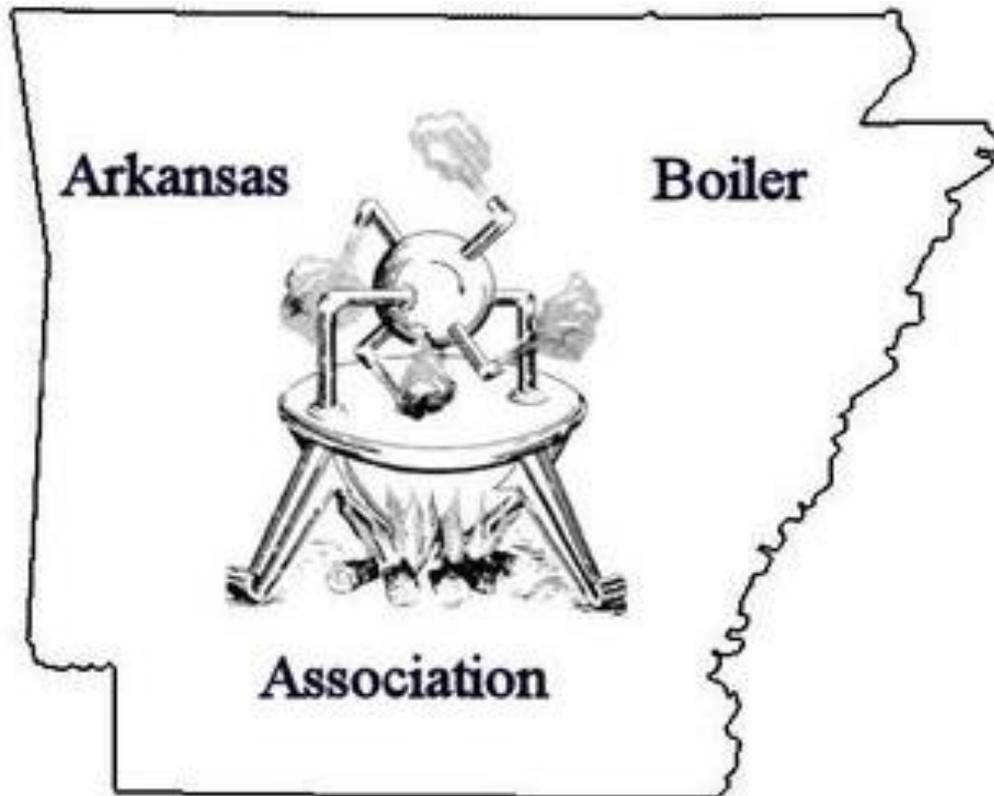


Boiler Operator Study Guide



OUR MISSION: The Arkansas Boiler Association exists to promote safety in the inspection, operation, construction and repairs of boilers and pressure vessels. This will be accomplished through effective communication between all involved parties and education of its members and the public.

BOILER OPERATOR STUDY GUIDE

PLEASE NOTE THE ARKANSAS BOILER DIVISION REQUIRES THE FOLLOWING:

- ❖ *The Application to take the Arkansas Boiler Operator Examination can be found, completed, and brought with you to take the examine at <https://www.labor.arkansas.gov/>*
- ❖ *The State of Arkansas Boiler Division requires the Completed Application be signed by your Employer verifying your 6-Months on the Job Training and must be submitted to the Arkansas Boiler Inspector before Testing.*
- ❖ *The State of Arkansas Boiler Division requires a \$25.00 Testing Fee to be paid on-line before Testing date: <https://www.labor.arkansas.gov/>*
- ❖ *The State of Arkansas Boiler Division requires the \$25.00 Testing Fee each time the test is taken with a New Application Submitted.*
- ❖ *Recommended Study Material: ABA Study Guide and the American Technical Publisher (ATP) “High Pressure Boiler Book”
<http://www.atplearning.com/>*

BOILER OPERATOR STUDY GUIDE

The information presented on this page is an excerpt from the Arkansas Department of Labor Boiler Inspection Division and the property of the State of Arkansas and is referenced here as such:

ARKANSAS DEPARTMENT OF LABOR BOILER INSPECTION DIVISION

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 device 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.”

BOILER OPERATOR STUDY GUIDE

CONTINUED:

The information presented on this page is an excerpt from the Arkansas Department of Labor Boiler Inspection Division and the property of the State of Arkansas and is referenced here as such:

ARKANSAS DEPARTMENT OF LABOR BOILER INSPECTION DIVISION

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

**** “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.”**

****“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.

Before any welding is allowed to be performed on a boiler in the State of Arkansas, The Department of Labor, Boiler Inspection Division shall be consulted to assure compliance with the State Laws, Rules, and Regulations.

The State of Arkansas, Department of Labor, Boiler Division requires the Boiler Inspection Certificate and the Boiler Operator’s License be displayed in or near the boiler room.

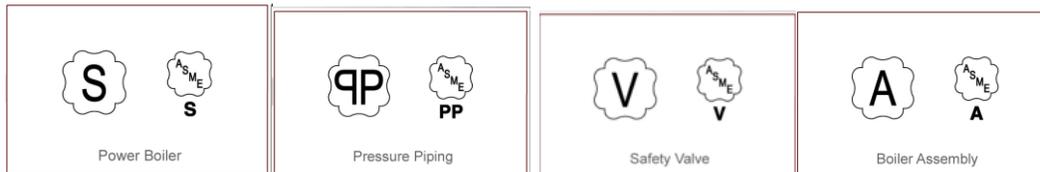
BOILER OPERATOR STUDY GUIDE

Boiler Codes and Standards

ASME (American Society of Mechanical Engineers)

- **Section I** – Rules for Construction of Power Boilers
- **Section IV** – Rules for Construction of Heating Boilers
- **Section VI** – Recommended Rules for the Care and Operation of Heating Boilers
- **Section VII** – Recommended Guidelines for the Care of Power Boilers
- **Section VIII** – Rules for Construction of Pressure Vessels
- **CSD-1** – Controls and Safety Devices for Automatically Fired Boilers
- **B31.1** – Power Piping Code
 - **NBIC (National Board Inspection Code)**
 - **NFPA-85**
 - **Jurisdictional Codes (Varies by State)**
- **Inspection Frequency – Adopted Codes & Standards**

ASME BPVC, Section 1, PG-105 CERTIFICATION MARKS USED WITH DESIGNATORS



- S – Power Boiler Designator**
- M – Miniature Boiler Designator**
- E – Electric Boiler Designator**
- A – Boiler Assembly Designator**
- PP – Pressure Piping Designator**
- V – Boiler Pressure Relief Valve Designator**
- PRT – Fabricated Parts Designator**

DATA STAMPING – WATERTUBE Drum-Type BOILERS – ASME BPVC, Section 1, PG-111.5.1

The ASME Code Stamping shall be performed directly on a head of the steam outlet drum near and above the manhole. **These Stampings shall be left uncovered** or an easily removable marked cover may be provided over the stamping when a boiler is covered with insulation, or jacketed.

DATA STAMPING – SCOTCH MARINE BOILERS – ASME BPVC, Section 1, PG-111.6

The ASME Code Stamping shall be performed directly on either side of the boiler shell near the normal water level line and as near as practical to the front tubesheet. **These Stampings shall be left uncovered** or an easily removable marked cover may be provided over the stamping when a boiler is covered with insulation, or jacketed.

