How to Trap Steam Distribution Systems

Steam distribution systems link boilers and the equipment actually using steam, transporting it to any location in the plant where its heat energy is needed.

The three primary components of steam distribution systems are boiler headers, steam mains and branch lines. Each fulfills certain requirements of the system and, together with steam separators and steam traps, contributes to efficient steam use.

Drip legs. Common to all steam distribution systems is the need for drip legs at various intervals (Fig. CG-27). These are provided to:

1. Let condensate escape by gravity from the fast-moving steam.
2. Store the condensate until the pressure differential can discharge it through the steam trap.

Figure CG-27. Drip Leg Sizing
The properly sized drip leg will capture condensate. Too small a drip leg can actually cause a venturi "piccolo" effect where pressure drop pulls condensate out of the trap. See Table CG-13 on page CG-19.

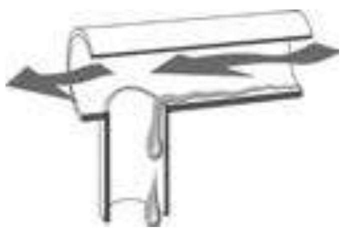


Chart CG-6. Recommendation Chart (See Page CG-4 for "Feature Code" References.)		
Equipment Being Trapped	**1st Choice and Feature Code**	**Alternate Choice**
Boiler Header	IBLV M, E, L, N, B, Q	*F&T

*On superheated steam never use an F&T type trap.
Always use an IB with an internal check valve.

Chart CG-7. Recommendation Chart			
Equipment Being Trapped	**1st Choice, Feature Code and Alternate Choice(s)**	**0 - 30 psig**	**Above 30 psig**
Steam Mains and Branch Lines Non-freezing Conditions	B, M, N, L, F, E, C, D, Q	*IB	*IB
	Alternate Choice	F&T	**F&T
Steam Mains and Branch Lines Freezing Conditions	B, C, D, E, F, L, M, N, Q, J	*IB	*IB
	Alternate Choice	Thermostatic or CD	

*Provide internal check valve when pressures fluctuate.
**Use IBLV above F&T pressure/temperature limitations.
NOTE: On superheated steam, use an IB with an internal check valve.

Boiler Headers

A boiler header is a specialized type of steam main that can receive steam from one or more boilers. It is most often a horizontal line which is fed from the top and in turn feeds the steam mains. It is important to trap the boiler header properly to assure that any carryover (boiler water and solids) is removed before distribution into the system.

Steam traps that serve the header must be capable of discharging large slugs of carryover as soon as they are present. Resistance to hydraulic shock is also a consideration in the selection of traps.

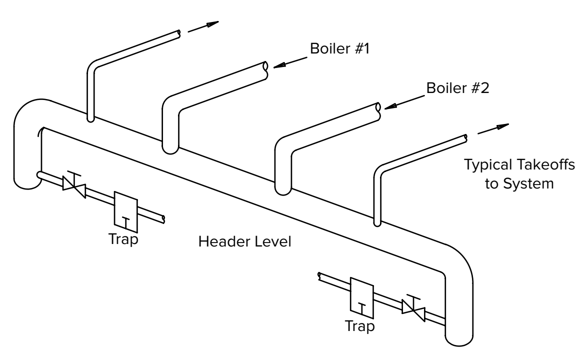
Trap selection and safety factor for boiler headers (saturated steam only). A 1.5:1 safety factor is recommended for virtually all boiler header applications. The required trap capacity can be obtained by using the following formula: Required Trap Capacity = Safety Factor x Load Connected to Boiler(s) x Anticipated Carryover (typically 10%).

EXAMPLE: What size steam trap will be required on a connected load of 50,000 lbs/hr with an anticipated carryover of 10%? Using the formula:
Required Trap Capacity = 1.5 x 50 000 x 0.10 = 7 500 lbs/hr.

The ability to respond immediately to slugs of condensate, excellent resistance to hydraulic shock, dirt-handling ability and efficient operation on very light loads are features that make the inverted bucket the most suitable steam trap for this application.

Installation. If steam flow through the header is in one direction only, a single steam trap is sufficient at the downstream end. With a midpoint feed to the header (Fig. CG-28), or a similar two-directional steam flow arrangement, each end of the boiler header should be trapped.

Figure CG-28. Boiler Headers



Drip leg same as the header diameter up to 4".
Above 4", 1/2 header size, but never less than 4".

Steam Mains

One of the most common uses of steam traps is the trapping of steam mains. These lines need to be kept free of air and condensate in order to keep steam-using equipment operating properly. Inadequate trapping on steam mains often leads to water hammer and slugs of condensate that can damage control valves and other equipment.

There are two methods used for the warm-up of steam mains—supervised and automatic. Supervised warm-up is widely used for initial heating of large-diameter and/or long mains. The suggested method is for drip valves to be opened wide for free blow to the atmosphere before steam is admitted to the main. These drip valves are not closed until all or most of the warm-up condensate has been
discharged. Then the traps take over the job of removing condensate that may form under operating conditions. Warm-up of principal piping in a power plant will follow much the same procedure.

Automatic warm-up is when the boiler is fired, allowing the mains and some or all equipment to come up to pressure and temperature without manual help or supervision.

CAUTION: Regardless of warm-up method, allow sufficient time during the warm-up cycle to minimize thermal stress and prevent any damage to the system.

Trap selection and safety factor for steam mains (saturated steam only). Select trap to discharge condensate produced by radiation losses at running load. Sizing for start-up loads results in oversized traps, which may wear prematurely. Size drip legs to collect condensate during low-pressure, warm-up conditions. (See Table CG-13 on page CG-21.) Condensate loads of insulated pipe can be found in Table CG-10. All figures in the table assume the insulation to be 75% effective. For pressures or pipe sizes not included in the table, use the following formula:

$$C = \frac{A \times U \times (T_1 - T_2)E}{H}$$

Where:

C = Condensate in lbs/hr-foot

A = External area of pipe in square feet (Table CG-10, Col. 2)

U = Btu/sq ft/degree temperature difference/hr from Chart CG-7 (page CG-19)

T_1 = Steam temperature in °F

T_2 = Air temperature in °F

E = 1 minus efficiency of insulation (Example: 75% efficient insulation: 1 - .75 = .25 or E = .25)

H = Latent heat of steam (See Steam Table on page CG-5)

Table CG-10. Condensation in Insulated Pipes Carrying in Quiet Air at 70°F (Insulation assumed to be 75% efficient.)

Pressure, psig		15	30	60	125	180	250	450	600	900
Pipe Size (in)	sq ft Per Lineal ft	Pounds of Condensate Per Hour Per Lineal Foot								
1	.344	.05	.06	.07	.10	.12	.14	.186	.221	.289
1-1/4	.434	.06	.07	.09	.12	.14	.17	.231	.273	.359
1-1/2	**.497**	**.07**	**.08**	**.10**	**.14**	**.16**	**.19**	**.261**	**.310**	**.406**
2	.622	.08	.10	.13	.17	.20	.23	.320	.379	.498
2-1/2	.753	.10	.12	.15	.20	.24	.28	.384	.454	.596
3	**.916**	**.12**	**.14**	**.18**	**.24**	**.28**	**.33**	**.460**	**.546**	**.714**
3-1/2	1.047	.13	.16	.20	.27	.32	.38	.520	.617	.807
4	1.178	.15	.18	.22	.30	.36	.43	.578	.686	.897
5	**1.456**	**.18**	**.22**	**.27**	**.37**	**.44**	**.51**	**.698**	**.826**	**1.078**
6	1.735	.20	.25	.32	.44	.51	.59	.809	.959	1.253
8	2.260	.27	.32	.41	.55	.66	.76	1.051	1.244	1.628
10	**2.810**	**.32**	**.39**	**.51**	**.68**	**.80**	**.94**	**1.301**	**1.542**	**2.019**
12	3.340	.38	.46	.58	.80	.92	1.11	1.539	1.821	2.393
14	3.670	.42	.51	.65	.87	1.03	1.21	1.688	1.999	2.624
16	**4.200**	**.47**	**.57**	**.74**	**.99**	**1.19**	**1.38**	**1.927**	**2.281**	**2.997**
18	4.710	.53	.64	.85	1.11	1.31	1.53	2.151	2.550	3.351
20	5.250	.58	.71	.91	1.23	1.45	1.70	2.387	2.830	3.725
24	**6.280**	**.68**	**.84**	**1.09**	**1.45**	**1.71**	**2.03**	**2.833**	**3.364**	**4.434**

Table CG-11. The Warming-Up Load from 70°F, Schedule 40 Pipe

Pressure, psig		2	15	30	60	125	180	250
Pipe Size (in)	wt of Pipe Per ft (lbs)	Pounds of Condensate Per Lineal Foot						
1	1.69	.030	.037	.043	.051	.063	.071	.079
1-1/4	2.27	.040	.050	.057	.068	.085	.095	.106
1-1/2	**2.72**	**.048**	**.059**	**.069**	**.082**	**.101**	**.114**	**.127**
2	3.65	.065	.080	.092	.110	.136	.153	.171
2-1/2	5.79	.104	.126	.146	.174	.215	.262	.271
3	**7.57**	**.133**	**.165**	**.190**	**.227**	**.282**	**.316**	**.354**
3-1/2	9.11	.162	.198	.229	.273	.339	.381	.426
4	10.79	.190	.234	.271	.323	.400	.451	.505
5	**14.62**	**.258**	**.352**	**.406**	**.439**	**.544**	**.612**	**.684**
6	18.97	.335	.413	.476	.569	.705	.795	.882
8	28.55	.504	.320	.720	.860	1.060	1.190	1.340
10	**40.48**	**.714**	**.880**	**1.020**	**1.210**	**1.500**	**1.690**	**1.890**
12	53.60	.945	1.170	1.350	1.610	2.000	2.240	2.510
14	63.00	1.110	1.370	1.580	1.890	2.340	2.640	2.940
16	**83.00**	**1.460**	**1.810**	**2.080**	**2.490**	**3.080**	**3.470**	**3.880**
18	105.00	1.850	2.280	2.630	3.150	3.900	4.400	4.900
20	123.00	2.170	2.680	3.080	3.690	4.570	5.150	5.750
24	**171.00**	**3.020**	**3.720**	**4.290**	**5.130**	**6.350**	**7.150**	**8.000**

Table CG-12. Pipe Weights Per Foot in Pounds

Pipe Size (in)	Schedule 40	Schedule 80	Schedule 160	XX Strong
1	1.69	2.17	2.85	3.66
1-1/4	2.27	3.00	3.76	5.21
1-1/2	**2.72**	**3.63**	**4.86**	**6.41**
2	3.65	5.02	7.45	9.03
2-1/2	5.79	7.66	10.01	13.69
3	**7.57**	**10.25**	**14.32**	**18.58**
3-1/2	9.11	12.51	-	22.85
4	10.79	14.98	22.60	27.54
5	**14.62**	**20.78**	**32.96**	**38.55**
6	18.97	28.57	45.30	53.16
8	28.55	43.39	74.70	72.42
10	**40.48**	**54.74**	**116.00**	**-**
12	53.60	88.60	161.00	-
14	63.00	107.00	190.00	-
16	**83.00**	**137.00**	**245.00**	**-**
18	105.00	171.00	309.00	-
20	123.00	209.00	379.00	-
24	**171.00**	**297.00**	**542.00**	**-**

How to Trap Steam Distribution Systems

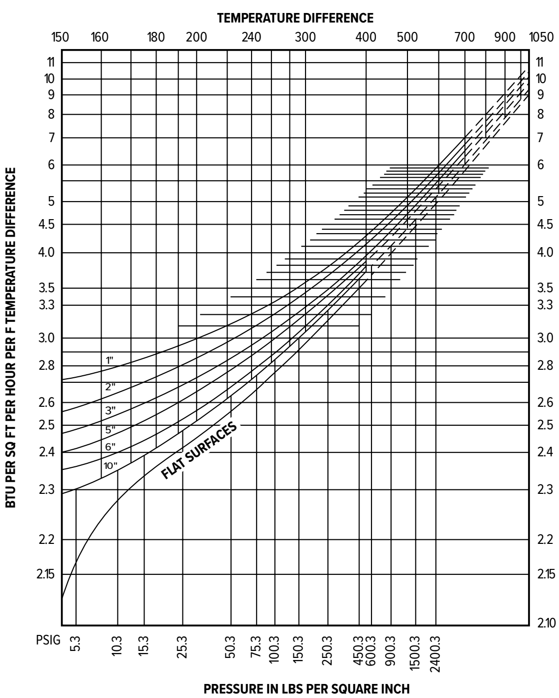
For traps installed between the boiler and the end of the steam main, apply a 2:1 safety factor. Apply a 3:1 safety factor for traps installed at the end of the main or ahead of reducing and shutoff valves that are closed part of the time.

The inverted bucket trap is recommended because it can handle dirt and slugs of condensate and resists hydraulic shock. In addition, should an inverted bucket fail, it usually does so in the open position.

Installation. Both methods of warm-up use drip legs and traps at all low spots or natural drainage points such as:

Ahead of risers
End of mains
Ahead of expansion joints or bends
Ahead of valves or regulators

Chart CG-7. Btu Heat Loss Curves



Install drip legs and drain traps even where there are no natural drainage points (See Figs. CG-29, CG-30 and CG-31). These should normally be installed at intervals of about 300' and never longer than 500'.

On a supervised warm-up, make drip leg length at least 1-1/2 times the diameter of the main, but never less than 10". Make drip legs on automatic warm-ups a minimum of 28" in length. For both methods, it is a good practice to use a drip leg the same diameter as the main up to 4" pipe size and at least 1/2 of the diameter of the main above that, but never less than 4". See Table CG-13.

Table CG-13. Recommended Steam Main and Branch Line Drip Leg Sizing

M	D	H	
		Drip Leg Length Min. (in)	
Steam Main Size (in)	Drip Leg Diameter (in)	Supervised Warm-Up	Automatic Warm-Up
1/2	1/2	10	28
3/4	3/4	10	28
1	**1**	**10**	**28**
2	2	10	28
3	3	10	28
4	**4**	**10**	**28**
6	4	10	28
8	4	12	28
10	**6**	**15**	**28**
12	6	18	28
14	8	21	28
16	**8**	**24**	**28**
18	10	27	28
20	10	30	30
24	**12**	**36**	**36**

Chart CG-8. Recommendation Chart
(See Page CG-4 for "Feature Code" References.)

Equipment Being Trapped	1st Choice and Feature Code	Alternate Choice
Steam Separator	IBLV B, M, L, E, F, N, Q	*DC

*DC is 1st choice where steam quality is 90% or less.

