GENERATION-OAHU DIVISION
OPERATOR TRAINEE TRAINING PROGRAM

Section 12
BOILERS AND ACCESSORIES

OBJECTIVES:

1. Discuss the three boiler types.
2. Identify and discuss the following boiler accessories.
   a. Safety Valves
   b. Steam Drum and Internals
   c. Soot Blowers
   d. Boiler Water Treatment and Control
   e. Boiler Gauge Glasses
   f. Drum Vent and Superheat Drains
   g. Boiler Fill and Drain System
   h. Air Preheaters
   i. Steam Air Heaters
   j. Draft Equipment
   k. Boilers Sealing and Cooling Air
   l. Aspirating Air
   m. Hydrostatic Testing

Generation-Oahu Division
Operator Trainee Training Program

Section 12
BOILERS AND ACCESSORIES

All steam generators, usually referred to as boilers, are designed for a specific performance. A boiler is a device where the chemical energy in fuel is converted to heat energy in steam. When a boiler is supplied with feedwater at a specified temperature and a given amount of fuel, it is designed to deliver a specific quantity of steam to the turbine at the required pressure and temperature. How this is accomplished varies from plant to plant.

A brief description of three (3) boiler types is given before covering the accessories of a boiler which are usually fairly universal and apply to all boilers. For the purpose of this discussion the accessories include: safety valves, steam drum, soot blowers, water treatment, gauge glasses, boiler vents and drains, fill and drain system, air preheaters, steam air heaters, draft fans, boiler sealing and cooling air, aspirating air, and hydrostatic testing.

Waiau #3 & 4 boilers are Babcock & Wilcox radiant type steam generators: three drum, water tube, utilizing natural circulation, with water cooled furnace (Figure 12.1). The boilers are each designed to produce 447,000 lb/hr of superheated steam at 875 psig and 905 F.

Water enters the boiler at the economizer through the feedwater stop-check valve. Passing through the economizer, the water enters the steam drum and, due to its low temperature and high density, travels down two (2) downcomers (one on either side of the steam drum) to the mud drum.

Exposed to the radiant heat, the water forms steam and the water steam mixture rises in the water wall tubes and returns to the steam drum where the saturated steam is separated from the water and travels to the superheater.

The superheater is known as the Babcock & Wilcox continuous tube, suspended vertical type superheater in three sections arranged for counter flow. The saturated steam enters the rear of the third section, flows through this section, the intermediate section, the attemperator and first superheater section, and finally passes into the outlet header and the main steam line.

The superheater is designed to provide maximum accessibility and maximum cleanability. All sections of the superheater are supported from the water cooled roof tubes located above the superheater. Steam temperature control is provided for by the attemperator.

The economizer is of the continuous tube type, providing for counterflow of gas and water, assuring maximum efficiency of this heating surface. The gas flow is down through the economizer and the water flow is up, discharging into the steam drum.

The furnace is completely water cooled, the floor consisting of tubes lined with brickwork, and the walls in the radiant section being studded. This type of construction is gas and air tight, not dependent on insulation or a steel casing for tightness.

A vertical bank of boiler tubes is placed between the furnace and the superheater. A water cooled baffle is provided for the roof of the furnace and under the boiler steam drum.

The air heater is of the vertical tubular type with a single gas passage through the tubes and single air passage around the tubes; the gas and air being in counter flow. The forced draft fan will discharge the air into the casing around the tubes and out at the bottom into the hot air duct. From there, the air travels to the windbox and air registers and into the furnace to become combustion gas. Traveling up the radiant section, then across and down the convection section, the gas enters the air heater at the bottom and discharges at the

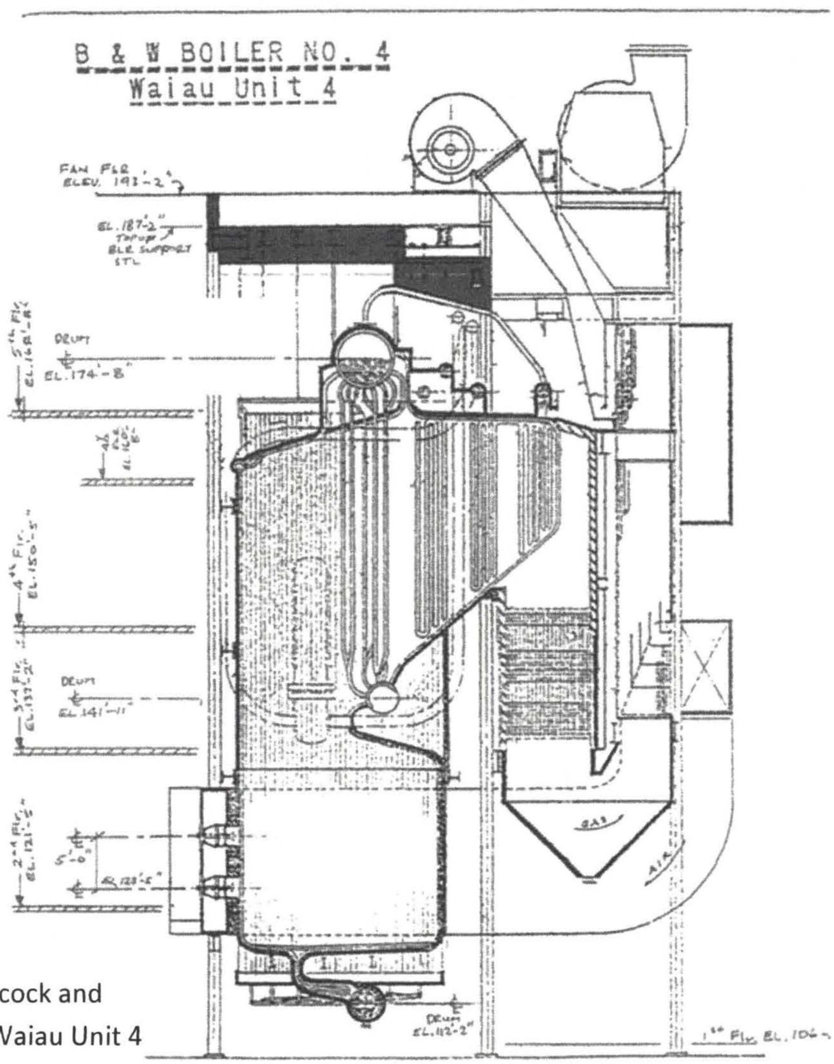


Figure 12.1 Babcock and Wilcox Boiler—Waiau Unit 4

top into an induced draft fan and out the stack.

STEAM GENERATION

The boiler is a Babcock and Wilcox single drum, radiant type with a pressurized furnace with water cooled walls, a continuous tube two-stage superheater, a continuous tube economizer, a Ljungstrom regenerative air preheater, a forced draft air system, and a single spray-type attemperator. The boiler has-a continuous rated output of 485,000 pounds of steam per hour at 1315 psig and 950°F at the superheater outlet. It is capable of producing 506,000 pounds of steam per hour. See Figure 12.2.

The boiler drum is equipped with three safety valves having a total relieving capacity of 545,000 pounds of steam per hour. In addition, there is a fourth safety valve and an electromagnetic relief valve located in the secondary superheater outlet.

The boiler drum is furnished with two water level gauges. A vision duct, using a mirror system, permits remote observation of one of these gauges in the control room. The drum is also provided with a water level recorder and indicator mounted on the control room panel. Five skin

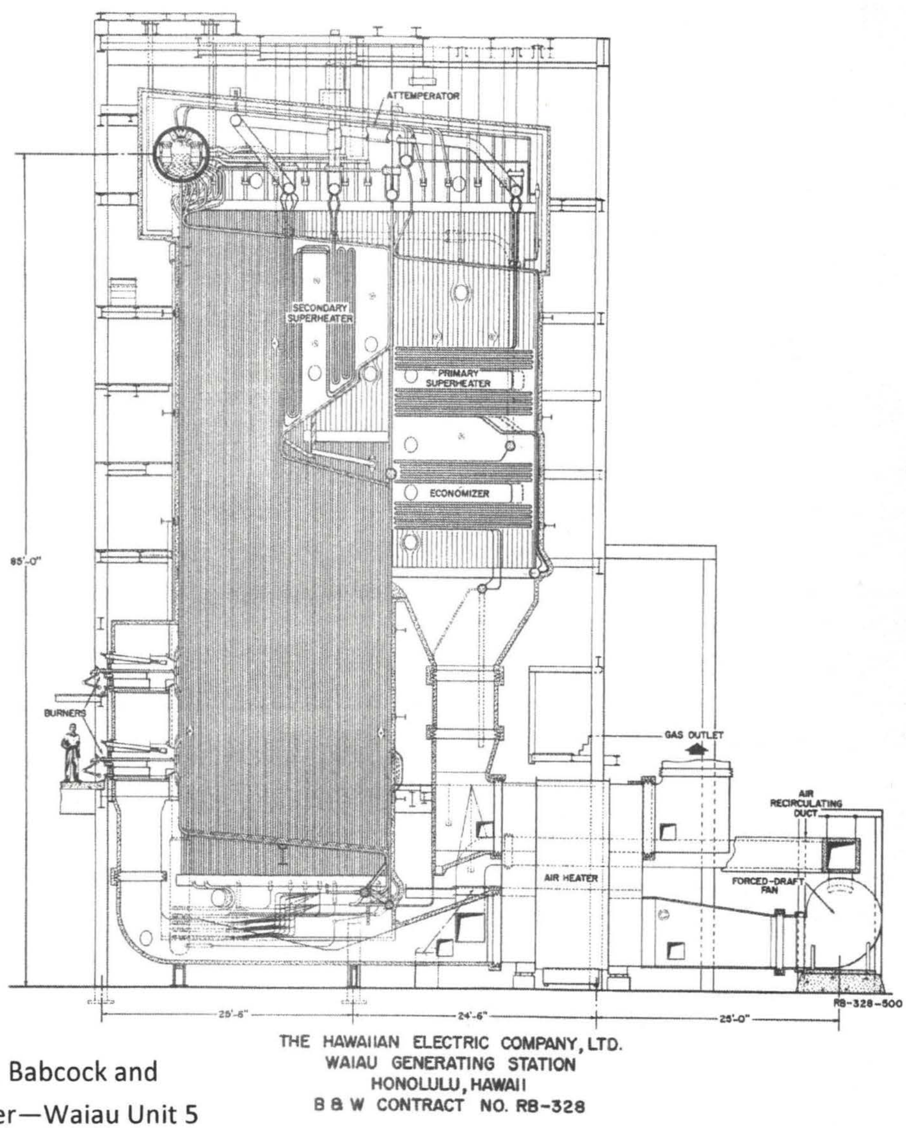


Figure 12.2 Babcock and Wilcox Boiler—Waiau Unit 5

thermocouples arc connected to the boiler drum, nine on the secondary superheater, and one on the saturated steam header for observation of the metal temperatures.

The boiler is fired with oil which is fed through six mechanical atomizing fuel oil burners. To provide for the required 10 to 1 turn down range, the oil burners are designed for an operating oil pressure of 1050 psig and up to 10 inches water gauge air pressure drop across them. As a complement to the turn down range, the forced draft fan is equipped with both inlet vane and discharge damper control. The combustion control system supplements these design criteria in that it goes directly to measurement of the fuel oil flow as a control index, with the quantity of oil fired being controlled by a valve in the return line from the burners in direct proportion to the combustion control loading pressure. In addition, the supply of oil to the burners is controlled in a predetermined relation to oil burned.

