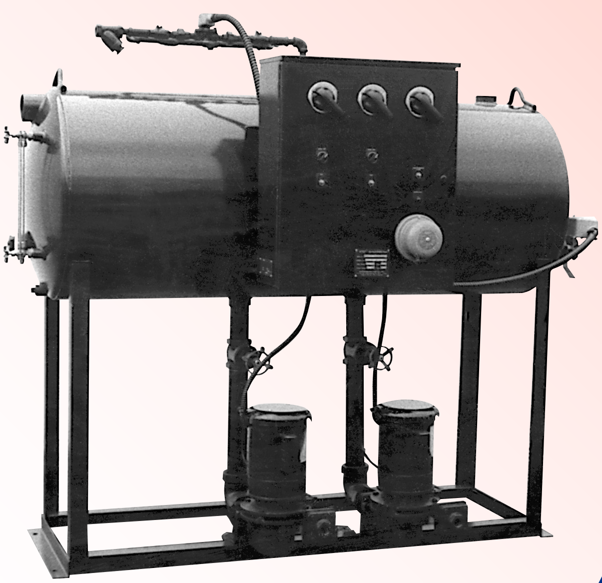
SHIPPENSBURG PUMP CO. INC.
P.O. BOX 279, SHIPPENSBURG, PA 17257
PH 717-532-7321 • FAX 717-532-7704
WWW.SHIPCOPUMPS.COM

Pride

Quality

Craftsmanship

BULLETIN 107
Revised 5/17



Custom Design
TYPE SHM
Steel Horizontal Make-up Boiler Feed Pumps
and
Custom Design
TYPE SHEM
Steel Horizontal Make-up Boiler Feed Pumps

NOTE: If unit used as a surge tank, pumps should run continuously.

SHIPCO® PUMPS Single Stage Units are equipped with Mechanical Seals rated up to a standard 250°F.

SHIPCO® PUMPS Multi-Stage Units are equipped with Mechanical Seals rated up to a standard 300°F.

Higher pump pressures and larger pump capacities are available.

When should a Boiler Feed Unit be used?

In general, a boiler feed unit should be used on all installations using today's high efficiency boilers.

1. High efficiency boilers have less water capacity than older, less efficient boilers. The excess system condensate must be collected and stored in the boiler feed unit instead of being returned to the boiler directly.
2. High efficiency boilers require the water level to be maintained in a smaller relative range. The boiler level controls operate the boiler feed pumps, keeping the water level in an efficient operating range.
3. Make-up water for the system can be added to the boiler feed receiver. The cold city water (usually at 50°F or less) is mixed with the return condensate to produce a blend temperature and reduce thermal shock to the boiler.
4. Properly sizing the boiler feed receiver for the system lag time and mixed high demand cycles in spring and fall allows adequate storage for high condensate. Reusing high quality condensate in lieu of raw make-up water reduces corrosion in the boiler and piping.

Corrosion from Oxygen Pitting is a Costly Problem!

Proper water treatment utilizing mechanical deaeration is inexpensive when compared to replacing equipment prematurely. Removal of oxygen and carbon dioxide can help stop destructive and costly corrosion in steam process and steam heating applications. Dissolved oxygen in feed-water is the main cause of corrosion in boilers. Dissolved carbon dioxide is not corrosive; however, the carbonic acid formed in condensate is very corrosive and attacks the equipment and piping (see Figure A). Oxygen and carbon dioxide are not very corrosive under atmospheric conditions, but as heat and pressure increase these gases rapidly become aggressive.

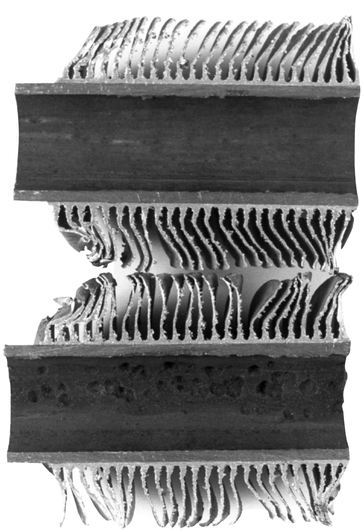


FIGURE A

Mechanical deaeration is the preferred method of removing these chemicals since you can treat the oxygen chemically, but the carbon dioxide, some carbonates and bicarbonates still remain. A boiler feed with preheat should be used when the blend temperature of condensate returns and make-up water is less than 200°F, and economic conditions do not permit use of a deaerator rated .03 or .005 cubic centimeter of oxygen per liter. (Refer to Deaerator Series Booklet for more information on SHIPCO® Deaerator models.)

