SHIPCO® PUMPS

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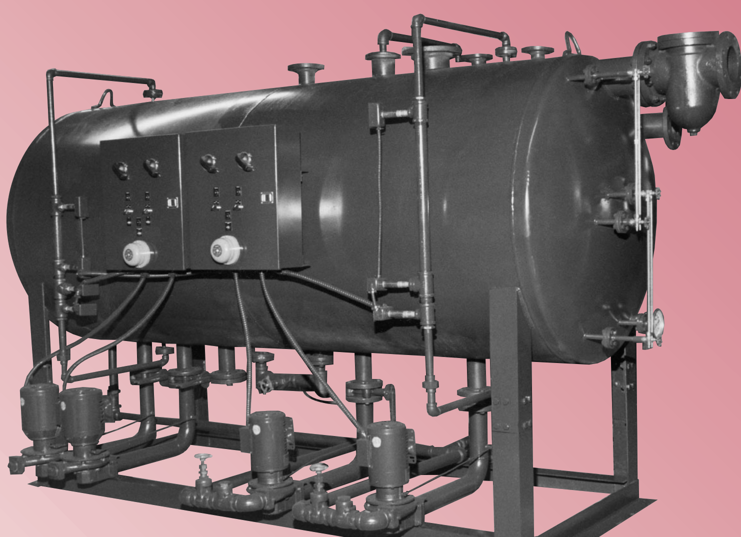


TYPE .03 DA

Deaerating Boiler Feed Pumps

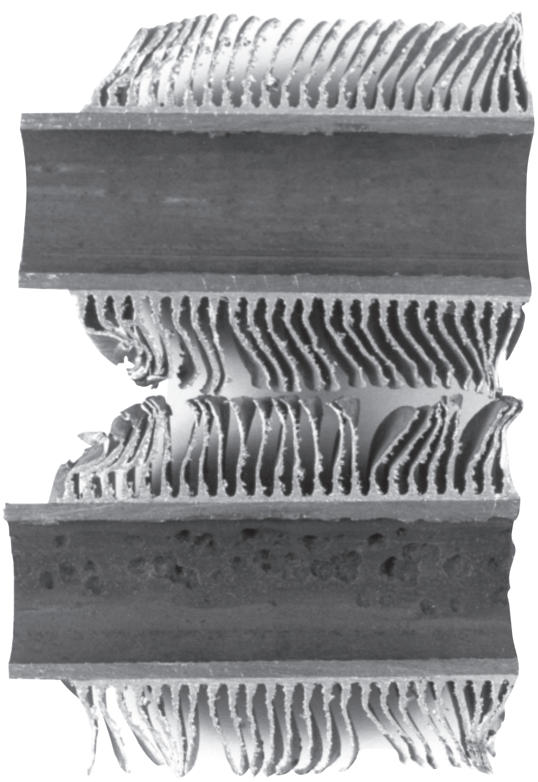
SHIPCO® PUMPS are equipped with Mechanical Seals rated for temperatures up to 300˚F as standard.

SHIPCO®'s deaerating boiler feed units are designed to remove the dissolved oxygen and carbon dioxide in boiler feed water. The standard .03 design removes the dissolved oxygen to a maximum level of .03 cc/liter in the effluent.

The .03 design is the recommended unit for low pressure boilers. The corrosive conditions that occur when oxygen and carbon dioxide are present in boiler feed water accelerate as the temperature increases. Each 20° to 30°F temperature rise approximately doubles the corrosive aggressiveness.

The mechanical deaeration achieved by the SHIPCO® .03 deaerating boiler feed unit is one of the most economical methods for removing corrosive gases from boiler feed water. The atmospheric design provides unrestricted venting of the non-condensing gases. Utilizing a two compartment unit enables the flash steam that escapes the deaeration compartment to be recovered by the direct contact vent condenser in the accumulator compartment. This method of operation allows full utilization of equipment at various load ranges with a minimal vent loss. This is one advantage over pressurized units that require a constant vent loss at all load ranges through the fixed orifice.

