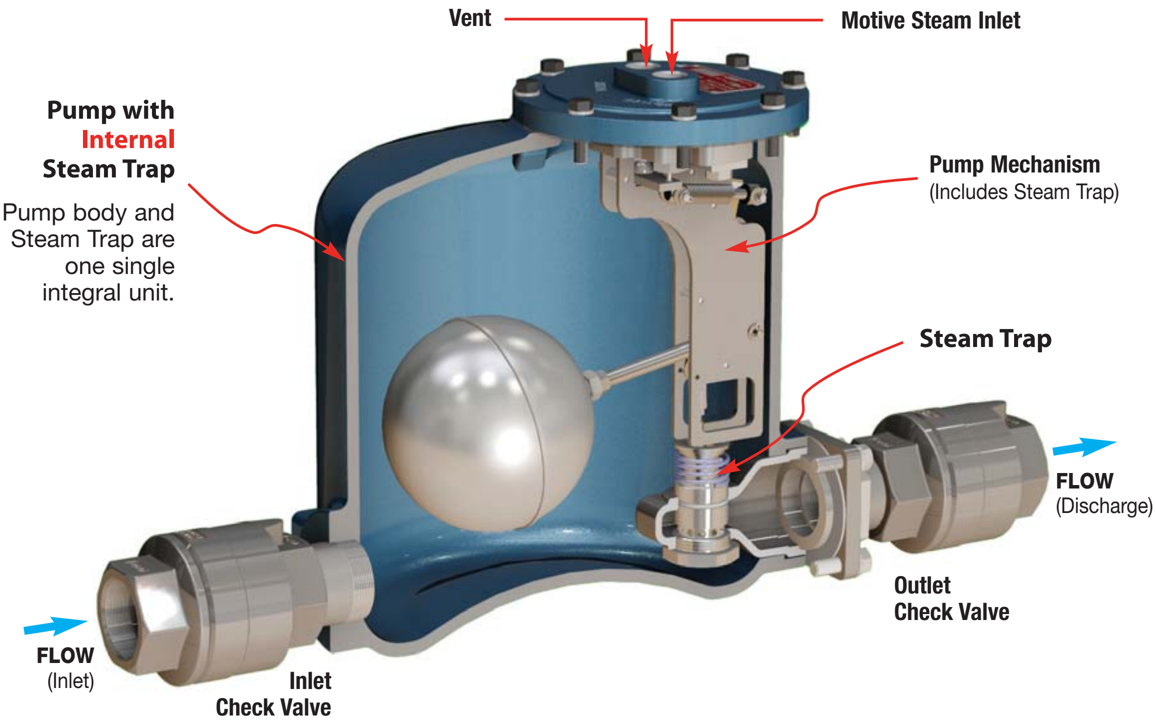
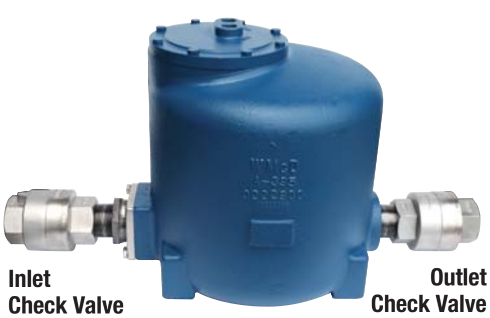
What is a Pump-Trap used for?

A **Pump-Trap** is used in place of a Steam Trap to drain condensate from a process application when the steam pressure in the process is not sufficient to push the condensate thru the steam trap and into the condensate return line. When steam pressure in a Heat Exchanger is less than the back pressure on the discharge side of the steam trap, the condensate backs up, causing inconsistent heat transfer and potential waterhammer. This frequently occurs on applications where a temperature control valve is used to supply steam to a Heat Exchanger based on product temperature and flow rate. The temperature control valve increases and decreases steam flow to the Heat Exchanger to satisfy the temperature set point. When system demand is high, the steam pressure in the Heat exchanger is most likely adequate to overcome system back pressure; however, when system demand decreases, steam pressure to the Heat Exchanger must also decrease and can fall below the back pressure. This condition is referred to as Stall, since it causes condensate to back up into the Heat Exchanger. To prevent condensate backup under stall conditions, a pump-trap must be used in place of a steam trap.



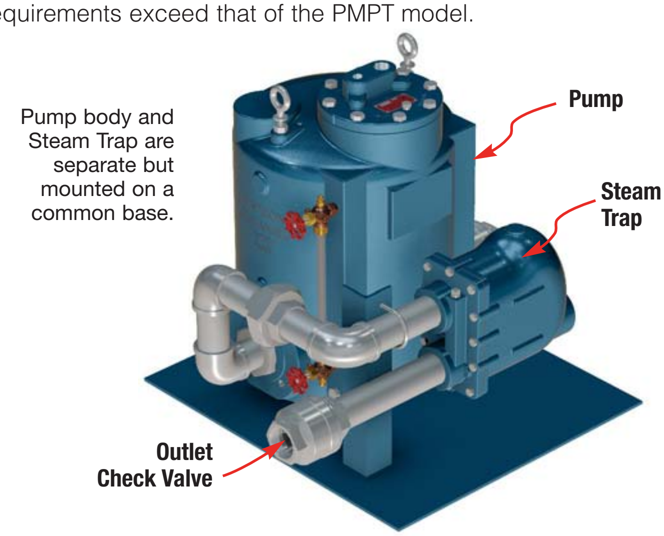
Pump with Internal Steam Trap (PMPT)

The **PMPT** pressure motive pump has an internal steam trap. The compact design makes it a suitable choice for most applications.



Pump with External Steam Trap (WPT)

The **WPT** is a stand-alone pump unit with a separate steam trap mounted on a common base. It is used when capacity requirements exceed that of the PMPT model.



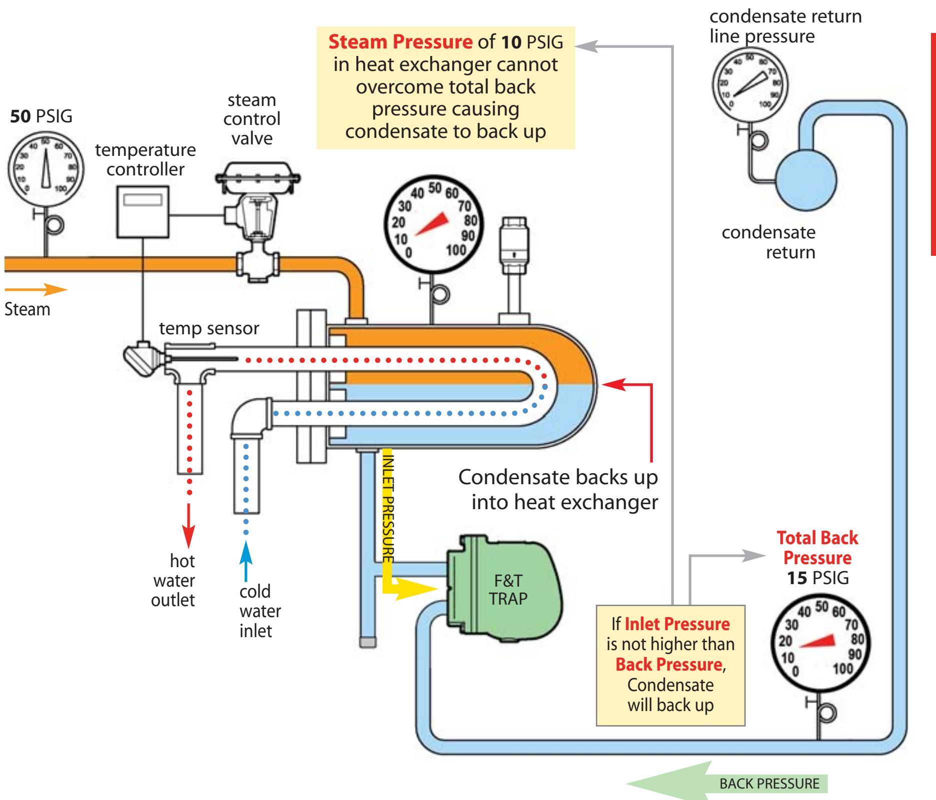
Why use a Pump-Trap?