OIL FIRING SYSTEM

The furnace is fired by six Babcock & Wilcox manually retractable, air register, return flow, circular fuel oil burners mounted in two horizontal rows of three each. Design normal temperature of the oil is 235° F throughout the entire load range. Each burner is sized for a constant supply flow of 5,350 pounds of oil per hour, with the quantity of oil fired being controlled by a valve in the return line from the burners.

DRAFT SYSTEM

A forced draft fan supplies combustion air to the furnace at a pressure varying from 5 to 16 inches water gauge. The boiler requires quantities of air ranging up to 496,000 pounds per hour dependent upon load conditions. After leaving the fan, air is passed through the preheater and air flow venturi section to the windbox. To protect the cold side of the air preheater from corrosion, an air recirculation system is provided. By recirculating the warm air the average cold side temperature may be increased. The quantity of air recirculated is controlled by averaging the impulses of two thermal elements; one located in the leaving flue gas stream and one in the entering air stream. This average impulse operates a set of flow control vanes in the recirculation duct.

Air passes from the windbox through the burner registers and is mixed with the fuel oil spray to form the combustion mixture.

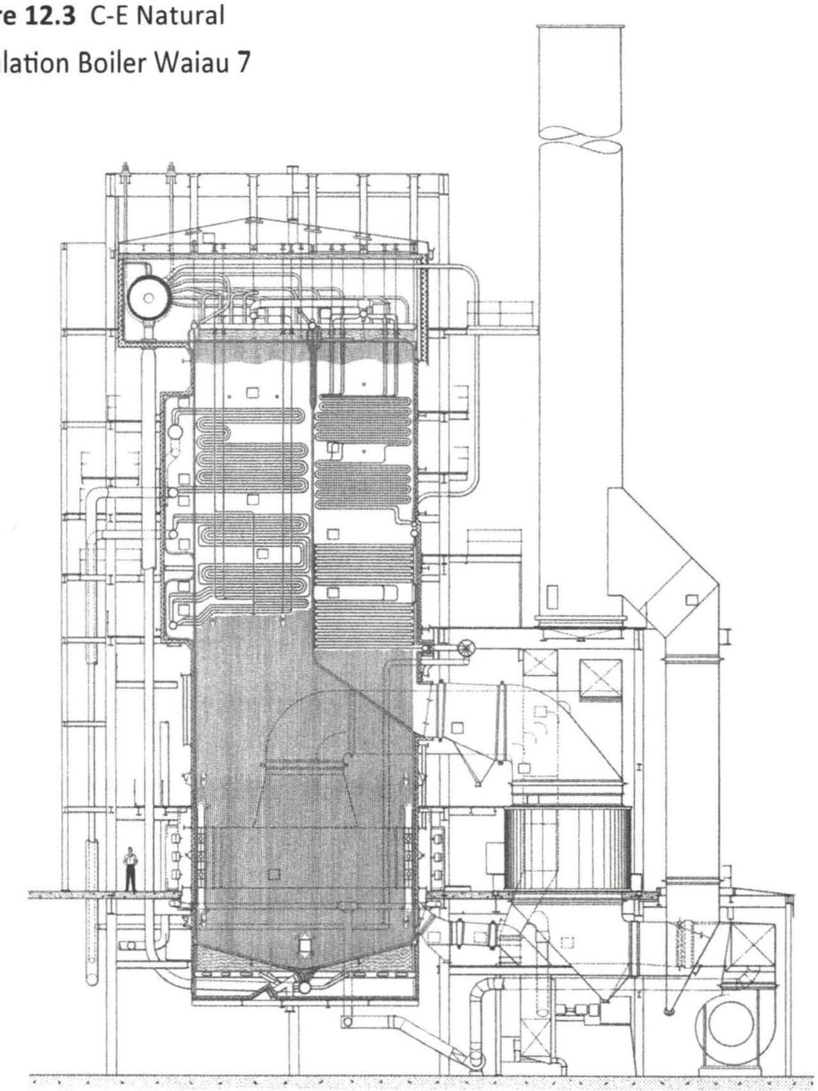
SUPERHEATER & ATTEMPERATOR

The boiler uses primary and secondary superheaters with a water spray-type attemperator located in the line connecting them. Spray water for the attemperator is taken from a point in the discharge line from the boiler feed pumps. Flow of spray water is controlled by the air flow load index readjusted by steam temperature, and with spray water flow tie-back.

ATMOSPHERIC BLOWOFF

The atmospheric blowoff tank serves as a collection point for water and steam from the several water wall header drains and the continuous blowdown line from the boiler. The amount of blowdown is regulated so that the total solids concentration in the boiler will not exceed 1000·ppm. The water entering the tank partially flashes into steam which is exhausted to the atmosphere. The

Figure 12.3 C-E Natural Circulation Boiler Waiau 7



remaining impurities and water are drained to waste.

WATER & SATURATED STEAM CYCLES

C-E Natural Circulation Boiler. The water circuits are shown on Figure 12.3.

Basically the system functions as follows:

Feedwater is supplied to the steam drum, from the economizer outlet header through the two economizer outlet links. The water side of the steam drum is connected with the furnace front and rear wall inlet header through four downtakes.

The front and rear wall inlet header feeds the front and rear furnace wall tubes; the furnace side walls are supplied by the two side wall inlet headers. The front and rear wall inlet header connects with sidewall inlet headers through supply tubes.

The furnace rear wall tubes slope forward and up to form the furnace arch and the furnace wall in back of the front horizontal superheater and reheater sections. These tubes are spread out in the upper part of the furnace to permit passage of the flue gases. The rear boiler wall, in back of the rear horizontal superheater and economizer, is formed by the superheater connecting tubes, which also form the furnace roof.

The water in the furnace side walls absorbs heat. The resulting mixture of water and steam is collected in the outlet headers and discharged into the steam drum through a series of riser tubes. Steam generated in the first two tubes in each side wall is supplied directly to the steam drum. In the steam drum, separation of water and steam takes place. The boiler water mixes with the incoming feed water. The saturated steam is led to the rear horizontal superheater via the superheater connecting tubes.

Passing through the various superheater stages, the steam is superheated to the design superheat temperature. From the front horizontal superheater outlet header the superheated steam is led to the turbine via the main steam line. From the high pressure section of the turbine, steam is returned to the Reheater to be "reheated" to the design temperature. Reheated steam is returned to the remaining turbine stages.

C-E DESUPERHEATERS

The Superheater Desuperheater. One desuperheater is installed in the link leading from the rear horizontal superheater outlet header to the front horizontal superheater inlet header. A steam assisted water spray nozzle is fitted in the entering end of the desuperheater to make it possible to reduce the steam temperature, when necessary, and maintain the same at its design value within the limits of the nozzle capacity.

The desuperheaters are positioned before the high temperature superheater and the reheater to ensure against water carryover to the turbine. This also eliminates the necessity for high temperature resisting materials in the desuperheater construction itself.

AIR AND GAS FLOW

(See Figure 12.4)

Air Flow. Total Unit air requirement is provided by one forced draft fan, which delivers air for:

- Combustion -Main Burners (oil guns)
- Combustion - Pilot Torches
- Sealing- Furnace Openings, Soot Blowers
- Sealing- Gas Recirculating Duct

Main Burner Combustion Air is pre-heated by two regenerative type air heaters which utilize the residual heat of the flue gases leaving the furnace. The combustion air is admitted to the main burner windbox compartments through individual dampers.

Pilot Torch Combustion Air is taken off the

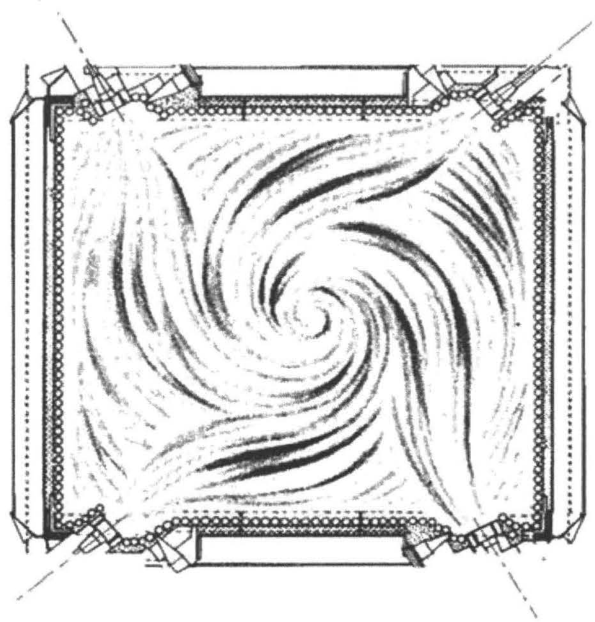


Figure 12.4 - Tangential burner arrangement - view looking down into furnace.

crossover duct connecting the F.D. Fan outlets. It is admitted to the four pilot torch windboxes through the bottom inlet connections. A booster fan with automatic control damper is provided in the pilot torch air supply manifold to maintain a constant air pressure drop across the pilot torch windboxes.

Sealing Air is required to seal off furnace openings (observation ports, soot blower wall boxes, etc.) as the furnace is pressurized. Sealing air is taken off the pilot torch air manifold upstream of the pilot torch fan.

NOTE: Sealing air is supplied continuously and is to be distinguished from aspirating air, such as used to seal off oil guns, observation ports, etc. Aspirating air, which is supplied only when used, is normally compressed air from the station air system.

Gas Recirculating Duct Sealing Air is taken off the burner air duct at the air heater outlet

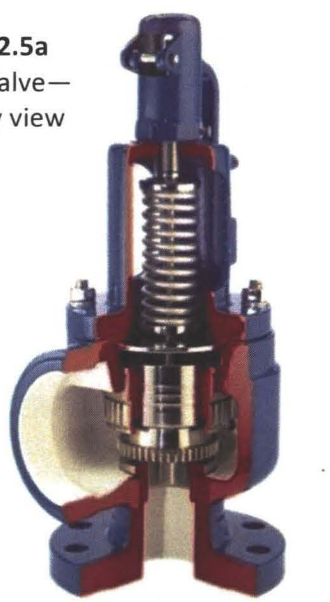
Gas Flow. Flue gases travel upward through the furnace, then downward through the boiler gas pass. From the economizer outlet, the flue gases are led to the air preheaters through two separate ducts. The air heater gas outlet ducts lead to a common stack. A portion of the flue gases leaving the gas pass can be recirculated through the furnace by means of a gas recirculating fan.

SAFETY VALVES

The safety valve (Figures 12.5a & 12.5b) is a protective device designed and set for relieving the boiler steam pressure to prevent exceeding the maximum allowable working pressure by more than 6% at maximum evaporation. At least one valve on the boiler must be set at or below the maximum allowable working pressure. If more valves are used, the highest setting shall not be more than 3% above the maximum allowable working pressure. The blowdown of each valve is set at approximately 3%.

