Skidmore

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selection guide

boiler feed and condensate pump systems

A SELECTION GUIDE FOR BOILER FEED AND CONDENSATE PUMP SYSTEMS

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The Selection of
Boiler Feed & Condensate Pump Systems

The selection of the proper condensate and/or boiler feed systems is not difficult; however, all boiler, pump, and control manufacturers show their product applied, but not the other equipment that is to make up a complete workable system. Many times the user may be misled into using portions of each and most often he ends up with a system that will not work, or is more complex and expensive than the job requires.

We believe the simplest, least complex system, that will do the required job is the best. Please bear in mind that usually the person who will be operating the system does not have the experience, reference data and knowledge that you may have, so it is best to keep the system simple and workable.

In order to understand the basics of a boiler feed and/or condensate system, let's start off with a few definitions and the purpose of the more common components in a system.

A. Hartford Loop

1. The Hartford Loop is a connection into the equalizer between the steam supply header and the return connections, see figure No. 1.

2. Hartford Loop equalizes the pressures between the steam outlet and the return of the boiler. It originally was required on a gravity wet return system to insure equalization thus permitting condensate to return to the boiler by gravity.

3. It eliminates the need for a check valve and prevents syphoning of water from the boiler to an unsafe level. With the use of the modern condensate pump system this is not applicable.

4. The equalizer portion of the Hartford Loop provides a natural condensate drain for the main header and is particularly useful when there is a possibility of boiler water carry over, which can occur when a boiler is subjected to large sudden loads, higher than normal water line, improperly treated or dirty boiler water. If you wish to use the equalizer only see figure No. 3.

5. Use a Hartford Loop whenever a code or insurance company calls for one or its function is desirable. When the Hartford Loop was originated most boilers were coal fired and had no means of immediately cutting off the fire when a low water condition occured. With todays mechanical gas/oil burners and dual low water cutoff requirements, a Hartford Loop/equalizer is not nearly as important as it used to be and is used most often as a header drain only.

6. It is important that the Hartford Loop/pump discharge connection into the side of the equalizer be sized so that the water velocity does not exceed 4 ft./sec. See the following table:

PIPE SIZE	GPM
1″	10
1-1/4″	18
1-1/2″	25
2″	42
2-1/2″	60
3″	90
3-1/2″	120
4″	160

   If the connection into the equalizer has too much velocity and the equalizer is under sized the pumped condensate will back up into the equalizer above the boiler water line and will cause too high of a water line in the boiler and/or nuisance low water cutoffs. See figure No. 1.

7. Do not use a Hartford Loop:

   (a) On high pressure boilers. Boiler manufacturers provide a boiler feed connection on all high pressure boilers and recommend using it as most boiler feed connections are provided with baffles to eliminate expansion, contraction and shock. See figure No. 6.

   (b) On multiple boiler installations where water levels are not the same height.

   (c) On a multiple boiler installation where one boiler is used most of the time, we recommend the use of a boiler feed system, as the Hartford Loop and equalizer usually requires more expensive header piping and valving.

   (d) When a boiler requires a large amount of makeup water, as with some process loads. We recommend the use of a boiler feed system with a submerged steam sparging tube to preheat the blend of return and makeup water to at least 180°F. If large quantities of 160°F or lower temperature water is pumped into a boiler, thermal shock and/or flue gas condensation can and will occur.

B. Boiler Header

The boiler header is most often used on multiple boiler installations as shown in figure No. 12 and on single high pressure boilers as shown in figure No. 6.

We recommend that you always keep the vertical rise off the boiler and the header at least the same size as the boiler outlet nozzle. By using a full size outlet you help eliminate one of the causes of syphoning and carry over. Small outlet sizes will increase the steam velocity and tend to pull wetter steam and water off of the boiler.

The header will trap the excess water in the steam, therefore, provide a trap large enough to keep the header drained.

Little authentic information is available on the sizing of steam headers on multiple boiler installations. For sizing we recommend that you determine the maximum load that must be carried by any portion of the header under any conceivable method of operation and then refer to your standard steam sizing tables for horizontal pipes at ⅛ lb. per 100 ft. and select accordingly. We do not believe you can oversize a steam header as it will provide some additional steam storage space.

C. Condensate Pump

1. A condensate pump is used to collect and return condensate directly to a boiler or to a boiler feed unit. It is always controlled by the float switch within its receiver and is never controlled by the boiler mounted level control. It pumps only when its receiver is full and not on boiler water level demand.

2. A condensate pump never has any means of supplying boiler system makeup water.

3. A condensate pump should not be used for pumping water directly into a boiler operating over 15# s.w.p., refer to A (7) (a).

4. When using a condensate pump, boiler makeup water must be supplied to the boiler by some other means. The methods for supplying boiler water are as follows:

   (a) Boiler mounted float operated mechanical feeder which must be sized to replace the water being evaporated by the boiler at the lowest available city water pressure. See figure Nos. 2 & 4.

   (b) Boiler mounted combination mechanical float operated feeder and low water cutoff. See figure No. 2.

   (c) Boiler mounted combination liquid level control and low water cutoff with switching contacts to operate an electrical operated makeup valve. See figure No. 4.

   (d) Always supply a manual bypass or hand valves to supply city water direct into the boiler for use at time of startup or emergency conditions in compliance with local codes. See figure No. 2, 3 & 4.

D. Condensate Pump Selection

1. Most manufacturers rate their pumps in square feet of equivalent direct radiation (E.D.R.) (240 BTU/EDR).

   (a) The GPM pumping capacity of single units is usually 3 times the system condensing rate. The system condensing rate is 1/2 GPM per 1000 sq. ft. EDR. Example as follows:

$$\frac{\text{6000 sq. ft. EDR system}}{2 \times \text{1000 EDR}} = \text{3 GPM sys. cond. rate.}$$

   3 GPM system cond. rate × 3 = 9 GPM pump required.

   As you can see the pump will run 1/3 of 1 hour under full load conditions. See Skidmore catalogs for Type "VC", "VJ", "HP", Multiplex, & "STH" condensate pumps.