Mechanical deaeration is the preferred method of removing dissolved gases in boiler feed water. The dissolved oxygen in feed water is the major cause of boiler corrosion, which can be treated chemically; however, most feed water also contains dissolved carbon dioxide, some carbonates and bicarbonates. These compounds are not removed by oxygen inhibitors. The carbon dioxide in steam is not corrosive; however, the carbonic acid formed in condensate is very corrosive and attacks the equipment and piping. If left undetected, the level of carbon dioxide in a feed water system will continue to increase the level of carbonic acid and corrosiveness of the condensate. The only effective means of carbon dioxide removal is mechanical deaeration.



OXYGEN PITTING IS A COSTLY PROBLEM!
PROPER WATER TREATMENT UTILIZING MECHANICAL DEAERATION IS VERY INEXPENSIVE WHEN COMPARED TO REPLACING EQUIPMENT PREMATURELY!

[1] When should a single-compartment .03 DA deaerating heater be used?

A good general rule is to select a single-compartment .03 DA unit on systems having 80% or more make-up.

[2] When should a two-compartment .03 DA-2C [or two-tank .03 DA-2T] deaerating heater be used?

Use a two-compartment .03 DA-2C [or a two-tank .03 DA-2T] design on systems having more than 20% return condensate.

It is no secret that constant balanced flows provide the best results when deaerating feed water. The two-compartment [or 2-tank design] allows the system to intermittently return condensate to the accumulator compartment. The capacity of the accumulator is such that it has ample capacity for storing the condensate from the system. The system lag time for returning condensate to the accumulator will determine the required size of the accumulator compartment. A good general rule is to size the compartment for a minimum 10 minutes of storage.

The condensate is blended with any required make-up water in the accumulator compartment. This feed water is then transferred to the deaeration compartment by the transfer pump through a balanced transfer valve. This balanced flow enables the steam control valve to maintain the constant temperature critical for good deaeration.

Good engineering practice has shown from experience that the percentage of make-up required in a given system will determine the style of deaerator to be used. Systems requiring less than 80% make-up should have an accumulator. The intermittent return condensate is collected and blended with the make-up water to be deaerated on a balanced demand based on system load.This will assure an ample quantity of deaerated feed water.

Type .03 DA Deaerating Boiler Feed Pumps

The single compartment design consists of a boiler feed receiver constructed of black steel (300 Series stainless steel available for longer life) in which we install a horizontal spray manifold for pumped returns, a top baffled inlet for gravity returns and low pressure drips, a pneumatic modulating make-up valve for even control of make-up water, and a direct injection steam heating assembly with a pneumatic steam control valve and temperature regulator. The receiver also is equipped with a vent, an overflow loop, a magnesium anode, and is mounted on a structural steel stand. Our receivers are elevated to provide the NPSH required by our pumps. The boiler feed pumps are mounted on the structural support stand and connected to the receiver by a suction pipe that includes a suction isolation valve for servicing the pump.

The single compartment design is normally recommended for applications either having a large percentage of make-up water (i.e., 80% or more) or a very even modulated return system into the deaerator. The secret to good deaeration is creating constant flows and temperatures. This prevents radical changes in the level of deaeration and wild swings in the demand on the heating assembly.

Type .03 DA-2C Deaerating Boiler Feed Pumps

The two-compartment design assures continuously modulated flows for optimum deaeration with minimum vent loss. The receiver made of black steel, Plasite lined or made of 300 Series stainless steel design permits return condensate and make-up water to enter the accumulation section. The feed-water is then transferred into the deaeration compartment by the transfer pump through a modulating valve. The continuously running transfer pump supplies feed-water to the stainless steel spray manifold in the deaeration compartment and the vent condenser in the accumulator compartment. Orifices, installed in the transfer piping, balance the flow between the deaeration spray manifold and the vent condenser. A direct injection steam heating assembly in the deaeration compartment maintains a constant temperature at saturation. A water make-up assembly supplies make-up water to the accumulator compartment to compensate for system losses. The vent condenser located in the accumulator compartment assures a minimum vent loss. The entire unit is vented (unrestricted) for atmospheric operation.

Type .03 DA-2T Deaerating Boiler Feed Pumps

The two-tank or separate receiver design assures continuously modulated flows for optimum deaeration with a minimum vent loss plus the flexibility of design. The remote accumulation is a collection and storage area for return condensate. The make-up water is added in the accumulator section. The blend of return condensate and make-up water is then transferred to the deaerator section by the transfer pumps. The continuously running transfer pump supplies feed-water to the stainless steel spray manifold in the deaeration receiver. A direct injection steam heating assembly in the deaerator maintains a constant temperature at saturation. A water make-up assembly supplies make-up water to the surge tank to compensate for system losses. The entire unit is vented (unrestricted) for atmospheric operation.