The steam pressure control point for a plant generally maintains a relatively constant pressure at the turbine throttle. As boiler load increases the drum pressure must rise to maintain a constant turbine throttle pressure due to the increasing

Figure 12.5a
Safety Valve—Cutaway view



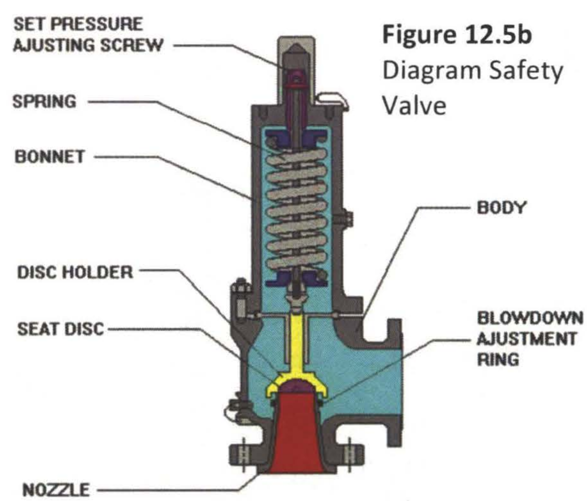


Figure 12.5b
Diagram Safety Valve

pressure drop through superheater sections. The setting for safety valves on the superheater outlet is lower than any drum safety as it is desirable to have the superheater safety lift first and thus maintain steam flow through these sections for ample cooling.

Most installations make use of an Electromatic Relief Valve (Figure 12.6) to minimize maintenance of the regular safety valves. This valve is located on the superheater outlet and can be isolated for repairs. It is set to relieve before all other safety valves. When on automatic it is actuated electrically from a pressure sensing device with a tap to the superheater outlet or two taps, one from the superheater outlet and one from the drum. It may also be operated manually by a switch located on the boiler control panel. The drum sensor is set to relieve at a higher pressure.

OPERATION

The conventional type safety valve, as seen in Figure 12.5a, is a spring loaded valve with the compressed force of the spring being opposed by the force of the boiler steam pressure acting against the inlet face of the valve disc, Figure 12.7A.

When the pressure force becomes great enough, the load on the relatively small seating surface of the disc will overcome the spring tension and the valve will start to lift, Figure 12.7B. The slight amount of steam discharged is deflected upward. The steam now reacts against the additional area of the lower face of the disc outside of the seat and causes the valve to pop open, Figure 12.7C.

As the steam pressure decreases, the disc assembly will return to the intermediate lift position (Figure 12.7B) and as the area has decreased plus the spring tension the valve

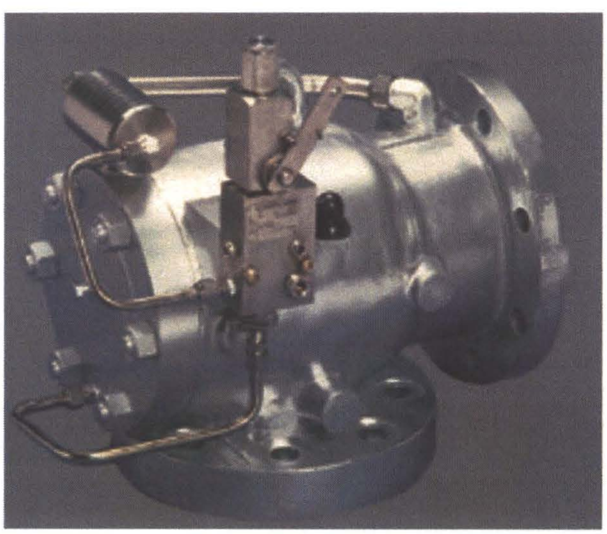


Figure 12.6a
Electromatic Relief Valve

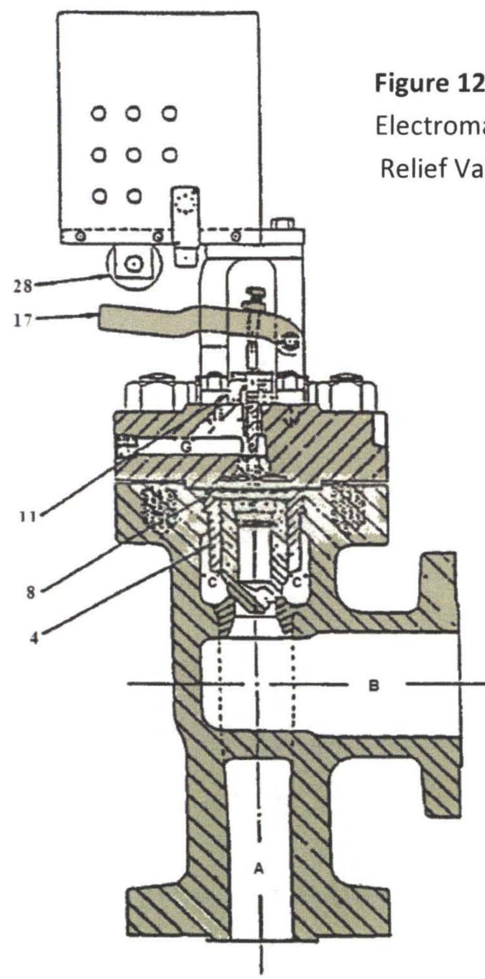
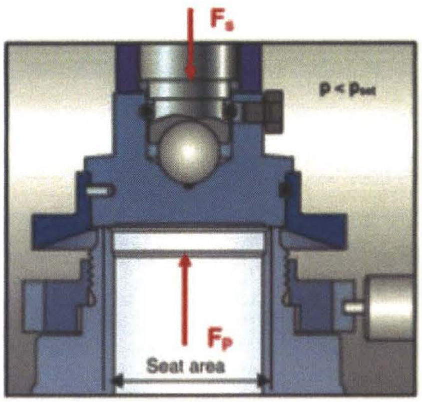


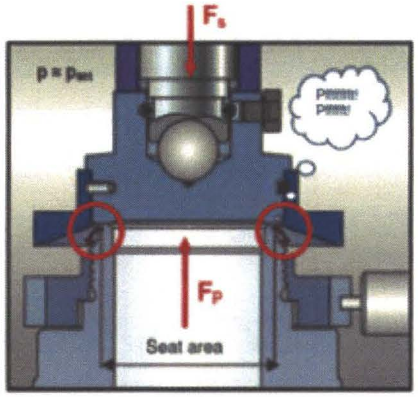
Figure 12.6b
Electromatic
Relief Valve



NORMAL OPERATION

p < p set

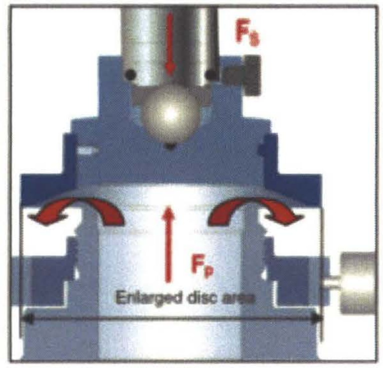
Figure 12.7a



AT SET PRESSURE

p = pset

Figure 12.7b



MAIN VALVE OPENING

p > pset

Image Credit - www.leser.com

Figure 12.7c

will snap shut. The difference in steam pressure between point of valve lift until the valve seats is called the blowdown and should be set for approximately 3% of lifting pressure.

The Electromatic Relief Valve is a pressure relief valve typically controlled by an electrical signal resulting from high system pressure or manually by closing a switch at the boiler control board. It may be set to operate from the pressure sensing line to an electrically operated solenoid which will trigger the relief valve.

Referring to Figure 12.6b, steam under pressure from the boiler enters the main valve through the inlet Chamber A and passes upward around exhaust Chamber B into Chamber C. The main valve disc is held closed by the steam pressure in Chamber E. Steam enters this Chamber E through the clearance space between the main valve disc and its guide 4. The steam pressure is equal in Chambers E and C when the escape through port G is prevented by pilot valve disc 8 being closed. The pilot valve disc is held closed by spring 11 to build up steam pressure in Chamber E. The pilot valve disc will open by operating level 17 under the action of the solenoid plunger head 28.

When the pilot valve opens, steam is released from Chamber E through port G faster than steam is supplied through the clearance space around the main valve plug. The resultant unbalance of pressures in Chamber E and C lift the main valve from its seat permitting the steam to escape from Chamber C to B.

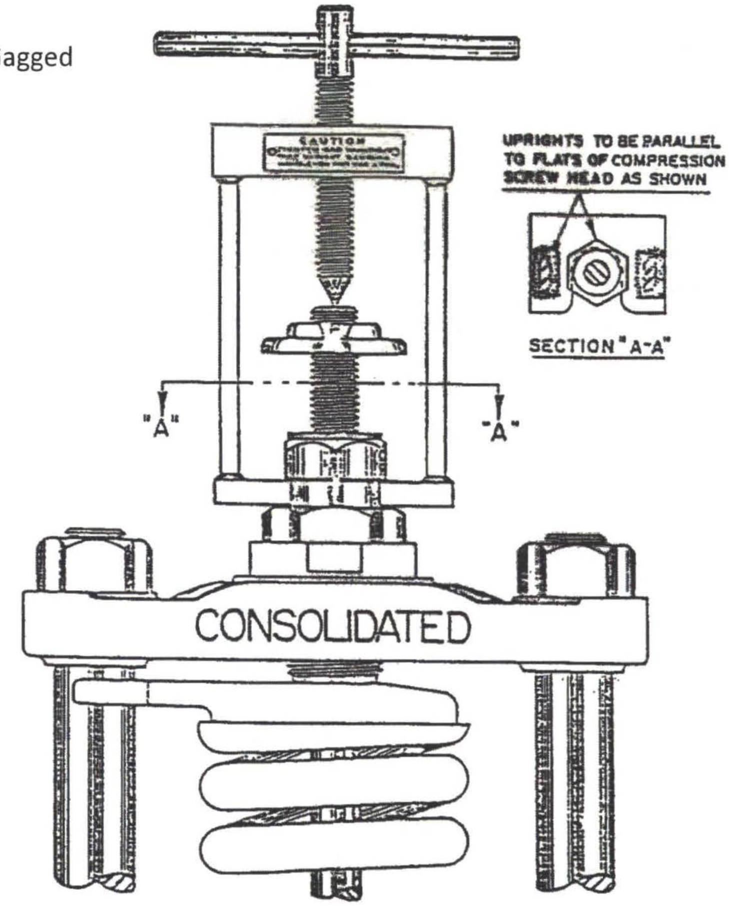
When the pilot valve closes as a result of the solenoid being de-energized (lower sensor pressure) steam is trapped in Chamber E where it builds up pressure and forces the main valve disc to seat, thereby closing the main valve.

The Electromatic Relief Valve is considered in operation when its maintenance stop valve is open and its control switch is set to the automatic position.

GAGGING SAFETY VALVES

Under certain conditions a leaking or weeping safety valve may be gagged. If a gag is not properly applied the safety valve stem may be bent which usually results in further damage to the valve seat and ultimately will cause a shutdown of the boiler.

Figure 12.8 Gagged Safety Valve



The gag must be carefully installed making certain it is straight with the safety valve stem. Without using a wrench, apply the gag load by tightening the handle with both hands using only the wrists for leverage. (Figure 12.8)

A safety valve that is gagged when the valve is hot will usually start to weep again as the valve cools and will require tension applied on the gag. Never leave a cold safety valve gagged and then start up the boiler as the valve will expand from increasing temperature and damage to the valve stem and disc will result.

STEAM DRUM AND INTERNALS

The main steam drum is the highest part of the boiler. It is in the drum where the initial separation of water and saturated steam takes place. The drum is a huge mass of steel weighing many tons. The shell can be up to approximately 6 inches thick by 6 feet in diameter and 40 or more feet long. Refer to Figures 12.9 and 12.10.

The drum generally contains internal equipment for:

- Distributing incoming feedwater.
- Adding chemicals for water treatment.
- Continuous blowdown, to control boiler water chemical limits

Separating steam from the water.