Problem:

Condensate Backs Up Into Heat Exchanger

The diagram shows a temperature control valve delivering steam to a Heat Exchanger that is using steam to heat water. Condensate formed in the heat exchanger is being discharged through the steam trap into the condensate return line. This particular application demonstrates what happens when the return line is elevated and/or pressurized. The plant steam pressure on the inlet side of the control valve would be adequate to purge (push) the condensate through the trap and into the return line. However, the steam pressure in the heat exchanger is controlled by the valve and is dependent on the demand of the system. When the demand for HOT water is low, the steam pressure in the Heat Exchanger falls below the back pressure and the system backs up with condensate, creating unstable temperature control and waterhammer. This undesirable condition, referred to as Stall, occurs when the steam pressure in the heat exchanger falls to or below the system back pressure due to a decrease in the demand (flow rate) of hot water.

Heat Exchanger System with Steam Trap

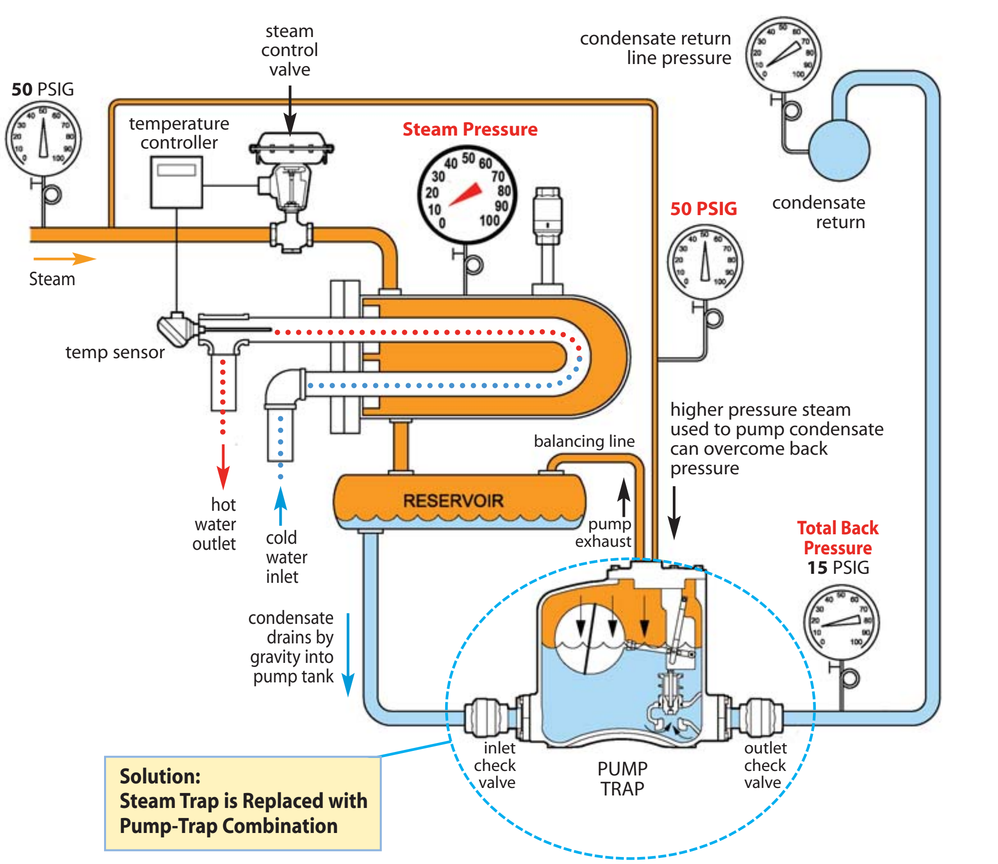


Solution:

Use a Pump-Trap to Avoid Condensate Back-up & Improve Temperature Control

To eliminate condensate backing up (STALL), the standard float trap is replaced with a PUMP-TRAP. When steam pressure in the Heat Exchanger is greater than the back pressure, the steam pressure will push the condensate through the Pump-Trap and it functions like a standard float-operated trap. When the steam pressure to the Heat Exchanger drops below the back pressure, the condensate backs up inside the PUMP-TRAP, raising the float. When the trip point of the mechanism is reached, the high-pressure steam valve will open to drive the condensate out.

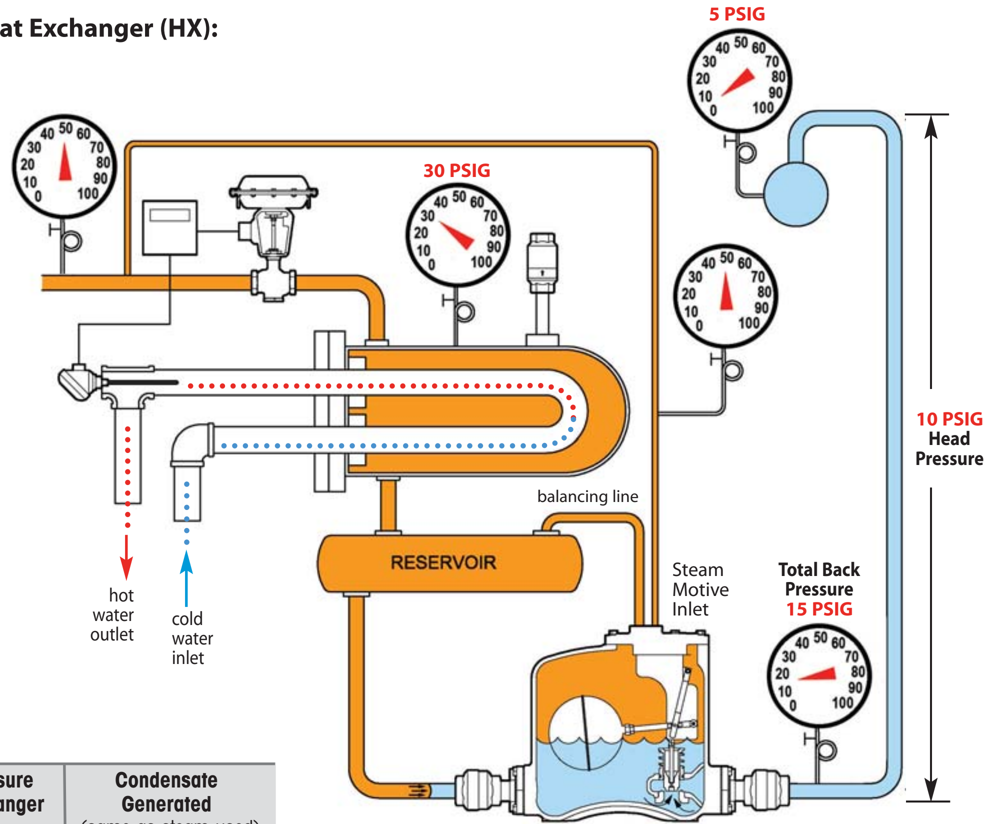
Heat Exchanger System with Pumping Trap



How a Pump-Trap Works

Operation of a PUMP-TRAP with a Heat Exchanger (HX):

