feed-water pump use.

SUMMARIZE:

1. Discuss the operation, selection, and advantages of a centrifugal pump for a boiler feed-water system.

TESTING:

1. How does a centrifugal pump operate?
2. What factors would you consider when selecting a pump for use in a boiler feed-water system?
3. Name as many advantages as you can for using a centrifugal pump.

ASSIGNMENT:

Complete Assignment 6-E-2 in Related Science Manual—2.

OBJECTIVES:

1. Be able to define the terms: suction lift or suction head, discharge head, and friction head.
2. Be able to calculate the total head on a centrifugal pump.
3. Be able to convert foot head to pounds per square inch.

AIDS:

1. Blackboard

PROCEDURE:

1. Using a drawing explain suction lift and suction head.
2. Show and explain discharge head.
3. Explain the losses due to friction when a liquid flows through a line.
4. Review how to convert ft. hd. to p.s.i. and p.s.i. to ft. hd.
5. Show and explain the formulas for finding total head on a pump:

   $T.H. = D.H. + F.H. + S.L.$

   $T.H. = D.H. + F.H. - S.H.$

6. Set up and solve two problems using the following values:

Discharge head	–	75 ft.
Suction lift	–	10 ft.
Friction head	–	5 ft.
Discharge at pump	–	100 p.s.i.
Suction pressure	–	20 p.s.i.
Friction head	–	20 ft.

SUMMARIZE:

1. Solution of above problems
2. Converting of head to p.s.i. and p.s.i. to head.

TESTING:

1. Find the total head on a pump from the following information:

Discharge pressure	–	200 p.s.i.
Suction head	–	50 ft.
Friction head	–	25 ft.

ASSIGNMENT:

Complete Assignment 6-E-2-M1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe purpose, location, and types of injectors.
2. Be able to describe how an injector works.
3. Be able to describe the reasons for injector failure.
4. Be able to explain the fireman's responsibility regarding feed-water injectors.

AIDS

1. Overhead projector
2. Transparencies on single- and double-tube injectors.

PROCEDURE:

1. Discuss purpose of an injector.
2. Explain why it is not considered efficient.
3. Using overhead projector, discuss parts and explain the operation.
4. Discuss kinetic and potential energy.
5. Explain why the location of the steam line is critical.
6. Discuss why the city water meter must be protected.
7. Discuss reasons for injector failure.
8. Stress importance of fireman being able to use injector and why it must be used periodically.

SUMMARIZE:

1. Reason for having injector.
2. Importance of using injector.

TESTING:

1. What will happen if temperature of water feeding injector gets too hot?
2. Why must the injector be used at regular intervals?

ASSIGNMENT:

Complete Assignment 6-E-3 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain why careful planning and design is essential for boilerroom piping.
2. Be able to explain how and why steam lines are pitched.
3. Be able to explain why expansion stresses must be allowed for in steam lines.

AIDS:

1. Blackboard
2. Overhead projector
3. Transparencies of piping layouts

PROCEDURE:

1. Using blackboard, start with boiler and lay out piping system. Show an engine and a process line.
2. Discuss purpose of valves and accessories in system.
3. Explain why careful design is essential for safe and efficient operation.
4. Discuss proper pitching of steam lines.
5. Discuss expansion stress and how it is handled.
6. Discuss insulation and why it is needed, i.e., radiant heat loss, etc.
7. Explain why different grades of piping are used.
8. Discuss danger of water in steam lines and how it is removed.
9. Using overhead projector, show some typical plant layouts.

SUMMARIZE:

1. Intelligent design for safety and efficiency of operation
2. Danger of water pockets
3. Need for insulation

TESTING:

1. What is meant by radiant heat losses?
2. What would happen if no expansion bends or joints were installed in steam lines.

ASSIGNMENT:

Complete Assignment 7-A-1 in Related Science Manual–2.

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OBJECTIVES:

1. Be able to explain why expansion must be allowed for in pipe lines.
2. Be able to calculate amount of expansion that will take place in the lines.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain what is meant by expansion and contraction.
2. Explain how coefficient of linear expansion per inch varies with material being used.
3. Using blackboard, show coefficient of linear expansion per inch for:

Bronze	=	.00001111
Wrought iron	=	.0000068
Steel	=	.0000067
Cast iron	=	.0000065

4. Show formula and explain:

$$\text{Expansion in inches} = L \times C \times (T_1 - T_2) \times 12$$

L = Length of pipe in feet
C = Coefficient of expansion
T_1 = Final temperature
T_2 = Initial temperature

5. Solve sample problem.

SUMMARIZE:

1. Why expansion must be considered.
2. Formula and meaning of the letters.

TESTING:

1. Using answer in sample problem, question students on what would happen to steam line if no expansion allowance were made.

ASSIGNMENT:

Complete Assignment 7-A-1-M1 in Related Science Manual–2.

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OBJECTIVES:

1. Be able to locate and to explain the purpose of the main steam stop and automatic non-return valves.
2. Be able to explain the fireman's responsibility toward main stop and automatic non-return valves.

AIDS:

1. Overhead projector
2. Transparencies of O.S. and 1/4 gate valve and an automatic non-return valve
3. Cutaway gate valve
4. Cutaway automatic non-return valve

PROCEDURE:

1. Discuss purpose and location of all valves on main steam line leaking boiler.
2. Using overhead projector and transparency of O.S. and Y. gate valve in open and closed position, point out how easy it is to know if the valve is open or closed.
3. Using transparency, show how automatic non-return valve works.
4. Using model of gate valve, show how valve offers no resistance to flow of steam.
5. Using model of non-return valve, show how valve can be closed but can only be open by pressure.
6. Discuss how to cut boiler in on line by hand.
7. Discuss how to cut boiler in on line using non-return valve.

SUMMARIZE:

1. A.S.M.E. Code requirements on number, type and location of valves.
2. Purpose of non-return and main steam stop.

TESTING:

1. Why would you equalize pressure around main stop before opening it?

ASSIGNMENT:

Complete Assignment 7-B-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to locate and to explain the purpose of pressure regulators.
2. Be able to explain how a pressure regulator functions.

AIDS:

1. Overhead projector
2. Transparency of a pressure regulator.
3. Cutaway model of regulator

PROCEDURE:

1. Discuss the basic purpose of a pressure regulating valve.
2. Using transparency, show the parts and how they function in the regulator.
3. Using a sketch, show how this valve is installed in the steam line.
4. Explain why the steam is superheated after the valve.

SUMMARIZE:

1. Purpose of valve
2. Function of valve

TESTING:

1. Why are pressure regulators used in plants?
2. How does a pressure regulator function?

ASSIGNMENT:

Complete Assignment 7-B-2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to locate and to explain the purpose of steam traps.
2. Be able to explain the importance of trap maintenance.

AIDS:

1. Overhead projector
2. Transparencies of traps
3. Cutaways of traps

PROCEDURE:

1. Discuss reasons for traps.
2. Using overhead projector, explain how traps function.
3. Using cutaways of traps, discuss trap problems.
4. Explain why trap maintenance is vital to plant efficiency.
5. Discuss how to detect faulty traps.

SUMMARIZE:

1. Purpose and location
2. Stress trap maintenance

TESTING:

1. What are the end results of a trap that is stuck open?

ASSIGNMENT:

Complete Assignment 7-C-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to locate and to explain the purpose of steam and exhaust separators.
2. Be able to explain the operator's responsibility regarding separators.

AIDS:

1. Overhead projector
2. Transparencies of steam and exhaust separators

PROCEDURE:

1. Discuss the purpose and location of a live steam separator.
2. Explain the difference between a live steam separator, a receiver separator, and an exhaust separator.
3. Discuss the type of plant where each of the above is used.
4. Using overhead projector, explain how each type of separator works.
5. Discuss the theory of operation.
6. Explain the operator's responsibility.

SUMMARIZE:

1. Types of separators
2. Theory of operation
3. Plants using separators

TESTING:

1. What type of plant needs a receiver separator?
2. Why are exhaust separators only used in plants that have reciprocating engines?

ASSIGNMENT:

Complete Assignment 7-D-1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to calculate the efficiency of a live steam separator.