The Data Stamping shall be on all ASME Boilers and Pressure Vessels

BOILER OPERATOR STUDY GUIDE

STEAM PRESSURE AND TEMPERATURE RELATIONSHIP	
Gauge Pressure*	Temperature†
20	259
30	274
40	287
50	298
60	307
70	316
80	324
90	331
100	338
150	366
200	388
250	406
300	422

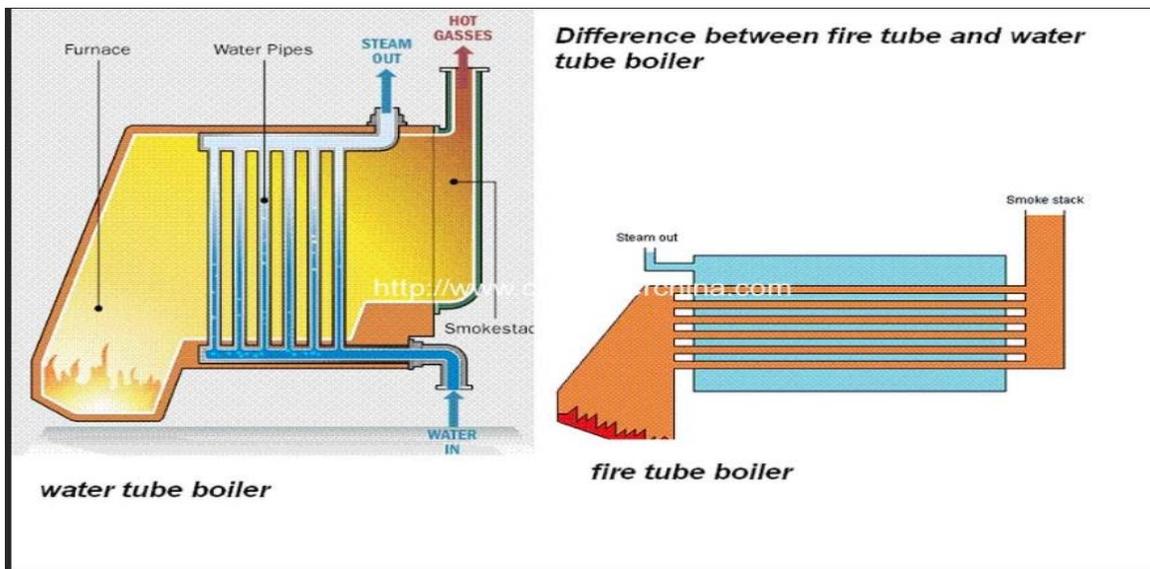
* in psi
† in °F

NOTE: gauge pressure + atmospheric pressure (14.7) = absolute pressure
100 psig + 14.7 = 114.7 psia

(Reference American Technical Publishers High Pressure Boilers Page 6)

- **As Steam pressure in a boiler increases, there is a corresponding increase in temperature of the water and the steam**
- **As Steam pressure in a boiler increases, the boiling point of the water in the boiler also increases.**
- **As the steam pressure increases, the cubic feet of the volume occupied per pound of the steam vapor decreases.**

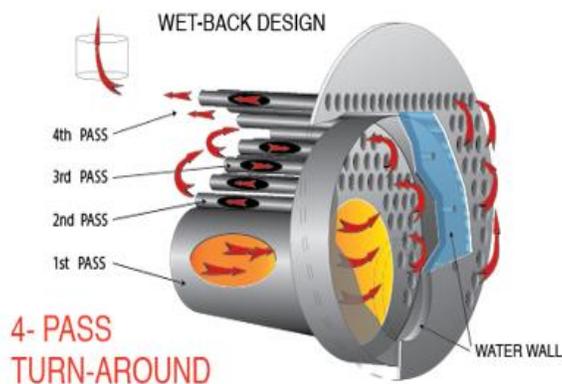
BOILER OPERATOR STUDY GUIDE



Water tube boiler – Boiler that has water inside the tubes with heat and gases of combustion around the tubes.

Water Tube Circulation - heated water becomes less dense and rises to the steam drum where it gives up the heat (steam bubbles) then the cooler water (denser) sinks down to the mud drum.

Fire tube boiler – Boiler in which hot gases of combustion pass through the tubes that are surrounded by Water.

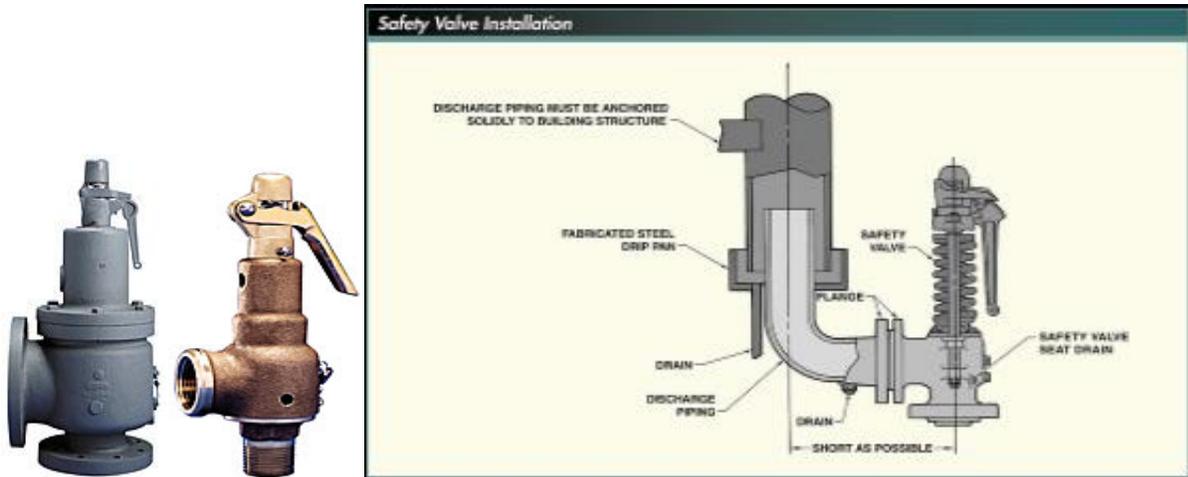


Waterwalls can eliminate the need for refractory and increase the Steaming Capacity of a Firetube boiler

- **Boiler Horsepower (BHP)** is defined as the evaporation into dry saturated steam of 34.5 lb. of water/hr from and at a feedwater temperature of 212-degree Fahrenheit.
- **High Pressure Steam Boiler** – operates at a steam pressure above 15 PSIG.

BOILER OPERATOR STUDY GUIDE

Safety Relief Valve - The purpose of the Safety Relief Valve is to relieve the boiler pressure if/when it exceeds the maximum allowable working pressure.



- The pressure relief valve capacity (lbs/hr of steam) shall be such that the pressure relief valve(s) will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6% above the highest pressure at which any valve is set and in no case to more than 6% above the maximum allowable working pressure of the boiler.
- Is considered by ASME to be the most important safety device on a boiler. ASME states that all Steam Boilers shall be equipped with at least one Safety Relief Valve. Boilers with more than 500 square feet of heating surface shall be equipped with two or more safety relief valves.
- Only a qualified safety valve technician or the manufacturer's qualified representative shall change or adjust the pressure setting or internal components of a safety relief valve.
- No valve or cutoff device shall be placed to restrict the inlet or outlet ports of a Safety Relief Valve. The inlet and outlet connection to/from the Safety Relief Valve shall not be reduced so as to restrict the inlet or outlet ports.
- The Safety Relief Valve on a high-pressure steam boiler must have a National Board (NB) Stamping and ASME Certification Mark with a "V" Designator.
- DATA PLATE of a SAFETY RELIEF VALVE - A plate securely fastened to a safety relief valve shall contain data & stamping required by the ASME and be a National Board Capacity Certified Valve.

BOILER OPERATOR STUDY GUIDE

Boiler Water Level / Pump Control & Primary Low Water Cut-Off

- Installed in Individual Water Columns
- May share a common steam connection but must have separate pipe connections below the water line.
- Maintains the water level in the boiler at the Normal Operating Water Level

Low Water Fuel Cutoff:

- Installed above lowest safe permissible water level as per boiler manufacturers recommendations.
- The Boiler Operator should verify the proper operation of the low-water cutoff by blowing down the water column drain valve daily.
- The Evaporation Test (Slow Drain) should be performed monthly on the primary to simulate the actual condition of a feedwater pump failure.
- Document the Low Water Fuel Cutoff Testing in a boiler operations log.
- The Low Water Fuel Cutoff must prevent Start-up or Cut the Fuel Off if the water level in the boiler is below the safe water level as per the Manufacturers Recommendations.



You must blowdown the water columns daily to flush the sludge and sediment from the bowl to prevent build-up of mud.

BOILER OPERATOR STUDY GUIDE

Boiler Feedwater Supply - BPVC Section 1, PG-61

- Boilers having more than 500 square feet of heating surface shall have at least two means of feeding water to the boiler.
- Each source (pump) providing feedwater to the boiler shall be capable of supplying water to the boiler at a pressure of 3% higher than the highest setting of any pressure relief valve on the boiler proper.
- For Boilers that are fired with solid fuel not in suspension, and for boilers whose setting or heat source can continue to supply sufficient heat to cause damage to the boiler if the feedwater supply is interrupted, one such means of feeding water shall not be susceptible to the same interruption as the other, and each shall provide sufficient water to prevent damage to the boiler.

Feedwater Stop Valve – A valve that is opened or closed by the operator and typically used to isolate the feedwater to the boiler. A globe valve or a gate valve should be utilized for this application. The valve should be located as close to the boiler as practical in order to isolate the boiler in the event of leaking fittings.