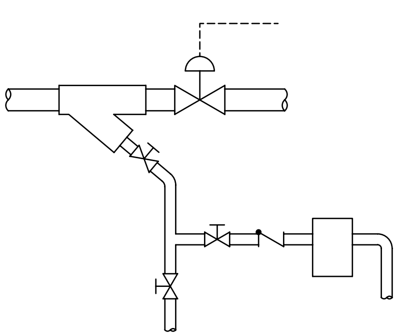


Figure CG-29.
Trap draining strainer ahead of PRV.

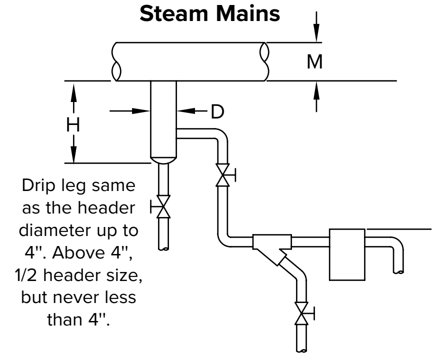


Figure CG-30.
Trap draining drip leg on main.

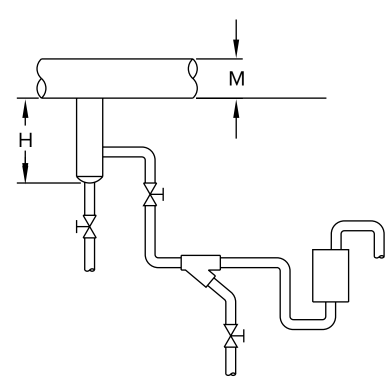


Figure CG-31.
Trap draining drip leg at riser. Distance "H" in inches ÷ 28 = psig static head for forcing water through the trap.

Branch Lines

Branch lines are take-offs from the steam mains supplying specific pieces of steam-using equipment. The entire system must be designed and hooked up to prevent accumulation of condensate at any point.

Trap selection and safety factor for branch lines. The formula for computing condensate load is the same as that used for steam mains. Branch lines also have a recommended safety factor of 3:1.

Installation. Recommended piping from the main to the control is shown in Fig. CG-32 for runouts under 10' and Fig. CG-33 for runouts over 10'. See Fig. CG-34 for piping when control valve must be below the main.

Install a full pipe-size strainer ahead of each control valve as well as ahead of the PRV, if used. Provide blowdown valves, preferably with IB traps. A few days after starting the system, examine the strainer screens to see if cleaning is necessary.

Separators

Steam separators are designed to remove any condensate that forms within steam distribution systems. They are most often used ahead of equipment where especially dry steam is essential. They are also common on secondary steam lines, which by their very nature have a large percentage of entrained condensate.

Trap selection and safety factors for separators. Apply a 3:1 safety factor in all cases, even though different types of traps are recommended, depending on condensate and pressure levels.

Use the following formula to obtain the required trap capacity:

Required trap capacity in lbs/hr = safety factor x steam flow rate in lbs/hr x anticipated percent of condensate (typically 10% to 20%).

EXAMPLE: What size steam trap will be required on a flow rate of 10 000 lbs/hr? Using the formula:

Required trap capacity =
3 x 10 000 x 0.10 = 3 000 lbs/hr.

The inverted bucket trap with large vent is recommended for separators. When dirt and hydraulic shock are not significant problems, an F&T type trap is an acceptable alternative.

An automatic differential condensate controller may be preferred in many cases. It combines the best features of both of the above and is recommended for large condensate loads that exceed the separating capability of the separator.

Installation

Connect traps to the separator drain line 10" to 12" below the separator with the drain pipe running the full size of the drain connection down to the trap take-off (Fig. CG-35). The drain pipe and dirt pocket should be the same size as the drain connection.

Branch Lines

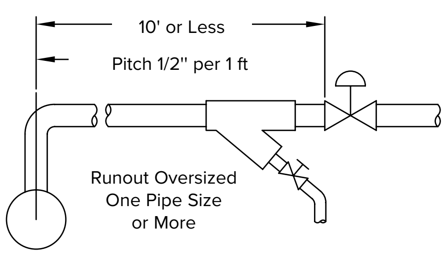


Figure CG-32. Piping for runout less than 10 ft. No trap required unless pitch back to supply header is less than 1/2" per ft.

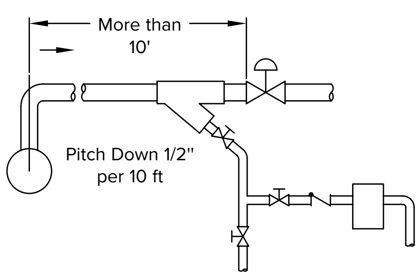


Figure CG-33. Piping for runout greater than 10'. Drip leg and trap required ahead of control valve. Strainer ahead of control valve can serve as drip leg if blowdown connection runs to an inverted bucket trap. This will also minimize the strainer cleaning problem. Trap should be equipped with an internal check valve or a swing check installed ahead of the trap.

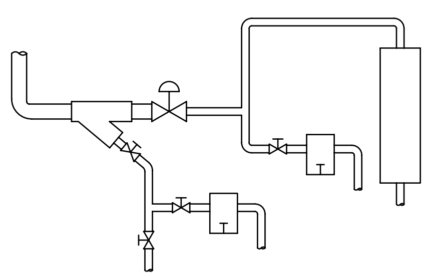


Figure CG-34. Regardless of the length of the runout, a drip leg and trap are required ahead of the control valve located below steam supply. If coil is above control valve, a trap should also be installed at downstream side of control valve.

Steam Separator

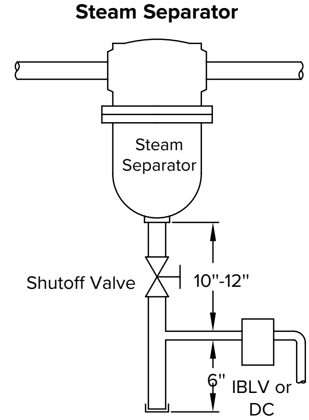


Figure CG-35. Drain downstream side of separator. Full-size drip leg and dirt pocket are required to ensure positive and fast flow of condensate to the trap.

How to Trap Steam Tracer Lines

Steam tracer lines are designed to maintain the fluid in a primary pipe at a certain uniform temperature. In most cases, these tracer lines are used outdoors, which makes ambient weather conditions a critical consideration.

The primary purpose of steam traps on tracer lines is to retain the steam until its latent heat is fully utilized and then discharge the condensate and non-condensable gases. As is true with any piece of heat transfer equipment, each tracer line should have its own trap. Even though multiple tracer lines may be installed on the same primary fluid line, unit trapping is required to prevent short circuiting. See page CG-15.

In selecting and sizing steam traps, it's important to consider their compatibility with the objectives of the system, as traps must:

1. Conserve energy by operating reliably over a long period of time.
2. Provide abrupt periodic discharge in order to purge the condensate and air from the line.
3. Operate under light load conditions.
4. Resist damage from freezing if the steam is shut off.

The cost of steam makes wasteful tracer lines an exorbitant overhead no industry can afford.

Trap Selection for Steam Tracer Lines.
The condensate load to be handled on a steam tracer line can be determined from the heat loss from the product pipe by using this formula:

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

Where:

Q = Condensate load, lbs/hr

L = Length of product pipe between tracer line traps in ft

U = Heat transfer factor in Btu/sq ft/°F/hr (from Chart CG-7, page CG-21)

ΔT = Temperature differential in °F

E = 1 minus efficiency of insulation (example: 75% efficient insulation or 1 - .75 = .25 or E = .25)

S = Lineal feet of pipe line per sq ft of surface (from Table CG-29, page CG-55)

H = Latent heat of steam in Btu/lb (from Steam Table, page CG-5)

Typical Tracer Installation

Figure CG-36.

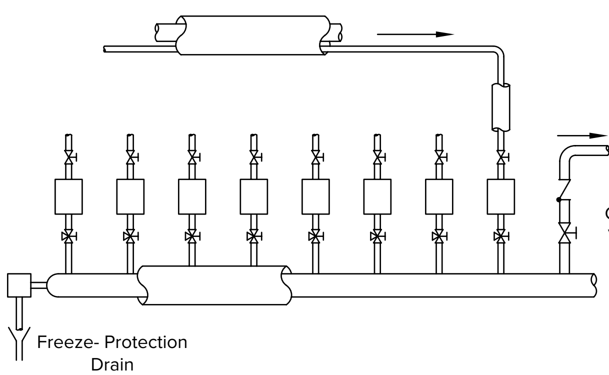


Figure CG-37.

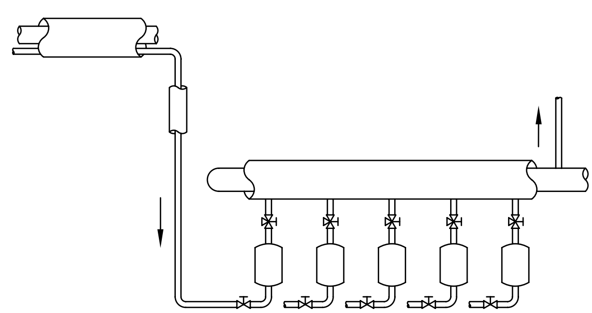


Chart CG-9. Recommendation Chart (See Page CG-4 for "Feature Code" References.)		
Equipment Being Trapped	**1st Choice and Feature Code**	**Alternate Choice**
Tracer Lines	*IB A, B, C, L, J, N, I, K	Thermostatic or CD

*Select a 5/64" steam trap orifice to conserve energy and avoid plugging with dirt and scale.

Table CG-14. Pipe Size Conversion Table (Divide lineal feet of pipe by factor given for size and type of pipe to get square feet of surface.)

Pipe Size (in)	Iron Pipe	Copper or Brass Pipe
1/2	4.55	7.63
3/4	3.64	5.09
1	**2.90**	**3.82**
1-1/4	2.30	3.05
1-1/2	2.01	2.55
2	**1.61**	**1.91**
2-1/2	1.33	1.52
3	1.09	1.27
4	**.848**	**.954**

How to Trap Steam Tracer Lines

EXAMPLE: Three tracer lines at 100 psig steam pressure are used on a 20” diameter, 100’ long insulated pipe to maintain a temperature of 190°F with an outdoor design temperature of -10°F. Assume further that the pipe insulation is 75% efficient. What is the condensate load?

Using the formula:

$$Q = \frac{100 \text{ ft} \times 2.44 \text{ Btu/sq ft -°F - hr} \times 200\text{°F} \times .25}{0.191 \text{ lin ft/sq ft} \times 880 \text{ Btu/lb}} = 72 \text{ lbs/hr}$$

Now divide by three in order to get the load per tracer line — 24 lbs/hr.

On most tracer line applications, the flow to the steam trap is surprisingly low; therefore, the smallest trap is normally adequate. Based on its ability to conserve energy by operating reliably over a long period of time, handle light loads, resist freezing and purge the system, an inverted bucket trap is recommended for tracer line service.

Safety factor. Use a 2:1 safety factor whether exposure to ambient weather conditions is involved or not. Do not oversize steam traps or tracer lines. Select a 5/64” steam trap orifice to conserve energy and avoid plugging with dirt and scale.

Installation

Install distribution or supply lines at a height above the product lines requiring steam tracing. For the efficient drainage of condensate and purging of non-condensables, pitch tracer lines for gravity drainage and trap all low spots. This will also help avoid tracer line freezing. (See Figs. CG-36, CG-37 and CG-38.)

To conserve energy, return condensate to the boiler. Use vacuum breakers immediately ahead of the traps to ensure drainage on shutdown on gravity drain systems. Freeze-protection drains on trap discharge headers are suggested where freezing conditions prevail.

Figure CG-38. Typical Tracer Installation

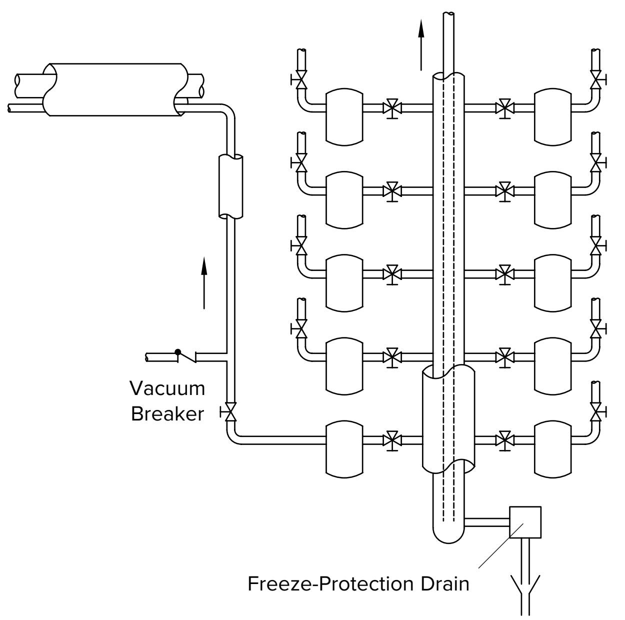
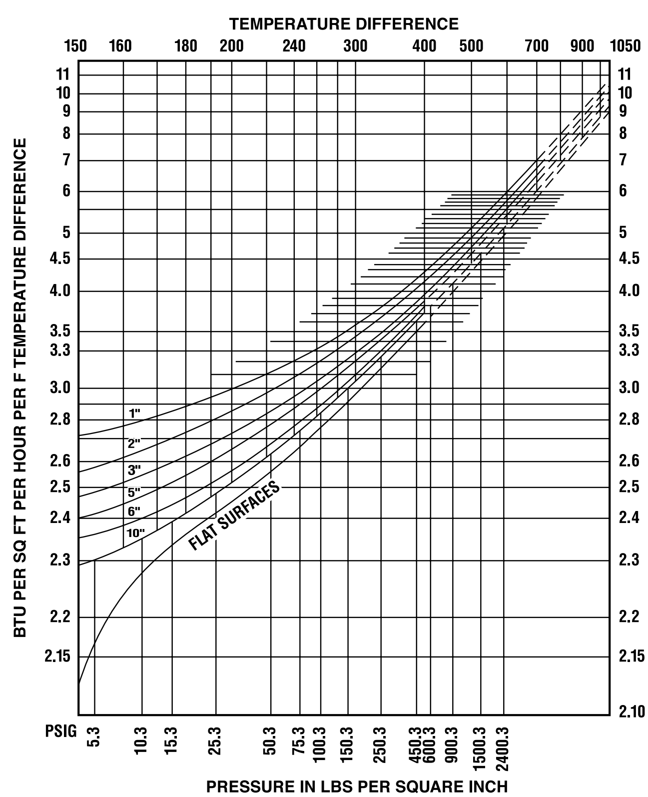


Chart CG-10. Btu Heat Loss Curves
Unit heat loss per sq ft of surface of uninsulated pipe of various diameters (also flat surface) in quiet air at 75°F for various saturated steam pressures or temperature differences.



