Drum Internals

Learning Outcome

When you complete this module you will be able to:

Describe drum internals.

Learning Objectives

Here is what you will be able to do when you complete each objective:

1. Describe the general principles and equipment used to separate steam and water in a steam drum.

2. Sketch and describe a steam drum internal feedwater pipe.

3. Identify and describe a steam drum continuous blowdown line.

4. Identify and describe a steam drum internal chemical feed line.

PURPOSES OF THE BOILER STEAM DRUM

In a modern boiler, the steam drum can serve several purposes:

1. It provides a place for the storage of steam, so that load increases can be accomplished quickly and smoothly.

2. It provides a place in which to install equipment that will separate water out of the steam, before the steam goes to superheaters, turbines, etc.

3. It provides a place in which equipment can be installed that will remove impurities from the steam, thus preventing these impurities from depositing on other surfaces, such as turbine blades.

4. It provides a place from which heavy concentrations of impurities in the water can be removed, via the blowdown line.

5. It provides a place for the distribution of feedwater into the water circuits of the boiler.

6. It provides a place for the introduction of water treatment chemicals into the boiler.

The term “drum internals” is generally taken to mean all the devices installed within the boiler steam drum. This includes various types of steam separators, chemical feed lines, boiler feedwater lines, and continuous blowoff lines.

SEPARATION OF STEAM AND WATER

At low pressures, the lower density steam has a strong natural tendency to rise to, and disengage from, the water surface in the steam drum. The separation of the water and steam in low pressure systems can be accomplished without the aid of mechanical separators, as shown in Fig. 1.

As the pressure rises, mechanical equipment becomes necessary. The dry pipe shown in Fig. 2 changes the direction of flow of the steam and water mixture, and causes most of the water to drop back into the drum, allowing the relatively dry steam to leave the drum. The dry pipe is an early form of separator that is still found on some low pressure boilers.

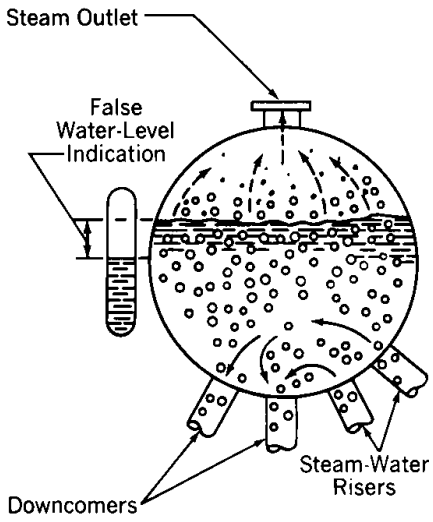

Figure 1
Steam Separation in Boiler Drum Without Baffles

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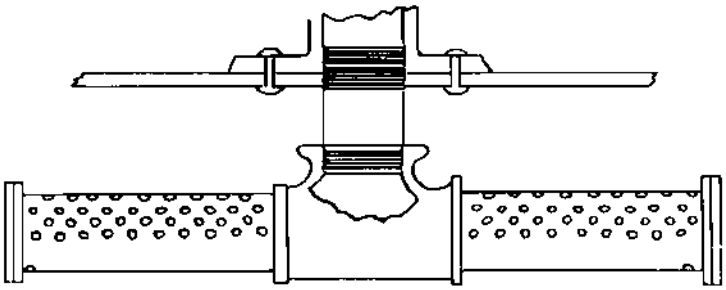

Figure 2
Dry Pipe

In a modern boiler drum, the separation of steam from the mixture delivered by the riser portions of the circuit usually takes place in three steps. The primary and secondary separation removes nearly all the water from the mixture, so that in effect, no steam is circulated back through the circuit, see Fig. 3. The third separation, or steam scrubbing, removes or reduces the amount of contaminants in the steam that leaves the drum.