The steam pressure to the HX will vary depending on the flow rate of hot water required by the system. Let's assume the HX was sized for a maximum flow rate of 40 GPM of HOT water at 140˚F using 30 PSIG steam. When maximum flow rate of water is required, the 30 PSIG steam pressure is more than adequate to push the condensate generated thru the steam trap against the 15 PSIG back pressure. Now, if the hot water requirement reduces from 40 to 20 GPM, the steam flow (lbs/hr) to the Heat Exchanger must drop by about half. Since it is the same size HX, the steam temperature (steam pressure) must also reduce (see table below).

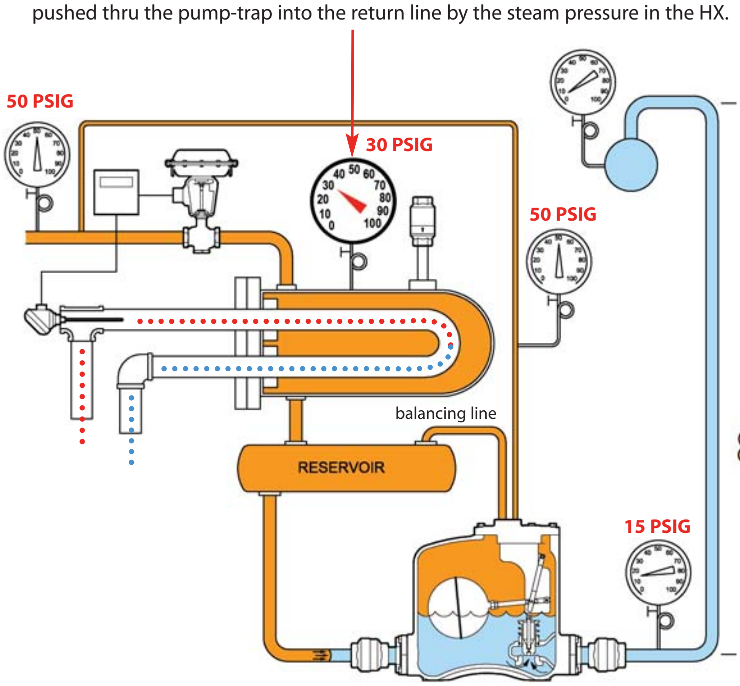


Steam Pressure vs. Hot Water Required

Flow Rate Water (gallons per minute)	Steam Usage (lbs/hr)	Steam Pressure in Heat Exchanger (PSIG)	Condensate Generated (same as steam used)	
40	1,900	30	1,900	**Trap Mode**
35	1,650	15	1,650	*Stall Point*
32	1,530	10	1,530	**Pump Mode**
20	950	-6.6 (Vacuum)	950	

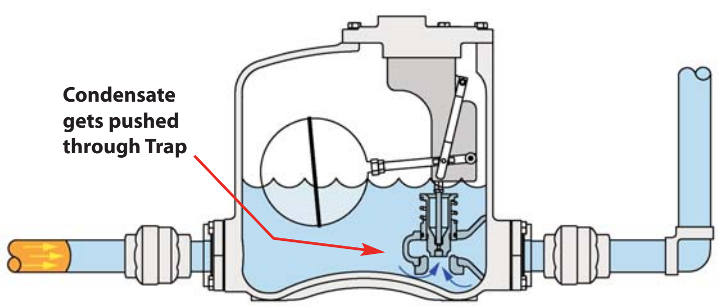
TRAP Mode

The system is operating with **30 PSIG** inlet pressure to the heat exchanger. The Pump-Trap unit functions like a standard float-operated trap. Condensate is pushed thru the pump-trap into the return line by the steam pressure in the HX.



Vent Outlet: Open position, allowing pressure in the pump tank to equal pressure in the heat exchanger, allowing condensate to freely enter Pump-Trap by gravity, even under vacuum.

Motive Inlet: Closed position

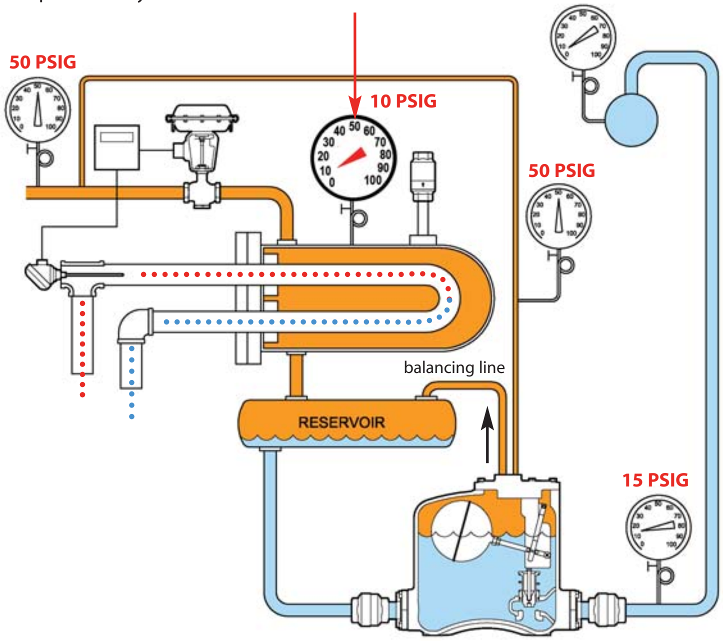


1 TRAPPING Mode: Inlet steam pressure is higher than back pressure. Steam pushes condensate through Pump-Trap.

How a Pump-Trap Works

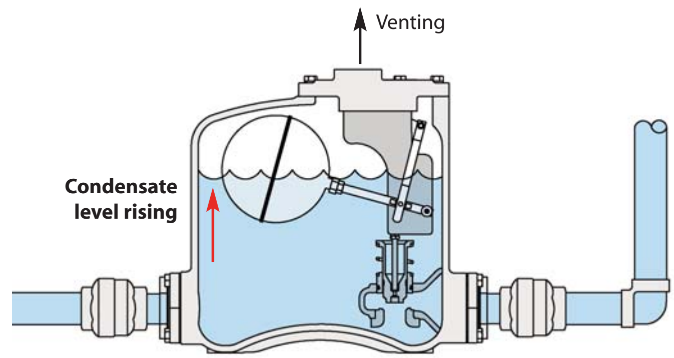
PUMP Mode

The pressure in the HX has now dropped to **10 PSIG**. This was in response to a fall off in demand of hot water. Based on this particular size HX, 10 PSIG steam will heat 32 GPM of water. Since back pressure is 15 PSIG, the system is stalled and condensate is beginning to back up into the system and the float continues to rise.