At first glance, this may seem confusing due to the idea that superheated steam produces no condensate; therefore, the steam lines carrying superheated steam should not have any condensate in them. This is true once the system is up to temperature and pressure, but condensate removal is necessary up to this point. This section will explain what superheated steam is and the applications for its use.

The specific heat of any substance (using Btu standards) is the quantity of heat required to raise the temperature of 1 pound by 1 degree F. With this definition, the specific heat of water is 1, and the specific heat of superheated steam varies according to temperature and pressure. Specific heat decreases as the temperature rises but increases as the pressure goes up.

Superheated steam is customarily made by the addition of an extra set of coils inside the boiler or in the exhaust area of the boiler so as to use the “waste” heat from the boiler. Or, by the addition of a superheat chamber somewhere after the boiler, attached to the steam main. A schematic diagram of a steam generator with a superheated section of coil is shown below.

Properties of Superheated Steam

Superheated steam has several properties that make it unsuitable as a heat energy exchange medium yet ideal for work and mass transfer. Unlike saturated steam, the pressure and temperature of superheated steam are independent. As superheat is formed at the same pressure as the saturated steam, the temperature and volume increase.

In high heat release boilers with relatively small drums, separation of steam from water is extremely difficult. The combination of the small volume of water in the drums and rapid load swings produces severe shrink and swell conditions in the drum, which promotes water carryover.

This water can be removed with separators and traps in the steam outlets, but they are not 100% efficient. In applications where dry steam is a necessity, additional superheating coils are placed in the boiler furnace as convection passes. More heat is added to the steam to vaporize the water carryover, which adds a small amount of superheat to guarantee absolutely dry steam.

Because superheated steam can give up so little heat before it converts back to saturated steam, it is not a good heat-transfer medium. Some processes, such as power plants, require a dry heat in order to do work. Whatever the type of power unit, superheat helps reduce the amount of condensation when starting from cold. Superheat also increases the power output by delaying condensation during the expansion stages in the equipment. Having drier steam at the exhaust end will increase the life of turbine blades.

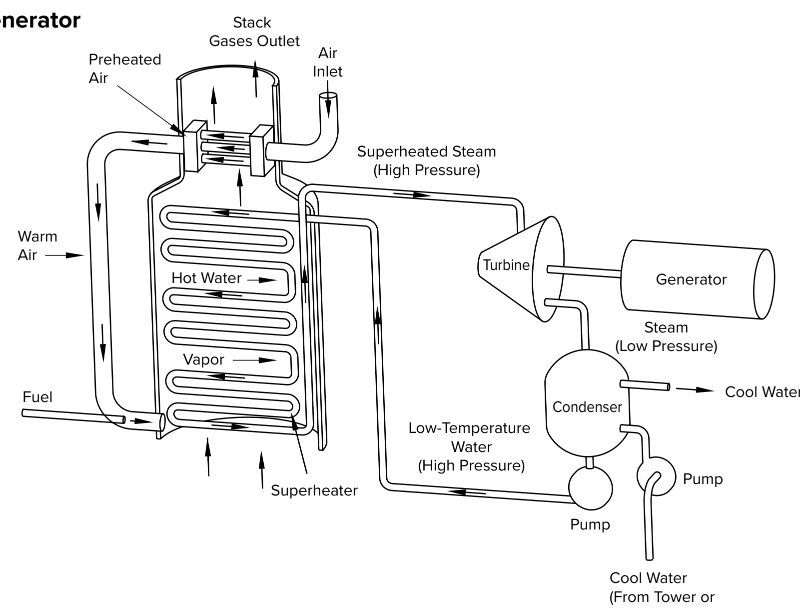
Superheated steam can lose heat without condensing whereas saturated steam cannot. Therefore, superheated steam can be transported through very long steam lines without losing sufficient heat to condense. This permits the delivery of dry steam throughout the entire steam system.

Why Trap Superheated Systems?

The primary reason for traps on superheat systems is the start-up load. It can be heavy because of the large size of the mains. On start-up, manual valves will most likely be used since time is available to open and to close the valves. This is known as supervised start-up. A second reason for steam traps is to handle emergencies such as superheater loss or by-pass, which might require operation on saturated steam. In these unscheduled events, there is no time available for manually opening valves; therefore, steam traps are a necessity.

These are the situations for which proper trap sizing is a must. Condensate must be removed as it forms in any steam system to keep efficiency high and to minimize damaging water hammer and erosion.

Figure CG-39. Steam Generator



How to Trap Superheated Steam Lines

Sizing Superheat Loads to Traps

The condensate load to a trap used on superheat will vary widely from severe start-up loads to virtually no load during operation. Consequently, this is a demanding application for any steam trap.

During start-up, very large lines are being filled with steam from cold conditions. At this time, only saturated steam at low pressure is in the lines until the line temperature can be increased. This is done slowly over a long period so the lines are not stressed. Large condensate flow combined with low pressure is the start-up condition that requires the use of large capacity traps. These oversized traps are then required to operate at very high pressures with very low capacity requirements during normal superheat operation.

Typical start-up loads can be roughly calculated as follows:

Using:

$$C = \frac{0.114\ Wp\ (t2\text{-}t1)}{H}$$

Where:

C = Amount of condensate in pounds

Wp = Total weight of pipe (from Table CG-12 on page CG-20)

H = Total heat of X pressure minus Sensible heat of Y Pressure (Latent heat of steam. For long warm-up times, use the total heat of saturated steam at the superheat steam supply pressure (X) minus the sensible heat of saturated steam at the average pressure (Y) during the warm-up time involved.)

0.114 = Specific heat of steel pipe in btu/lb °F

EXAMPLE:

Assuming a 100°F/hr (37°C/hr) heat-up

14'' (35 cm) diameter Schedule 80 line

Supply superheated steam at 1 200 psig 1070°F (85 bar, 577°C)

Ambient temperature is 70°F (21°C)

200 feet (61 m) of run between traps

For the first two hours:

W = (200 ft) (107 lb/ft) = 21 400 lb (9727 kg)

t(2) - t(1) = 270 - 70 = 200°F (93°C)

H = 1 184.8 btu/lb - 196.27 btu/lb = 988.5 btu/lb = (474 kJ)

$$C = \frac{(0.114\ \text{btu/lb °F})\ (21\,400\ \text{lb})\ (200\text{°F})}{988.5\ \text{btu/lb}} = 493\ \text{lb}\ (224\ \text{kg})$$

For the second two hours:

The only thing that changes is the sensible heat of the saturated steam at average pressure during the time involved.

$$C = \frac{(0.114\ \text{btu/lb °F})\ (21\,400\ \text{lb})\ (200\text{°F})}{851.1\ \text{btu/lb}} = 573\ \text{lb}\ (260\ \text{kg})$$

Table CG-15. Time Period Table

Time Period	Average Pressure psig (barg)	Temperature at End of Time Period °F (°C)	14" Line Condensation Rate lb/hr (kg/hr)
1st 2 hours	5 (.35)	270 (132)	247 (112)
2nd 2 hours	140 (9.8)	470 (243)	286 (130)
3rd 2 hours	700 (49)	670 (354)	352 (160)
4th 2 hours	1 200 (85)	870 (465)	288 (131)
5th 2 hours	1 200 (85)	1 070 (577)	260 (118)

NOTE: For the average pressure of 1,200 psig (85 bar), assume H to be the latent heat of 1,200 psig (85 bar) steam plus superheat at temperature at the end of the period.

To ensure the condensate is removed efficiently, proper drip leg sizing and piping recommendations should also be followed when installing traps on superheat systems. The Table CG-13 on page CG-21 lists the proper drip leg size for given pipe sizes.

The question arises whether insulation should be used on the drip leg, piping leading to the trap, and the trap. The answer is no; unless it is mandatory for safety reasons, this section of the steam system should not be insulated. This ensures that some condensate is continuously being formed ahead of the trap and going to it, thus prolonging the trap's life.

Types of Superheat Traps

Bimetallic

A bimetallic trap is set to not open until condensate has cooled to a temperature below saturation. For the existing pressure, it will remain closed whenever steam of any temperature is in the trap. As the steam temperature rises, the pull of the bimetallic element becomes greater, providing a greater sealing force on the valve. Superheated steam tends to seal the valve better. The bimetallic trap also has the ability to handle large start-up loads. For these reasons, this trap is a good choice for superheat.

During superheat operation, the condensate in the trap must cool to a temperature below the saturation temperature before the trap can open. Condensate may back up into the line and cause damage to the lines, valves and equipment if drip leg size and length before the trap are insufficient.

Inverted Bucket

A water seal prevents steam from getting to the valve, promoting no live steam loss and long life. The valve at the top makes it impervious to dirt and permits removal of air. Large start-up loads can be handled, and the trap can still accommodate small running loads. There are problems associated with its application on superheat, mostly associated with the necessity of maintaining its water seal or "prime." Proper piping is necessary to maintain a prime in the IB.

For proper inverted bucket piping on superheat, refer to Figure CG-31 on page CG-21. When sizing a superheat trap, size for start-up load with no safety factor. Body materials should be selected on the basis of maximum pressure and temperature, including superheat.

How to Trap Space Heating Equipment

Space heating equipment such as unit heaters, air handling units, finned radiation and pipe coils is found in virtually all industries. This type of equipment is quite basic and should require very little routine maintenance. Consequently, the steam traps are usually neglected for long periods of time. One of the problems resulting from such neglect is residual condensate in the heating coil, which can cause damage due to freezing, corrosion and water hammer.

Trap Selection and Safety Factors

Different application requirements involving constant or variable steam pressure determine which type and size of trap should be used. There are two standard methods for sizing traps for coils.

1. **Constant Steam Pressure.**
   INVERTED BUCKET TRAPS AND F&T TRAPS—Use a 3:1 safety factor at operating pressure differentials.

2. **Modulating Steam Pressure.**
   F&T TRAPS AND INVERTED BUCKET TRAPS
   WITH THERMIC BUCKETS

- 0-15 psig steam—2:1 safety factor at 1/2 psi pressure differential
- 16-30 psig steam—2:1 at 2 psi pressure differential
- Above 30 psig steam—3:1 at 1/2 of maximum pressure differential across the trap.

INVERTED BUCKET TRAPS WITHOUT THERMIC BUCKETS
Above 30 psig steam pressure only—3:1 at 1/2 of maximum pressure differential across the trap.

Trap Selection for Unit Heaters and Air Handling Units

You may use three methods to compute the amount of condensate to be handled. Known operating conditions will determine which method to use.

1. **Btu method.** The standard rating for unit heaters and other air coils is Btu output with 2 psig steam pressure in the heater and entering air temperature of 60°F. To convert from standard to actual rating, use the conversion factors in Table CG-16 (page CG-29). Once the actual operating conditions are known, multiply the condensate load by the proper safety factor.

2. **CFM and air temperature rise method.** If you know only CFM capacity of fan and air temperature rise, find the actual Btu output by using this simple formula: Btu/hr = CFM x 1.08 x temperature rise in °F.

EXAMPLE: What size trap will drain a 3 500 CFM heater that produces an 80°F temperature rise? Steam pressure is constant at 60 psig.

Using the formula:
3 500 x 1.08 x 80 = 302 400 Btu/hr.
Now divide 302 400 Btu/hr by 904.5 Btu (from the Steam Tables) to obtain 334 lbs/hr and then multiply by the recommended safety factor 3. The application needs a trap with a 1 002 lbs/hr capacity.

Derive the 1.08 factor in the above formula as follows:
1 CFM x 60 = 60 CFH
60 CFH x .075 lbs of air/cu ft = 4.5 lbs of air/hr
4.5 x 0.24 Btu/lb -°F (specific heat of air) = 1.08 Btu/hr °F - CFM.

3. **Condensate method.**
   Once you determine Btu output:
   a. Divide Btu output by latent heat of steam at steam pressure used. See Column 2 of Table CG-16 (page CG-29) or the Steam Table (page CG-5). This will give the actual weight of steam condensed. For a close approximation, a rule of thumb could be applied in which the Btu output is simply divided by 1,000.
   b. Multiply the actual weight of steam condensing by the safety factor to get the continuous trap discharge capacity required.

Chart CG-11. Multipliers for Sizing Traps for Multiple Coils

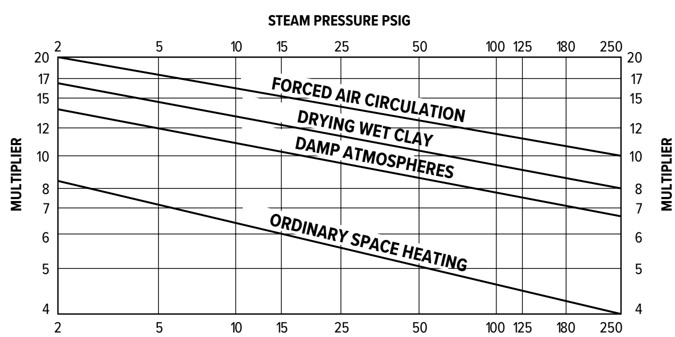


Chart CG-12. Recommendation Chart
(See Page CG-4 for "Feature Code" References.)

Equipment Being Trapped	1st Choice and Feature Code	Constant Pressure		1st Choice and Feature Code	Variable Pressure	
		0-30 psig	Above 30 psig		0-30 psig	Above 30 psig
Unit Heaters	B, C, E, K, N	IBLV	IBLV	B, C, G, H, L	F&T	*F&T
	Alternate Choice	F&T	*F&T	Alternate Choice	IBLV	IBLV
Air Handling Units	B, C, E, K, N, O	IBLV	IBLV	B, C, G, H, L	F&T	*F&T
	Alternate Choice	F&T	*F&T	Alternate Choice	IBT	IBLV
Finned Radiation & Pipe Coils	B, C, E, K, N	IBLV	IBLV	B, C, G, H, L	F&T	F&T
	Alternate Choice	Thermostatic	Thermostatic	Alternate Choice	IBLV	IBLV

*Use IBLV above F&T pressure/temperature limitations.
PLEASE NOTE: 1. Provide vacuum breaker wherever subatmospheric pressures occur.
2. Do not use F&T traps on superheated steam.

Trap Selection for Pipe Coils and Finned Radiation

Pipe coils. Insofar as possible, trap each pipe individually to avoid short circuiting.