AIDS:

1. Blackboard

PROCEDURE:

1. Using blackboard, show formula and explain how to use it.
2. Solve sample problem on blackboard.

SUMMARIZE:

1. Explain formula and how to substitute valves.

TESTING:

1. Why must we always write a formula before we substitute valves?

ASSIGNMENT:

Complete Assignment 7-D-1-M1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to locate and to explain the purpose of a dry pipe and cyclone separator in saturated steam drums.

AIDS:

1. Overhead projector
2. Transparency of dry pipe and cyclone

PROCEDURE:

1. Explain the purpose of a dry pipe and a cyclone separator.
2. With the transparency, explain how the separators are installed and how they function.
3. Using a drawing, show how the separators would be connected if a superheater was in the boiler.
4. Explain quality of steam. How it is changed by using a separator?

SUMMARIZE:

1. Location of separators
2. Purpose of separators
3. Function of separators

TESTING:

1. Why is it necessary to use a drum-type steam separator?
2. Describe how a dry pipe operates.
3. How does a cyclone separator operate?

ASSIGNMENT:

Complete Assignment 7-D-2 in Related Science Manual—2.

OBJECTIVES:

1. Be able to explain the difference between saturated and superheated steam.
2. Be able to explain why superheated steam is used.
3. Be able to explain how superheaters are protected during operation and warm up.

AIDS:

1. Overhead projector
2. Transparencies of different types of superheaters

PROCEDURE:

1. Define saturated and superheated steam.
2. Using overhead projector, describe radiant and convection type superheaters.
3. Discuss reasons for using superheaters.
4. Discuss how superheater temperature is controlled.
5. Explain why superheaters have safety valves, and why the valve must pop first.
6. Discuss how to handle superheater drains during warm up.
7. Discuss changes in temperature in radiant and convection type superheaters when boiler rating is increased.

SUMMARIZE:

1. Definitions of saturated and superheated steam
2. Reasons for using superheated steam
3. Temperature control

TESTING:

1. What effect does rating increase have on radiant and convection type superheaters?

ASSIGNMENT:

Complete Assignment 7-E-1 in Related Science Manual—2.

OBJECTIVES:

1. Be able to locate and to explain purpose of two types of desuperheaters.
2. Be able to explain the operator's responsibility regarding desuperheaters.

AIDS:

1. Overhead projector
2. Transparencies of two types of desuperheaters

PROCEDURE:

1. Define saturated, superheated and desuperheated steam.
2. Discuss the purpose of desuperheaters and why they are necessary.
3. Explain location of both types of desuperheaters.
4. Using overhead projector, describe how each type of desuperheater works.
5. Discuss importance of watching the temperature of desuperheated steam.
6. Explain why nozzle must be kept clean.

SUMMARIZE:

1. Purpose
2. Type
3. Reasons for using desuperheater

TESTING:

1. What would happen if the spray nozzles were clogging, and how would the operator know of this condition?

ASSIGNMENT:

Complete Assignment 7-F-1 in Related Science Manual—2

OBJECTIVE:

1. Be able to explain the origin of coal, oil, and gas.

AIDS:

1. Wall chart showing formation of oil in ground.

PROCEDURE:

1. Discuss how coal was formed.
2. Using chart, show earth formation and structure.
3. Discuss gas formation

SUMMARIZE:

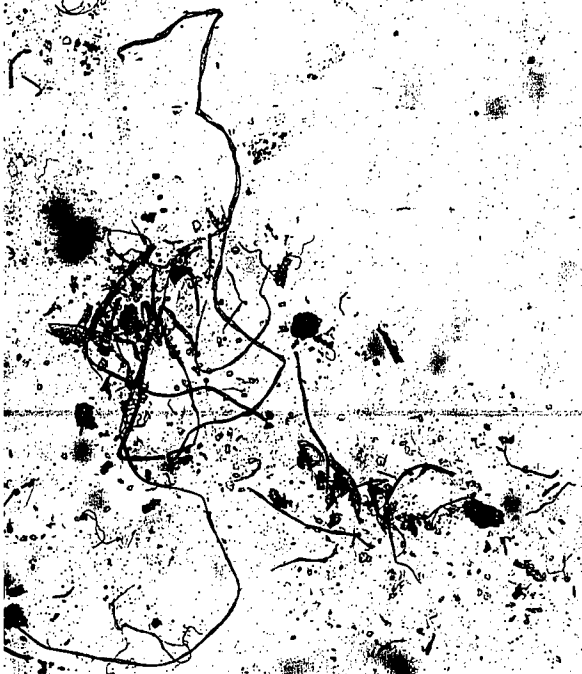
1. Theory of coal, oil, and gas formation

TESTING:

1. Why are coal and oil referred to as fossil fuels?

ASSIGNMENT:

Complete Assignment 8-A-1 in Related Science Manual–2.



OBJECTIVES:

1. Be able to explain how fuel oil is classified.
2. Be able to explain what is meant by B.t.u. content.

AIDS:

1. Teaching material supplied by American Petroleum Institute

PROCEDURE:

1. Use wall chart showing chemistry of petroleum refining.
2. Use wall chart showing distillation.
3. Discuss methods of classifying oil.
4. Define residual oil, crude oil, distillate oil, and blended oil.
5. Discuss specific gravity and its relationship with A.P.I.
6. Discuss B.t.u. content of oil, and the formula used to find B.t.u.'s per pound.

SUMMARIZE:

1. Classification
2. Specific gravity
3. B.t.u. content
4. Formula

TESTING:

1. What is the relationship between specific gravity and B.t.u. content of fuel oil?

ASSIGNMENT:

Complete Assignment 8-B-1 in Related Science Manual—2.

Conversion of Specific Gravity to A.P.I. Assignment 8-B-1-M1

OBJECTIVES:

1. Be able to convert specific gravity to degrees A.P.I.
2. Be able to convert degrees A.P.I. to specific gravity.

AIDS:

1. Blackboard

PROCEDURE:

1. Discuss specific gravity and degrees A.P.I.
2. Explain how to use the formula:

$$\text{Sp. Gr. } 60/60F = \frac{141.5}{131.5 + \text{Degrees A.P.I}}$$

3. Using formula Sp. Gr. 60/60F, explain how to transpose to get formula:

$$\text{Degrees A.P.I.} = \frac{141.5}{\text{Sp. Gr. } 60/60F} - 131.5$$

4. Solve sample problem using each formula.

SUMMARIZE:

1. How to transpose formula from degrees A.P.I. to specific gravity and vice versa.

TESTING:

1. How many decimal places must be used when finding Sp. Gr. 60/60F?

ASSIGNMENT:

Complete Assignment 8-B-1-M1 in Related Science Manual–2.

OBJECTIVE:

1. Be able to describe the properties of fuel oil.

AIDS:

1. Material from American Petroleum Institute

PROCEDURE:

1. Using material and wall charts, discuss properties found in fuel oil.
2. Discuss useful elements in fuel.
3. Explain low sulphur law in New Jersey.
4. Define:
   a. Flash point
   b. Fire point
   c. Pour point
   d. Viscosity
5. Discuss dangers in low flash point fuel.
6. Discuss B.t.u. content of oil

SUMMARIZE:

1. Useful elements in oil
2. Dangers such as low flash point fuel

TESTING:

1. What happens to viscosity of oil when it is heated?
2. Would you prefer a high or low pour oil?

ASSIGNMENT:

Complete Assignment 8-B-2 in Related Science Manual 2.

OBJECTIVE:

1. Be able to calculate the B.t.u content of fuel oil when its degrees A.P.I. is known.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain that B.t.u. content is found by using a bomb calorimeter.
2. Discuss how an approximate B.t.u. content can be found by using the formula:

$$\text{B.t.u./lbs} = 17780 + (54 \times \text{A.P.I.})$$

3. Solve sample problem.

SUMMARIZE:

1. Actual B.t.u. content with bomb calorimeter.
2. Approximate B.t.u. by formula

TESTING:

1. How can you find B.t.u.'s per gallon?

ASSIGNMENT:

Complete Assignment 8-B-2-M1 in Related Science Manual—2.