Deaerator Boiler Feed Pump Selection & Sizing

Selection is based on gallons per minute (GPM), pounds per square inch (PSIG), net positive suction head (NPSH) and receiver size.

Determine GPM

The evaporation rate of one boiler horsepower is .069 gallons per minute.

Other conversion equivalents: One boiler horsepower equals 33,475 BTU/hr. or 34.5 lbs./hr. or 139.4 sq. ft. EDR.

Boiler feed pumps for on-off operation are sized at two (2) times this evaporation rate.

Boiler feed pumps for continuous operation (generally 15 motor HP and larger) are sized at one and a half ($1\frac{1}{2}$) times this evaporation rate. In addition, extra flow for recirculation with deaerator boiler feed pumps may have to be added. The SHIPCO® centrifugal Model “P” and “D” pumps do not require any additional flow. SHIPCO® pumps with motors 5 HP and less have a bleed line that serves this function, and in pumps with motors $7\frac{1}{2}$ HP and larger a bypass orifice is used in a recirculation line for this purpose.

Boiler feed pumps are sized based on the maximum number of boilers each pump is feeding.

Determine PSIG

The deaerator boiler feed pumps are sized to overcome the **operating** pressure of the boiler + friction loss in pipe + valve loss + feed valve loss (if any) + stack economizer (if any) + vertical lift from pump to boiler + safety margin of approximately 10 PSIG. The amount of these values added together, is normally expressed in feet of head. To convert feet of head to PSIG, 2.31 ft. = 1 PSIG.

Generally, the feed valve loss is 20 PSIG and the stack economizer loss is 20 PSIG when estimating the pump discharge pressure. Stack economizer requires a continuously running pump in the system.

The standard rules of thumb are:

- High-pressure boilers running on–off from a boiler level controller add 20 PSIG to the operating pressure (not the design pressure).
- High-pressure boilers running continuously pumping through a modulating valve add 30 PSIG to the operating pressure (always better to get pressure drop through valve).
- High-pressure boilers running continuously pumping through a modulating valve and a stack economizer add 50 PSIG to the operating pressure.
- Low-pressure boilers (running between 1 to 15 PSIG) generally use pumps with a discharge pressure of 20 PSIG.

If the boilers run at more than one pressure setting (like a night setback), an additional pump(s) is needed to handle this pressure and the steam control regulator must be sized for this nighttime low-pressure setback.

Determine NPSH

NPSH stands for Net Positive Suction Head. The **available NPSH** is essentially the measure of how close the water in the suction passage of the pump is to boiling, with the attendant formation of steam within the impeller, thus diminishing the pump's performance.

Since we have a deaerator where the water is at the saturation point or boiling point, the **available NPSH** is at zero, located at the bottom of the steam manifold.

Various physical designs of pump have various **NPSH requirements**. In order for any pump to operate successfully, the NPSH **available** must be **greater** than the NPSH **requirements.** With a deaerator the only way you can increase the NPSH available is to elevate the tank a greater distance than the pump requires. For example, a pump with an NPSH requirement of 4 ft. must be elevated at least 4 ft. plus a safety factor (usually 1 to 2 ft.). The SHIPCO® model "P" pump requires only 2 ft. of NPSH at the best efficiency point; therefore, our standard elevation is 4 ft. or 48 inches.

Suction strainers hurt NPSH calculations since you can't measure the pressure drop through a strainer. In addition, if it works it will destroy the pump by causing it to run dry. For this reason suction strainers are **never** used with centrifugal pumps like the SHIPCO® model "P" or "D" pumps. Suction strainers are only used when turbine pumps are supplied since even a little dirt and debris will cause this style of pump to go bad due to the close tolerances within the design. The standard rule of thumb is to add one additional foot of stand elevation to compensate for this suction strainer.

Determine Receiver Size

The receiver size on a deaerator is based on the total load of all boilers being fed by the unit at any one time. The receiver size is generally based on 10 minutes of net storage when using a single compartment with returns.

If the system utilizes a surge tank with the deaerator, then the surge tank will be sized to handle the 10 minutes of net storage time required, with the deaerator being sized for only 5 minutes of net storage.