Delivering relative dry steam to the superheaters.

The steam delivered from the drum generally travels through three stages:

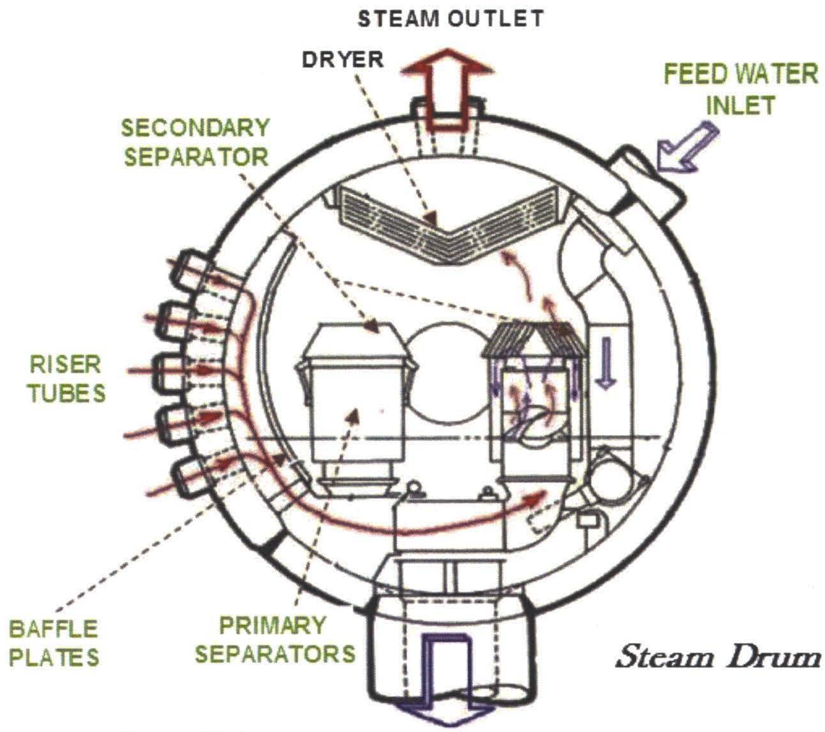
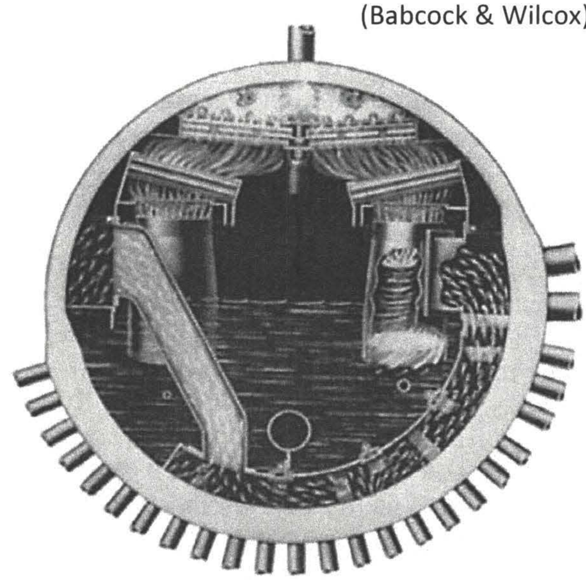


Figure 12.9

1. Primary separation
2. Secondary separation
3. Dryer

Figure 12.10— Double row arrangement of cyclones steam separators for primary steam separation with secondary scrubber elements at top of drum. (Babcock & Wilcox)



CYCLE

The steam and water entering the drum from the waterwall tubes or risers is collected in an area formed by internal baffles with one or more rows of centrifugal or cyclone separators. As stated previously, the steam is released in three-stages:

Primary Separation. The cyclone separator which is the primary stage and which spins the mixture, thereby throwing the water to the outside and leaving the steam on the inside. Just above the spinner is a skim off lip which captures the water at the outer wall and returns it to the drum through the enclosed area surrounding the inner chamber. The steam then proceeds upward to the next stage.

Secondary Separation. This stage consists of two opposed banks of closely spaced, thin corrugated sheets which direct the steam-in a tortuous- path and force any remaining water against the corrugated plates. Since the velocity is relatively low in this area the water cannot be again picked up from the wetted surface and therefore runs down the plates back to the water in the drum.

Dryer. The third stage is the screen dryer which removes any water still remaining in the steam prior to entering the superheater section of the boiler.

OPERATION

The boiler drum, because of its size, must have prime consideration during its lifetime. Temperature changes must be made gradually during light-off; normal operation, or shutdown. The rate of change should not exceed 80-100°F per hour and the temperature difference between top and bottom of the drum should be limited to IOO°F or less. These figures are a rule of thumb. The boiler manufacturer's manuals have graphs that indicate actual allowable temperature vs pressure and temperature vs time limitations for heating and cooling. Unequal or too rapid heating or cooling of the drum can cause unequal thermal expansion with subsequent high stresses in the drum metal. If the heating and cooling processes are not carefully controlled these stresses can become large enough to damage the drum. Water used to fill a cold boiler drum should not be hot enough to flash. Feedwater slowly to avoid steam and water hammer.

When force cooling a boiler the drum level should be carried as high as possible without carrying over into the superheaters. This will ensure uniform cooling and very little temperature differential between the drum top and bottom.

SOOT BLOWERS

There are many different types of soot blowers used as boiler accessories. Regardless of their type they all have a few things in common, namely the ability to remove ash and soot from boiler tubes by a chilling action as well as by velocity. Usually superheated steam or air is employed in the fireside soot blowers and being cooler than the tube surface the steam will have a cracking effect in removing the soot. The force or velocity of the steam is also effective in cleaning the tubes.

On boilers provided with retractable blowers the steam must not be shut off until the blower is fully retracted otherwise the lance would be damaged due to being exposed to hot flue gas temperatures without any cooling steam flow. Routine lubrication is necessary for all blowers to operate satisfactorily. Correct steam pressure, as controlled through an orifice on each blower, is important for proper operation and area of cleaning.

Under normal conditions a soot blowing lance should remain turning as long as it is in the furnace and has steam flowing through the lance. This is to protect the boiler tubes from impingement in case the steam is striking them. Some blowers have two separate motors, one for travel and one for rotation.

Retractable blowers are provided with one and often two venturi type openings near the end of the lance, they clean a wide area by moving the lance in and out along the tube banks while turning in a 360° arc.

Stationary blowers remain inside the cooler section of the boiler, usually the economizer area, and have a row of openings along the length of the lance for cleaning. This type of lance also turns in a 360° arc.

Usually boiler loading should be between one-half and full load before blowing soot, to ensure enough draft to carry the soot out of the furnace and up the stack. Frequency of blowing soot depends largely on the type of fuel used. Generally once a day or more often when burning oil and once a month or more when burning gas fuel. Steam supply headers must be free of water before blowing soot. Steam supply header drains should be left open when not blowing soot.

Always start blowing soot in the hottest section of the boiler and blow toward the coolest section, blowing in this sequence allows the loosened soot to be carried along with the flue gas and out the stack.

Retractable soot blower carriage areas must remain free of foreign material, otherwise the blower may be damaged as it operates.

MANUALLY OPERATED BLOWERS

This type of blower is found on some of the earlier boiler installations. They may be of the chain operated type, the hand crank type or the semiautomatic, air operated type with air and steam operated manually. When the chain or hand crank is moved the steam valve opens and the blowing starts. This type of blower remains inside the cooler section of the boiler.

For best results the blower should be turned slowly and take approximately 20 seconds for each revolution. The blower should be operated until the stack exit gas is clear which indicates a clean area. With the 360° cam type blower, at the end of the blowing cycle the rotation of the blower must be reversed to permit a trigger to engage with the opening valve cam in order to close the steam valves.

The semi-automatic type of air operated retractable blower operates in the following manner. The air is turned on to the air drive and when the lance starts to move inward the steam supply is opened. The lance should be observed turning and moving steadily into the furnace. When the lance reaches the end of its travel a limit switch will reverse the air drive and retract the lance.

When the lance is fully retracted the steam supply is manually closed and the air motor stops. The air supply must then be shut off to the drive motor.

Air preheaters must be blown after all the other soot blowing is completed. Refer to the air preheater section for further details.

AUTOMATIC BLOWERS

The later installed boilers have fully automatic sequential operation of the soot blower units. Some are air motor and some electric motor driven. Individual operation of any blower is possible from the control panel or from a push-button station located near each blower. The control panel's function is to automatically operate the selected blowers in sequence, indicate normal operation and provide adequate alarms for the protection of the blower system.

Alarms associated with soot blowing are:

- Blowing header pressure low.
- Control air failure.

BOILER WATER TREATMENT AND CONTROL

Chemical control of the boiler water should be given prime consideration. The treatment specified may vary according to plant location and boiler design but the basic objectives of boiler water treatment are always the same. They are:

- To minimize corrosion.
- To keep the boiler clean, prevent or minimize scale or deposit formation.

- To keep the steam pure, minimize carry-over of solids and silica with the steam into the superheater and turbine.

CORROSION CONTROL

Oxygen Removal. It is a known fact that iron rusts in the presence of oxygen and moisture. This process speeds up as temperature rises. In boiler feedwater, most of the dissolved oxygen is removed by mechanical means either through a deaerator or a deaerating section of the main condenser. To remove the last trace of the remaining dissolved oxygen, a chemical oxygen scavenger is used. In a lower pressure boiler (below 1800 psig), sodium sulfite is injected into the boiler water. For a higher pressure boiler (over 1800 psig) a proper amount of hydrazine (according to dissolved oxygen concentration) is injected into the feedwater before it enters the boiler. Sodium sulfite will react with oxygen to form sodium sulfate and hydrazine will react with oxygen to form nitrogen and water. To illustrate the harm that can be done by a little oxygen remaining in the water after deaeration, consider that one pound of oxygen takes at least three and one-half pounds of iron from the boiler. If there were one part per million of oxygen in the feedwater of a boiler steaming at 850,000 lb/hr, every hour the .85 pound of oxygen would remove 2.97 pounds of iron. While boiler drums have thick walls the tubes do not, especially when oxygen attack usually takes the form of localized pits. It would not take too much iron removal for a pit to go through a tube wall.

Alkalinity in pure water with the absence of oxygen, iron will react with water to form iron oxide and hydrogen. The rate of reaction depends on the alkalinity of the water. To measure alkalinity, a pH scale from 0 to 14 is adopted with pH 7 as neutral. When the pH of a water is below 7, it is acidic; when it is above 7, it is alkaline. It is found that with a pH of 9-11, depending on operating pressure, the corrosion rate of iron is at the minimum. At a pH higher or lower than these values, the rate of attack increases. The pH of boiler water can be maintained, in most cases, by keeping the sodium phosphate and sodium hydroxide concentration within the established control range. For a newer boiler, pH determination with a meter is required as part of the control. The later installed boilers are provided with dissolved hydrogen analyzers on the drum steam and main steam to monitor this type of corrosion. If the dissolved hydrogen value increases without a change in boiler load, the cause should be found immediately and corrective measures should be taken.

KEEPING THE BOILER CLEAN

The danger of a scale or deposit formation is its interference with proper heat transfer in a boiler tube. Even a thin coat of scale or small patch of deposit in a high temperature zone can result in overheated metal and a ruptured tube. Most of the deposits found in a boiler are corrosion products - iron and other metal oxides. We can again see the importance of maintaining boiler chemical control to keep the corrosion rate as low as possible. Scale is formed by the impurity of feedwater. Even the best of feedwater contains minute amounts of impurities. Contamination of feedwater systems such as condenser leaks can add a large amount of scale forming materials in a short period of time.