OBJECTIVES:

1. Be able to describe how coal is classified.
2. Be able to define rank and grade.
3. Define B.t.u. content.

AIDS:

1. Blackboard

PROCEDURE:

1. Discuss how coal is classified.
2. Explain what is meant by rank and grade.
3. Explain volatile and fixed carbon.
4. Discuss difference between hard and soft coal.
5. Explain why furnace volume must be greater when burning soft coal.
6. Explain how the B.t.u. of coal are found with the bomb calorimeter.
7. Discuss the purpose of DuLong's formula.

SUMMARIZE:

1. Classification – rank and grade
2. Hard coal – fixed carbon
3. Soft coal – volatile matter

TESTING:

1. Why does furnace volume differ when burning hard and soft coal?

ASSIGNMENT:

Complete Assignment 8-C-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe the properties of coal.
2. Be able to describe what a proximate analysis shows.
3. Be able to describe what an ultimate analysis shows.

AIDS:

1. Blackboard

PROCEDURE:

1. Discuss NO CASH
2. Discuss ultimate and proximate analysis.
3. Explain why hard coal is called hard coal.
4. Discuss why hard coal does not smoke.
5. Explain why soft coal is called soft coal.
6. Discuss useful elements.

SUMMARIZE:

1. Ultimate analysis
2. Proximate analysis
3. NO CASH

TESTING:

1. What are the effects of sulphur in fuel?

ASSIGNMENT:

Complete Assignment 8-C-2 in Related Science Manual–2.

OBJECTIVE:

1. Be able to calculate the heating value of coal with DuLong's formula.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain how heating value is actually determined by using a calorimeter.
2. Discuss how approximate heating value can be determined by using DuLong's formula.
3. Discuss ultimate analysis.
4. Show formula on blackboard and explain what it means.
5. Solve sample problem.

SUMMARIZE:

1. Calorimeter – actual heating value
2. DuLong's formula – approximate heating value

TESTING:

1. What are the useful elements in coal?

ASSIGNMENT:

Complete Assignment 8-C-2-MT in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe how gas is classified.
2. Be able to describe how the heating value of gas is determined.

AIDS:

1. Blackboard

PROCEDURE:

1. Discuss classification of gas.
2. Explain how heating value will differ in gas.
3. Discuss chemical makeup of casing head gas, blast furnace gas, and coke oven gas.
4. Explain how heating value is obtained.

SUMMARIZE:

1. Classification
2. B.t.u. content

TESTING:

1. What is the chemical symbol for methane?

ASSIGNMENT:

Complete Assignment 8-D-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe the properties of natural and manufactured gas.

AIDS:

1. Wall chart showing natural gas location in U.S.

PROCEDURE:

1. Discuss properties of natural gas and its B.t.u. content.
2. Discuss the types, properties, and B.t.u. content of manufactured gas.
3. Explain the difference between dry and wet gas.
4. Discuss the difference between sweet and sour gas.
5. Using wall chart, show how natural gas is trapped.

SUMMARIZE:

1. Properties and B.t.u. content of natural gas versus manufactured gas.

TESTING:

1. What does sour gas smell like?

ASSIGNMENT:

Complete Assignment 8-D-2 in Related Science Manual—2.

OBJECTIVE:

1. Be able to describe the safe storage and handling of oil, coal, and gas.

AIDS:

1. Any manufacturer's data on coal storage and oil storage.
2. Literature from insurance companies on furnace explosions.

PROCEDURE:

1. Discuss flash point of fuel.
2. Discuss type of fire extinguishers for use on oil fires.
3. Discuss spontaneous combustion.
4. Discuss how to prevent and handle spontaneous combustion.
5. Explain why soft coal is more conducive to spontaneous combustion than hard coal.
6. Discuss how to check for gas leaks.
7. Explain why vents from gas lines and controls should be piped out of the boilerroom.

SUMMARIZE:

1. Need for good engineering practice while handling oil, coal, or gas.

TESTING:

1. Why isn't hard coal subjected to spontaneous combustion?

ASSIGNMENT:

Complete Assignment 8-E-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to locate the fuel oil tanks in the school plant.
2. Be able to explain the reasons for knowing the location of all fuel oil piping in a plant.

AIDS:

1. Overhead projector
2. Transparencies of fuel oil piping.

PROCEDURE:

1. Discuss fireman's responsibility.
2. Explain why temperatures and pressures are important.
3. Using a transparency, explain how pumps can be changed over, how heaters can be isolated from the system, and how the temperature of the oil is controlled.
4. Locate relief valves and return lines.
5. Discuss tank vents and why they are necessary.
6. Explain why steam and electrical pumps are used.

SUMMARIZE:

1. Fireman must know all details of plant.

TESTING:

1. What is the result of air in the oil lines?

ASSIGNMENT:

Complete Assignment 9-A-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain the purpose of fuel oil pumps.
2. Be able to describe the basic types of fuel oil pumps.
3. Be able to explain the need for fuel oil heaters.

AIDS:

1. Overhead projector
2. Transparencies of types of fuel oil pumps.
3. Transparencies of types of fuel oil heaters.

PROCEDURE:

1. Discuss purpose of fuel oil pumps.
2. Explain why oil is recirculated back to tank.
3. Discuss types of fuel oil pumps using overhead projector.
4. Discuss why relief valves are necessary and where they are located.
5. Explain why oil in tanks must be headed.
6. Discuss why and how temperature is and must be controlled in oil storage tanks.
7. Using overhead projector, discuss and show the types of fuel oil heaters.

SUMMARIZE:

1. Purpose of fuel oil pump
2. Purpose of heating oil in storage tank and at burner.

TESTING:

1. Why must temperature of oil in storage tank be controlled.

ASSIGNMENT:

Complete Assignment 9-A-2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to identify the parts of a gear pump.
2. Be able to list the advantages and disadvantages of gear pumps.

AIDS:

1. Overhead projector
2. Transparencies of types of gear pumps.
3. Cutaway model of gear pump

PROCEDURE:

1. Using overhead projector and transparencies, show the types of gear pumps.
2. Discuss the parts of a pump.
3. Compare gear pumps with centrifugal and reciprocating pumps.
4. Explain the reason for relief valves and locate the valve.
5. Explain why gear pumps are suitable for fuel oil pumps.
6. Explain the advantages and disadvantages of gear pumps.
7. Use cutaway of gear pump to explain its operation.

SUMMARIZE:

1. Advantages
2. Disadvantages

TESTING:

1. Why is a relief valve necessary?
2. Where is the relief valve located?

ASSIGNMENT:

Complete Assignment 9-A-3 in Related Science Manual—2.

OBJECTIVES:

1. Be able to describe how a pressure atomizing burner works.
2. Be able to describe how the amount of oil burned is controlled.

AIDS:

1. Overhead projector
2. Transparencies of types of mechanical atomizing burners

PROCEDURE:

1. Using overhead projector, explain how oil is atomized in burners.
2. Discuss how quantity of oil delivered by atomizer is controlled.
3. Discuss how some reduction in burning rate can be realized by changing oil pressure.
4. Explain how only minor load changes can be handled this way. Any large load changes require changing either the burner tips or the number of burners operating.
5. Discuss need for fairly high oil pressure (100–250 p.s.i) and also high oil temperature (160°- 240°F.).

SUMMARIZE:

1. Oil under high pressure and high temperature is required

TESTING:

1. How can plant load be controlled using mechanical atomizing burners?

ASSIGNMENT:

Complete Assignment 9-A-4 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain why rotary cup burners are used.
2. Be able to describe how oil pattern can be regulated.

AIDS:

1. Overhead projector
2. Transparencies of rotary cup burner – belt and direct drive.

PROCEDURE:

1. Using overhead projector, discuss both direct and belt drive burners.
2. Discuss how burners can be used for gas and oil.
3. Explain how rotary burners are excellent for complete automatic firing.
4. Discuss reason for air switch and how it works.
5. Explain how atomization takes place.
6. Discuss reason for secondary air.

SUMMARIZE:

1. Excellent for complete automatic firing
2. Importance of air switch.

TESTING:

1. If primary air fan failed in our plant what would happen? How would you recognize and correct the condition?

ASSIGNMENT:

Complete Assignment 9-A-5 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe the types of steam atomizing burners.
2. Be able to describe how steam atomizing burners work.