   (b) The pumping capacity of duplex units is usually figured the same way as the single unit with the thought that the 2nd pump is a standby. However, in reality you may figure lower GPM capacities per pump so that under full load conditions one (1) pump will run 1/2 the time and you will still have extra capacity if the system tends to return large slugs of condensate to the pump due to long steam and return mains, large fresh air coils, etc. Example:

$$\frac{\text{6000 sq. ft. EDR system}}{2 \times \text{1000 EDR}} = \text{3 GPM sys. cond. rate}$$

   3 GPM system condensing rate × 2 = 6 GPM per pump.

   The maximum total pumping rate of the duplex pump will be 12 GPM, which is more than adequate for a 6,000 sq. ft. EDR system with a condensing rate of 3 GPM. The receiver of a duplex pump operating as outlined above should be increased at least one standard size.

2. Pump discharge pressure should be not less than the steam working pressure of the boiler or the relief valve relieving pressure. Don't forget:

   (a) The hydrostatic head.

   (b) The pipe and fitting resistance.

   (c) Resistance or drop thru any automatic valves.

   (d) Size the duplex pump discharge line to handle the total GPM from both pumps. See figure No. 5.

3. We recommend the following trim for single unit condensate pumps:

   (a) Float switch (standard).

   (b) Inlet suction strainer.

   (c) Discharge pressure gauge.

   (d) Discharge check valve.

   (e) Magnetic starter, receiver mounted and wired, with 3 leg overload protection and test-off-automatic switch.

   (f) Thermometer.

   (g) Water gauge glass.

4. We recommend the following trim for duplex condensate pumps: (See figure No. 5)

   (a) Mechanical alternating float switch (standard).

   (b) Emergency safety float switch to energize the magnetic starters on the standby pump and/or both pumps under extreme load conditions or failure of the lead pump.

   (c) Inlet suction strainer.

   (d) Discharge pressure gauge.

   (e) Discharge check valves.

   (f) Magnetic starters, receiver mounted and wired, with 3 leg overload protection and test-off-automatic switch.

   (g) Thermometer.

   (h) Water gauge glass.

5. Pump construction for most condensate pump applications consists of:

   (a) Single stage bronze centrifugal impeller up to 75# discharge pressure. For pressures above 75# consider a multi-centrifugal or turbine pump.

   (b) Cast iron volute. We prefer that the volute be bolted directly to the receiver thus providing large free area to the eye of the impeller. (Skidmore type "VC", "VJ" and Multiplex.)

   (c) 212° mechanical shaft seal. We do not recommend the use of 250° shaft seals unless the system requires them as they are expensive and may delay delivery. Please consider that if you have an open vented receiver all condensate above boiling will flash to steam.

   (d) Open drip proof 1750 or 3500 RPM close coupled motor with stainless steel shaft or standard frame motor with flexible coupling and channel base. Please don't place too much importance on the motor RPM. Usually the 1750 RPM impeller will not handle as high discharge pressure as efficiently as will a 3500 RPM impeller. Most often the 3500 RPM motor is less costly and more readily available. With todays modern motors life expectancy, operating efficiency and noise levels of both motors are comparable.

6. When specifying condensate pumps with cylindrical receivers with the pumps on a base below the receiver consider:

   (a) Higher than normal return inlet heights.

   (b) Space limitations.

   (c) This type of pump does provide more available N.P.S.H. than a receiver mounted pump. Please refer to Skidmore Technical Bulletin 23T, Pages 2 and 3, and Skidmore Type "HP" and "STH" catalogs.

7. Receivers on most standard condensate pumps are made of 10 gauge steel and are usually adequate; however, if you desire something better for corrosion resistance consider:

   (a) Cast iron.

   (b) 3/8" thick steel in lieu of cast iron.

   (c) Cylindrical steel receivers with ground welds, sand blasted surfaces and lined with 5 coats of one mil thick phenolic resin baked on after each coat. Beware of cheap, improperly applied and inferior linings that can and will cause more problems than no lining at all. Note lined receivers must be large enough to accommodate a manhole for access.

8. Hot condensate over 200° should not be pumped by a standard condensate pump, if you anticipate quantities of hot condensate returning to the pump that will give you a total blend temperature above 200°, please consider the following:

   (a) Returning the hot condensate thru a domestic water convertor.

   (b) Use process water in a convertor to cool the condensate.

   (c) Use cooling tower water in a convertor to cool the condensate. Never cool the condensate by adding city water into the condensate.

   (d) Use a vented flash tank ahead of the pump.

   (e) Use a pressurized receiver unit as a trap and maintain the same pressure in it as in the piece of equipment being drained, such as an absorption unit. Provide a float switch to start and stop the pump when the water level rises. The receiver is vented to the atmosphere when there is no steam. The pressure in the receiver induces a false head on the pump, keeps the impeller flooded and permits the pump to handle condensate at temperatures above the atmospheric boiling point without cavitation in the impellers. (See Skidmore Technical Bulletin #23-T). Provide 250° seals or possibly water cooled seals for this type unit. Don't forget to consider that the condensate will not flash to steam as long as it is under high pressure but if pumped into a lower pressure or vented receiver it will flash to steam.

E. Boiler Feed Pumps

1. Please consider the following:

   (a) Boiler feed pumps are used to pump condensate and makeup water directly into the boiler or boilers.

   (b) Boiler feed pumps are always controlled by the boiler mounted pump control.

   (c) Boiler feed pumps are always equipped with an automatic makeup valve. All normal makeup is made thru this control. The only exception is the manual/emergency fill valve on the boiler (See figure No. 6).

2. We will describe specific boiler feed applications later, however, they are generally used as follows:

   (a) To feed a single low pressure boiler with a large makeup requirement. Caution, do not use a condensate pump for this application. (See figure No. 6.)

   (b) To feed 2 or more high or low pressure boilers. (See figure No. 12.)

   (c) To feed all high pressure boilers 20# steam and higher.

