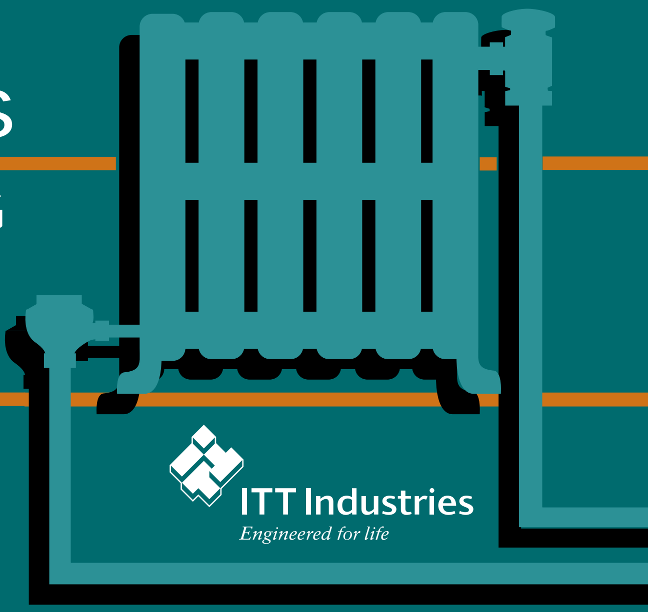
HS-203(C)

Hoffman SPECIALTY

STEAM TRAPS

ENGINEERING DATA MANUAL

- Application
- Selection
- Installation
- Piping Diagrams



ITT Industries

Engineered for life

Contents

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Steam Trap Functional Requirements

Selecting the proper type of steam trap is an important element in steam systems.

There are many types of steam traps each having its unique characteristics and system benefits. Hoffman Specialty offers thermostatic, thermodisc, float and thermostatic, and bucket traps which are the most commonly used types. Deciding which type of trap to use is sometimes confusing and, in many cases, more than one type can be used. The following is intended to point out system conditions that may be encountered and the characteristics of each type of trap.

Within steam systems, important considerations must be taken into account. These considerations include venting of air during start-up; variations of system pressures and condensing loads; operating pressure and system load; continuous or intermittent operation of system; usage of dry or wet return lines; and overall probability of water hammer.

Air Venting

At start-up all steam piping, coils, drums, tracer lines, or steam spaces contain air. This air must be vented before steam can enter. Usually the steam trap must be capable of venting the air during this start-up period. A steam heating system will cycle many times during a day. Fast venting of air is necessary to obtain fast distribution of steam for good heat balance. A steam line used in process may only be shut down once a year for repair and venting of air may not be a major concern.

Modulating Loads

When a modulating steam regulator is used, such as on a heat exchanger, to maintain a constant temperature over a wide range of flow rates and varying inlet temperatures, the condensate load and differential pressure across the trap will change. When the condensate load varies, the steam trap must be capable of handling a wide range of conditions at constantly changing differential pressures across the trap.

Differential Pressure Across Trap

When a trap drains into a dry gravity return line, the pressure at the trap discharge is normally at O psig. When a trap drains into a wet return line or if the trap must lift condensate to an overhead return line, there will normally be a positive pressure at the trap discharge. To assure condensate drainage, there must be a positive differential pressure across the trap under all load conditions.

Water Hammer

When a trap drains high temperature condensate into a wet return, flashing may occur. When the high temperature condensate at saturation temperature discharges into a lower pressure area, this flashing causes steam pockets to occur in the piping, and when the latent heat in the steam pocket is released, the pocket implodes causing water hammer. Floats and bellows can be damaged by water hammer conditions.

When traps drain into wet return lines, a check valve should be installed after the trap to prevent backflow. The check valve also reduces shock forces transmitted to the trap due to water hammer. Where possible, wet returns should be avoided.

Application

The design of the equipment being drained is an important element in the selection of the trap. Some equipment will permit the condensate to back up. When this occurs the steam and condensate will mix and create water hammer ahead of the trap. A shell and tube heat exchanger has tube supports in the shell. If condensate backs up in the heat exchanger shell, steam flowing around the tube supports mixes into the condensate and causes steam pockets to occur in the condensate. When these steam pockets give up their latent heat, they implode and water hammer occurs, the water hammer often damages the heat exchanger tube bundle. The trap selection for these types of conditions must completely drain condensate at saturation temperature under all load conditions.

Steam mains should be trapped to remove all condensate at saturation temperature. When condensate backs up in a steam main, steam flow through the condensate can cause water hammer. This is most likely to occur at expansion loops and near elbows in the steam main.

Applications such as tracer lines or vertical unit heaters do not mix steam and condensate. In a tracer line, as the steam condenses, it flows to the end of the tracer line. Back up of condensate ahead of the trap does not cause water hammer. Steam does not pass through condensate.

Vertical unit heaters normally have a steam manifold across the top. As the steam condenses in the vertical tubes, it drains into a bottom condensate manifold. Because steam does not pass through the condensate, water hammer should not occur.

TRAP OPERATION

A review of the trap operating principle will show how various types of traps meet the different system characteristics.

Float & Thermostatic Traps

Advantages

Completely drains condensate at saturation temperature.

Modulates to handle light or heavy loads, continuous discharge equal to condensing load.

Large ports handle high capacities.

Separate thermostatic vent allows fast venting of air during start-up.

Modulating ports provide long life.

Cast iron bodies.

Disadvantages

Float or bellows may be damaged by water hammer.

Primary failure mode is closed.

Does not withstand freezing temperatures.

Pressure limit of 175 psig.

Primary Applications

Heating main drip traps.

Shell & tube heat exchangers.

Tank heaters with modulating temperature regulators.

Unit heaters requiring fast venting.

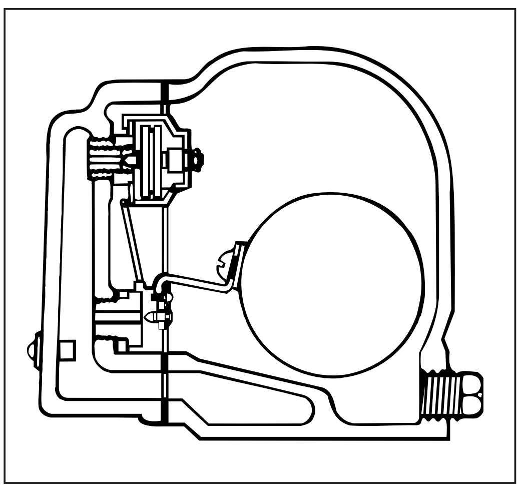
Steam humidifiers.

Air blast heating coils.

Air pre-heat coils.

Modulating loads.

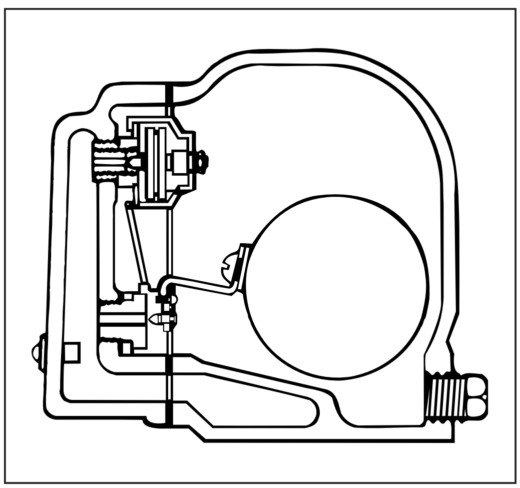
Fast heating start-up applications.



FLOAT & THERMOSTATIC TRAP

During start-up the thermostatic vent is open to allow free passage of air.

The thermostatic vent will close at near saturation temperature. The balanced design will allow venting of noncondensables that collect in the float chamber, when operating at design pressure.



FLOAT & THERMOSTATIC TRAP

The condensate port is normally closed during no load. As condensate enters the float chamber, the seat opens to provide drainage equal to the condensing rate.

Bucket Traps

Advantages
Completely drains condensate at saturation temperature.

Open bucket will tolerate moderate water hammer.

Available in pressures up to 250 psig.

Normal failure mode is open.

Cast iron bodies.

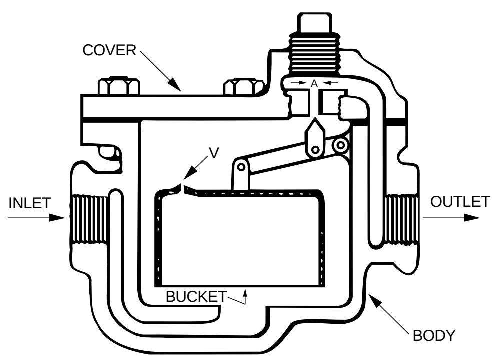
Disadvantages
Marginal air handling during start-up.

Cycles fully open or closed.

May lose prime during light loads and blow live steam.

Requires manual priming to provide water seal.

Does not withstand freezing temperatures.



BUCKET TRAP
The trap body must be manually primed at initial start-up. Under operation the body will remain full of condensate.

During start-up, air is vented through the bleed hole in the top of the bucket into the return line.

Condensate entering the trap will flow around the bucket and drain through the open seat.

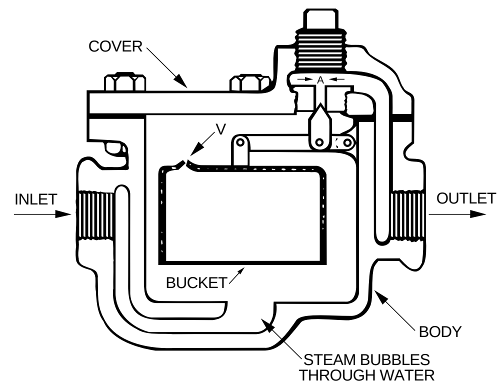
Primary Applications
Process main drip traps.

Where condensate is lifted or drains into wet return line.

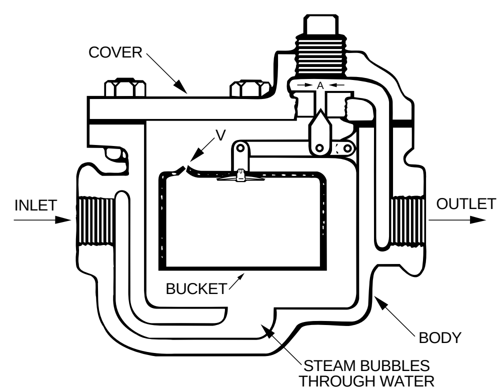
Drum type roller dryers.

Steam separators.

Siphon type or tilting kettles.



BUCKET TRAP
As steam flows into the trap it collects in the top of the bucket. The buoyancy of the steam raises the bucket and closes the seat.



BUCKET TRAP WITH OPTIONAL THERMAL VENT.
An optional thermal vent installed in the bucket allows faster air venting during start-up.

Thermostatic Bellows Type Trap

Advantages

Sub-cools condensate usually 10° to 30°F.

Normally open at start-up to provide fast air venting.

Follows steam saturation curve to operate over wide range of conditions.

Brass bodies.

Self draining.

Energy efficient.

Compact size and inexpensive.

Fast response to changing conditions.

Fail open models.

Disadvantages

Water hammer can damage bellows.

Superheat can damage bellows if it exceeds trap temperature rating.

Pressure limit of 125 psig.

Cooling leg required in some applications.

Applications

Radiators, convectors, unit heaters.

Cooking kettles.

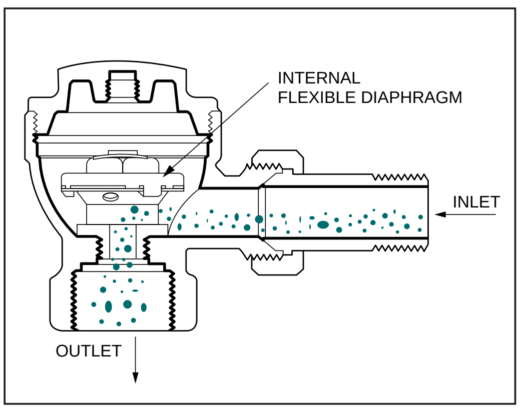
Sterilizers.

Heating coils.

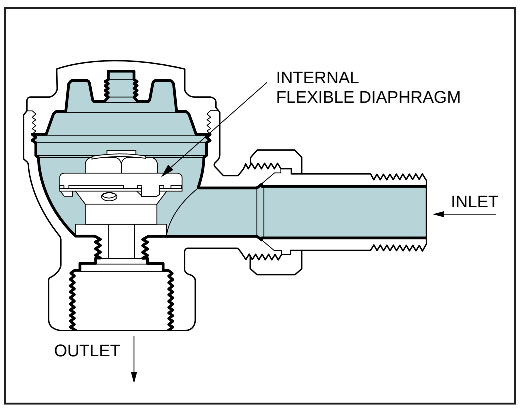
Tracer lines.

Evaporators.

NOTE: A solid fill expansion element (see Hoffman Specialty 17K) thermostatic trap should be used where water hammer (cavitation) may occur.



THERMOSTATIC TRAP
Thermostatic traps are normally open. This allows fast venting of air during start-up.



THERMOSTATIC TRAP
Cold condensate during start-up drains through the trap. As temperatures reach 10° to 30° F of saturation, the trap closes.

During operation, thermostatic traps find an equilibrium point to drain condensate approximately 10° to 30°F below saturation at a continuous flow.

Disc Traps

Advantages

Completely drains condensate at saturation temperature.

May be installed vertically, to drain trap body when steam is off, to prevent freezing.

Compact size.

Easily serviced in line, replaceable seat and disc (some models).

All stainless steel.

Will tolerate water hammer and superheat.

Disadvantages

Noise.

Sensitive to dirt, prevents tight closing of disc.

Available in sizes up to 1" only.

Applications

Steam tracer lines where maximum temperature is required.

Outdoor applications including drips on steam mains.

Drying tables.

Tire mold press and vulcanizing equipment

Dry kilns.

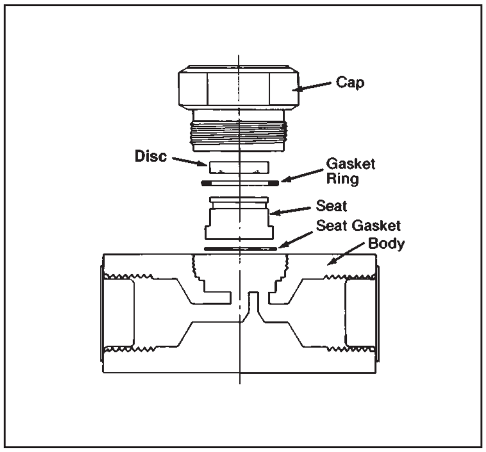
Pressing machines.

Rugged applications (superheat & water hammer).

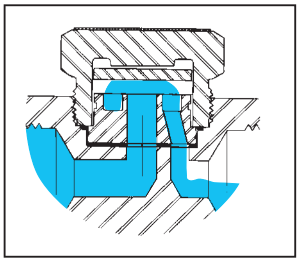
Description

Thermodisc steam traps provide dependable performance for applications with light to moderate condensate loads. Thermodisc traps are excellent for high pressure drip and steam tracing applications.

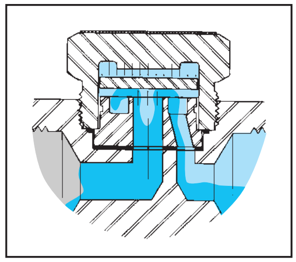
Because the disc is the only moving part, the traps are rugged and resistant to damage. However, if the seat and disc require servicing they may be easily replaced without removing the trap body from the piping.



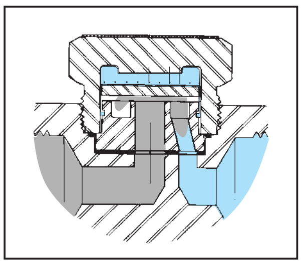
Disc Trap Operation



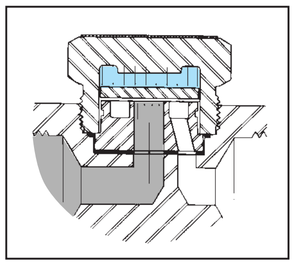
Start-Up
The disc is pushed off the seat by the inlet pressure and is held open by the impact force of the condensate hitting the disc.



Operating
As the condensate nears saturation temperature, greater amounts of flash steam will appear. Some of the flash steam escapes to the area above the disc, causing the pressure above the disc to increase, pushing the disc closer to the seat.



Closing
When all the condensate is discharged, flash steam enters the seat-disc chamber at high velocity. This high velocity causes a sudden pressure drop at the lower side of the disc and it snaps closed against the seat.



Closed
At the instant the disc snaps closed on the seat, the pressure above the disc is approximately equal to the upstream line pressure. The disc is held closed because the pressurized area above the disc is much larger than the inlet area. The pressure above the disc decreases either by steam condensation or by non-condensables being removed via the micro-bleed on the disc. When the pressure is low enough, the disc is pushed off the seat and the process is repeated.

Orifice Traps

Advantages

No moving parts to wear.

Disadvantages

Does not close against steam.

Small hole easily plugs due to dirt.

Backs up condensate on heavy loads and during start-up.

Does not respond to modulating loads.

Does not vent air when handling condensate—causes slow system start-up and may cause water hammer.

Not easily recognized as trap during energy survey.

Built-in small screen plugs easily.

Discharges condensate at saturation temperature with some live steam, often causes excessive condensate temperatures and cavitation at condensate pumps.

Waste energy.

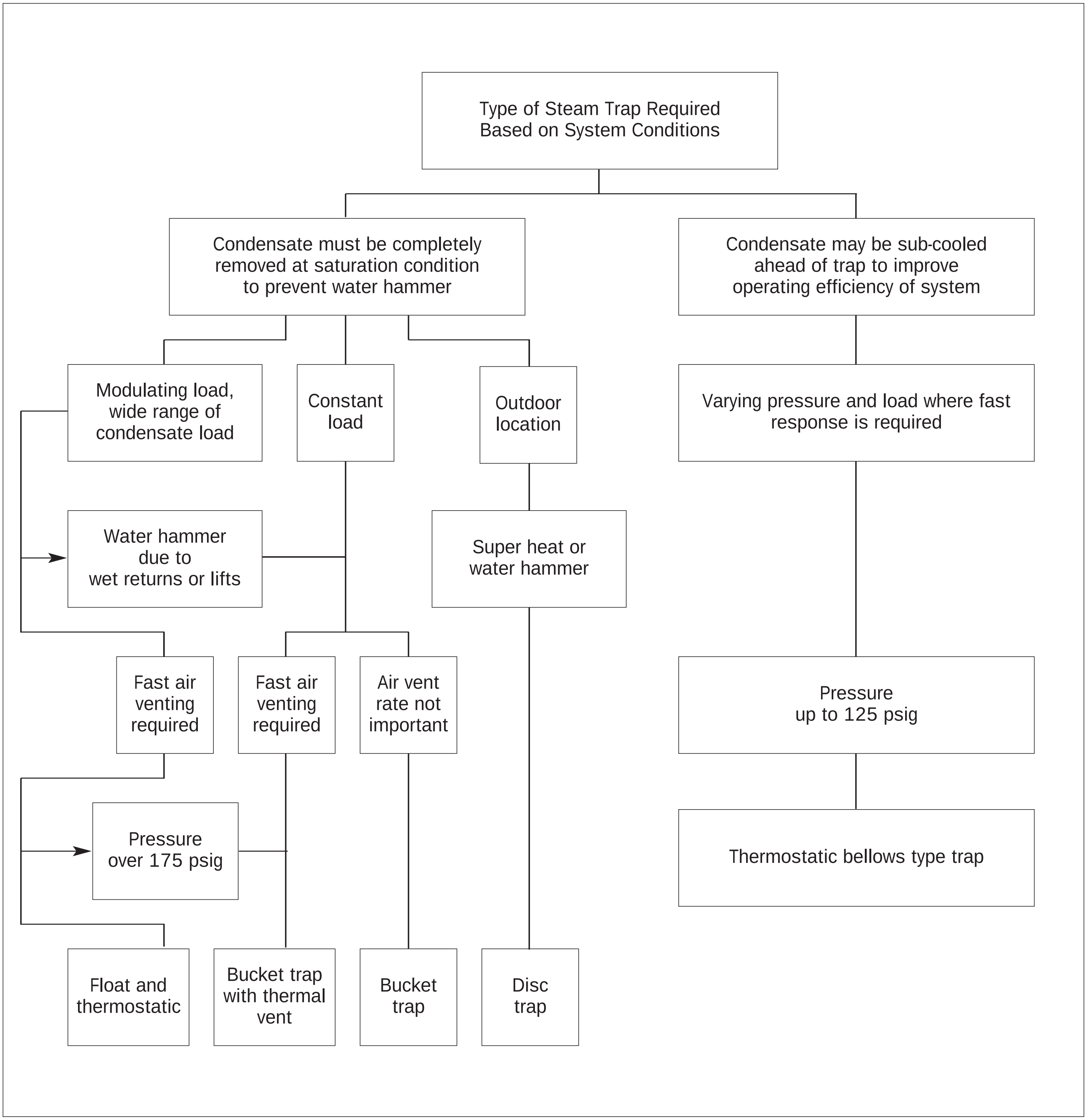
Sizing critical.