Feedwater Check Valve - The check valve on the water feed inlet to the boiler and allows flow in only one direction. The check valve closes when the feedwater pump is off or when the boiler is not calling for water. This prevents the boiler from backflowing steam and water to the feedwater tank or Deaerator.

Replacing a Feedwater Check Valve - The operator should never attempt to replace the check valve with steam pressure on the boiler.

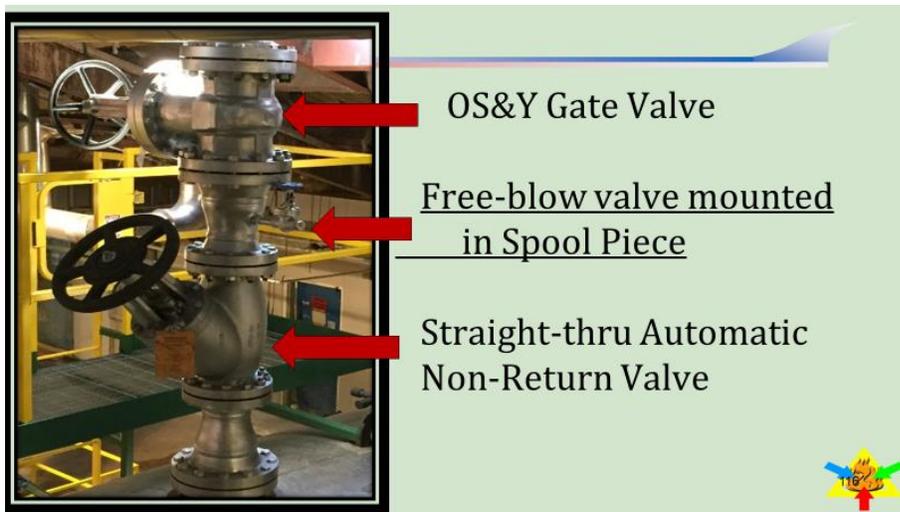
Deaerating Feedwater Heater – A pressurized ASME Code Vessel utilized to heat the feedwater for the boiler to an optimum pressure / temperature of 5 psi & 227 Degree Fahrenheit thereby removing the dissolved oxygen and other corrosive gases.

Purpose of the Deaerating Feedwater Heater – Utilizes steam to mechanically scrub the dissolved oxygen and corrosive gases and to preheat the feedwater, thereby preventing thermal shock to the boiler.

BOILER OPERATOR STUDY GUIDE

Boiler Steam Stop Valves

- Main steam stop valve is used to place boilers on-line or to isolate the steam.
- Main steam stop valve can be an OS&Y Gate valve, or an automatic non-return valve can be used, but the automatic non-return valve must be located as close to the boiler steam outlet flange as possible.
- When utilizing a gate valve for a Main steam stop valve an OS&Y Gate Valve should be installed so that the stem indicates when the valve is open or closed.
- When two or more boilers are connected to a common steam header (in battery) and the boilers are equipped with manway openings, two steam stop valves must be utilized with a free-blowing drain between the valves.
- Two OS&Y Gate Valves can be used or an automatic non-return valve & an OS&Y Gate valve.... Either configuration must have a Free-Blow Drain between the valves to test the integrity of the valves and to drain the trapped condensate.
- A Free-Blowing Drain Valve is used to remove condensate from the main steam line and as a testing method for Boiler Inspectors to verify the tightness of the boiler steam valves before an internal inspection.



EXAMPLE: AUTOMATIC NON-RETURN VALVE WITH OS&Y GATE VALVE

BOILER OPERATOR STUDY GUIDE

Boiler Steam Pressure Gauges

- The Dial on a steam gauge must be graduated from 1 1/2 to 2 times the maximum allowable working pressure (MAWP).
- Steam Gauges must be connected to the highest part of the steam space in a High-Pressure Steam Boiler
- When installing a Steam Pressure Gauge, a gauge siphon should be utilized to protect the steam gauge from the high temperature of the steam.

Blowdown Valves and Piping - Blowdown valves are used to clear out sludge and sediment from the lowest point of a Firetube boiler or the Mud Drum of a Watertube boiler.

1. ASME requires two bottom blowdown valves in series when over 100psi
 2. Quick-opening valve, closest to the boiler shell. Opened first & closed last
 3. Screw type is slow opening and utilized to perform the actual blowdown
 4. Full size to discharge point with no reductions in pipe size
 5. Place boiler in manual Low fire, blowdown the rear valve of boiler first
 6. Rated for pressure and temperature with the fittings / pipe rated at Schedule 80 & valves rated at 250 psi - for boilers rated at over 125 PSI MAWP
- **QUICK-OPENING VALVE SHOULD BE OPENED FIRST AND CLOSED LAST!
UTILIZE THE SLOW-OPENING VALVE TO PERFORM THE BLOWDOWN**



- A **blowdown tank** is used to safely conduct the blowdown and to allow the flash steam to be discharged to atmosphere and the hot blowdown water to cool before sending it to the sewer.

BOILER OPERATOR STUDY GUIDE

- **Steam Generator** – Most engineers prefer the term *steam generator* instead of *steam boiler* because boiler refers to the physical change of the contained fluid whereas *steam generator* covers the whole apparatus in which this physical change is taking place. But in ordinary use, both are essentially the same. Most state laws are still written under the old, basic boiler nomenclature.
- **Steam traps:** are located in the steam system wherever steam releases its latent heat and condenses. The purpose of a steam trap is to have the steam first give up the latent heat of vaporization, by stopping the steam flow through the trap until it condenses. It then opens to allow the condensate to flow back to the condensate receiver as part of the boiler water loop.
- **Steam traps:** Leaking Steam traps are very inefficient and require routine testing. It has been stated, that at any given time, 20% of the steam traps in a large condensate return system have failed. A strainer should be installed ahead of a steam trap to prevent dirt, rust, weld beads, and contaminants from affecting the internal movements of the trap.
- **Economizer:** Utilizes the waste heat from the gases of combustion to heat the Boiler Feedwater. A “rule of thumb” states that for every 10 Degrees Fahrenheit you raise the feedwater temperature to a boiler using waste heat you gain 1% efficiency.

Forms of Draft:

- **Natural Draft** – Produced by natural action resulting from temperature differences between the ambient air and the hot gases of combustion. The height of the stack determines the amount of natural draft.
- **Forced Draft** – Mechanical Draft produced by a fan forcing combustion air into a furnace.
- **Induced Draft** – Draft produced by pulling air through the boiler furnace with a fan.
- **Combination Draft** – Draft produced from one or more Forced Draft fans located before the boiler and one or more Induced Draft fans after the Boiler.

BOILER OPERATOR STUDY GUIDE

COMBUSTION

- **Perfect Combustion** – Combustion that occurs when all the fuel is burned using only the theoretical amount of air. Only attainable in laboratory conditions!
- **Complete Combustion** – Combustion that occurs when all the fuel is burned using a minimum amount of Excess air. The goal of the Boiler Operator or Burner Technician is to tune the boiler for Complete Combustion & Optimum Efficiency.
- **Incomplete Combustion** – Combustion that occurs when all the fuel is not burned, resulting in **carbon monoxide**, soot, and smoke.
- **CARBON MONOXIDE – A COLORLESS, ODORLESS, TOXIC, & DEADLY GAS RESULTING FROM INCOMPLETE COMBUSTION.**
- **Water Hammer** – The passage of high-velocity slugs of water through a steam pipe. The impact of the slugs on valves, pipe elbows, or steam equipment can cause dangerous and destructive ruptures. Slugs or droplets of water are caused by pockets in the steam lines that are not adequately drained and by opening steam valves too rapidly.
- **ANSI/ASME, CSD-1** – The minimum standards for controls and safety devices shall be Controls and Safety Devices for Automatically Fired Boilers, ANSI/ASME, CSD-1 (1998 Edition and 1999 Addenda), which is adopted by the State of Arkansas and referenced and incorporated herein.
- **Safety Relief Valve** - An automatic, full-open, pop-action valve that pops open in the event of an overpressure of a steam boiler and prevents the pressure in the boiler from exceeding the Maximum Allowable Working Pressure.
- **Steam Stop Valve** - A valve that is opened to supply steam from the boiler or closed to isolate the steam discharging from the boiler. The Steam Stop Valve should always be opened slowly to allow the piping to heat gradually.