3. Two basic types of boiler feed pump systems are available. They are:

   (a) The rectangular receiver with the pumps mounted directly to the side of the receiver such as the Skidmore "VC", "VJ" or Multiplex unit. The "VC' and "VJ' series pumps can be supplied with single or duplex pumps and cast iron or steel receivers. The Multiplex unit can be supplied with single, duplex or triplex pumps on a steel receiver. (See figure No. 7.)

   (b) Cylindrical steel receiver mounted on a structural steel stand and base with 1 or 2 pumps mounted and piped. A 3rd and possibly a 4th pump may be installed on some of the larger units. You will note that in Figure 8 we have shown two types of pumps, however, others are available as follows:

      (1) Type "HCPS" or "J" close coupled centrifugal for discharge pressures up to 75#.

      (2) Type "HPC" flexible coupled centrifugal for discharge pressures up to 75#.

      (3) Type " STM" & "STP" flexible coupled turbine pumps for 20 to 200# discharge. We recommend that you consider the "HCPS", "J" and "HPC" pump for 20 to 60# in lieu of the turbine type.

      (4) We can provide pumps for 2' N.P.S.H. and 250°F water if required. For details please contact your Skidmore representive.

F. Boiler Feed Pump Selection

1. Before we proceed with our discussion and selection of a boiler feed system we should consider the following regarding condensing rates and terminology, as boiler feed systems are normally rated by boiler horsepower and/or pounds of steam per hour from and at 212°.

   (a) One boiler horsepower = 33,475 BTU. output.

   (b) One pound of steam from and at 212°F = 970.4 BTU.

   (c) One boiler horsepower = 139.479 sq. ft. E.D.R.

   (d) One boiler horsepower will condense .069 GPM.

   NOTE: .069 GPM of water leaves the boiler in the form of steam for every boiler horsepower produced.

   (EXAMPLE: 200 BHP × .069 = 13.8 GPM)

   (e) 1000 square feet E.D.R. will condense .496 GPM.

2. We are now ready to select a boiler feed system.

   The steps are as follows:

   (a) Determine the total boiler horsepower that will be supplied by each pump and then multiply by two so that the pump will run approximately 1/2 of the time under full load.

   (b) Sizing of the receiver is the next step in our selection. We have made a survey of the industry's practices and we find that many people base the receiver size on 8 to 12 min. of usable storage capacity, which is difficult to determine on either cylindrical or rectangular receivers. We therefore feel that by using a multipler for total tank capacitites we are able to provide adequate surge and usable storage capacities for most installations. Our recommendations are as follows: 1.4 gallon/boiler horsepower on systems totaling 20 to 75 BHP and 1.2 gallon/BHP on systems totaling 80 BHP and larger. An exception to the above would be a system that has several or one large condensate pumps or other devices that can send large quantities of water back in a short period of time.

   (c) The following are examples using the information as outlined in 5(a) and 5(b) above.

      (1) One 40 HP boiler operating at 15# and supplied by one pump — 40 BHP × .069 = 2.76 GPM cond. rate × 2 = 5.52 GPM pump required. Refer to Skidmore Bulletin No. 10D - "VC", "VJ" Condensate and

Boiler Feed Pumps, Page 3. Our selection would be No. VCS 42 with 6 GPM at 20#, 1/2 HP 1750 RPM motor or No. VJS-42 with a 3450 RPM motor. The next step is to select the receiver size — 40 BHP × 1.4 = 56 gallon receiver. Our VCS-42 pump has a standard 21 gallon receiver, so we must increase it to a 65 gallon standard receiver which is the closest to our requirement. A standby pump may be added without increasing the receiver capacity. See figure No. 7.

(2) Two 75 HP boilers operating at 40# and supplied by one pump — 2 × 75 BHP × .069 × 2 = 20.7 GPM. Refer to Multiplex Bulletin 11D Page 10 Our selection is No. VCS-154 with 22½ GPM at 50# discharge and 1½ HP 3450 RPM motor. The receiver will be figured as follows: 2 × 75 HP × 1.2 = 180 gallon. Select the standard 200 gal. Multiplex receiver.

(3) Two 75 HP boilers operating at 100# pressure and each supplied by its individual pump — one boiler × 75 HP × .069 × 2 = 10.35 GPM per pump. Refer to Bulletin No. 17A-1 "TM" Boiler Feed Systems selection table No. 812½ - with 12 GPM at 125# discharge pressure 3 HP 1750 RPM motor. The receiver will be 2 × 75 × 1.2 = 180 gallon. Select the standard 209 gallon receiver (see figure No. 8).

3. We previously stated that boiler feed pumps are always equipped with automatic valves to provide all the normal makeup water required by the boilers. We recommend that all makeup valves be sized so that when they are fully open they will pass the GPM required by the boiler condensing rate (BHP × .069) plus 20%. Example:

20 BHP × .069 × 1.2 = 1.44 GPM valve capacity.

Most systems have at least 45# city water pressure. We, therefore, have figured the valve types and sizes to be used as follows:

(a) Mechanical float operated Figure No. 9.

3/8″ 0 to 10 GPM
1/2″ up to 18 GPM
3/4″ up to 34 GPM
1″ up to 49 GPM

(b) Electric makeup feeders Figure No. 10.

1/2″ 0 to 25 GPM
3/4″ up to 35 GPM
1″ up to 55 GPM
1-1/4″ up to 100 GPM

We recommend on systems over 300 HP and requiring more than 50% continual makeup that you consider the use of a modulating pneumatic makeup feeder, consult your Skidmore representative for details.

4. Preheating of the makeup and condensate is required if the blend temperature is below 160°F.. Continual feeding of a boiler at low temperature water will cause serious boiler damage such as thermal shock, and flue gas condensation. Normally a building heating system will return condensate from 160°F to 190°F. If, however, there is a process load which wastes live steam and requires makeup water in large enough quantity to bring the blend temperature below 160°F we should calculate the blend temperature and provide a submerged heater (See figure No. 11).

EXAMPLE: 35% of 40°F makeup and 65% of returned condensate at 170°F —

35% × 40° = 14.0°
65% × 170° = 110.5°

Average feed water temperature - 124.5°F

124°F definitely requires feed water preheating. Therefore, if we have a 400 HP boiler and it condenses (400 × .069) 27.6 GPM we need to heat 27.6 GPM from 124.5°F to the recommended feed water temperature of at least 180°F in order to properly size our preheater assembly.