Model SHM (Floor-mounted) or SHEM (Elevated) Boiler Feed Units:

SHM and SHEM boiler feed units are fitted with horizontal, black steel receiver as standard. The SHM model is floor mounted; the SHEM is elevated on a structural steel frame. The tanks are ASME code constructed heavy gauge black steel receivers for years of service. Numerous sizes of receivers are available to permit flexibility and economical selections. Pumps are bronze-fitted with industry standard motors. Various pump models are available. A brief summary of different pump models is provided below.

Units are typically furnished with a float actuated electric solenoid valve. Make-up water is added to the system at this point to blend the cold make-up water with the hotter return condensate which reduces the thermal shock to the boiler. The furnished valves are piston pilot operated with a cushioned closing feature and epoxy-resin molded waterproof coil. This type of valve has been very reliable, providing years of service.

The floor-mounted SHM model is designed for applications with low gravity returns. Another major advantage of a floor-mounted style is *avoiding expense of seismic bracing* by fitting the receiver with low NPSH pumps for high temperatures applications. There is a tendency for people to elevate all boiler feed units due to a lack of understanding of pump Net Positive Suction Head (NPSH). *However, boiler feed units are not required to be elevated—it depends on the job specific requirements.*

Various options and accessories are available including:

- Receivers can be 300 series stainless steel or lined to increase corrosion protection.
- Tank dimensions can be *custom designed* to fit special footprint requirements or fit through doorways and/or elevators.
- Tank thickness can be *custom designed* for non-standard requirements.

- On elevated models, stands can be structural steel or square tubing. Stands also can be made to be removable to help fit through entranceways.
- Motors can be either 1750 RPM or 3500 RPM and single-phase or three-phase. If needed, special duty motors such as washdown or explosion proof are available.
- Pumps can be sized for 50 Hz applications outside the U.S.
- Various styles of make-up valves.
- Manual three-valve bypass around solenoid make-up valves (see Figure B).
- Air gap assembly for make-up to meet state and/or local requirements.
- Inlet basket strainers to screen out debris in lieu of strainers when using non-turbine boiler feed pumps (see Article on Suction Strainers in Bulletin for more information).
- Water level gauge to monitor water level in tank.
- Various styles of thermometers including dial, angle, digital, stainless steel, explosion proof, etc.
- On floor-mounted unit, suction isolation valves (see Figure C) allow pump maintenance to be done without need to drain the receiver.
- Manways and/or handholes to access inside of tank.
- Alarm bell with silencing relay and dry contacts for connect to building alarm systems.
- Low water cutoff to turn off boiler feed pumps if water level in tank gets too low.
- Low water and high water alarm to alert plant operators.
- Vinyl or metal jacketed insulation.
- Control panels that meet various NEMA ratings such as NEMA 1, NEMA 2, NEMA 4, NEMA 7, NEMA 12, etc. Panels may include either combination integral starter/circuit breakers or NEMA-rated starters with fused-disconnect or circuit breakers.
- Single point connection for control panels.
- Control circuit disconnects.
- Magnesium anode.
- Inlet cascade baffle.
- Preheat. When injecting live steam into a receiver, external style float switch assemblies should be used because of the turbulence created that would cause a regular internal float switch assembly to bounce around. See Figure D.

Preheat Option

A boiler feed unit with a preheat option consists of a boiler feed receiver having an inlet for gravity and/or pumped returns. A stainless steel diffuser tube should be utilized for high-pressure returns and/or drips can be installed below the water line. A direct injection style heater assembly, sometimes called a preheat tube, made of slotted, stainless steel schedule 40 pipe is installed below the water to admit steam that is being regulated through a temperature regulator. Make-up water is admitted through a slow closing solenoid valve and external float switch assembly. An external float switch assembly should be used in lieu of an internal style for make-up, for cut-offs and alarms due to turbulence of the steam mixing with the water inside the vessel. Figure E shows a "typical" layout. Not all options are shown.