AIDS:

1. Overhead projector
2. Transparencies of types of atomizing burners.

PROCEDURE:

1. Using overhead projector, discuss inside and outside mixing burners.
2. Discuss the temperature and pressure of oil required.
3. Discuss type of oil that can be burned.
4. Discuss steam consumption.
5. Discuss initial cost versus operating cost.
6. Discuss importance of controlling steam consumption.

SUMMARIZE:

1. Almost any oil can be burned
2. Initial cost versus operating cost

TESTING:

1. Why must steam consumption be regulated?

ASSIGNMENT:

Complete Assignment 9-A-6 in Related Science Manual—2.

OBJECTIVES:

1. Be able to explain why stokers were developed.
2. Be able to describe the types of stokers.

AIDS:

1. Overhead projector.
2. Transparencies of types of stokers

PROCEDURE:

1. Discuss why stokers were developed.
2. Discuss historical development.
3. Explain three general classes of stokers.
4. Discuss 4 functions of a stoker.
5. Using transparencies, discuss over-, under- and cross-feed stokers.

SUMMARIZE:

1. Four functions
2. Reason for development
3. Three classes

TESTING:

1. Why can't a caking coal be burned in a cross-feed stoker?

ASSIGNMENT:

Complete Assignment 9-B-1 in Related Science Manual—2.

OBJECTIVES:

1. Be able to describe the development of pulverizers.
2. Be able to describe the types of pulverizers.

AIDS:

1. Overhead projector
2. Transparencies of types of pulverizers

PROCEDURE:

1. Discuss reasons for interest and development of pulverizers.
2. Explain why the cement industry was first in development of pulverizers.
3. Discuss diesel trying to use pulverized coal.
4. Discuss principle of operation.
5. Explain classification.
6. Using overhead projector, show different types of pulverizers.
7. Discuss advantages and disadvantages.

SUMMARIZE:

1. Reason for interest
2. Basic principles involved

TESTING:

1. Why isn't pulverized coal adaptable for diesel engines?

ASSIGNMENT:

Complete Assignment 9-B-2 in Related Science Manual—2.

OBJECTIVES:

1. Be able to explain the purpose of gas piping.
2. Be able to describe the types of valves and controls used.

AIDS:

1. Overhead projector
2. Schematic transparencies of both high-pressure and low-pressure gas service.

PROCEDURE:

1. Discuss difference of high-pressure gas service and low-pressure gas service.
2. Using transparency of low-pressure gas service, discuss valves and controls, and the purpose they serve.
3. Review light off sequence.
4. Using transparency of high-pressure gas service, discuss valves and controls, and the purpose they serve.
5. Review light off sequence.
6. Discuss reasons for color coding lines and the need for instant checks if you think there is a gas leak.
7. Discuss how to check for gas leaks.
8. Explain the danger of an open flame.

SUMMARIZE:

1. Difference between high-pressure and low-pressure gas service.
2. Importance of color-code and checking leaks.

TESTING:

1. Is it unwise to use an open flame to check for gas leaks? Why?

ASSIGNMENT:

Complete Assignment 9-C-1 in Related Science Manual-2.

OBJECTIVES:

1. Be able to explain the purpose of combustion controls.
2. Be able to explain how the on-off combustion control works.

AIDS:

1. Blackboard

PROCEDURE:

1. Discuss purpose of combustion controls and what they control.
2. Using blackboard, show the location of the pressure-trol and the modulating pressure-trol.
3. Discuss why siphons are necessary and how they must be installed.
4. Discuss high and low fire.
5. Explain why the burner must start up and shut down in low fire.
6. Explain why modulating pressure-trol should be set to keep burner firing periods longer than off periods.
7. Explain spauling.
8. Discuss limitation of on and off controls.

SUMMARIZE:

1. Purpose of combustion controls
2. Reason for siphon, and how to install a siphon.

TESTING:

1. Why must siphons be used?
2. How must siphons be installed?

ASSIGNMENT:

Complete Assignment 9-D-1 in Related Science Manual—2.

OBJECTIVES:

1. Be able to explain the purpose and function of a temperature regulator.
2. Be able to explain the purpose and function of a pressure regulator.
3. Be able to explain the purpose and function of a pressure safety relief valve.

AIDS:

1. Blackboard
2. Cutaway models

PROCEDURE:

1. Explain the purpose of a temperature regulator in a fuel oil system.
2. Explain how the temperature regulator functions.
3. Explain the purpose of a pressure regulator in a fuel oil system.
4. Explain how the pressure regulator functions.
5. Explain the importance of the safety relief valves in the system.
6. Explain how the safety relief valves function.
7. Show the cutaways and explain how each control functions.

SUMMARIZE:

1. Purpose and function of:
   a. Pressure regulator
   b. Temperature regulator
   c. Safety relief valve

TESTING:

1. Discuss the purpose of each valve.
2. Discuss how each valve functions.

ASSIGNMENT:

Complete Assignment 9-D-2 in Related Science Manual-2.

OBJECTIVES:

1. Be able to describe the purpose of a programer.
2. Be able to describe how a programer works.

AIDS:

1. Overhead projector
2. Transparencies of figures 9-D-3-1, 9-D-3-2, and 9-D-3-3
3. Chassis of fireye

PROCEDURE:

1. Discuss purpose of programer.
2. Using transparencies and fireye chassis, point out location of cam assembly, show contacts found on the 5 cams, and show location on chassis.
3. Discuss flame relay, master relay, lockout switch, and locate each.
4. Using transparency of programing sequence, turn timer by hand on chassis. Point out what is happening in sequence and what contacts and relays are being affected.

SUMMARIZE:

1. Purpose of programer
2. Importance of knowing what is happening at each point of timer indicator.

TESTING:

1. Why is it important for an operator to know the programing sequence and the time factors involved in the plant?

ASSIGNMENT:

Complete Assignment 9-D-3 in Related Science Manual—2.

OBJECTIVE:

1. Be able to explain the basic principles of combustion and the combustion equations.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain the chemical composition of the commercial fuels: nitrogen, oxygen, carbon, sulphur, and hydrogen.
2. Explain the composition of air: nitrogen, oxygen, inert gasses, carbon dioxide, and water vapor.
3. Show with the use of chemical equations how oxygen in the air combines with carbon, hydrogen, and sulphur in the fuel.
4. Explain what the end products of combustion are and how they can affect our environment.

SUMMARIZE:

1. Show and explain each equation:

$$C+O_2 \rightarrow CO_2 + Heat$$
$$2C+O_2 \rightarrow 2CO + Heat$$
$$2CO+O_2 \rightarrow 2CO_2 + Heat$$
$$2H_2+O_2 \rightarrow 2H_2O + Heat$$
$$S+O_2 \rightarrow SO_2 + Heat$$

TESTING:

1. What is combustion?
2. What does air contain?
3. What elements do we find in a commercial fuel?

ASSIGNMENT:

Complete Assignment 10-A-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe the types of combustion taking place in the furnace of a boiler.
2. Be able to describe why it is necessary to be able to control the combustion process.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain what is meant by:
   a. Primary air
   b. Secondary air
   c. Excess air
2. Show the air flow on a rotary cup burner.
3. Show the air flow on a combination oil and gas burner.
4. Show the air flow on a pulverized coal burner.
5. Discuss perfect, complete, and incomplete combustion.
6. Discuss the air pollution code and how it will affect the operators of residual fuel oil equipment.

SUMMARIZE:

1. Perfect, complete, and incomplete combustion
2. Primary, secondary and excess air

TESTING:

1. Why can't perfect combustion take place in a boiler?
2. What does primary air control?
3. What does secondary air control?
4. What are the results of using more excess air than is needed?

ASSIGNMENT:

Complete Assignment 10-B-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain the combustion process.
2. Be able to explain what is needed for complete combustion of oil, gas, and coal.