FORMULA: GPM × 60 × 8.33 × temperature rise = BTUH.

EXAMPLE: 27.6 GPM × 60 × 8.33 × [180° - 124.5°] = 765,590 BTUH.

$$\frac{765{,}590 \text{ BTUH}}{33{,}475 \text{ BTU/BHP}} = 22.9 \text{ BHP or}$$

$$\frac{765{,}590 \text{ BTU}}{970.4 \text{ BTU/lb. of steam}} = 788.9 \text{ lbs./hr.}$$

To heat our makeup, and please note that our 400 BHP boiler is now producing for the heating load 400 BHP less 22.9 BHP which equals 377.1 BHP; from this you can see that if we have over 50% makeup our actual usable boiler horsepower is reduced considerably.

When the fresh makeup water is preheated you not only eliminate the possibility of boiler thermal shock and flue gas condensation but you will also provide some rough deaerating or elimination of oxygen that is present in the fresh water.

See figure No. 11 for details of the typical preheat system which can be installed on all boiler feed units described.

G. Boiler Feed Valves

Boiler feed valve selection is most important to the total boiler/boiler feed system, since if an improper or inadequate valve is used the system will not work satisfactorily. The following is our suggestion on the selection of boiler feed valves.

1. **Solenoid Valve:** To be used on small low pressure systems with little makeup, with the valve to

open at the same time the pump starts. An electric on/off boiler pump control is required.

2. **Diaphragm Pilot Solenoid Operated:** To be used on medium sized high and low pressure systems 10 BHP to 250 HP. The valve opens at the same time the pump starts. An electric on/off boiler pump control is required.

3. **Motorized on/off Valve:** This valve should be used on high or low pressure boilers 250 BHP to 500 HP with heavy heating demand or process loads. This valve must have 15 sec. or less opening time and if 15 sec. timing is not available add an end switch that can make contact when the valve is ¼ open. The end switch will start the pump at ¼ open thus protecting the pump from dead head conditions. An electric on/off boiler pump control is required.

4. **Modulating Electric Valve:** Should be used on high or low pressure boilers under heavy continuous loads at 500 HP and larger. This valve requires the use of a boiler water level control equipped with a 35 OHM modulating potentiometer to match the potentiometer in the boiler feed valve. The valve also has an end switch that will start the pump in the ¼ open position.

5. **Modulating Pneumatic Valves** may be considered if you have 500 BHP or more under heavy and continuous loads and the boiler feed pumps are 10 HP or more and run continuous. This system requires the use of a special modulating pneumatic boiler level control and a separate electric low water cutoff. The pumps must be protected by an adjustable differential bypass or bypassing orifice to return some water to the boiler feed system receiver so that full dead head conditions cannot damage the pump.

When selecting any of the above boiler feed valves check the "CV" factor for pressure drop and above all specify the type of valve and compatible boiler control that is required.