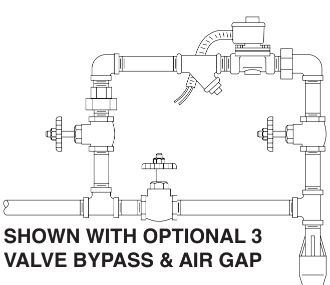


FIGURE B
Three-valve Make-up Bypass

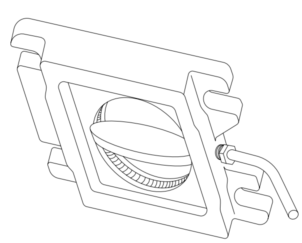


FIGURE C
Suction Isolation Valve (On Floor-mounted Units)

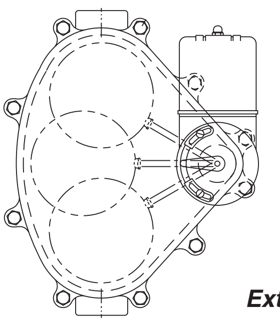


FIGURE D
External Float Switch Assembly

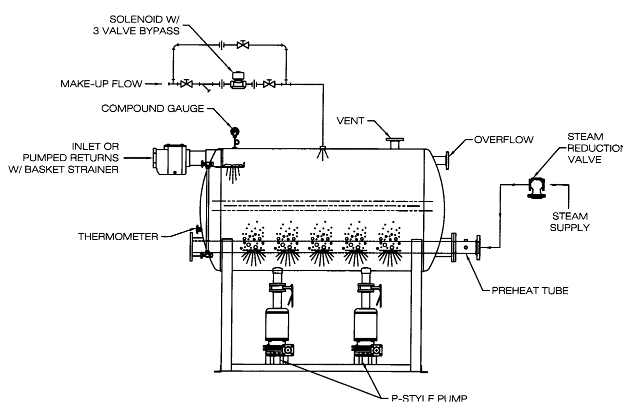


FIGURE E

Sizing Boiler Feed Units

A properly sized and correctly installed Boiler Feed Unit can help reduce your overall operating costs by:

- Maintaining the proper water level for the most efficient operation.
- Retaining the high quality condensate to be reused and blended with the required make-up, thus reducing thermal shock and corrosion.

Sizing Pump Flow Rate

Pump selection is based on flow rate (GPM) and pump discharge pressure (PSIG). Boilers are usually rated in boiler horsepower (BHP). The evaporation rate (also referred to as condensing rate) of one boiler horsepower (BHP) is .069 gallons per minute (GPM). Therefore, to calculate the evaporation rate, multiply the BHP by .069. For example, the evaporation for 200 BHP would be 13.9 GPM (200 x .069).

However, sometimes the load of boilers may be stated in other metrics such as Square Feet EDR or lbs/hr. The table below shows equivalences to convert to BHP. For example, to convert EDR to BHP, divide load by 139.4.

	Condensing Rate (GPM)	BTUs/Hr.	Lbs/Hour	Sq. Ft. EDR
1 Boiler HP (BHP)	.069	33,475	34.5	139.4
1,000 Sq. Ft. EDR	.50	240,000	247.3	1,000

FIGURE F

Boiler Feed Applications

Pump flow rates are sized differently depending on the application:

a. Pumps Run On/Off

b. Pumps Run Continuously

For *On/Off applications*, the boiler feed pumps are typically sized at 2.0 times the evaporation rate.

For *Continuous Run* applications, the boiler feed pumps are typically sized at 1.5 times the evaporation rate.

This method of sizing boiler feed pumps helps to balance the boiler conditions and reduce thermal shock to the boiler. Thermal shock can be caused if the feed pumps are oversized. Oversizing also tends to cause short cycling. (Note: Some boiler manufacturers have special requirements that differ from the above guidelines.)

Surge Tank Applications

Surge tank pumps must be continuous run and are sized at the evaporation rate or full load of system.

For both boiler feed and surge tank applications, SHIPCO® pumps are fitted with bleed lines that eliminate the need for bypass orifices in most applications since the bleed line provides sufficient flow to protect the mechanical seal if the pump should dead head.