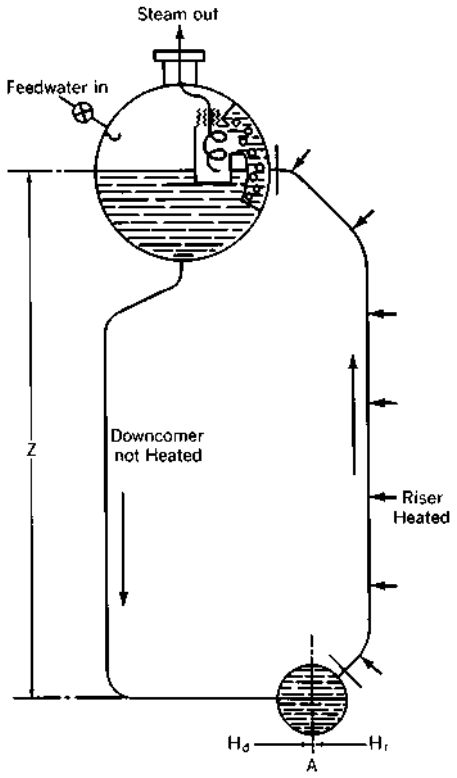

Figure 3
Simple Circuit Showing Primary Steam Separation

PRIMARY SEPARATORS

At higher pressures, the steam becomes more dense and its tendency to separate from water is not as strong. Thus, steam will be carried through the steam drum and back into the downcomers unless means are taken to prevent such action.

The cyclone steam separator was developed to remove the steam from the mixture of steam and water in the steam drum, and to provide the downcomers with steam-free water. These mechanical separators are installed in single or double rows in the steam drums as indicated in Fig. 4.

All of the steam and circulating water from the risers is collected behind a manifold baffle and then discharged into the cyclones. The water in the mixture will have a mass of between two (2) and twenty-five (25) times the mass of steam in the mixture. The circulation ratio depends on the boiler design and the firing rate of the boiler.

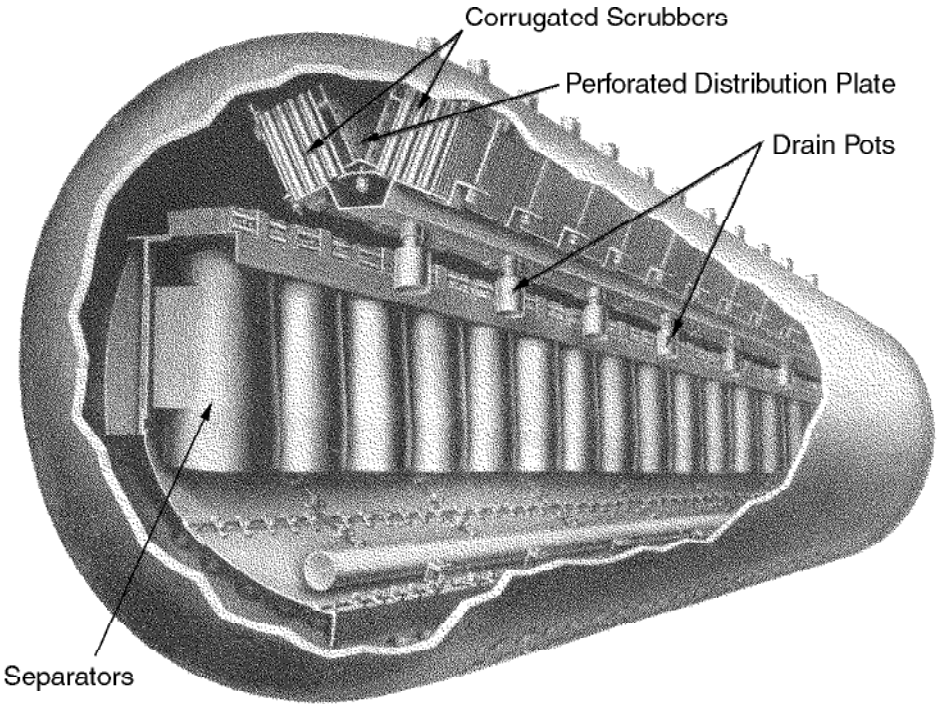

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Figure 4
Cyclone Separators and Steam Scrubbers
(Courtesy of Babcock and Wilcox)