figure 1 - hartford loop connection

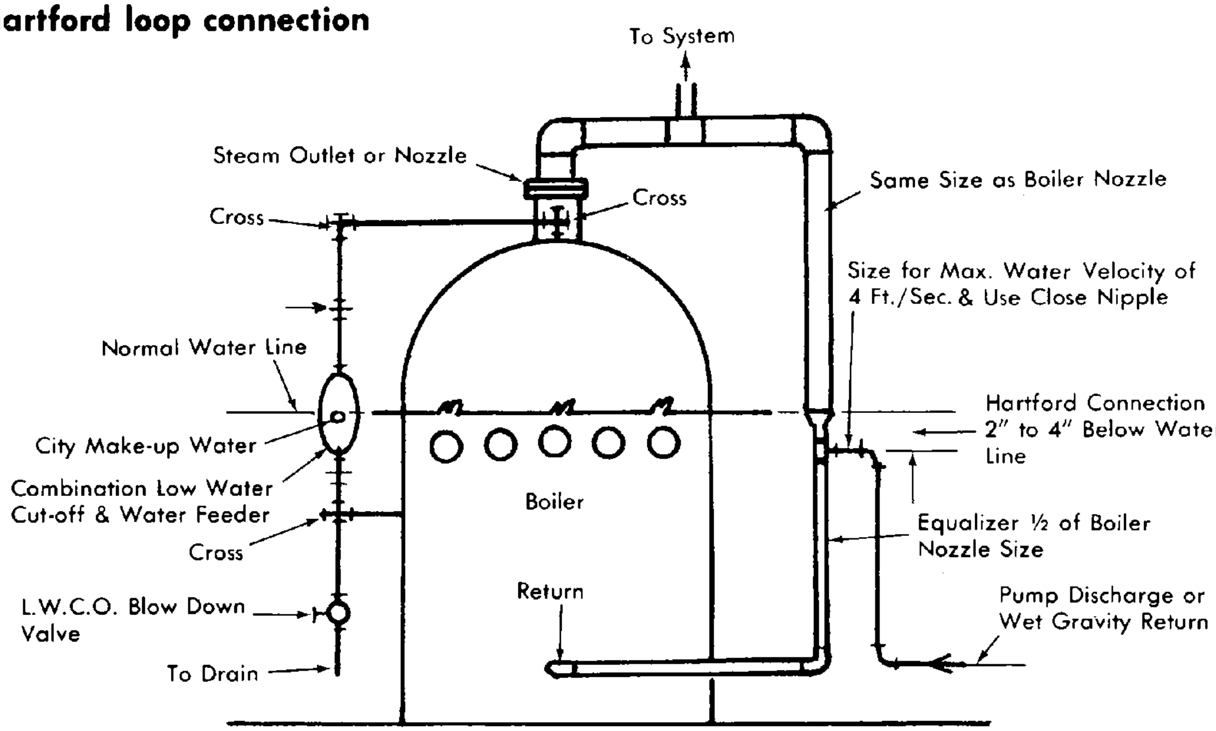

figure 2 - pump connection with hartford loop

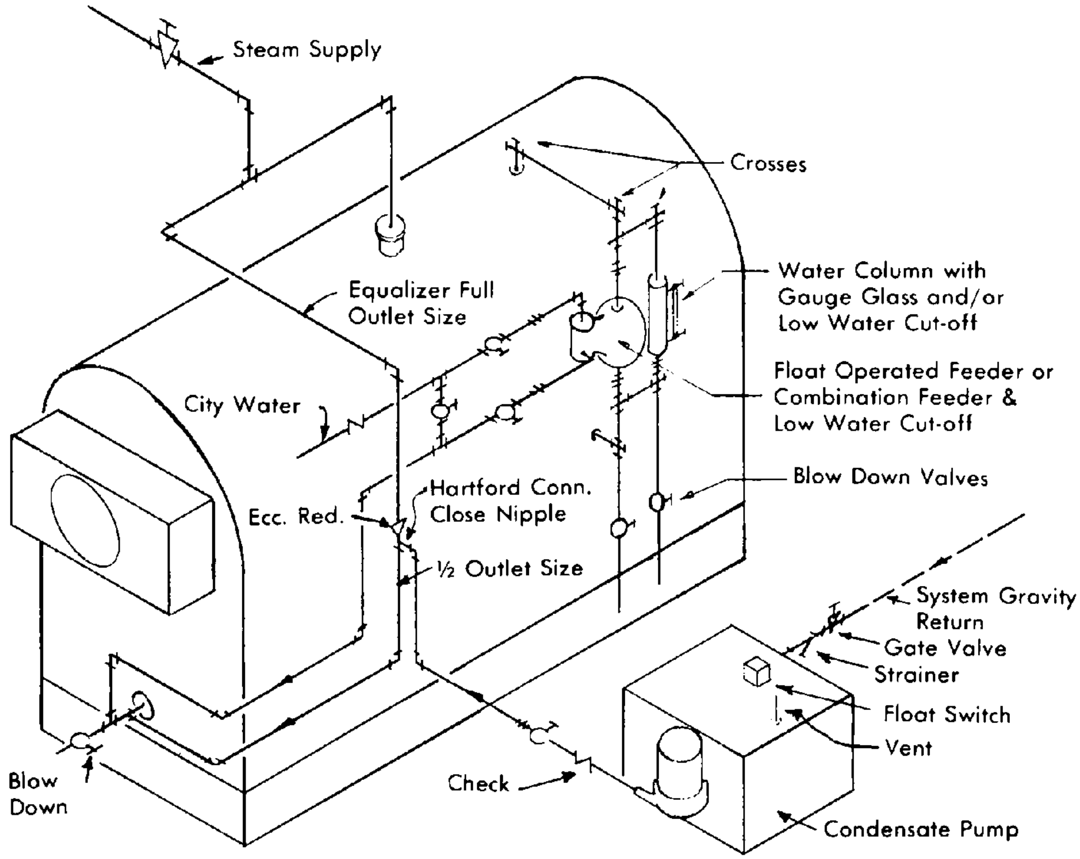

figure 3 - pump connection with equalizer

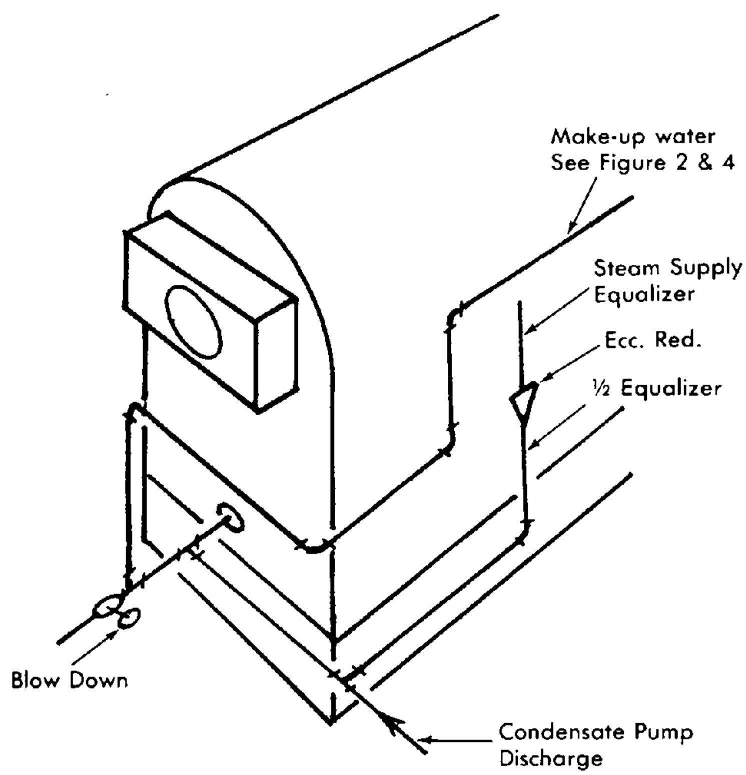

figure 4 - liquid level control with low water cutoff

