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Pride

Quality

Craftsmanship

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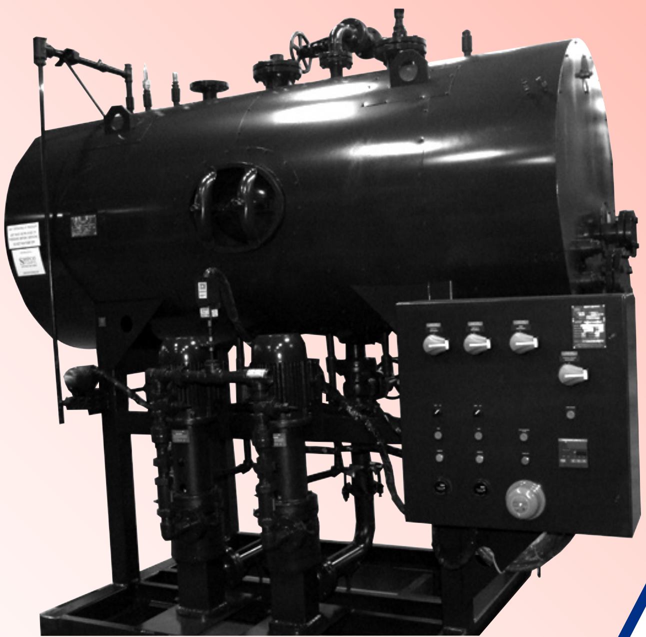


TYPE .005 DA-ISTP

Internal Spray Tray Deaerating Pressurized Boiler Feed Pumps

AND

TYPE .005 DA-ISTP-2T

when separate surge tank is utilized

SHIPCO® *Deaerators can save you money!!!*

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

Why a Deaerator? What Does It Do?

A deaerator is a special kind of boiler feed pump that minimizes the corrosiveness of the boiler feed water and pumps this water into the boiler as needed. It reduces the corrosiveness by heating the water, thus removing harmful dissolved gases (oxygen and carbon dioxide) by driving them out of solution.

Since corrosion, like other chemical reactions, increases with temperature, a higher rated deaerator is needed for higher temperature boilers. The temperature and pressure of boiling water rise simultaneously; it is therefore important to use the best type of deaerator for high pressure boilers to protect the boiler and the system from corrosion while minimizing boiler chemicals.

Lower priced, less effective deaerators can be a good compromise for low pressure boilers. Standard industry ratings are .005 for the highest rated, and .03 for the less expensive deaerators (Rating .005 = .005 cubic centimeters of oxygen remain per liter of feed water). This .005 rating is equivalent to about 7 parts per billion by weight, which is a minute amount of remaining oxygen. The .03 cc/liter rating represents about 44 parts per billion of oxygen in the water by weight.

Actual performance can vary a lot and depends on the force of the boiling water (temperature and turbulence), and the steadiness of the flow into the deaeration compartment (transients), as well as other factors which will be mentioned in "How a SHIPCO® Deaerator Works."

Good performance depends on hard boiling, therefore the generated steam must be highly condensed before the gases are vented to atmosphere to avoid loss of steam. Design and proper controls are equally important for the efficient operation of the deaerator. Properly operated deaerators require drastically fewer oxygen scavenging boiler treatment chemicals.

In summary, deaeration achieves the following:

- Removes air (oxygen and carbon dioxide)
- Raises feed water temperature (reduces boilershock)
- Improves heat transfer (air acts as an insulator, hindering heat transfer in the system)
- Saves money (limits chemicals, limits boiler retubing, saves return lines, heat exchangers & process equipment)

Fundamentals for Outstanding Deaerator Design

1) Temperature
2) Time
3) Turbulence
4) Thin Film
5) Transients
6) Venting

Use 5 T's and 1 V as an aid to remember these very important requirements.

Heat is required to raise the water **temperature** in your deaerator to full saturation temperature for the internal pressure of the deaerator. The temperature must remain at the boiling point to ensure oxygen removal.

Time is required to remove all traces of dissolved oxygen. The more time allowed in each step of the deaerating process the more effective the deaerator becomes.