The steam and water mixture swirls into the cyclones at high velocity, producing what is called a centrifugal force that is many times greater than the gravity separating force. This centrifugal action forces the water toward the periphery of the cyclones. The less dense steam flows up the central portion of the cyclones, and passes through a small corrugated scrubber at the top of the cyclone cylinder. This is illustrated in Fig. 5.

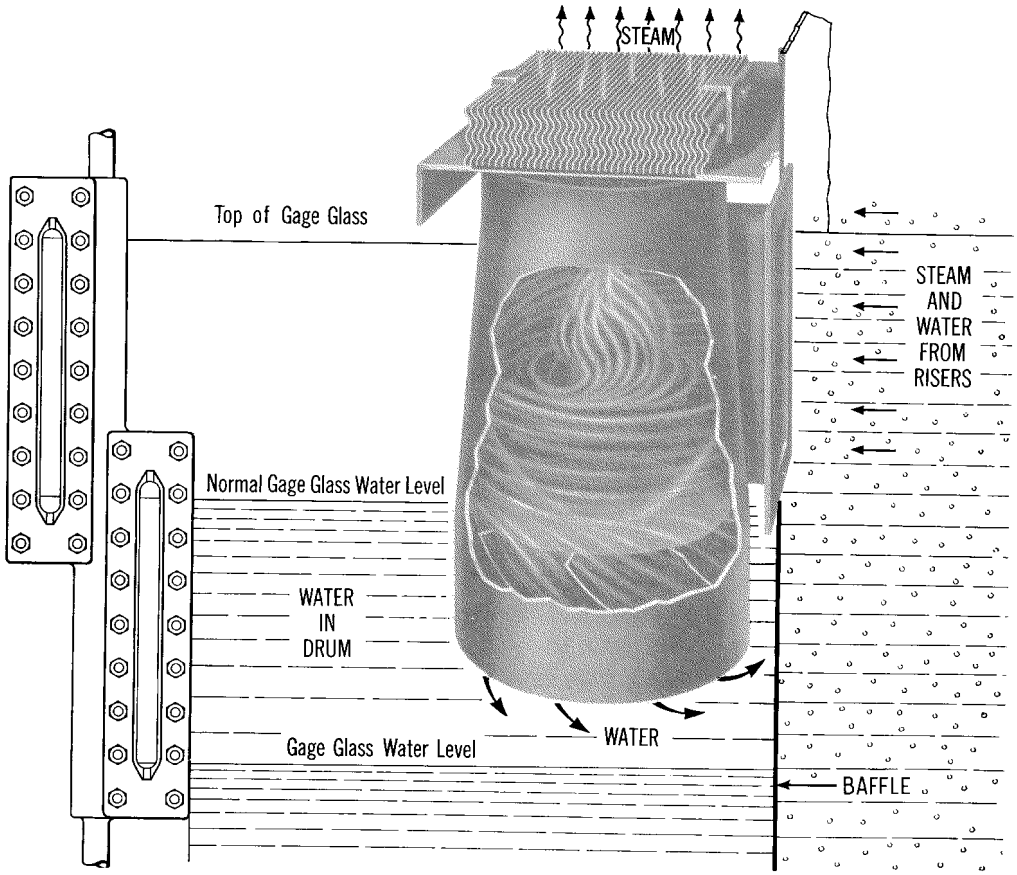


Figure 5
Cyclone Steam Separator
(Courtesy of Babcock and Wilcox)

The steam leaves the top of the cyclone at a velocity low enough to prevent entrainment of water by the steam. This ensures that the steam quality is not affected by large variations in the water to steam ratio. Directional vanes at the bottom of the cyclone guide the water into the separator drum, utilizing the velocity energy in the water to overcome the head of water outside the cyclone. This prevents flooding of the cyclones, even when the water level in the steam drum is close to the top of the cyclone. It also permits a reasonably wide variation in the drum water level, without affecting circulation or steam quality.