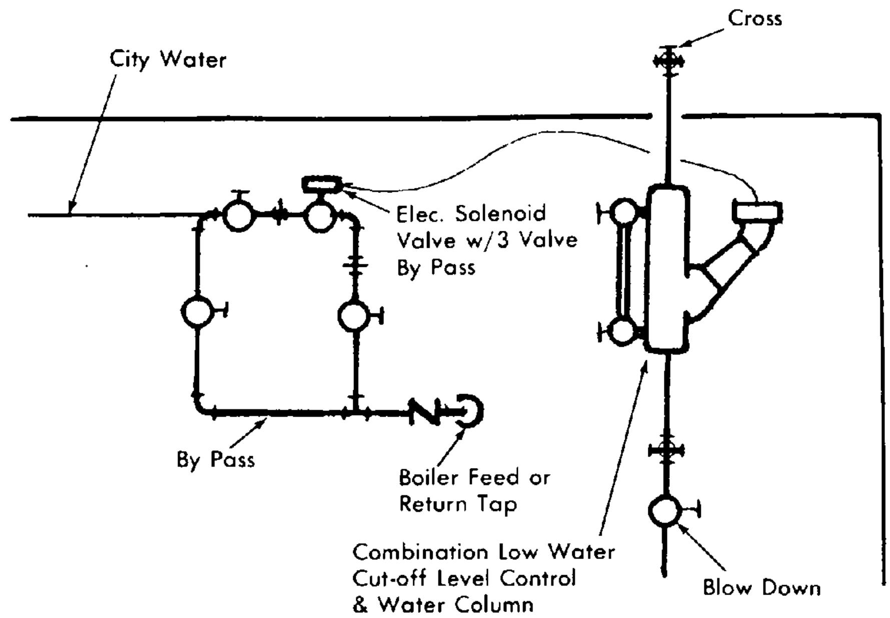

figure 5 - duplex condensate pump

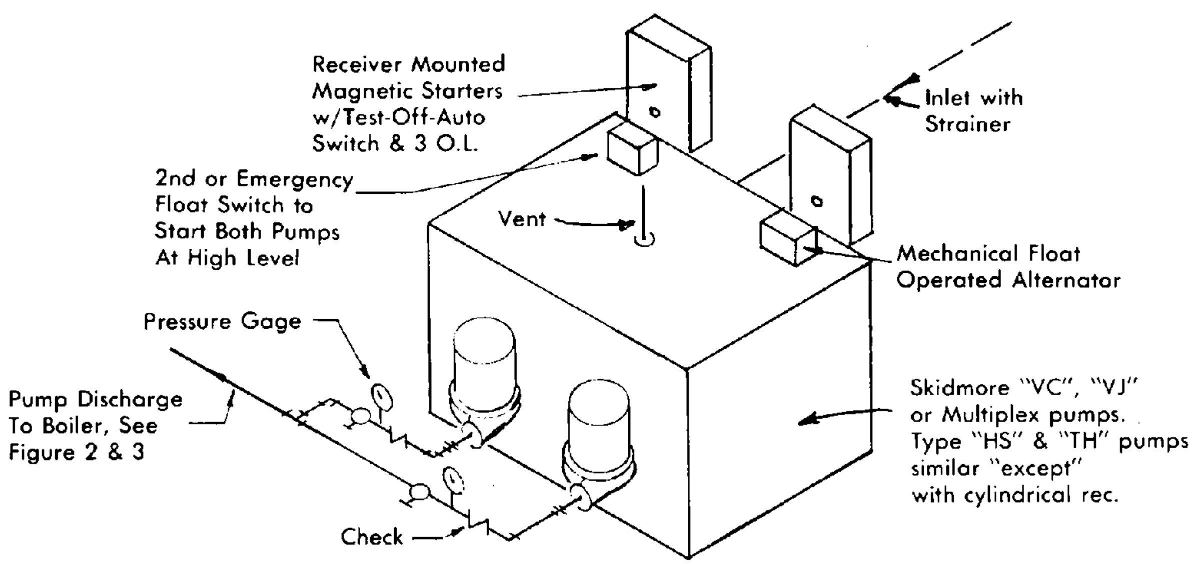

figure 6 - boiler feed connections - single boiler

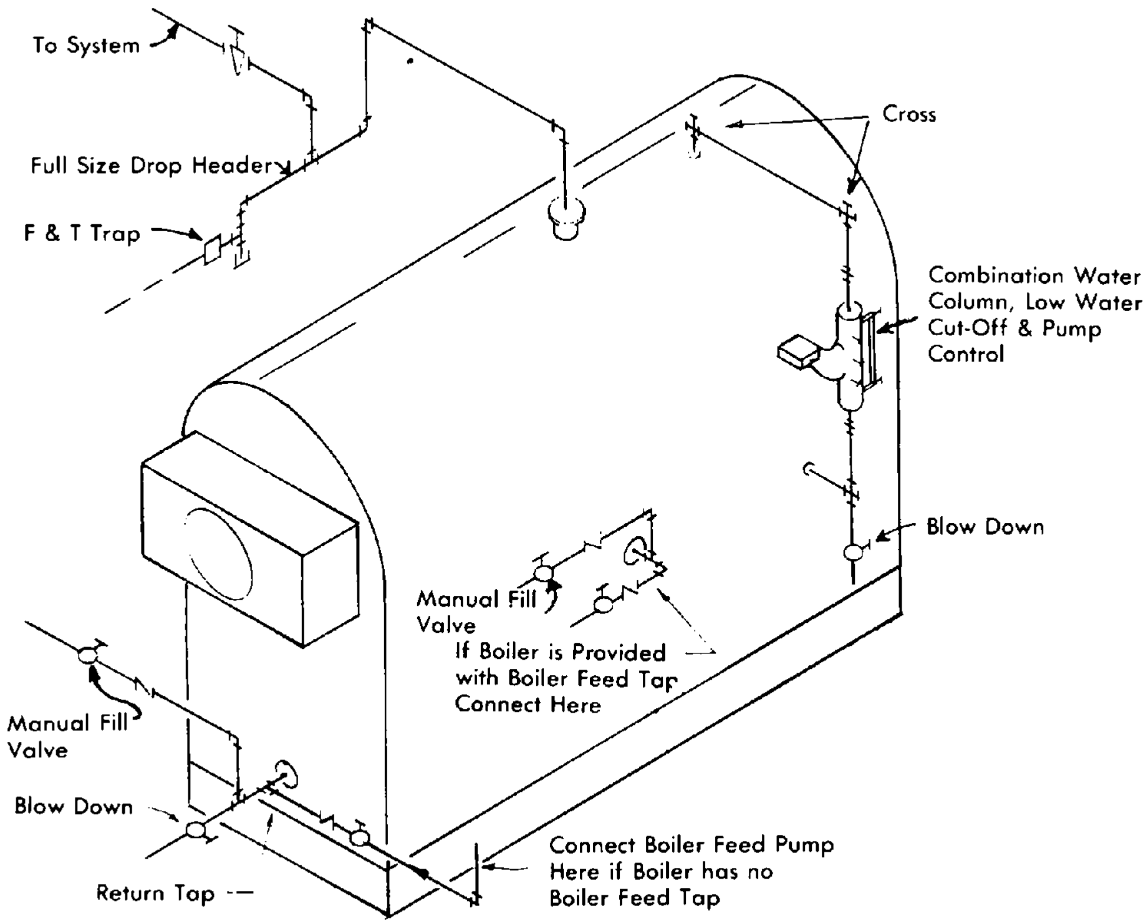

figure 7 - boiler feed connections with rectangular receiver