Single pipe coils. To size traps for single pipes or individually trapped pipes, find the condensing rate per linear foot in Table CG-18 (page CG-29). Multiply the condensing rate per linear foot by the length in feet to get the normal condensate load.

For quick heating, apply a trap selection safety factor of 3:1 and use an inverted bucket trap with a thermic vent bucket. Where quick heating is not required, use a trap selection safety factor of 2:1 and select a standard inverted bucket trap.

Multiple pipe coils. To size traps to drain coils consisting of multiple pipes, proceed as follows:

1. Multiply the lineal feet of pipe in the coil by the condensing rate given in Table CG-18. This gives normal condensate load.
2. From Chart CG-11 (page CG-27), find the multiplier for your service conditions.
3. Multiply normal condensate load by multiplier to get trap required continuous discharge capacity. **Note that the safety factor is included in the multiplier.**

Finned radiation. When Btu output is not known, condensing rates can be computed from Tables CG-17 and CG-19 (page CG-29) with sufficient accuracy for trap selection purposes. To enter Table CG-19, observe size of pipe, size of fins, number of fins and material. Determine condensing rate per foot under standard conditions from Table CG-19. Convert to actual conditions with Table CG-17.

Safety factor recommendations are to:

1. Overcome the short circuiting hazard created by the multiple tubes of the heater.
2. Ensure adequate trap capacity under severe operating conditions. In extremely cold weather the entering air temperature is likely to be lower than calculated, and the increased demand for steam in all parts of the plant may result in lower steam pressures and higher return line pressures—all of which cut trap capacity.
3. Ensure the removal of air and other non-condensables.

WARNING: For low-pressure heating, use a safety factor at the actual pressure differential, not necessarily the steam supply pressure, remembering that the trap must also be able to function at the maximum pressure differential it will experience.

Installation

In general, follow the recommendations of the specific manufacturer. Figs. CG-40, CG-41, CG-42 and CG-43 represent the consensus of space heating manufacturers.

NOTE: For explanation of safety drain trap, see Fig. CG-66 (page CG-49).

Figure CG-40. Trapping and Venting Air Heat Coil

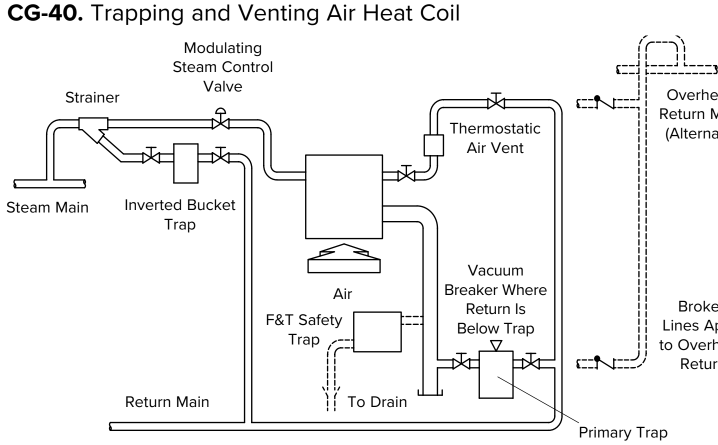


Figure CG-42. Generally approved method of piping and trapping high-pressure (above 15 psi) horizontal discharge heaters. Figs. CG-40 and CG-41 drip leg should be 10”-12” minimum.

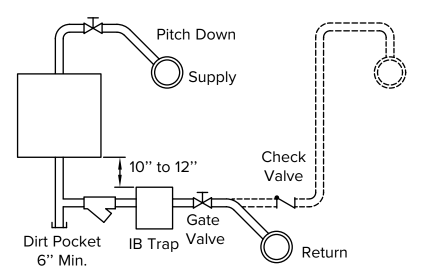


Figure CG-41. Trapping and Venting Air Heat Coil

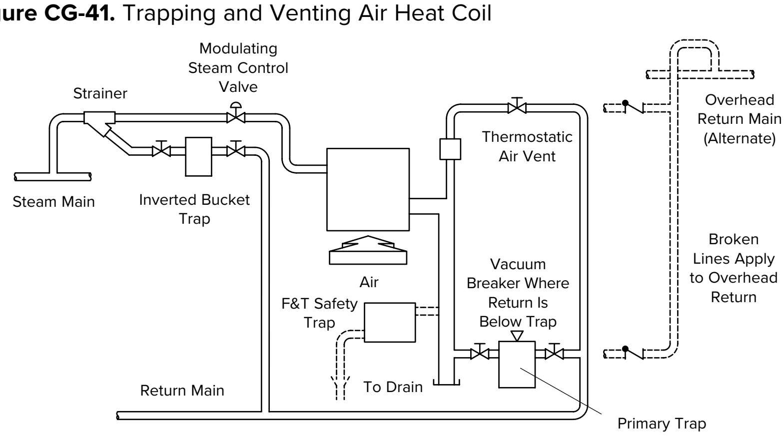
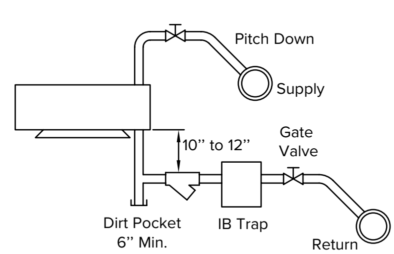


Figure CG-43. Generally approved method of piping and trapping low-pressure (under 15 psi) vertical discharge heaters.



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How to Trap Space Heating Equipment

Table CG-16. A Table of Constants for determining the Btu output of a unit heater with conditions other than standard — standard being with 2 lbs steam pressure at 60°F entering air temperature. To apply, multiply the standard Btu capacity rating of heater by the indicated constant. (Reprinted from• ASHRAE Guide by special permission.)

Steam Pressure lbs Per sq in	Latent Heat of Steam	Entering Air Temperature °F											
		-10	0	10	20	30	40	50	60	70	80	90	100
2	966.3	—	—	—	—	—	1.155	1.078	1.000	0.926	0.853	0.782	0.713
5	960.7	1.640	1.550	1.456	1.370	1.289	1.206	1.127	1.050	0.974	0.901	0.829	0.760
10	**952.4**	**1.730**	**1.639**	**1.545**	**1.460**	**1.375**	**1.290**	**1.211**	**1.131**	**1.056**	**0.982**	**0.908**	**0.838**
15	945.5	1.799	1.708	1.614	1.525	1.441	1.335	1.275	1.194	1.117	1.043	0.970	0.897
20	939.3	1.861	1.769	1.675	1.584	1.498	1.416	1.333	1.251	1.174	1.097	1.024	0.952
30	**928.5**	**1.966**	**1.871**	**1.775**	**1.684**	**1.597**	**1.509**	**1.429**	**1.346**	**1.266**	**1.190**	**1.115**	**1.042**
40	919.3	2.058	1.959	1.862	1.771	1.683	1.596	1.511	1.430	1.349	1.270	1.194	1.119
50	911.2	2.134	2.035	1.936	1.845	1.755	1.666	1.582	1.498	1.416	1.338	1.262	1.187
60	**903.9**	**2.196**	**2.094**	**1.997**	**1.902**	**1.811**	**1.725**	**1.640**	**1.555**	**1.472**	**1.393**	**1.314**	**1.239**
70	897.3	2.256	2.157	2.057	1.961	1.872	1.782	1.696	1.610	1.527	1.447	1.368	1.293
75	893.8	2.283	2.183	2.085	1.990	1.896	1.808	1.721	1.635	1.552	1.472	1.392	1.316
80	**891.1**	**2.312**	**2.211**	**2.112**	**2.015**	**1.925**	**1.836**	**1.748**	**1.660**	**1.577**	**1.497**	**1.418**	**1.342**
90	885.4	2.361	2.258	2.159	2.063	1.968	1.880	1.792	1.705	1.621	1.541	1.461	1.383
100	880.0	2.409	2.307	2.204	2.108	2.015	1.927	1.836	1.749	1.663	1.581	1.502	1.424

Table CG-17. Finned Radiation Conversion Factors for steam pressures and air temperatures other than 65°F air and 215°F steam.

Steam Pressure (psig)	Steam Temp. (°F)	Entering Air Temperature °F						
		45	55	65	70	75	80	90
.9	215.0	1.22	1.11	1.00	.95	.90	.84	.75
5	227.1	1.34	1.22	1.11	1.05	1.00	.95	.81
10	**239.4**	**1.45**	**1.33**	**1.22**	**1.17**	**1.11**	**1.05**	**.91**
15	249.8	1.55	1.43	1.31	1.26	1.20	1.14	1.00
30	274.0	1.78	1.66	1.54	1.48	1.42	1.37	1.21
60	**307.3**	**2.10**	**2.00**	**1.87**	**1.81**	**1.75**	**1.69**	**1.51**
100	337.9	2.43	2.31	2.18	2.11	2.05	2.00	1.81
125	352.9	2.59	2.47	2.33	2.27	2.21	2.16	1.96
175	**377.4**	**2.86**	**2.74**	**2.60**	**2.54**	**2.47**	**2.41**	**2.21**

Table CG-18. Condensing Rates in Bare Pipe Carrying Saturated Steam

Steam Pressure (psig) Temp. Rise From 70°		Pounds of Condensate Per hr Per Lineal ft					
Pipe Size (in)	sq ft Per Lineal ft	15 180	30 204	60 237	125 283	180 310	250 336
1/2	.220	.13	.15	.19	.26	.30	.35
3/4	.275	.15	.19	.24	.33	.38	.45
1	**.344**	**.19**	**.23**	**.28**	**.39**	**.46**	**.54**
1-1/4	.434	.23	.28	.36	.49	.57	.67
1-1/2	.497	.26	.32	.41	.55	.65	.76
2	**.622**	**.33**	**.40**	**.50**	**.68**	**.80**	**.93**
2-1/2	.753	.39	.47	.59	.81	.95	1.11
3	.916	.46	.56	.70	.96	1.13	1.31
3-1/2	**1.047**	**.52**	**.63**	**.80**	**1.08**	**1.27**	**1.50**
4	1.178	.58	.70	.89	1.21	1.43	1.72

Table CG-19. Finned Radiation Condensing Rates with 65°F air and 215°F steam (for trap selection purposes only).

	Pipe Size (in)	Fin Size (in)	Fins Per Inch	No. of Pipes High on 6" Centers	Condensate lbs/hr Per Foot of Pipe
Steel Pipe, Steel Fins Painted Black	1-1/4	3-1/4	3 to 4	1	1.1
				2	2.0
				3	**2.6**
	1-1/4	4-1/4	3 to 4	1	1.6
				2	2.4
				3	**3.1**
	2	4-1/4	2 to 3	1	1.5
				2	2.4
				3	**3.1**
Copper Pipe Aluminum Fins Unpainted	1-1/4	3-1/4	4	1	1.6
				2	2.2
				3	**2.8**
	1-1/4	4-1/4	5	1	2.2
				2	3.0
				3	**3.6**

How To Trap Process Air Heaters

Process air heaters are used for drying paper, lumber, milk, starch and other products as well as preheating combustion air for boilers.

Common examples of this type of equipment are process dryers, tunnel dryers, and combustion air preheaters. Compared with air heaters for space heating, process air heaters operate at very high temperature, 500°F not being uncommon. These extremely high-temperature applications require high pressure (and occasionally superheated) steam.

Trap Selection and Safety Factor

Determine the condensate load for process air heaters with the following formula:

$$Q = \frac{F \times Cp \times d \times 60 \text{ min/hr} \times \Delta T}{H}$$

Where:

Q = Condensate load in lbs/hr
F = Cubic feet of air per minute
Cp = Specific heat of air in Btu/lb—°F (from Table CG-34, page CG-57)
d = Density of air—.075 lbs/cu ft
ΔT = Temperature rise in °F
H = Latent heat of steam in Btu/lb (Steam Table, page CG-5)

EXAMPLE: What would be the condensate load on a tunnel dryer coil handling 2 000 CFM of air and requiring a 100°F temperature rise? The steam pressure is 45 psig. Using the formula:

$$Q = \frac{2\,000 \times .24 \times .075 \times 60 \times 100}{915}$$

$$Q = 236 \text{ lbs/hr}$$

Multiplying by a safety factor of 2—which is recommended for all constant pressure process air heaters—indicates that a trap with a capacity of 472 lbs/hr will be required. This is based on one coil. For higher air temperature rises, additional coils in series may be required.

Safety Factors

For constant steam pressure, use a safety factor of 2:1 at operating pressure differential. For modulating steam pressure, use a safety factor of 3:1 at 1/2 of maximum pressure differential across the trap.

Installation

Give piping for an entire piece of process air heating equipment—including all steam trap connections—adequate allowance for expansion due to the wide temperature variations. Mount traps 10"-12" below the coils with a dirt pocket of at least 6". On both constant and modulated pressure heaters, install a vacuum breaker between the coil and the steam trap. Install an air vent on each coil to remove air and other non-condensables that can cause rapid corrosion.
See Fig. CG-44.

Consider a safety drain if condensate is elevated after the trap or if back pressure is present. See page CG-49 for piping diagram and explanation.

Figure CG-44. Process Air Heater

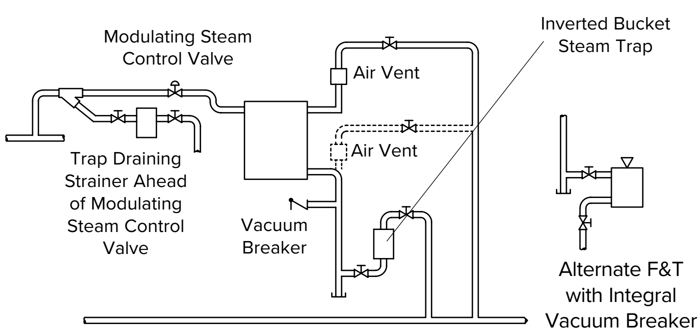


Chart CG-13. Recommendation Chart
(See Page CG-4 for "Feature Code" References.)

Equipment Being Trapped	1st Choice and Feature Code	Constant Pressure 0-30 psig	Constant Pressure Above 30 psig	1st Choice and Feature Code	Variable Pressure 0-30 psig	Variable Pressure Above 30 psig
Process Air Heaters	A, B, F, I, K, M	IB	IB	B, C, G, H, L	F&T	*F&T
	Alternate Choice	F&T	IBLV	Alternate Choice	IBLV	IBLV

*Use IBLV above F&T pressure temperature limitations.

PLEASE NOTE:
1. Provide vacuum breaker wherever subatmospheric pressures occur.
2. Do not use F&T traps on superheated steam.