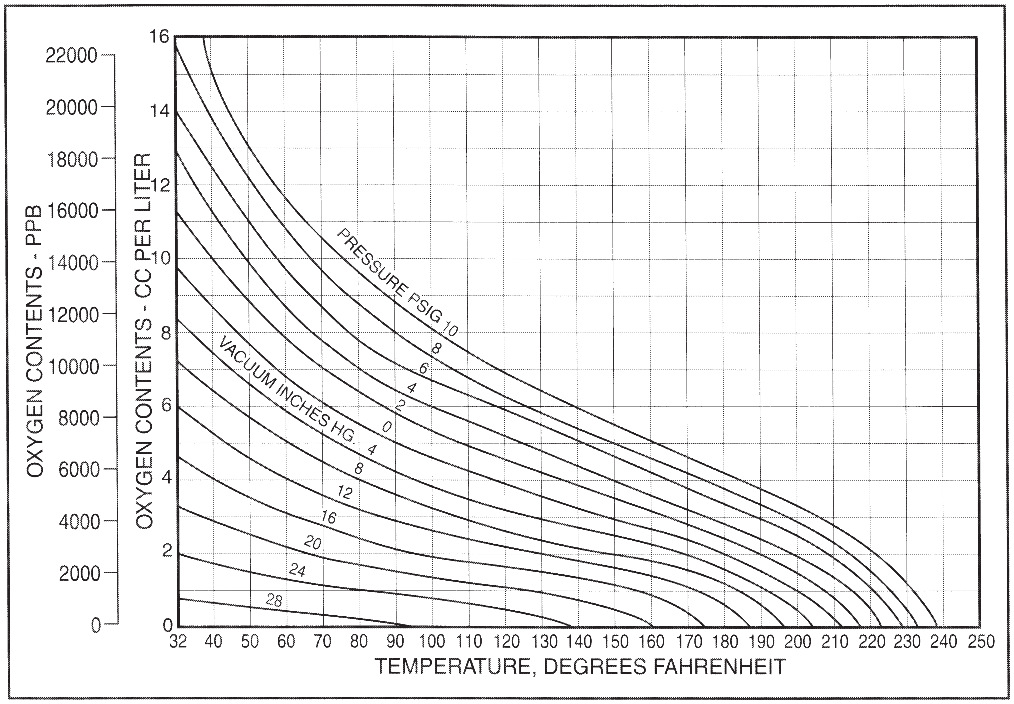
Turbulence is required to vigorously scrub all the gas bubbles. Steam added at the bottom of the unit through the steam manifold assembly causes steam bubbles to rise and carry any remaining tiny air bubbles to the surface. This process helps overcome surface tension that retains dissolved gases.

A **thin film** is required to decrease the distance tiny bubbles must travel to be released. By reducing the time required to accomplish release, the quantity that can be handled by a given size unit is increased. This increase is accomplished by spraying the water through nozzles and then by continuing the process over a series of baffles.

By controlling all **transients** with modulating controls and allowing returns to enter a surge tank with pumps running continuously, temperature and capacity variations are minimized. Quick and sudden changes can cause air to redissolve very rapidly.

Venting of the liberated non-condensable gases with the escape of some steam to atmosphere must occur. If these gases are not allowed to escape, deaeration could not happen.

How a SHIPCO® Deaerator Works – Important Features



The principle on which a deaerator works is Henry's Law, expressed graphically above. At the chosen pressure the amount of dissolved gases goes to zero when the water is at the boiling temperature for that particular pressure. Since it takes time for a bubble of oxygen to form and rise, boiling the water hard shortens this time. It is therefore possible to have a deaerator work at vacuum, atmospheric pressure, or a higher pressure. Atmospheric and low pressure (5 PSI) are most often used. SHIPCO® manufactures both of these deaerators. Advantages and disadvantages are as follows:

Atmospheric Advantages:

- No ASME Code tank expense
- No float drainer for overflow
- No safety valve
- Less steam loss at partial load
- No orifice in vent
- Shell & tube vent condenser/preheater advantages for larger temperature rise heating requirements

Pressurized Advantage:

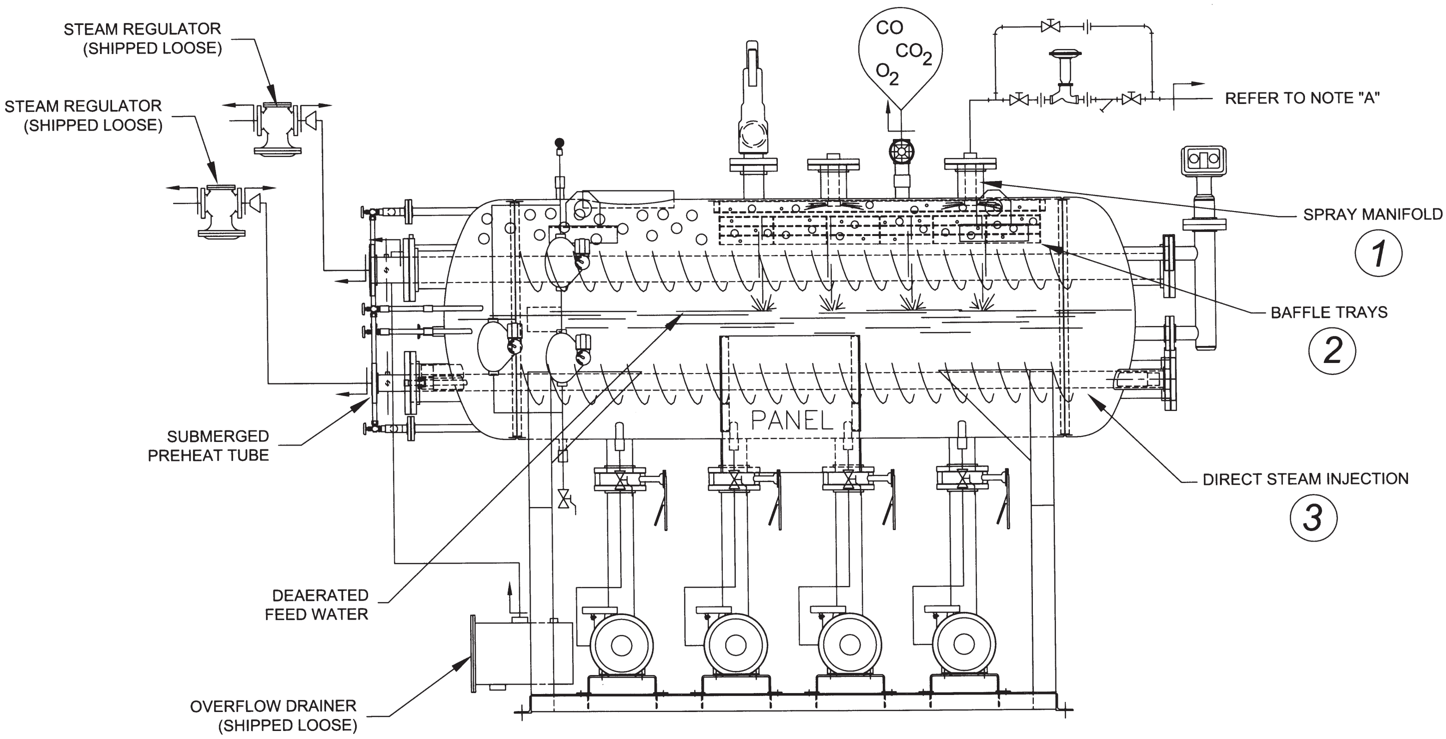
- Faster response of pressure pilot

A steam manifold is boiling the water hard near the bottom of the tank with volumes of steam rising. The incoming water is sprayed into the top of the tank just below the vent, condensing the steam and heating the incoming water. It then cascades through the baffles further heating the water, condensing more steam, and releasing oxygen which travels up toward the vent with the steam. The water, then mostly deaerated, drops to the surface where the bubbling steam purges the last of the oxygen. The deaerated water is stored until the boiler calls for water and it is pumped from the bottom of the tank to the boiler.

Important Features:

1) A path in one direction for the steam to carry the oxygen toward the vent, effectively isolating it from the deaerated water.
2) Spring-loaded spray nozzles that provide a fine spray at varying flow rates for rapid heating and oxygen removal.
3) A series of baffles further providing for heating of water, condensing of steam, and release of oxygen, as well as providing the one-direction pathway.
4) A steam manifold with narrow slits to provide good distribution of fine steam bubbles to scrub the last of the oxygen from the stored water. It will operate relatively quietly above 160°F.
5) This scrubbing heater (a little above the bottom) assures the pumps are getting the most thoroughly deaerated water in the unit. Since heat rises, steam added at the bottom is more effective in heating the bottom as opposed to adding heat at a higher level. Furthermore, the rising steam bubbles are very effective in carrying any remaining tiny air bubbles to the surface.
6) Noticeably better deaeration can be obtained when flows increase or decrease gradually. Sudden increases or decreases, such as a large on and off flow from a condensate pump, will hinder performance unless a surge tank is used with modulated flows from the surge tank to the deaerator tank. A system with 80% to 100% make-up water can operate efficiently without a surge tank as the water flow can be modulated from the domestic water supply, but larger percentages of pumped returns require a surge tank for best performance.