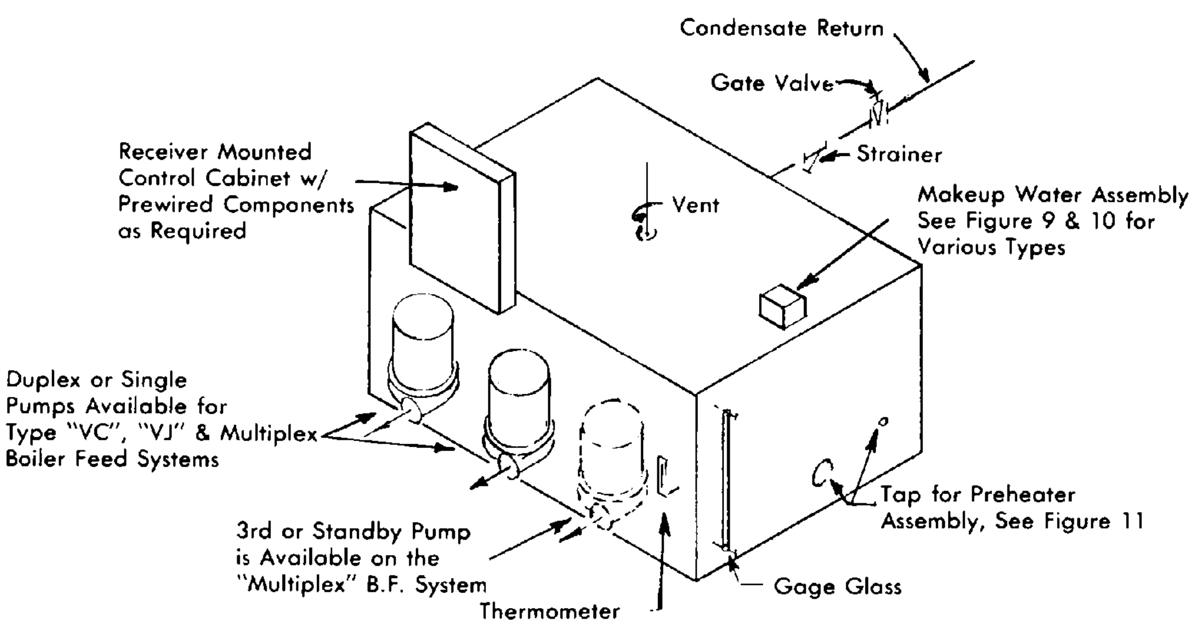

figure 8 - boiler feed system with cylindrical receiver

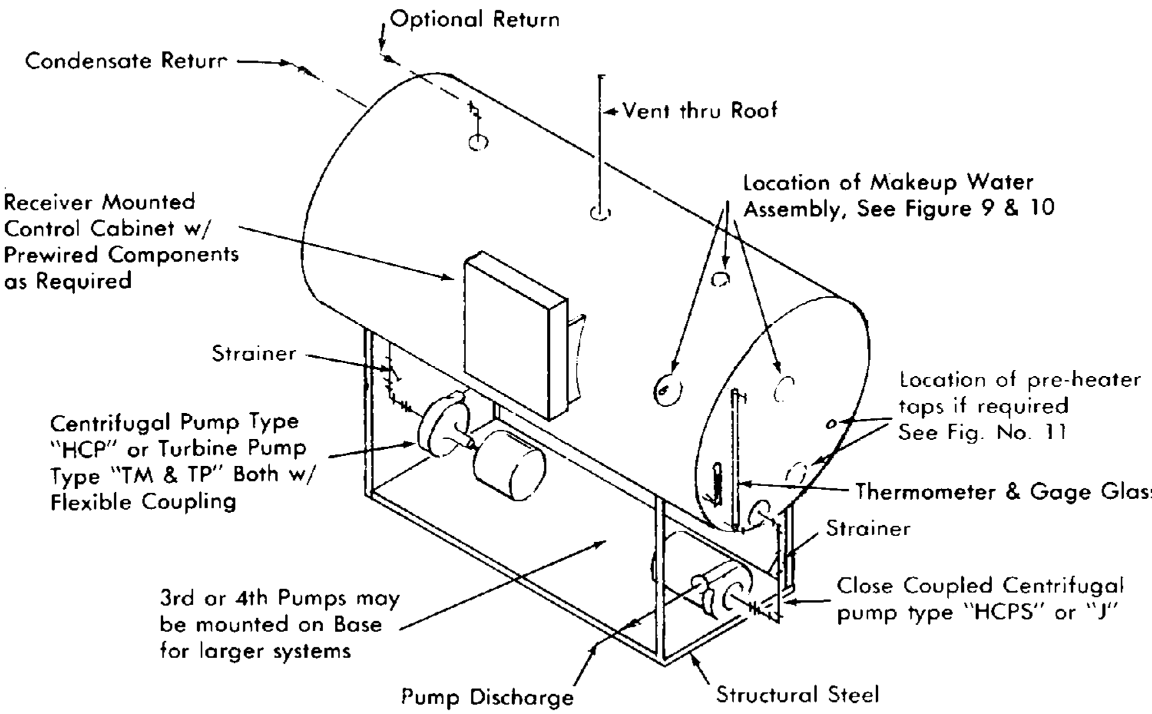

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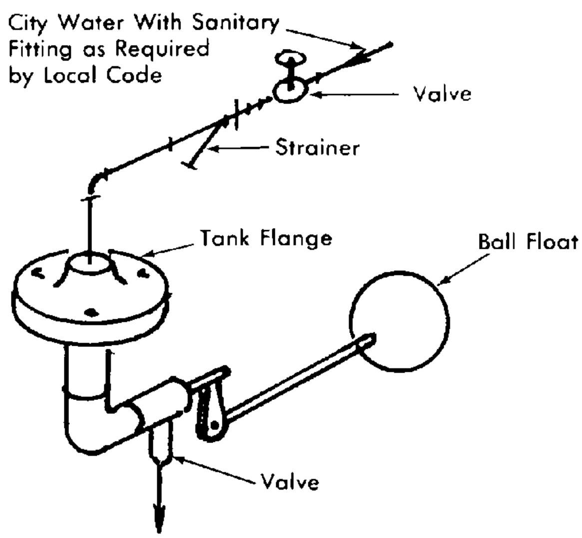
figure 9 - mechanical make-up feeder