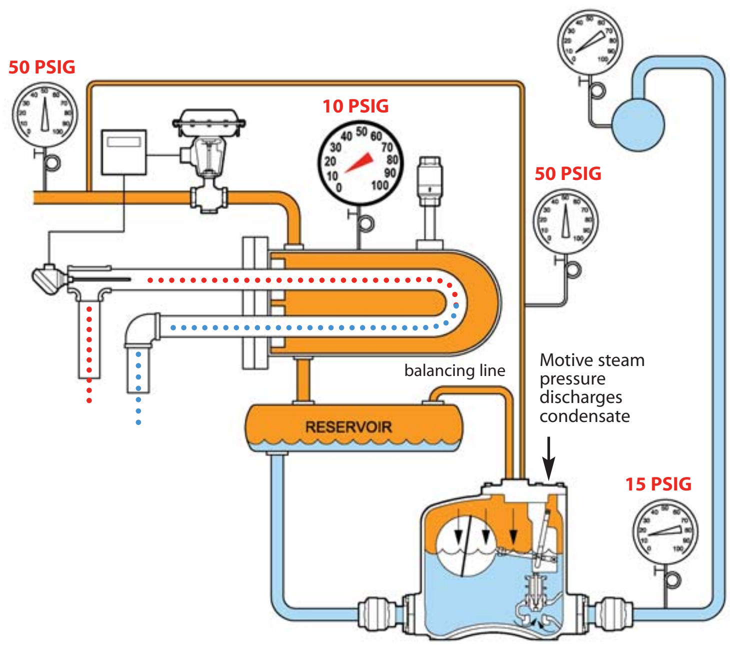
Vent Outlet: Open position, allowing pressure in the pump tank to equal pressure in the heat exchanger, allowing condensate to freely enter Pump-Trap by gravity.

Motive Inlet: Closed position



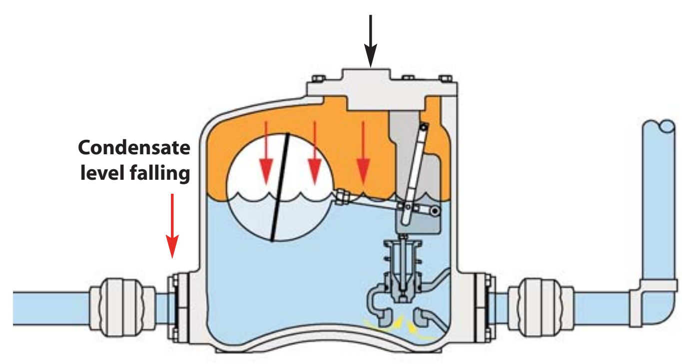
2 PUMP TANK FILLS: Inlet steam pressure falls below back pressure. Steam can no longer push the condensate through the Steam Trap.

Condensate rises to a level that the float triggers the inlet steam valve and closes the vent valve. Full line pressure steam (50 PSIG) enters thru the inlet valve on top of the pump body to discharge the condensate. Because of check valves, condensate will not flow back to HX and is discharged to the condensate return line. Unit will continue to operate and cycle in pump mode as long as pressure in the HX is below back pressure. Pump-Trap will also operate in vacuum conditions.

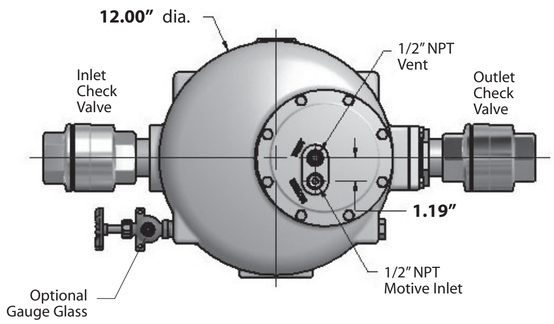


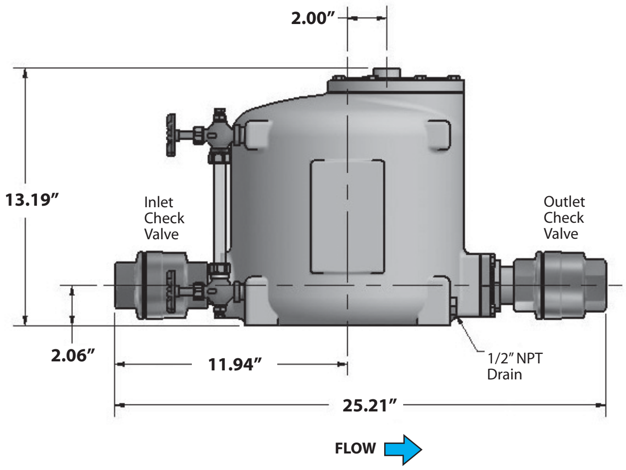
Vent Outlet: Closed

Motive Inlet: Open; steam pressure (50 PSI) enters tank and discharges condensate.



3 PUMP Mode: Pump is activated. When the pump tank has filled to the trip point, the mechanism triggers, opening the motive gas inlet valve and simultaneously closing the vent valve. This allows motive pressure to enter the pump body, which drives the condensate thru the outlet check valve and into the condensate return line. During the discharge cycle, the liquid level and the float inside the pump tank drop. When the lower trip point is reached, the mechanism closes the motive inlet valve and opens the vent valve so the pump-trap can fill on the next cycle.