BOILER OPERATOR STUDY GUIDE

- **Gauge Glass** – ASME BPVC.1 PG-60 - A High Pressure Steam Boiler shall have a LIVE water level indicator that consists of a glass column that indicates the water level in the Boiler.
- **Gauge Glass** – ASME BPVC.1 PG-60.1 – The lowest visible water level in a gauge glass shall be at least 2 inches above the lowest permissible water level, as determined by the boiler Manufacturer.
- **Gauge Glass** – ASME BPVC.1 PG-60.1.2 – The gauge glass shall be fitted with a drain cock or valve having an unrestricted drain opening of not less than ¼” diameter to facilitate cleaning. When the boiler MAWP exceeds 100 PSI, the gauge glass shall be fitted with a connection to install a valved drain to a point of safe discharge.
- **Water Column** - A hollow boiler fitting mounted outside the boiler proper that reduces the turbulence to provide a more accurate reading of the water level in the boiler.
- **Try Cocks** - valves located on the water column of a boiler that are used to determine the boiler water level if the gauge glass is broken or if the operator is in doubt of the water level. (Not Required)
- **Low Water Fuel Cutoff** - The control required on all boilers to shut off the fuel to the burner should the water level in the boiler drop to the lowest, safe, permissible level as per the boiler manufacturers recommendation.
- **Water Column Drain Valve** – A Valve providing a means for daily flushing of the water column to keep the chamber and lines clean. Most importantly, it provides a means of testing the low water cutoff.
- **Steam Pressure Gauge** - Indicates the steam pressure in the boiler in pounds per square inch. Should have a range 1 ½ times to 2 times the Safety Valve Pressure setting. Always connected to the highest part of the steam side of a boiler and should be easily visible for the Operator.

BOILER OPERATOR STUDY GUIDE

- **Gauge Siphon** - The device installed between the steam gauge and the boiler. Protects the Bourdon tube in a Pressure Gauge from the high temperature of the Steam.
- **Bottom Blowdown Valve** - Located at the lowest part of the water side of a firetube boiler or the mud drum of a water tube boiler so that sludge and sediment can be removed from the bottom of the Boiler.
- **Automatic non-return valves & Main Steam Stop Valves** – can be used to isolate the boiler from the steam piping or main steam header where multiple boilers are in battery.
- **Superheated Steam** – Contains more heat energy than saturated steam at the same pressure and is primarily utilized in the Power Generation Industry.
- **Steam Operating Pressure Control** - The ON/OFF control with an adjustable differential that regulates the operating range of the boiler between the cut-in pressure and the cut-out pressure by opening and closing electrical contacts.
- **Hi-Limit Pressure Control** - The ON/Off control with a manual reset that sends a signal to the combustion control system to shut down the burner in the event the steam pressure has exceeded the shut-off setting of the operating pressure control limit.
- **Boiler Explosion** - Caused by a sudden drop in boiler steam pressure (failure on the steam side) without a corresponding drop in boiler water temperature.
- **Furnace Explosion** – caused by an uncontrolled amount of fuel, fuel vapor, or dust igniting in the boiler furnace, usually resulting from a failure to purge prior to light off or an improper fuel to air ratio.

BOILER OPERATOR STUDY GUIDE

- **Air-Flow Switch** - Proves that combustion air is being supplied to the burner from the Forced Draft fan. The air-flow switch will cause a safety shutdown should there be a loss of combustion air to the burner, thereby preventing a furnace explosion.
- **Burner Management System** -(programmer, flame safeguard system or sequencing system) – system of control devices and control logic used to ensure safe burner operation. Common checks and procedures – pre-ignition checks, purge cycles, lighting the pilot, lighting the main flame, and post purge during shutdown.
- **Flame Scanner** – Safety device with a Flame Sensor that detects the presence of the pilot and the main flame and signals to the burner management system whether it is safe to operate the Boiler.
- **Boiler Chemicals** – Chemicals added to the boiler water that change the scale-forming salts into a non-adhering sludge.
- **Scale** – An accumulation of compounds such as calcium carbonate and magnesium carbonate on the water side of the heating surfaces of a boiler.
- **Boiler Water Carryover** – a term used to describe the water in the boiler leaving with the steam
- **Causes of Boiler Water Carryover**
 - The Boiler Operator did not check the water level and the boiler water level is too high and allowing priming (dangerous).
 - The high water could be caused by a malfunctioning level controller or a leaking valve on a continuous feedwater system.
 - The steaming capacity of the boiler has been exceeded and pulling water out of the boiler.
 - The Boiler Operator opened the steam valve too rapidly
 - There is a high concentration of Total Dissolved Solids (TDS) in the boiler water due to lack of operator monitoring and control.
 - The Chemical Levels in the boiler are too high causing Carryover.
 - Grease, fat, or oil contamination causes Foaming and Carryover.

BOILER OPERATOR STUDY GUIDE

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. **Boiler Operator** shall be able to explain the function and operation of all controls on the boiler or boilers and know the results of a control failing.
2. **Boiler Operator** shall know the water level of the boiler must be checked to make certain the water is at the Normal Operating Water Level (NOWL).
3. **Boiler Operator** must never add water to a Boiler when the water in the Gauge Glass is not visible and the burner is firing.
4. **Boiler Operator** shall verify the Deaerator or Feedwater Tank has sufficient water to supply the boiler and must know all possible methods of feeding water to the boiler or boilers.
5. **Boiler Operator** shall know how to conduct a safe and efficient bottom blowdown of the boiler as well as the function and sequence to safely perform a bottom blowdown.
6. **Boiler Operator** shall know how to conduct the Testing of the low-water fuel cutoffs and what would happen if the water was permitted to drop below the lowest permissible operating level with the burner firing.
7. **Boiler Operator** shall know what would happen if the water in the boiler was carried too high causing dangerous water hammer of the piping and damage to the equipment.
8. **Boiler Operator** shall know how to safely shut down & isolate the boiler or boilers.
9. **Boiler Operator** should allow the boiler to cool to ambient temperature if possible before draining. Never drain a hot boiler!

BOILER OPERATOR STUDY GUIDE

10. **Boiler Operator** shall understand and follow the daily operating, blowdown, testing of Safety Devices as per Manufacturer's Recommendations.
11. **Boiler Operator** shall follow the proper Boiler Water Treating Program, established by the Manufacturer or by competent water treatment personnel.
12. **Boiler Operator** shall thoroughly understand how to properly warm up the boiler with sufficient time to allow all of the heating surfaces to expand uniformly.
13. **Boiler Operator** shall possess such other qualifications as might be reasonably necessary for safe operation of the steam system.
14. **Boiler Operator** must comprehend and understand the potential for a Catastrophic Explosion if water is added to a hot boiler when there is no water visible in the gauge glass and the burner is firing.
15. **Boiler Operator** shall know the applicable laws and regulations required by the Arkansas Boiler Inspection Division.
16. **Boiler Owner / Operator** should know - before placing a boiler in service, it is important to be certain that the boiler has been installed in compliance with the State of Arkansas Boiler Code in every respect with all applicable permits secured, and the boiler installation be approved with the required Permit-to-Operate issued by the Arkansas Boiler Inspection Division.
17. **Boiler Operator** shall know Automatic Controls and Devices are useless unless they are tested for proper operation and the testing logged in a Boiler Operations Log for each boiler.
18. **Boiler Operator** shall know the importance of maintaining an accurate Boiler Log to record the operating parameters of the boiler(s).

BOILER OPERATOR STUDY GUIDE

- 19. Boiler Operator shall know the FIRST DUTY of the Boiler Operator is to check the Water Level of the Boiler(s) upon first entering the Boiler Room.**
- 20. Boiler Operator shall know there is no substitute for a dependable competent licensed Boiler Operator. Automatic controls and devices are helpers, however, without verification of proper operation, can fail.**
- 21. Boiler Operator shall understand the importance of maintaining a clean-operational gauge glass and how a leaking gauge glass will show a faulty water level in the boiler.**
- 22. Boiler Operator shall understand the importance of maintaining the feedwater pump in good operational condition.**
- 23. Boiler Operator shall understand the ASME Code requires that a boiler with more than 500 square feet of heating surface shall have two means of supplying feedwater and the importance of maintaining an operational spare feedwater pump.**
- 24. Boiler Operator shall know the feedwater pump or other source for supplying the boiler with feedwater must be capable of supplying water to the boiler at a pressure no less than 3% higher than the highest setting of any safety relief valve on the boiler.**
- 25. Boiler Operator shall know any leakage of liquid fuel or Natural Gas has the potential to cause a catastrophic explosion or a fire.**
- 26. Boiler Operator shall know how to isolate the fuel from the boiler room in the event of fire and where the isolation points are located.**
- 27. Boiler Operator shall know all Steam Boilers shall have installed an audible alarm system to work in union with their other operating control devices, unless the boiler is operated under constant attendance by the boiler operator.**

