BOILER OPERATOR

STUDY GUIDE

ARKANSAS DEPARTMENT OF LABOR
BOILER INSPECTION SECTION
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Arkansas
Department of Labor
Boiler Inspection Division

Boiler Operator Study Guide

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PLEASE NOTE:

THE BACK PAGE OF THIS STUDY GUIDE IS YOUR APPLICATION TO TAKE THE BOILER OPERATOR EXAMINATION.

YOU MUST BRING THE COMPLETED APPLICATION WITH YOU WHEN YOU COME FOR TESTING ALONG WITH THE TESTING FEE OF $25.00.

THIS APPLICATION MUST BE SIGNED BY SOMEONE VERIFYING YOUR 6-MONTHS ON-THE-JOB TRAINING.

THE BOILER OPERATOR EXAMINATION AND FIRST YEAR LICENSE IS $25.00.

EACH TIME THE TEST IS TAKEN, A NEW APPLICATION AND $25.00 TESTING FEE MUST BE SUBMITTED.

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THIS IS A GENERAL STUDY GUIDE. THE SAMPLE QUESTIONS ARE ONLY EXAMPLES OF POSSIBLE QUESTIONS ON THE EXAMINATION.

GENERAL INFORMATION AND SAMPLE STUDY QUESTIONS

BOILERS SUBJECT TO BE OPERATED BY LICENSED OPERATORS AND QUALIFICATIONS FOR LICENSING

This Division is regularly requested by employers, companies, owners and operators of steam boilers to advise the recommended qualifications necessary in order for an operator to participate in an examination and obtain a boiler operator license as required by the State of Arkansas Boiler and Pressure Vessel Law, Act 494 of 1961.

The Arkansas Boiler Safety Law, Act 494 of 1961, Section 7, provides the following:

"All boilers subject to the provisions of this Act shall either (1) be continuously monitored by a mechanical or electronic devise approved by the Director of the Arkansas Department of Labor, or (2) be checked at least once each hour when a plant is in operation or when any public building is occupied, provided such boilers are equipped with approved-type automatic appliances. Boilers that are manually operated must be under constant attendance whenever they are in use for any purpose. Boilers fifty (50) horsepower and over, as rated by the manufacturer, and boilers used in hospitals, hotels, schools, theatres, and office buildings, but not limited to must be under regular attendance by a licensed operator who holds a certificate of competency issued by the Boiler Inspection Division.

The Boiler Inspection Division shall conduct examinations for each applicant seeking a boiler operator's license. The examination may be either written or oral.

Each applicant shall pay a fee of twenty-five ($25.00) dollars for the examination and first license. Each license must be renewed annually. The annual renewal fee shall be seventeen ($17.00) dollars. Before the applicant may participate in an examination, he must have had not less than six (6) months' on-the-job training. Proof of proper training must be furnished to the Department prior to examination.

Any operator found operating a boiler without a certificate issued by the Boiler Inspection Division, or operating a boiler knowing it to be defective, shall have his license revoked at once."

It is important that the Boiler Operator have a thorough knowledge and understanding of the purpose of the following valves, controls and fittings, as required on steam boilers:

1. **SAFETY VALVE: Prevents boiler pressure from rising above the setting of the valve by relieving excessive steam pressure, guarding against hazards of over pressure.**

2. **STEAM SUPPLY STOP VALVE: The valve installed at the steam outlet of the boiler to shut off the flow of steam.**

3. **STEAM PRESSURE GAUGE: Indicates the steam pressure in the boiler in pounds per square inch.**

4. **STEAM GAUGE SYPHON:** **The device installed between the steam gauge and the boiler to provide a water seal, so that live steam will not enter the gauge to cause a false reading or damage to the gauge.**

5. **INSPECTOR'S TEST G AUGE CONNECTION AND COCK:** **Provides the necessary connection to check the accuracy of the steam pressure gauge on the boiler.**

6. **WATER COLUMN:** **The hollow casting or forging connected at the top to the boiler's steam space and at bottom to the water space. The water gauge glass and water test cocks are installed on the column.**

7. **WATER GLASS AND GAUGE FIXTURES:** **To visibly show the water level in the boiler.**

8. **WATER TEST GAUGES OR TRY COCKS:** **For testing the water level in the boiler should the water glass be out of service temporarily for any reason.**

9. **DRAIN VALVE UNDER THE WATER COLUMN AND SWITCH:** **To provide a means for daily flushing under the water column and water level controls to keep the chamber and lines clean, so the water will register accurately in the glass. Also provides a means of testing the low water cutoff.**

10. **BLOWOFF VALVE:** **To provide a method of draining, flushing and blowing off the boiler at the low point to remove the concentrated solids, sediment, seals and sludge of keeping the boiler clean.**

11. **WATER FEED INLET STOP VALVE:** **The shutoff valve required next to the boiler on the water feed inlet, so that the entire line can be manually shut off if it is necessary to work on the pump or check valve. It should never be closed when the pump is to operate.**

12. **WATER FEED INLET CHECK VALVE:** **The check valve on the water feed inlet that closes to prevent steam or water from the boiler backing up into the water feed line.**

13. **LOW WATER CUTOFF:** **The control required on all boilers to shut off the main fuel burner when the water reaches the lowest, safe, permissible level.**

14. **STEAM PRESSURE OPERATING CONTROL:** **To maintain the desired steam operating pressure on the boiler by regulating the burner to the steam pressure setting.**

15. **HI-LIMIT PRESSURE CONTROL:** **Is in addition to the operating control to shut off the main fuel burner supply when the pressure in the boiler exceeds the desired maximum setting.**

16. **100% FLAME SAFEGUARD:** **The pilot safety device to shut off the main fuel burner valve and the pilot burner in the event of a pilot failure and to prevent the main burner from turning on until a safe pilot is established.**

"Any person found operating a boiler without an operator's license shall be subject to an administrative fine of not less than twenty-five dollars ($25.00) and not more than one hundred dollars ($100.00)."

The applicant who takes the Boiler Operator's Examination shall be a person who is familiar with the boiler or boilers and who has properly been instructed in their safe operation. The recommended minimum standards to be used by the employer to determine the competency of a person to participate in an examination to obtain an Operator's license are:

1. He shall be able to explain the function and operation of all controls on the boiler or boilers.

2. He shall be able to light off the boiler or boilers in a safe manner.

3. He shall know all possible methods of feeding water to the boiler or boilers.

4. He shall know how to blowdown the boiler or boilers in a safe manner.

5. He shall know what would happen if the water was permitted to drop below the lowest permissible operating level.

6. He shall know what would happen if the water in the boiler was carried too high.

7. He shall know how to shut down the boiler or boilers.

8. He shall understand and follow the daily operating, blowdown and maintenance instruction sheet as published by the Manufacturer.

9. He shall follow the proper Boiler Water Treating Program, established by the Manufacturer or by competent water treating personnel.

10. He shall thoroughly understand how to properly operate and maintain the boiler in a safe manner.

11. He shall possess such other qualifications as might be reasonably necessary for safe operation of the steam system.

12. He shall know the applicable laws and regulations required by the Arkansas Boiler Inspection Division.

13. Before placing a boiler in service, it is important to be certain that the boiler has been installed in compliance with the State Boiler code in every respect, all applicable permits secured, and the boiler installation be approved with the required Permit-to-Operate issued by the Arkansas Boiler Inspection Division.

Your compliance with the above requirements regarding the licensing of Boiler Operators in the State of Arkansas will be greatly appreciated. We must maintain competent safe operation of steam boilers at all times. There is no substitute for a dependable competent licensed Boiler Operator. Automatic controls and devices are helpers; not his replacement.

STUDY GUIDE SAMPLE QUESTIONS

1. Which valve is between the boiler and the return pump?

Answer: Check Valve

2. What is the function of the check valve?

Answer: To prevent the water from returning to the condensation tank from the boiler after the pump shuts off.

3. Four safety features required on the steam boiler are:

Answer: Safety relief valve, blow-down valve, low water cut-off, and pressure gauge

4. Safety relief valves should be set by:

Answer: Qualified safety valve technician/firm

5. Which pressure is considered to be that of a low-pressure boiler?

Answer: 0 – 15 PSI MAWP

6. What could happen if a steam valve is opened quickly?

Answer: Water could be siphoned out of the boiler causing damage to boiler and steam lines.

7. Why are steam lines insulated?

Answer: To prevent loss of heat during steam transfer.

8. What operating pressure indicates a high-pressure boiler?

Answer: 16 PSI and above

9. A steam valve should be opened slowly. True or false?

Answer: True

10. Improper mixtures of gas and air causes soot in boiler flues. True or false?

Answer: True

11. What is a water injector (feed pump)?

Answer: A mechanical device for forcing water into a boiler against high pressures.