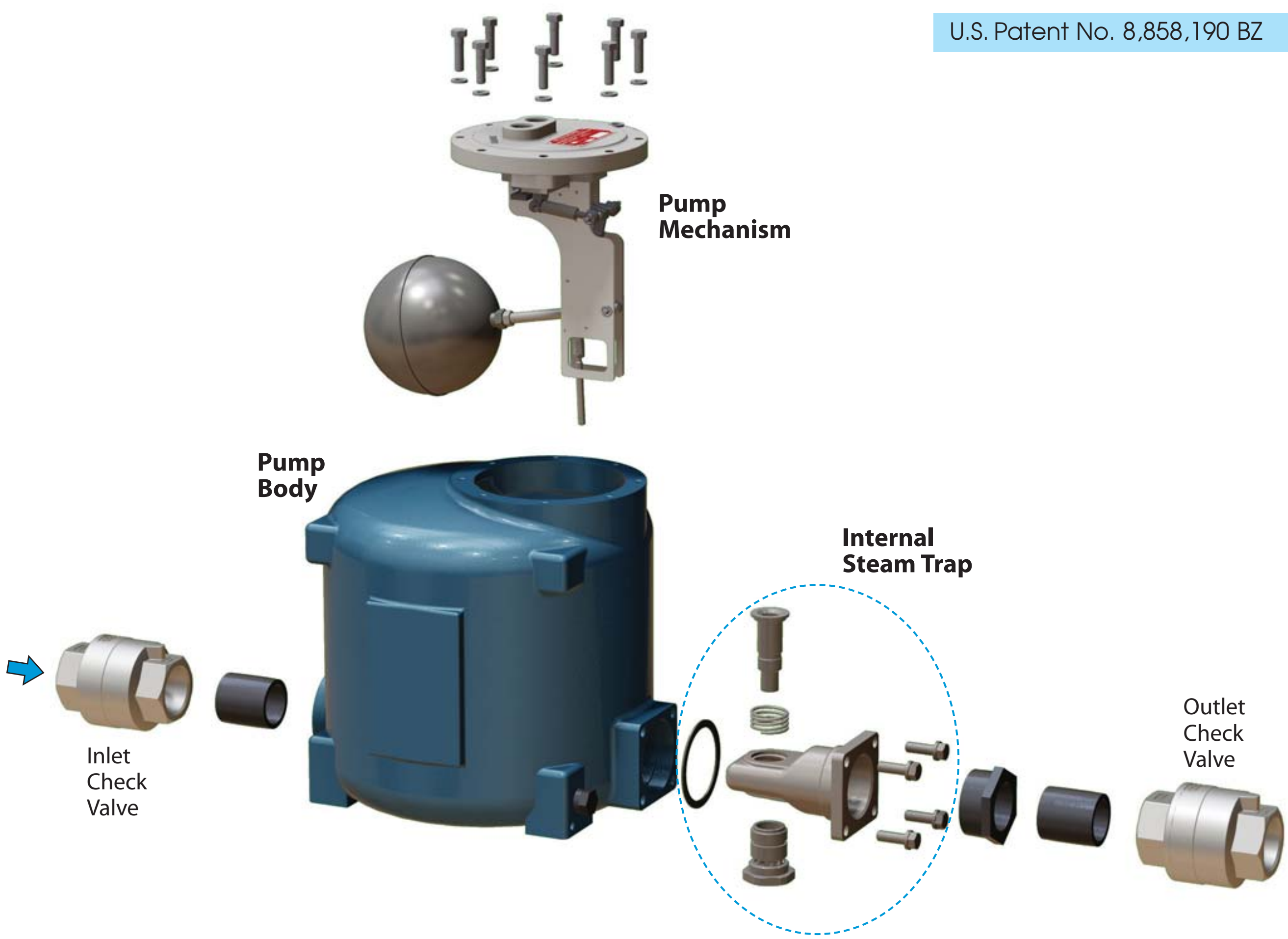


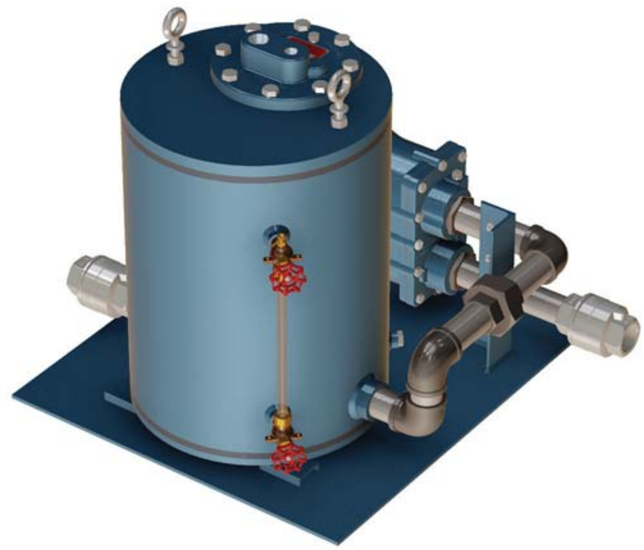
MATERIALS	
Body PMPT	**Ductile Iron SA-395**
Body PMPTS	**Stainless Steel CF3M**
Cover	Stainless Steel CF8
Cover Gasket	Garlock
Cover Bolts	Steel
Inlet Valve	Hardened Stainless Steel 40 Rc
Vent Valve	Hardened Stainless Steel 40 Rc
Ball Float	300 Stainless Steel
Check Valves	Stainless Steel 316SS CF3
Springs	Inconel-X-750
Other Internal Components	Stainless Steel

Size	Model **Code**	PMO **PSI**	Weight **lbs**
Ductile Iron Pump Body (NPT)			
1" x 1"	**PMPT-1X1-N-SS**	125	85
1-1/2" x 1-1/2"	**PMPT-1.5X1.5-N-SS**	125	95
Stainless Steel Pump Body (NPT or 150# FLG)			
1-1/2" x 1-1/2"	**PMPTS-1.5X1.5-N-SS**	125	95
1-1/2" x 1-1/2"	**PMPTS-1.5X1.5-F150-SS**	125	98

The PMPT Pump-Trap consists of pump tank, internal mechanism & trap, and inlet & outlet stainless steel check valves.

U.S. Patent No. 8,858,190 BZ



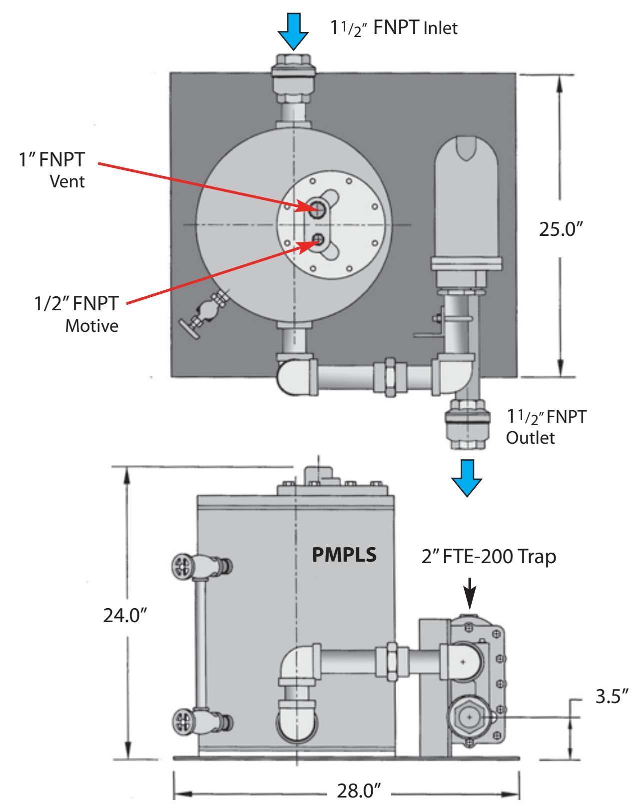


WPT-Series Pump-Trap Combinations simplify Selection & Installation of Pressure Motive Pumps

- **3 size ranges available**
- **Up to 13,000 lbs/hr of condensate load**

WPT3 • 1 1/2 x 1 1/2

(**PMPLS** with 2″ FTE-200 Steam Trap)



Typical Applications

WPT Pump-Trap Combinations are excellent for draining condensate from heat exchangers and other equipment whose steam pressure is modulated by a temperature regulator or a temperature control valve. In these applications the steam pressure in the heat exchanger may not be sufficient to overcome the back pressure in the condensate return line. When this condition occurs, the pressure powered pump takes over and uses high pressure steam supplied to the pump to discharge the condensate. When sufficient pressure does exist, the WPT functions like a standard steam trap.

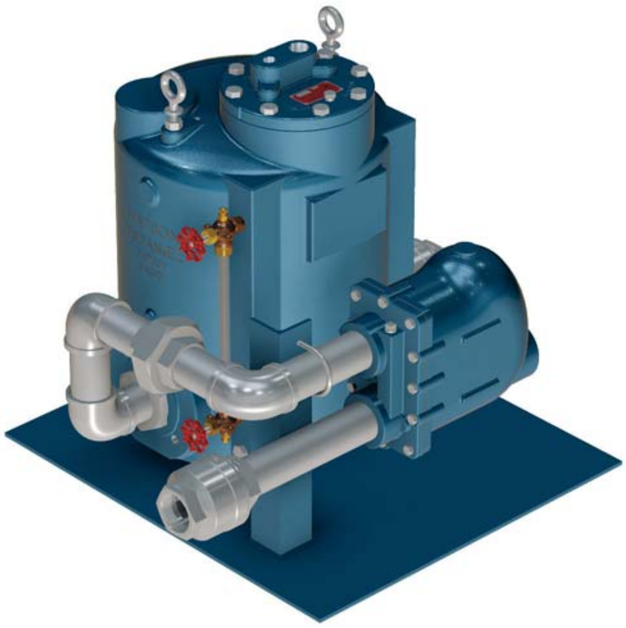
Pump-Traps facilitate condensate discharge under all operating conditions, including vacuum.