Submerged coils are heat transfer elements that are immersed in the liquid to be heated, evaporated or concentrated. This type of coil is found in virtually every plant or institution that uses steam. Common examples are water heaters, reboilers, suction heaters, evaporators and vaporizers. These are used in heating water for process or domestic use, vaporizing industrial gases such as propane and oxygen, concentrating in-process fluids such as sugar, black liquor and petroleum, and heating fuel oil for easy transfer and atomization.

Different application requirements involving constant or variable steam pressure determine which type of trap should be used. Trap selection factors include the ability to handle air at low differential pressures, energy conservation and the removal of dirt and slugs of condensate. Three standard methods of sizing help determine the proper type and size traps for coils.

Safety Factor

1. **Constant Steam Pressure.** INVERTED BUCKET TRAPS OR F&T TRAPS—use a 2:1 safety factor at operating pressure differentials.
2. **Modulating Steam Pressure.** F&T TRAPS OR INVERTED BUCKET TRAPS.
   1. 0-15 psig steam—2:1 at 1/2 psi pressure differential.
   2. 16-30 psig steam—2:1 at 2 psi pressure differential.
   3. Above 30 psig steam—3:1 at 1/2 of maximum pressure differential across the trap.
3. **Constant or Modulating Steam Pressure with Syphon Drainage.** An automatic differential condensate controller with a safety factor of 3:1 should be used. An alternate is an IBLV with a 5:1 safety factor.

Apply the safety factor at full differential on constant steam pressure. Apply the safety factor at 1/2 maximum differential for modulating steam pressure.

Shell and Tube Heat Exchangers

One type of submerged coil is the shell and tube heat exchanger (Fig. CG-45). In these exchangers, numerous tubes are installed in a housing or shell with confined free area. This ensures positive contact with the tubes by any fluid flowing in the shell. Although the term submerged coil implies that steam is in the tubes and the tubes are submerged in the liquid being heated, the reverse can also be true, where steam is in the shell and a liquid is in the tubes.

Trap Selection for Shell and Tube Heat Exchangers

To determine the condensate load on shell and tube heaters, use the following formula when actual rating is known.* (If heating coil dimensions alone are known, use formula shown for embossed coils. Be sure to select applicable "U" factor):

$$Q = \frac{L \times \Delta T \times C \times 500 \times sg}{H}$$

Where:

Q	=	Condensate load in lbs/hr
L	=	Liquid flow in GPM
ΔT	=	Temperature rise in °F
C	=	Specific heat of liquid in Btu/lb-°F (Table CG-33, page CG-57)
500	=	60 min/hr x 8.33 lbs/gal
sg	=	Specific gravity of liquid (Table CG-33)
H	=	Latent heat of steam in Btu/lb (Steam Table, page CG-5)

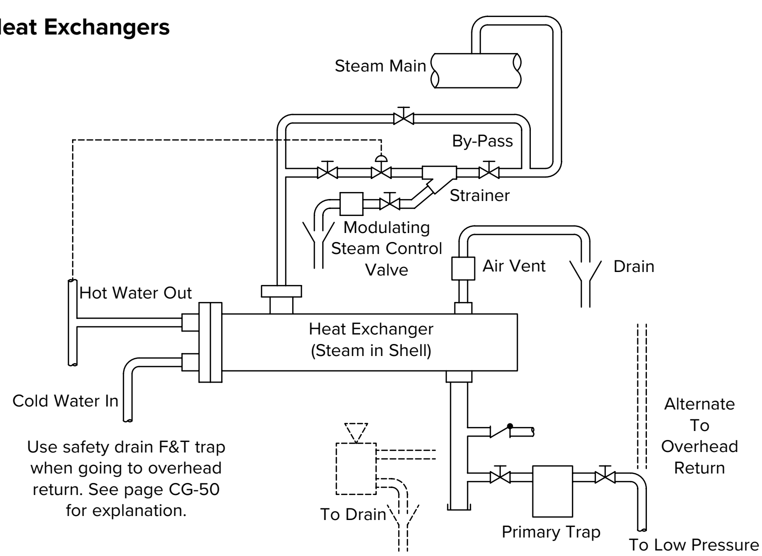
EXAMPLE: Assume a water flow rate of 50 GPM with an entering temperature of 40°F and a leaving temperature of 140°F. Steam pressure is 15 psig. Determine the condensate load.

Using the formula:

$$Q = \frac{50 \text{ GPM} \times 100°\text{F} \times 1 \text{ Btu/lb-°F} \times 500 \times 1.0 \text{ sg}}{945 \text{ Btu/lb}} =$$

*** Size steam traps for reboilers, vaporizers and evaporators (processes that create vapor) using the formula for EMBOSSED COILS on page CG-32.**

Figure CG-45. Shell And Tube Heat Exchangers
(Typical Piping Diagram)



Rule of Thumb for Computing Condensing Rate for Water Heaters: Raising the temperature of 100 gallons of water 1°F will condense one pound of steam.

Embossed Coils

Very often open tanks of water or chemicals are heated by means of embossed coils (Fig. CG-46). Upsetting grooves in the sheet metal of the two halves produce the spaces for the steam. When welded together, the halves form the passages for steam entry, heat transfer and condensate evacuation.

Trap Selection for Embossed Coils

Calculate the condensate load on embossed coils with the following formula:

Q = A x U x Dm

Where:

Q = Total heat transferred in Btu per hour
A = Area of outside surface of coil in sq ft
U = Overall rate of heat transfer in Btu per hr-sq ft-°F. See Tables CG-20 and CG-21.
Dm = Logarithmic mean temperature difference between steam and liquid (as between inlet and outlet of a heat exchanger) in °F

$$Dm = \frac{D1-D2}{\text{Log}_e \frac{(D1)}{(D2)}}$$

D1 = Greatest temperature difference
D2 = Least temperature difference

Logarithmic mean temperature difference can be determined with slightly less accuracy using the nomograph, Chart CG-16 (page CG-36).

U values are determined by tests under controlled conditions.

Table CG-20. Pipe Coil U Values in Btu/hr-sq ft-°F

Type of Service	Circulation	
	Natural	Forced
Steam to Water	50-200	150-1 200
1-1/2" Tube Heaters	180	450
3/4" Tube Heaters	200	500
Steam to Oil	10-30	50-150
Steam to Boiling Liquid	300-800	-
Steam to Boiling Oil	50-150	-

Tables CG-20 and CG-21 show the commonly accepted range for submerged embossed coils. For trap selection purposes, use a U value that is slightly greater than the conservative U value selected for estimating actual heat transfer.

EXAMPLE:

A = 20 sq ft of coil surface
U = 175 Btu/sq ft-hr-°F

Conditions:
Water in: 40°F
Water out: 150°F

Steam pressure: 125 psig or 353°F
D1 = 353 - 40, or 313
D2 = 353 - 150, or 203

Dividing by 4 to get within range of Chart CG-16 (page CG-36), we have:
D1 = 78.25
D2 = 50.75

Mean difference from chart is 63°F.
Multiplying by 4, the mean temperature difference for the original values is 252°F. Substituting in the equation:

Q = 20 x 175 x 252 = 882 000 Btu/hr

Btu transferred per hour.
Latent heat of steam at 125 psig = 867.6

$$\frac{882\ 000}{867.6} = 1\ 016 \text{ lbs condensate per hr}$$

To determine trap capacity required, multiply condensing rate by the recommended safety factor.

Table CG-21. Embossed Coil U Values in Btu/hr-sq ft-°F

Type of Service	Circulation	
	Natural	Forced
Steam to Watery Solutions	100-200	150-275
Steam to Light Oil	40-45	60-110
Steam to Medium Oil	20-40	50-100
Steam to Bunker C	15-30	40-80
Steam to Tar Asphalt	15-25	18-60
Steam to Molten Sulphur	25-35	35-45
Steam to Molten Paraffin	25-35	40-50
Steam to Molasses or Corn Syrup	20-40	70-90
Downtherm to Tar Asphalt	15-30	50-60

Figure CG-46. Thermostatic Controlled Embossed Coil, Syphon Drained

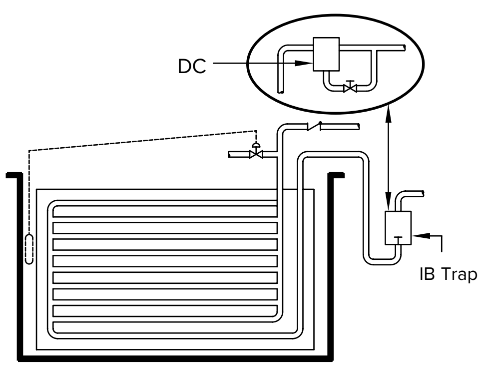
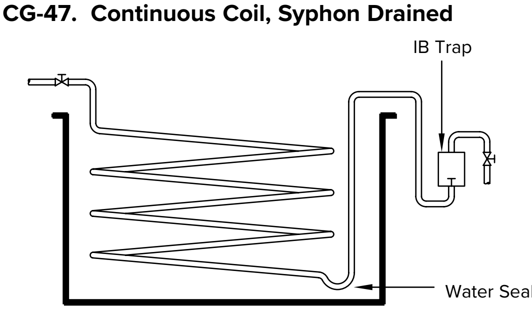


Figure CG-47. Continuous Coil, Syphon Drained



Pipe Coils

Pipe coils are heat transfer tubes immersed in vessels that are large in volume compared to the coils themselves (Fig. CG-47, page CG-32). This is their primary difference when compared to shell and tube heat exchangers. Like embossed coils, they may be drained by gravity or syphon drained, depending on the conditions prevailing at the installation site. Unlike embossed coils, most pipe coils are installed in closed vessels.

Trap Selection for Pipe Coils

Determine the condensate load for pipe coils by applying one of the formulas, depending on known data. If capacity is known, use the formula under shell and tube heat exchangers. When physical dimensions of coil are known, use the formula under embossed coils.

Installation

When gravity drainage is utilized on shell and tube heat exchangers, embossed coils and pipe coils, locate the steam trap below the heating coil. Under modulating pressure, use a vacuum breaker. This can be integral in F&T traps or mounted off the inlet piping on an inverted bucket trap. Place an ample drip leg ahead of the trap to act as a reservoir. This ensures coil drainage when there is a maximum condensate load and a minimum steam pressure differential.

Avoid lifting condensate from a shell and tube heat exchanger, embossed coil or pipe coil under modulated control. However, if it must be done, the following is suggested:

1. Do not attempt to elevate condensate more than 1' for every pound of normal pressure differential, either before or after the trap.
2. If condensate lift takes place after the steam trap, install a low-pressure safety drain. (See page CG-49).
3. If condensate lift takes place ahead of the steam trap (syphon lift), install an automatic differential condensate controller to efficiently vent all flash steam.

For Pounds of Steam Condensed Per sq ft Per Hour of Submerged Coil Surface, see Chart CG-17 (page CG-36).

Chart CG-14. Recommendation Chart
(See Page CG-4 for "Feature Code" References.)

Equipment Being Trapped	1st Choice and Feature Code	Constant Pressure		1st Choice and Feature Code	Variable Pressure	
		0-30 psig	Above 30 psig		0-30 psig	Above 30 psig
Shell and Tube Heat Exchangers	B, C, E, F G, I, K N, Q	IBLV	IBLV	B, C, G, H, I, L	F&T†	F&T†
	Alternate Choice	DC F&T	DC *F&T	Alternate Choice	DC IBT	DC IBLV
Embossed Coils and Pipe Coils Syphon Drain	B, C, E, F, G, H, I K, N, Q	DC	DC	B, C, G, H, I, L	DC	DC
	Alternate Choice	IBLV	IBLV	Alternate Choice	F&T†	*F&T†
Embossed Coild and Pipe Coils Gravity Drain	B, C, E, F, G, I, K N, Q	IBLV	IBLV	B, C, G, H, I, L	F&T†	*F&T†
	Alternate Choice	DC F&T	DC F&T	Alternate Choice	DC IBT	DC IBLV

*Use IBLV above pressure/temperature limitations.
†If dirt and large volumes of air must be handled, an inverted bucket trap with an external thermostatic air vent can be used effectively.

Please Note:
1. Provide vacuum breaker wherever subatmospheric pressures occur.
2. Provide a safety drain when elevating condensate on modulating service.

How to Trap Evaporators

Evaporators reduce the water content from a product through the use of heat. They are very common to many industries, especially paper, food, textiles, chemical and steel.

An evaporator is a shell and tube heat exchanger where the steam is normally in the shell and the product is in the tubes and in motion. Depending upon the type of product and the desired results, more than one stage or effect of evaporation may be required. The triple effect is the most common, although as many as five or six can be found on some applications.

Single Effect

While the product is being forced through the tubes of the evaporator, heat is added to remove a specific amount of moisture. After this is completed, both the product vapor and the concentrated product are forced into the separating chamber where the vapor is drawn off and may be used elsewhere. The concentrate is then pumped off to another part of the process (Fig. CG-48).

Multiple Effect

In using the multiple effect method, there is a conservation of heat as steam from the boiler is used in the first effect, and then vapor generated from the product is used as the heat source in the second effect. The vapor generated here is then used as the heat source in the third effect and finally heats water for some other process or preheats the incoming feed (Fig. CG-49).

There are many variables in the design of evaporators due to their wide application to many different products. The steam capabilities for evaporators can vary from approximately 1 000 lbs per hour to 100 000 lbs per hour, while steam pressures may vary from a high of 150 psig in the first effect to a low of 24" mercury vacuum in the last effect.

Because evaporators are normally run continuously, there is a uniform load of condensate to be handled. It's important to remember that traps must be selected for the actual pressure differential for each effect.

The three major considerations when trapping evaporators are:
1. Large condensate loads.
2. Low pressure differentials in some effects.
3. The evacuation of air and contaminants.

Safety Factor

- When load is fairly constant and uniform, a 2:1 safety factor should be adequate when applied to an actual condensing load in excess of 50,000 lbs/hr.
- Below 50 000 lbs/hr, use a 3:1 safety factor.

For single and multiple effect evaporators, automatic differential condensate controllers are recommended. In addition to offering continuous operation, DC traps vent air and CO_2 at steam temperature, handle flash steam and respond immediately to slugs of condensate.