Applications

Should be limited to constant load continuous operation.

Selection Guide Chart

The proper type of steam trap selected is an important consideration in steam systems. There are many types of steam traps. Each has unique characteristics and system benefits. Hoffman Specialty offers thermostatic, float and thermostatic, bucket and disc traps. This line chart points out system conditions that may be encountered and suggests a trap that may best handle the requirement. Several types of traps may be used for a specific application. The line chart should be used only as a guide.



4 Step Method for Sizing

Step 1:
Collect All Required Information.

A. Determine maximum condensate load in Lbs./Hr. (Pounds per Hour). See "Helpful Hints—Approximating Condensate Loads" on page 12.

B. Inlet pressure at steam trap. It could be different than supply pressure at boiler. Heat exchanger applications with modulating control valves are good examples.

C. Back-pressure at steam trap. Pressure against outlet can be due to static pressure in return line or due to lifting to overhead return.

D. Determine Pressure Differential.
Inlet pressure (B) - Back-pressure (C) = Differential Pressure.

Step 2:
Select Proper Type ot Trap.

A. Other Things to Consider.
   1. Condensate Flow—Fluctuate? Continuous?
   2. Large Amount of Air?
   3. Pressure—Constant? Fluctuate?

B. Application.
   1. Main.
   2. Drip Leg.
   3. Process Heat Exchanger.
   4. Other.

C. Critical Process.
   1. Fail Cold.
   2. Fail Hot.

Step 3:
Apply Safety Factor.

A. SFA Recommended.
   1. Float & Thermostatic Trap 1.5 to 2.5.
   2. Bucket Trap 2 to 4.
   3. Thermostatic 2 to 4.
   4. Disc Traps 1 to 1.2.
   See specific applications.

B. The SFA Will Depend On Degree of Accuracy at Step 1.
   1. Estimated Flow.
   2. Estimated Pressure—Inlet.
   3. Estimated Pressure—Back.

Step 4:
Select Correct Trap Size.

A. Use manufacturer's capacity table to size trap. Capacity tables should be based on hot condensate (some specified temperature below saturation) rather than cold water rating. Hoffman Specialty published actual test data, unless stated, is 10°F. below saturation.

B. The trap seat rating must always be higher than the maximum inlet pressure specified.

C. When inlet to equipment is controlled by a modulating control valve, the trap size should be selected with a pressure rating greater than the maximum inlet pressure at the trap. The capacity should be checked at the minimum differential pressure to assure complete condensate removal under all possible conditions.

Helpful Hints, Formulas and Conversion Factors

Helpful Hints

Approximating Condensate Loads

Heating Water with Steam

lbs./hr. Condensate = $\frac{GPM}{2}$ x Temperature Rise °F.

Heating Fuel Oil with Steam

lbs./hr. Condensate = $\frac{GPM}{4}$ x Temperature Rise °F.

Heating Air with Steam Coils

lbs./hr. Condensate = $\frac{CFM}{900}$ x Temperature Rise °F.

SHEMA Ratings

Thermostatic traps and F & T traps for low pressures may be rated in accordance with the Steam Heating Equipment Manufacturers Association (SHEMA). SHEMA ratings have a built-in safety factor.

Formulas

1. Steam heats a liquid indirectly through a metallic wall.

—Cooking coils, storage tanks, jacketed kettles, stills.

Lbs./hr. condensate = $\frac{Q_l \times 500 \times S_g \times S_h \times (T_2\text{-}T_1)}{L}$

When:

Q_l = Quantity of liquid being heated in gal/min
S_g = Specific gravity
S_h = Specific heat
L = Latent heat in Btu/lb
500 = Constant for converting gallons per minute to pounds per hour.
T_2 = Final temperature
T_1 = Initial temperature

2. Steam heats air or a gas indirectly through a metallic wall.

—Plain or finned heating coils, unit space heaters.

Lbs./hr. condensate = $\frac{Q_g \times D \times S_h \times (T_2\text{-}T_1) \times 60}{L}$

When:

Q_g = Quantity of air or gas in ft^3/min.
D = Density in lb/ft^3
S_h = Specific heat of gas being heated.
T_1 = Initial temp.
T_2 = Final temp.
L = Latent heat in Btu/lb
60 = Minutes in hour

3. Steam heats a solid or slurry indirectly through a metallic wall.

—Clothing press, cylinder driers, platen press.

Lbs./hr. condensate = $\frac{970 \times (W_1\text{-}W_2) + W_1 \times (T_2\text{-}T_1)}{L \times T}$

When:

W_1= Initial weight of product
W_2= Final weight of product
T_1 = Initial temp.
T_2 = Final temp.
L = Latent heat in Btu/lb.
T = Time required for drying (hours).

Note: 970 is the latent heat of vaporization at atmospheric pressure. It is included because the drying process requires that all moisture in the product be evaporated.

4. Steam heats a solid through direct contact.

—Sterilizer, autoclave

Lbs./hr. condensate = $\frac{W \times S_h \times (T_2\text{-}T_1)}{L \times T}$

W = Weight of material being heated in lbs.
S_h = Specific heat of material being heated.
T_1 = Initial temp.
T_2 = Final temp.
L = Latent heat Btu/lb.
T = Time to reach final temp. (hours)

Conversion Factors

One Boiler Horsepower = 140 sq. ft. EDR or 33,475 Btu/hr. or 34.5 lbs./hr. steam at 212° F.

1,000 sq. ft. EDR yields .5 gpm condensate.

To convert sq. ft. EDR to lbs. of condensate—divide sq. ft. by 4.

.25 lbs./hr. condensate = 1 sq. ft. EDR.

One sq. ft. EDR (Steam) = 240 Btu/hr. with 215°F. steam filling radiator and 70°F. air surrounding radiator.

To convert Btu/hr. to lbs./hr.—divide Btu/hr. by 960.

One psi = 2.307 feet water column (cold).

One psi = 2.41 feet water column (hot).

One psi = 2.036 inches mercury.

One inch mercury = 13.6 inches water column.

Size condensate receivers for 1 min. net storage capacity based on return rate.

Size condensate pumps at 2 to 3 times condensate return rate.

Properties of Saturated Steam

The Properties of Saturated Steam table provides the relationship of temperature and pressure. The table also provides Btu heat values of steam and condensate at various pressures and shows the specific volume of steam at various pressures.

Saturated Steam:
Pure steam at the temperature corresponding to the boiling point of water.

Pressure psig:
Gauge pressure expressed as lbs./sq. in. The pressure above that of atmosphere. It is pressure indicated on an ordinary pressure gauge.

Sensible Heat:
Heat which only increases the temperature of objects as opposed to latent heat. In the saturation tables it is the Btu remaining in the condensate at saturation temperature.

Latent Heat:
The amount of heat expressed in Btu required to change 1 lb. of water at saturation temperature into 1 lb. of steam. This same amount of heat must be given off to condense 1 lb. of steam back into 1 lb. of water. The heat value is different for every pressure temperature combination shown.

Total Heat:
The sum of the sensible heat in the condensate and the latent heat. It is the total heat above water at 32° F.

Specific Volume Cu. Ft. Per Lb.:
The volume of 1 lb. of steam at the corresponding pressure.

See Properties of Saturated Steam table on the following page.

Properties of Saturated Steam

BELOW ATMOSPHERIC PRESSURE

Vacuum Inches of Mercury	Saturated Temp °F.	Specfic Volume Cu. ft. per lb.	Heat Content Btu per lb.		Latent Heat of Vaporization Btu per lb.
			Saturated Liquid	Saturated Vapor	
29	79	657.0	47	1094	1047
27	115	231.9	83	1110	1027
25	134	143.0	102	1118	1017
20	161	74.8	129	1130	1001
15	179	51.2	147	1137	990
10	192	39.1	160	1142	982
5	203	31.8	171	1147	976
1	210	27.7	178	1150	971

ABOVE ATMOSPHERIC PRESSURE

Pressure PSI (Gauge)	Saturated Temp ° F.	Specfic Volume Cu. ft. per lb.	Heat Content Btu per lb.		Latent Heat of Vaporization Btu per lb.
			Saturated Liquid	Saturated Vapor	
0	212	26.8	180	1150	970
1	215	24.3	183	1151	967
2	218	23.0	186	1153	965
3	222	21.8	190	1154	963
4	224	20.7	193	1155	961
5	227	19.8	195	1156	959
6	230	18.9	198	1157	958
7	232	18.1	200	1158	956
8	235	17.4	203	1158	955
9	237	16.7	205	1159	953
10	239	16.1	208	1160	952
11	242	15.6	210	1161	950
12	244	15.0	212	1161	949
13	246	14.5	214	1162	947
14	248	14.0	216	1163	946
15	250	13.6	218	1164	945
16	252	13.2	220	1164	943
17	254	12.8	222	1165	942
18	255	12.5	224	1165	941
19	257	12.1	226	1166	940
20	259	11.1	227	1166	939
25	267	10.4	236	1169	933
30	274	9.4	243	1171	926
35	281	8.5	250	1173	923
40	287	7.74	256	1175	919
45	292	7.14	262	1177	914
50	298	6.62	267	1178	911
55	302	6.17	272	1179	907
60	307	5.79	277	1181	903
65	312	5.45	282	1182	900
70	316	5.14	286	1183	897
75	320	4.87	290	1184	893
80	324	4.64	294	1185	890
85	327	4.42	298	1186	888
90	331	4.24	301	1189	887
95	334	4.03	305	1190	884
100	338	3.88	308	1190	882
105	341	3.72	312	1189	877
110	343	3.62	314	1191	877
115	347	3.44	318	1191	872
120	350	3.34	321	1193	872
125	353	3.21	324	1193	867
130	355	3.12	327	1194	867
135	358	3.02	329	1194	864
140	361	2.92	332	1195	862
145	363	2.84	335	1196	860

ABOVE ATMOSPHERIC PRESSURE (Cont.)

Pressure PSI (Gauge)	Saturated Temp ° F.	Specfic Volume Cu. ft. per lb.	Heat Content Btu per lb.		Latent Heat of Vaporization Btu per lb.
			Saturated Liquid	Saturated Vapor	
150	366	2.75	337	1196	858
155	368	2.67	340	1196	854
160	370	2.60	342	1196	854
165	373	2.53	345	1197	852
170	375	2.47	347	1197	850
175	378	2.40	350	1198	848
180	380	2.34	352	1198	846
185	382	2.29	355	1199	844
190	384	2.23	357	1199	842
195	386	2.18	359	1199	840
200	388	2.14	361	1199	838
210	392	2.05	365	1200	835
220	396	1.96	369	1200	831
230	399	1.88	373	1201	828
240	403	1.81	377	1201	824
250	406	1.75	380	1201	821
260	410	1.68	384	1201	817
270	413	1.63	387	1202	814
280	416	1.57	391	1202	811
290	419	1.52	394	1202	807
300	421	1.47	397	1202	805
325	429	1.37	405	1202	797
350	436	1.27	412	1202	790
375	442	1.19	419	1202	782
400	448	1.09	426	1202	774
425	454	1.06	432	1202	770
450	459	.972	438	1202	761
475	465	.948	444	1202	757
500	469	.873	449	1201	748
525	475	.850	455	1201	746
550	480	.820	461	1200	740
575	485	.784	466	1200	734
600	490	.733	472	1199	727
625	493	.721	476	1198	723
650	498	.692	481	1197	718
675	502	.645	485	1197	712
700	505	.642	490	1195	703
750	513	.598	498	1195	697
800	520	.555	514	1194	680
850	527	.521	523	1193	670
900	534	.489	532	1192	661
950	540	.462	540	1191	651
1000	548	.435	547	1189	642
1050	553	.413	550	1187	637
1100	558	.390	564	1185	621
1150	563	.372	572	1183	612
1200	567	.353	579	1182	603
1300	579	.322	593	1176	583
1400	588	.295	606	1172	565
1500	597	.271	619	1167	548
1570	604	.2548	624	1162	538
1670	613	.2354	636	1155	519
1770	621	.2179	648	1149	501
1870	628	.2021	660	1142	482
1970	636	.1878	672	1135	463
2170	649	.1625	695	1119	424
2370	662	.1407	718	1101	383
2570	674	.1213	743	1080	337
2770	685	.1035	770	1055	285
2970	695	.0858	801	1020	219
3170	705	.0580	872	934	62

Steam Flow in Pipes

REASONABLE VELOCITIES for fluid flow through pipes

Fluid	Pressure PSI (Gauge)	Service	Velocities—FPM
SATURATED STEAM	0-15	Heating Mains	4000-6000
SATURATED STEAM	50-up	Miscellaneous	6000-8000
SUPERHEATED STEAM	200-up	Turbine and Boiler Leads	10000-15000
WATER	25-40	City Service	120-300
WATER	50-150	General Service	300-600
WATER	150	Boiler Feed	600

SATURATED STEAM (lbs/hr) at 6000 ft/min (velocity) in iron or steel pipe

Pipe Size (Inches)	PRESSURE PSI (GAUGE)									
	5	10	15	30	50	75	100	125	200	250
½	30	40	45	60	90	120	150	180	270	330
¾	55	70	80	110	160	220	280	340	510	620
1	90	110	125	180	270	390	460	560	840	1020
1¼	160	200	225	325	480	650	820	990	1490	1830
1½	220	270	300	450	650	900	1100	1300	2060	2550
2	370	455	520	750	1100	1500	1900	2300	3450	4200
2½	525	650	750	1050	1600	2175	2750	3300	4950	6050
3	800	950	1350	1600	2500	3350	4250	5150	7700	9450
3½	1100	1350	1550	2200	3300	4550	5700	6900	10200	12700
4	1450	1800	2000	2900	4300	5850	7400	8900	13450	16400
5	2300	2800	3200	4600	6900	9300	11700	14100	21200	26000
6	3200	3900	4500	6400	9800	13200	16800	20300	30800	36900
8	5700	7000	8000	11400	17200	23300	29300	35400	53100	65200
10	9300	11400	13000	18900	28200	38000	48100	58100	87100	106500
12	13500	16600	18900	27000	40800	55300	69700	84200	126500	154700

COMPARATIVE CAPACITIES of different sizes of pipe

Pipe Size, Inches	½	¾	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10
Capacity Factor	2.0	3.5	5.5	10.0	13.5	22.5	31.5	48.5	65.0	84.0	105.	131.5	190.	255.	329.	430.	539.

EXAMPLE: To get size of pipe to serve a ½" and ¾" pipe, add factors: ½" factor (2) + ¾" factor (3.5) = 5.5 (1" factor).

Condensation in Pipes

CONDENSATION (lbs/hr) per 100 ft. pipe with 2-in. thick 85% magnesia insulation

Pressure PSI (Gauge)	DIAMETER OF PIPE IN INCHES												Pressure PSI (Gauge)	DIAMETER OF PIPE IN INCHES											
	¾	1	1½	2	2½	3	4	5	6	8	10	12		¾	1	1½	2	2½	3	4	5	6	8	10	12
1	2	3	3	4	4	5	6	7	8	11	13	15	50	4	4	5	6	7	9	11	13	16	19	24	28
3	2	3	3	4	4	5	6	7	9	11	14	15	70	4	5	6	7	8	10	13	15	18	22	27	32
5	3	3	4	4	5	5	6	7	10	12	14	17	100	5	5	7	8	9	12	15	18	20	25	31	37
10	3	3	4	4	5	5	7	9	11	13	15	18	125	5	6	7	8	9	13	16	19	22	28	35	41
20	3	3	4	5	5	5	8	10	12	15	18	21	150	6	6	8	9	10	14	17	21	24	31	38	45
30	3	4	5	5	6	7	9	11	13	16	20	24	200	6	7	8	9	11	15	19	24	28	35	44	51

Condensation in 3" and larger pipe are corrected for heat loss due to friction. Velocity taken at 8000 ft./min. Based on standard formulas.

CONDENSATION RATES at 70°F. (for bare steel pipe with natural movement of air)

Pipe Size (Inches)	STEAM PRESSURE PSI (Gauge) Pounds Condensed Per Hour, Per Lineal Foot of Pipe															Sq. Ft. of Surface = to 1 Lineal Ft. of Pipe
	1	2	4	6	8	10	20	30	40	50	75	100	125	150	200	
¾	.11	.13	.14	.14	.15	.15	.16	.18	.20	.22	.26	.29	.32	.35	.40	.275
1	.15	.15	.16	.16	.17	.18	.20	.23	.25	.27	.31	.35	.39	.42	.49	.345
1½	.21	.21	.22	.23	.23	.24	.28	.33	.36	.39	.45	.50	.55	.60	.69	.497
2	.24	.25	.26	.27	.27	.29	.33	.38	.42	.46	.54	.61	.68	.74	.81	.622
2½	.30	.31	.32	.33	.34	.36	.41	.46	.51	.55	.65	.73	.81	.88	.97	.752
3	.38	.39	.40	.41	.43	.44	.50	.56	.61	.66	.77	.86	.94	1.03	1.19	.917
4	.46	.47	.48	.49	.51	.53	.61	.68	.76	.83	1.04	1.11	1.23	1.33	1.50	1.179
5	.55	.56	.59	.60	.62	.64	.74	.83	.91	1.00	1.24	1.32	1.46	1.59	1.81	1.459
Per Sq. Ft. Heat. Surface	.34	.35	.36	.37	.39	.41	.47	.53	.59	.65	.73	.81	.90	1.00	1.15	

Flash Steam Explanation and Calculation

Flash Steam
When hot condensate above the saturation temperature under pressure, is released to atmospheric pressure, the excess heat is given off by reevaporation or what is commonly referred to as flash steam.

Flash steam is important because it contains heat which can often be utilized for economy. It is necessary to know how it is formed and how much will be formed under given conditions.

The Btu values given in the Properties of Saturated Steam tables provide the necessary data for calculating energy loss due to flash steam.

Float and thermostatic traps, bucket traps, and disc traps discharge condensate at approximately saturation temperature. Thermostatic traps discharge condensate 10° to 30°F. below the saturation temperature.

Flash Steam Heat Loss Calculation

The form provided to the right will allow you to easily calculate the flash steam loss and associated energy cost.