Sizing Pump Discharge Pressure

The rules-of-thumb for sizing the pump discharge pressure depend of whether pumps are used on a boiler feed unit or a surge tank and the type of application as explained below.

Boiler Feed Applications

Discharge pressure should be equal to the maximum boiler operating pressure, plus the increase in elevation, plus the friction loss of pipe, fittings, and valves, plus a safety margin of typically 5 to 10 PSIG. Good engineering practices also call for a balancing valve to be installed in the discharge piping. Balancing the pump will limit the motor horsepower load and help prevent cavitation.

Boiler feed units are usually located near the boilers they feed. To be safe you should determine the amount of vertical rise + friction loss in pipe + valve loss + feed valve loss (if any) + back pressure in line (boiler operating pressure) + a safety margin of approximately 5 PSIG. The amount of these values, or these values added together, are normally expressed in feet of head. To convert between PSIG and feet of head use the following equation: **2.31 feet of head = 1 PSIG**.

The discharge pressure on boiler feed pumps is sized differently depending on the type of application:

a. Boiler Feed Pump Runs On/Off

b. Boiler Feed Pump Runs Continuously (without a Stack Economizer)

c. Boiler Feed Pump Runs Continuously (with a Stack Economizer)

Boiler Feed On/Off applications generally have low-pressure steam boilers running in the range of .5 to 15 PSIG with returns. Returns could be gravity and pumped. Therefore, a discharge pressure of 20 PSIG should be adequate.

Boiler Feed Continuous Run without Stack Economizer application, an additional 10 PSIG is required to overcome the pressure drop through the modulating feed valve on the boiler. However, the Cv rating of the valve should be verified to ensure 10 PSIG is sufficient. Generally these applications have a high-pressure steam boiler.

Boiler Feed Continuous Run with Stack Economizer application, an additional 30 PSIG is required to overcome the pressure drop through both the modulating feed valve and the stack economizer. However, the Cv rating of the modulating valve and the pressure drop through the stack economizer should be verified to ensure the 30 PSIG is sufficient. Generally these applications have a high-pressure steam boiler.

Notes:

1) The discharge pressure for a boiler feed pump vessel must be able to overcome the boiler safety relief valve setting plus three percent of valve setting and meet most state and local codes.
2) The pressure drops mentioned above are based on the valves used in typical SHIPCO® designs. The pressure drops may vary based on the modulating valve used.

Surge Tank Applications

Transfer pumps run continuously. The discharge pressure of the transfer pumps on a surge tank are sized differently depending on the type of application:

a. Feeding an atmospheric deaerator
b. Feeding a pressurized deaerator

For *Atmospheric Deaerator* applications, the discharge pressure is 25 PSIG assuming a pressure drop of 10 PSIG through the modulating transfer valve.

For *Pressurized Deaerator* applications, the discharge pressure is 35 PSIG assuming a pressure drop of 10 PSIG through the modulating transfer valve and the safety relief valve set at 15 PSIG on the deaerator.

Notes:

1) The pressure drops mentioned above are based on the valves used in typical SHIPCO® designs. The pressure drops may vary based on the modulating valve used.

For more information on surge tanks, see SHIPCO® Bulletin 166.

Sizing Receiver

The rules-of-thumb for sizing the receiver depend on the application as explained below.

Boiler Feed Application

System boiler horsepower is defined as the total possible load of all boilers being fed by the boiler feed unit. For example: A quantity of two 100 HP boilers would have a system load of 200 HP if both boilers ran at the same time for even only a few minutes. Therefore, the boiler feed receiver must be based on the worst case condition.

For low-pressure boiler applications with a large percent of system returns (typically of low-pressure steam system), the receiver is typically sized to provide storage capacity of 15-20 Gross Gallons (which equates to 10-15 minutes Net Gallons).

For high-pressure applications with a large percent of make-up (i.e., minimal or no returns), a smaller storage capacity can be chosen—typically 15 Gross Gallons (which equates to 10 minutes Net Gallons).

SHIPCO® expresses the capacity of its boiler feed tank in gross Gallons because that is standard terminology for industry literature. Our literature always mentions Gross Gallons.