A deaerator without returns (100% make-up) requires only 5 minutes of net storage.

As demonstrated, the selection of the receiver size may vary based on the characteristics of the system.

Surge Tank Pump Selection & Sizing

What is a Surge Tank?

A surge tank is really another name for a boiler feed tank. It acts exactly like a boiler feed tank would except that it feeds a deaerator in lieu of a boiler. With a surge tank the make-up water is added into this tank and blended with the return water so as not to shock the deaerator with temperature and capacity variations. In addition the pumps on the surge tank must run continuously, pumping the water directly into the modulating transfer or make-up valve on the deaerator. The second transfer pump is a standby pump that is activated by a low-level switch on the deaerator. This standby pump runs automatically in case the lead pump fails or can't keep up.

A surge tank is not a condensate pump since a condensate pump turns on and off based on the water level in its receiver. When a condensate style unit is used as a surge tank, it defeats the entire purpose of a surge tank by allowing large variations in capacity and temperature into the system. The main purpose of the surge tank is to level out the transients or control the mood swings so the deaerator runs as smoothly as possible.

If controlling these variations in temperature were not important, there would be no need to use expensive controls that modulate on the deaerator.

What does a Surge Tank look like?

Since a surge tank is really another name for a boiler feed tank, as mentioned earlier, the tank can take many shapes and forms. The tank can be made out of stainless steel, cast iron (with a 20-year warranty against corrosion failure) to prevent against corrosion failure, or of black steel.

The surge tank can be an integral part of the deaerator, like a two-compartment style, or free standing by itself.

Also, the tank can be elevated or mounted on the floor like many of the types throughout the entire catalog. Yes, the surge tank may be placed on the floor. This is possible because at 150, 180 or even 200° F, the water temperature is low enough that NPSH is not a major concern. For example, with 194° F water you have 10.46 ft. of NPSH available. If you look at the pump curves in the catalog, the pumps, if properly selected, are 2 ft., 4 ft. or 6 ft. NPSH at the best efficient point on the curve. Hence, the NPSH available is greater than the pump NPSH requirement.

When is it used?

The general rules of thumb are as follows:

- On systems with **80% or more make-up** a surge tank is really not required.
- On systems with **more than 20% returns** a surge tank is required to achieve good deaeration.

Determine GPM

All deaerator units are rated in lbs/hr of steam. The transfer pumps on the surge tank units are sized based on this rating. Lbs/hr divided by 500 equals the evaporation rate in GPM for these pumps. The pumps are sized as follows:

If pumps are feeding a pressurized deaerator unit, the pump rate in GPM equals the evaporation rate of the deaerator.

If pumps are feeding an atmospheric style deaerator, the pump rate in GPM equals the evaporation rate of deaerator multiplied by 1.5. This is to allow recirculation of water through the vent condensers.

Recirculation for these continuously running transfer pumps may be required. The SHIPCO® Model "P" and "D" pumps have a bleed line, a standard that does not require any additional recirculation when pumping liquids lower in temperature than at the boiling point.

Determine PSIG

The surge tank pumps are sized to overcome the operating pressure of the deaerator = the spray nozzles + friction loss in pipe + safety margin + vertical lift. The amount of these values, or these values added together, are normally expressed in feet of head. To convert to pounds per square inch, or PSIG, 2.31 ft. = 1 PSIG.

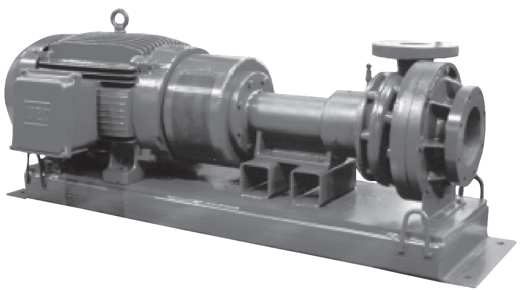
Generally, the surge tank is located beside the deaerator or is part of the deaerator itself; therefore, a pump discharge of 25 PSIG is used as our standard since we select transfer modulating valves on our deaerators for a 10 PSIG drop.

Determine Receiver Size

The receiver on a surge tank is sized based on the total load of all boilers in the system, the same sizing as that of a standard boiler feed unit. The receiver size is based on 10 minutes of net storage as a general rule of thumb.