Lines A, B, C, D, and E are based on the actual operating conditions. It may be necessary to estimate the average conditions when loads fluctuate.

Lines F, G, H and I can be filled in using the values from the Properties of Saturated Steam table.

The calculation for flash loss may now be made with the annual loss determined.

The calculation of energy cost may now be made to determine the flash loss and required heating of make-up water to replace the flash loss.

The amount of make-up water and water cost can also be determined using this form.

How to Calculate Your Own Flash Steam and Energy Loss
List Operating Conditions:

A. ____Initial Saturation Pressure.

B. ____Reduced Pressure.

C. ____System Load in Lbs. Per Hr..

D. ____Cost of Steam Per 1,000 Lbs.

E. ____Make-up Water Temperature ° F.

From Properties of Saturated Steam Table:

F. ____Btu/Lb. in Condensate at Initial Pressure.

G. ____Btu/Lb. in Condensate at Reduced Pressure.

H. ____Btu/Lb. Latent Heat in Steam at Reduced Pressure.

I. ____Btu/Lb. in Make-up Water.

Calculation of Flash Steam Loss

$\frac{F - G}{H}$ x 100 = % flash loss

______ x 100 = ______% of flash loss

C x % flash loss = lbs. per hr. loss

To obtain annual loss multiply lbs. per hr. loss x hr. per day x days per year process operates = lb. of flash steam annually.

Calculation of Energy Loss:
This calculation must take into consideration that, not only are we reducing the temperature of the returns, but that the condensate removed in the form of flash steam must be replaced with cooler make-up water.

% of returns x system load lbs./hr. x (F - G) = Btu/hr. condensate cooling.

% of flash loss x system load lbs./hr. x (F - I) = Btu/hr. make-up water loss.

Btu condensate cooling + make-up loss = Btu/hr. loss.

Btu/hr. loss x hr. per day x days per year = annual Btu loss.

Btu annual loss ÷ H = equivalent lb./yr. loss.

Lb./hr. loss ÷ 1,000 x D = annual cost of flash steam loss.

Lb./Year Flash Loss ÷ 8.33 = Gallons per year make-up water.

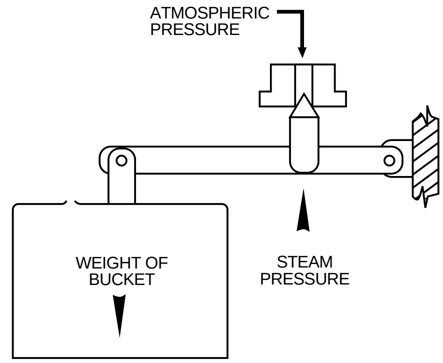
Operating Pressure Limits

Steam Trap Operating Pressure Selection
A given size float and thermostatic trap or bucket trap is offered with various orifice sizes which determine the maximum pressure rating. A Hoffman Specialty F & T trap for example is offered with seats rated 15 psi, 30 psi, 75 psi, 125 psi and 175 psi. A low pressure seat and pin has a larger orifice size which provides a higher condensate rating than a high pressure seat.

When actual operating pressure is higher than the seat rating, the differential pressure across the seat will prevent the trap from opening. Thus, the trap must be selected for the maximum differential pressure that will be encountered. The trap capacity tables show capacities at lower pressures to allow selection at various operating points.

A high pressure seat may be used at lower differential pressures, however, the capacity rating will be less than the same size trap with a low pressure rated seat.

Excessive Steam Pressure Forces Trap Closed



Installation and Calculating Differential Pressure

Trap Installation
Steam traps should be installed in an accessible location at least 15 inches below the condensate outlet of equipment or steam mains being drained. A 15 inch static head at the trap will provide approximately ½ psi differential across the trap when it drains into a vented gravity return system. During start-up, before a positive steam pressure is achieved, the static head is the only differential pressure across the trap. When the steam equipment is controlled by a temperature regulator, the steam pressure will be reduced as the valve modulates toward the closed position. When the pressure drops to O psi, the static head is the only differential pressure across the trap. The differential pressure across the trap can be increased by lowering the trap below the steam equipment. A 2.4 ft. static head will provide 1 psig. A greater differential pressure will reduce the size of the trap required.

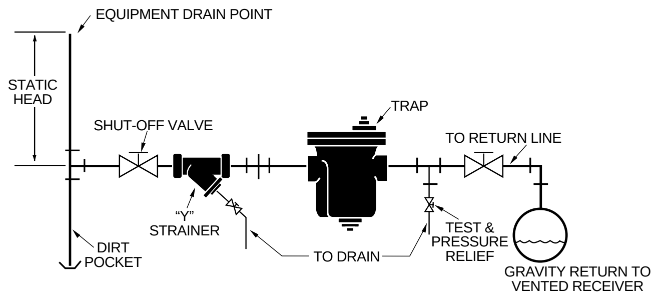
Piping Details
A dirt pocket should be provided ahead of the steam trap to collect scale and dirt. A shut-off valve should be provided ahead of the trap to permit service.

Strainers should be provided ahead of the steam trap to prevent dirt from entering the trap. Dirt entering the trap can deposit on the seat and prevent tight closing. A blow-off valve on the strainer will permit strainer screen cleaning. Unions or flanges should be provided to allow removal of the trap for testing, repair or replacement.

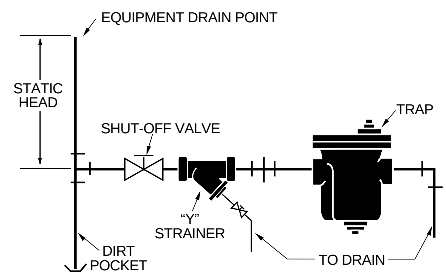
A test and relief valve installed after the trap permits visual indication of the trap operation, and assures that internal pressures are relieved prior to servicing.

A shut-off valve in the trap outlet to the return line isolates the trap from the return line for service.

Trap Installation
Trap draining to gravity return line



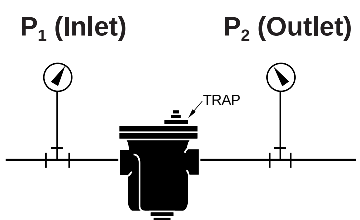
Trap Installation
Trap draining to open drain



The use of bypass piping around steam traps is not recommended. Bypass valves, if opened, may cause pressurization of condensate receivers and cause a safety hazard. Where stand-by protection is desired the use of a stand-by trap in parallel to the normal trap is recommended.

Where the trap drains into a pressurized return line or to an overhead return, a check valve should be installed after the trap to prevent backflow through the trap when the steam is off. The check valve also helps protect the trap from cavitation (water hammer) that may occur when traps discharge high temperature condensate into wet return lines. Water hammer occurs when high temperature condensate under pressure ahead of the trap discharges into a lower pressure return line. The high temperature condensate flashes, causing steam pockets to form. When these steam pockets give up their heat they implode and cause water hammer.

Differential Pressure = P_1 minus P_2



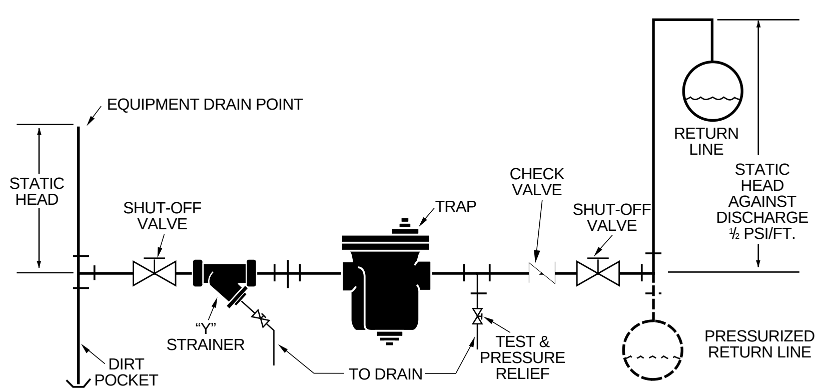
Differential Pressure

The differential pressure across the trap will be the sum of the minimum operating pressure, plus the positive static head at the trap inlet minus any back-pressure in the return line minus static head in the discharge piping. Trap capacities should be calculated at the minimum differential pressure to assure complete condensate drainage.

Lifts in the return piping should be avoided wherever possible. High temperature condensate discharging from the trap may flash at the lower return line pressure. The flashing into a wet return line will cause steam pockets. As these steam pockets lose their latent heat they implode, causing water hammer. Water hammer can damage traps, pipe and fittings.

Lifts in the discharge piping after a trap will cause back-pressure. A 2.4 ft. lift is equal to a 1 psig pressure. This is especially important on low pressure operation or where a modulating control valve is used to control the flow of steam. Reduced flow will cause pressure drops. A positive differential must be assured under all possible conditions to assure complete condensate drainage.

Trap Installation
Trap draining to overhead return line or pressurized return line



Drip Traps for Distribution Pipes

Drip Traps for Steam Distribution Piping
The steam distribution piping, often referred to as steam mains, provides the link between the boiler and the steam utilizing equipment. The steam piping must be kept free of air and condensate. This requirement is met with the use of steam traps installed in the piping. The traps used for draining the steam mains are commonly referred to as drip traps. If the steam mains are not adequately trapped the results are often water hammer in the piping. Water hammer is caused by slugs of condensate traveling at high speed in the steam pipes, which can damage valves and piping.

Drip traps are installed in the steam mains at all risers, ahead of all reducing valves, ahead of all regulators, at the end of mains, throughout the piping at intervals at least every 500 feet, at expansion joints and at all steam separators.

The size and type of drip traps used will depend on the method used in heating the steam mains to final pressure and temperature. The two methods commonly used are automatic start-up and supervised start-up.

In systems using automatic start-up the steam boiler is used to bring the mains up to final pressure and temperature without supervision. The drip traps must handle the full condensing load during start-up of the system.

In systems using supervised start-up the operator opens manual valves in the steam piping before steam is admitted to the system. When the system reaches normal pressure and temperature, the manual valves are closed. The drip traps for supervised start-up are sized only for the running load.

The sizing of drip traps will depend on the type of start-up used. During the initial start-up of automatic startup systems, a large amount of condensing occurs, bringing the steam piping from ambient temperature up to the final steam temperature.

When supervised start-up is used the drip trap is sized only to handle the heat loss through the steam piping.

Calculation of the running load is figured using the following formula:

lbs./hr. running load heat loss =

$$\frac{L \times U \times \Delta T \times E}{S \times H}$$

L = Length of steam line.

U = Heat transfer from curve in Figure 1.

T = Temperature difference between steam temperature and minimum ambient in degrees F.

E = 1- Efficiency of insulation (for 80% efficient insulation use 1.80 = .2).

S = Linear feet of pipe to provide 1 sq. ft. surface area.

H = Latent heat of steam in Btu/lb. (see Properties of Saturated Steam Table).

Calculation for warm-up load at start-up:

Warm-up load lb./hr. =

$W \times (T_1 - T_2) \times .114\ L$

W = Weight of pipe (see table below for weight per ft.).

T_1 = Steam temperature at saturation.

T_2 = Initial pipe temperature at ambient.

L = Latent heat of steam at final operating pressure.

.114= Specific heat of steel or wrought iron pipe.

S VALUE FT. OF PIPE PER SQ. FT. OF SURFACE AREA	
Pipe Size	**S Value**
1"	2.904
1¼"	2.301
1½"	2.010
2"	1.608
3"	1.091
4"	0.848
5"	0.686
6"	0.576
8"	0.442
10"	0.355
12"	0.299
14"	0.272
16"	0.238
18"	0.212
20"	0.191
24"	0.159

W VALUES WEIGHT OF WELDED SEAMLESS STEEL PIPE		
Nominal Pipe Size	**Schedule 40 Wt. Lbs. Per Linear Ft.**	**Schedule 80 Wt. Lbs. Per Linear Ft.**
½"	.85	1.09
¾"	1.13	1.47
1"	1.68	2.17
1¼"	2.27	3.0
1½"	2.72	3.63
2"	3.65	5.02
2½"	5.79	7.66
3"	7.58	10.25
4"	10.79	14.98
6"	18.97	28.57
8"	28.55	43.39

Example: Assume a steam supply header to feed tracer lines is 11/4” pipe size operating at 30 psig and is 800 ft. long, insulated 75% effect, minimum ambient at start-up is 10°F. Calculate running load and warm-up load.

Step 1

Running load lb./hr. $= \frac{L \times U \times \Delta T \times E}{S \times H}$

$$= \frac{800 \times 2.7 \times (274 - 10) \times .25}{2.301 \times 926}$$

= 66.9 lb./hr.

Step 2

Calculate warm-up load:

$$C = \frac{W \times (T_1 - T_2) \times .114}{L}$$

$$= \frac{(2.27 \times 800) \times (274 - 10) \times .114}{926}$$

= 59 lbs. of steam

A warm-up time must be selected to compute lbs./hr. Assuming a warm-up of 15 minutes, we must multiply 59 lbs. x 4 = 236 lbs./hr. Thus, the trap must be sized for 236 lbs./hr. for a 15 minute start-up period, plus a safety factor.

Step 3

We will size the trap for the large value (running load vs. warm-up load), which in almost all instances will be the warm-up load.

Traps should be sized with a safety factor to handle start-up and abnormal loads. Normal practice is to size the trap at three times the running load or two times the warm-up load.

The final sizing for our example would be to size the trap for 236 x 2 = 472 lbs./hr. condensate based on the differential pressure between the header supply pressure and return line pressure. Assuming a gravity return line, this would be 30 psi.

Step 4

Select the trap.

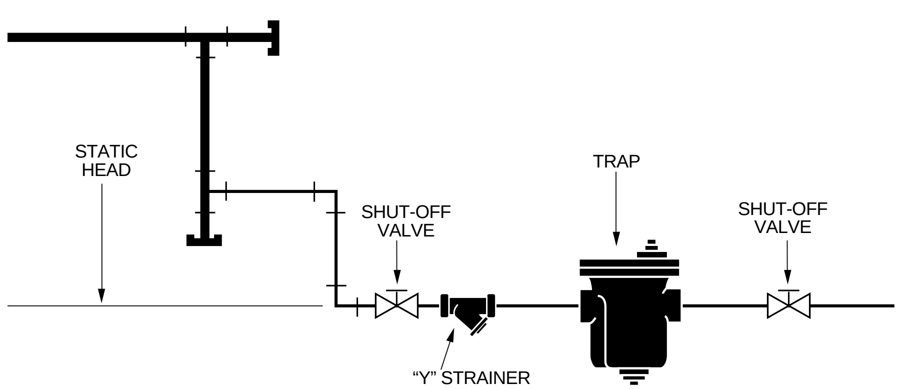
Based on the previous description of traps, if the trap from a steam header is not subject to freezing conditions, the normal selection would be an F & T or Bucket Trap.

If the trap is located in an area subject to freezing, to assure complete condensate drainage during shut-down, we should use either a Thermostatic or Thermodisc Trap. Based on the calculated condensate rate plus the applied safety factor, we would go directly to the trap manufacturer’s catalog and select the trap.

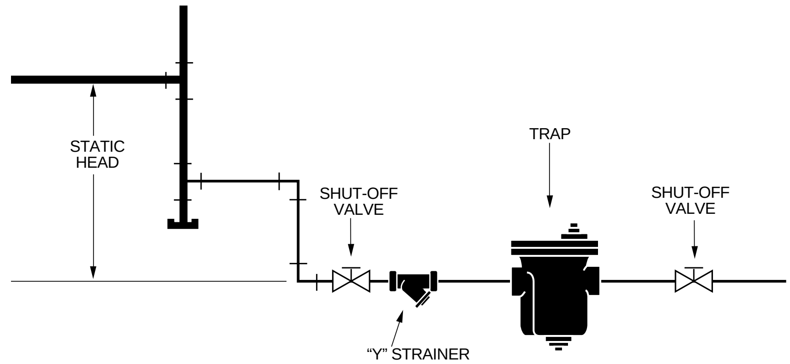
The drip trap should be installed in a drip connection that is at least equal to the size of the steam main for pipe size up to 4 inches. Above 4 inch size the drip connection should be at least 4 inches minimum or 1/2 the size of the steam main, whichever is larger. The height of the drip connections should be the larger of 5 inches or 1½ times the diameter of the pipe.

The static head will provide the differential pressure across the trap during automatic start-up until the steam pressure is above 0 psig. A 15 inch static head will provide 1/2 psi differential assuming the trap drains into a gravity return line. A 2.4 ft. static head will provide 1 psi differential pressure.

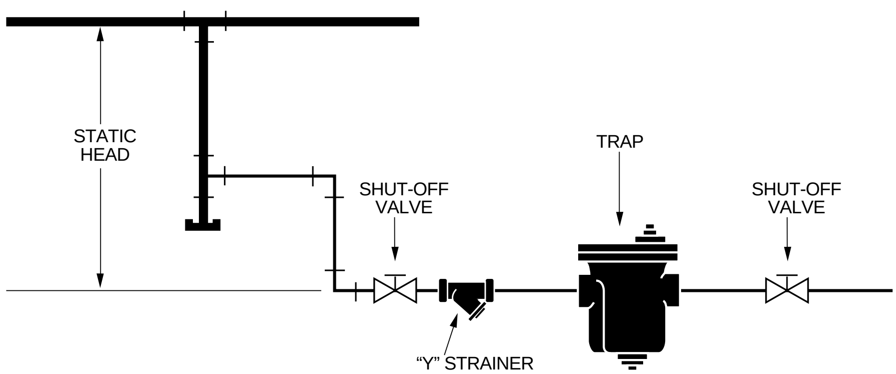
Installation at end of steam main drip trap



Installation of drip trap ahead of riser or expansion joint



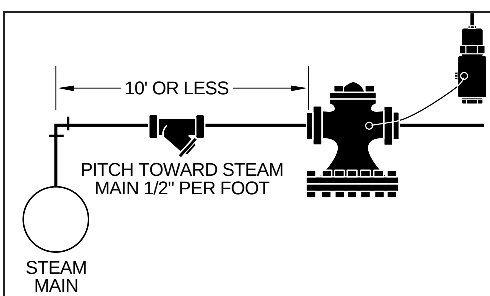
Installation of drip trap in long run of steam piping or ahead of control valves



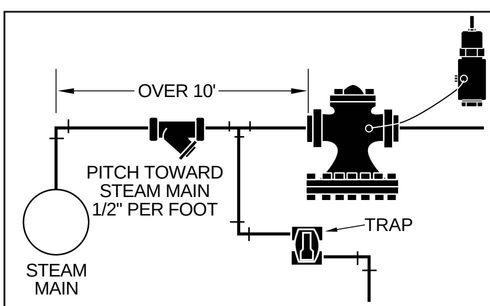
Trapping Ahead of Steam Regulators

When steam pressure or temperature regulator valves are installed in a steam line, condensate may back up ahead of the valve when it is off. When the valve opens with condensate backed up on the inlet side, the condensate will cause water hammer.

Where the branch connection to a control valve is less than 10 ft., the branch line may pitch toward the steam main to allow condensate to flow back into main.



When the branch line is over 10 ft., pitch the branch line toward the control valve and install a steam trap. The steam trap should be as close to the control valve as possible.