Sodium phosphate and sodium hydroxide in the boiler water can react with the scale forming materials, calcium and magnesium salts, and form a precipitate of calcium phosphate and magnesium hydroxide, which can be removed by boiler blowdown. During the period of contamination and high blowdown rate, boiler chemical concentrations should be maintained in order to protect the boiler from scale forming and from increased rate of corrosion. The source of contamination should be found and corrected as soon as possible.

KEEPING THE STEAM PURE

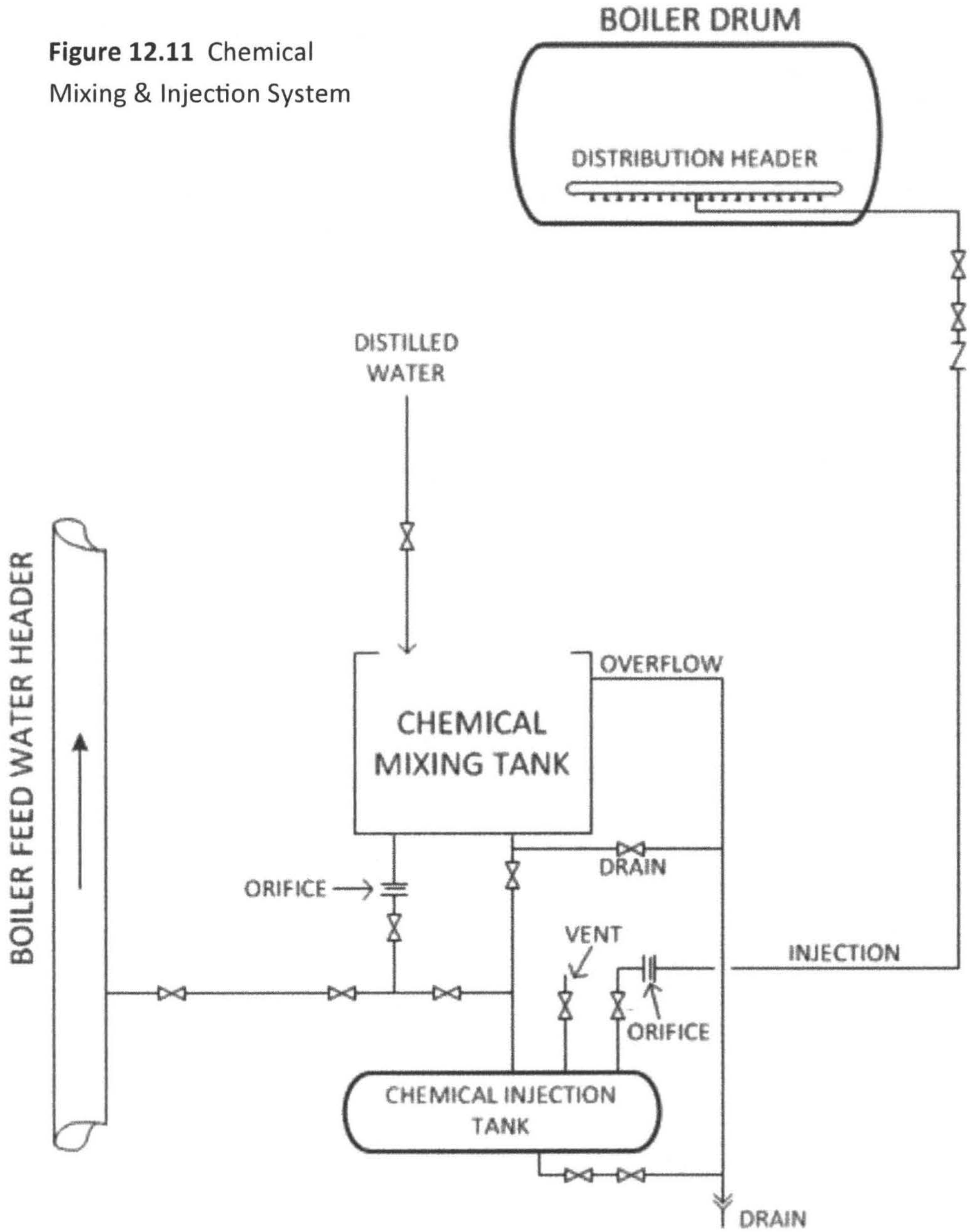
All solids that dissolve in boiler water have a tendency to be carried over with water droplets into the steam. These solids will eventually deposit on the superheater tubes and turbine blades. By controlling the total dissolved solids in the boiler water, carry-over can be minimized. The test normally used to indicate the relative amount of total dissolved solids is suppressed conductivity. It means essentially the suppressing of the higher conductivity of sodium hydroxide so that a reasonably direct relationship is obtained between total dissolved solids and conductivity. When tests indicate a high value, the boiler should be blown down.

Silica is another chemical control encountered in a power plant. Silica leaves the boiler as a vapor and condenses on the turbine blades. Since the quantity of silica that vaporizes varies with boiler pressure (temperature), silica concentration in the boiler water, and boiler water pH (alkalinity), limits are established on the various boilers consistent with these factors. In maintaining the established silica control limits, the decrease in turbine efficiency due to the deposition of silica is minimized. Control of the amount of silica in the steam below a specified amount is accomplished by establishing a maximum boiler steam drum pressure for a given silica concentration in the boiler water. A high concentration of silica in the boiler water is decreased by blowing down until silica is low enough to operate the boiler at normal operating pressure.

So far we have discussed the treatment and control, now we must find ways of actually injecting the desired chemicals into the boiler to aid in this control. The system is referred to as chemical mixing and injection system. This system consists of an open mixing tank where the chemicals are dissolved using either cool distilled water or hot boiler feedwater, Figure 12.11. Extreme care must be exercised when using the boiler feedwater because of its high pressure and temperature. A thorough mixing of the chemicals is necessary for proper injection into the boiler drum. Also if not properly mixed, the lines leaving the mixing and injection tank may plug. This not only results in inadequate injection of chemicals but also results in maintenance repairs to unplug the lines.

The chemicals are mixed in the mixing tank. The chemical injection tank must be drained of all water. The chemical solution drains from the mixing vessel to the injection tank. When the injection tank is full the tank is ready to be pressurized with feedwater. The valve to the drum may then be opened allowing the feedwater pressure to force the chemicals into the boiler drum. The injection line to the drum is provided with an orifice to ensure a slow feed and the header in the drum ensures an even distribution to all boiler circuits. Safety precautions must be adhered to when

Figure 12.11 Chemical Mixing & Injection System



handling boiler chemicals. If the concentration of chemicals in the boiler water is above limits another cycle must come into play. This is called the continuous blowdown system or just plain C.B. This system consists of a distribution header in the drum similar to the one shown in Figure 12.11.

BOILER GAUGE GLASSES

One or more gauge glasses are installed on a boiler drum to allow for visual observation of the water level. Figure 12.12 illustrates a typical glass, of an earlier designed boiler, in relation to the drum internals.

The gauge glasses are installed with lights, mirrors and ducting arrangements so the level may be observed from the control

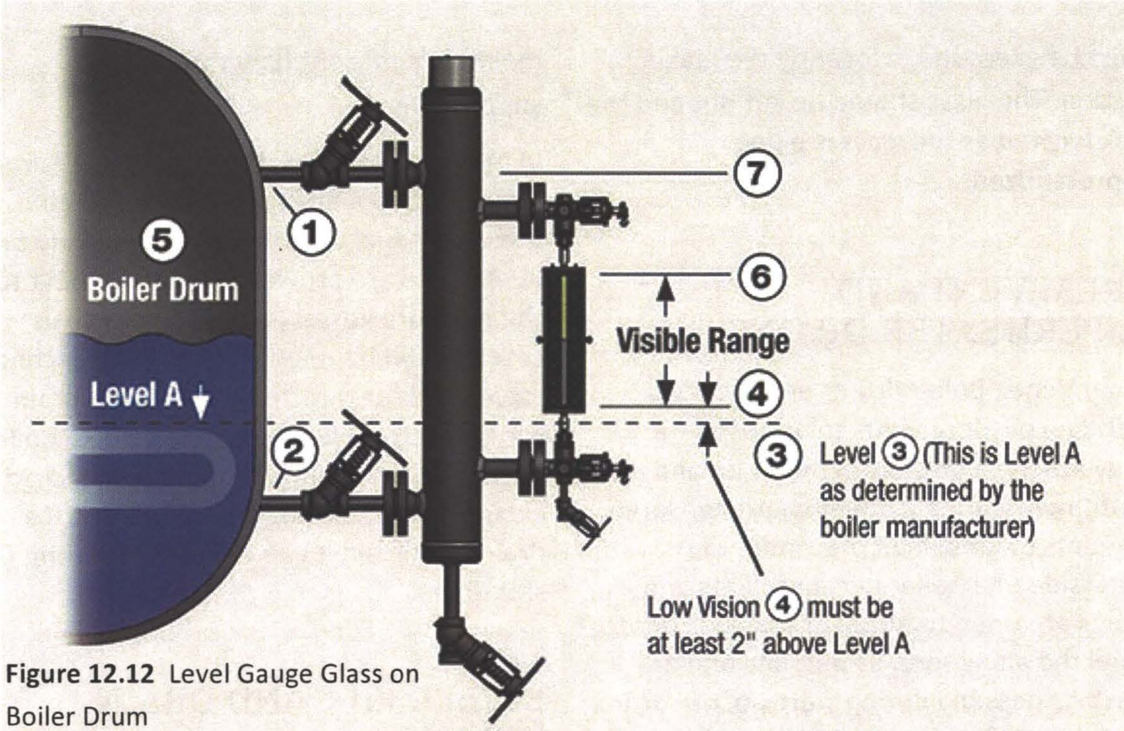


Figure 12.12 Level Gauge Glass on Boiler Drum

room area. The actual level is indicated by a light showing on the surface of the water level or by a color combination; green indicating water level and red steam space above the water level.

The gauge glass is provided with normally locked open drum stop valves to the upper (steam) and lower (water) portion of the water column or, as it is sometimes referred to, the circulating tie bar. The water column or tie bar provides circulation of steam and water and allows even temperature through the equipment external from the drum. The gauge glass is a part of or is attached by valving to the water column. This depends on the type and the manufacturer.

The gauge glass cock valves are installed so that both upper and lower valves may be operated remotely by a chain (Figure 12.13). This is necessary in case a gauge glass failure accompanied by heavy steam blowing occurs. The gauge glass can be secured from a distant point.

Chains being in place on the gauge glass cock valves are very important to assure safe operation. The only time the chains should be removed from the valve wheels is to repair the gauge glass. The only time the drum stop valves should be closed is to repair the chain operated gauge glass cock valves. If the gauge glass is leaking, caution

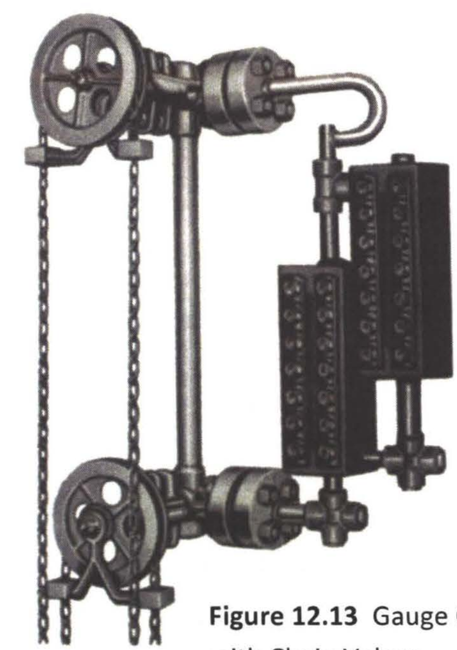


Figure 12.13 Gauge Glass with Chain Valves

must be exercised in locating the leaking section. The glass should be cut out and the leak located as the glass is being depressurized.