BOILER OPERATOR STUDY GUIDE

STUDY GUIDE SAMPLE QUESTIONS

1. Which valves are located between the boiler and the feedwater pump?
 - *Answer: Feedwater Stop Valve & Feedwater Check Valve. The Feedwater Stop Valve is always located as close to the boiler as possible so that the boiler can be isolated in the event of a leaking check valve or piping.*

2. What is the function of the check valve?
 - *Answer: To prevent the boiler pressure from forcing the boiler water back into a feedwater tank or deaerator when the pump shuts off. Allows flow in only one direction.*

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: A Qualified safety valve technician or representative of the manufacturer.*

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: Carryover and Priming of the Boiler Water, causing the boiler water to be siphoned out of the boiler resulting in water hammer to the steam lines & equipment.*

7. No valve of any description shall be placed between the required safety relief valve or valves and the boiler, or on the discharge pipe between the safety valve and the atmosphere!
 - *Answer: True*

8. A high-pressure boiler is one which generates steam or vapor at a pressure of above?
 - *Answer: Above 15 PSI*

BOILER OPERATOR STUDY GUIDE

9. How may the water-gauge glass on a Boiler indicate a false water level?

- *Answer: There may be an obstruction(s) in the water gauge fixture, water column, or the piping connecting the column to the boiler proper or the gauge glass valves are closed!*

10. What condition will cause smoke and soot resulting in a loss of heat transfer efficiency and the creation of dangerous carbon monoxide gases?

- *Answer: Incomplete Combustion*

11. What is the purpose of a Refractory Shelf or a baffle wall in a boiler?

- *Answer: To cause multiple passes in a firetube boiler for efficiency and to distribute flame evenly in a generation section of a watertube boiler for better heat transfer.*

12. A Residue formed in a boiler by adding feedwater chemicals to the boiler water to prevent the scale from forming on the tubes and turn the scale-forming salts _____?

- *Answer: Into a Non-Adhering Sludge*

13. High-Pressure Steam Boilers must be inspected internally and externally at least once each year. The inspection should be made during the same calendar month each year if possible.

- *Answer: True*

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 _____ on-the-job training and pass the State of Arkansas Boiler Operators Examination, before receiving the Arkansas Boiler Operator's License.

- *Answer: 6 months*

16. Water boils at what temperature at sea level?

- *Answer: 212°F*

BOILER OPERATOR STUDY GUIDE

17. If you went into a boiler room and the burner was firing, and there was no water visible in the gauge glass, you should immediately add water to the boiler. True or False?

- *Answer: False – Never add water to a boiler if there is no water in the gauge glass and the burner is firing! Adding water could cause a catastrophic explosion!*

18. In a firetube boiler the gases of combustion flow through the tubes and the boiler water _____?

- *Answer: surrounds the tubes*

19. In a watertube boiler the water passes through the tubes and the fire is on _____?

- *Answer: the outside of the tubes*

20. High Stack Temperature could be an indication of scale or soot?

- *Answer: True! However, the high stack temperature could be the result of the burner out of adjustment or a refractory shelf or baffle has fallen.*

21. A gauge glass allows you to see the water level in the boiler. If the boiler is equipped with only one gauge glass and if that gauge glass is broken and there are no Try Cocks to check the water level...

- *Answer: the boiler is unsafe and must be shutdown until a new Gauge Glass is installed.*

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

- *Answer: To relieve the boiler pressure and prevent the pressure from exceeding the MAWP (maximum allowable working pressure) of the boiler and thereby prevent a catastrophic explosion.*

23. A measurement of the quantity of heat. The quantity of heat necessary to raise the temperature of one pound of water by 1° Fahrenheit.

- *Answer: British Thermal Unit (BTU)*

24. A device used to remove condensate from the steam lines and heat exchangers preventing Water Hammer damage?

- *Answer: steam trap*

BOILER OPERATOR STUDY GUIDE

25. A Safety Relief Valve should open when the boiler pressure reaches the Maximum Allowable Working Pressure to prevent the boiler from an overpressure condition.

- *Answer: True*

26. Combustion that occurs when all the fuel is not burned, resulting in the formation of smoke, soot, and carbon monoxide?

- *Answer: Incomplete Combustion*

27. A Water Pressure Test performed on a new boiler or a pressure vessel to ensure its integrity or after repair work to the steam or water side has been accomplished to verify the integrity of the repair.

- *Answer: Hydrostatic Test*

28. What device is considered to be the most important safety device on a high-pressure steam boiler.

- *Answer: Safety Relief Valve*

29. The pH of the Boiler Water should be between 8.5 and 11?

- *Answer: True*

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

- *Answer: Low-water Fuel Cut-off*

31. Water that must be added to the boiler to make up for water leaving the boiler in the form of steam, leaks in the system, or water that is lost through boiler blowdowns.

- *Answer: Boiler Feedwater – the water leaving the boiler in the form of steam, or when the boiler is blown down, must be replaced with feedwater!*

32. A valve utilized to remove condensate that is trapped between the two steam valves on a boiler and to verify the main steam stop valves are not leaking steam. The discharge of this valve must be visible to the operator or inspector while manipulating the valve.

- *Answer: Free-Blowing Drain Valve*

BOILER OPERATOR STUDY GUIDE

33. You should do a manual lift test of the safety relief valve by testing it when the boiler is operating at a pressure of at least 75% the set pressure of the valve.

- *Answer: True*

34. The Boiler Operator should understand how the Boiler Controls and Safety Devices operate on a High-Pressure Steam Boiler. When in doubt, the operator should check ___?

- *Answer: The Manufacturer's Recommendations or Boiler Operations Manual*

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

- *Answer: True*

36. A device that uses waste heat from the gases of combustion to heat the feedwater and increase the efficiency of the boiler?

- *Answer: Economizer*

37. What would cause the water in a gauge glass to fluctuate up and down in an erratic manner:

- *Answer: The boiler water may be high in Total Dissolved Solids (TDS) with a very high conductivity, the boiler water may be contaminated with oils or grease, or a very high chemical concentration due to a malfunctioning chemical feed pump.*

38. Small particles of water carried out with the flow of steam from the boiler and into the main steam line and process equipment?

- *Answer: Carryover*

39. High-Pressure Steam Boilers, which meet CSD-1 recommendations for local alarms and safety devices, shall be maintained by _____ attendance by a licensed Boiler Operator.

- *Answer: Regular Attendance*

40. The three requirements for combustion are:

- *Answer: Fuel, heat and oxygen*

BOILER OPERATOR STUDY GUIDE

41. Explosions and accidents involving boilers and pressure vessels in the State of Arkansas must be reported to the Boiler Inspection Division within?

- *Answer: Twenty-Four (24) Hours*

42. The method whereby the Boiler water is treated before it enters the boiler to remove scale-forming salts, dissolved oxygen and non-condensable gases.

- *Answer: External Water Treatment*

43. Test that checks the operation of the low-water fuel cutoff and mimics the loss of a feedwater pump or loss of water going to the boiler and is considered a superior method of testing the low-water fuel cutoff.

- *Answer: Evaporation/Slow-Drain Test*

44. Boilers should be fired slowly when first starting up to allow the boiler tubes and shell(s) to warm up and to expand uniformly under the action of the increasing temperature and pressure.

- *Answer: True*

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: Steam Temperature and the temperature of the boiler water*

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 State Boiler 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*

BOILER OPERATOR STUDY GUIDE

50. Burning all of the fuel using only the theoretical amount of air for combustion and is only achievable in a laboratory?

- *Answer: Perfect Combustion (Stoichiometric Combustion)*

51. Water level carried in the boiler gauge glass during normal operation (approximately one-third to one-half glass)?

- *Answer: NOWL (Normal Operating Water Level)*

52. The maximum operating pressure rating of a boiler or a pressure vessel as determined by the design and construction of the boiler in conformance with the ASME code?

- *Answer: MAWP (Maximum Allowable Working Pressure)*

53. A form of Carryover, whereby, large slugs of water are carried out with the flow of steam from the boiler and into the main steam line and process equipment?

- *Answer: Priming*

54. Mechanical draft produced by a fan supplying or forcing air for combustion into the furnace?

- *Answer: Forced Draft*

55. A sequence initiated before ignition and after burner shutdown to remove any explosive combustibles and prevent a burner explosion?

- *Answer: Purge Period*

56. The pre-determined pressure at which a safety valve opens and remains open until the pressure drops. Prevents the steam pressure in the boiler from exceeding the maximum allowable working pressure (MAWP).