Selecting Steam Traps for Heat Exchangers

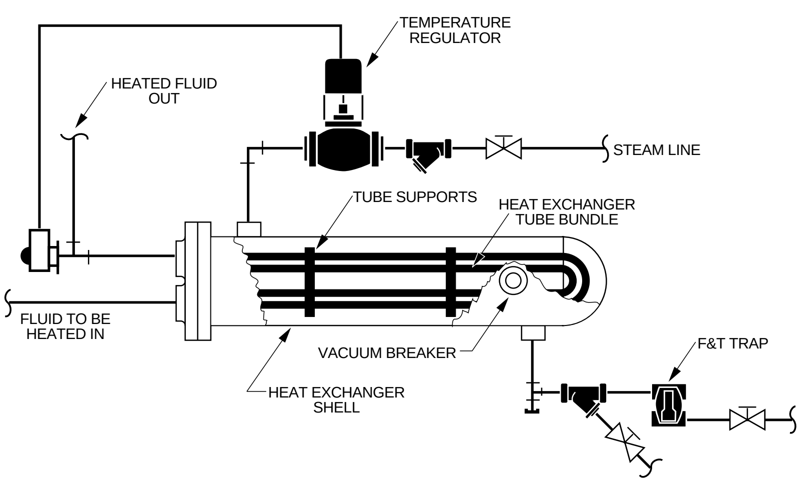
Steam heating devices using a modulating temperature regulator must operate over a wide range of conditions. As the temperature regulator controls the flow of steam, condesation causes a change in pressure. Thus, the steam trap must be capable of handling a wide range of capacities at varying pressures. Selection of the trap for these conditions is more involved than it would be for drip traps or steam equipment operating at constant pressure.

A heat exchanger is sized to heat a maximum expected flow rate through the tubes, over the maximum expected temperature rise with a predetermined maximum steam operating pressure.

When the tube side flow rate is reduced, or the incoming fluid being heated requires less of a temperature rise, the steam control valve partially closes, reducing the flow of steam to maintain a constant set temperature of the fluid being heated. The condensing of the steam under reduced load conditions results in a lower steam pressure in the shell of the heat exchanger.

During very low load conditions the condensing of the steam can create an induced vacuum in the shell of the heat exchanger. This condition requires that a vacuum breaker be installed to allow air to enter and relieve the induced vacuum. Without a vacuum breaker, the induced vacuum would cause a negative pressure differential across the trap and the condensate would not be drained from the heat exchanger shell.

Steam to Fluid Heat Exchanger



Complete condensate drainage under all varying pressure and condensing loads is essential to prevent tube damage due to water hammer. The steam flow in the heat exchanger shell must pass around the tube support sheets. If condensate builds up in the heat exchanger shell, it will condense rapidly as steam is mixed with it, causing water hammer. The water hammer is often evident by indentations in the tubes and collapsed tubes.

Thus, it becomes evident that the design condensing rate at design pressure is not the only load the trap must handle. The condensing load of a heat exchanger designed for 15 psi may in fact be in excess of 90% at 0 psig. When the heat exchanger is selected, a fouling factor is added to assure adequate tube area as scale builds up on the tube walls. Before this scale develops, the heat exchanger is in fact oversized which results in a lower steam operating pressure.

A steam trap must then be selected to handle the full condensing load with the heat exchanger operating at 0 psig. The heat exchanger may operate at a slight vacuum due to the condensing of steam. A vacuum breaker is required on a heat exchanger to prevent induced vacuum. The differential required to open the vacuum breaker is usually less than 0.25 psi.

Recommended practice is to install the trap as far below the heat exchanger as possible. The minimum distance should be 15 inches. A 15 inch static head will develop approximately 0.5 psig at the trap inlet, less the differential required to open the vacuum breaker. Assuming 0.25 psi to open the vacuum breaker, a properly sized trap must be capable of draining the full rated condensing load with 0.25 psi differential across the trap, draining into an atmospheric gravity return line. A static head of 2.4 feet will provide 1 psig. The differential required to open the vacuum breaker must be subtracted from the static pressure to determine the differential across the trap.

Selecting the type of trap becomes the next step. Traps that operate in response to temperature should be avoided for heat exchanger operation. This eliminates thermostatic traps from our selection. As described above, the trap must be capable of responding to varying condensing rates at various differential pressures. The two types of traps that can meet these requirements are Float and Thermostatic Traps and Bucket Traps. The Float and Thermostatic Trap has the ability to modulate over a wide range of conditions, providing a drainage rate equal to the system load. The Float and Thermostatic Trap also has a separate thermostatic vent to provide quick passage of air during start-up or during a change of condition. The bucket trap will completely drain the condensate but operates in cycles between full open and close. The bucket trap has a slower air venting rate unless fitted with a separate thermostatic element. Return line sizing can be minimized using the Float and Thermostatic Trap due to its modulating feature which provides a continual flow equal to the condensing rate.

General practice in sizing traps is to allow a safety factor in the selection. During start-up when the heat exchanger shell is cold, the steam piping is cold and the fluid to be heated may be at less than design temperature. All these conditions will cause a higher steam condensing rate. Float and Thermostatic Trap safety factors are normally 1.5 to 2.5 times rated load. Bucket Trap safety factors are normally 2 to 4 times rated load .

Guidelines for selecting traps for heat exchangers using modulating steam temperature regulators are as follows:

—Select capacity based on maximum condensing load at minimum differential pressure that can occur. The heat exchanger manufacturer can provide this information.

—No lifts should be installed in the return line piping. The trap must drain into an atmospheric gravity return line.

—Install a vacuum breaker to prevent induced vacuum in the heat exchanger from causing a reverse in differential pressure across the trap.

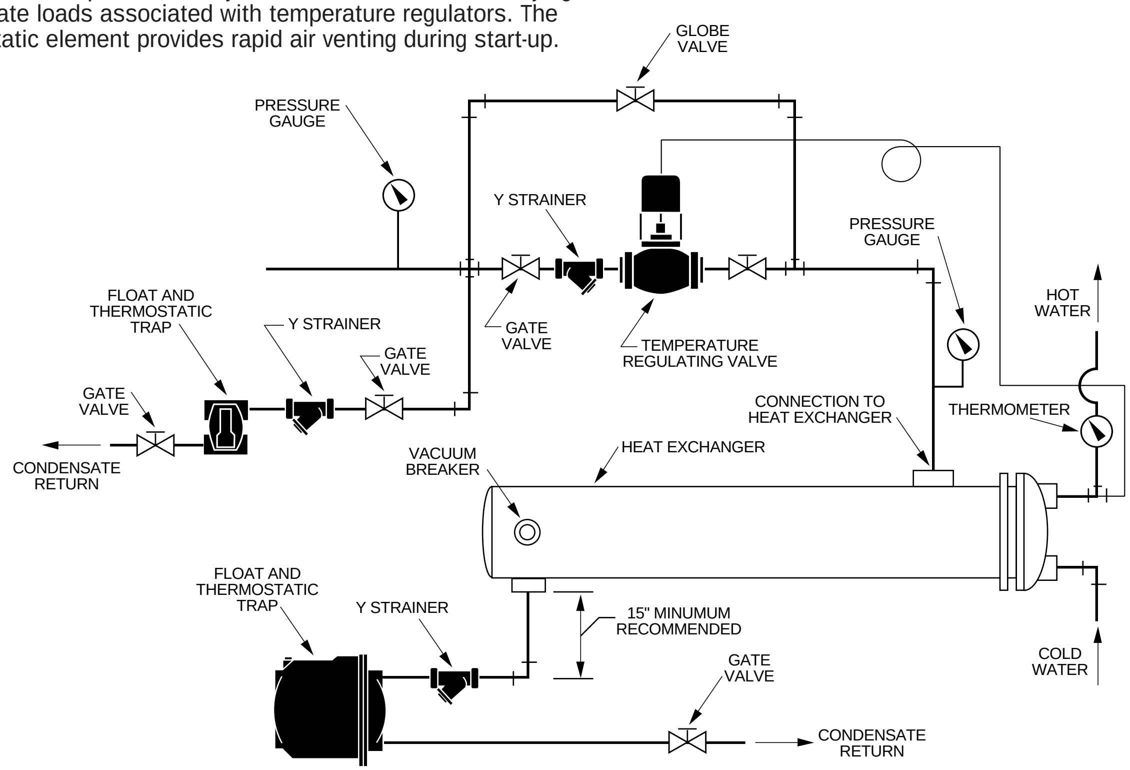
—Install the trap as far below the heat exchanger as possible to develop a static pressure to the trap inlet. The minimum should be 15 inches.

—Select a trap that provides complete drainage of condensate. Avoid use of temperature controlled traps.

—Allow an adequate safety factor for start-up conditions.

Typical Heat Exchanger Installation

Float & Thermostatic Traps assure complete condensate drainage at saturation temperature. They also modulate to handle varying condensate loads associated with temperature regulators. The thermostatic element provides rapid air venting during start-up.



Condensate Coolers

When heat exchangers are selected for operation above 2 psig, consideration should be given to the addition of a condensate cooler. The justification will vary depending on the size of the heat exchanger and the actual time the unit is in operation.

With a condensate cooler, the discharge from the trap on the primary heat exchanger is piped through a water-to-water heat exchanger. This lowers the condensate temperature and recovers wasted heat. A second trap is then installed on the discharge of the condensate cooler to maintain saturation pressure and prevent flashing and water hammer in the condensate cooler.

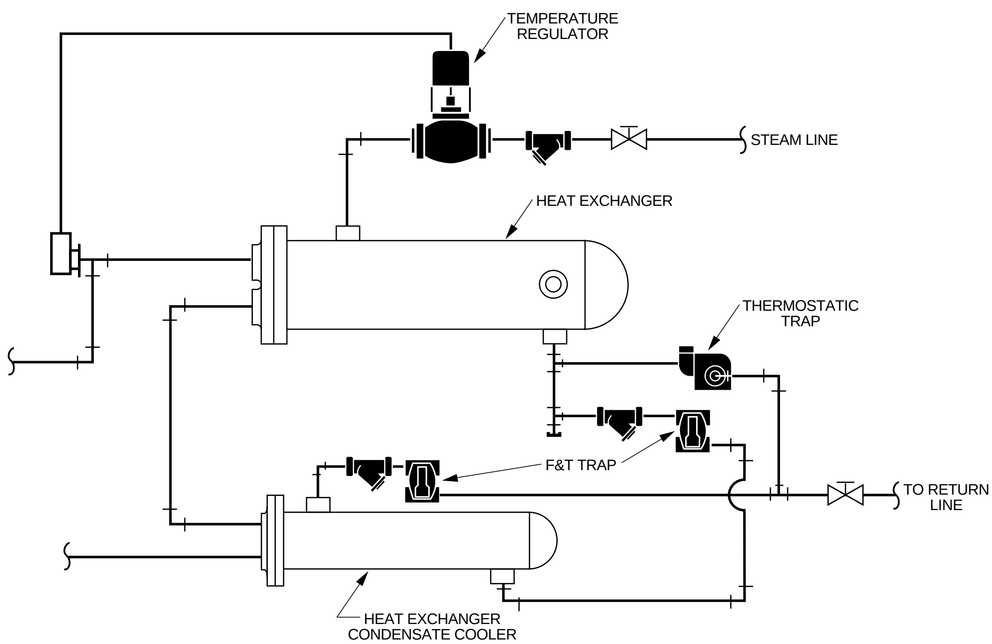
The water-to-water heat exchanger design differs from steam heat exchangers. The water-to-water heat exchanger has internal baffles to direct the water flow across the tubes to improve heat transfer. The water-to-water heat exchangers are externally distinguishable because the top and bottom shell openings are both the same size. The steam-to-water heat exchangers have a large opening in the top for the steam inlet and a smaller bottom outlet for the condensate drainage.

When a modulating steam regulator is used on the steam-to-water heat exchanger, the vacuum breaker will allow air to enter to prevent an induced vacuum from holding up condensate. The F & T Trap must be installed 15 inches below the heat exchanger to provide condensate drainage when the internal pressure drops to O psig. A separate Thermostatic Trap should be provided to allow the air to be vented when the pressure increases above O psig. This trap bypasses the condensate cooler to allow free passage of the air into the gravity return line.

The fluid in the condensate cooler on the tube side, may be the same fluid that is to be heated in the steam heat exchanger when the initial temperature is sufficiently low. When the initial temperature of the fluid is too high to cool the condensate below 212°F, other fluids may be heated. Heating domestic hot water or pre-heating boiler make-up water are two possibilities.

Piping Detail of Condensate Cooler

When fluid being heated is too hot to cool condensate below 212°F., other heating requirements may be circulated through the condensate cooler.



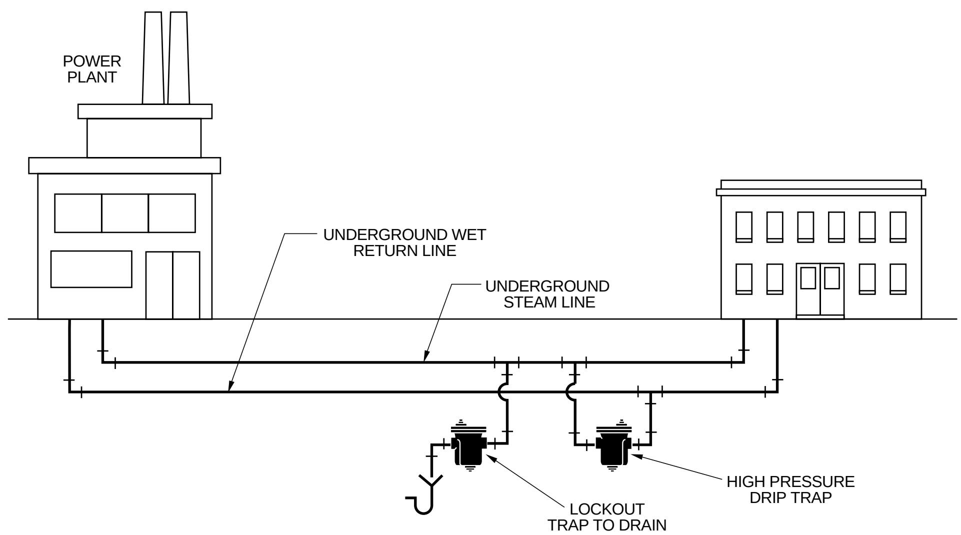
Lock-Out Traps for Start-Up Loads

Lock-out Traps For Draining Condensate Under Low Pressure.
In the discussion of trap operation, we pointed out that if the differential pressure across the trap seat exceeds the trap pressure rating, the trap will fail closed. This occurs when the differential force across the seat and pin exceeds the drop-away force created by the weight of the float or bucket and linkage. Under certain conditions we can use a trap with a low differential pressure in a high pressure application to drain condensate during start-up or operation at reduced pressure. Low pressure F & T or Bucket Traps may be used for lock-out applications.

Lock-out Trap Used to Drain Underground Steam Main.
One application of a lock-out trap is to drain condensate from underground steam lines during start-up. The low pressure trap connected to an open drain or sump drains condensate during start-up. When the steam line pressure exceeds the trap rating it will close and remain closed. The differential pressure will then allow the condensate to flow through the high pressure drip trap and be recovered through the return line.

This method may also be used where a modulating temperature regulator may reduce pressure ahead of the trap. When the regulator reduces the flow of steam, the pressure in the steam space drops due to the condensing rate in relation to steam flow. The low pressure trap connected to a sump or drain will then operate when the pressure drops approximately to the rated pressure of the trap.

Lock-out trap used to drain underground steam main

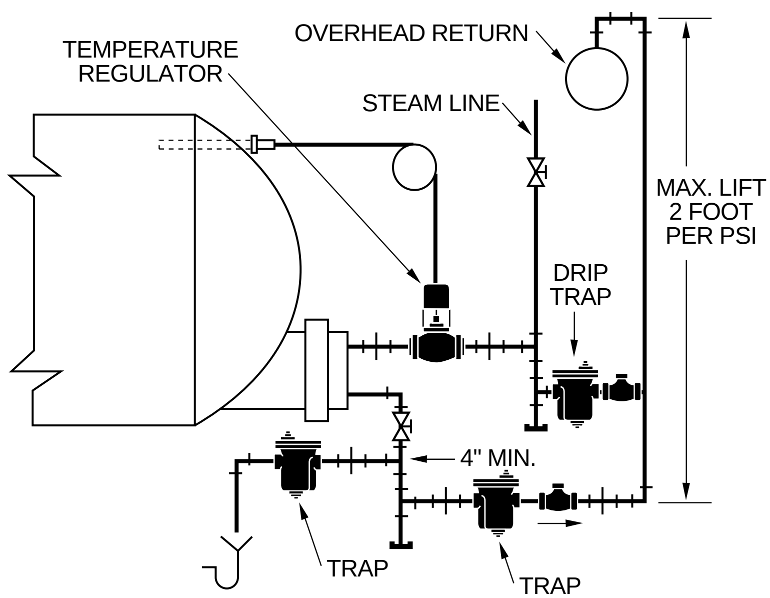


Draining Condensate to Overhead Returns

Draining Condensate to Overhead Returns or into Pressurized Return Lines
When a positive pressure is assured across the steam trap, 1 psi will raise condensate 2 feet. When a positive pressure is not assured, such as the case when using a steam control valve, provision must be made to drain condensate at reduced pressure loads and during initial start-up. The use of a second trap installed at a higher elevation and connected to a drain may be used as shown below. The normal trap is connected to the overhead return line with a check valve to prevent backflow. The second trap may be a low pressure trap. When condensate backs up 4 inches it will drain into the second trap which will drain condensate into a floor drain or sump.

When a trap drains into an overhead return line or pressurized return line, water hammer may occur due to high temperature condensate flashing as it drains through the trap into a lower pressure. The check valve after the trap protects it from the forces created by water hammer. It also prevents backflow through the trap when the steam is off.

Draining condensate to overhead return lines



Submerged Pipe Coils

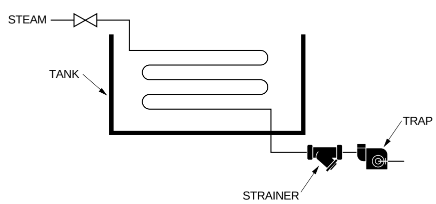
Submerged pipe coils are sometimes gravity drained, with the trap installed below the coil. Figure 2 shows such an installation. Use a safety factor of 2 for trap sizing.

When it is not practical to install the trap below the tank level, a lift fitting or water seal must be provided to bring the condensate to the trap level over the heated tank. Figure 3 shows a water seal arrangement. Note that the trap is installed below the siphon looped over the top of the tank. Condensate collects in the water seal and is elevated to the siphon loop by the differential pressure. A safety factor of 3 should be used.

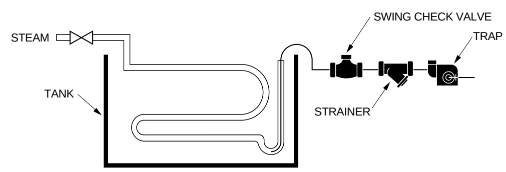
Large diameter coils may require yet another type of installation. Where the coil diameter is larger than the trap inlet size, the installation shown in Figure 4 should be used. A smaller tube is placed inside the large tube and insures that steam will not enter the trap until all of the condensate has been drained from the coil. The lift fitting tube is usually sized one pipe size smaller than the trap inlet, but never less than 1/2" pipe size.

The coils in Figures 2,3 and 4 are of the continuous type. Coils are often multi-circuited. A safety factor of 4 is needed where this is the case because of the higher warm-up load.

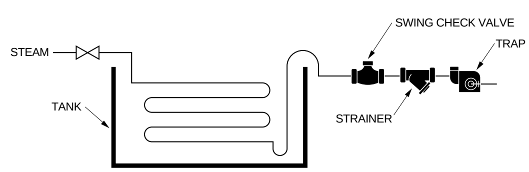
Embossed plate coils are piped in the same fashion as ordinary pipe coils. Where the coil is of the continuous type and gravity drained, the safety factor is 2 to 1. Siphon drained coils require a 3 to 1 safety factor. Multiple header plate coils should have a safety factor of 3 to 1 if they are gravity drained and 4 to 1 if siphon drained. Figure 5 illustrates these coil types.