Figure CG-48. Single Effect Evaporator System

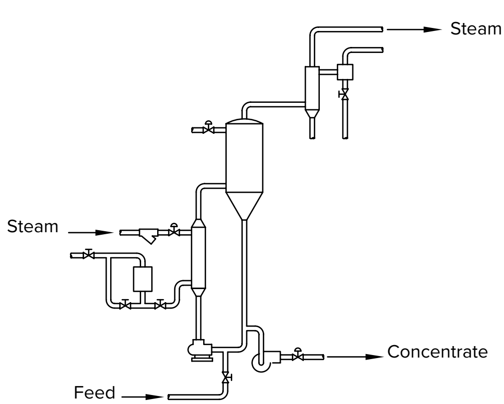


Figure CG-49. Triple Effect Evaporator System

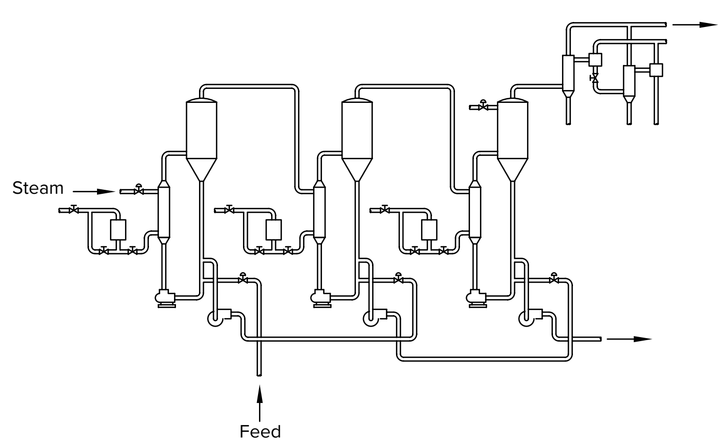


Chart CG-15. Recommendation Chart (See Page CG-4 for "Feature Code" References.)			
Equipment Being Trapped	**1st Choice, Feature Code and Alternate Choice(s)**	**0-30 psig**	**Above 30 psig**
Evaporator Single Effect	A, F, G, H, K, M, P	DC	DC
	Alternate Choices	IBLV F&T	IBLV F&T
Evaporator Multiple Effect	A, F, G, H, K, M, P	DC	DC
	Alternate Choices	IBLV F&T	IBLV F&T

Installation

Because an evaporator is basically a shell and tube heat exchanger with the steam in the shell, there should be separate steam air vents on the heat exchanger. Place these vents at any area where there is a tendency for air to accumulate, such as in the quiet zone of the shell. Install a separate trap on each effect. While the condensate from the first effect may be returned to the boiler, condensate from each successive effect may not be returned to the boiler due to contamination from the product.

Trap Selection for Evaporators

When calculating the condensate load for evaporators, take care in selecting the U value (Btu/hr-sq ft-°F). As a general rule, the following U values can be used:

- 300 for natural circulation evaporators with low pressure steam (up to 25 psig)
- 500 on natural circulation with high pressure (up to 45 psig)
- 750 with forced circulation evaporators

Use the following formula to compute heat transfer for constant steam pressure continuous flow heat exchangers.

$$Q = A \times U \times Dm$$

Where:

Q = Total heat transferred in Btu per hour

A = Area of outside surface of coil in sq ft

U = Overall rate of heat transfer in Btu/hr-sq ft-°F (See Tables CG-20 and CG-21 on page CG-32)

Dm = Logarithmic mean temperature difference between steam and liquid (as between inlet and outlet of a heat exchanger) in °F

$$Dm = \frac{D1-D2}{\text{Log}_e \frac{(D1)}{(D2)}}$$

Where:

D1 = Greatest temperature difference

D2 = Least temperature difference

Logarithmic mean temperature difference can be estimated by using the nomograph, Chart CG-16 (page CG-36).

EXAMPLE:

A = Heat transfer tubes: eight 3/4” OD tubes 12’ long

$$\frac{8 \times 12'}{5.09 \text{ (from Table CG-24)}} = 20 \text{ sq ft of coil surface}$$

U = 500 Btu/hr-sq ft-°F

Conditions:

Water in: 40°F

Water out: 150°F

125 psig or 353°F steam pressure:

D1 = 353°F - 40°F, or 313°F

D2 = 353°F - 150°F, or 203°F

Dividing by 4 to get within range of Chart CG-16, we have:

D1 = 78.25°F

D2 = 50.75°F

Mean difference from chart is 63°F. Multiplying by 4, the mean temperature difference for the original value is 252°F. Substituting in the equation:

Q = 20 x 500 x 252 = 2 520 000 Btu/hr transferred per hour

Latent heat of steam at 125 psig = 867.6

$$\frac{2\ 520\ 000}{867.69} = 2\ 900 \text{ lbs condensate per hour}$$

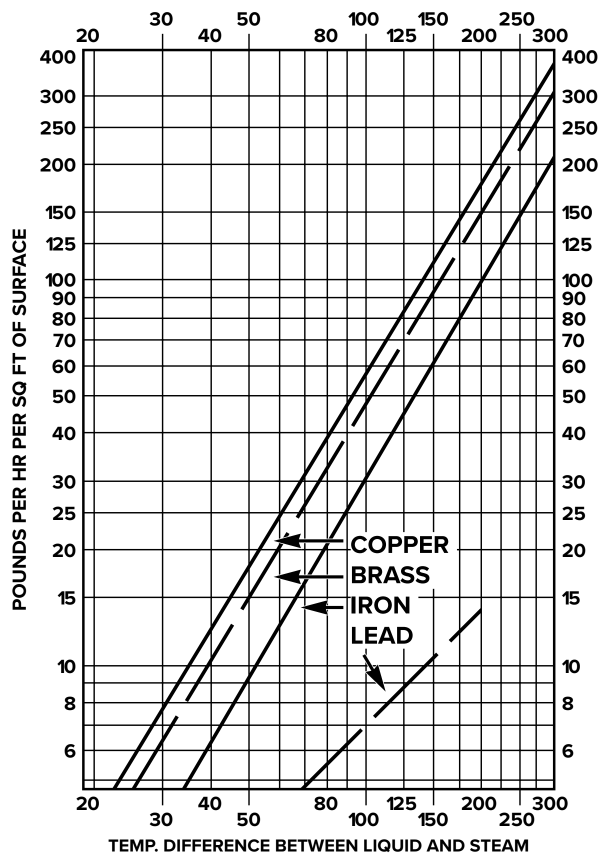
To determine trap capacity required, multiply the condensing rate by the recommended safety factor.

Table CG-22. Pipe Coil U Values in Btu/hr-sq ft-°F		
Type of Service	Circulation	
	Natural	Forced
Steam to Water	50-200	150-200
1-1/2" Tube Heaters	180	450
3/4" Tube Heaters	200	500
Steam to Oil	10-30	50-150
Steam to Boiling Liquid	300-800	-
Steam to Boiling Oil	50-150	-

Table CG-24. Pipe Size Conversion Table. (Divide lineal feet of pipe by factor given for size and type of pipe to get square feet of surface)		
Pipe Size (in)	Iron Pipe	Copper or Brass Pipe
1/2	4.55	7.63
3/4	3.64	5.09
1	**2.90**	**3.82**
1-1/4	2.30	3.05
1-1/2	2.01	2.55
2	**1.63**	**1.91**
2-1/2	1.33	1.52
3	1.09	1.27
4	**.848**	**.954**

Table CG-23. Embossed Coil U Values in Btu/hr-sq ft-°F		
Type of Service	Circulation	
	Natural	Forced
Steam to Watery Solutions	100-200	150-275
Steam to Light Oil	40-45	60-110
Steam to Medium Oil	20-40	50-100
Steam to Bunker C	15-30	40-80
Steam to Tar Asphalt	15-25	18-60
Steam to Molten Sulphur	25-35	35-45
Steam to Molten Paraffin	25-35	40-50
Steam to Molasses or Corn Syrup	20-40	70-90
Downtherm to Tar Asphalt	15-30	50-60

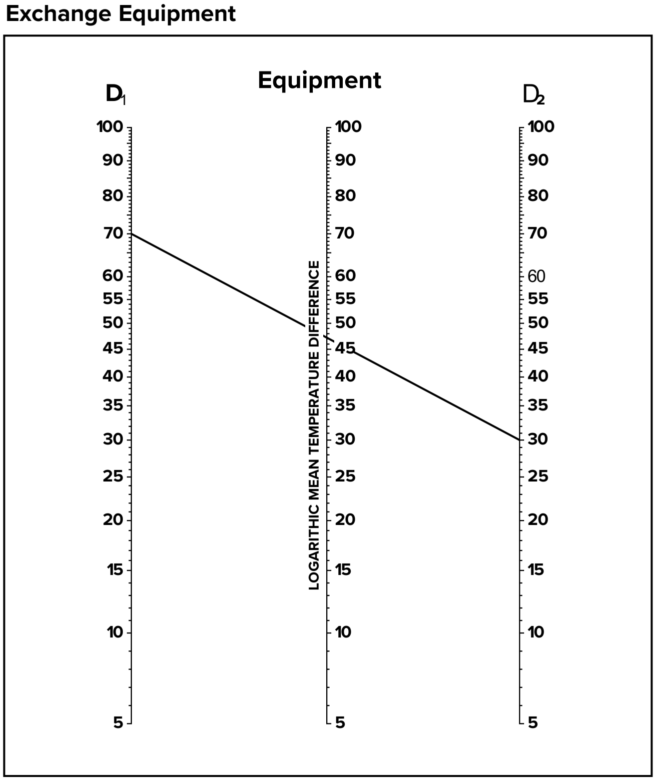
Chart CG-17. Pounds of Steam Condensed Per sq ft Per Hour of Submerged Coil Surface
(See "Conditions" conversion factors below chart)



Condition Factors
(Divide chart figures by proper factor)

CONDITIONS	FACTOR
Will remain bright	1
Moderate scale	2
Liquid contains up to 25% solids	3-5
Thick viscous liquids	4-8

Chart CG-16. Mean Temperature Difference Chart for Heat Exchange Equipment



Connect greatest temperature difference on scale D_1 with least temperature difference on scale D_2 to read logarithmic mean temperature difference on center scale.

How to Trap Jacketed Kettles

Steam jacketed kettles are essentially steam jacketed cookers or concentrators. They are found in all parts of the world and in almost every kind of application: meat packing, paper and sugar making, rendering, fruit and vegetable processing and food preparation—to name a few.

There are basically two types of steam jacketed kettles—fixed gravity drain and tilting syphon drain. Each type requires a specialized method for trapping steam, although the major problems involved are common to both.

The most significant problem encountered is air trapped within the steam jacket, which adversely affects the temperature. Jacketed kettles usually perform batch operations, and maintaining a uniform or “cooking” temperature is critical. With an excessive amount of air, wide variations in temperature occur and may result in burnt product and/or slow production. To be more specific, under certain conditions as little as 1/2 of 1% by volume of air in steam can form an insulating film on the heat transfer surface and reduce efficiency as much as 50%. See pages CG-9 and CG-10.

A second basic concern in the use of steam jacketed kettles is the need for a steady, thorough removal of condensate. Accumulation of condensate in the jacket leads to unreliable temperature control, reduces the output of the kettle and causes water hammer.

Trap Selection for Jacketed Kettles

Table CG-25 gives the required trap capacities for various size kettles based on the following assumptions:
U = 175 Btu/hr-sq ft-°F
Safety factor of 3 included.

EXAMPLE: What would be the recommended trap capacity for a 34” gravity drained kettle at 40 psig steam? Reading directly from the chart, a trap with a capacity of 1 704 lbs/hr at the operating pressure is required.

For an alternative method of determining condensate, use the following formula:

$$Q = \frac{G \times sg \times Cp \times \Delta T \times 8.3}{H \times t}$$

Where:

Q = Condensate loads (lbs/hr)
G = Gallons of liquid to be heated
sg = Specific gravity of the liquid
Cp = Specific heat of the liquid
ΔT = Temperature rise of the liquid °F
8.3 = lbs/gal of water
H = Latent heat of the steam (Btu/lb)
t = Time in hours for product heating

EXAMPLE: Select a trap for a 250-gallon kettle using 25 psig steam to heat a product with a specific gravity of 0.98 and a specific heat of 0.95 Btu/lb-°F. Starting at room temperature of 70°F, the product will be heated to 180°F in 1/2 hour. (Assume 3:1 safety factor.) Using the formula:

$$Q = \frac{250 \text{ gal} \times 0.98 \times 0.95 \text{ Btu/lb-°F} \times 110\text{°F} \times 8.3 \text{ lbs/gal}}{933 \text{ Btu/lb} \times 0.5 \text{ hr}}$$

$$= \frac{212\ 500}{466.5}$$

$$= 455 \text{ lbs/hr}$$

Now simply multiply by a safety factor of 3 to get 1,365 lbs/hr of condensate and select the proper type and capacity trap.

Based on the standard requirements and problems involved with fixed gravity drained kettles, the most efficient type trap to use is the inverted bucket.

The inverted bucket trap vents air and CO_2 at steam temperature and provides total efficiency against back pressure. The primary recommendation for tilting syphon drained kettles is the automatic differential condensate controller. In addition to providing the same features as the IB, the DC offers excellent air venting ability at very low pressure and excellent flash steam handling ability. If an IB trap is selected for syphon drained service, use a trap one size larger.

General Recommendations for Maximum Efficiency

Desirable Cooking Speed. Because the product cooked has such an important bearing on trap selection, a plant with many jacketed kettles should conduct experiments using different sizes of traps to determine the size giving best results.

Steam Supply. Use steam lines of ample size to supply steam to the kettles. Locate the inlet nozzle high up on the jacket for best results. It should be slotted so as to give steam flow around the entire jacket area.

Installation

Install traps close to the kettle. You can further increase the dependability and air-handling capability by installing a thermostatic air vent at high points in the jacket. See Figs. CG-50 and CG-51.

Never drain two or more kettles with a single trap. Group drainage will invariably result in short circuiting.

Chart CG-18. Recommendation Chart
(See Page CG-4 for “Feature Code” References.)