Other characteristics of the steam system may also influence the receiver size:

- For example, if the piping system served by the boiler is in a heating system extending over a considerable area, the amount of time required for the condensate return will be slow. Under such conditions, it is advisable to select a receiver of larger capacity.
- If the piping is concentrated in a high office building on a small ground area, experience dictates that the condensate returns quickly, and a small receiver size may be chosen.

Surge Tank Application

On surge tank applications, the receiver is typically sized to provide 15 minutes Gross Gallons of storage, which equates to approximately 10 minutes of Net Gallons.

Sizing Steam Regulator for Preheat (if option included)

Shipco® preheat tubes are designed for a 5–7, PSIG of pressure (i.e., the steam pressure entering the preheat tube after the supply pressure is reduced).

To size a steam regulator requires information on the following variables:

- Condensing Rate or Equivalently System Load expressed in GPM
- Available pressure (PSIG) at the steam regulator
- Blend Temperature (°F)
- Target Temperature (°F)

The condensing rate can be calculated if the system load is expressed in other metrics by using the Power and Heat Equivalency Table (see Figure F).

The blend temperature of the returns plus make-up water is calculated as follows:

Percent of Make-up x Temperature (°F) of Make-up = **M**
Percent of Returns x Temperature (°F) of Returns = **R**

(M+R) = Blend Temperature

Example: For 30% make-up at 50°F and 70% returns at 150°F, blend temperature = 120°F.

(.30 x 50) + (.70 x 150) = 15 + 105 = 120

If the blend temperature is 120°F and the applications require the blend temperature to be heated up to 200°F, then the Target Temperature = 200 (°F).

The Temperature Rise is the difference between the Target Temperature and the Blend Temperature.

Target Temperature - Blend Temperature = Temperature Rise

The steam regulating valve controls the amount of steam required to maintain temperature at the target temperature. The size of the steam regulating valve is based on 1) lbs/hr of steam required to raise the blend temperature to the target temperature and 2) steam supply pressure (PSIG).

$$\frac{\text{Load (in gallons per minute) x Temperature rise}}{2} = \text{Steam required (lbs/hr)}$$

Example: Assume system load of 100 HP Boiler is operating at 100 PSIG; Blend temperature of 120°F; Heating feed water to 200°F; One boiler horsepower equals .069 gallons per minute; 100 BHP x .069 GPM = 6.9 load in gallons per minute

$$\frac{\text{6.9 GPM x (200-120)}}{2} = \text{276 lbs/hr of steam required}$$

Using the values for the amount of steam supplied (lbs/hr) and the steam supply pressure (PSIG), the size and type of regulator valve can be selected.

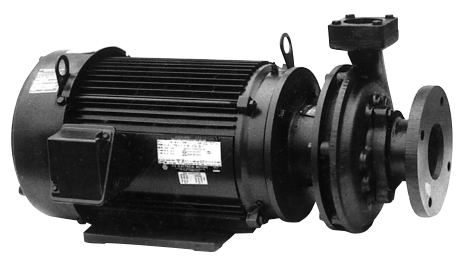
Another critical design factor for preheat to keep in mind is that the higher the supply pressure, the smaller the valve and therefore the lower the cost.

MODEL D

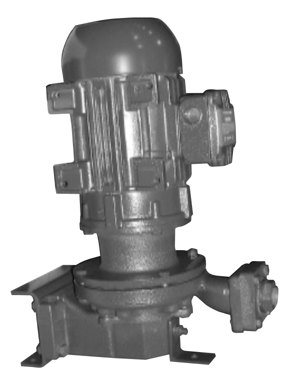
The Model D Pump is the center of all Shipco® Units. These pumps are bronze fitted and are designed with NPSH requirements in mind. Vertical mounting saves floor space and avoids dirt and water. Industry standard motors available in single or three phase, 1750 RPM or 3500 RPM. Vertical or horizontal flanged style available. All units are equipped with mechanical seals rated for 250°F as standard. (Higher temperature seals and special faces available upon request.)

MODEL P

The Model P Pump pumps high temperature condensate. This 2 ft. NPSH pump has mechanical seals rated for 250°F as standard. (Higher temperature seals and special faces available upon request.) Industry standard motors available in single or three phase, 3500 RPM. Vertical or horizontal styles available. This bronze fitted pump has an axial flow propeller to provide the necessary NPSH that high temperature water can not, thus assuring cavitation free operation. The P Pump also contains straightening vanes to ensure that the water enters the suction cavity as smooth and straight as possible.