NOTE: Top Mount Shown, Side Mount is Similar

figure 10 - electrical make-up feeder

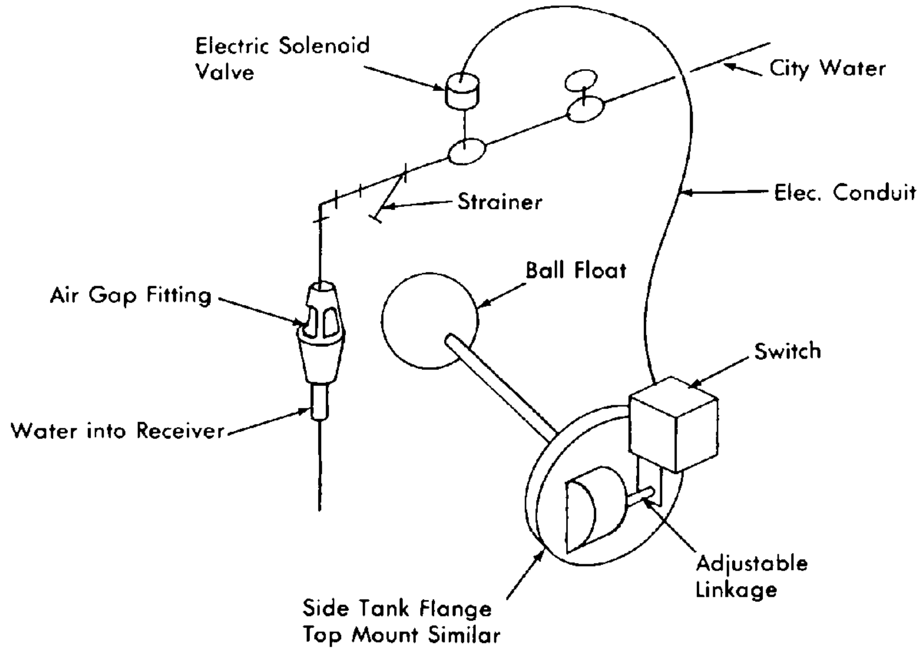


figure 11 - pre-heater assembly

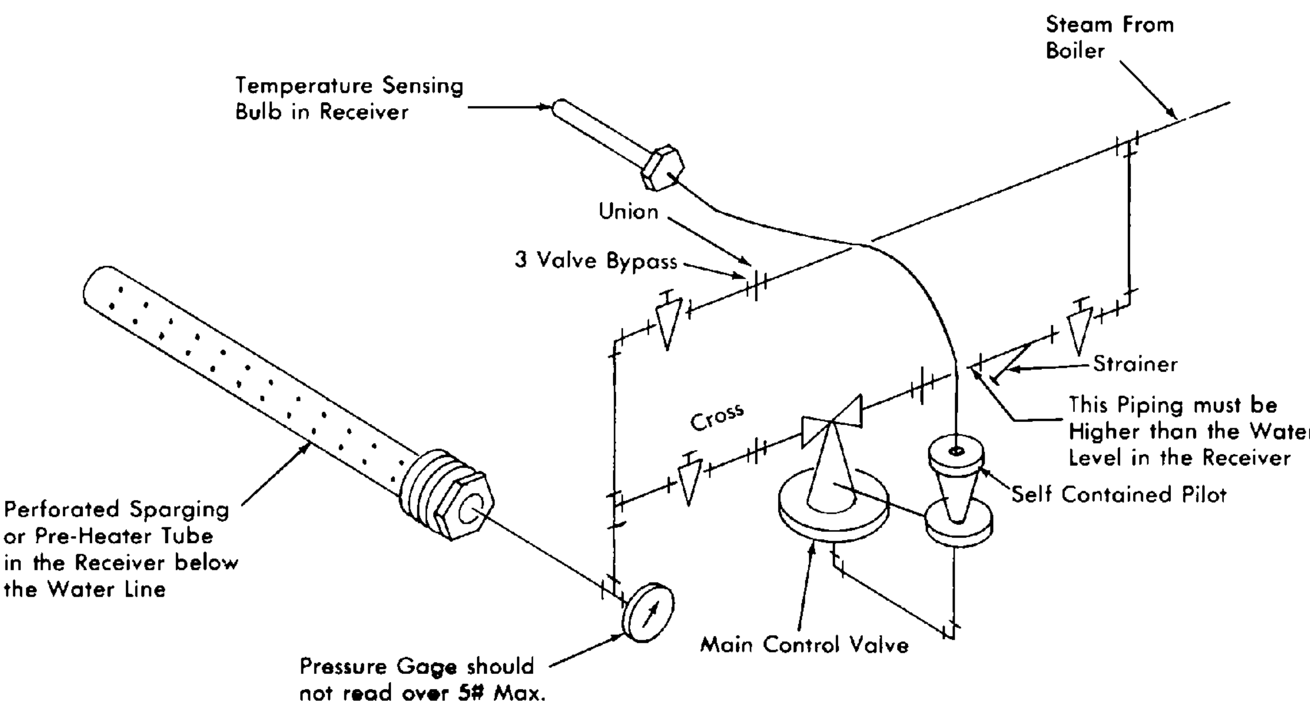


figure 12 - boiler feed connections multiple boilers