Equipment Being Trapped	1st Choice and Feature Code	Alernate Choices
Jacketed Kettles Gravity Drain	IBLV B, C, E, H, K, N	F&T or Thermostatic
Jacketed Kettles Syphon Drain	DC B, C, E, G, H, K, N, P	IBLV

Figure CG-50. Fixed Gravity Drained Kettle

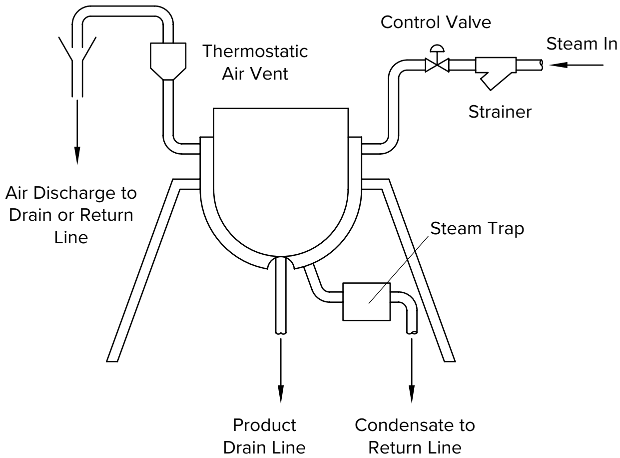


Figure CG-51. Tilting Syphon Drained Kettle

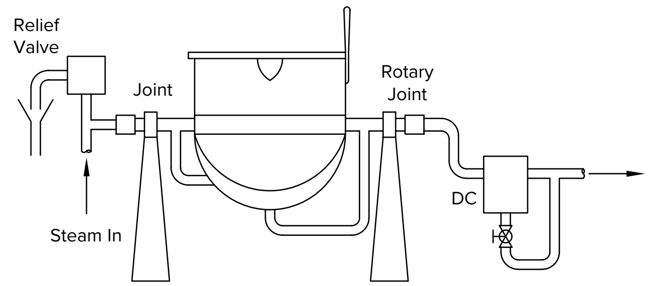


Table CG-25. Condensate Rates in lbs/hr for Jacketed Kettles—Hemispherical Condensing Surface
Safety factor 3:1 is included. Assume U = 175 Btu/hr-sq ft-°F, 50°F starting temperature.

Kettle Diameter (in)	Heat Transfer Surface (sq ft)	U.S. Gallons of Water in Hemisphere	U.S. Gals. Water per in. of Height Above Hemisphere	Steam Pressure								
				5 psig 227°F	10 psig 240°F	15 psig 250°F	25 psig 267°F	40 psig 287°F	60 psig 307°F	80 psig 324°F	100 psig 338°F	125 psig 353°F
18	3.50	7	1.10	339	366	387	426	474	522	564	603	642
19	3.90	8	1.20	378	408	432	477	528	582	630	669	714
20	**4.35**	**9**	**1.35**	**420**	**456**	**483**	**531**	**588**	**651**	**702**	**747**	**798**
22	5.30	12	1.65	513	555	588	648	717	792	855	912	972
24	6.30	16	1.95	609	660	699	768	852	942	1 017	1 083	1 155
26	**7.40**	**20**	**2.30**	**717**	**774**	**822**	**903**	**1 002**	**1 107**	**1 194**	**1 272**	**1 356**
28	8.50	25	2.65	822	891	942	1 038	1 149	1 269	1 371	1 461	1 557
30	9.80	31	3.05	948	1 026	1 089	1 197	1 326	1 464	1 581	1 686	1 797
32	**11.20**	**37**	**3.50**	**1 086**	**1 173**	**1 242**	**1 368**	**1 515**	**1 674**	**1 809**	**1 926**	**2 052**
34	12.60	45	3.95	1 221	1 320	1 398	1 539	1 704	1 881	1 944	2 166	2 310
36	14.10	53	4.40	1 365	1 476	1 566	1 722	1 908	2 106	2 277	2 424	2 586
38	**15.70**	**62**	**4.90**	**1 521**	**1 644**	**1 743**	**1 917**	**2 124**	**2 346**	**2 535**	**2 700**	**2 877**
40	17.40	73	5.45	1 686	1 821	1 932	2 124	2 355	2 601	2 808	2 991	3 189
42	19.20	84	6.00	1 860	2 010	2 130	2 343	2 598	2 868	3 099	3 300	3 519
44	**21.10**	**97**	**6.60**	**2 043**	**2 208**	**2 343**	**2 577**	**2 856**	**3 153**	**3 405**	**3 627**	**3 867**
46	23.00	110	7.20	2 229	2 409	2 553	2 808	3 111	3 435	3 711	3 954	4 215
48	25.30	123	7.85	2 451	2 649	2 808	3 087	3 423	3 780	4 083	4 350	4 638
54	**31.70**	**178**	**9.90**	**3 076**	**3 324**	**3 523**	**3 875**	**4 296**	**4 743**	**5 125**	**5 458**	**5 820**
60	39.20	245	12.30	3 798	4 104	4 350	4 785	5 304	5 856	6 327	6 738	7 185
72	56.40	423	17.70	5 469	5 910	6 264	6 890	7 638	8 433	9 111	9 703	10 346

Closed, stationary steam chamber equipment includes platen presses for the manufacture of plywood and other sheet products, steam jacketed molds for rubber and plastic parts, autoclaves for curing and sterilizing and retorts for cooking.

Product Confined in Steam Jacketed Press

Molded plastic and rubber products such as battery cases, toys, fittings and tires are formed and cured, and plywood is compressed and glue-cured in equipment of this type. Laundry flatwork ironers are a specialized form of press with a steam chamber on one side of the product only.

Trap Selection and Safety Factor
The condensate load for closed, stationary steam chamber equipment is determined by use of the following formula:

$$Q = A \times R \times S$$

Where:

Q = Condensate load in lbs/hr
A = Total area of platen in contact with product in sq ft
R = Condensing rate in lbs/sq ft-hr (For purposes of sizing steam traps, a 3 lbs/sq ft-hr condensing rate may be used)
S = Safety factor

EXAMPLE: What is the condensate load for a mid platen on a press with 2' x 3' platens, upper and lower? Using the formula:

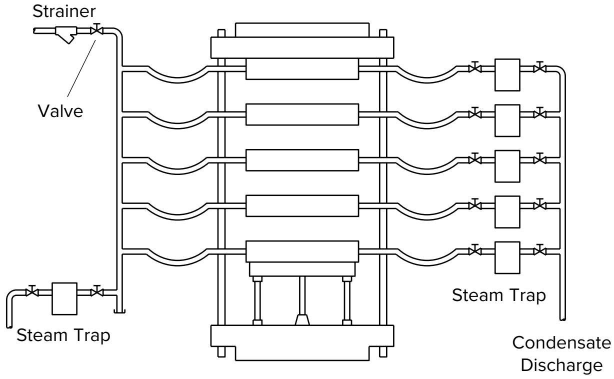
Q = 12 sq ft x 3 lbs/sq ft-hr x 3 = 108 lbs/hr

End platens would have half this load.

The safety factor recommended for all equipment of this type is 3:1.

The inverted bucket trap is the recommended first choice on steam jacketed chambers, dryers and ironers because it can purge the system, resist hydraulic shock and conserve energy. Disc and thermostatic type traps may be acceptable alternatives.

Figure CG-52. Product Confined In Steam Jacketed Press



Installation

Although the condensate load on each platen is small, individual trapping is essential to prevent short circuiting, Fig. CG-52. Individual trapping ensures maximum and uniform temperature for a given steam pressure by efficiently draining the condensate and purging the non-condensables.

Direct Steam Injection Into Product Chamber

This type of equipment combines steam with the product in order to cure, sterilize or cook. Common examples are autoclaves used in the production of rubber and plastic products, sterilizers for surgical dressings and gowns, and retorts for cooking food products already sealed in cans.

Trap Selection and Safety Factor
Calculate the condensate load using the following formula:

$$Q = \frac{W \times C \times \Delta T}{H \times t}$$

Where:

Q = Condensate load in lbs/hr
W = Weight of the material in lbs
C = Specific heat of the material in Btu/lb-°F (See page CG-57)
ΔT = Material temperature rise in °F
H = Latent heat of steam in Btu/lb (See Steam Tables on page CG-5)
t = Time in hours

EXAMPLE: What will be the condensate load on an autoclave containing 300 lbs of rubber product which must be raised to a temperature of 300°F from a starting temperature of 70°F? The autoclave operates at 60 psig steam pressure and the heat-up process takes 20 minutes. Using the formula:

$$Q = \frac{300 \text{ lbs} \times .42 \text{ Btu/lb-°F} \times 230\text{°F}}{904 \text{ Btu/lb} \times .33 \text{ hr}} = 96 \text{ lbs/hr}$$

Multiply by a recommended safety factor of 3:1 to get the required capacity—288 lbs/hr.

Since steam is in contact with the product, you can anticipate dirty condensate. In addition, the vessel is a large volume chamber that requires special consideration in the purging of condensate and non-condensables. For these reasons, an inverted bucket trap with an auxiliary thermostatic air vent installed at the top of the chamber is recommended.

Where no remote thermostatic air vent can be installed, incorporate the large volume air purging capabilities in the steam trap itself. An automatic differential condensate controller should be considered a possible first choice on large chambers. As an alternative, an F&T or thermostatic trap should be used and be preceded by a strainer, the latter receiving regular checks for free flow.

Installation

Because the steam and condensate is in contact with the product, the trap discharge should almost always be disposed of by some means other than return to the boiler. In virtually all cases this equipment is gravity drained to the trap. However, very often there is a condensate lift after the trap. Because steam pressure is usually constant, this does not present a problem. For thorough air removal and quicker warm-up, install a thermostatic air vent at a high point of the vessel. See Fig. CG-53.

Product in Chamber—Steam in Jacket

Autoclaves, retorts and sterilizers are also common examples of this equipment; however, the condensate is not contaminated from actual contact with the product and can be returned directly to the boiler. Steam traps with purging ability and large volume air venting are still necessary for efficient performance.

Trap Selection and Safety Factor
Size steam traps for "product in chamber–steam in jacket equipment" by using the same formula outlined for direct steam injection. The safety factor is also 3:1.

The inverted bucket trap is recommended because it conserves steam, purges the system and resists hydraulic shock.

Use the IB trap in combination with a thermostatic air vent at the top of the chamber for greater air-handling capability. As an alternative, an F&T or thermostatic trap could be used. On large chambers, where it's not possible to install the air vent, an automatic differential condensate controller should be considered a possible first choice.

Installation

With "product in chamber—steam in jacket equipment," the steam and condensate do not come in contact with the product and can be piped to the condensate return system. Where possible, install an auxiliary thermostatic air vent at a remote high point on the steam chamber. See Fig. CG-54.

Chart CG-19. Recommendation Chart (See Page CG-4 for "Feature Code" References.)

Equipment Being Trapped	1st Choice and Feature Code	Alternate Choices
Product Confined Steam Jacketed Press	IB A, B, E, K	CD and Thermostatic
Direct Steam Injection into Product Chamber	*IB A, B, E, H, K, N, Q	**DC
Product in Chamber–Steam in Jacket	*IB A, B, E, H, K	Thermostatic and F&T and **DC

*An auxiliary air vent is recommended.
**First choice on large volume vessels.

Figure CG-53. Direct Steam Injection Into Product Chamber

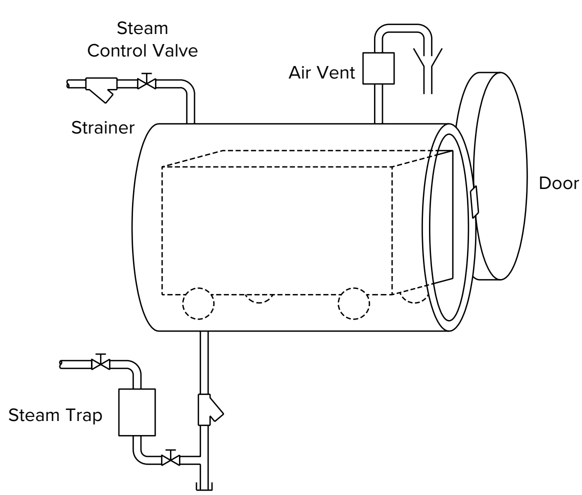
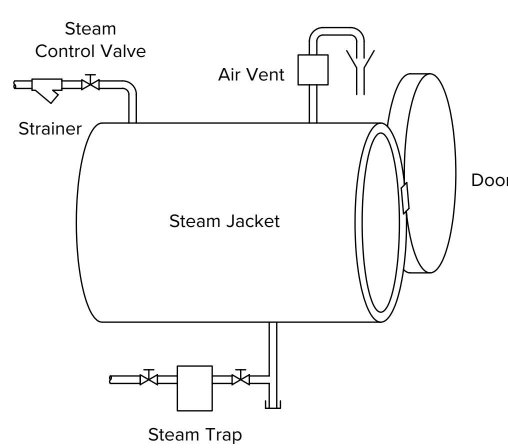


Figure CG-54. Product in Chamber—Steam in Jacket



There are two classifications of rotating dryers which vary significantly in both function and method of operation. The first dries a product by bringing it into contact with the outside of a steam-filled cylinder. The second holds the product inside a rotating cylinder where steam-filled tubes are used to dry it through direct contact. In some applications a steam jacket surrounding the cylinder is also used.

Safety Factor
The safety factor for both kinds of dryers depends on the type of drainage device selected.

- If an automatic differential condensate controller (DC) is installed, use a safety factor of 3:1 based on the maximum load. This will allow sufficient capacity for handling flash steam, large slugs of condensate, pressure variations and the removal of non-condensables. The DC performs these functions on both constant and modulated pressure.
- If an inverted bucket trap with large vent is used, increase the safety factor in order to compensate for the large volume of non-condensable and flash steam that will be present. Under constant-pressure conditions, use a safety factor of 8:1. On modulated pressure increase it to 10:1.

Rotating Steam Filled Cylinder with Product Outside

These dryers are used extensively in the paper, textile, plastic and food industries, where common examples are dry cans, drum dryers, laundry ironers and paper machine dryers. Their speed of operation varies from 1 or 2 rpm to surface velocities as high as 5 000 rpm. Operating steam pressure ranges from subatmospheric to more than 200 psig. Diameters can vary from 6” or 8” to 14’ or more. In all cases syphon drainage is required and flash steam will accompany the condensate.

Trap Selection
Condensate loads can be determined by use of the following formula:

Q = 3.14D x R x W

Where:

Q = Condensate load in lbs/hr

D = Diameter of the dryer in ft

R = Rate of condensation in lbs/sq ft-hr

W = Width of dryer in ft

EXAMPLE: Determine the condensate load of a dryer 5 ft in diameter, 10 ft in width and with a condensing rate of 7 lbs/sq ft-hr. Using the formula:

Condensate load = 3.14(5) x 7 x 10 = 1 100 lbs/hr

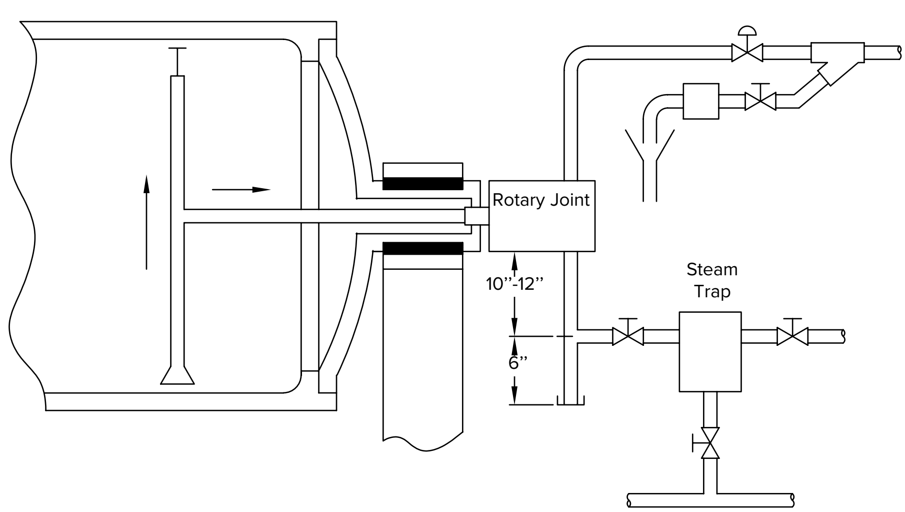
Based on its ability to handle flash steam, slugs of condensate and purge the system, a DC is the recommended first choice. An IBLV may be adequate if proper sizing procedures are followed.