- *Answer: Set Lifting Pressure or Set Popping Pressure*

57. The passing of air through a furnace prior to light-off to remove any fuels or fuel vapors, thereby preventing a furnace explosion.

- *Answer: Pre-Purge*

58. The passing of air through a furnace after normal burner shutdown?

- *Answer: Post-Purge*

BOILER OPERATOR STUDY GUIDE

59. What determines the size and capacity of a Safety Relief Valve?

- *Answer: The pounds of steam per hour it can discharge at the set lifting pressure.*

60. In the State of Arkansas, a High-Pressure Steam Boiler of fifty (50) Horsepower and over, and steam boilers used in hospitals, hotels, motels, schools, day cares, nursing homes, theatres, and office buildings must be _____ by a licensed operator who holds a certificate of competency issued by the Boiler Inspection Division.

- *Answer: under Regular Attendance*

61. The Accumulation of residue produced from impurities in the boiler water.

- *Answer: Sludge*

62. A dangerous banging condition that is caused by steam and water mixing in a steam line and will cause damage to Pipe, Valves, and Process Equipment?

- *Answer: Water Hammer*

63. Used to refract the heat and protect the metal of the boiler from overheating and is found in boiler doors and components, etc.

- *Answer: Refractory*

64. A device utilized to control the conductivity (Total Dissolved Solids) of the boiler water by skimming the impurities in the boiler water near the surface of the boiler water. Usually located just above the top row of tubes or 3” to 4” below the Normal Operating Water Level.

- *Answer: Surface Blowdown or “Surface Skimmer Blowdown”*

65. When removing a boiler from service for an extended period of time the boiler should be?

- *Answer: The Boiler should be laid up Dry by placing Desiccant in both the Fireside & the Waterside. The Boiler can also be laid up Dry using a Nitrogen Blanket.*

BOILER OPERATOR STUDY GUIDE

66. A data sheet used to record pressures, temperatures and other operating conditions of a boiler on a continuous basis?

- *Answer: Boiler Log*

67. The most common type of feedwater pump utilized to supply the feedwater to a High-Pressure Steam Boiler?

- *Answer: Centrifugal Feedwater Pump*

68. As an average, how many BTU's are present in a cubic foot of Natural Gas?

- *Answer: 1,000 BTU's in a cubic foot of Natural Gas as an average*

69. A Device to supply natural gas to the burner at the required volume & pressure needed for proper combustion.

- *Answer: Gas Pressure Regulator*

70. 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.

- *Answer: Boiler Vent*

70. An ASME Coded tank vented to the atmosphere that protects sewer lines from boiler pressure and high temperature boiler water when blowing down.

- *Answer: Blowdown Separator*

71. The water column & gauge glass on Boilers of the horizontal fire-tube type shall be set, so that, when the water level is at the lowest reading in the water-gauge glass, there shall be at least ____ inches of water over the highest point of the tubes, flues, or crown sheet.

- *Answer: 3 inches*

72. The rapid fluctuations of the boiler water level that can lead to priming or carryover. Caused by impurities and entrained solids on the surface of the boiler water forming a film over the steam bubbles. Causes are oil, fat, grease, faulty boiler chemistry with heavy chemical concentrations.

- *Answer: Foaming*

BOILER OPERATOR STUDY GUIDE

73. Pumps water from the open feedwater heater or Deaerator and delivers it to the boiler at the proper pressure and capacity.

- *Answer: Boiler Feedwater Pump*

74. Salts such as calcium carbonate and magnesium carbonate, that when in solution, tend to form a hard, brittle scale on hot surfaces.

- *Answer: Scale-Forming Salts*

75. A Protective device used on a Steam Pressure Gauge to protect the Bourdon Tube from the high temperature of the steam.

- *Answer: Gauge Siphon*

76. Regular Attendance, as defined, states the Boiler Operator must inspect the boiler for proper operation and log the required readings once each hour. Boiler must be equipped with local operating and safety devices and should have local alarm lights and buzzers?

- *Answer: True – Arkansas Boiler Code requires the hourly check as defined by regular attendance*

77. A Safety Device used to shut off the fuel to the burner in the event the primary low- water fuel cutoff fails in a low water condition and requires the operator to manually reset the control once the water level in the boiler has been re-established. The control is usually located ¾” to 1” below the level of the primary low-water fuel cutoff.

- *Answer: Secondary (auxiliary) Low-Water Fuel Cutoff with a Manual Reset*

78. The lowest part of the water side of a Watertube Boiler, where the bottom blowdown valves are located to conduct the bottom blowdown.

- *Answer: Mud Drum*

79. A measure of the ability of electrons to flow through a solution. Utilized to measure the Total Dissolved Solids in the boiler water.

- *Answer: Conductivity*

80. A Device that detects the invisible infrared light rays produced by the combustion process of the burner that are emitted by both the pilot flame and the main flame?

- *Answer: Flame Scanner*

BOILER OPERATOR STUDY GUIDE

81. Ancillary equipment used to heat fuel oil to the correct temperature so it can be pumped and burned. The heater can be either steam or electric.

- *Answer: Fuel Oil Heater*

82. Occurs when fuel or combustible gas has built up in the fire side of the boiler. Common causes are leaking fuel valves, failure of combustion air fans, or failure to purge the furnace.

- *Answer: Furnace Explosion*

83. Steel rods (round or square) used in boilers to reinforce flat surfaces to prevent bulging. Primarily used to reinforce the flat surfaces of the tubesheets in firetube boilers.

- *Answer: Stays and Stay bolts*

84. A type of feedwater heater operating with steam and water in direct contact. The direct contact design will heat the water and mechanically scrub the dissolved oxygen from the feedwater prior to being pumped to the boiler.

- *Answer: Deaerating Feedwater Heater or Deaerator*

85. A Pump that delivers the fuel oil to the burner at the proper volume and pressure to atomize and burn the fuel.

- *Answer: Fuel Oil Pump*

86. Installed on boiler main steam lines to allow for the safe expansion and contraction of the steam piping.

- *Answer: Expansion Bends*

87. A measure of the amount of calcium and magnesium salts in the boiler water usually expressed as grains per gallon or parts per million?

- *Answer: Hardness*

88. A tube in a Watertube Boiler or waterwall that maintains circulation in which the water flows downward between the drums or headers?

- *Answer: Downcomer Tube*

89. A Burner for firing oil in which the oil is atomized by compressed air which is forced into and through one or more streams of oil, breaking the oil into a fine spray for combustion?

- *Answer: Air-Atomizing Oil Burner*

BOILER OPERATOR STUDY GUIDE

90. Persons, companies, firms, and/or businesses that wish to perform repairs, welding, or alterations on ASME constructed pressure vessels, or within the vessels code boundaries, must have in place a written Quality Control system acceptable to the department, and have authorization from the National Board to perform such repairs or alterations. In all cases,

- *Answer: The Arkansas Department of Labor, Boiler Inspection Division, must be notified prior to starting repairs or alterations.*

91. Is gauge pressure or absolute pressure used in the ASME Boiler Code for Maximum Allowable Working Pressure for a Boiler or a Pressure Vessel?

- *Answer: Gauge Pressure, which is the pressure above atmospheric pressure in PSI and this is what is read by the boiler operator on the steam gauge.*

92. When a boiler is taken off-line for inspection, the boiler shall be cooled slowly to a temperature that will allow the boiler inspector to safely inspect the boiler without risk of burns. At what point will the boiler be safe to inspect?

- *Answer: When the boiler is cool enough to enter the firebox or furnace and as near ambient temperature as possible.*

93. How often should the boiler operator test the low-water fuel cutoff on a high-pressure Steam Boiler?

- *Answer: At least once per day, or each shift if more than one shift of operation is in effect*

94. Why should the water column and the low-water fuel cutoff chambers be flushed daily by draining the respective devices?

- *Answer: To keep the chambers free of mud and sediment, thus allowing the gauge glass to accurately display the water level, and to test the low-water fuel cutoff to make certain it shuts off the burner in the event of a low-water condition.*

BOILER OPERATOR STUDY GUIDE

95. The gauge glass on a horizontal firetube boiler shows the lowest possible water level in the glass at which the boiler can safely be operated at. How many inches above the tubes should this level be in a firetube boiler?

- *Answer: The Code requires water to be 3 inches above the top row of tubes when the water in the glass is at its lowest visible level, unless otherwise specified by the boiler manufacturer.*

96. The positioning of the gauge glass on a Watertube Boiler can vary according to the manufacture and the design of the Watertube Boiler. When in doubt of the correct water level, you should _____?