Pump-Trap Features

- Pump and Steam Trap are pre-mounted together on a single base for easy installation
- Higher capacities than Pump-Trap combinations with internal steam traps (PMPT)
- Engineering and selection is simplified using a pre-mounted system

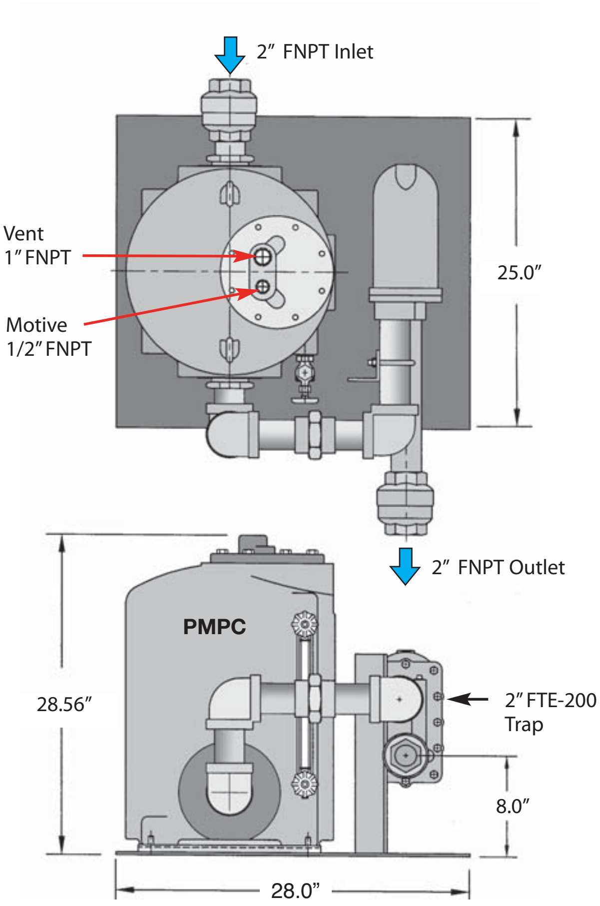
NOTE: Reservoir - Pump-Trap Combination may require a reservoir above the pump to collect condensate generated in the heat exchanger during the discharge cycle of the pump. Consult Reservoir Sizing Guidelines or contact factory for additional information.

MATERIALS	WPT3		WPT4		WPT5	
	Pump	Trap	Pump	Trap	Pump	Trap
Body	**Carbon Steel**	**Ductile Iron SA-395**	**Ductile Iron SA-395**	**Ductile Iron SA-395**	**Ductile Iron SA-395**	**Ductile Iron SA-395**
Cover	Carbon Steel	Ductile Iron SA-395	Ductile Iron SA-395	Ductile Iron SA-395	Ductile Iron SA-395	Ductile Iron SA-395
Cover Gasket	Garlock	Garlock	Garlock	Garlock	Garlock	Garlock
Cover Bolts	Steel	Steel	Steel	Steel	Steel	Steel
Inlet Valve	17-4 Ph SS 40 Rc	n/a	17-4 Ph SS 40 Rc	n/a	17-4 Ph SS 40 Rc	n/a
Vent Valve	17-4 Ph SS 40 Rc	n/a	17-4 Ph SS 40 Rc	n/a	17-4 Ph SS 40 Rc	n/a
Ball Float	304 SS	304 SS	304 SS	304 SS	304 SS	304 SS
Check Valves	316 SS	n/a	316 SS	n/a	316 SS	n/a
Springs	Inconel-X-750	n/a	Inconel-X-750	n/a	Inconel-X-750	n/a
Other Internal Components	Stainless Steel	Stainless Steel	Stainless Steel	Stainless Steel	Stainless Steel	Stainless Steel



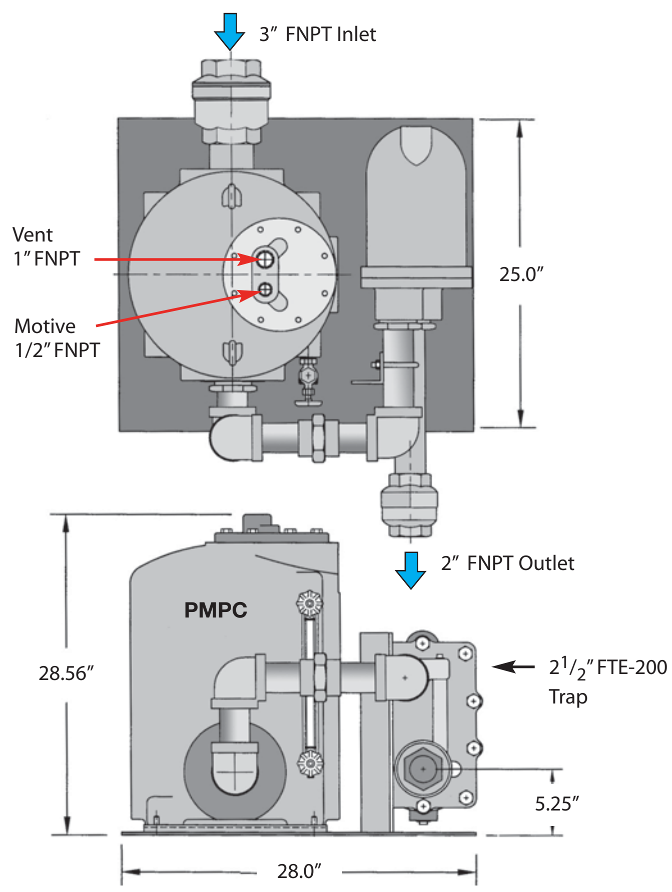
WPT4 • 2″ x 2″

(**PMPC** with 2″ FTE-200 Steam Trap)



WPT5 • 3″ x 2″

(**PMPC** with 2$^1/_2$″ FTE-200 Steam Trap)



PMPT & WPT Pump-Trap Combinations (Operating in **Pump** Mode)