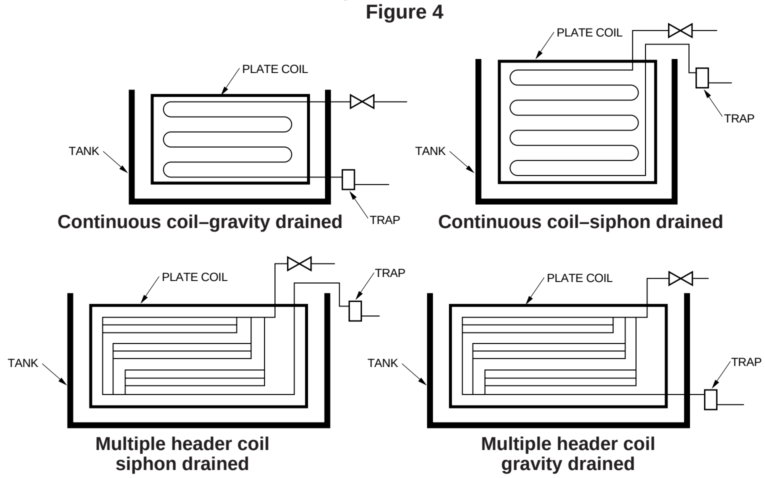
Continuous coils–gravity drained
Figure 2



Continuous coils–siphon drained
Figure 3



Large diameter continuous coil siphon drained
Figure 4



Typical embossed plate coil installations
Figure 5

Jacketed Kettles

Jacketed Kettles

Kettles are often of the tilting type. These require the use of a siphon drain. Siphon drains may either be internal or external. The Fig. 6 shows both types.

As shown in the illustration, external siphons are surrounded by ambient air, while the internal siphon is surrounded by steam.

Flash steam tends to form in siphons and the trap must be able to operate properly with a certain amount of it present in the condensate. Figure 7 illustrates how this takes place, and how a steam main is drained. First, condensate drains into the water seal. Steam in the siphon above the water seal condenses, dropping the pressure. Condensate rises in the siphon as this takes place. The siphon may form and break several times before it is established and condensate enters the trap.

A check valve must be used to hold the siphon while it is forming. This should be installed after the strainer as shown. Once the siphon is established, the drop in static pressure as the elevation decreases causes some of the hot condensate to "flash off." The presence of steam in the condensate decreases its density and actually assists the flow. An external type siphon loses some heat by radiation to the ambient air and the condensate within it tends to cool. As a result, the amount of flash steam is less than in an internal siphon, which absorbs heat from the steam surrounding it.

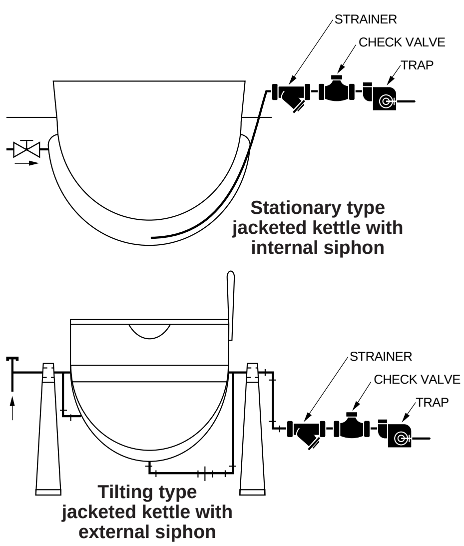
Air Handling Capability

The excellent air handling capability of Thermostatic Traps makes them suitable for trapping applications where quick air removal is required. For example, batch processes resulting in on-off operation of steam heating equipment are prone to air problems. The steam space becomes filled with air in between heating cycles. Unless this air is quickly removed with the condensate, slow heating of the batch results. Thermostatic Traps must be fitted with a cooling leg, when used for this purpose, to minimize back up of condensate into the equipment.

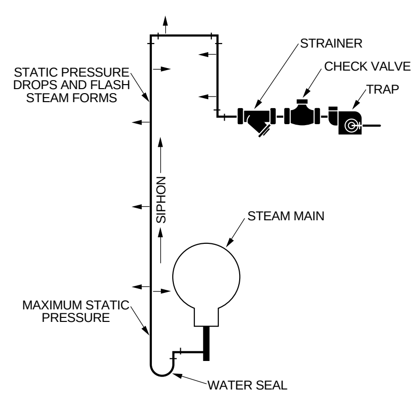
Figure 8 shows a steam kettle serviced by a Thermostatic Trap. A cooling leg with a minimum length of 5 ft. is provided to insure enough cooling of the condensate to open the trap.

Notice the check valve provided at the trap outlet. This prevents back drainage of the condensate in the vertical line. A check valve should always be provided at the trap outlet where vertical lifts exists.

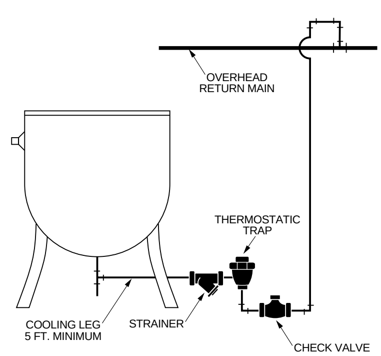
The safety factor for steam kettles is usually 3 times rated capacity. Siphon type kettles may use either F & T or Bucket Traps. Stationary kettles may use Thermostatic Traps.



External and internal jacketed kettles
Figure 6



Principle of condensate line siphon
Figure 7



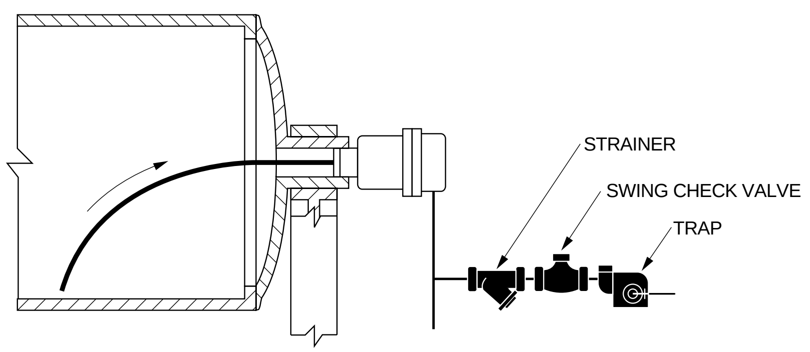
Steam kettle showing cooling leg
Figure 8

Cylinder Dryers

Cylinder dryers are widely used in the processing industry. Since they are usually rotating in nature, siphon drainage of the condensate is involved. Figure 9 shows a typical arrangement. Condensate is drained from the bottom of the rotating cylinder by a typical siphon arrangement.

Because of their large volume and surface area, traps for this type of application should be sized with a substantial safety factor. This is required to eliminate the air and handle the large warm-up load. It is not uncommon to use safety factors of between 5 and 8 for cylinder dryers.

Siphon drained cylinder dryer — Figure 9



Unit Heaters

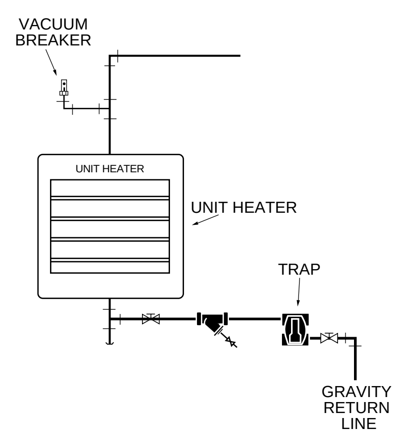
Unit heaters may be selected to operate over a wide range of pressures. Operation may have maintained steam pressure in coils with a thermostat to control the fan or steam control may be on-off as heat load is required.

Small low pressure unit heaters up to 15 psi often use Thermostatic Traps. Large unit heaters or those operating at higher pressure may use F & T as first choice and Bucket Traps as second choice.

When the ambient air may be below freezing or when outside make-up air is used, a vacuum breaker is required to prevent an induced vacuum from occurring when the steam is turned off. Induced vacuum causes a reverse differential pressure across the trap and holds up condensate in the coils. This is the major cause of coil freezeup. The trap must also be able to drain by gravity to assure complete condensate removal.

The recommended safety factor for sizing traps for unit heaters is 3 times rated capacity. Low pressure traps may be sized using SHEMA rating without any additional safety factor.

Unit heater



Steam Radiators

Radiators

Radiators normally use Thermostatic Traps to drain condensate. The Thermostatic Trap is a pressure balanced device that will open usually 10° to 30° F. below saturation temperature. A Thermostatic Trap on a low pressure 3 psi system will open at approximately 190° to 200°F. A 10° to 30° F. drop in condensate temperature normally occurs in the return piping in a low pressure heating system. This controls the return condensate at about 160°F. and simplifies the selection of condensate return units.

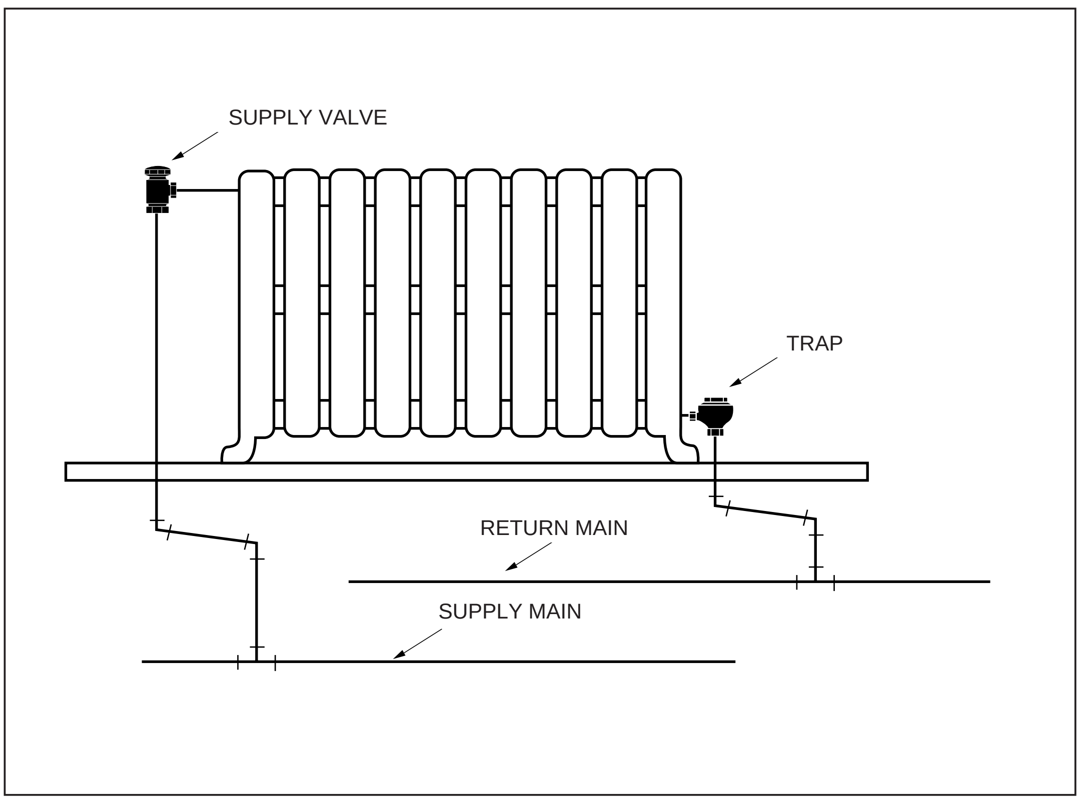
Low pressure Thermostatic Traps are normally rated in sq. ft. E.D.R. heating load and have a SHEMA rating which allows the proper safety factor.

Thermostatic Traps are inexpensive in relation to other types of traps. This makes them attractive for heating systems where many large numbers of traps are required.

Trap Damage from Water Hammer

When automatic temperature controlled supply valves are used, water hammer may occur when the valve closes. This occurs due to the condensing of steam in the radiator causing an induced vacuum. The induced vacuum may pull in flash steam from the return line. As this steam enters the condensate in the bottom of the radiator, steam pockets form and implode as they lose their heat. The forces of water hammer (cavitation), can quickly destroy bellows or diaphragm type radiator traps. A solid fill Hoffman Specialty 17K is designed to withstand this service.

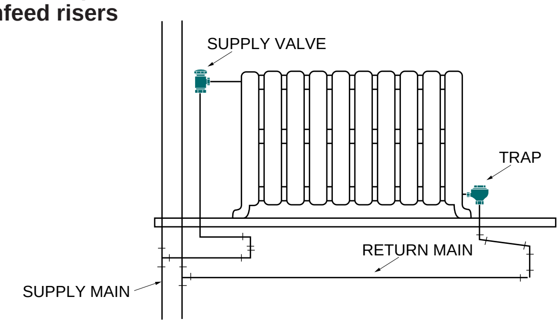
Water hammer may also occur during start-up when lifts are present in the discharge piping after the trap.



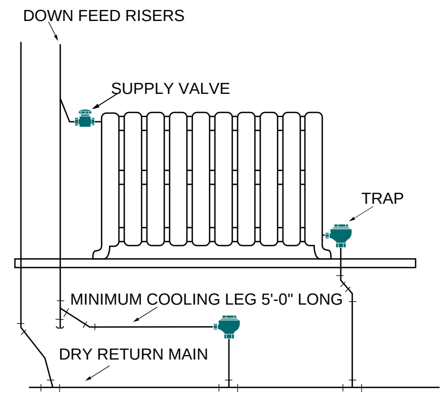
The piping and radiator connections shown in this section are diagrammatic and illustrate the proper method of making piping connections. They are not dimensional and cannot be scaled for pipe size or product size.

Two pipe steam systems radiator connections

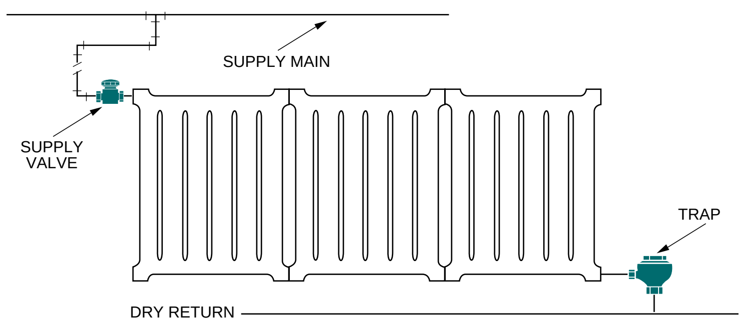
Radiator connections taken from up or downfeed risers



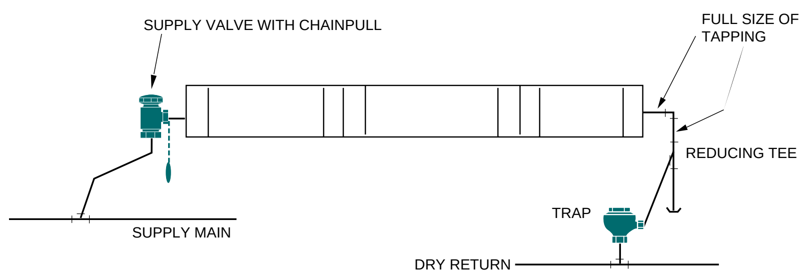
Dripping heel of downfeed riser into dry return



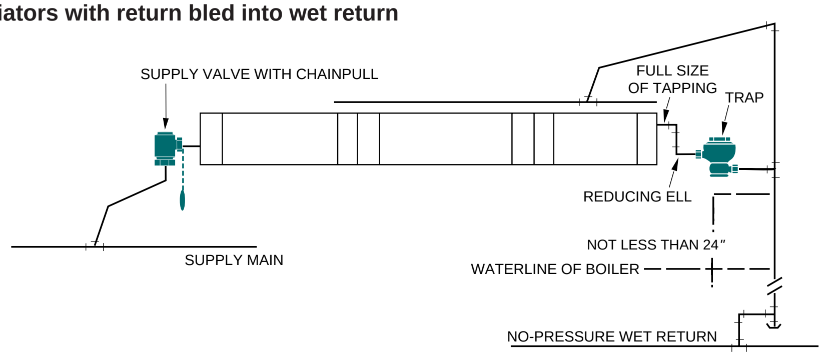
Connections to radiator wall panel



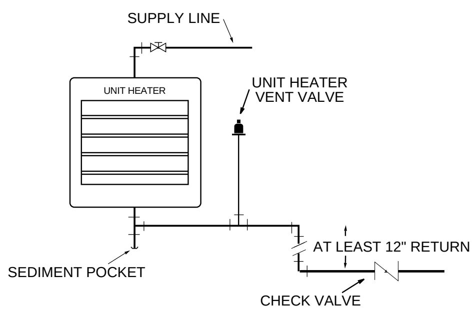
Connections to ceiling radiator located above supply & return



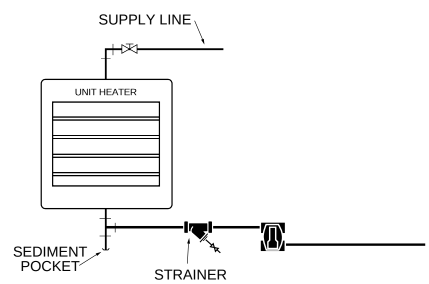
Connections to ceiling radiators with return bled into wet return



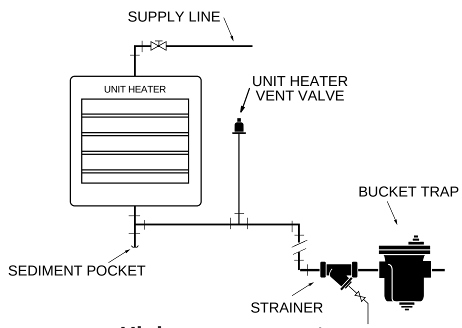
Piping connections for unit heaters (steam)



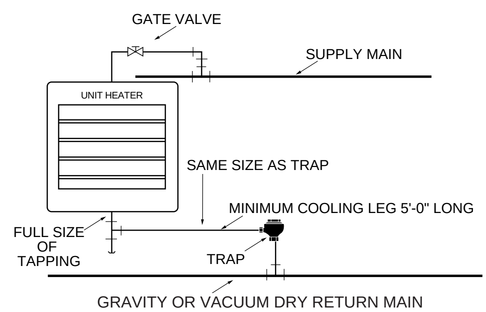
Low pressure closed gravity system



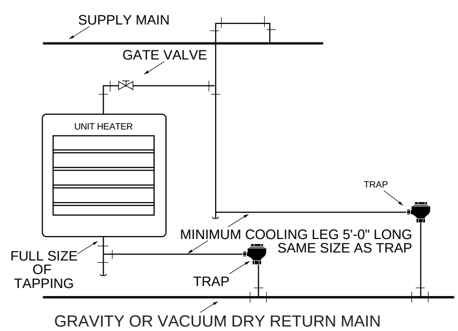
Vacuum or low pressure open gravity system



High pressure system

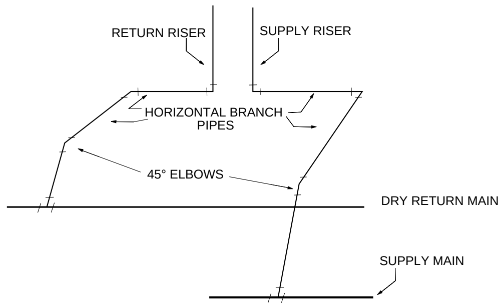


Unit heater connections for two pipe gravity or vacuum system

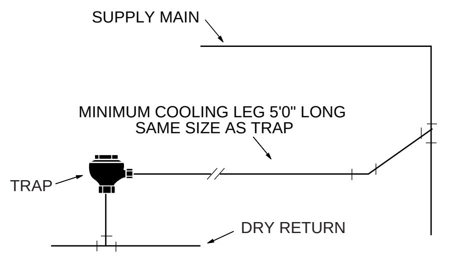


Unit heater connections for two pipe gravity or vacuum system with supply branch dripped through trap