DRUM VENT AND SUPERHEATER DRAINS

Drum Vents. Boiler drums are provided with one or more vents to atmosphere. They are used only during start-up and shutdown. During a boiler shutdown large amounts of air will be present in the waterside of a boiler because vents and drains are open to atmosphere. In order to expel the air as soon as possible and as much as possible during start-up, the drum vents must be open as pressure is being raised on a boiler and closed when the boiler pressure reaches approximately 25 psig.

To keep the waterside of a boiler from going into a vacuum when shutting do the drum vent(s) should be open when the pressure has decayed to 25 psig. Usually unnecessary leaks develop when a boiler goes into a vacuum as header caps and drum manholes are pressure sealed and not designed to withstand a negative pressure.

Superheater Drains. These serve two distinct purposes:(1) provide a means of flow through a superheater bank when starting up a boiler and (2) provide a means of removing water or moisture from the superheater during a boiler start-up.

Normally all superheater drains are opened prior to lighting off a boiler. The drains are throttled or closed as the temperature indicates the superheater is dry. The outlet or final superheater drain, though throttled, should be left open until the boiler is supplying enough steam to the turbine to maintain sufficient flow through the superheater.

In most installations, the superheater drains are routed to a blowdown tank or well through a dual valve arrangement. Any time dual valves are provided, the valve next to the pressure vessel (superheater in this case) should be open wide and the second valve used for throttling. A plugged drain can cause trouble when starting up a boiler. Because of this, drains should be checked clear prior to shutting down a boiler. If a drain is plugged it can be opened during the shutdown.

BOILER FILL AND DRAIN SYSTEM

Boilers in general may be filled through their blowdown headers and drain lines by means of a common boiler water transfer system or directly from the distilled water system. Depending on the type of installation, the boilers may be drained using the same piping arrangement to the boiler water transfer tank, the blowdown tank, the blowdown well, the acid pond, or directly to the sewer.

Those units utilizing a boiler transfer system, consist of a transfer tank, pumps, and necessary headers to supply a number of boilers. Other units have only distilled water pumps taking suction from the distilled water tank and through headers to supply one or more boilers.

Regardless of the system, the boilers should be filled in much the same way. The drum vents must be open and the gauge glass available. If a transfer tank is used, the tank must be filled with distilled water.

In lining up the boiler valving to start filling, it is very important that valving to other boilers connected to the fill header be checked over thoroughly and properly secured. Also the fill and drain systems are usually divided in two sections, a low pressure section (transfer) and high pressure section (blowdown) because of this, proper valving is important. Usually the low pressure section is protected from over pressurizing by a relief valve. One further check that should be made, the blowdown header valving to waste must be checked closed.

Prior to filling the boiler the transfer system should be flushed. If it is possible to have contaminated water in the transfer headers, the water must be recirculated and tested. Boiler filling should always be carried out from the lowest possible point of the boiler. This is necessary as filling from the bottom forces the air upward to the drum and vent. The vent prevents trapping air in the boilers. It is also desirable to fill from the bottom as the water usually used for filling is low in dissolved oxygen. If filled from the top, the water splashing down would pick up O_2 from the air bubbling up through it. In some installations, filling would be through the Yarway blowdown valves and into a mud drum or downcomers. Other boilers are provided with lower waterwall headers that have drain and fill valves. The economizer, if installed, is provided with an individual fill line and valve connected between the fill header and the economizer.

When conditions are such that filling can start, the lower filling valves and the economizer fill valve may be opened. The boiler transfer or distilled water pumps may be started to fill the boiler to the desired level in the drum. For boiler start-up, one or two gauge glass ports are usually sufficient. The boiler setting must be patrolled periodically during the filling operation. Filling for a hydrostatic test is covered later in this section.

When the filling is complete all fill valves must be closed and the pumps shut down. When the economizer fill valve is closed the economizer recirculation· valve should be opened. This will provide assurance that the economizer stays full of water with a level showing in the drum.

In draining a boiler, the same piping and valves are used as in filling. Pressure must be otf the boiler and the drum vents open.

In earlier designed plants a boiler water transfer system is usually used. In this case, the water may be drained to the transfer tank or to waste.

On boilers designed with economizers it is possible to fill or drain only portions of the boiler. The drum and economizer may be drained through the economizer and the waterwalls not affected. Also the waterwalls may be filled or drained and not affect the economizer. This is helpful as in the case of an economizer tube leak, it is not necessary to drain the whole boiler in order to make repairs. As long as the economizer recirculation is closed and the drum and economizer is drained, no water can flow into the economizer from the waterwalls.

AIR PREHEATERS

Two types of air preheaters may be provided, a tubular type, Figure 12.14, whereby the hot flue gases pass through the tubes and the air on the outside of the tubes, thus cooling the flue gases and heating the air for combustion. As this type of preheater has no moving pans there is little to discuss other than the preheater is a heat exchanger. However, such things as acid dew point, cold end average, steam air heaters, etc., do apply and are covered in the following discussions on rotating type air preheaters. The rotating bundle type (Ljungstrom) is the most recent type, in which the bundle is revolved through the hot gas and cold air side of the boiler and the heat transfer is from heating and cooling the bundle. The following discussion will cover the Ljungstrom type as all later installed boilers are provided with these rotating air preheaters.

One or two (depending on boiler) Ljungstrom air preheaters are provided for each boiler. Combustion air from the forced draft fan passes through one side of the heater while hot flue gas from the boiler passes through the opposite side. The heater consists of a rotating cylinder with internal heating surfaces. Some are installed horizontally and some vertically. Figure 12.15 shows a vertical unit and Figure 12.16 shows a horizontal unit.