AIDS:

1. Blackboard

PROCEDURE:

1. Review chemical theory of combustion
2. Define:
   a. Primary air
   b. Secondary air
   c. Excess air
   d. Perfect combustion
   e. Complete combustion
   f. Incomplete combustion
3. Explain M - A - T - T in detail:
   a. Explain what is meant by ratio of air and fuel and how it must vary during changes in firing rate.
   b. Explain why it is important to bring air and oil in intimate contact with each other.
   c. Explain why combustion must be completed in combustion chamber.
4. Discuss the actual burning of these fuels under industrial conditions: coal, gas, and oil.

SUMMARIZE:

1. Mixture, atomization, temperature, and time.

TESTING:

1. In detail, how is coal burned?
2. In detail, how is oil burned?
3. In detail, how is gas burned?

ASSIGNMENT:

Complete Assignment 10-C-1 in Related Science Manual-2.

OBJECTIVES:

1. Be able to explain the purpose of combustion gas analyzers.
2. Be able to explain how a combustion gas analyzer functions.

AIDS:

1. Gas analyzers

PROCEDURE:

1. Discuss the terms:
   a. Perfect combustion
   b. Complete combustion
   c. Incomplete combustion
   d. Co_2, CO, O_2
2. Explain the purpose of a gas analysis.
3. Explain how to determine the amount of CO_2 in a given sample of flue gas using a fyrite analyzer.
4. Explain how an orsat analyzer is used. Start with a 100 cc. sample.
5. Analyze the results and discuss how they can be used.

SUMMARIZE:

1. Function of the fyrite
2. Function of the orsat
3. Interpretation of results

TESTING:

1. Why bother with gas analysis?
2. How are CO_2, O_2, and CO readings obtained?

ASSIGNMENT:

Complete Assignment 10-D-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to use the results from a flue gas analysis.
2. Be able to calculate for excess air used in the combustion process.
3. Be able to determine the correct amount of excess air to have when burning coal, oil, or gas.

AIDS:

1. Blackboard

PROCEDURE:

1. Discuss the results found from a flue gas analysis.
2. Show and explain the purpose of the formula.

$$\% \text{ Excess Air} = \frac{O_2 - \frac{1}{2}CO}{.263N_2 + \frac{1}{2}CO - O_2} \times 100$$

3. Set up and solve these sample problems:

	CO_2	O_2	CO	N_2
a.	12.6	3.7	2.3	81.4
b.	13.2	5.8	0.0	81

4. Explain the amount of excess air needed for coal, oil, and gas.

SUMMARIZE:

1. The setting up and solving of problems to find excess air.

TESTING:

1. How much excess air does it take to obtain complete combustion?
2. Have each student solve the following problem for excess air:

CO_2	O_2	CO	N_2
12%	5%	2%	81%

ASSIGNMENT:

Complete Assignment 10-D-1M in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe how the combustion of oil takes place in a steam boiler furnace.
2. Be able to describe how the combustion of coal takes place in a steam boiler furnace.
3. Be able to describe how the combustion of gas takes place in a steam boiler furnace.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain how oil and air are introduced and burned in a steam boiler furnace.
2. Explain how coal is burned on a grate. (Soft and hard coal)
3. Explain how coal is burned in suspension.
4. Explain how gas is burned in a steam boiler furnace.
5. Discuss furnace volume in relation to good combustion of oil, coal, and gas.

SUMMARIZE:

1. Burning oil
2. Burning coal
3. Burning gas

TESTING:

1. Why are gas and oil easier to burn than coal?
2. What is the basic difference between burning hard coal and soft coal?

ASSIGNMENT:

Complete Assignment 10-E-1 in Related Science Manual-2.

OBJECTIVES:

1. Be able to describe the importance of the proper furnace volume on combustion.
2. Be able to determine the amount of furnace volume needed for a given boiler output.

PROCEDURE:

1. Explain the importance of having sufficient furnace volume to complete combustion.
2. Explain what is meant by heat release and how it affects furnace volume.
3. Discuss the amount of furnace volume needed for:

   a. Oil — .75 – 1 cu. ft./b. hp.

   b. Coal — Stokers — 1.5 – 2.25 cu. ft./b. hp.
      Pulverizers — 1.4 – 2.5 cu. ft./b. hp.

   c. Gas — .75 cu. ft./b. hp.

SUMMARIZE:

1. Furnace volume for oil
2. Furnace volume for coal
3. Furnace volume for gas

TESTING:

1. How does furnace volume affect combustion?
2. Discuss furnace volume needed for various fuels.

ASSIGNMENT:

Complete Assignment 10-E-2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to calculate the theoretical amounts of air needed per pound of fuel.
2. Be able to calculate the theoretical amounts of oxygen per pound of fuel.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain what is meant by ultimate analysis.
2. Explain the formula for finding the theoretical amounts of air needed.
3. Solve sample problems for:
   a. Theoretical amount of lbs. air/lbs. fuel.
   b. Theoretical amount of lbs. O_2/ lbs. fuel
   c. Using 20% excess air, find the actual air required.
   d. Find the oxygen needed in part for 3c above.

SUMMARIZE:

1. Ultimate analysis
2. Formula for lbs air/lbs. fuel.

TESTING:

1. Have students solve sample problems.

ASSIGNMENT:

Complete Assignment 10-E-3 in Related Science Manual—2.

OBJECTIVES:

1. Be able to calculate the pounds of steam generated per unit of fuel.
2. Be able to explain the purpose for calculating the pounds of steam per unit of fuel.
3. Be able to explain the reasons for maintaining a running record of the pounds of steam generated per unit of fuel.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain the reasons for maintaining operating records for all steam generating equipment.
2. Discuss the purpose of calculating the pounds of steam generated per pound of fuel.
3. Show and explain how to calculate the pounds of steam per unit of fuel for coal, oil, and gas.
4. Discuss overall boiler performance relating to pounds of steam generated compared with the fuel used.

SUMMARIZE:

1. Daily records
2. Boiler performance

TESTING:

1. What factors could affect the steam generating performance of a boiler?
2. How could you find the evaporation of steam per pound of fuel in a steam plant?

ASSIGNMENT:

Complete Assignment 10-E-4 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe how a differential pressure flowmeter functions.
2. Be able to describe how a differential pressure flowmeter is constructed.

AIDS:

1. Blackboard
2. Transparency of meter
3. Overhead projector

PROCEDURE:

1. Explain where differential flowmeters are used.
2. Explain the methods that are used to measure flow.
3. Explain how the differential pressure is transmitted and then converted to rate of flow.
4. Using the transparency, explain how the complete meter functions.

SUMMARIZE:

1. Boilerroom uses of differential flowmeter
2. How differential flowmeter functions

TESTING:

1. Where are these meters used?
2. How do they work?
3. What useful purpose do they serve?

ASSIGNMENT:

Complete Assignment 11-A-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain how a positive displacement flowmeter functions.
2. Be able to describe the basic construction of a positive displacement flowmeter.
3. Be able to explain how a variable area flowmeter functions.
4. Be able to describe the basic construction of a variable area flowmeter.

AIDS:

1. Blackboard
2. Overhead projector
3. Transparencies of meters

PROCEDURE:

1. Explain where positive displacement flowmeters are used.
2. Explain where variable area flowmeters are used.
3. Explain how each functions:
   a. Positive displacement
   b. Rotameter
   c. Area meter
4. Discuss why the pressure differential is constant in the variable area meter.
5. Explain why these meters are calibrated for the fluid they are going to measure.
6. Using the transparencies, discuss how each flowmeter functions.

SUMMARIZE:

1. The function of:
   a. Variable area meters
   b. Positive displacement meters

TESTING:

1. Where are these flowmeters used?
2. For what fluids are they used?
3. How does each type of meter function?

ASSIGNMENT:

Complete Assignment 11-A-2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain how a draft gage is constructed.
2. Be able to explain how a draft gage functions.

AIDS:

1. Overhead projector
2. Transparencies of draft gages

PROCEDURE:

1. Explain what draft is.
2. Discuss the various points from which draft is measured.
3. Explain how draft gages are constructed.
4. Using the transparencies, explain how each draft gage functions.

SUMMARIZE:

1. Construction of draft gages
2. How draft gages function.

TESTING:

1. What is draft?
2. How is draft measured?
3. What instruments are used to measure draft?

ASSIGNMENT:

Complete Assignment 11-B-1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to convert inches of draft pressure to pounds per square inch.