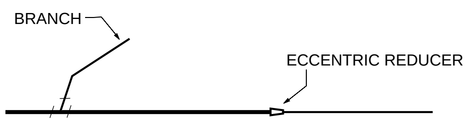
Two pipe–
steam trap installations



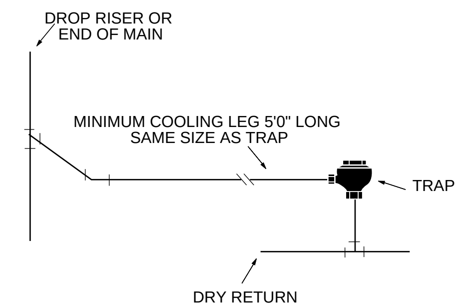
Connections for upfeed risers



Dripping end of supply main into dry return

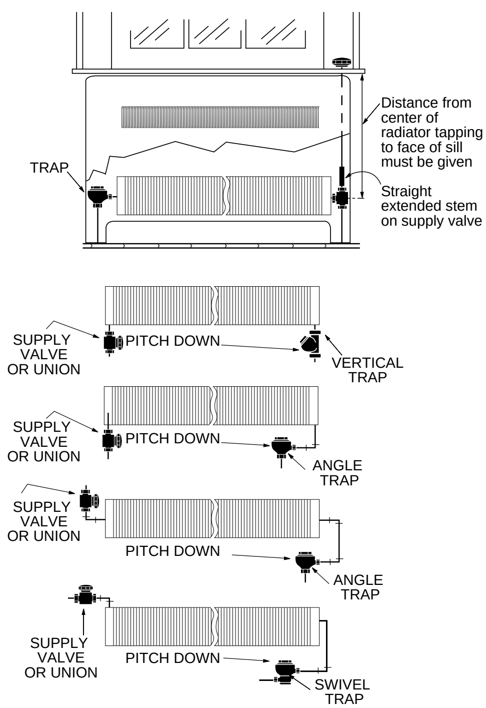


Method of reducing size of main

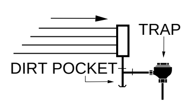


Dripping drop riser or end of main into dry return

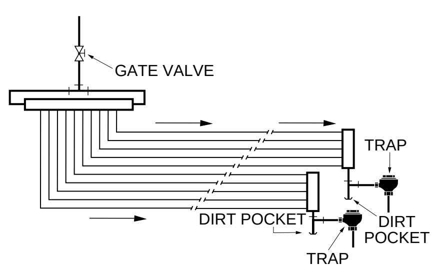
Two pipe steam systems convector connections



Exposed pipe coils–
two pipe steam

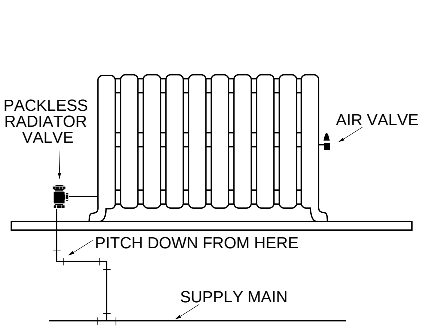


Connections to header coils of not over 8 pipes

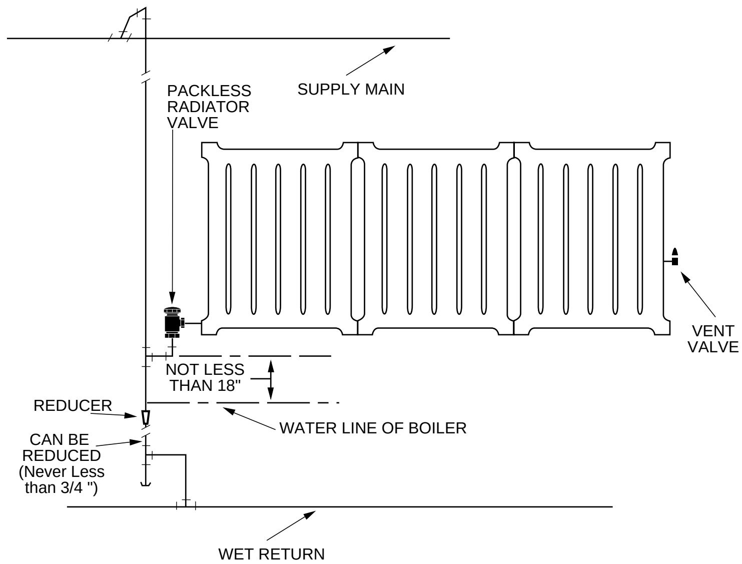


Connections to header coils having more than 8 pipes

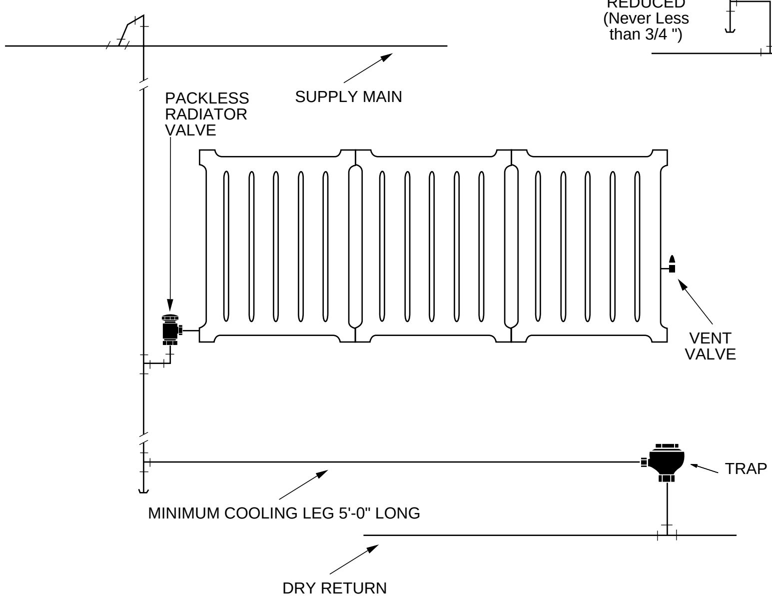
One pipe steam systems radiator connections



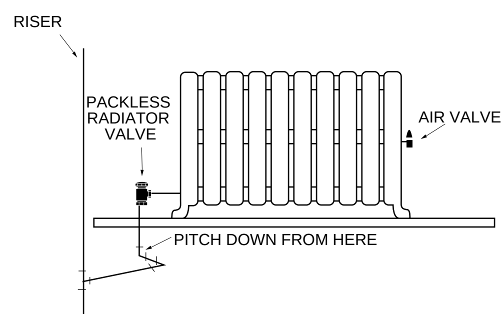
Upfeed connection to radiator



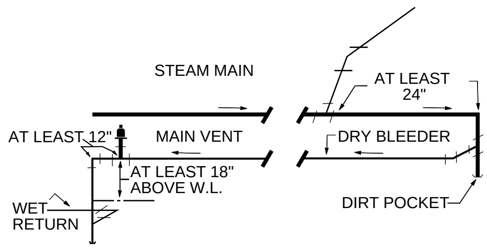
Downfeed connections with wet return



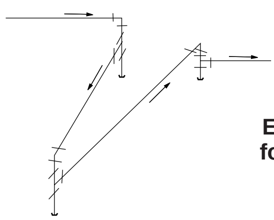
Downfeed connections dripping riser into condensation pump return



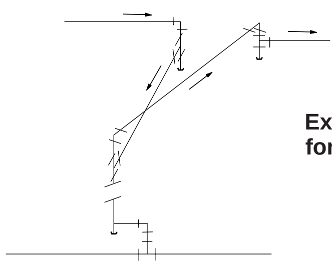
Radiator connection taken from up or downfeed riser



Dripping end of one pipe steam main where same extends beyond wet return

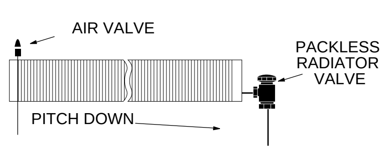


Expansion joint made up of pipe for horizontal pipes–dripped into wet return

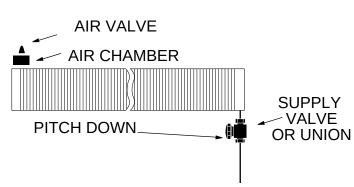


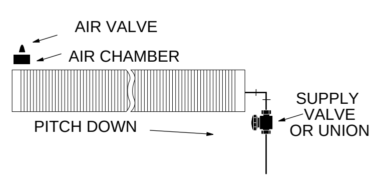
Expansion joint made up of pipe for horizontal pipes–not dripped

One pipe steam systems convector connections

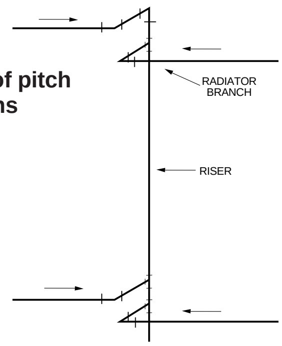


Venting concealed radiator of header type–air vent tapping in top

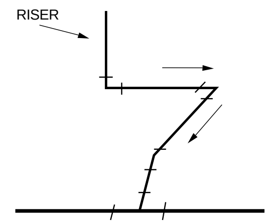




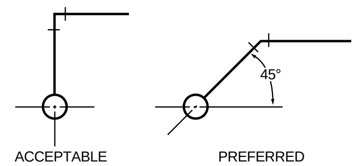
NOTE:
→
Indicates direction of pitch in piping connections



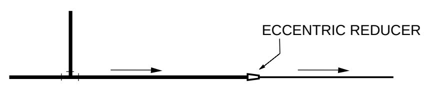
Method of taking double radiator branch connections from riser



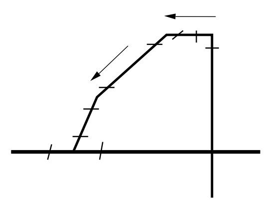
Upfeed branch connection taken from main at 45°



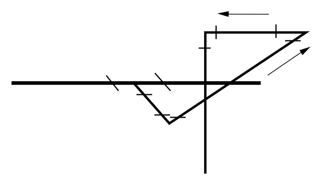
Method of taking branches from mains



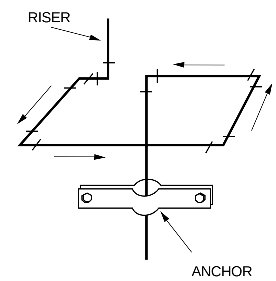
Method of reducing size of mains



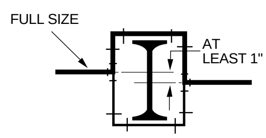
Drop riser branch taken from top of main at 45°



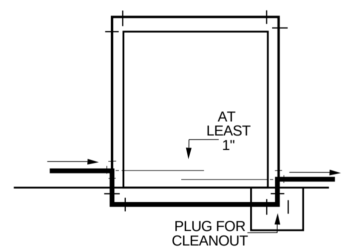
Drop riser taken from bottom of main



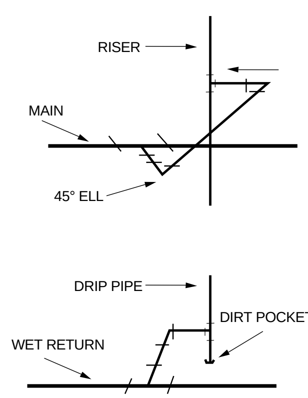
Expansion joint made up of pipe for risers



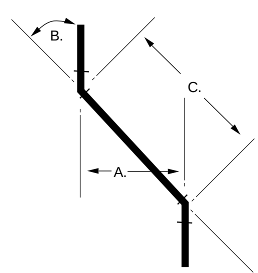
Looping main around beam



Looping dry return main around door



Riser branch taken from bottom of main and dripped into wet return



B	Constant
11 ¼°	5.126
22 ½°	2.613
30°	2.000
45°	1.414
60°	1.155

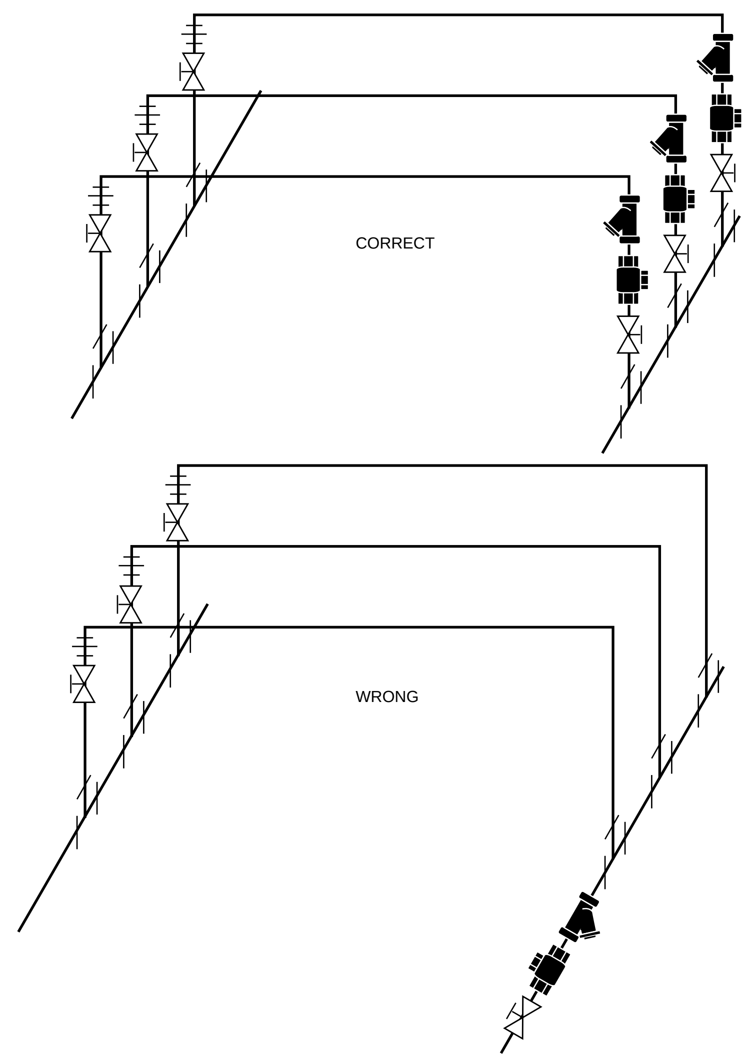
To find C—multiply A by constant for angle B

Trapping Steam Tracer Lines

Each individual steam tracer line requires a separate trap to assure condensate drainage. When more than one tracer line is manifolded into a common trap, condensate can back up in the line with the greatest pressure drop.

Individual tracer line trap selection guide:

1. **Bucket Traps** may be used for tracer lines in areas not subject to freezing. The tracer lines should be installed for gravity drainage when Bucket Traps are used. Condensate will drain at saturation temperature for maximum heat transfer. Bucket Traps are normally too expensive for larger tracer applications.
2. **Thermodisc Traps** were designed for tracer line applications. The pulsation of the thermodisc opening will cause condensate collected at low points to move through the tracer line. When installed according to manufacturer's instructions, Thermodisc Traps completely drain all condensate from the body when the steam is off, to prevent freezing. Thermodisc Traps drain condensate at saturation temperature for maximum heat transfer. They are inexpensive and the Hoffman 650 Series allow complete replacement of the seat and disc without removing the trap body from the line.
3. **Thermostatic Traps** open in response to temperature, not condensate level. Use where maximum heat transfer is not important. Thermostatic Traps normally open 10° to 30°F. below saturation temperature to extract the maximum Btu's from the steam before draining condensate. Applications using Thermostatic Traps should be pitched to allow gravity condensate drainage. Thermostatic Traps selected for tracer lines should fail open. When the steam is off, the thermostatic element will open draining condensate to prevent freezing.
4. **F & T Traps** should never be used for tracer line applications. They are subject to freezing when located in low ambient conditions when the steam is off. They are more expensive and normally fail in a closed position.

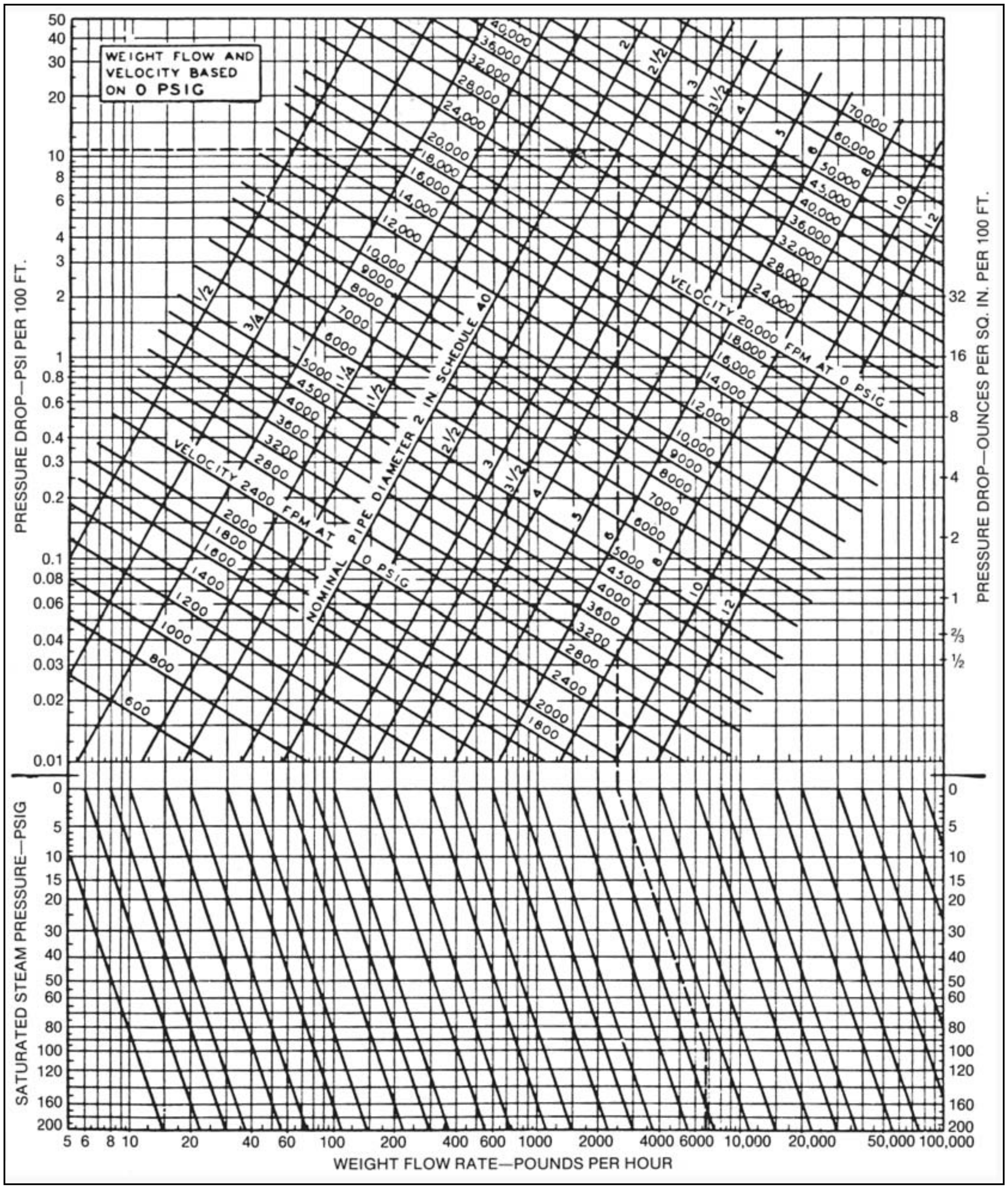


1. Each tracer line must have its own trap.

2. A common trap with manifold tracer lines may cause short circuiting through lines with lower pressure drop.

3. Longer lines will back-up condensate and will not provide adequate heat transfer.

4-Step Method for Sizing Steam Lines



Based on Moody Friction Factor where flow of condensate does not inhibit the flow of steam.