12. What is the purpose of a baffle wall in a boiler?

Answer: To distribute flame evenly

13. If a boiler is not kept clean internally, scales will form and cause the boiler not to blister. True or false?

Answer: False

14. A boiler operator operating a boiler without a license shall be guilty of a misdemeanor and upon conviction thereof shall be punished by a fine of not less than $25.00 and not more than $100.00, and in addition may be imprisoned for not more than 2 years, or both. True or false?

Answer: True

15. A boiler operator must have the following number of months on-the-job training before he can take the operator's examination.

Answer: 6 months minimum

16. Water boilers at what temperature?

Answer: 212ºF

17. If you went into a boiler room and the fire was on, and there was not water in the boiler, you should immediately add water to the boiler. True or False?

Answer: False

18. In a fire tube boiler the water flows through the tubes.

Answer: False

19. In a water tube boiler the fire passes through the tubes.

Answer: False

20. What are the two basic types of boilers?

Answer: Fire tube and water tube

21. A gauge glass allows you to see how much water is in the boiler.

Answer: True

22. What is the purpose of a safety relief valve on the boiler?

Answer: To relieve the boiler pressure when it exceeds the MAWP (maximum allowable working pressure) and thereby prevent an explosion.

23. What is an induced draft?

Answer: Fan or fans on the exhaust side of boiler pulling air through the boiler.

24. A steam trap is a device used to release condensation and hold steam in a radiator or return line. True or false?

Answer: True

25. Should a pressure relief valve open when the MAWP is exceeded by 6%?

Answer: Yes

26. A boiler operator operating a boiler that he knows is unsafe may, or may NOT have his license revoked.

Answer: False

27. Which type of material is used for boiler gaskets?

Answer: Asbestos or Neoprene

28. The main purpose of draining the glass gauge is to verify that the pipes to the gauge are clean and open.

Answer: True

29. Water is changed to steam by:

Answer: The application of heat.

30. A safety device used to cut fuel to the boiler when the water level falls below a safe level.

Answer: Low-water cut-off

31. A low-water cut-off device does not affect the fuel to the boiler when the water level drops.

Answer: False

32. Valves on the water column to check the accuracy of glass gauge and determine the water level in a boiler, when glass gauge is suddenly broken are called:

Answer: Gauge cocks

33. You cannot check a safety relief valve by opening it at full working pressure.

Answer: False

34. A boiler is used for what purpose?

Answer: To produce steam or hot water for heat

35. The three most common fuels for firing boilers are coal, gas and oil.

Answer: True

36. The parts of a high-pressure boiler containing pressure (not fitting or appliances) are made out of:

Answer: Steel

37. The primary function of a boiler is to:

Answer: Produce steam

38. Water will boil and turn to steam at 212º degrees F at atmosphere pressure.

Answer: True

39. The two types of boilers are:

Answer: Fire tube and water tube

40. The three requirements for combustion are:

Answer: Fuel, heat and oxygen

41. The three most common fuels used in boilers are:

Answer: Coal, gas and oil

42. A high-pressure steam boiler operates at a pressure above 15 psi.

Answer: True

43. The heat and gases of combustion pass through the tubes in a fire tube boiler.

Answer: True

44. Boilers should be fired slowly when first starting up because of the following reason:

Answer: To allow the boiler to expand uniformly under the action of the increasing pressure.

45. Regardless of the type of fuel being used, before lighting a boiler during a cold start-up, the operator must first:

Answer: Check for the correct water level

46. As boiler steam pressure increases, there is a corresponding increase in the:

Answer: Temperature

47. Incomplete combustion can be caused by:

Answer: Lack of sufficient air supply to the fuel as it is being burned.

48. With the respect to the Arkansas Boiler and Pressure Vessel Law; Any operator found operating a boiler without a certificate issued by the Boiler Inspection Division, or operating a boiler knowing it to be defective shall:

Answer: Have his license revoked at once

49. The three types of drafts are:

Answer: Induced, Forced and Natural

50. In a water tube boiler, the heat and gases of combustion pass around the tubes.

Answer: True

*****STUDY GUIDE DEFINITIONS*****

A

ABSOLUTE PRESSURE- The sum of gauge pressure and atmospheric pressure.
ACCESSORY- Piece of equipment not directly attached to the boiler but necessary for its operation.
ACCUMULATION TEST- Test used to establish the relieving capacity of boiler safety valves.
AIR COCK- See BOILER VENT.
AIR EJECTOR- Steam-driven device that removes air and other noncondensable gases from the condenser, thus maintaining a higher vacuum.
AIR FLOW SWITCH- Proves that primary air is supplied to the burner.
AIR TO FUEL RATIO- Amount of air and fuel supplied to the burner over high and low fire.
AIR HEATER- Supplies heated air for combustion. Located in the breeching between the boiler and chimney.
AMBIENT TEMPERATURE- Temperature of the surrounding air.
ALKALINITY- Determined by boiler water analysis. Boiler water with a PH over 7 is considered alkaline.
ANTHRACITE COAL- Hard coal that has a high fixed carbon content.
ASH HOPPER- Large receptacle used to store ashes until they can be disposed of.
ASME CODE- Code written by the American Society of Mechanical Engineers that controls the construction, repairs and operation of steam boilers and their related equipment.
ATMOSPHERIC PRESSURE- Pressure at sea level (14.7 psi).
ATOMIZE- To break up liquid into a fine mist.
AUTOMATIC NONRETURN VALVE- Valve located on the steam line closest to the shell of the boiler that cuts the boiler in on the line and off-line automatically. This valve also protects the system in the event of a large steam leak on any boiler.
AUXILIARIES- Equipment necessary for the operation of a boiler.

B

BAFFLES- Direct the path of the gases of combustion so that the maximum heat will be absorbed by the water before the gases of combustion enter the breeching and chimney.
BALANCED DRAFT- When the intake damper is automatically controlled by the pressure in the furnace. Furnace pressure is maintained slightly below atmospheric pressure.
BENT-TUBE BOILER- A water tube boiler with more than one drum in which the tubes connect the drums.
BITUMINOUS COAL- Soft coal that has a high volatile content.
BLOWDOWN TANK- Coded tank vented to the atmosphere that protects sewer lines from boiler pressure and high temperature when blowing down.
BLOWDOWN VALVES- Found on the boiler blowdown line at the lowest part of the water side of the boiler.
BOILER CAPACITY- Pounds of steam per hour that a steam boiler is capable of producing.
BOILER EXPLOSION- Caused by a sudden drop in pressure (failure on the steam side) without a corresponding drop in temperature.
BOILER HORSEPOWER- The evaporation of 34.5 pounds of water per hour from and at a feedwater temperature of 212°F.
BOILERS IN BATTERY- Two or more boilers connected to a common steam header.
BOILER LAY-UP- Removing a boiler from service for an extended period of time. A boiler can be laid up wet or dry.
BOILER ROOM LOG- A data sheet used to record pressures, temperatures and other operating conditions of a boiler on a continuous basis.
BOILER SHUTDOWN- A sequence of operations completed when taking a boiler off-line.
BOILER START-UP- A sequence of operations completed when preparing a steam boiler for service.
BOILER TUBES- Used to carry water or heat and gases of combustion. May be straight or bent tubes.

BOILER VENT- Line coming off the highest part of steam side of the boiler that is used to vent air from the boiler when filling with water and when warming the boiler. Also used to prevent a vacuum from forming when taking the boiler off-line. Also known as air cock.
BOURDON TUBE- Connected by linkage to a pointer that registers pressure inside pressure gauges.
BOX HEADER- Requires staybolts to prevent the headers from bulging. Found on older water tube boilers.
BREECHING- Duct connecting boiler to chimney.
BRITISH THERMAL UNIT (BTU)- A measurement of the quantity of heat. The quantity of heat necessary to heat one pound of water to 1°F.
BURNING IN SUSPENSION- Combustion of a fuel when burned in air without support.
BUTTERFLY VALVE- A balanced valve used to control gas flow to gas-fired boilers.
BYPASS DAMPER- Controls the air temperature in air heaters to prevent corrosion.
BYPASS LINE- A pipeline that passes around a control, heater or steam trap. Used so that a plant can operate while equipment is serviced or repaired.