Boiler Feed Pumps

SHIPCO® offers a wide variety of boiler feed pump types with various models and styles designed specifically to pump hot condensate over a wide range of flow and pressure applications. Pumps are centrifugal single or multi-stage and can be vertical or horizontal flange mounted with 1750 RPM or 3500 RPM motors in single or three phase. Pumps are low NPSH designed bronze fitted with removable wear ring and impeller and equipped with industry standard motors that can be purchased locally.

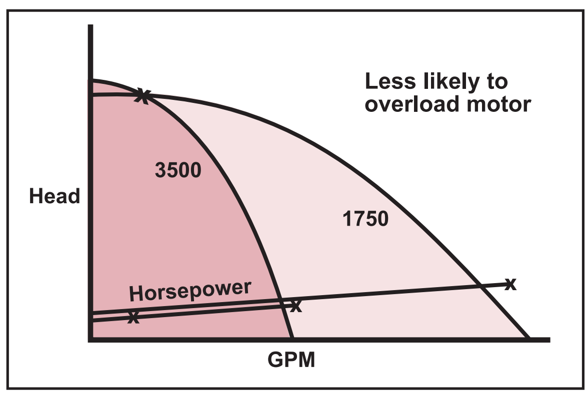


The pump design typically furnished on deaerators is a multi-stage, AWF style of pump. This pump is centrifugal, bronze-fitted design. Pump typically used for applications with flows up to 500 GPM and pressures up to 340 PSIG. Pump types (such as 221 AWF, 231 AWF, 616 AWF, etc.) selected depend on the design operating conditions–flow rate, discharge pressure and NPSH requirements; impellers trimmed to operating conditions. Pumps come standard with an ASA flanged suction and discharge. Pumps also have coupling guards. Pumps are furnished with bleed lines, sometimes called seal flushing lines, to help prevent the pump from vapor binding and to allow pump operation against a dead shut-off for a period of time without burning mechanical seals. Silicon carbide/Viton seals provided are for temperatures up to 300°F. All pumps come equipped with an automatic flow control valve for balancing or throttling pump to the designed condition point.

On all deaerator applications where pump is running continuously, an additional stainless steel bypass orifice must be installed when motor horsepower exceeds 7 1/2 HP.

Why Do We Recommend 3500 RPM Centrifugal Pumps for Most Boiler Feed Applications?

1) More efficient than 1750 RPM for most condensate and boiler feed applications.
2) Operating and repair costs are lower because pumps are more efficient and the motors and parts are less expensive.
3) Less likely to overload motor than 1750 RPM pumps because of much steeper head—capacity, characteristic especially for small capacities. If actual head on the pump is lower than the design head, the pump will operate at higher capacities with accompanying higher power. The 3500 RPM pump maximum load is lower.
4) Just as durable as 1750 RPM centrifugal pumps for the same head and capacity. Centrifugal pumps are not subject to the wear problems of regenerative turbine pumps which are frequently chosen to run at 1750 RPM because of this inherent limitation.
5) NPSH requirements are low for the lower capacities and can be further reduced by use of the "P" modification for higher capacities where the NPSH available is unusually low.



Are Suction Strainers Necessary on Centrifugal Pumps?

It is often asked whether a pump suction strainer is necessary or recommended. The purpose of a suction strainer is to act as a particulate strainer or filter ahead of the pump. This prevents large particles from entering the pump.

Before the introduction of the low-flow/high-head multi-stage centrifugal type pump, turbine type pumps were used almost exclusively for on/off boiler feed service for steam boilers. Back in the 1920s, a turbine pump was the only pump available for high-pressure pump applications since multi-stage, centrifugal pumps were not yet available. The turbine pump impeller was designed with very close tolerances within the pump. Any grit or sediment that entered the pump would result in accelerated erosion of these close-tolerance areas, leading to premature pump wear and loss of performance. These pump characteristics made the use of a strainer a necessity with a turbine type pump.

During the 1960s, ITT Domestic® and other manufacturers introduced multi-stage, centrifugal pumps into the high-pressure steam market. Then during the 1980s, manufacturers such as Grundfos, Gould, etc., started marketing multi-stage, centrifugal pumps and offering the pumps to boiler manufacturers who make feed tanks but not pumps. This strategy caused the boiler manufacturers to start specifying multi-stage, centrifugal pumps in lieu of turbines because the manufacturers now had a source for pumps.