The cyclone steam separator has no moving parts, and simply transforms a small portion of the circulating force into the centrifugal force required to separate the steam and water.

A second type of separator is the turbo separator. Referring to Fig. 6, the steam and water mixture enters near the top of the drum and is directed, by a baffle, down the inside wall of the drum to the turbo separator. A separating force is created when the high velocity steam and water mixture passes through the spinner blades. The spinner blades impart a spin to the mixture; causing the water to flow down the outside of the separator, and the steam to pass upwards into the secondary separator. The velocity of the steam is reduced by the time the steam reaches the secondary separator, and therefore water is not entrained by the steam. The turbo separator does not have a water seal, as is the case with the cyclone separator. This type of separator has no capacity limit and is not affected by water level changes. It is also arranged in rows, which run the entire length of the steam drum.

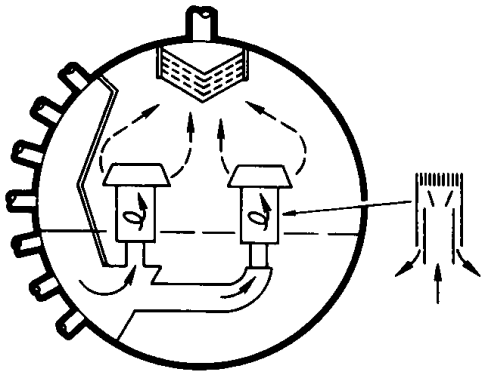
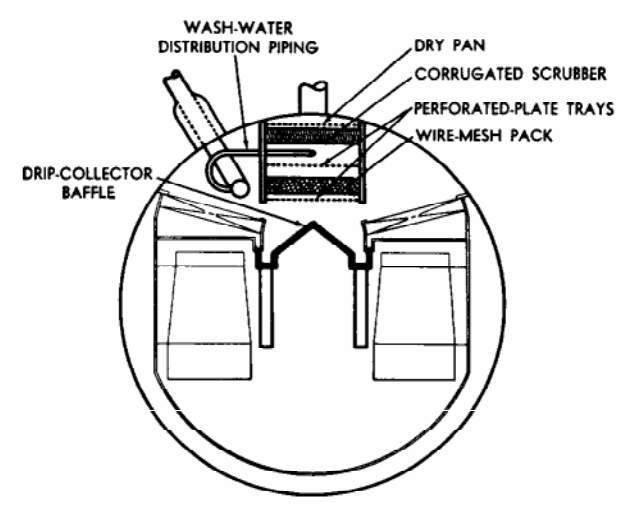


Figure 6
Turbo Separators

Secondary Separators

Once the relatively slow moving steam leaves the primary separators, it passes into the secondary separators. The secondary separators are generally rows of closely fitted corrugated metal plates located directly above the primary separators. These plates cause the steam to change direction many times and the water deposited on the plates drains from the bottom of the assembly to the water in the drum. The secondary separator also runs the length of the boiler drum. Fig. 7 (b) shows the secondary separators above the turbo separators and Fig 5 shows the corrugated plates above a cyclone separator.