C

CALIBRATE- Adjusting a pressure gauge to conform to a test gauge.
CARRYOVER- Particles of water that flow with the steam into the main steam line.
CAUSTIC EMBRITTLEMENT- The collection of high alkaline material that leads to breakdown and weakening of boiler metal.
CENTRIFUGAL FORCE- Force caused by a rotating impeller that builds up in a centrifugal pump. Most boiler feed pumps are this type.
CENTRIFUGAL PUMP- Works on the principle of centrifugal force that is converted into pressure.
CHAIN (TRAVELING) GRATE STOKER- A cross-feed stoker that is used with larger capacity boilers because of its ability to feed coal at a faster rate than other stokers.
CHECK VALVE- Automatic valve that controls the flow of a liquid in one direction.
CHEMICAL COMPOUND- Formed when two or more chemical elements combine into a new substance.
CHEMICAL CONCENTRATION- The amount of a specific chemical in the boiler water.
CHEMICAL ENERGY- Energy in the fuel converted to heat energy during the combustion process.
CHIMNEY- Used to create draft. Also an outlet to the atmosphere for the gases of combustion.
COAL BUNKER- An overhead bin where large quantities of coal are stored.
COAL CONVEYOR- Mechanism on a stoker that moves coal to the coal scale.
COAL FEEDER- Controls the flow of coal entering the pulverizer.
COAL GATE- Used to control the depth of coal entering the boiler furnace on chain grate stokers.
COAL RAM- Distributes coal evenly into the center retort on underfeed stokers and forces the coal up to the top where it is burned.
COAL SCALE- Measures and records the amount of coal fed to stoker-fired or pulverized coal fired boilers.
COMBUSTIBLE MATERIAL- Any material that burns when it is exposed to oxygen and heat.
COMBUSTION- The rapid union of oxygen with an element or compound that results in the release of heat.
COMBUSTION CONTROL- Regulates the air to fuel ratio supplied to the burner.
COMPLETE COMBUSTION- The burning of all supplied fuel using the minimum amount of excess air.
COMPRESSIVE STRESS- Occurs when two forces of equal intensity act from opposite directions, pushing toward the center of an object. Fire tubes in a fire tube boiler are subjected to compressive stress.
CONDENSATE- Steam that has lost its heat and has returned to water.
CONDENSATE PUMP- Used to return condensed steam to the open feedwater heater.
CONDENSATE TANK- Where condensed steam (water) is stored before it is delivered back to the open feedwater heater by the condensate pump.
CONDENSE- Process whereby steam turns back to water after the removal of heat.
CONDUCTION- A method of heat transfer in which heat moves from molecule to molecule.

CONDUCTIVITY- A measure of the ability of electrons to flow through a solution.
CONTINUOUS BLOWDOWN- Used to control chemical concentrations and total dissolved solids in the boiler water.
CONVECTION- A method of heat transfer that occurs as heat moves through a fluid.
CONVECTION SUPERHEATER- Located in a boiler and receives heat from convection currents.
COUNTERFLOW- Principle used in heat exchangers where the medium being heated flows in one direction and the medium supplying the heat flows in the opposite direction.
CRACKING OPEN- Slowing opening a steam valve to allow pressure to equalize.
CROSS "T" - Used on connections on a water column for inspection of steam and water lines to ensure they are clean and clear.
CYCLONE SEPARATOR- Separates water droplets from steam using centrifugal force and by changing direction.

D

DAMPER- Used to control the flow of air or gases.
DATA PLATE- A plate that must be attached to a safety valve containing data required by the ASME code.
DEADWEIGHT TESTER- Used to test a pressure gauge so that it can be recalibrated.
DEAERATING FEEDWATER HEATER- Type of open feedwater heater equipped with a vent condenser.
DESUPERHEATING- Removing heat from superheated steam to make it suitable for process.
DISCHARGE PIPING- Piping attached to the outlet side of a safety valve that conveys steam to the atmosphere.
DRAFT- The difference in pressure between two points that causes air or gases to flow.
DRY PIPE SEPARATOR- A closed pipe perforated at the top with drain holes on the bottom that remove moisture from the steam.
DUPLEX STRAINERS- Remove solid particles from the fuel oil in fuel oil systems.

E

ECONOMIZER- Uses the gases of combustion to heat the feedwater.
ELEMENT- A basic substance consisting of atoms.
ENTHALPY- Total heat in the steam.
EROSION- Wearing away of metal caused by the wet steam.
EQUALIZING LINE- Line used to warm up the main steam line and equalize the pressure around the main steam stop valve.
EVAPORATION TEST- Test that checks the operation of the low water fuel cutoff.
EXCESS AIR- Air more than the theoretical amount of air needed for combustion.
EXHAUSTER- Discharges a mixture of coal and warm air to the burner.
EXPANSION BENDS- Installed on boiler main steam lines to allow for expansion and contraction of the lines.
EXTERNAL TREATMENT- Boiler water treated before it enters the boiler to remove scale-forming salts, oxygen and noncondensable gases.
EXTRACTION STEAM- Steam that is extracted from a steam turbine at a controlled pressure for process.

F

FEEDWATER- Water that is supplied to the steam boiler.
FEEDWATER HEATER- Used to heat feedwater before it enters the steam and water drum.
FEEDWATER LINES- Lines leaving the open feedwater pump and going to the boiler.
FEEDWATER PUMP- Takes water from the open feedwater heater and delivers it to the boiler at the proper pressure.
FEEDWATER REGULATOR- Control used to maintain a NOWL that cuts down the danger of high or low water.

FEEDWATER TREATMENT- Can be internal, using chemicals, or external, using water softeners. Protects boiler from scale and corrosion.
FIELD-ERECTED BOILER- Boiler that must be erected in the field because of its size and complexity.
FIREBOX- The part of the boiler where combustion of fuel takes place.
FIRE TUBE BOILER- Has heat and gases of combustion passing through tubes surrounded by water.
FIRING RATE- Amount of fuel the burner is capable of burning in a given unit of time.
FITTINGS- Trim found on the boiler that is used for safety, and/or efficiency.
FLAME FAILURE- When the flame in the furnace goes out.
FLAME SCANNER- Device found on a boiler that proves pilot and main flame.
FLAREBACK- Flames discharging from the boiler through access doors or ports caused by delayed ignition or furnace pressure buildup.
FLASH ECONOMIZER- A heat recovery system used to reclaim the heat from the boiler blowdown water and used in conjunction with the continuous blowdown system.
FLASH POINT- Temperature at which fuel oil, when heated, produces a vapor that flashes when exposed to an open flame.
FLASH STEAM- Created when water at a high temperature has a sudden drop in pressure.
FLASH TANK- Used with a continuous blowdown system to recover the flash steam from the water being removed from the steam and water drum.
FLAT GAUGE GLASS- Type of gauge glass used for pressure over 250 psi.
FLEXIBLE JOINT- Used to allow for expansion and contraction of steam or water lines.
FLOW METER- Meter used to measure the flow of steam or water in the system.
FLY ASH- Small particles of noncombustible material found in gases of combustion.
FLY ASH PRECIPITATOR- An electric device that traps and holds fly ash until it is properly disposed of.
FOAMING- Rapid fluctuations of the boiler water level that can lead to priming or carryover. Caused by impurities on the surface of the boiler water.
FORCED DRAFT- Mechanical draft produced by a fan supplying air to the furnace.
FREE-BLOWING DRAIN- Used to remove condensate from the main steam line.
FRONT HEADER- Connected to the steam and water drum by downcomer nipples.
FUEL OIL HEATER- Used to heat fuel oil so it can be pumped and is at the correct temperature for burning. Can be electric or steam.
FUEL OIL PUMP- Pump that takes fuel oil from the fuel oil tank and delivers it to the burner at the proper pressure.
FURNACE EXPLOSION- Occurs when fuel or combustible gas build up in the fire side of the boiler.
FURNACE VOLUME- Amount of space available in a furnace to complete combustion.
FYRITE ANALYZER® - Instrument used to measure the percentage of carbon dioxide in the gases of combustion.

G

GALVANOMETER- Used to measure small electric currents.
GAS ANALYZER- Used to analyze the gases of combustion to determine combustion efficiency.
GAS CALORIMETER- Used to determine the BTU content of natural gas.
GAS COCK- A manual quick-closing shutoff valve.
GAS LEAK DETECTOR- Device used to locate gas leaks in a boiler room.
GAS MIXING CHAMBER- Where air and gas mix before they enter the furnace in low pressure gas burners.
GAS PRESSURE REGULATOR- Used to supply gas to the burner at the required pressure needed for combustion of the gas.
GASES OF COMBUSTION- Gases produced by the combustion process.
GATE VALVE- Valve used on boilers as the main steam stop valve that when open offers no restriction to flow. Must be wide open or fully closed.
GAUGE GLASS- Device installed on water column to visually check the water level (may be tubular or flat). Lowest visible level must be 3 inches above the tubes on horizontal fire tube boilers.

GAUGE GLASS BLOWDOWN VALVE- Valve used to remove any sludge and sediment from gauge glass lines.
GAUGE PRESSURE- Pressure above atmospheric pressure that is read on a pressure gauge and is recorded as psi or psig.
GLOBE VALVE- Used to take a piece of equipment out of service for maintenance. Used in conjunction with a bypass line and bypass valve.
GRADE- Refers to the size, heating value and ash content of coal.
GRATES- Where the combustion process starts in a coal-fired furnace.