PUMP CAPACITIES – *Condensate (lbs/hr); using steam as a motive pressure*

Motive Pressure (PSIG)	Total Back Pressure (PSIG)	PMPT 1" x 1" 6" Fill Head	PMPT 1 1/2" x 1 1/2" 6" Fill Head	WPT3 1 1/2" x 1 1/2" 12" Fill Head	WPT4 2" x 2" 12" Fill Head	WPT5 3" x 2" 12" Fill Head
5	2	1,064	1,850	1,310	2,320	4,270
10	5	1,049	1,824	1,760	3,740	6,230
10	2	1,200	2,087	2,350	5,640	9,450
25	15	1,026	1,784	2,700	4,690	7,230
25	10	1,151	2,002	3,020	5,970	9,370
25	5	1,257	2,186	3,780	6,850	11,400
50	40	877	1,525	2,090	3,410	5,040
50	25	1,115	1,939	3,620	6,650	10,200
50	10	1,286	2,237	4,080	7,140	11,500
75	60	882	1,533	2,250	3,730	5,660
75	40	1,102	1,916	3,470	6,010	8,770
75	15	1,298	2,257	4,390	7,920	12,400
100	80	884	1,538	2,620	4,390	6,140
100	60	1,058	1,841	3,390	5,780	8,120
100	40	1,192	2,074	4,310	6,940	10,000
100	15	1,331	2,314	4,620	8,000	12,300
125	115	737	1,281	2,280	3,490	4,440
125	100	886	1,541	2,880	4,420	5,720
125	80	1,030	1,792	3,520	5,700	7,630
125	60	1,146	1,992	4,110	6,880	9,390
125	40	1,243	2,161	4,910	7,800	11,100
125	15	1,351	2,350	5,120	8,420	12,900
150	120	-	-	2,560	3,640	5,100
150	100	-	-	3,020	4,610	6,270
150	80	-	-	3,630	5,780	8,140
150	60	-	-	4,230	6,910	9,920
150	40	-	-	4,830	7,930	11,700
150	15	-	-	5,230	8,590	13,300

PMPT & WPT Pump-Trap Combinations (Operating in **Trap** Mode)

TRAP CAPACITIES – *Condensate (lbs/hr)*

Differential Pressure (PSI)	PMPT	WPT3 & WPT4	WPT5
1/4	1,511	2,770	7,200
1/2	2,137	4,100	12,300
1	3,020	5,700	17,400
2	4,030	7,400	25,400
5	4,354	9,900	27,600
10	4,841	11,800	32,600
15	5,150	13,400	36,000
20	5,686	14,400	39,300
30	6,425	16,400	43,100
40	7,711	18,000	46,600
50	8,000	19,000	49,200
75	9,100	21,000	54,700
100	10,334	23,000	58,800
125	11,451	24,500	61,900
200	NA	29,200	74,000

Recommended Reservoir sizes for Pump-Trap Applications

RESERVOIR PIPE LENGTH in feet (ft)

Condensate Load (lbs//hr)	Reservoir Pipe Size (Diameter)				
	3"	4"	6"	8"	10"
0-500	2′				
1,000	2′				
1,500	3′	2′			
2,000	3.5′	2′	1′		
3,000		3′	2′		
4,000		4′	2′	1′	
5,000		6′	3′	2′	
6,000			3′	2′	
7,000			3′	2′	
8,000			4′	2′	
9,000			4.5′	3′	2′

Pump-Trap Sizing:

When the steam pressure in the heat exchanger is higher than the return line back pressure, the PUMP-TRAP functions like a standard float-operated TRAP, allowing the steam pressure in the heat exchanger to discharge the condensate. Under these conditions, the unit is in TRAP mode. When the steam pressure in the heat exchanger falls below the back pressure, the condensate backs up into the body of the pump-trap, raising the float and opening the motive steam inlet valve, which then pumps the condensate into the return line. Under these conditions, the unit is in PUMP mode. We therefore have two separate and distinct capacities; the **PUMP CAPACITY** (when operating in Pump Mode) and the **TRAP CAPACITY** (when operating in Trap Mode).

In the example below, the system will be analyzed to determine when the Pump-Trap is in Trap Mode and when it is in Pump Mode, and the specific capacity requirement of the pump. If the total back-pressure of the condensate return line is known, the Pump-Trap should be selected with sufficient pump capacity to handle the condensate load at the system stall point. (i.e.; when the steam pressure is equal to the total back-pressure). Alternatively, if the total back-pressure is not known, it is best to select a pump-trap with enough pump capacity to handle the maximum condensate load of the application. (i.e., at maximum steam pressure and flow). Refer to Sizing Charts.

Reservoir Sizing: (Refer to chart on previous page)

When using a Pump-Trap, a condensate holding reservoir should be installed above the pump-trap and below the heat exchanger (shown below). This will enable the condensate to collect while the pump is in the discharge cycle, thus preventing condensate backup. When back pressure against the pump outlet is less than 50% of the steam pressure to the heat exchanger, the pipe lengths given in the chart can be reduced by half.

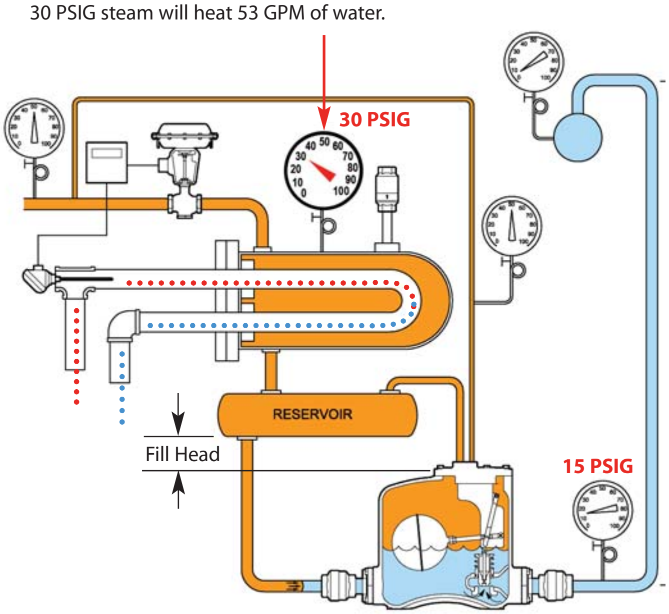
Heat Exchanger (HX) using Steam to heat Hot Water

The following example describes a Heat Exchanger (HX) using Steam to heat domestic hot water for a medium size apartment complex. Note that the hot water usage varies significantly depending on the time of day. The physical size of the heat exchanger needed (sq. ft. of surface area) is based on the following criteria: **(1)** MAXIMUM water usage (GPM), **(2)** the temperature rise of the water, and **(3)** what pressure steam will be used to heat the water during maximum demand.
Note: The selection of the steam pressure (which determines the steam temperature), to heat the water at maximum demand (flow rate), is the primary factor in heat exchanger sizing.

The application is requiring water to be heated from **45˚F** to **140˚F** in a HX using Steam. The maximum flow rate has been determined to be **60 GPM**. The Steam Trap will be discharging into a condensate return line that may have a Total Back Pressure of **15 PSIG** and the flow rate of heated water could be as low as **20 GPM**. The facility engineer has chosen to base the HX size on using **50 PSIG** of steam pressure. Therefore, the size of the heat exchanger was selected based on heating **60 GPM** of water using **50 PSIG** of steam.

TRAP Mode

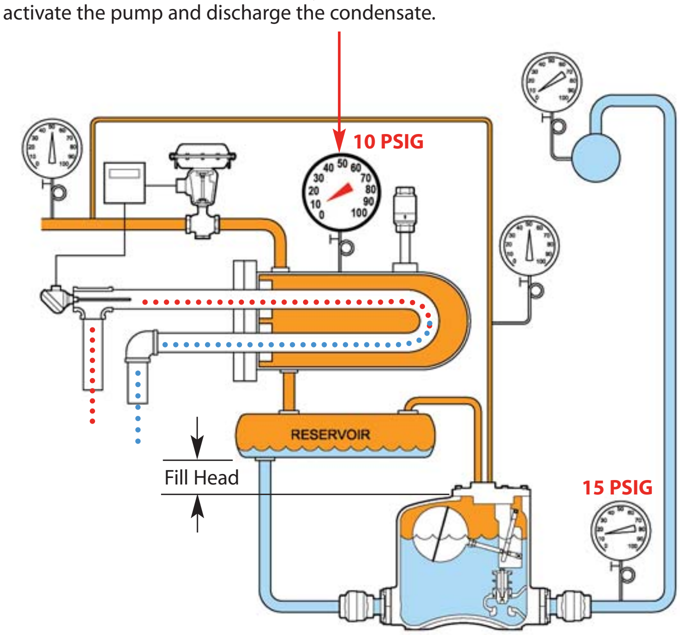
The system is operating with **30 PSIG** inlet pressure to the heat exchanger. The Pump-Trap unit functions like a standard float operated trap. Condensate is pushed thru into the return line by the steam pressure in the HX. Based on this particular size HX, 30 PSIG steam will heat 53 GPM of water.