Basic Chart for Weight-Flow Rate and Velocity of Steam in Schedule 40 Pipe Based on Saturation Pressure of 0 PSIG

Figure 10

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Velocity of Steam

General Heating Applications—
4,000 to 6,000 fpm.
Process Pipe—
6,000 to 12,000 fpm.

Sample Problem Using Steam Velocity Charts (Fig. 10).

General Heating Application—2,000 lbs./hr. Required at 30 psi supply pressure.

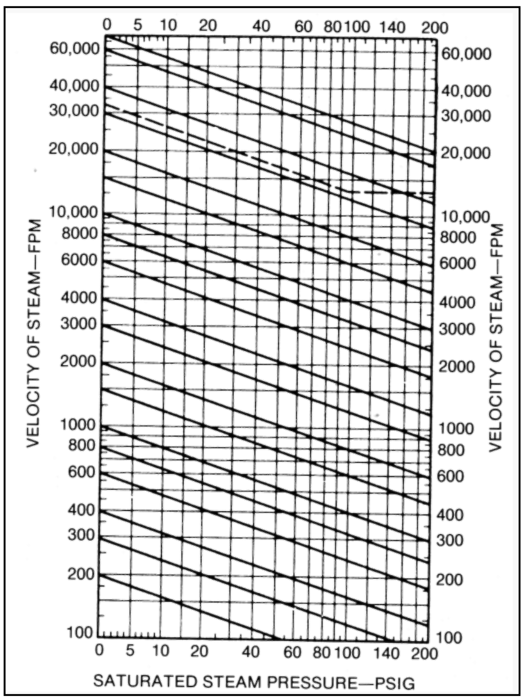
Size Pipe and Determine Velocity and Pressure Drop

Step 1

Correct 30 psi flow rate to 0 psi on basic chart. This is done by entering bottom at 2,000 lbs./hr. Follow this point vertically to the 30 lb. line, then follow slope to the 0 psi line.

Step 2

Draw vertical line from 0 point into upper curve. Stop at some point above 6,000 fpm. Velocity shown is 0 psi steam and requires correction.



Velocity Multiplier Chart

Figure 10 (continued)

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Step 3

Try 3 inch pipe showing 10,000 fpm velocity and pressure drop of approximately .9 psi per 100 feet.

Step 4

Use velocity multiplier chart. Enter left column at 10,000 fpm, follow sloping line to 30 psi. Read corrected velocity of 6,000 fpm in right column.

NOTE:

1. Use velocity chart to correct 6,000 fpm, required velocity, to 10,000 fpm before using basic chart.

2. Heat exchanger steam entrance nozzles are normally sized at reduced velocities to avoid impingement damage to the tube bundle. Check with heat exchange manufacturer for nozzle size.

Example of Use of Basic and Velocity Multiplier Charts.

Given:

a. Weight-Flow Rate = 6700 lb. per hr.
b. Initial Steam Pressure = 100 psig.
c. Pressure Drop = 11 psi per 100 ft.

Find:

a. Size of Schedule 40 pipe required.
b. Velocity of steam in pipe.

Solution: The following steps are illustrated by the broken line on Fig. 10:

Step 1. Enter Fig. 10 at a weight-flow rate of 6700 lb. per hr. and move vertically to the horizontal line at 100 psig.

Step 2. Follow along inclined multiplier line (upward and to the left) to horizontal 0 psig line. The equivalent weight flow at 0 psig is about 2500 lb. per hr.

Step 3. Follow the 2500 lb. per hr. line vertically until it intersects the horizontal line at 11 psi per 100 ft. pressure drop. The nominal pipe size is 2½ in. The equivalent steam velocity at 0 psig is about 32,700 fpm.

Step 4. To find the steam velocity at 100 psig, locate the value of 32,700 fpm on the ordinate of the velocity multiplier chart at 0 psig.

Step 5. Move along the inclined multiplier line (downward and to the right) until it intersects the vertical 100 psig pressure line. The velocity as read from the right (or left) scale is about 13,000 fpm.

NOTE: The preceding Steps 1 to 5 would be rearranged or reversed if different data were given.

ASHRAE Method for Sizing Return Lines

Condensate that collects ahead of a steam trap is approximately at saturation temperature and corresponds to the operating pressure. As the condensate (normally above 212°F.) drains into the return line, it must flash to reach saturation temperature at atmospheric pressure. The excess Btu's are released in the form of flash steam in the return lines. The return lines must be sized to handle the volume of steam and condensate at reasonable velocities to minimize any backpressure. The volume of steam is normally several times the volume of condensate and is generally maintained at less than 7,000 feet per minute.

The following tables are for horizontal return lines draining to a return system. Return lines should pitch 1½ in. per 10 ft. of horizontal run. Select the return line size based on the steam operating pressure and the allowable △p/L, psi/100 ft. Selections for 100 and 150 psig steam for either a vented return system or a 15 psig pressurized return system such as a flash tank, deaerator or closed return system.

Example: A condensate return system has a steam supply at 100 psig and the return line is at 0 psig and not vented. The return line is horizontal and must have a capacity of 2500 lbs./hr. What size pipe is required?

Solution: Since the system will be throttling non-subcooled condensate from 100 psig to 0 psig there will be flash steam and the system will be a dry-closed return with horizontal pipe. Select a pressure drop of ¼ psi/100 ft. and use a 2½ in. pipe for this system.

FLOW RATE (lbs./hr.) FOR DRY RETURN LINES

Flow Rate (lbs./hr.)	Supply Pressure= 5 psig Return Pressure=0 psig		
Pipe Size (in.)	△ p/L, psi/100 ft.		
	1⁄16	¼	1
½	240	520	1100
¾	510	1120	2400
1	1000	2150	4540
1¼	2100	4500	9500
1½	3170	6780	14,200
2	6240	13,300	a
2½	10,000	21,300	a
3	18,000	38,000	a
4	37,200	78,000	a
6	110,500	a	a
8	228,600	a	a

Flow Rate (lbs./hr.)	Supply Pressure= 15 psig Return Pressure=0 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1⁄16	¼	1
½	95	210	450
¾	210	450	950
1	400	860	1820
1¼	840	1800	3800
1½	1270	2720	5700
2	2500	5320	a
2½	4030	8520	a
3	7200	15,200	a
4	14,900	31,300	a
6	44,300	a	a
8	91,700	a	a

Flow Rate (lbs./hr.)	Supply Pressure= 30 psig Return Pressure=0 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1⁄16	¼	1
½	60	130	274
¾	130	280	590
1	250	530	1120
1¼	520	1110	2340
1½	780	1670	3510
2	1540	3270	a
2½	2480	5250	a
3	4440	9360	a
4	9180	19,200	a
6	27,300	a	a
8	56,400	a	a

Flow Rate (lbs./hr.)	Supply Pressure= 50 psig Return Pressure=0 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1⁄16	¼	1
½	42	92	200
¾	91	200	420
1	180	380	800
1¼	370	800	1680
1½	560	1200	2520
2	1110	2350	a
2½	1780	3780	a
3	3190	6730	a
4	6660	13,800	a
6	19,600	a	a
8	40,500	a	a

Flow Rate (lbs./hr.)	Supply Pressure= 100 psig Return Pressure=0 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1⁄16	¼	1
½	28	62	133
¾	62	134	290
1	120	260	544
1¼	250	540	1130
1½	380	810	1700
2	750	1590	a
2½	1200	2550	a
3	2160	4550	a
4	4460	9340	a
6	13,200	a	a
8	27,400	a	a

Flow Rate (lbs./hr.)	Supply Pressure= 150 psig Return Pressure=0 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1⁄16	¼	1
½	23	51	109
¾	50	110	230
1	100	210	450
1¼	200	440	930
1½	310	660	1400
2	610	1300	a
2½	980	2100	a
3	1760	3710	a
4	3640	7630	a
6	10,800	a	a
8	22,400	a	a

Flow Rate (lbs./hr.)	Supply Pressure= 100 psig Return Pressure=15 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1⁄16	¼	1
½	56	120	1100
¾	120	260	2400
1	240	500	4540
1¼	500	1060	9500
1½	750	1600	14,200
2	1470	3100	a
2½	2370	5000	a
3	4230	8860	a
4	8730	18,200	a
6	25,900	53,600	a
8	53,400	110,300	a

Flow Rate (lbs./hr.)	Supply Pressure= 150 psig Return Pressure=15 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1⁄16	¼	1
½	43	93	200
¾	93	200	420
1	180	390	800
1¼	380	800	1680
1½	570	1210	2500
2	1120	2350	4900
2½	1800	3780	7800
3	3200	6710	a
4	6620	13,800	a
6	19,600	40,600	a
8	40,500	83,600	a

a For these sizes and pressure losses, the velocity is above 7000 fpm. Select another combination of sizes and pressure loss.

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Testing Steam Traps

Where a test valve is installed in the trap discharge piping, visual inspection is the most positive method of testing.

Thermostatic Traps, and F & T Traps modulate in operation. The discharge should be steady. Bucket Traps and Disc Traps cycle and the discharge should be intermittent. The trap is often discharging condensate above 212°F. When this high temperature condensate discharges to atmosphere flash steam may be present. Flash steam is normal and is not an indication of trap failure. Flash steam is a low velocity white colored discharge with a large stream of condensate. If the trap is blowing live steam it will be at high velocity—a clear area will be present ahead of where the steam begins to condense. Then, a bluish steam will begin and there will be less condensate along with the steam.

When no test valve is installed other methods may be used.

When the piping ahead of the steam trap is cold, this is an indication that the trap has failed in a closed position.

Temperature measuring devices may be used to test thermostatic traps. The temperature immediately ahead of the trap should be lower than the steam coil, radiator, etc.

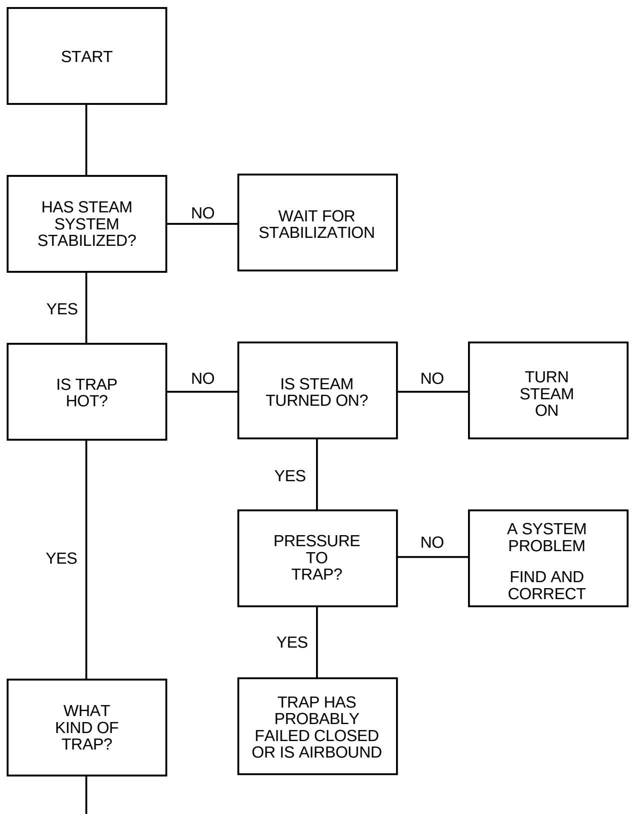
Listening devices may be used to test traps that cycle, these include Bucket Traps and Disc Traps. As the linkage or disc opens, a low pitch sound occurs as condensate discharges. The linkage or disc closing can then be heard. No other sound should follow. A trap blowing live steam will have a higher pitch whistle as steam blows across the orifice.

F & T Traps modulate and discharge at saturation temperature. A fast response temperature scanner may be used to test operation. You will be looking for two-phase flow in the discharge line. Two-phase flow has steam in the discharge line and will be over 212° F. along the piping. Flash steam normally condenses in a short length of piping and will drop in temperature along the pipe. Live steam carried through the pipe will maintain a near constant temperature.

Where several traps are used in similar applications make a comparison between different trap discharge temperatures. You will soon be able to pick out a defective trap. Both a listening device and a temperature scanner should be available to spot trap problems.

Sight checkers provide a positive way to check steam traps. A sight checker would be installed in the outlet piping from the trap. When the trap opens the ball check lifts off the seat. It can be seen moving inside the glass enclosure. When the trap closes the ball should seat. If the trap is blowing live steam the ball will move inside the housing.

Many independent trap survey companies will do field testing of traps. Due to the high cost of waste energy from defective steam traps, a trap survey normally has a good payback.



Check list–step by step

Testing Steam Traps

Objective:
Determine if trap is performing properly & efficiently.

Types of Tests:
Temperature, pressure, flow.

How to Check:
Listening device, temperature device, visual.

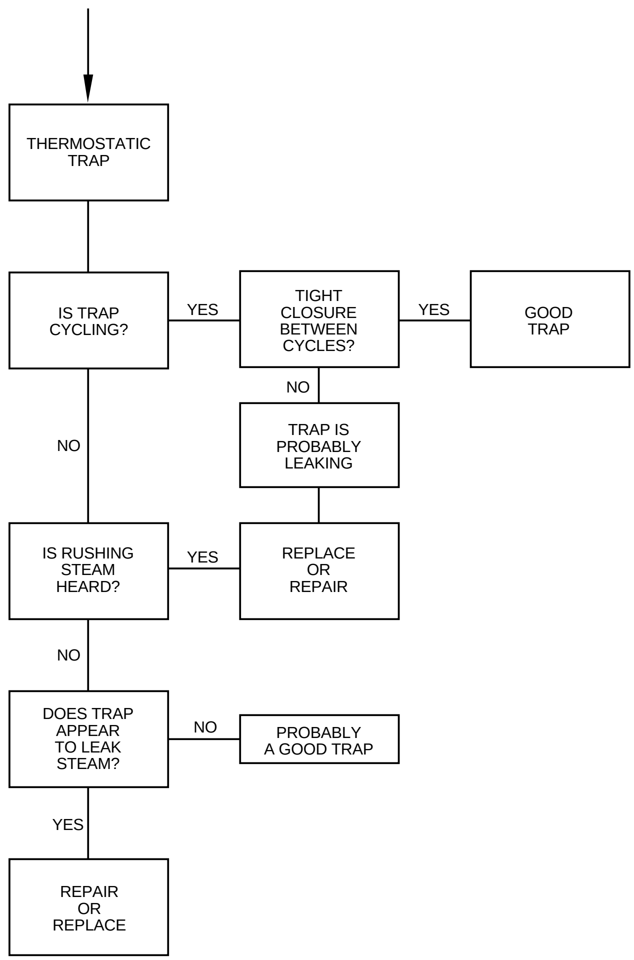
Listening Devices:
Screwdriver, stethoscope, ultrasonic tester.

Temperature Devices:
Gloves, water gun, crayons, pyrometer, infrared.

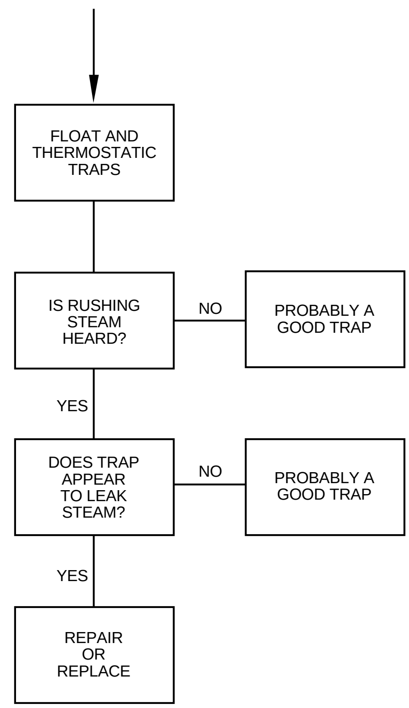
Real Reason:
Hot-cold, Go/no go, Repair or replace.

Trap Type
is a Factor

Thermostatic
- Modulates
- Discharges continuously.
- Sound test—rush of condensate, hiss of live steam.
- Visual—must distinguish between flash & live steam.



Float & Thermostatic
- Modulating device.
- Element passes air.
- More intense—for failed element passing steam.
- Orifice failure—erosion.
- Must distinguish between live steam & flash steam.
- Crushed ball—failure mode is closed.

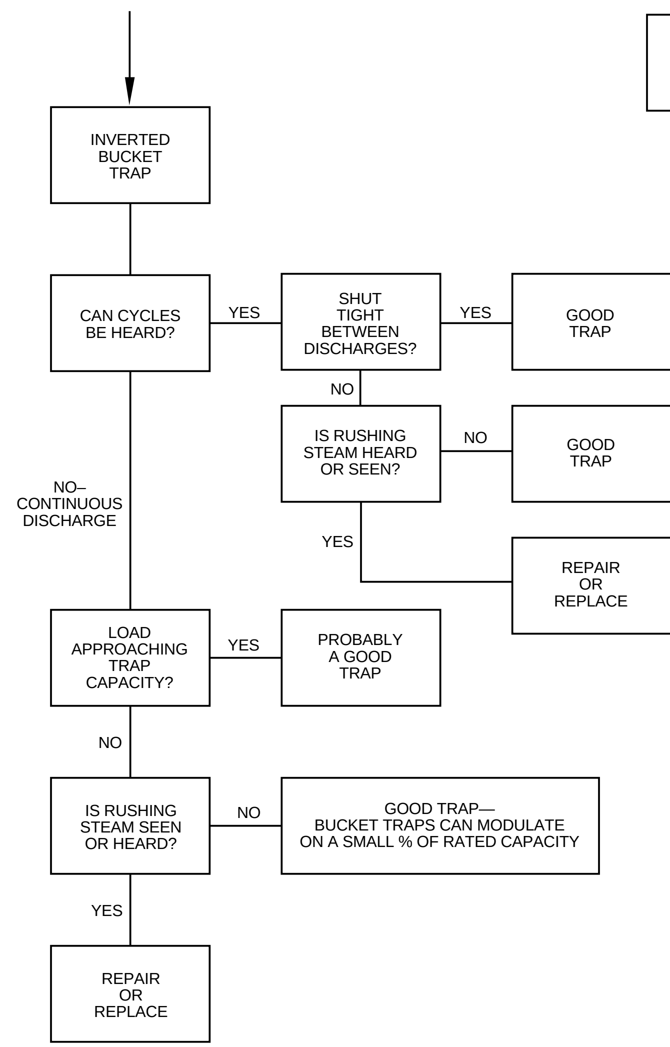


Bucket Trap

- Discharges full capacity then shuts off.
- Muffled rattle of bucket on outer chamber.
- Violent bucket rattle & sound of rushing steam—lost prime.
- Clogged air vent—fails closed.
- Discharge under loads

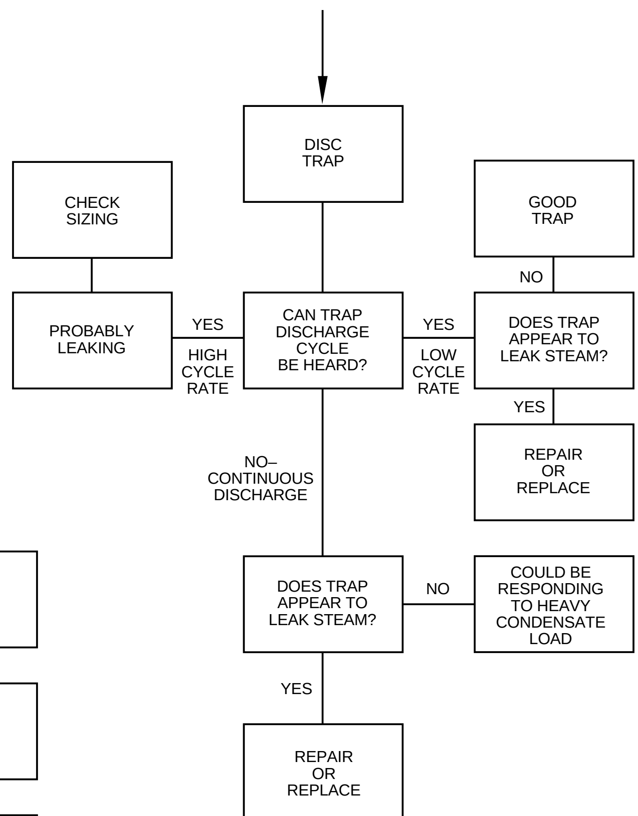
  —Modulates under light load

  —Continuous discharge at full capacity.