H

HANDHOLE- A part found on both fire tube and water tube boilers that is removed when cleaning the water side of the boiler.
HEAT ENERGY- Kinetic energy caused by molecular motion within a substance.
HEAT EXCHANGER- Any piece of equipment where heat is transferred from one substance to another.
HEAT RECOVERY SYSTEM- Equipment that is installed to reclaim heat that is normally lost during the blowdown process.
HEAT TRANSFER- Movement of heat from one substance to another that can be accomplished by radiant conduction or convection.
HEATING SURFACE- That part of the boiler that has heat and gases of combustion on one side and water on the other.
HEATING VALUE- Expressed in BTU's per gallon or per pound. Heating value varies with the type of fuel used.
HIGH AND LOW WATER ALARM- Warns the operator of high or low water.
HIGH FIRE- Point of firing cycle when burner is burning the maximum amount of fuel per unit of time.
HIGH PRESSURE STEAM BOILER- Boiler that operates at a steam pressure over 15 psi and over 6 boiler horsepower.
HORIZONTAL RETURN TUBULAR BOILER- Type of fire tube boiler that consists of a drum suspended over the firebox.
HOT WELL- A reservoir located at the bottom of a condenser where condensate collects.
HUDDLING CHAMBER- Part on a safety valve that increases the area of the safety valve disc, thus increasing the total upward force, causing the valve to pop open.
HYDRAULIC COUPLING- Coupling between the drive element and fan or pump.
HYDROGEN- A basic element present in gas, coal and fuel oil.
HYDROSTATIC PRESSURE- Water pressure per vertical foot (.433) exerted at the base of a column of water.
HYDROSTATIC TEST- Water test made on a boiler after repair work on the steam or water side or overheating of boiler metal.

I

IGNITION- The lightoff point of a combustible material.
IGNITION ARCH- Made of refractory material that absorbs the heat from the fire and radiates it back to the green coal.
IMPELLER- The rotating element found in a centrifugal pump that converts centrifugal force into pressure.
IMPINGMENT (FUEL OIL)- Fuel oil striking brickwork or the boiler heating surface that results in formation of carbon deposits and smoke.
INCOMPLETE COMBUSTION- Occurs when all the fuel is not burned, resulting in the formation of smoke and soot.
INDUCED DRAFT- Draft that is produced mechanically using a fan located between the boiler and the chimney.
INFRARED- Invisible light rays produced by the combustion process and detected by a flame scanner.

INSULATION- Material used to cover steam, water, and fuel oil lines to cut down on radiant heat losses.
INTEGRATOR- A calculating device used on differential-pressure flow meters to determine hourly or daily flow rates.
INTERLOCK- Used with burner controls to ensure proper operating sequence.
INTERNAL FEEDWATER LINE- Perforated line located at the NOWL in the boiler that distributes the relatively cool feedwater over a large area to prevent thermal shock to the boiler metal.
INTERNAL FURNACE- Furnace that is located within the boiler and is surrounded by water in the scotch marine boiler.
INTERNAL OVERFLOW- A pipeline located in an open feedwater heater that prevents the water level from exceeding a fixed level and flooding the system.
INTERNAL TREATMENT- The addition of chemicals directly into the boiler water to control pitting, scale and caustic embrittlement.
INSTRUMENT (BOILER)- Device that measures, indicates, records and controls boiler room systems.
ION (ZEOLITE) EXCHANGER- Water softener that uses zeolite to soften water for use in the boiler.

L

LIGHTING OFF- The ignition of the fuel.
LIGNITE- Coal with a low heating value (BTU content) and a high moisture content.
LIME-SODA PROCESS- A process that uses lime and soda ash to soften water.
LIMIT CONTROL- A control switch that shuts off the fuel when temperature or pressure exceeds the normal operating control setting.
LIVE STEAM- Steam that leaves the boiler directly without having its pressure reduced in process operations.
LOW FIRE- Point of firing cycle where burner is burning the minimum amount of fuel per unit of time.
LOW PRESSURE STEAM BOILER- Boilers that operate at a steam pressure of no more than 15 psi.
LOW WATER- Whenever the water level in the gauge glass is below the NOWL.
LOW WATER FUEL CUTOFF- A device located a little below the NOWL that shuts off the boiler burner in the event of low water, preventing burning out of tubes and possible boiler explosion.

M

MAIN HEADER- That part of the system which connects boilers in battery and then distributes the steam to wherever it is needed.
MAIN STEAM STOP VALVE- Valve or valves found on the main steam line leaving the boiler.
MAKEUP WATER- Water that must be added to the boiler to make up for leaks in the system, water that is lost through boiler blowdowns, or condensate that is dumped because of contamination.
MALLEABLE IRON- Used for construction of water columns in boilers carrying a pressure between 250 psi and 350 psi.
MANHOLE- Opening found on the steam and water side of a boiler that is used for cleaning and inspection of the boiler.
MANOMETER- Instrument used to measure boiler draft.
MANUAL RESET VALVE- Used to secure the gas in the event of a low water condition or a pilot flame failure on a low pressure gas system.
MASTER CONTROL- Unit that receives the primary signal and relays signals to individual control units.
MAWP (MAXIMUM ALLOWABLE WORKING PRESSURE)- Determined by the design and construction of the boiler in conformance with the ASME code.
MERCURY SWITCH- Switch in which the movement of mercury in a capsule controls the flow of electricity in a circuit.
MICA- Used to protect the flat gauge glass from the etching action of steam and water.
MICROPROCESSOR- A computer acting as a flame-monitoring device that programs the burner, blower motor, ignition and fuel valves to provide for safe burner operation.

MODULATING MOTOR- Receives signals from the modulating pressure control and repositions the air to fuel ratio linkage.
MODULATING PRESSURE CONTROL- Located at the highest part of the steam side of the boiler and sends a signal to the modulating motor that controls firing rate.
MUD DRUM- Lowest part of the water side of a water tube boiler.
MULTIPLE-PASS BOILER- Boilers that are equipped with baffles to direct the flow of the gases of combustion so that the gases make more than one pass over the heating surfaces.

N

NATURAL DRAFT- Caused by the difference in weight between a column of hot gases of combustion inside the chimney and a column of cold air of the same height outside the chimney.
NATURAL GAS- A combustible gas found in pockets trapped underground that consists mainly of methane.
NONADHERING SLUDGE- Residue formed in a boiler when scale-forming salts are created by adding feedwater chemicals.
NONCONDENSABLE GASES- Gases found in boiler makeup water (oxygen) and in condensate returns.
NONVOLATILE- Any substance not easily vaporized under average temperature.
NORMAL OPERATING CONTROL - Device that controls pressure or temperature in a specific range (see PRESSURE CONTROL).
NOWL (NORMAL OPERATING WATER LEVEL)- Water level carried in the boiler gauge glass during normal operation (approximately one-third to one-half glass).

O

OIL SEPARATOR- A device that removes oil from the exhaust steam before it enters the open feedwater heater.
OPERATING RANGE- Range that must be set when using an ON/OFF combustion control in order to prevent extremes in firing rate.
ORIFICE PLATE- Plate with a fixed opening that is installed in a pipeline to give a certain pressure drop across the opening where liquid or steam is flowing.
ORSAT ANALYZER- A flue gas analyzer that measures the percentage of carbon dioxide, oxygen and carbon monoxide in the gases of combustion.
OUTSIDE STEM AND YOKE VALVE (OS&Y)- Shows by the position of the stem whether it is open or closed. Used as boiler main steam stop valves.
OVERFEED STOKER- Air introduced over the fire to aid in complete combustion. Used mostly when burning soft coal that has a high volatile content.

P

PACKAGE BOILER- Comes completely assembled with its own feedwater pumps, fuel system and draft fans.
PACKING GLAND- Holds packing or seals in place on valves and pumps to minimize leakage.
PERFECT COMBUSTION- Burning of all the fuel with the theoretical amount of air. Can only be achieved in a laboratory.
PILOT- Used to ignite fuel at the proper time in a firing cycle.
PIPELINE HEATER- Electric heater attached to the fuel oil line in order to maintain proper fuel oil temperature (viscosity) for moving fuel oil.
PNEUMATIC SYSTEM- A system of control that uses air as the operating medium.
PNEUMERCATOR- A fuel oil level indicating device that gives a direct reading in gallons.
POPPING PRESSURE- Predetermined pressure at which a safety valve opens and remains open until the pressure drops.
POP-TYPE SAFETY VALVE- Valve with a predetermined popping pressure.
POSITIONING CONTROLLER- A control that regulates air and fuel going to a boiler furnace.