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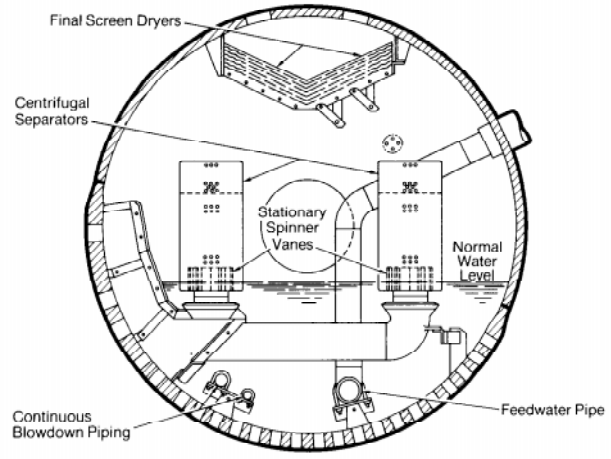
(a) Natural Circulation



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(b) Controlled Circulation

Figure 7
Drum Internals

DRYERS

The dryers or steam scrubbers are located at the top of the drum and are the last stage of moisture and contaminant removal before the steam leaves the boiler drum. The dryer or scrubber is generally a wire mesh or screen that will pick up any droplets of water and allow them to drop back to the water in the drum. Figs. 7 and 8 show the screen or mesh dryer. Figs. 4 and 9 show corrugated metal plate dryers with the drain pots or pipes to return the removed water to the water below. A more complicated type scrubber is shown in Fig. 7 (a) where perforated trays, stainless wire mesh, and wash water are used for the removal of silica from the steam.

INTERNAL FEED PIPE

An internal feedwater pipe is used on most boilers. Fig. 8 shows an internal feedwater pipe entering the boiler through the drum head, and Fig. 1 shows a feedwater pipe that extends nearly the entire length of the steam drum. The internal feedwater pipe is arranged so that it reduces the risk of thermal shock and excessive turbulence by controlling the point at which the feedwater mixes with the water in the drum. On smaller boilers, this may be accomplished by a short feed pipe which discharges against a baffle. Larger boilers use a feedwater pipe which runs nearly the full length of the steam drum and is perforated over its entire length.

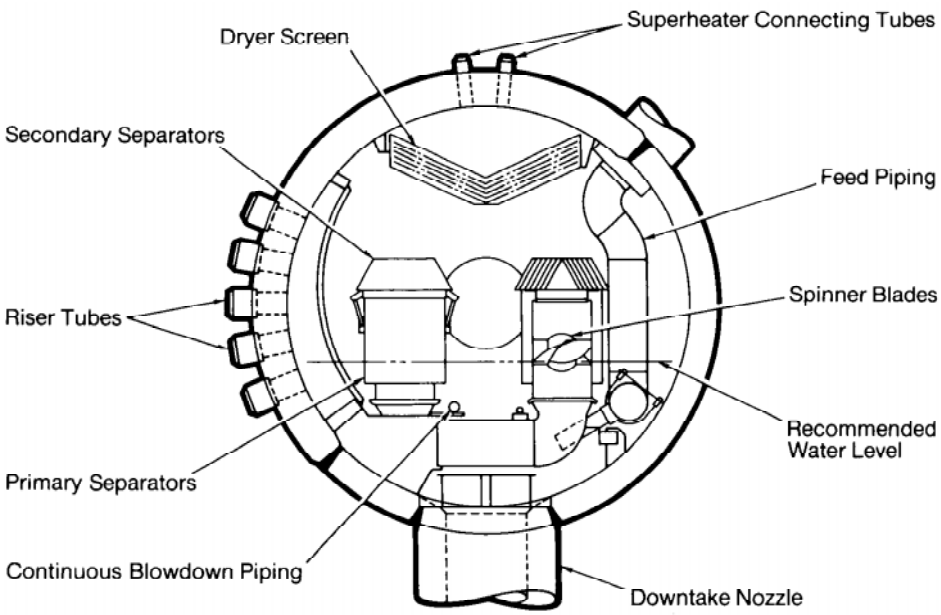

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Figure 8
Internal Feed Pipe

CONTINUOUS BLOWDOWN PIPE

The continuous blowdown, or blowoff, is located several centimetres below the normal water level in the steam drum. This is where the water having the greatest concentration of dissolved solids is found. Fig. 9 shows the location of the continuous blowdown pipe.