MECHANICAL DEAERATION IS A COST EFFECTIVE MEANS TO ACHIEVE EFFICIENT BOILER PLANT OPERATION



NOTE "A"
MAKE-UP CONNECTION IF SINGLE-TANK DESIGN
TRANSFER CONNECTION IF TWO-TANK DESIGN

SHIPCO® HAS A THREE-STEP APPROACH

1. Incoming feed water is introduced into the deaeration structure by stainless steel spray nozzles. The fine spray provides the increased surface area for heat absorption and release of the non-condensable gases.
2. The falling droplets of feed water next form a film to cascade down the tray section of the deaeration structure. Maintaining a thin film keeps the surface area exposed for steam scrubbing.
3. Directly injecting the steam into the deaerated feed water holding section provides a continuous steam scrubbing, preventing re-absorption of the non-condensables.

SHIPCO® DEAERATORS CAN SAVE YOU MONEY...

BY REMOVING “AIR”.

COMPARED TO REDUCED CAPACITY OF THERMAL EQUIPMENT.

BY REMOVING BARRIERS TO EFFECTIVE HEAT TRANSFER.

COMPARED TO LOST PRODUCTION TIME AND EXPENSIVE REPAIR OR REPLACEMENT OF PREMATURELY CORRODED BOILERS, BOILER TUBES, CONDENSATE RETURN LINES, HEAT EXCHANGERS, OR PROCESS EQUIPMENT.

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 ($1^1/_2$) 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 $7^1/_2$ 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, are 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 additon 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.

How to Determine Transfer Pump (Gallons per Minute) 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 transfer pumps are feeding a deaerator on a free-standing by itself surge tank (-2T) system, the pump rate in GPM equals the evaporation rate or the total load rating on the deaerator. For example, if deaerator system is rated 10,000 lbs/hr, then each transfer pump should be rated for 20 GPM.

If transfer pumps feeding a deaerator with the surge tank are part of the complete unit like our two-compartment model (-2C), the transfer pumps are sized differently based on being an atmospheric or pressurized deaerator.

If a pressurized two-compartment deaerator unit is used (-2C), the pump rate equals the evaporation rate or the total load rating on the deaerator (as mentioned earlier).

If an atmospheric two-compartment deaerator is used (.005 DA-2C or .03 DA-2C), the pump rate in GPM equals the evaporation rate of the deaerator multiplied by 1.5. For example, if deaerator is rated 10,000 lbs/hr, then each transfer pump should be rated for 30 GPM (20 GPM x 1.5). This is to allow recirculation of water through the vent condensers. *In addition, this is the only type of surge tank where NPSH is a concern and pumps should have an NPSH requirement lower than the height of the stand to be safe.*

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

How to Determine the Pump Discharge Pressure PSIG

The surge tank pumps are sized as follows:

A) To overcome the operating pressure of the deaerator

B) Spray nozzles

C) Friction loss in pipe

D) Vertical lift between deaerator and surge tank

E) Safety margin generally 5 PSIG

F) Pressure drop associated with transfer valve

The amount of these values, or these values added together, is 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 when it is part of the deaerator itself; therefore, a transfer pump discharge of 35 PSIG is used as our standard since our standard transfer modulating valves are sized for 100% of the deaerator load with a 10 PSIG drop across valve.

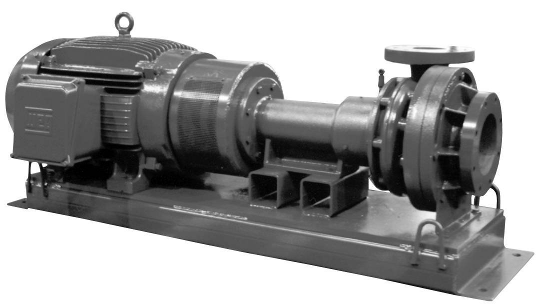
Determine Receiver Size

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.

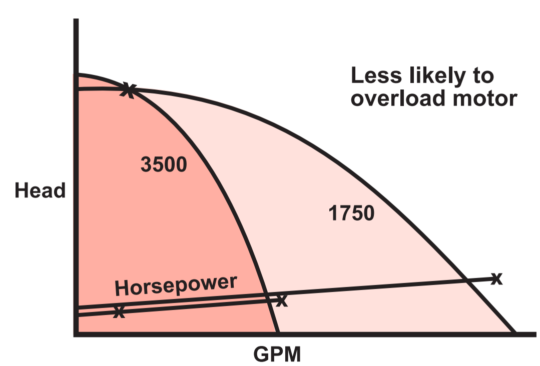
The pump design typically furnished on deaerators is a multi-stage, AWF style of pump. This pump is a centrifugal, bronze-fitted design. Pump is typically used for applications with flows up to 500 GPM and pressures up to 340 PSIG. Pump types (such as 221 AWF, 231 AWF, 616 AWF, etc.) selected depend 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 pump 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.

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