AIDS:

1. Blackboard

PROCEDURE:

1. Discuss the importance of being able to convert from inches of water column to pounds per square inch.
2. Explain how to convert from inches of water to p.s.i.
3. Solve two sample problems.

SUMMARIZE:

1. Review the sample problems.

TESTING:

1. Have students solve a conversion problem.

ASSIGNMENT:

Complete Assignment 11-B-1-M1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain how thermocouples work.
2. Be able to list the uses of thermocouples in steam generating plants.

AIDS:

1. Overhead projector
2. Transparencies of thermocouples

PROCEDURE:

1. Explain how the thermocouple works.
2. Using the transparencies, explain how the electrical current moves the meter or recorder needle.
3. Explain where thermocouples are used in steam generating plants.
4. Explain the purpose of using thermocouples in and around the steam generating plant.

SUMMARIZE:

1. How thermocouples work.
2. Where thermocouples are used.
3. Purpose of thermocouples.

TESTING:

1. Discuss with students:
   a. How a thermocouple works.
   b. Where thermocouples are used.
   c. Purpose of thermocouples.

ASSIGNMENT:

Complete Assignment 11-C-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain the purpose of recorders.
2. Be able to explain how to use the data from a recorder.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain purpose of recorders.
2. Explain types of recorders.
3. Discuss boilerroom recorders.
4. Explain how high efficiency is maintained by using recorders.

SUMMARIZE:

1. Purpose and types of recorders
2. Boilerroom recorders and use of date

TESTING:

1. Where are recorders used?
2. What is the purpose of a recorder?
3. How are recorders used in steam plants?

ASSIGNMENT:

Complete Assignment 11-D-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain the purpose of a smoke indicating device.
2. Be able to describe how the smoke indicating device works.

AIDS:

1. Overhead projector
2. Transparencies of Ringelmann charts and photoelectric type indicator.

PROCEDURE:

1. Explain the New Jersey Code on air pollution.
2. Explain the purpose and how to use the Ringelmann charts.
3. Show the photoelectric type of indicator and name all of its parts.
4. Explain how the photoelectric type works.
5. Explain the value of having a continuous strip chart to measure smoke density.

SUMMARIZE:

1. Ringelmann charts
2. Function of photoelectric unit.

TESTING:

1. Why worry about smoke?
2. Why are the Ringelmann charts important?
3. How does a photoelectric unit operate?

ASSIGNMENT:

Complete Assignment 11-E-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain the fundamentals of the chemistry of boiler water.
2. Be able to define the basic terminology used in boiler water chemistry.

AIDS:

1. Cutaways of scale on a tube and corrosion on a tube.

PROCEDURE:

1. General discussion of all possible sources of water.
2. Discuss possible impurities in each source of supply.
3. Explain steam boiler water needs.
4. Discuss the results of improper boiler water treatment.
5. Explain the importance of knowing the correct terminology when discussing boiler water treatment.

SUMMARIZE:

1. Impurities in water
2. Effect on a steam boiler
3. Naming of terms

TESTING:

1. Name the sources of water.
2. What impurities do they contain?
3. What conditions can this cause in a steam boiler?

ASSIGNMENT:

Complete Assignment 11-E-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe the danger of neglecting proper boiler water conditioning.

AIDS:

1. Pictures of boiler failures from inspection companies.

PROCEDURE:

1. Discuss the danger from each condition:
   a. Caustic embrittlement
   b. Scale formation
   c. Corrosion
   d. Carryover
2. Explain the A.S.M.E. Code in respect to boiler water conditioning.
3. Explain that prevention would have been far easier than the corrective measures after damage has occurred.

SUMMARIZE:

1. Danger of each condition.

TESTING:

1. General discussion of student reaction to these dangers if they were operators of the boiler.

ASSIGNMENT:

Complete Assignment 12-A-2 in Related Science Manual–2.

OBJECTIVE:

1. Be able to explain how boiler water is chemically treated to maintain a proper balance of chemicals.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain how to chemically treat a steam boiler for scale-forming salts.
2. Explain how to prevent corrosion in a steam boiler.
3. Explain how to control or prevent caustic embrittlement.
4. Explain how to control carryover.
5. Show and explain the chemical reactions that are taking place in boiler water.

SUMMARIZE:

1. Maintaining correct chemical balance in the steam boiler.

TESTING:

1. What conditions are we trying to control in a steam boiler?
2. How do we control these conditions?

ASSIGNMENT:

Complete Assignment 12-B-1 in Related Science Manual—2.

OBJECTIVES:

1. Be able to describe the basic types of systems that are used for external treatment of boiler water.

AIDS:

1. Blackboard

PROCEDURE:

1. Name the basic water softening systems.
2. Explain the cold soda-lime process.
3. Explain the hot soda-lime process.
4. Explain the ion exchange or zeolite process.
5. Discuss the advantages and disadvantages of each system.
6. Explain the purpose of protecting the steam boiler even when using softened water.

SUMMARIZE:

1. Types of softener
2. Function of each

TESTING:

1. Name the softening systems in use today.
2. General discussion of the function of each type.

ASSIGNMENT:

Complete Assignment 12-B-2 in Related Science Manual—2.

OBJECTIVES:

1. Be able to explain how to maintain a proper level of chemicals in the boiler.
2. Be able to explain how to control the total solids in the boiler.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain how an alkalinity test is taken and what it determines.
2. Explain how to increase alkalinity in a boiler.
3. Explain how to take a comparison test for phosphates and what to do if you have a low reading.
4. Explain how a sulphite determination is done, and how to add sodium sulphite when it is low.
5. Explain how to find the total solids present in the water, and how to blow down the boiler.
6. Explain surface blow to control surface film to reduce surface tension.
7. Explain the batch method compared with continuous feeding of chemicals into a boiler.
8. Explain that level of chemicals and total solids are determined by pressure-temperature within the vessel.

SUMMARIZE:

1. Testing boiler water
2. Adding chemicals
3. Control of solids

TESTING:

1. What tests are taken on boiler water?
2. How is the chemical level maintained?
3. What are total solids? Where do they come from?
4. How are total solids controlled?

ASSIGNMENT:

Complete Assignment 12-C-1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to explain the purpose of a blowdown tank.
2. Be able to locate the blowdown tank in the school plant.

AIDS:

1. Overhead projector
2. Transparency of blowdown tank

PROCEDURE:

1. Discuss the purpose of a blowdown tank.
2. Explain why it is located between the boiler and the sewer system.
3. Using the transparency, explain how the blowdown tank functions. Name all of the parts.

SUMMARIZE:

1. Reasons for blowing down
2. Purpose of tank
3. How it works

TESTING:

1. Why can't we connect the blowdown link to the sewer system?
2. What is the purpose of the tanks?
3. How does the tank function?

ASSIGNMENT:

Complete Assignment 12-C-2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain the terminology and uses of compressed air.
2. Be able to explain the principles of operation of a compressed air system.
3. Be able to explain the A.S.M.E. Code requirements.

AIDS:

1. Overhead projector
2. Transparencies on types of compressors

PROCEDURE:

1. Discuss uses of compressed air.
2. Discuss reciprocating and centrifugal types.
3. Discuss type of compressor requiring lubrication and dangers involved.
4. Discuss:
   a. Free air
   b. Capacity
   c. Piston displacement
   d. Displacement per minute
5. Using transparencies, discuss types of compressors.

SUMMARIZE:

1. Uses
2. Dangers such as oil, etc.

TESTING:

1. When figuring piston displacement per cubic foot per minute in multistage compressor, do you use a high-pressure cylinder, a low-pressure cylinder, or both? Explain.

ASSIGNMENT:-

Complete Assignment 13-A-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to identify the parts of a compressed air system.
2. Be able to describe a compressed air cycle.

AIDS:

1. Overhead
2. Transparency of air compressor showing components.

PROCEDURE:

1. Using transparency, discuss air cycle. Start at air intake and end at air receiver.
2. Explain the purpose of each component found in the system.
3. Explain why synchronous motors must start under no-load conditions.
4. Discuss the piston speed limitations of reciprocating compressors.
5. Explain the need for cooling water in the system.
6. Explain what is meant by a coded tank.
7. Discuss why receivers must be inspected and by whom.