Disc

- Best test is sound.
- Trap cycling is audible.
- Disc slams against seat.
- Leaking seat—would be heard.
- Rapid cycle—excessive wear.
- Machine gunning—live steam.



Definition of Heating Terms

The definitions given in this section are only those applying to heating and particularly as used in this book. Some do not define the terms for all usages.

Absolute Humidity: The weight of water vapor in grains actually contained in one cubic foot of the mixture of air and moisture.

Absolute Pressure: The actual pressure above zero. It is the atmospheric pressure added to the gauge pressure. It is expressed as a unit pressure such as lbs.per sq. in. absolute.

Absolute Temperature: The temperature of a substance measured above absolute zero. To express a temperature as absolute temperature add 460° to the reading of a Fahrenheit thermometer or 273° to the reading of a Centigrade.

Absolute Zero: The temperature (-460°F. approx.) at which all molecular motion of a substance ceases, and at which the substance contains no heat.

Air: An elastic gas. It is a mechanical mixture of oxygen and nitrogen and slight traces of other gases. It may also contain moisture known as humidity. Dry air weighs 0.075 lbs. per cu. ft.

One Btu will raise the temperature of 55 cu. ft. of air one degree F.

Air expands or contracts approximately 1/490 of its volume for each degree of rise or fall in temperature from 32° F.

Air Change: The number of times in an hour the air in a room is changed either by mechanical means or by the infiltration of outside air leaking into the room through cracks around doors and windows, etc.

Air Cleaner: A device designed for the purpose of removing air-borne impurities such as dust, fumes, and smokes. (Air cleaners include air washers and air filters.)

Air Conditioning: The simultaneous control of the temperature, humidity, air motion, and air distribution within an enclosure. When human comfort and health are involved, a reasonable air purity with regard to dust, bacteria,and odors is also included. The primary requirement of a good air conditioning system is a good heating system.

Air Infiltration: The leakage of air into a house through cracks and crevices, doors, windows, and other openings, caused by wind pressure and/or temperature difference.

Air Valve: See Vent Valve.

Atmospheric Pressure: The weight of a column of air, one square inch in cross section and extending from the earth to the upper level of the blanket of air surrounding the earth. This air exerts a pressure of 14.7 pounds per square inch at sea level, where water will boil at 212°F. High altitudes have lower atmospheric pressure with correspondingly lower boiling point temperatures.

Boiler: A closed vessel in which steam is generated or in which water is heated by fire.

Boiler Heating Surface: The area of the heat transmitting surfaces in contact with the water (or steam) in the boiler on one side and the fire or hot gases on the other.

Boiler Horsepower: The equivalent evaporation of 34.5 lbs. of water per hour at 212° F. to steam at 212° F. This is equal to a heat output of 33,475 Btu per hour, which is equal to approximately 140 sq. ft. of steam radiation (EDR) .

British Thermal Unit (Btu): The quantity of heat required to raise the temperature of 1 lb. of water 1°F. This is somewhat approximate but sufficiently accurate for any work discussed in this book.

Bucket Trap (Inverted): A float trap with an open float. The float or bucket is open at the bottom. When the air or steam in the bucket has been replaced by condensate the bucket loses its buoyancy and when it sinks it opens a valve to permit condensate to be pushed into the return.

Bucket Trap (Open): The bucket (float) is open at the top. Water surrounding the bucket keeps it floating and the pin is pressed against its seat. Condensate from the system drains into the bucket. When enough has drained into it so that the bucket loses its buoyancy it sinks and pulls the pin off its seat and steam pressure forces the condensate out of the trap.

Calorie (Small): The quantity of heat required to raise 1 gram of water 1°C (approx.).

Calorie (Large): The quantity of heat required to raise 1 kilogram of water 1°C (approx.).

Centigrade: A thermometer scale at which the freezing point of water is 0° and its boiling is 100°.

Central Fan System: A mechanical indirect system of heating, ventilating, or air conditioning consisting of a central plant where the air is heated and/or conditioned and then circulated by fans or blowers through a system of distributing ducts.

Chimney Effect: The tendency in a duct or other vertical air passage for air to rise when heated due to its decrease in density.

Coefficient of Heat Transmission (Over-all)-U-: The amount of heat (Btu) transmitted *from air to air* in one hour per square foot of the wall, floor, roof, or ceiling for a difference in temperature of one degree Fahrenheit *between the air on the inside and outside of the wall, floor, roof, or ceiling.*

Column Radiator: A type of direct radiator. This radiator has not been sold by manufacturers since 1926.

Comfort Line: The effective temperature at which the largest percentage of adults feel comfortable.

Comfort Zone (Average): The range of effective temperatures over which the majority of adults feel comfortable.

Concealed Radiator: See Convector.

Condensate: Water formed by cooling steam. The capacity of traps, pumps, etc., is sometimes expressed in lbs. of condensate they will handle per hour. One pound of condensate per hour is equal to approximately 4 sq. ft. of steam heating surface (240 Btu per hour per sq. ft.).

Conductance (Thermal)-C-: The amount of heat (Btu) transmitted from surface to surface, in one hour through one square foot of a material or construction for the thickness or type under consideration for a difference in temperature of one degree Fahrenheit between the two surfaces.

Conduction (Thermal): The transmission of heat through and by means of matter.

Conductivity (Thermal)-k-: The amount of heat (Btu) transmitted in one hour through one square foot of a homogenous material one inch thick for a difference in temperature of one degree Fahrenheit between the two surfaces of the material.

Conductor (Thermal): A material capable of readily transmitting heat by means of conduction.

Convection: The transmission of heat by the circulation (either natural or forced) of a liquid or a gas such as air. If natural, it is caused by the difference in weight of hotter and colder fluid.

Convector: A concealed radiator. An enclosed heating unit located either within, adjacent to, or exterior to the room or space to be heated, but transferring heat to the room or space mainly by the process of convection. A shielded heating unit is also termed a convector. If the heating unit is located exterior to the room or space to be heated, the heat is transferred through one or more ducts or pipes.

Convertor: A piece of equipment for heating water with steam without mixing the two. It may be used for supplying hot water for domestic purposes or for a hot water heating system.

Cooling Leg: A length of uninsulated pipe through which the condensate flows to a trap and which has sufficient cooling surface to permit the condensate to dissipate enough heat to prevent flashing when the trap opens. A thermostatic trap may require a cooling leg to permit the condensate to drop enough in temperature to permit the trap to open.

Degree-Day: (Standard) A unit which is the difference between 65° F. and the daily average temperature when it is below 65°F. The "degree day" on any given day is equal to the number of degrees F. that the average temperature for that day is below 65° F.

Dew-Point Temperature: The air temperature corresponding to saturation (100 percent relative humidity) for a given moisture content. It is the lowest temperature at which air can retain water vapor.

Direct-Indirect Heating Unit: A heating unit located in the room or space to be heated which is fully or partially closed. The enclosed portion is used to heat air which enters from outside the room.

Direct Radiator: Same as radiator.

Domestic Hot Water: Hot water used for purposes other than house heating such as laundering, dishwashing, bathing, etc.

Down-Feed One-Pipe Riser (Steam): A pipe which carries steam downward to the heating units and into which heating units drain condensation.

Down-Feed System (Steam): A steam heating system in which the supply mains are above the level of the heating units which they serve.

Dry-Bulb Temperature: The temperature of the air as determined by an ordinary thermometer.

Dry Return (Steam): A return pipe in a steam heating system which carries both condensation and air.

Dry Saturated Steam: Saturated steam containing no water in suspension.

Equivalent Direct Radiation (E.D.R.): See Square Foot of Heating Surface.

Extended Heating Surface: Heating surface consisting of ribs, fins, or extended surfaces which receive heat by conduction from the prime surface.

Extended Surface Heating Unit: A heating unit having a relatively large amount of extended surface which may be integral with the core containing the heating medium or assembled over a core, making good thermal contact by pressure, or by being soldered to the core or by both pressure and soldering. An extended surface heating unit is usually placed within an enclosure and functions as a convector.

Fahrenheit: A thermometer scale at which the freezing point of water is 32° and its boiling point is 212° above zero.

Flash (Steam): The rapid passing into steam of water at a high temperature when the pressure it is under is reduced so that its temperature is above that of its boiling point for the reduced pressure. For example: If hot condensate is discharged by a trap into a low pressure return or into the atmosphere, a certain percentage of the water will be immediately transformed into steam. It is also called re-evaporation .

Float & Thermostatic Trap: A float trap with a thermostatic element for permitting the escape of air into the return line.

Float Trap: A steam trap which is operated by a float. When enough condensate has drained (by gravity) into the trap body the float is lifted. In turn, the pin lifts off its seat. This permits the condensate to flow into the return until the float has been sufficiently lowered, to close the port. Temperature does not affect the operation of a float trap.

Furnace: That part of a boiler or warm air heating plant in which combustion takes place. Complete heating unit of a warm air heating system.

Gauge Pressure: The pressure above that of the atmosphere. It is the pressure indicated on an ordinary pressure gauge. It is expressed as a unit pressure such as lbs. per sq. in. gauge.

Head: Unit pressure usually expressed in ft. of water or mil-inches of water.

Heat: That form of energy into which all other forms may be changed. Heat always flows from a body of higher temperature to a body of lower temperature. See also: Latent Heat, Sensible Heat, Specific Heat, Total Heat, Heat of the Liquid.

Heat of the Liquid: The heat (Btu) contained in a liquid due to its temperature. The heat of the liquid for water is zero at 32° F. and increases 1 Btu approximately for every degree rise in temperature.

Heat Unit: In the foot-pound-second system, the British Thermal Unit (Btu) in the centimeter-gram-second system, the calorie (cal.).

Heating Medium: A substance such as water, steam, or air used to convey heat from the boiler, furnace, or other source of heat to the heating units from which the heat is dissipated.

Heating Surface: The exterior surface of a heating unit. See also Extended Heating Surface.

Heating Unit: Radiators, convectors, base boards, finned tubing, coils embedded in floor, wall, or ceiling, or any device which transmits the heat from the heating system to the room and its occupants.

Horsepower: A unit to indicate the time rate of doing work equal to 550 ft.-lb. per second, or 33,000 ft.-lb. per minute. One horsepower equals 2545 Btu per hour or 746 watts.

Hot Water Heating System: A heating system in which water is used as the medium by which heat is carried through pipes from the boiler to the heating units.

Humidistat: An instrument which controls the relative humidity of the air in a room.

Humidity: The water vapor mixed with air.

Insulation (Thermal): A material having a high resistance to heat flow.

Latent Heat of Evaporation: The heat (Btu per pound) necessary to change 1 pound of liquid into vapor without raising its temperature. In round numbers this is equal to 960 Btu per pound of water.

Latent Heat of Fusion: The heat necessary to melt one pound of a solid without raising the temperature of the resulting liquid. The latent heat of fusion of water (melting 1 pound of ice) is 144 Btu.

Mechanical Equivalent of Heat: The mechanical energy equivalent to 1 Btu which is equal to 778 ft.-lb.

Mil-Inch: One one-thousandth of an inch (0.001”).

One-Pipe Supply Riser (Steam): A pipe which carries steam to a heating unit and which also carries the condensation from the heating unit. In an up feed riser steam travels upwards and the condensate downward while in a down feed both steam and condensate travel down.

One-Pipe System (Hot Water): A hot water heating system in which one pipe serves both as a supply main and as a return main. The heating units have separate supply and return pipes but both are connected to the same maln.

One-Pipe System (Steam): A steam heating system consisting of a main circuit in which the steam and condensate flow in the same pipe. There is one connection to each heating unit which serves as both the supply and the return.

Overhead System: Any steam or hot water system in which the supply main is above the heating units. With a steam system the return must be below the heating units; with a water system, the return may be above the heating units.

Panel Heating: A method of heating involving the installation of the heating units (pipe coils) in the walls, floor or ceiling of the room.

Panel Radiator: A heating unit placed on, or flush with, a flat wall surface and intended to function as a radiator. Do not confuse with panel heating system.

Pressure: Force per unit area such as lb. per sq. inch. Unless otherwise qualified, it refers to unit static gauge pressure. See Static, Velocity, Total Gauge and Absolute Pressures.

Pressure Reducing Valve: A device used to decrease the pressure of a gas or liquid.

Prime Surface: A heating surface with the heating medium on one side and air (or extended surface) on the other.

Radiant Heating: A heating system in which the heating is by radiation only. Sometimes used in a Panel Heating System.

Radiation: The transmission of heat in a straight line through space.

Radiator: A heating unit located in the room to be heated and exposed to view. A radiator transfers heat by radiation to objects "it can see" and by conduction to the surrounding air which in turn is circulated by natural convection.

Recessed Radiator: A heating unit recessed in a wall but not enclosed.

Reducing Valve: See Pressure Reducing Valve.

Re-Evaporation: See Flash.

Refrigeration, Ton of: See Ton of Refrigeration.

Relative Humidity: The amount of moisture in a given quantity of air compared with the maximum amount of moisture the same quantity of air could hold at the same temperature. It is expressed as a percentage.

Return Mains: The pipes which return the heating medium from the heating units to the source of heat supply.

Reverse-Return System (Hot Water): A two-pipe hot water heating system in which the water from several heating units is returned along paths so that all radiator circuits of the system are of equal length .

Sensible Heat: Heat which increases the temperature of objects as opposed to latent heat.

Specific Heat: In the foot-pound-second system, the amount of heat (Btu) required to raise one pound of a substance one degree Fahrenheit. In the centimeter-gram-second system, the amount of heat (cal.) required to raise one gram of a substance one degree C. The specific heat of water is 1.

Split System: A system in which the heating is accomplished by radiators or convectors and ventilation by separate apparatus.

Square Foot of Heating Surface: Equivalent direct radiation (EDR). By definition, that amount of heating surface which will give off 240 Btu per hour when filled with a heating medium at 215°F. and surrounded by air at 70° F. The equivalent square foot of heating surface may have no direct relation to the actual surface area.

Static Pressure: The pressure at which a pipe will burst. It is used to overcome the frictional resistance to flow through the pipe. It is expressed as a unit pressure and may be in absolute or gauge pressure. It is frequently expressed in feet of water column or in the case of pipe friction in mil-inches of water column per ft. of pipe.

Steam: Water in the vapor phase. The vapor formed when water has been heated to its boiling point, corresponding to the pressure it is under. See also Dry Saturated Steam, Wet Saturated Steam, Superheated Steam.

Steam Heating System: A heating system in which the heating units give up their heat to the room by condensing the steam furnished to them by a boiler or other source.

Steam Trap: A device for allowing the passage of condensate and air but preventing the passage of steam. See Thermostatic, Float, Bucket Trap.

Superheated Steam: Steam heated above the temperature corresponding to its pressure.

Supply Mains: The pipes through which the heating medium flows from the boiler or source of supply to the run-outs and risers leading to the heating units.

Tank Regulator: See Temperature Regulator.

Temperature Regulator: A device for controlling the admission of steam to a hot water or liquid heating device in correct quantities so that the temperature of the liquid will remain constant.

Thermostat: An instrument which responds to changes in temperature and which directly or indirectly controls the room temperature.

Thermostatic Trap: A steam trap which closes when the steam reaches it and opens when the temperature surrounding it drops. This occurs when cold condensate or air reaches it. The temperature sensitive element is usually a sealed bellows or series of diaphragm chambers containing a small quantity of volatile liquid.

Ton of Refrigeration: The heat which must be extracted from one ton (2,000 lbs.) of water at 32° F. to change it into ice at 32°F. in 24 hours. It is equal to 288,000 Btu/24 hours, 12,000 Btu/hour, or 200 Btu/minute.

Total Heat: The latent heat of vaporization added to the heat of the liquid with which it is in contact.

Total Pressure: The sum of the static and velocity pressures. It is also used as the total static pressure over an entire area, that is, the unit pressure multiplied by the area on which it acts.

Trap: See Steam Trap, Thermostatic Trap, Float Trap, and Bucket Trap.

Two-Pipe System (Steam or Water): A heating system in which one pipe is used for the supply main and another for the return main. In a two-pipe hot water system each heating unit receives a direct supply of the heating medium.

Unit Heater: A heating unit consisting of a heat transfer element, housing, fan with motor, and outlet deflectors or diffusers. It is usually suspended from the ceiling and its heat output is controlled by starting and stopping the fan by a room thermostat. The circulation of the heating medium (steam or hot water) is usually continuous. It is used primarily for industrial heating.

Unit Pressure: Pressure per unit area as lbs. per sq. in.

Up-Feed System (Hot Water or Steam): A heating system in which the supply mains are below the level of the heating units which they serve.

Vacuum Heating System (Steam): A one- or two-pipe heating system equipped with the necessary accessory apparatus to permit the pressure in the system to go below atmospheric.

Vapor: Any substance in the gaseous state.

Vapor Heating System (Steam): A two-pipe heating system which operates at or near atmospheric pressure and returns the condensation to the boiler or receiver by gravity.

Velocity Pressure: The pressure used to create the velocity of flow in a pipe. It is expressed as a unit pressure.

Ventilation: Air circulated through a room for ventilating purposes. It may be mechanically circulated with a blower system or through circulation with an open window, etc.

Vent Valve (Steam): A device that permits air to be forced out of a heating unit or pipe and closes against water and steam.

Vent Valve (Water): A device that permits air to be forced out of a heating unit or pipe and closes against water.

Warm Air Heating System: A warm air heating plant consists of a heating unit (fuel-burning furnace) enclosed in a casing, from which the heated air is distributed to the various rooms of the building through ducts. If the motive head producing flow depends on the difference in weight between the heated air leaving the casing and the cooler air entering the bottom of the casing, it is termed a gravity system. A booster fan may, however, be used in conjunction with a gravitydesigned system. If a fan is used to produce circulation and the system is designed especially for fan circulation, it is termed a fan furnace system or a central fan furnace system. A fan furnace system may include air washer, filters, etc.

Wet Bulb Temperature: The lowest temperature which a water-wetted body will attain when exposed to an air current.

Wet Return (Steam): That part of the return main of a steam heating system which is completely filled with water of condensation.

Wet Saturated Steam: Saturated steam containing some water particles in suspension.

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