POSTPURGE- The passing of air through a furnace after normal burner shutdown.
POUR POINT- Lowest temperature at which fuel oil flows as a liquid.
PREPURGE- The passing of air through a furnace prior to lightoff.
PRESSURE CONTROL- Attached to the highest part of the steam side of a boiler to control its operating range.
PRESSURE GAUGE- Calibrated in pounds per square inch. Used to indicate various pressures in the system.
PRESSURE-REDUCING GOVERNOR- Used on low pressure gas burner systems to reduce the gas pressure to 0 psi.
PRESSURE-REDUCING STATION- Where higher pressure steam is reduced in pressure for plant process.
PRIMARY AIR- Air supplied to the burner that regulates the rate of combustion.
PROCESS STEAM- Steam used in the plant for manufacturing purposes.
PRODUCTS OF COMBUSTION- Gases that are formed as a fuel is burned in the furnace.
PROGRAMMER- Control that puts the burner through a firing cycle.
PROPORTIONING CHEMICAL FEED PUMP- Pump that can be adjusted to feed chemicals to a boiler over a 24-hour period.
PROVING PILOT- Sighting the pilot through the scanner to verify that the pilot is lit.
PROXIMATE ANALYSIS- Provides information regarding moisture content, volatile matter, fixed carbon and ash content of coal.
PSI (POUNDS PER SQUARE INCH)- Unit of measurement used to express the amount of pressure present in a given structure or system.
PULVERIZING MILL- Grinds coal to the consistency of talcum powder before it is delivered to the furnace, where it burns in suspension.
PUMP CONTROLLER- Starts and stops a feedwater pump, depending on the water level in the boiler.
PURGE PERIOD- Before ignition and after burner shutdown when explosive combustibles are removed.
PYROMETER- High-pressure thermocouple used to measure furnace temperatures.

Q

QUALITY OF STEAM- Term used to express the moisture content present in saturated steam. Quality of steam effects the BTU content of the steam.
QUICK-CLOSING VALVE- Valve that requires a one-quarter turn to be fully open or closed.

R

RADIANT SUPERHEATER- A nest of tubes that the saturated steam passes through to acquire heat.
RANK- Refers to how hard the coal is.
RATE OF COMBUSTION- The amount of fuel that is being burned in the furnace per unit of time.
RAW WATER- Untreated water from wells or city water lines.
REAR HEADER- Found on straight-tube water tube boilers. Connected to front header by water tubes.
RECIPROCATING PUMP- Positive-displacement pump used to pump liquids.
RECORDER- An instrument that records data such as pressures and temperatures over a period of time.
REFRACTORY- Brickwork used in boiler furnaces and for boiler baffles.
RELIEF VALVE- Used to protect liquid systems from excessive pressure.
RESET- Switch that must be reset manually after tripping.
RETORT- Space below the grates of an underfeed stoker.
RINGELMANN- Chart used as a means of determining smoke density.
RIVETS- Fasteners used to connect steel plates.
ROTOMETER- Variable-area flow meter that measures the flow of a fluid.

S

SAFETY VALVE BLOWDOWN- Drop in pressure between popping pressure and reseating pressure (usually 2 to 8 psi below popping pressure).
SAFETY VALVE CAPACITY- Measured in pounds of steam per hour safety valves can discharge.
SATURATED STEAM- Steam at a temperature that corresponds with its pressure.
SCALE- Deposits caused by improper boiler water treatment.
SCALE-FORMING SALTS- Salts such as calcium carbonate and magnesium carbonate that when in solution tend to form a hard, brittle scale on hot surfaces.
SCANNER- Device that monitors the pilot and main flame of the furnace.
SCOTCH MARINE BOILER- A fire tube boiler with an internal furnace.
SECONDARY AIR- Air needed to complete the combustion process.
SEDIMENT- Particles of foreign matter present in boiler water.
SHEAR STRESS- Occurs when two forces of equal intensity act parallel to each other but in opposite directions.
SINUOUS HEADER- Found on water tube boilers. Tubes are expanded, rolled and beaded into front and rear headers.
SIPHON- Protective device used between the steam and Bourdon tube in a steam pressure gauge.
SLOW-OPENING VALVE- Valve that requires five full turns of its handwheel to be fully open or closed.
SLUDGE- Accumulation residue produced from impurities in water.
SMOKE DENSITY- Varies from clear to dark. Determined by the amount of light that passes through the smoke as it leaves the boiler.
SMOKE INDICATOR- An indicating or recording device that shows the density of the smoke leaving the chimney.
SOLENOID VALVE- An electromagnetic valve positioned open or closed.
SOLID STATE- An electronic system using transistors in place of electronic tubes.
SOOT- Carbon deposits resulting from incomplete combustion.
SOOT BLOWERS- Used to remove soot from around tubes to increase boiler efficiency. Mostly found on water tube boilers.
SPALLING- Hairline cracks in boiler brickwork (refractory) due to changes in furnace temperature.
SPONTANEOUS COMBUSTION- Occurs when combustible materials self-ignite.
STAYBOLTS- Bolts used in boilers to reinforce flat surfaces to prevent bulging.
STEAM AND WATER DRUM- The pressure vessel in a steam boiler that contains both steam and water.
STEAM BOILER- A closed pressure vessel in which water is converted to steam by the application of heat.
STEAMBOUND- Condition that occurs when the temperature in the open feedwater heater gets too high and the feedwater pump cannot deliver water to the boiler.
STEAM SEPARATOR- Device used to increase the quality of steam. Found in the steam and water drum.
STEAM SPACE- The space above the water line in the steam and water drum.
STEAM STRAINER- Used before steam traps and turbine throttle valves to remove solid impurities.
STEAM TRAP- An automatic device that removes gases and condensate from steam lines and heat exchangers without the loss of steam.
STEAM TURBINE- Used to drive boiler auxiliaries or generators in large plants.
STOPCOCK- A quick-opening or closing valve usually found on gas lines.
STRIP CHART- Recording chart that records temperatures and pressures in the system.
SUCTION PRESSURE- Pressure on the liquid at the suction side of a pump.
SULFUR- A combustible element found in coal and fuel oil.
SUPERHEATED STEAM- Steam at a temperature above its corresponding pressure.
SUPERHEATER- Used to increase the amount of heat in the steam.
SUPERHEATER DRAIN- Valve found on the superheater header outlet. Used to maintain flow throughout the superheater during start-up and shutdown.
SURFACE BLOWDOWN VALVE- Used to remove impurities from the surface of the water in a steam and water drum.

SURFACE CONDENSER- A shell-and-tube vessel used to reduce the exhaust pressure on the outlet end of turbines or engines.
SURFACE TENSION- Caused by impurities on the top of the water in the steam and water drum.
SUSPENSION SLING- Used to support the drum of the HRT boiler.
SYNCHRONIZE- To balance out combustion controls before switching to automatic.

T

TENSILE STRESS- Occurs when two forces of equal intensity act on an object, pulling in opposite directions. Affects boiler plates and staybolts.
THERM- Unit used to measure BTU content of natural gas. A therm has 100,000 BTU.
THERMAL EFFICIENCY- The ratio of the heat absorbed by the boiler to the heat available in the fuel per unit of time.
THERMOCOUPLE- Used to measure temperatures in the system and send them back to a recording chart.
THERMOMETER- Instrument used to measure temperature (degree of heat). Calibrated in degrees Celsius or degrees Fahrenheit.
THROUGH STAYS- Found on fire tube boilers (HRT and scotch marine) to keep front and rear tube sheets from bulging.
TOTAL FORCE- Total pressure that is acting on an area, determined by diameter and pressure.
TRY COCKS- Secondary way of determining the water level.
TUBE BRUSHES- Used in fire tube boilers to remove soot from inside of tubes.
TUBE SHEET- Tubes are rolled, expanded and beaded into front and rear tube sheets of HRT and scotch marine boilers and upper and lower tube sheets of vertical fire tube boilers.
TUBULAR GAUGE GLASS- Round gauge glass used for pressures up to and including 250 psi.
TURBINE STAGES- That part of the turbine where steam gives up its energy to the turbine blades. As the steam pressure drops, the stages (blades) become larger.
TURBULENCE- Movement of water in the steam and water drum.

U

ULTRAVIOLET- A form of light that is produced during combustion.
UNDERFEED STOKER- A coal-firing system that introduces the coal under the fire.
U-TUBE MANOMETER- When filled with mercury, used to measure vacuum. U-tube manometers are calibrated in inches.