SUMMARIZE:

1. Need for clean filtered air.
2. Air cycle

TESTING:

1. What would happen if you tried to start a synchronous motor driven compressor under load?

ASSIGNMENT:

Complete Assignment 13-B-1 in Related Science Manual–2.

OBJECTIVE:

1. Be able to calculate the capacity of an air compressor.

AIDS:

1. Blackboard

PROCEDURE:

1. Explain the factors that can affect the capacity of an air compressor.
2. Explain efficiency, and discuss the factors that affect it.
3. Review Boyle's Law of Pressure and Volume (constant temperature).
4. Show and explain how to derive the formula:

$$\text{Cubic Feet/Min} = \frac{15 \times A_C \times L_S \times N}{P_2}$$

from $P_1V_1 = P_2V_2$

5. Show and explain two sample problems. Use the following values:

   a. 10" X 12" double acting machine running at 300 r.p.m. and discharging at 90 p.s.i.

   b. 16" X 14" double acting machine running at 200 r.p.m. and discharging at 75 p.s.i.

SUMMARIZE:

1. The formula:

$$\text{Cubic Feet/ Min} = \frac{15 \times A_C \times L_S \times N}{P_2}$$

2. Solving the sample problems

TESTING:

1. Have the class do two air capacity problems, and discuss the results in class.

ASSIGNMENT:

Complete Assignment 13-B-1-M1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to start and stop a two-stage compressor.
2. Be able to determine what air compressor readings should be taken and recorded.

AIDS:

1. Overhead projector
2. Transparency 13-C-1-1

PROCEDURE:

1. Discuss why compressors must start up on No-Load.
2. Using transparency review start up procedure.
3. Discuss the shut down procedure.
4. Explain the importance of hourly readings.
5. Discuss the machine "Trip Out" if it is started under load.

SUMMARIZE:

1. Start up
2. Shut down

TESTING:

1. Can the compressor be started up under load?

ASSIGNMENT:

Complete Assignment 13-C-1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to describe the required maintenance for air compressors.

AIDS:

1. Blackboard

PROCEDURE:

1. Using the blackboard, discuss manufacturer's recommendations on first 50 hours, first 200 hours, and every 4000 hours.
2. Show how to set up a maintenance schedule.
3. Discuss need for clean air.
4. Explain importance of oil change and reason for special high flash oil.

SUMMARIZE:

1. Preventative maintenance is better than repair maintenance.

TESTING:

1. Why is a maintenance schedule important?

ASSIGNMENT:

Complete Assignment 13-D-1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to explain the safety practices and procedures to follow when working with electrical equipment.

AIDS:

1. Shop – electrical safety list

PROCEDURE:

1. Discuss the uses of electricity in the modern plant.
2. Discuss each rule and regulation on the electrical safety list.
3. Explain how accidents can be prevented by practicing safety at all times.

SUMMARIZE:

1. All rules and regulations on safety list.

TESTING:

1. List as many safety rules as you can.
2. What are the main causes of electrical accidents?

ASSIGNMENT:

Complete Assignment 14-A-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to define voltage, amperage, ohm, wattage, direct current, and alternating current.
2. Ohm's Law
3. Electrical power

AIDS:

1. Blackboard

PROCEDURE:

1. Review basic terms:
   a. Volt
   b. Ampere
   c. Ohm
   d. Watt
   e. D.C. and A.C.
2. Explain Ohm's Law for the relationship between voltage, resistance, and current in a D.C. circuit.
3. Show and explain the equation:
   $E = I \times R$
4. Show how to use Ohm's Law by doing a sample problem.
5. Explain electrical power in terms of
   Watts = Voltage X Amperage
6. Show how to combine the two equations:
   $E = IR$ and $W = EI$
7. Show how to calculate total power in a circuit. Solve at least two problems.
8. Show how to convert watts to kilowatts.

SUMMARIZE:

1. Terms: volt, amp, ohm, watt, A.C. and D.C.
2. Ohm's Law and a problem using Ohm's Law.
3. Formulas for power:
   $W = E \times I$, $W = \frac{E^2}{R}$ $W = I^2R$
4. Solve power problems.

TESTING:

1. Discuss electrical terms: volt, amp, ohm, watt, A.C. and D.C.
2. What is Ohm's Law, and where is it used?
3. Have students set up a problem that can be solved with Ohm's Law.

4. How can the power in an electrical circuit be found?
5. Discuss the formulas that can be used to find power.
6. Have the students solve a power problem.

ASSIGNMENT:

Complete Assignment 14-B-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to identify electrical circuits.
2. Be able to solve problems in series, parallel, and series-parallel circuits for voltage, amperage, and resistance.
3. Be able to solve problems for total power in a circuit.

AIDS:

1. Blackboard

PROCEDURE:

1. Show a series circuit, and explain that the current is the same throughout the circuit.
2. Explain that the current is dependent upon the total resistance, and show how to calculate the current in the circuit.
3. Show that the sum of the voltages across each resistor is equal to the applied voltage in a series circuit.
4. Show a parallel circuit, and explain that the voltage is the same across each branch.
5. Explain that the current in each branch of the circuit is dependent upon the resistance and voltage in that branch.
6. Explain that the total current equals the sum of the branch currents.
7. Show how to find the total resistance in a parallel circuit.
8. Show a series-parallel circuit, and explain that it must be broken up into simpler series of parallel circuits for problem solving.
9. Explain how power is calculated in an electrical circuit.
10. Set up and solve two series-parallel problems for resistance, current, voltage, and power.

SUMMARIZE:

1. Series circuits
2. Parallel circuits
3. Series-parallel circuits
4. Solution of problems in each of the above circuits

TESTING:

1. How do you find the total resistance in a series, parallel, and series-parallel circuit?
2. How do you find the current in a series, parallel, and series-parallel circuit?
3. How can the power used in a circuit be determined?

ASSIGNMENT:

Complete Assignment 14-B-2 in Related Science Manual—2.

OBJECTIVES:

1. Be able to describe how the pressure-trol, aquastat, and low water cutoff are connected in the burner control circuit.

AIDS:

1. Blackboard
2. Cutaway models of pressure-trol
3. Aquastat and low water cutoff

PROCEDURE:

1. Explain the function of the following controls:
   a. Pressure-trol
   b. Aquastat
   c. Low water cutoff
2. Show the cutaway models, and explain how the wiring connections are made.
3. Show a line drawing of how the controls will be wired together electrically.
4. Explain the purpose of the transformer and how it protects the system.
5. Explain briefly how the coil operates the relay for burner circuit.

SUMMARIZE:

1. The basic circuit
2. How it functions
3. The safety of these controls.

TESTING:

1. What is the purpose of the pressure-trol, aquastat, and the low water cutoff?
2. How is the basic control circuit of a burner wired?
3. From where is the power for the circuit taken?
4. What does the relay coil do?

ASSIGNMENT:

Complete Assignment 14-B-3 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain the purpose of starters, relays, and switches.
2. Be able to explain how the starters and relays function.

AIDS:

1. Overhead projector
2. Transparencies of relays, starters, and switches.

PROCEDURE:

1. Explain what a relay is and how it functions.
2. Explain that relays are made for many functions and may have one or more pairs of contacts.
3. Explain what starters are including overload protection.
4. Using a line drawing, show a simple starter circuit.
5. Discuss the purpose and types of manual and automatic switches. Use examples from power plants.
6. Discuss the transparencies of relays, starters, and switches. What is the function of each?

SUMMARIZE:

1. Purpose and function of relays
2. Purpose and function of starters
3. Purpose and function of switches

TESTING:

1. How does a relay work?
2. What are the types of relays?
3. How does a starter work?
4. What can a starter control?
5. Name some of the different types of switches.

ASSIGNMENT:

Complete Assignment 14-C-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain the purpose of fuses, breakers, and heaters.
2. Be able to explain how fuses, breakers, and heaters function.