- *Answer: Consult the Manufacturer's Recommendations for the Normal Operating Water Level*

97. A formal request, in writing, to utilize a Remote Monitoring System on a High Pressure Steam Boiler (safety relief valve is set at greater than 15 psi) must describe the system, the equipment, what is presently installed, and what the plans are for remote monitoring. This formal request, in writing, must be reviewed and shall only be approved by?

- *Answer: The Chief Boiler Inspector, Boiler Inspection Division, State of Arkansas*

98. A Deaerating Feedwater Heater is used to heat the feedwater prior to being pumped to the boiler to prevent thermal shock and to remove gases from the feedwater to prevent _____ of the tubes.

- *Answer: Oxygen Pitting*

99. A manually operated remote shutdown switch or circuit breaker located just outside the boiler room and marked for easy identification.

- *Answer: Emergency Shutdown Switch (E-STOP) NBIC 2.5.3.2*

100. You discover a Safety Relief Valve on a High-Pressure Steam Boiler vented inside the boiler room and not vented to atmosphere. What is the danger?

- *Answer: Should the Safety Valve lift the steam would scald a person standing near the outlet of the safety relief valve! The steam may also damage equipment, such as electrical, located in the boiler room.*

BOILER OPERATOR STUDY GUIDE

~ A ~

ABSOLUTE PRESSURE- The sum of gauge pressure and atmospheric pressure.

ACCUMULATION TEST- Test used to establish the relieving capacity of boiler safety valves.

AIR HEATER- Supplies heated air for combustion. Located in the breeching between the boiler and chimney.

AIR TO FUEL RATIO- The ratio of the weight, or volume, of air to fuel.

ALKALINITY- Determined by boiler water analysis. Boiler water with a PH over 7 is considered alkaline or base.

AMBIENT TEMPERATURE- Temperature of the surrounding air.

ANCILLARY EQUIPMENT - Piece of equipment not directly attached to the boiler but necessary for its operation.

ATMOSPHERIC PRESSURE- Pressure at sea level (14.7 psi).

ATOMIZE- To break up liquid into a fine mist.

AUTOMATIC NON-RETURN VALVE- Valve located on the steam line closest to the shell of the boiler that cuts the boiler on-line and off-line automatically.

~ 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 exit the boiler and 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 tubes connect the drums.

BLACK LIGHT – In magnetic particle inspection, light in the near ultraviolet range of wave lengths.

BLOWBACK – The number of pounds per square inch of pressure drop in a boiler from the point where the safety valve pops to the point where the safety valve re-seats.

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 firetube boiler and the mud drum of a watertube boiler.

BOILER (steam)– A closed vessel in which water is heated, steam is generated, under pressure by the application of heat from combustible fuels, electricity, or nuclear energy.

BOILER CAPACITY- Pounds of steam per hour that a steam boiler is capable of producing.

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 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.

BOILING OUT – The boiling of a highly alkaline water in a boiler pressure parts for the removal of oils, greases, etc. prior to normal operation on a new boiler or after major repairs.

BOURDON TUBE- Connected by linkage to a pointer that registers pressure inside pressure gauges.

BREECHING- The exhaust discharge duct to connect the boiler to stack.

BRINELL TEST – A hardness test performed by pressing a steel ball of standard hardness into a surface by a standard pressure.

BRITISH THERMAL UNIT (BTU)- A measurement of the quantity of heat. The quantity of heat necessary to raise the temperature of one pound of water by 1°Fahrenheit.

BOILER OPERATOR STUDY GUIDE

BURNER MANAGEMENT SYSTEM (BMS) – A system of control devices and control logic used to ensure safe burner operation.

BUTTERFLY VALVE- A characterized valve used to control the gas flow to the burner.

BYPASS DAMPER- Controls the air temperature in air heaters or economizers in order to maintain sufficient temperature to prevent condensation of the flue gases.

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 carried out with the flow of the steam into the main steam line and process equipment. Usually a result of foaming. Carryover is caused by faulty boiler water condition.

CAUSTIC CRACKING – Also called caustic embrittlement cracking, usually occurring in carbon steels or iron-chromium nickel alloys that are exposed to concentrated hydroxide solutions at temperatures of 400 to 480°f

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 converted into water pressure by a rotating impeller.

CHECK VALVE- A valve designed to prevent reversal of flow and allow the flow of a liquid in one direction.

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 natural draft. Also referred to as a boiler stack and used to allow the exhausting of the gases of combustion to the atmosphere.

COMBUSTION- The rapid reaction of oxygen with a fuel that results in the release of heat.

COMBUSTION AIR AND VENTILATION – NBIC 2.5.4 - The equipment room shall have an adequate air supply to permit clean & safe combustion, minimize soot formation, and maintain a minimum of 19.5% oxygen in the air of the boiler room.

COMBUSTION AIR REQUIREMENTS – NBIC 2.5.4 – The combustion and ventilation air should be supplied by either an unobstructed air opening or by power ventilation or fans.

COMBUSTION AIR REQUIREMENTS – NBIC 2.5.4 – Unobstructed air openings shall be sized on the basis of 1 square inch (650 sq. mm) free area per 2000 Btu/hr (586 W) Burner Input

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 firetube boiler are subjected to compressive stress.

CONDENSATE- Steam that has lost its latent heat and has returned to water.

CONDENSATE PUMP- Used to return condensed steam (condensate) to the open feedwater heater.

CONDENSATE TANK- Utilized to store condensate (condensed steam) before it is delivered back to the open feedwater heater (Deaerator) by the condensate return pump.

CONDENSE- Process whereby steam turns back to water after the removal of its latent 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. Used to measure the Total Dissolved Solids in the boiler water.

BOILER OPERATOR STUDY GUIDE

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.

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 of a SAFETY RELIEF VALVE - A plate securely fastened to a safety relief valve shall contain data & stamping required by the ASME and be a National Board Capacity Certified Valve.

DATA STAMPING – SCOTCH MARINE BOILERS – ASME BPVC, Section 1, PG-111.6

The ASME Code Stamping shall be performed directly on either side of the boiler shell near the normal water level line and as near as practical to the front tubesheet. These Stampings shall be left uncovered or an easily removable marked cover may be provided over the stamping when a boiler is covered with insulation, or jacketed.

DATA STAMPING – WATERTUBE Drum Type BOILERS – ASME BPVC, Section 1, PG-111.5.1

The ASME Code Stamping shall be performed directly on a head of the steam outlet drum near and above the manhole. These Stampings shall be left uncovered or an easily removable marked cover may be provided over the stamping when a boiler is covered with insulation, or jacketed.

DEAERATING FEEDWATER HEATER- Type of open feedwater heater utilized to mechanically scrub the dissolved oxygen & gases from the boiler feedwater prior to being supplied to the boiler.

DE-SUPERHEATING- 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.

~ E ~

ECONOMIZER- Utilizes the waste heat from the gases of combustion to heat the feedwater.

ELEMENT- A basic substance consisting of atoms.

ENTHALPY- Total heat in the steam specifically the total of the Latent Heat & the Sensible Heat

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 to allow the steam line to warm-up slowly.

EMERGENCY SHUTDOWN SWITCH (E-STOP) NBIC 2.5.3.2 – A manually operated remote shutdown switch or circuit breaker located just outside the boiler room and marked for easy identification.

EVAPORATION TEST / SLOW DRAIN - Test that checks the operation of the low water fuel cutoff and mimics the loss of a feedwater pump to allow the boiler water level to fall slowly.

EXCESS AIR- Air more than the theoretical amount of air needed for combustion and necessary to achieve complete combustion in a burner.

EXPANSION BENDS- Installed on boiler main steam lines to allow for the safe expansion and contraction of the steam piping.

EXTERNAL TREATMENT- Boiler water treated before it enters the boiler to remove scale-forming salts, dissolved oxygen and non-condensable gases.

BOILER OPERATOR STUDY GUIDE

~ F ~

FEEDWATER- Water that is supplied to the steam boiler.

FEEDWATER HEATER- Used to heat feedwater and prevent thermal shock before it enters the boiler.

FEEDWATER SUPPLY PIPING - Lines leaving the open feedwater pump and going to the boiler to maintain the operating water level of the boiler and replace the water in the boiler due to evaporation.

FEEDWATER PUMP- Pumps water from the open feedwater heater or Deaerator and delivers it to the boiler at the proper pressure and capacity.

FEEDWATER REGULATOR- Control used to maintain a consistent NOWL that cuts down the danger of high or low water. Typically utilized on a modulating feedwater system.