V

VACUUM- A pressure below atmospheric pressure.
VACUUM GAUGE- Pressure gauge used to measure pressure below the atmosphere that is calibrated in inches of mercury.
VAPORSTAT- Control with a large diaphragm that makes it highly sensitive to low pressure.
VARIABLE-AREA FLOW METER- Measures the flow of a substance by how much resistance is created by a float or piston which changes the area (size) of the flow path.
VENT CONDENSER- Removes oxygen and other noncondensable gases in a deaerating feedwater heater.
VENTURI- A constricting device used in pipelines to measure flow.
VERTICAL FIRE TUBE BOILER- One-pass boiler that has fire tubes in a vertical position. Vertical fire tube boilers are classified as wet-top or dry-top.

W

WARPING- Bending or distortion of boiler or superheater tubes, usually caused by overheating.
WATER COLUMN- Reduces fluctuations of boiler water to obtain a better reading of the water level in the boiler gauge glass. Located at the NOWL.

WATER COLUMN BLOWDOWN VALVE- Valve on the bottom of the water column used to remove sludge and sediment that might collect at the bottom of the water column.
WATER HAMMER- A banging condition that is caused by steam and water mixing in a steam line.
WATER SOFTENING- The removal of scale-forming salts from water.
WATER TUBE BOILER- Boiler that has water in the tubes with heat and gases of combustion around the tubes.
WATERWALL- Vertical or horizontal tubes found in the furnace area of water tube boilers that lengthen the life of the refractory.
WATERWALL BLOWDOWN VALVE- Approved valve used to remove sludge and sediment from waterwalls and waterwall headers.
WEIGHT-TYPE ALARM WHISTLE- Alarm whistle which signals high or low water by the gain or loss of buoyancy of weights in water within the water column.
WINDBOX (PLENUM CHAMBER)- Pressurized air chamber that supplies air to a furnace.

Z

ZEOLITE- A resin material that is used in the process of softening water.

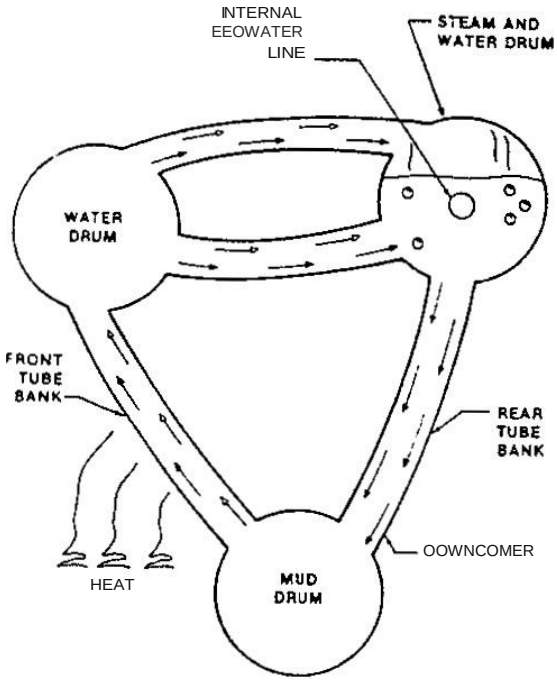
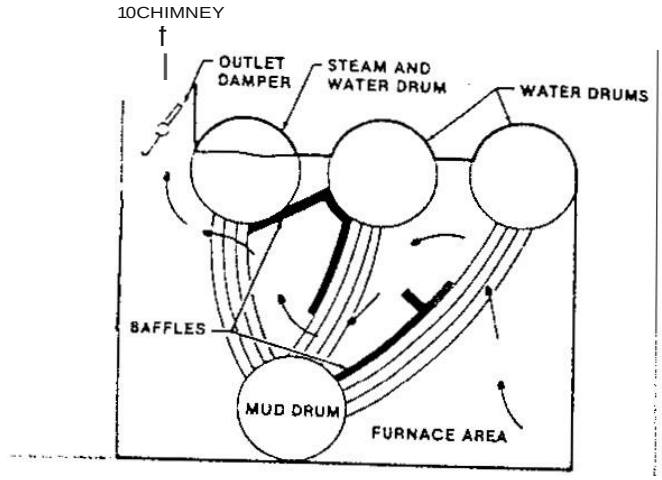
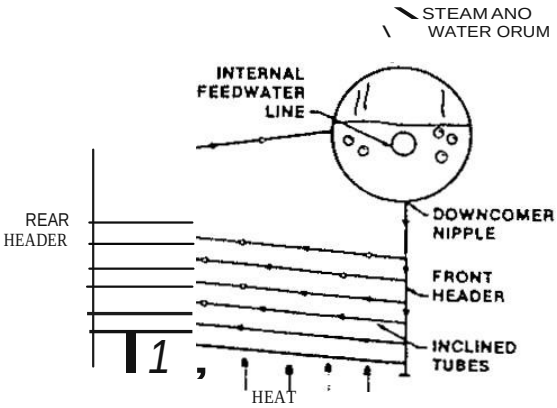


Figure 15. Bent.tube boilers operate at higher pressures and steam capaci1ies than straight-tube boilers, and their design provides for improved water circulation.

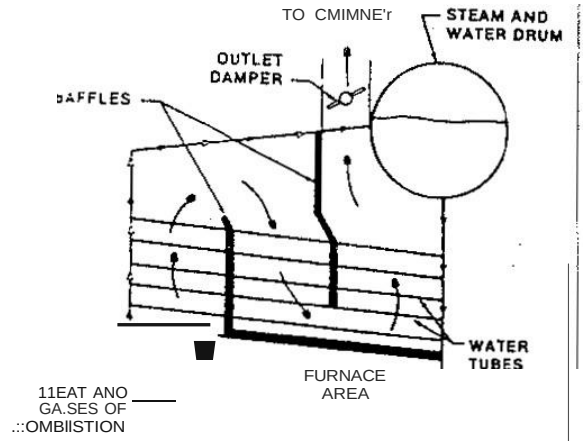


BENT-TUBE WATER TUBE BOILER



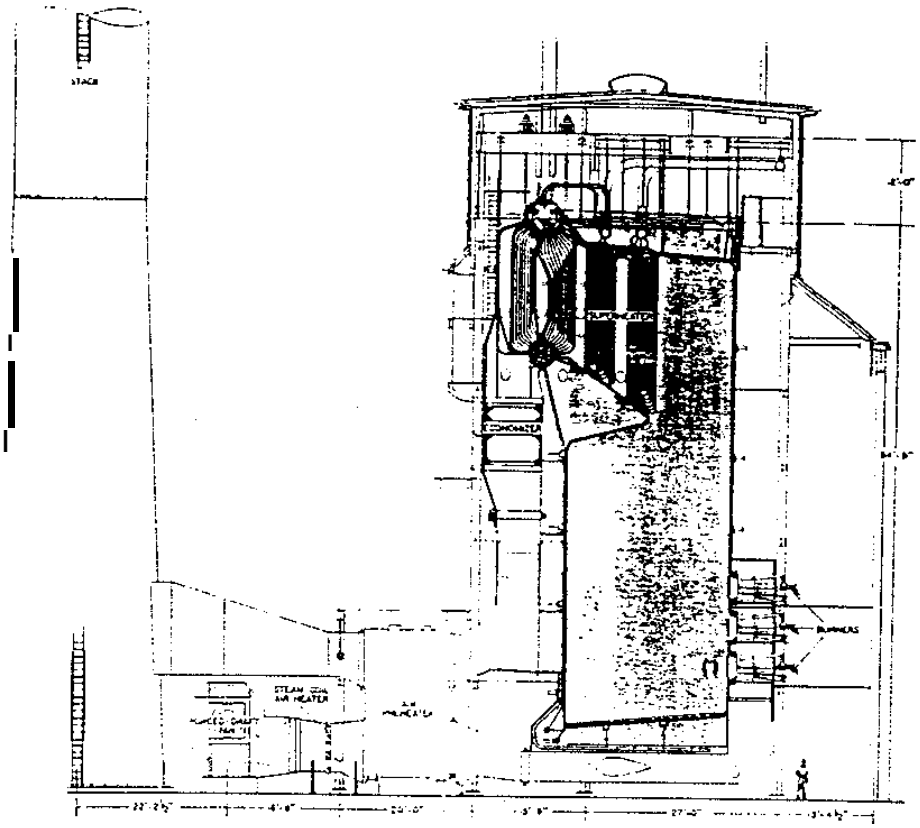
STRAIGHT-TUBE
BOILER CIRCUIT

Figure 1-1•. Straight·tube b_oilers have Indined tubes to increase circulation. Water ts introduced to the boiler through an intemal feedwater line.



STRAIGHT-TUBE WATER TUBE BOILER

Figure 1 11. Baffles direct the flow of gases of c:..omoustion across generating tubes.