AIDS:

1. Fuses, circuit breaker, and a relay with heaters

PROCEDURE:

1. Explain the purpose of fuses, circuit breakers and heaters.
2. Explain where fuses, circuit breakers, and heaters are used.
3. Explain the functions of fuses, circuit breakers, and heaters.
4. Discuss the importance of using the correct size for a given circuit.
5. Discuss the advantages and disadvantages of fuses, breakers, and heaters.
6. Show students the various fuses, circuit breakers, and heaters.

SUMMARIZE:

1. The purpose of fuses, circuit breakers, and heaters.

TESTING:

1. Where are fuses used? Why?
2. Where are circuit breakers used? Why?
3. Where are heaters used? Why?

ASSIGNMENT:

Complete Assignment 14-C-2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe the types of basic electrical meters.
2. Be able to explain the uses of basic electrical meters.

AIDS:

1. Voltmeter, ohmmeter, ammeter, and megger.

PROCEDURE:

1. Show and explain the various types of electrical meters available.
2. Explain how each one is used.
3. Discuss trouble shooting with electrical meters.
4. Stress the need to understand the use of a meter before you use it to prevent damage and extensive repairs.
5. Explain the need for caution when working on live electrical equipment.

SUMMARIZE:

1. Types of meters
2. How to use each type

TESTING:

1. Name each type of meter discussed.
2. For what is type of meter used?

ASSIGNMENT:

Complete Assignment 14-D-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to take over a shift.
2. Be able to perform the routine duties of a boiler operator.

AIDS:

1. Blackboard

PROCEDURE:

1. Discuss the State rules and regulations for boiler operation.
2. Discuss the reasons why it is important to take over a shift properly.
3. Discuss the procedure on how to take over a boilerroom shift.
4. Discuss the reasons why it is important for the student to know the routine duties of a boiler operator.

SUMMARIZE:

1. Review the procedure for taking over a shift and the routine duties of a boiler operator.

TESTING:

1. Name six things that the boiler operator must do when taking over a shift.
2. Name six things that the boiler operator is responsible for when he is operating a boiler plant.

ASSIGNMENT:

Complete Assignment 15-A-1 in Related Science Manual–2.

OBJECTIVES:

1. Be able to describe the routine procedure for starting up a boiler plant.
2. Be able to describe the routine procedure for shutting down a boiler plant.
3. Be able to describe the routine procedure for laying up a boiler – wet or dry.

AIDS:

1. Blackboard

PROCEDURE:

1. Discuss reasons for a thorough plant check before lighting off.
2. Explain why boiler must be carefully inspected.
3. Discuss reasons for State or insurance inspection for plants that have been idle for over a year.
4. Discuss the suggested startup procedure.
5. Discuss suggested shutdown procedure.
6. Stress importance of proper use of drains.
7. Explain reasons for proper layup of boilers.
8. Discuss reasons for a wet or dry layup.
9. Explain use of chemicals and the reasons for their use for layup, etc.
10. Discuss removal of ash, coal, and soot.

SUMMARIZE:

1. Reason for establishing a startup routine.
2. Reason for establishing a shutdown routine.

TESTING:

1. Who decides how to layup a boiler?

ASSIGNMENT:

Complete Assignment 15-A-2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to handle low water in a steam boiler.
2. Be able to handle high water in a steam boiler.

AIDS:

1. Blackboard

PROCEDURE:

1. Discuss the danger of a low water condition in the boiler.
2. Discuss the causes of low water conditions.
3. Describe the effects to the boiler of a low water condition.
4. Explain how to prevent a low water condition.
5. Discuss the procedure for handling a low water condition.
6. Discuss the dangers of a high water condition.
7. Discuss the possible reasons for high water conditions.
8. Discuss the procedure for handling high water conditions.
9. Discuss the importance of the operator being alert at all times.

SUMMARIZE:

1. Procedure on handling low water
2. Procedure on handling high water

TESTING:

1. How do you take care of low water condition?
2. How do you take care of high water condition?

ASSIGNMENT:

Complete Assignment 15-C-1 in Related Science Manual–2.

OBJECTIVE:

1. Be able to know what to do if you have a flame failure.

AIDS:

1. Blackboard

PROCEDURE:

1. Discuss flame failure control on a package boiler.
2. Explain how to handle a flame failure on a package boiler.
3. Discuss what is meant by a furnace explosion.
4. Explain how to handle a flame failure on a large boiler without flame failure protection.
5. Discuss reasons for flame failure with oil, gas, and coal.

SUMMARIZE:

1. Danger of flame failure
2. How to prevent furnace explosion

TESTING:

1. Is it necessary to purge a pulverized coal furnace after a flameout?

ASSIGNMENT:

Complete Assignment 15-C-2 in Related Science Manual–2.

OBJECTIVES:

1. Be able to explain why the fire side and the water side of boilers must be kept clean.
2. Be able to explain the necessity of boiler inspection.
3. Be able to explain the purpose of boiler layup.
4. Be able to replace boiler gage glass.

AIDS:

1. Blackboard

PROCEDURE:

1. Discuss sulfur and its effects on boiler metal.
2. Discuss the insulating quality of soot.
3. Explain why scale can build up.
4. Discuss formation of sludge and sediment.
5. Explain danger of scale, sludge, and sediment buildup.
6. Explain the law on inspection boiler certificates, fines, etc.
7. Discuss how to prepare boiler for inspection. Stress safety.
8. Review basic boiler layup.
9. Discuss changing of gage glass on dead boiler and on live boiler.

SUMMARIZE:

1. Proper routine cleaning and maintenance means safer and efficient boiler.

TESTING:

1. Who issues boiler certificates?
2. Where must they be posted?
3. What fines are involved?

ASSIGNMENT:

Complete Assignment 16-A-1 in Related Science Manual–2.

OBJECTIVE:

1. Be able to explain the basic burner routine for rotary cup, air atomizing, and gas burners.

AIDS:

1. Overhead projector
2. Transparencies of rotary cup, air atomizing, and gas burners.

PROCEDURE:

1. Using overhead projector and transparency of rotary cup burner, discuss:
   a. General maintenance
   b. Daily maintenance
   c. 3-week maintenance
   d. 3-month maintenance
   e. Annual maintenance
2. Using transparency on air atomizing HEV-E-OIL burner, discuss maintenance on:
   a. Metering oil pump
   b. Primary air pump
   c. Air pump lubrication system
   d. Oil air tank
   e. Oil nozzle
3. Using transparency on Bryant gas burner, discuss maintenance on:
   a. Gas lines to burner
   b. Pressure regulator
   c. Pilot lines
   d. Ignition electrode

SUMMARIZE:

Maintenance will vary with type of plant equipment.

TESTING:

1. Why should all plants develop a planned routine schedule of maintenance?

ASSIGNMENT:

Complete Assignment 16-B-1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to explain basic valve care.

AIDS:

1. Cutaways of several valves.

PROCEDURE:

1. Explain how the valve functions.
2. Explain where stress is set up in the valve.
3. Explain what happens when too much stress is set up in the valve.
4. Discuss the effects of a leaking valve.
5. Explain packing and gland servicing.
6. Explain why the disc, gate, and seat have to be renewed or ground.
7. Explain the reasons for good servicing and maintenance.
8. Explain valve service selection.

SUMMARIZE:

1. Function of valves
2. Basic servicing

TESTING:

1. What parts of a valve wear?
2. What would you consider routine service on a valve?
3. Why is it important to have all valves in good condition?

ASSIGNMENT:

Complete Assignment 16-C-1 in Related Science Manual—2.

OBJECTIVE:

1. Be able to explain basic pump care and service.

AIDS:

1. Cutaway of a pump or transparency of pump

PROCEDURE:

1. Show and describe the parts that wear on a pump.
2. Discuss packing and packing glands versus mechanical shaft seals.
3. Discuss bearing and bearing wear.
4. Discuss shaft wear and its effect on packing and pump operation.
5. Explain the purpose and types of lubrication used on pumps.
6. Discuss the importance of maintaining pump in good operating condition.

SUMMARIZE:

1. Packing and seals
2. Bearings
3. Lubrication

TESTING:

1. What parts wear on a pump?
2. What care is given to packing glands and mechanical shaft seals?
3. Discuss bearing life on a pump.
4. Discuss pump lubrication.

ASSIGNMENT:

Complete Assignment 16-C-2 in Related Science Manual–2.