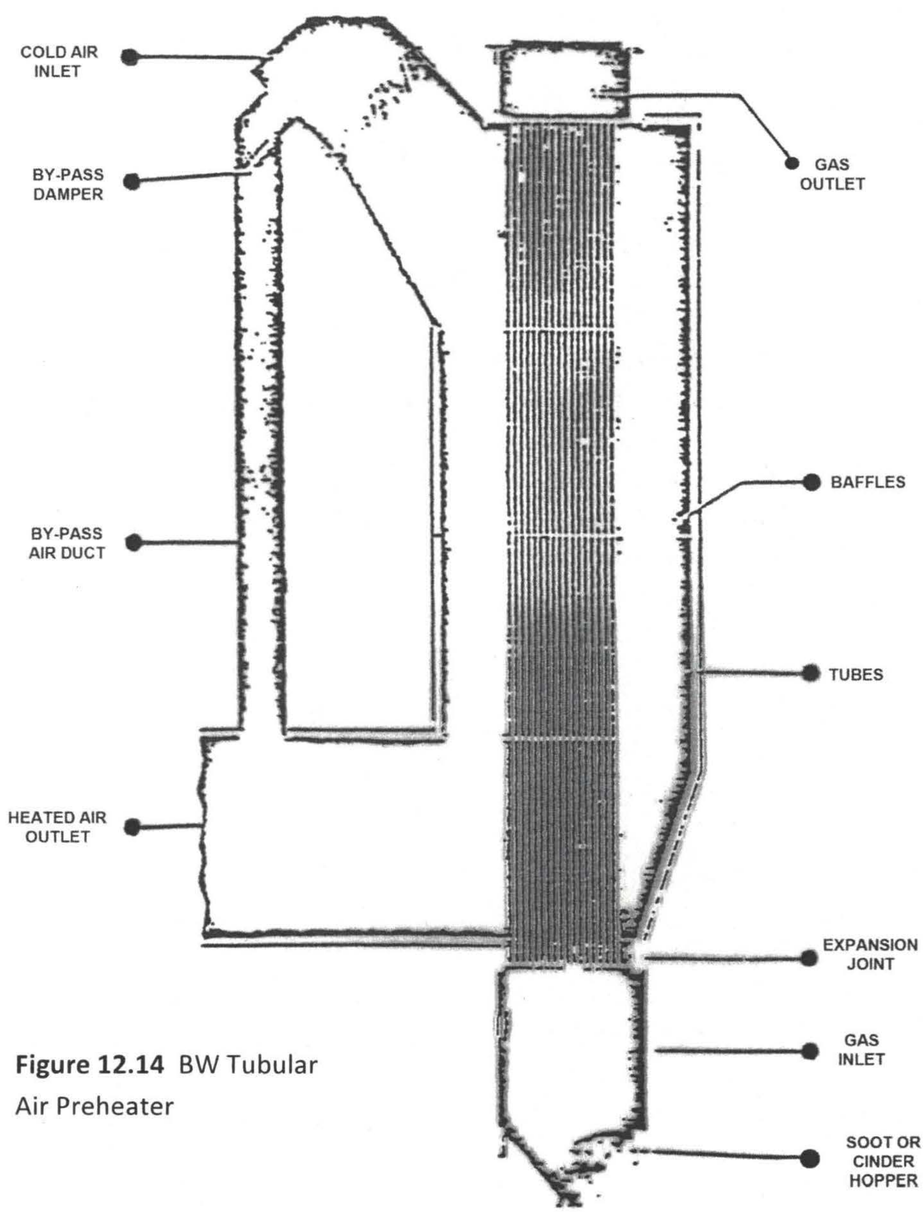


Figure 12.14 BW Tubular Air Preheater

Figure 12.15 Vertical Air Preheater

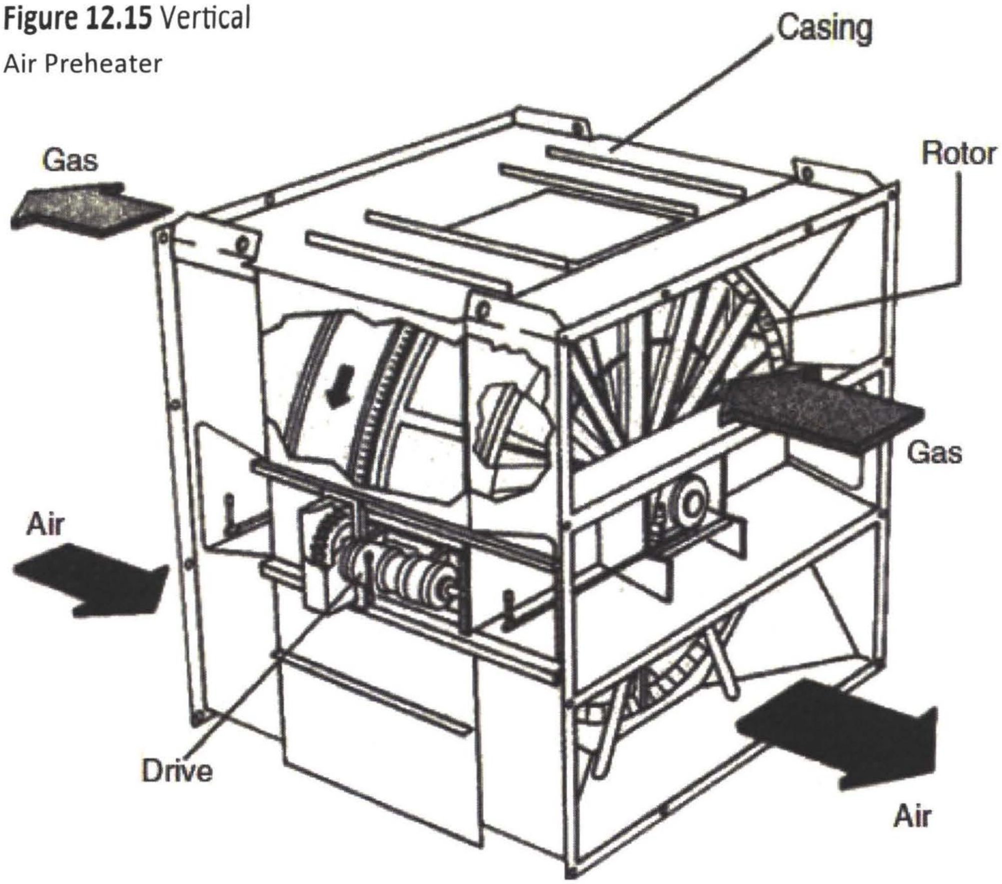
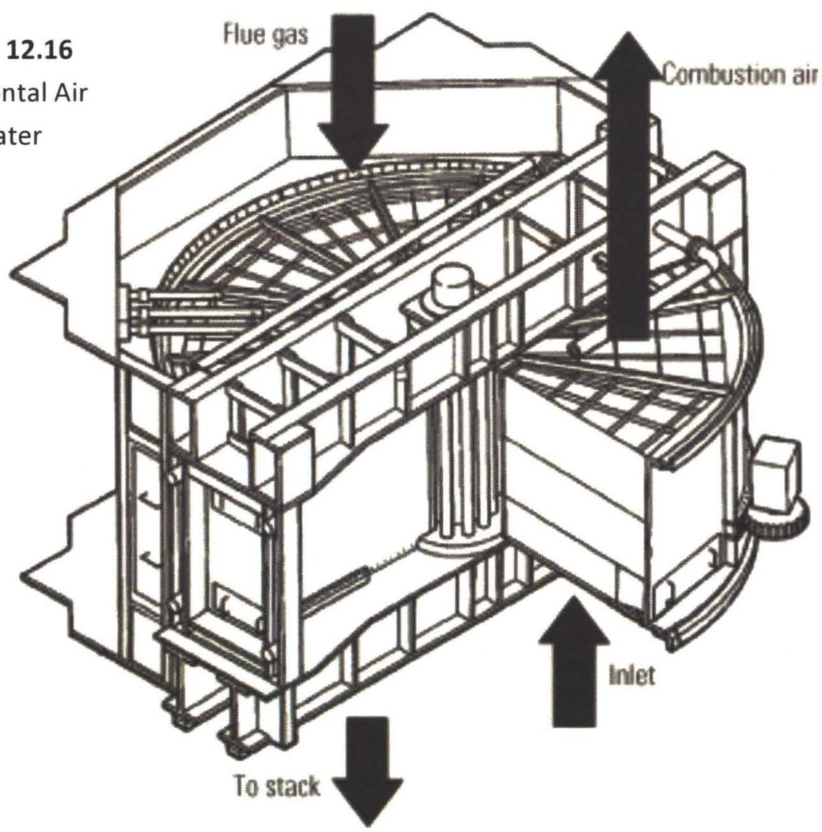


Figure 12.16 Horizontal Air Preheater



Heat transfer is by the regenerative process in which the rotating element is heated while passing through the hot gas and gives up its heat to the air as it passes through the air side.

As the flue gas is being cooled in its travel through the air preheater bundle, a practical limit of thickness of the bundle is reached in the design. Corrosion will begin if the gases are cooled to a dew point temperature. Acid is formed from the combination of sulphur products in the fuel with water vapor. Metal temperatures may be controlled above the so-called dew point of the gases by bypassing incoming air, recirculating air or by the use of steam air heaters.

If the cold end average gas temperature which is the average between the incoming air and the flue gas outlet, is controlled at 145°F while burning gas fuel and 185°F when burning oil fuel, very little or no corrosion should take place. The temperatures are approximate as the control point depends on the amount of sulphur in the fuel. The element is rotated by an electric drive motor or an air motor drive is provided for backup. The electric drive operates the unit at 1-3 rpm through a speed reducer while the air drive is approximately 1 rpm.

An interchange of hot gases and cold air within the unit is held to a minimum by radial, circumferential, and rotor post seals. These seals form a definite air passage through one-half of the heater and gas passage through the other half.

Each air preheater is further provided with manually operated water washing devices and automatic soot blowing devices.

The later designed preheaters have an oil bath plus a forced lubricating system which is automatically started or stopped by a temperature sensor. The earlier boilers have only the oil bath for lubrication with cooling water jackets.

AIR PREHEATER OPERATION

The air preheater lubricating oil systems and cooling water must be available when starting up. If the air preheaters are available for service their manual isolation dampers must be open and they should be in operation during the boiler purge.

When burning oil fuel, the air preheater must be in service and should not be shut down. This air preheater operation is different from gas burning as combustible deposits which could ignite are most likely to collect on the preheater surface when starting up a cold boiler on oil fuel.

During normal boiler operation the air preheater requires nothing more than routine inspections such as looking for oil leaks, adequate cooling water, oil temperatures normal (less than 125°F), and listening for rubs or any unusual sounds. The circumferential seal can be inspected from the inspection ports provided and should be checked periodically.

If an air preheater stops, with the boiler in operation, every attempt must be made to restore it to service with the electric or air drive. Otherwise permanent damage to the bundle can result due to expansion if the flue gas temperature is above 900°F. It is usually necessary to reduce load and/or close manual dampers to keep the flue gas temperature within allowable limits. Operation at this temperature must be limited to the time necessary to restart the air preheater.

To eliminate the possibility of an air

preheater fire, soot must be blown on a regular schedule. Any time fireside soot has been blown, the air preheaters must also be blown. When burning oil fuel, the air preheaters should be blown at least once a shift. When burning gas fuel, once a week is usually sufficient.

In shutting down a boiler, the air preheater's soot should be blown before the fuel is tripped. The air preheater normally remains in operation until the gas inlet temperature reaches 350°F or less.

If the boiler is shut down for an extended time such as an overhaul, the air preheater is usually washed with water during the outage. This further aides in maintaining clean surfaces and helps eliminate the possibility of a fire when starting up. How the air preheaters are washed differs from plant to plant.

AIR PREHEATER FORCED OIL SYSTEM

The oil system is designed to supply the support bearings with a bath of clean oil. To accomplish this, the oil is circulated by means of a motor driven pump through a filter and cooling system.

AIR PREHEATER DRIVES

The air preheaters are provided with two types of drives, an electric motor with an air motor drive as backup. The drives for turning the rotor are usually applied at the outer edge of the bundle. A pin rack mounted on the rotor engages with a pinion which is a part of the drive after the speed reducer. Operation of the electric or air motor, through the speed reducer will rotate the air preheater.

The air motor drive may also be used to control the speed of the rotor during water washing of the air preheater. The electric and the air drives should never be engaged at the same time. In the most recent installations, it is only necessary to shut down the main electric drive and start the auxiliary drive.

AIR PREHEATER CLEANING DEVICES

The air preheater soot blowing system consists of an electric or air driven blower coupled to a gear driven crank mechanism which moves the steam blowing nozzle. The arc covered by the nozzle subjects the entire area of the preheater bundle to the cleaning action of the nozzle. To maintain the desired steam pressure, usually 200-250 psig, an orifice is installed in the steam line to the blower.

The steam used for blowing the air preheaters must be dry. As the steam for the fireside blowers is usually saturated steam from the drum, it is necessary to provide a separate steam supply for the air preheaters. Dry steam from after the primary superheater section of the boiler is usually used for this purpose.

Before blowing the air preheaters, the steam headers must be drained of any wet steam and condensate. A complete blowing cycle consists of one pass across the bundle heating surface, usually adjusted for blowing from the outer edge of the bundle toward the shaft. When the arc of the nozzle reaches the center of the bundle the steam is shut off. The nozzle will change directions and move to the outer edge of the bundle before stopping.

Air preheaters are washed when the boiler is shut down and the bundle temperature is 300°F or less. The cleaning device for washing may be of three (3) types:

1) a combination steam or water device
2) a separate washing device which is no different than the steam blower
3) a header arrangement installed above the bundle with evenly spaced nozzles and the whole bundle is washed at one time.

The soot hopper blank flanges and drain valves must be open before water washing. In plants that have the boiler water transfer system, the water used for washing is usually water drained from the boiler. In other plants it is usually a convenient source such as station service, raw water, or fire water.

Water washing may be done automatically and in zones (or three sections) across the bundle or the wash system may be operated manually. The washing is done on both passes of the nozzle across the bundle. The washing is usually considered completed when the pH of the drains is higher than 6.0.

DRAFT EQUIPMENT- FANS

A fan is a pump designed to handle gases rather than liquids.· Just as with pumps, there are many different types of fans. The fans used for boiler draft applications, however, are always of the centrifugal type.

Forced Draft Fans must supply the total volume of air required for combustion at a discharge pressure sufficient to overcome the flow resistance in the ducts, steam air heaters, air preheaters, and windbox. In the newer installations the forced draft fans must also overcome the resistance of the total boiler flue gas pass to the stack.

Induced Draft Fans must create a sufficient pressure differential to cause the required quantity of flue gas at full load to pass through the resistances from the furnace to the fan and discharge to the stack at approximately atmospheric pressure. Additional capacity must be built into each fan to offset leakages and infiltrations.

Combustion air for each boiler is supplied by one or two forced draft fans. The fan(s) takes suction from the atmosphere and discharges air through the steam air heaters and the air preheater(s) to supply ducts and on to the windbox. The supply ducts contain metering orifices and in installations with dual fans and air preheaters, manual shutoff dampers are provided ahead of the air preheater.

The F.D. fan(s) is a horizontal, centrifugal unit with a constant speed of approximately 1200 rpm. The F.D. fans usually have backward curved fan blades which produce low air velocities for a given fan speed, Figures 12.17 & 12.18. Air is controlled by means of inlet vanes and aided by dampers in the discharge duct.

Flue gases leaving the boiler pass through the gas side of the air preheater(s) to an associated induced draft fan. The I.D. fan(s) discharges into the boiler stack. On some installations manual dampers are provided on the stack side of the air preheater.