ΔP Trap = 30 psig - 15 psig
= 15 psi

PUMP Mode

In response to a reduction in demand of hot water, the pressure in the HX has now dropped to **10 PSIG**. Based on this particular size HX, 10 PSIG steam will heat 43 GPM of water. Since back pressure is **15 PSIG**, the system is stalled and condensate backs up into the system; the float will continue to rise to activate the pump and discharge the condensate.



PUMPING TRAPS

Summary of conditions for a Heat Exchanger (HX) using Steam to heat Water

Set of conditions used to size the Heat Exchanger:

1)	Maximum Flow of Hot Water		=	**60 GPM**
2)	Water temperature required	T_o	=	**140˚F**
3)	Steam Pressure in Heat Exchanger		=	**50 PSIG**
4)	Temperature of 50 PSIG Steam	T_s	=	**298˚F**
5)	Inlet Water Temperature	T_i	=	**45˚F**
6)	Temperature Rise of Water (140˚ F - 45˚F = 95˚ F)		=	**95˚F**

What is the Heat Transfer Rate (E) to heat 60 GPM of water from 45˚to 140˚F?

$$E \left[\frac{Btu}{hr}\right] = \textbf{Water Flow Rate (GPM)} \times \textbf{500} \times \textbf{Temp Rise (˚F)}$$

$$= 60 \times 500 \times [140˚ - 45˚F]$$

$$= \textbf{2,850,000} \text{ Btu/hr}$$

How much Steam Flow is required?

$$Q_s \text{ (steam)} = \frac{E}{LH} \quad \text{(For 50 psi steam, the LH is 912 Btu/lb)}$$

$$= \frac{2{,}850{,}000 \text{ Btu/hr}}{912 \text{ Btu/lb}}$$

$$= \textbf{3,125} \text{ lbs/hr}$$

E = U x A x ΔT — Fundamental formula for heat transfer and the basic formula for HX sizing

The formula shows that the heat transfer rate (**E**) between the hot steam and cold water is directly proportional to the Surface contact area (**A**) inside the HX and the difference in temperature between the steam and water (ΔT). The more surface area (larger HX) the more heat will get transferred or the hotter the steam temperature (higher pressure) the more heat will get transferred.

E = **Heat Transfer Rate** in Btu/hr of the energy in the steam to the water. The flow of steam (Q_s) required in lbs/hr is determined by dividing **E** by the Latent Heat of Steam (LH) in Btu/lb.

U = is referred to as the **Overall Heat Transfer Coefficient**. This depends on the HX type and the materials involved. Typical **U** values are 120 for Stainless Steel and 200 for Copper. We will use 120 for Stainless Steel HX.

A = The internal **Surface Area** (size) of the HX in Sq. Ft. The size of a HX is determined by the surface contact area between the Steam and Water.

ΔT = **Average Temperature Difference** between Steam & Water. Since the water temperature changes as it flows thru the HX, we need to use the average temperature difference between the steam temperature and the water temperature. See formula below:

Average Temperature Difference

$$\Delta T = \frac{(T_s - T_i) + (T_s - T_o)}{2}$$

$$= \frac{(298 - 45) + (298 - 140)}{2}$$

ΔT = 205˚F = Avg Temp. Difference

Heat Exchanger Size

E = U x A x ΔT

Above formula is rearranged to solve for **A**:

$$A = \frac{E}{U \times \Delta T}$$

$$= \frac{2{,}850{,}000}{120 \times 205}$$

A = 116 (sq ft.)

The actual size of a Heat Exchanger depends on many factors; however, based on the criteria given, **116** sq. ft of surface area is required to heat 60 GPM of water from 45˚F to 140˚F, based on a steam pressure of 50 PSIG.

Stall Condition:

When the steam pressure in the HX is equal to the back pressure of **15 PSIG**, the condensate will no longer drain out of the HX. The Pump-Trap will now need to operate in Pump Mode to remove the condensate from the HX. We need to calculate how much condensate will be produced when there is **15 PSIG** in the HX.

$$\Delta T = \frac{(T_S - T_i) + (T_S - T_o)}{2}$$

$$= \frac{(250 - 45) + (250 - 140)}{2}$$

From the steam table, 15 PSIG steam has a temp of 250˚F

$$\Delta T = 157.5^\circ F = \text{Avg Temp. Difference}$$

To find out how much energy will be transferred to the water, we use the **ΔT** calculated above in our heat transfer equation.

$$E = U \times A \times \Delta T$$

$$= 120 \times 116 \times 157.5$$

$$= \mathbf{2{,}192{,}400} \text{ Btu/hr}$$

To determine how much steam is required to heat the water, we use the following formula. (LH = Latent Heat.)

$$Q_s \text{ lbs/hr} = \frac{E}{LH} = \frac{2{,}192{,}400}{946}$$

(For 15 psig steam, the LH is 946 Btu/lb)

Steam Flow = **2,318** lbs/hr

When the HX stalls, we will be using 2,318 lbs/hr of steam and will need to pump 2,318 lbs/hr of condensate. The pump-trap must be sized to handle this condensate load since it is the maximum load under stall conditions (see table below).

Table based on a HX size of 116 ft^2 and back pressure of 15 PSIG

The following table summarizes the above results and shows how the steam flow, pressure, temperature and latent heat vary as a function of the water flow rate. It can be seen that the system is operating in **Trap Mode** between water flow rates of 60 to ~46 GPM, and in **Pump Mode** between ~46 to 20 GPM (based on 15 PSIG back pressure). Also, at flow rates below 35 GPM, the steam pressure inside the HX is below atmospheric pressure (0 PSIG).

Flow Rate Water (GPM)	Steam Usage (lbs/hr)	Steam Pressure in HX (PSIG)	Steam Temp in HX (°F)	Latent Heat of Steam (Btu/lb)	Condensate Generated (lbs/hr)	Trap Differential Pressure (PSI)	System Condition	
60	**3,125**	**50**	**298**	**912**	**3,125**	**35**	Trap Mode	**(Maximum Heat Load)**
57.0	2,943	40	287	920	2,943	25		
53.2	2,720	30	274	929	2,720	15		
48.8	2,466	20	259	940	2,466	5		
46.2	**2,318**	**15**	**250**	**946**	**2,318**	**0**	(Stall Point)	Steam Pressure = Back Pressure
42.9	2,140	10	239	953	2,140	---	Pump Mode	
35.0	1,715	0	212	970	1,715	---		
29.2	1,409	-5	192	983	1,409	---	(Vacuum)	
20	**948**	**-10**	**161**	**1,002**	**948**	---		**(Minimum Heat Load)**