Centrifugal pumps, by their design, are more durable. A centrifugal pump does not have the same close tolerances of a turbine pump—it has a more robust design that enables grit and sediment to pass through without clogging the impeller volute area. Therefore, the use of a suction strainer is neither mandatory nor recommended. Instead, an inlet basket on the return piping into the receiver and a wye strainer on the make up water piping are recommended.

Below is a list of considerations regarding the use of suction strainers with centrifugal pumps:

- **Suction Losses:** The addition of a strainer in the suction line of a pump increases the losses in the suction line, thereby decreasing the NPSH available to the pump. As the strainer fills with particles, the pressure drop across the strainer increases, further reducing the NPSH available. This situation becomes more critical as the temperature of the pumped water increases. When a feed water pump is pumping from a deaerator, the water is already at the flash point, and any increase in the suction losses could lead to a flashing condition and pump cavitations.
- **Increased system maintenance:** Because of the reason stated above, it is important that the strainer screen be checked and cleaned regularly. If the installation is in a remote area and maintenance checks are rare, a clogged strainer will eventually lead to pump failure and a low water condition in the boiler.
- **Can particles get into the pump without a strainer?** SHIPCO® recommends use of inlet strainers on all deaerators and boiler feed tanks to help prevent particles from getting into the pump. In addition the suction piping typically extends 2" to 3" up into the receiver (often referred to as a vortex breaker). This extension helps prevent any sediment and large particles from leaving the tank through the suction opening. In SHIPCO® deaerators, the water entering the deaerator must travel through a series of spray valves, baffles, trays and other restricted flow paths before deaeration is complete and the water is ready for use. The number and size of the particles that will make it through this path and into the storage area are limited.

As the engineering community continues to improve its understanding of the functions of centrifugal and turbine pumps, engineers are starting to remove requirements for suction strainers from specifications.

SHIPCO® believes that any benefit of a suction strainer is far outweighed by the risks, which can lead to pump failures and other system problems.

Why Inject Steam Below the Water Line of the Storage Section in Our Deaerator Designs?

Injecting steam into the storage section (also referred to as water reserve) of deaerators provides several advantages over other designs. Primarily, it helps prevent the reabsorption of oxygen into the deaerated water since steam injected below the water line keeps the water in the storage section in constant agitation. It provides a heat source for load swings that enables the storage section to operate as a steam accumulator if a rapid load swing should occur. Finally, it keeps the water in the storage section moving, which prevents chlorides from becoming stagnant.

In a system *without a surge tank but large quantities of uncontrolled returns*, the addition of make-up water, when required, will create a load swing that will be the difference in temperatures between the hotter system returns and the colder make-up water. An advantage of SHIPCO®'s design is that the deaerator has some stored energy in reserve in the storage section creating the capability to continuously scrub water in the storage section to prevent re-absorption of oxygen. When a sudden change in pressure occurs, steam will be released from the storage water, helping maintain the level of deaeration desired.

For deaerator designs where steam is only injected above the water line in the storage section, any oxygen that is re-absorbed into the effluent cannot be released without agitation and the water temperature in the storage section reaching the saturation point (i.e., boiling point). The saturation temperature throughout the depth of the storage section varies. For example, the saturation temperature is higher at the bottom of the receiver than at the water surface. At the bottom of the receiver, the saturation temperature depends on both the internal tank pressure plus the pressure generated by the weight of the water from the surface to the bottom of the tank.

While various designs exist within the industry, most deaerator manufacturers use the same or similar type of steam control valves since steam control valves are very responsive to detecting pressure changes inside the storage tank

Our goal in manufacturing deaerators is to provide a reliable unit that will meet or exceed customer requirements. Supporting this goal, we are fortunate to have an independent, third-party test of our .005 "dome-style", pressurized deaerator that confirms our design of injecting steam below the water line produces results that exceed rated performance. The test shows that the highest reading for dissolved oxygen was only 5 parts per billion (ppb) — below the industry-standard rating of 7 ppb for a .005-rated deaerator.

(Note: We recommend using a surge tank to lessen the effects of load swing in a system when condensate returns are 20 percent or more of system load. With a surge tank, make-up water is mixed with system returns for a blended effluent that is pumped to the deaerator by transfer pumps.)

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