The I.D. fan(s) is a horizontal centrifugal unit with a constant speed, 500-600 rpm (depending on plant). The I.D. fans are usually provided with forward curved fan blades which produce high flue gas velocities for a given fan speed, Figure 12.19. In some installations the I.D. fans may have straight fan blades which produce

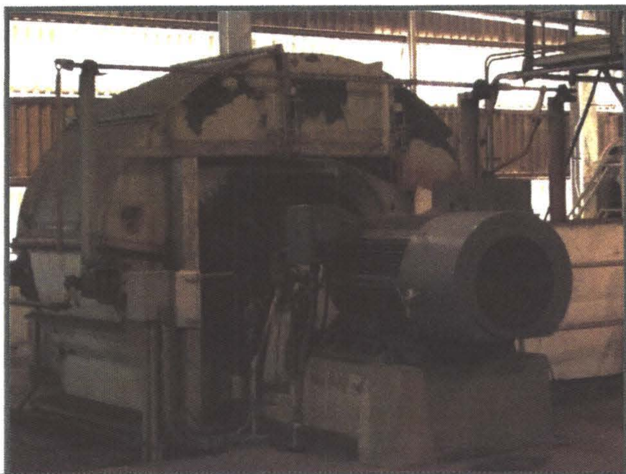


Figure 12.17 FD Fan (Waiau 3)

Figure 12.19 ID Fan (Waiau 3)

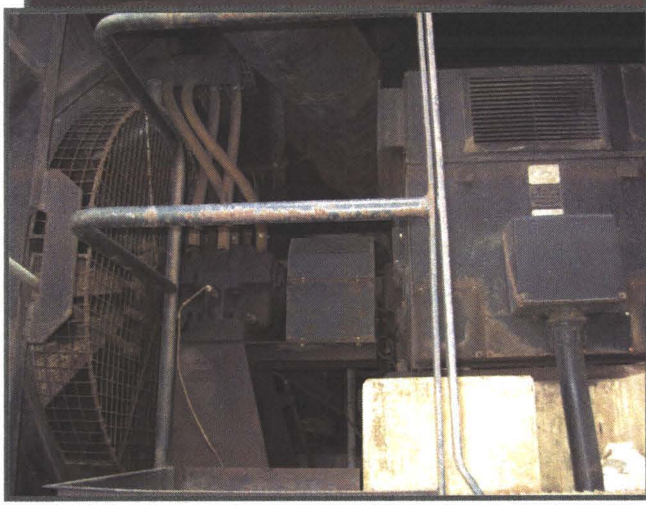


Figure 12.18
FD Fan Blades

velocities somewhere between the forward and backward curved blade velocities. Flue gas flow is controlled by means of inlet and outlet dampers. As the I.D. fan is handling hot flue gas the fan housing and duct is insulated. In later installed boilers the fan is not provided. The entire boiler setting is under a positive pressure and to prevent hot gases from leaking to atmosphere the setting is air tight.

Flue gas recirculation fans are used to control reheat temperature and assist in the control of Nitric oxide emissions from the stack. The fans operate at constant speed, approximately 900 rpm. Hot gas is diverted from the boiler outlet duct and discharged by the recirculation fan back into the furnace below the bottom row fires and also in a higher section of the furnace above the top row burners. Another way to introduce hot gas back to the furnace is to direct the gas by ductwork to the inlet side of the forced draft fan. Approximately 15% of the forced draft fan capacity is utilized to accomplish this. In some installations, leaving the top row of fires out of service but the draft registers open and reboring larger openings in the fuel burning equipment assists in Nitric oxide control. The theory behind the above mentioned conditions is the control of furnace temperature. The formation of Nitric Oxide increases very rapidly as furnace temperatures increase above approximately 2900°F. Due to changes made to assist in Nitric Oxide (NOx) control the configuration of combustion in the furnace changes. The "fire" now bums in a greater area of the furnace and so must be controlled to keep upper areas of the boiler free of flame.

The recirculation fan(s) is horizontal, centrifugal, and driven by an electric motor. Gas flow is controlled by means of inlet dampers. If the recirculation fan(s) is shut down the dampers close and sealing air is automatically admitted between suction and discharge dampers to keep from circulating hot .gases through the fan(s) and to prevent bypassing the normal furnace path if the dampers are not completely tight.

The fan bearings for all three types of fans just covered are self-lubricated and jacketed with water cooling from the closed cooling water system. The fan motors are air-cooled. The fan motors have only fibrous filters to keep the circulated air that passes across the motor rotor and windings clean.

One further part of the draft equipment worth mentioning is the boiler stack. The stack is used to discharge the products of combustion at an elevation high enough to avoid their being a nuisance to the surrounding community. The higher the stack the more draft will be available to help pull the hot gases out of the boiler.

Alarms associated with the boiler F.D. and I.D. fans are as follows:

Bearing temperatures.
Motor winding temperature.
Motor overcurrent.
Low fan speed
Undervoltage

The recirculation fan is protected by:

Bearing temperature.
Motor winding temperatures.
Motor overcurrent.
Undervoltage.
Temperature between dampers.
Temperature after dampers.
Low fan flow differential trip.
Fan dampers open.

BOILER SEALING AND COOLING AIR

Because some boilers are designed as a pressurized unit it is necessary to have cooling and sealing air. Its purpose is to keep the hot flue gases within the furnace enclosure. The various pieces of equipment and boiler sections supplied with sealing and cooling air are as follows:

Soot Blower. Air seals are provided where the blowers penetrate the furnace.

Boiler Inspection Ports. Sealing air is supplied to the ports when they are closed. For opening, the port doors are interlocked mechanically with aspirating air, supplied by the station air system.

Boiler Void or Penthouse. The boiler penthouse is the enclosed area above the furnace roof. This area usually contains the boiler steam drum, upper waterwall and division wall headers, and superheat and reheat headers. It is usually pressurized with sealing air at forced draft fan discharge pressure. This prevents flue gas from leaking through the furnace roof and filling the penthouse with possible combustible gases and prevents an accumulation of an explosive mixture in this area. The seal air pressure is approximately 3" water gauge higher than the flue gas pressure at this point. The possible points of leakage through the furnace roof are at the points where the waterwall tubes penetrate the roof.

Sealing Air to the Gas Recirculation Fans Breeching. Between the isolation dampers and the outlet dampers on the discharge side of the recirculation gas fan, a manual shutoff supply of seal air is provided. This supply is also piped to the suction of the recirculation fan.

A manual shutoff damper is provided where the seal air takes off the F.D. duct just before the steam air heaters. The seal air dampers to the recirculation fan discharge have automatically operated dampers that close if the recirculation fan is in operation and open when the fan is shut down. The seal air to the recirculation fan suction is a manually operated damper and is open only when maintenance is required on the fan and is closed during normal operation.

ASPIRATING AIR

The station air supply is normally used for furnace door aspirating service when dealing with a pressurized furnace. This service is necessary as the air will cool the door-opening, preventing hot gases from escaping the furnace and burning the individual inspecting the furnace. The inspection doors are so designed that it is necessary to turn on the aspirating air before the door can be opened.

HYDROSTATIC TESTING

In a normal operating plant a hydrostatic test (hydro) is usually applied to a boiler before a routine overhaul or after repairing a tube leak. There are exceptions to these rules and each case is studied to determine the necessity of a hydro. A hydro is applied to determine if there are leaks of any kind on the water or steam side of the boiler. Pressure is increased to the test value using the boiler feed pump.

The water and steam side of the boiler is filled with distilled water that is at a temperature no more or less than 100°F of the boiler metal temperature. The boiler must be full of water and all possible air expelled through the drum and superheat vents before pressure is applied to start the hydro.

Proper valving is very important when setting up to hydro a boiler. A nonreturn and/or a boiler steam stop valve is provided and must be closed. The allowable temperature difference mentioned earlier, between the water and boiler metal temperature, also applies to boiler or turbine stop valves.

As boiler gauge glasses have a tendency to leak from cold water and high pressure, the glasses should be cut out after filling and before increasing pressure. It is also necessary to have boiler pressure indication available. On some boilers a low pressure gauge is provided, this gauge must be cut out of service prior to exceeding the pressure rating of the gauge.

FILLING FOR HYDRO

In filling for a hydro it is first necessary to fill and establish a level in the drum gauge glass, then the fill valving to the water walls and economizer must be secured.

The superheater filling operation is very much the same as filling the water side of the boiler. The top most superheater header vent(s) must be open to expel all possible air, the superheater drain valves must be closed. With the filling pumps (boiler transfer or distilled water) in operation, the fill valve must be open into the superheater section and fill until an increase is observed in the drum gauge glass. This ensures that the superheater is completely filled with water.

When the drum level has increased and is approximately half full, the superheater fill valves may be closed and filling the waterwalls re-established. The superheater and drum vents must remain open until the boiler is full. The operation of filling will continue until fairly heavy venting is observed from all vents. Closing and reopening the vents usually helps in expelling most of the air. After all possible air is vented from the boiler, the vent valves are closed. The filling pumps remain in operation until the boiler pressure increases to the pressure capacity of the pumps. It is very important that a constant check be made around the boiler setting during the pressure increase.

Leaks of any magnitude should be noted and reported. The amount of pressure placed on a boiler is usually somewhat below the normal operating pressure. When this pressure is reached the boiler feed pump may be shut down and the boiler inspected for leaks.

At the conclusion of the hydro, the boiler drains may be cracked open and the pressure allowed to slowly decay to approximately 25 psig at which time the boiler vents must be opened to keep the boiler from going into a vacuum.

Section 12

BOILERS AND ACCESSORIES

Study Questions

1. What is the purpose of the safety valve in boiler operation?

2. If more than one safety valve is used, how is the highest setting determined?

3. The setting for safety valves on the superheater outlet is lower than any drum safety valve.

   True \ False

4. The Electromatic Relief Valve is used ____________.

   a. to minimize maintenance of regular safety valves.

   b. on the superheater outlet and can be isolated for repairs.

   c. and set to relieve before all other safety valves.

   d. All of the above.

5. The difference in steam pressure between point of valve lift until the valve seats is called the blowdown. True \ False

6. What is meant by "gagging" a safety valve?

7. The main steam drum is the highest part of the boiler. True \ False

8. The main steam drum is where the initial separation of water and saturated steam takes place. True \ False

9. Steam from the drum generally travels through three stages. They are:

   a.

   b.

   c.

10. Great care must be taken of the boiler drum. What is the major consideration to keep in mind to avoid stressing the drum metal?

11. Soot blowers commonly use a chilling action and velocity to remove ash, soot, and slag from boiler tubes. True \ False

12. Boiler loading should be less than one-half load before blowing soot. True \ False

13. When burning oil, how often should soot be blown?

14. Always start blowing soot at the coolest section of the boiler and blow toward the hottest section. True \ False

15. What are three (3) alarms associated with soot blowing?

   a.

   b.

   c.

16. What are three (3) basic objectives of boiler water treatment?

   a.

   b.

   c.

17. Why is it necessary to remove dissolved oxygen from boiler feedwater?

18. How is alkalinity measured?

19. Scale in the boiler is formed by the impurity of ____________________.

20. When test show that there is a large amount of dissolved solids in boiler water, the boiler should be ____________________________.

21. Why are gauge glasses installed on boiler drums?

22. What is the purpose of drum vents?

23. Superheater drains serve two purposes. They are:

    a.

    b.

24. When filling the boiler, the drum vents must be open and the gauge glass available. True \ False

25. Why should boiler filling be from the lowest point of the boiler?

26. What is the purpose of air preheaters?

27. What is the purpose of steam air heater?

28. Forced draft fans produce high flue gas velocities while induced draft fans produce low air velocities. True \ False

29. List two (2) reasons for boiler stacks to be as tall as possible.

    a.

    b.

30. List three (3) alarms associated with Forced Draft Fans and Induced Draft Fans.

    a.

    b.

    c.

31. Why is it necessary to have boiler sealing and cooling air?

32. List at least three (3) pieces of equipment and/or boiler sections that are supplied with sealing and cooling air.

    a.

    b.

    c.

33. Aspirating air is open before the furnace inspection doors are opened.
    True \ False

34. A hydrostatic test is usually applied to a boiler after a routine overhaul.
    True \ False

35. A hydro is applied to determine if there are leaks of any kind on the water or steam side of the boiler. True \ False