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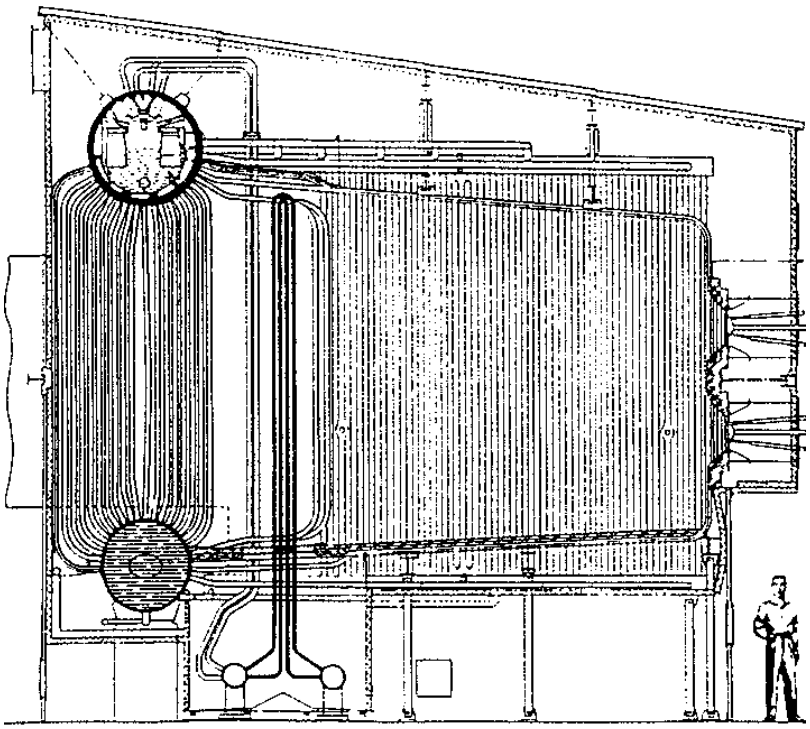

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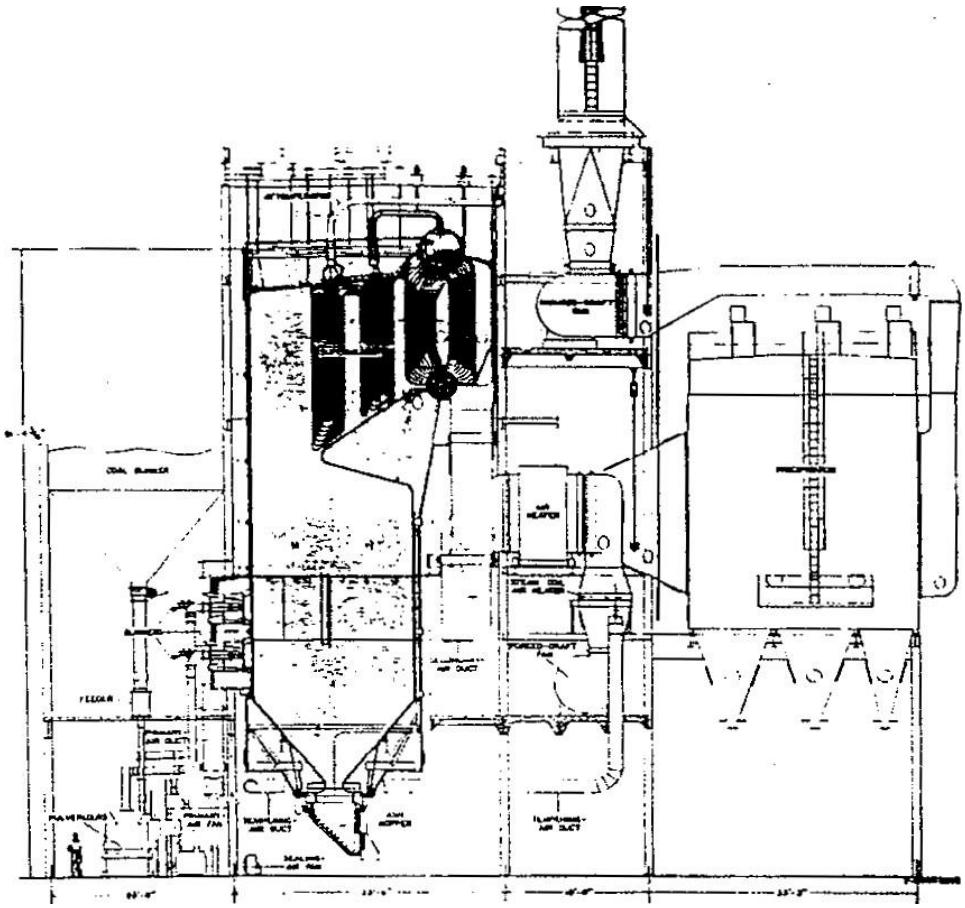
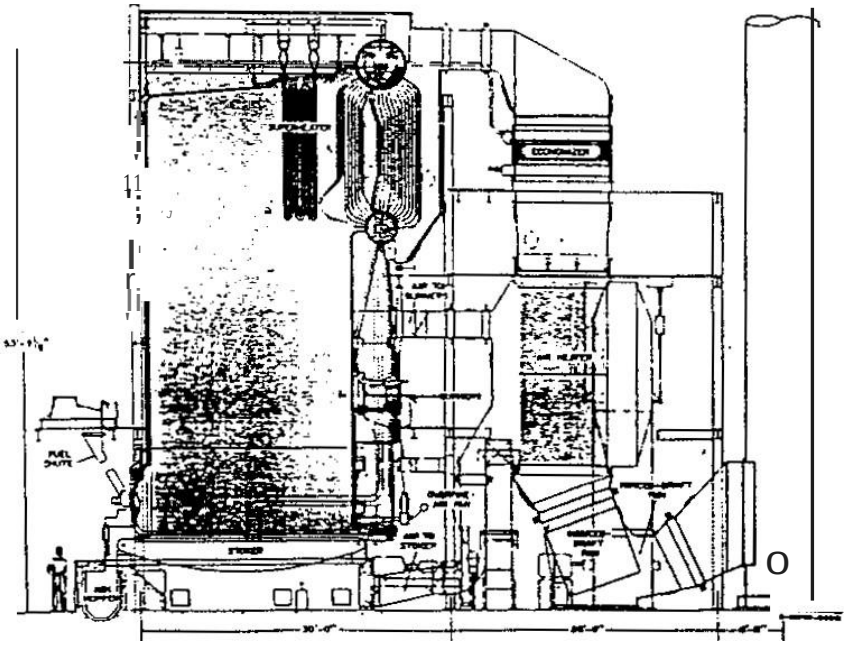


Fiiure 4-25. Stirling power boiler for burning pulverized coal. *(Courtesy of Bak:or.:k & Wilcox)*



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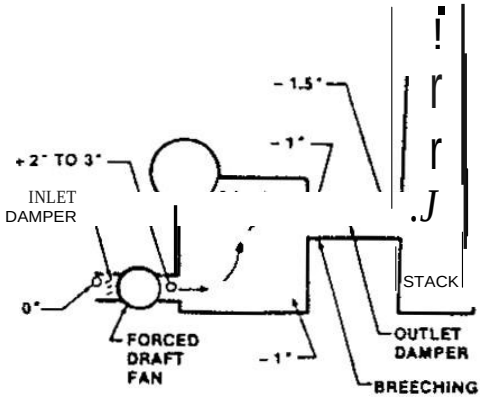
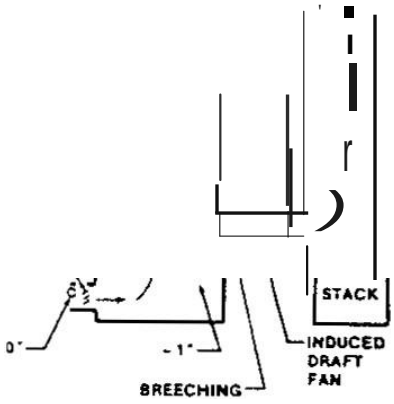
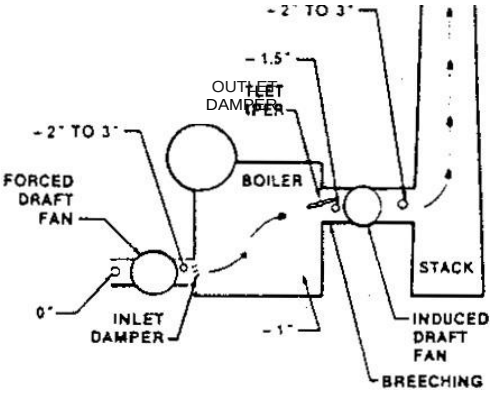


FORCED DRAFT SYSTEM



INDUCED DRAFT SYSTEM



COMBINATION FORCED
AND INDUCED DRAFT SYSTEM

Figure 6-4. The three types of mechanical draft are forced, induced, and combination forced and induced.