FEEDWATER TREATMENT- Treatment that encompasses both internal treatment (chemicals added to the boiler), or external treatment using water softeners or reverse osmosis systems. 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 and initiates a safety lockout of the Burner Management System (BMS).

FLAREBACK- Flames discharging from the boiler through access doors or ports caused by delayed ignition, furnace pressure buildup, or a failure to open exhaust stack dampers.

FLASH BLOWDOWN HEAT RECOVERY SYSTEM - A heat recovery system used to reclaim the heat from the surface 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.

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 (oil, fat, grease, chemical concentrations)

FORCED DRAFT- Mechanical draft produced by a fan forcing the combustion air into the furnace.

FREE-BLOWING DRAIN- A valve installed between the two main steam stop valves on a boiler to remove trapped condensate from the main steam line, but more importantly, to establish the integrity of the steam valves on a boiler when inspecting the boiler while other boilers in battery are steaming.

FRONT HEADER- Connected to the steam and water drum by downcomer nipples.

FUEL OIL HEATER- Used to heat fuel oil at the correct temperature so it can be pumped and burned. 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 volume & pressure.

FURNACE EXPLOSION- Occurs when fuel or combustible gas has built up in the fire side of the boiler. Common causes are leaking fuel valves, failure of combustion air fans, or failure to purge the furnace.

FURNACE VOLUME- Amount of space available in a furnace to complete combustion.

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~ G ~

GAS ANALYZER- Used to analyze the gases of combustion to determine combustion efficiency.

GAS COCK- A manual quick-closing shutoff valve.

GAS LEAK DETECTOR- Device used to locate gas leaks in a boiler room.

GAS PRESSURE REGULATOR- Used to supply gas to the burner at the required volume & 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 or per manufacturers recommendations.

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 (pounds per square inch) or PSIG (pounds per square inch gauge).

GLOBE VALVE- A valve that is typically used for throttling services and can be utilized as a bypass valve to throttle feedwater to a boiler in the event of a failure of the automatic feedwater regulator.

~ H ~

HANDHOLE- A part found on both fire tube and water tube boilers that is removed for inspection and cleaning of 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 and preheat the boiler feedwater. Utilized primarily with surface continuous blowdown systems.

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 WATER ALARM- Warns the operator of high-water condition in the boiler. High water condition in a boiler is considered dangerous due to the potential of causing damage from water hammer to the equipment, valves, and the steam pipe.

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.

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.

HYDROGEN- A basic element that is 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- A pressure test made using water to test the integrity of the pressure vessel after manufacture or after repair work on the steam or water side of a boiler or a pressure vessel.

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~ I ~

IGNITION- The lightoff point of a combustible material.

IMPELLER- The rotating element found in a centrifugal pump that converts centrifugal force into pressure.

INCOMPLETE COMBUSTION- Occurs when all the fuel is not burned, resulting in the formation of smoke, soot, and dangerous carbon monoxide.

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 for burn protection and to reduce the radiant heat losses.

INTERLOCK- Used with burner controls to ensure proper operating sequence.

INTERNAL FEEDWATER LINE- Perforated line located just below the NOWL in a watertube boiler that distributes the relatively cool feedwater over a large area to prevent thermal shock to the boiler metal.

INTERNAL FURNACE (Main Furnace Tube)- Furnace that is located within the boiler and is surrounded by water in the scotch marine firetube 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, corrosion, 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.

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 normal operating water level.

LOW WATER FUEL CUTOFF- A device located below the normal operating water level (NOWL) of a boiler and is positioned according to the manufacturer guidelines, The Low Water Fuel Cutoff shuts off the burner in the event of a low water condition, preventing damage to the tubes and a possible boiler rupture or explosion.

~ M ~

MAIN STEAM HEADER- That part of the steam 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.

MAKE-UP WATER- Water that must be added to the boiler to replenish the water that is evaporated to steam and supplied to the process.

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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 SECONDARY LOW-WATER FUEL CUTOFF - Used to shut off the fuel to the burner in the event the primary low water fuel cutoff fails in a low water condition and requires the operator to manually reset the control once the water level in the boiler has been re-established. The control is usually located $\frac{3}{4}$ " to 1" below the level of the primary low water fuel cutoff.

MAWP (MAXIMUM ALLOWABLE WORKING PRESSURE)- Determined by the design and construction of the boiler in conformance with the ASME code.

MICROPROCESSOR (Burner Management System BMS)- 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 works in conjunction with a jack shaft to position 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 the firing rate of the burner.

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 GAS- A combustible gas that is found in pockets trapped underground and consists mainly of methane.

NON-ADHERING SLUDGE- Residue formed in a boiler when scale-forming salts are created by adding feedwater chemicals. The chemicals prevent the sludge from adhering to the tubes and allows the sludge to be discharged utilizing the bottom blowdown valve.

NON-CONDENSABLE GASES- Gases found in boiler makeup water (oxygen) and in the condensate.

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 ~

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 and measure the capacity of the liquid or steam flowing within the pipe.

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 valve(s).

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~ P ~

PACKAGE BOILER- A Boiler that is shipped from the factory 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.

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.

POST-PURGE- The passing of air through a furnace after normal burner shutdown to remove any fuel.

POUR POINT- Lowest temperature at which fuel oil flows as a liquid.

PRE-PURGE- The passing of air through a furnace prior to light-off to remove any fuel or fuel vapors.

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 STATION- Where steam pressure is reduced for a specific 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 initiates the pre-purge and controls 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.

PSI (POUNDS PER SQUARE INCH)- Unit of measurement used to express the amount of pressure present in a given structure or system.

PUMP CONTROLLER- Starts and stops a feedwater pump, depending on the water level in the boiler.

PURGE PERIOD- Before ignition and after burner shutdown to remove any explosive combustibles.

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 affects the BTU content of the steam.

QUICK-CLOSING VALVE- Valve that requires a one-quarter turn to be fully open or closed.

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~ R ~

RADIANT SUPERHEATER- A nest of tubes that the saturated steam passes through to acquire heat.

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.

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 – Refracts the heat and protects the boiler doors, components, etc. from overheating.

RELIEF VALVE- Used to protect liquid systems from excessive pressure.

RESET- Switch that must be reset manually after tripping.

RINGELMANN- Chart used as a means of determining smoke density.

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 but never more than 4%).

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 burner or 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. Utilized as a bottom blowdown valve for boilers.

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 opacity or 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.

STAYS AND STAYBOLTS- steel rods (round or square) used in boilers to reinforce flat surfaces to prevent bulging. Primarily used to reinforce the flat surfaces of the tubesheets in firetube boilers.

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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. Prevents water hammer of steam lines and equipment.

STEAM TURBINE- Used to drive boiler auxiliaries or generators in large plants.

STOPCOCK (GAS COCK)- A quick-opening or closing valve found on gas lines.

SUCTION PRESSURE- (Net Positive Suction Pressure NPSH) Pressure on the liquid at the suction side of a pump and is calculated in Feet.

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 (skimmer valve) - Used to remove impurities from the surface of the water in a steam and water drum of a watertube boiler or the area just above the top row of tubes in a firetube boiler.

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- Test Valves mounted on a water column to serve as a Secondary means of determining the water level in a boiler.

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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.

~ 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.

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 or in process equipment.

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 in a watertube boiler.

WINDBOX (PLENUM CHAMBER)- Pressurized air chamber that supplies air to a furnace.

~ Z ~

ZEOLITE- A resin material that is used in the ion exchange process of a water softener. A Brine (Salt) solution is utilized to charge the Zeolite Resin and remove the Calcium and Magnesium Hardness from the resin.

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OUR MISSION: The Arkansas Boiler Association exists to promote safety in the inspection, operation, construction and repairs of boilers and pressure vessels. This will be accomplished through effective communication between all involved parties and education of its members and the public.

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Selected Bibliography

ASME Boiler and Pressure Vessel Codes, Sections 1 through IX, American Society of Mechanical Engineers

ASME CSD-1, Controls and Safety Devices

NBIC - National Board Inspection Code, National Board of Boiler and Pressure Vessel Inspectors, Columbus, Ohio

Power Piping Code, ANSI B31.1, American National Standards Institute, New York

National Fire Protection Codes, NFPA-85

Administrative Rules of the Boiler Inspection Division of the State of Arkansas Department of Labor, Boiler Inspection Division, Little Rock, Arkansas

American Technical Publishers, High Pressure Boilers, Orland Park, Illinois

Pressure Vessel Systems, Kohan, A. L., McGraw-Hill

Plant Services and Operations Handbook, Kohan, A. L., McGraw-Hill

The Babcock & Wilcox Company, Steam Edition 41, Barberton, Ohio