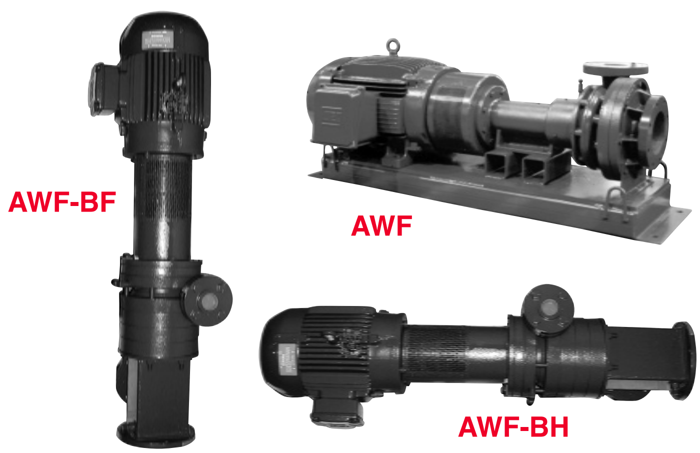
MODEL D & P — Horizontal



MODEL D & P — Vertical

MODEL AW/AWF/AWF-B MULTI-STAGE

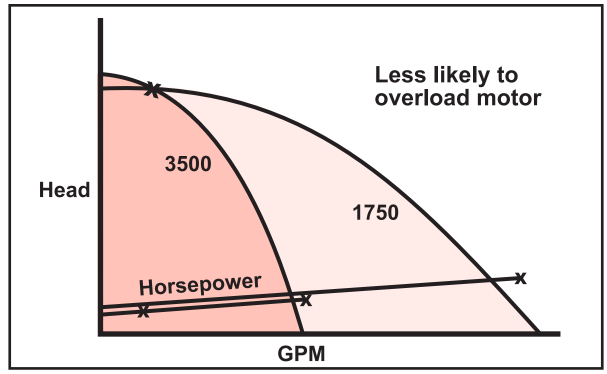
Flexible Coupled (AWF) Multistage Bronze Fitted Pumps. Pumps have ASA flanged suction and discharge openings. Pumps are low NPSH design, 3500 RPM with three phase motors. AWF pumps have coupling guards. Flows up to 500 GPM and pressures up to 340 PSIG. All pumps are equipped with Carbide/Viton mechanical seals rated up to 300°F as standard. All pumps come equipped with an automatic flow control valve for balancing or throttling pump to the designed condition point. The AWF-B version can be mounted in either horizontal or vertical positions to save floor space. Model AW is the close coupled version (picture not shown).



MODEL AW / AWF / AWF-B — Multi-Stage

Why Are 3500 RPM Centrifugal Pumps Recommended for Most Boiler Feed and Surge Tank 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 (see diagram below). 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 that 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 a "propeller" (also referred to as an "inducer") for higher capacities where the NPSH available is unusually low.

Why Are Suction Strainers Not Recommended on Non-Turbine 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 is limited.

As the engineering community begins to better understand the functions of centrifugal and turbine pumps, the engineers are starting to remove requirements for suction strainers from specifications.

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

Consequences of Injecting Chemicals into Steam System

Blow down separators are used to remove the residue left from chemicals added to the boiler. However, did you ever consider what the impact of chemicals is on the mechanical seal on a boiler feed pump? The chemicals will scratch and scar the seal facing of the mechanical seal and thus cause premature seal failure. Premature failure will in turn cause the motor bearings to go bad and destroy the pump if not replaced.

The manufacturers of boiler feed pumps state very clearly (check the installation instructions) that chemicals should not be injected directly into a boiler feed tank or deaerator. Chemicals are to be fed into the system after the boiler feed pumps discharged.

SHIPPENSBURG PUMP COMPANY, INC., P.O. BOX 279, SHIPPENSBURG, PA 17257 • PHONE 717-532-7321 • FAX 717-532-7704 • WWW.SHIPCOPUMPS.COM
PRINTED IN THE U.S.A. • BEIDEL PRINTING HOUSE, INC., 717-532-5063