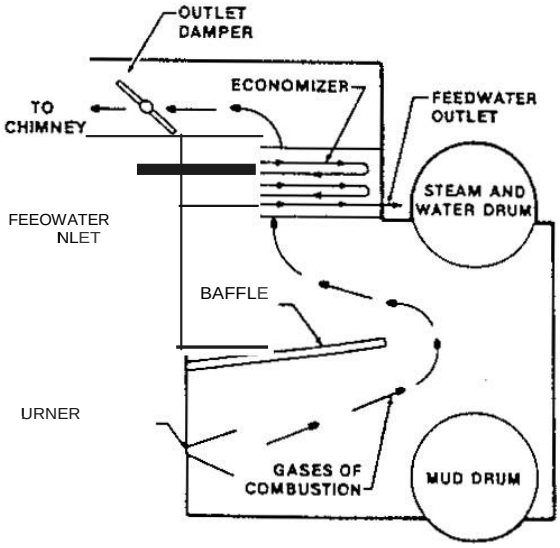
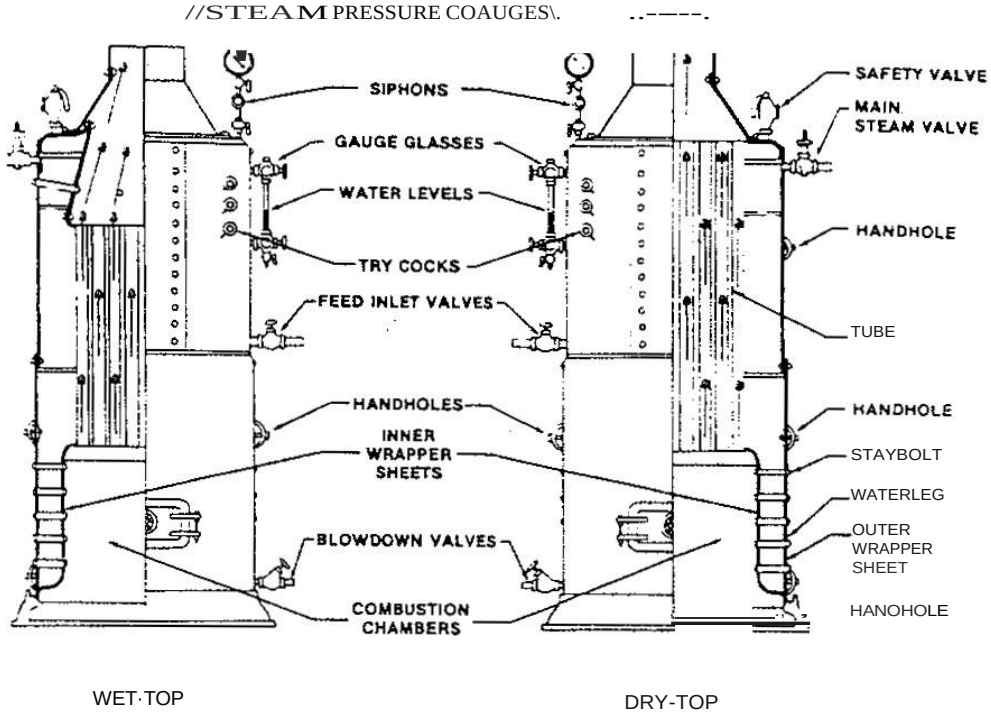


Figure 4-5. Gases of combustion are used to raise boiler leedwater temperature . For every 10°F rise in boiler feedwater temperature, there is approximately a 1% savings in fuel.



Vertical fire tube boilers require less floor space than HAT boilers.

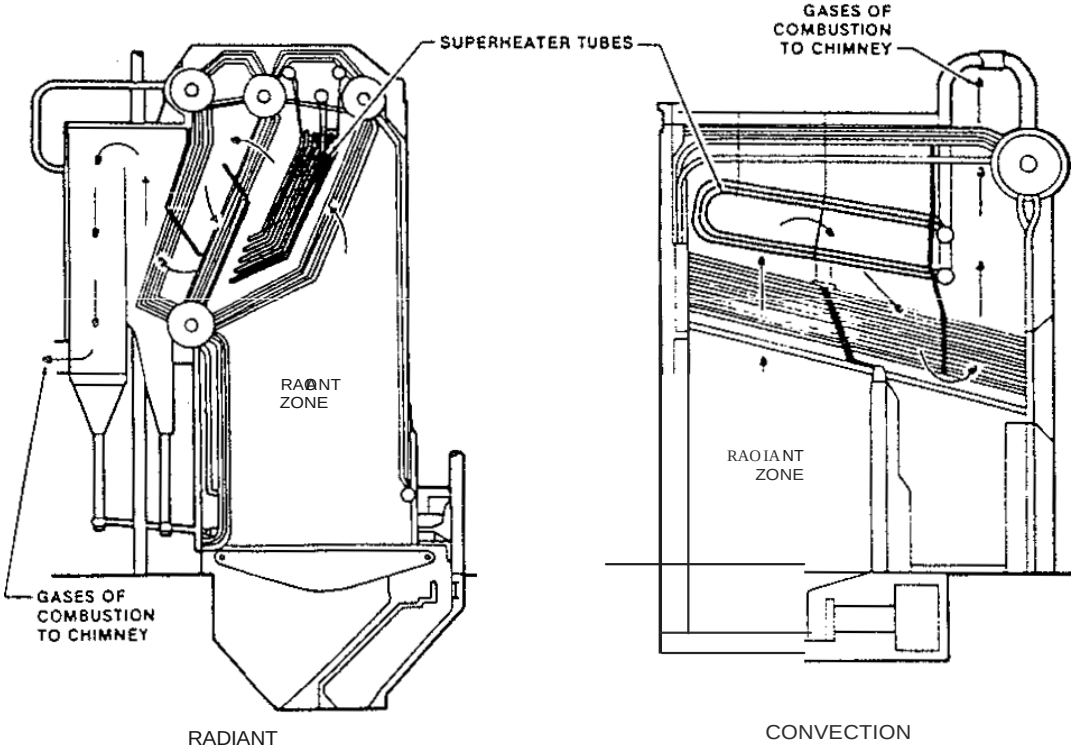


Figure 216. Steam boilers may have radiant or convection superheaters.

ARKANSAS DEPARTMENT OF LABOR
BOILER INSPECTION DIVISION
10421 West Markham
Little Rock, Arkansas 72205

APPLICATION FOR BOILER OPERATOR'S LICENSE "TYPE" (Circle One) **HIGH PRESSURE LOW PRESSURE**

ARKANSAS CODE ANNOTATED 20-23-404. OPERATORS.

(a) The Boiler Inspection Division shall conduct examinations for each applicant seeking a boiler operator's license. Before an applicant may participate in an examination, he/she must have not less than six (6) months on-the-job training. Proof of this must be furnished to the Boiler Inspection Division by his/her employer prior to the examination.

(b) Any operator found operating a boiler without a certificate issued by the Boiler Inspection Division or operating a boiler knowing it to be defective shall have his/her license revoked at once. Any person found operating a boiler without an operator's license shall be subject to an administrative fine of not less than twenty-five dollars ($25.00) and not more than one hundred dollars ($100.00).

PLEASE PRINT OR TYPE

NAME OF APPLICANT _____ **Soc. Sec. No.** _____
FIRST, MIDDLE INITIAL, LAST

ADDRESS _____
STREET or PO BOX

_____
CITY, STATE, ZIP CODE

BOILER OPERATING EXPERIENCE

LOCATION	TYPE & SIZE	FROM	TO
LOCATION	TYPE & SIZE	FROM	TO

The training of any Boiler Operator remains the sole responsibility of the employer. Issuance of a license only indicates that the applicant has passed a general written examination, pertaining to the operation of boilers. Act 1163 of 1997 requires the Boiler Inspection Division to transfer name, address, and social security number information on applicants to the Office of Child Support Enforcement. Social security numbers shall otherwise be maintained in a confidential manner as required by Act 1163 of 1997.

DO NOT WRITE IN THIS SPACE

_____
Type Exam

_____
Examined at

_____
Date Grade

Type of License to be issued: HIGH LOW RESTRICTED

LICENSE NUMBER _____ ISSUE #_____

_____
SIGNATURE OF EXAMINER

_____
SIGNATURE OF APPLICANT

EMPLOYER CERTIFICATION

I hereby affirm that the applicant herein has had the necessary training required to participate in the examination.

_____
Name of Employer

_____
Address

_____
City, State, Zip

_____
Employer Signature and Title

_____
Telephone