As the name implies, it continuously removes a controlled amount of concentrated water from the drum. The amount of blowdown is controlled by a special regulating or metering valve, equipped with an indicator that shows how much the valve is opened. The amount the valve is opened depends on the results of periodic boiler water tests.

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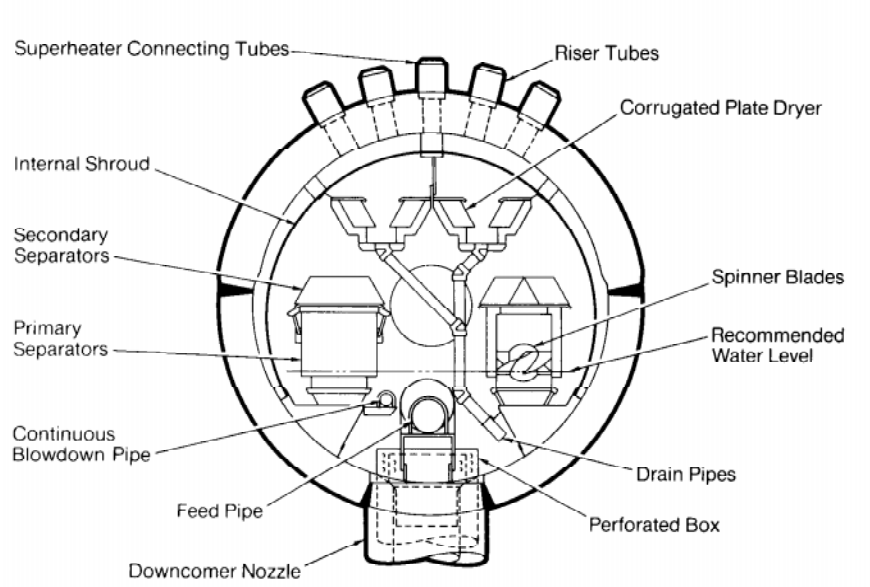

Figure 9
Continuous Blowdown Pipe

CHEMICAL FEED PIPE

Chemicals which are used for the control of scale, corrosion, and sludge within the boiler are fed into the drum by means of an internal pipe as shown in Fig. 10. The perforated chemical feed pipe extends into the drum and is positioned to ensure rapid mixing of the chemicals with the entering feedwater.

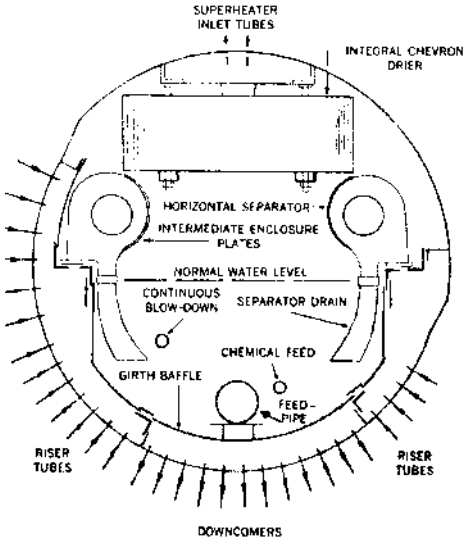

Figure 10
Drum Internals, Including Internal Chemical Feed Pipe

References and Reference Material

For more information on this topic, the following are recommended:

1. Babcock & Wilcox. *Steam/its generation and use*. 39th ed. New York: Babcock & Wilcox; 1978.

2. Salisbury, J. Kenneth. *Kent's Mechanical Engineers' Handbook - Power*. 12th ed. New York: John Wiley & Sons.

3. Singer, Joseph G., ed. *Combustion - Fossil Power Systems.* 3rd ed. Windsor, CT: Combustion Engineering Inc.; 1981.

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