Chart CG-20. Recommendation Chart
(See Page CG-4 for “Feature Code” References.)

Equipment Being Trapped	1st Choice and Feature Code	Alternate Choice
Rotating Dryers	DC A, B, K, M, P, N	IBLV*

*On constant pressure use 8:1 safety factor, and on modulated pressure use 10:1.

Figure CG-55. Product Outside Dryer



A revolving cylinder drained with a syphon—an internal syphon surrounded by steam. Some condensate flashes back to steam due to the steam jacketed syphon pipe and syphon lifting during evacuation.

Product Inside a Rotating Steam Heated Dryer

This type of dryer finds wide application in meat packing as well as food processing industries. Common examples are grain dryers, rotary cookers and bean conditioners.

Their speed of rotation is relatively slow, usually limited to a few rpm, while steam pressure may range from 0-150 psig. These slower rotating speeds permit the condensate to accumulate in the bottom of the collection chamber in practically all cases. Again, syphon drainage is required and flash steam is generated during condensate removal.

Trap Selection

The condensate load generated by these dryers can be determined through use of the following formula:

$$Q = \frac{N \times L \times R}{P}$$

Where:

Q = Condensate in lbs/hr

N = Number of tubes

L = Length of tubes in ft

R = Condensing rate in lbs/sq ft-hr (typical 6-9 lbs/sq ft-hr)

P = Lineal ft of pipe per sq ft of surface (see Table CG-26)

EXAMPLE: What will be the condensate load on a rotary cooker containing 30 1-1/4" steel pipes 12' in length with a condensing rate of 8 lbs/sq ft-hr?
Using the formula:

$$Q = \frac{30 \times 12 \times 8}{2.30} = 1\,252 \text{ lbs/hr}$$

A differential controller is recommended on these dryers for its purging and flash steam handling ability.

The IBLV again requires proper sizing for certain applications.

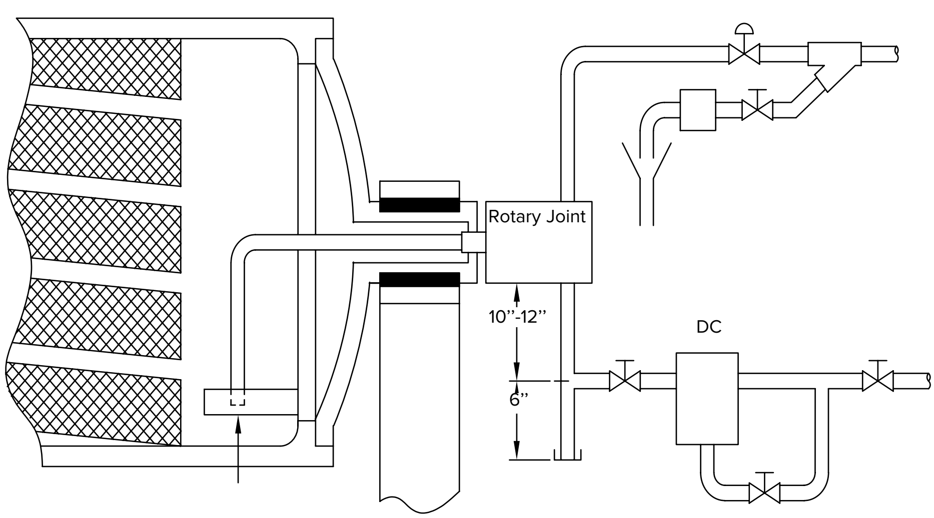
Installation

In all cases, condensate drainage is accomplished through a rotary joint, Figs. CG-55 and CG-56. The DC should then be located 10"-12" below the rotary joint with an extended 6" dirt pocket. These provide a reservoir for surges of condensate and also a pocket for entrained scale.

Table CG-26. Pipe Size Conversion Table (Divide lineal feet of pipe by factor given for size and type of pipe to get square feet of surface)

Pipe Size (in)	Iron Pipe	Copper or Brass Pipe
1/2	4.55	7.63
3/4	3.64	5.09
1	**2.90**	**3.82**
1-1/4	2.30	3.05
1-1/2	2.01	2.55
2	**1.61**	**1.91**
2-1/2	1.33	1.52
3	1.09	1.27
4	**.848**	**.954**

Figure CG-56. Product Inside Dryer



A revolving cylinder drained with a syphon—an internal syphon surrounded by steam. Some condensate flashes back to steam due to the steam jacketed syphon pipe and syphon lifting during evacuation.

How to Trap Flash Tanks

When hot condensate or boiler water, under pressure, is released to a lower pressure, part of it is re-evaporated, becoming what is known as flash steam. The heat content of flash is identical to that of live steam at the same pressure, although this valuable heat is wasted when allowed to escape through the vent in the receiver. With proper sizing and installation of a flash recovery system, the latent heat content of flash steam may be used for space heating; heating or preheating water, oil and other liquids; and low pressure process heating.

If exhaust steam is available it may be combined with the flash. In other cases, the flash will have to be supplemented by live make-up steam at reduced pressure. The actual amount of flash steam formed varies according to pressure conditions. The greater the difference between initial pressure and pressure on the discharge side, the greater the amount of flash that will be generated.

To determine the exact amount, as a percentage, of flash steam formed under certain conditions, refer to page CG-6 for complete information.

Trap Selection

The condensate load can be calculated using the following formula:

$$Q = L - \frac{L \times P}{100}$$

Where:

Q = Condensate load in lbs/hr (to be handled by steam trap)

L = Condensate flow into flash tank in lbs/hr

P = Percentage of flash

EXAMPLE: Determine the condensate load of a flash tank with 5,000 lbs/hr of 100 psig condensate entering the flash tank held at 10 psig. From page CG-6, the flash percentage is P = 10.5%. Using the formula:

$$Q = 5\,000 - \frac{(5\,000 \times 10.5)}{100} = 4\,475 \text{ lbs/hr}$$

Due to the importance of energy conservation and operation against back pressure, the trap best suited for flash steam service is the inverted bucket type with large bucket vent. In addition, the IB operates intermittently while venting air and CO_2 at steam temperature.

In some cases, the float and thermostatic type trap is an acceptable alternative. One particular advantage of the F&T is its ability to handle heavy start-up air loads.

Chart CG-21. Recommendation Chart (See Page CG-4 for "Feature Code" References.)		
Equipment Being Trapped	**1st Choice and Feature Code**	**Alternate Choice**
Flash Tanks	IBLV B, E, M, L, I, A, F	F&T or *DC

*Recommended where condensate loads exceed the separating capability of the flash tank.

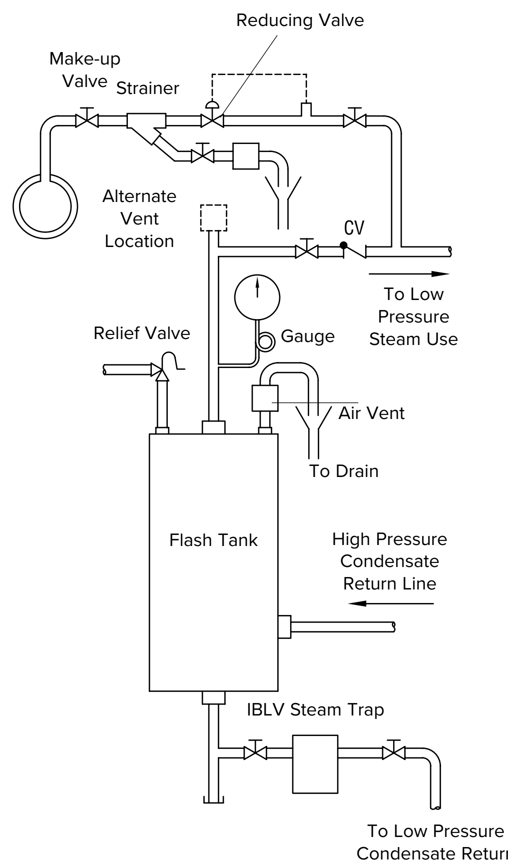
Refer to Chart CG-3 (page CG-6) for percentage of flash steam formed when discharging condensate to reduced pressure.

A third type of device that may be the preferred selection in many cases is the automatic differential condensate controller. It combines the best features of both the IB and F&T and is recommended for large condensate loads that exceed the separating capability of the flash tank.

Safety Factor

The increased amount of condensate at start-up and the varying loads during operation accompanied by low pressure differential dictates a safety factor of 3:1 for trapping flash tanks.

Figure CG-57. Typical Flash Tank Piping Sketch



Flash steam tank with live steam make-up, showing recommended fittings and connections. The check valves in the incoming lines prevent waste of flash when a line is not in use. The by-pass is used when flash steam cannot be used. Relief valves prevent pressure from building up and interfering with the operation of the high pressure steam traps. The reducing valve reduces the high pressure steam to the same pressure as the flash, so they can be combined for process work or heating.

Installation

Condensate return lines contain both flash steam and condensate. To recover the flash steam, the return header runs to a flash tank, where the condensate is drained, and steam is then piped from the flash tank to points of use, Fig. CG-57. Since a flash tank causes back pressure on the steam traps discharging into the tank, these traps should be selected to ensure their capability to work against back pressure and have sufficient capacity at the available differential pressures.

Condensate lines should be pitched toward the flash tank, and where more than one line feeds into a flash tank, each line should be fitted with a swing check valve. Then, any line not in use will be isolated from the others and will not be fed in reverse with resultant wasted flash steam. If the trap is operating at low pressure, gravity drainage to the condensate receiver should be provided.

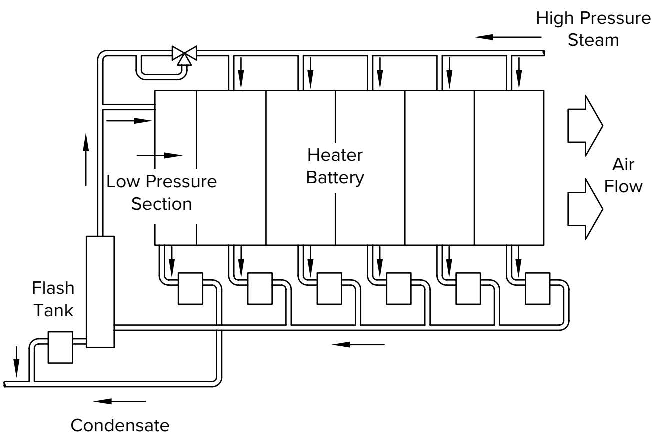
Generally, the location chosen for the flash tank should meet the requirement for maximum quantity of flash steam and minimum length of pipe.

Condensate lines, the flash tank, and the low pressure steam lines should be insulated to prevent waste of flash through radiation. The fitting of a spray nozzle on the inlet pipe inside the tank is not recommended. It may become choked, stop the flow of condensate, and produce a back pressure to the traps.

Low pressure equipment using flash steam should be individually trapped and discharged to a low pressure return. Large volumes of air need to be vented from the flash tank; therefore, a thermostatic air vent should be used to remove the air and keep it from passing through the low pressure system.

Figure CG-58. Flash Steam Recovery from an Air Heater Battery

Flash is taken from the flash tank and combined with live steam, the pressure of which is reduced to that of the flash by a reducing valve.



Flash Tank Dimensions

The flash tank can usually be conveniently constructed from a piece of large diameter piping with the bottom ends welded or bolted in position. The tank should be mounted vertically. A steam outlet is required at the top and a condensate outlet at the bottom. The condensate inlet connection should be 6''-8'' above the condensate outlet.

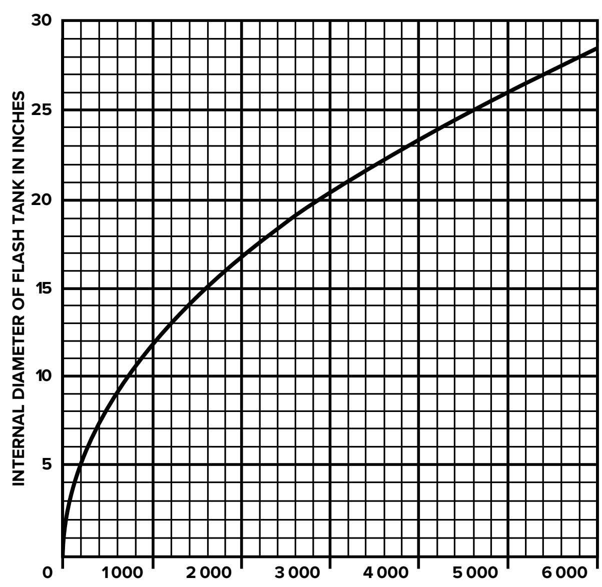
The important dimension is the inside diameter. This should be such that the upward velocity of flash to the outlet is low enough to ensure that the amount of water carried over with the flash is small. If the upward velocity is kept low, the height of the tank is not important, but good practice is to use a height of 2'-3'.

It has been found that a steam velocity of about 10' per second inside the flash tank will give good separation of steam and water. On this basis, proper inside diameters for various quantities of flash steam have been calculated; the results are plotted in Chart CG-22. This curve gives the smallest recommended internal diameters. If it is more convenient, a larger tank may be used.

Chart CG-22 does not take into consideration pressure—only weight. Although volume of steam and upward velocity are less at a higher pressure, because steam is denser, there is an increased tendency for priming. Thus it is recommended that, regardless of pressure, Chart CG-22 be used to find the internal diameter.

Chart CG-22.
Determination of Internal Diameter of Flash Tank to Handle a Given Quantity of Flash Steam

Find amount of available flash steam (in pounds per hour) on bottom scale, read up to curve and across to vertical scale, to get diameter in inches.



How to Trap Absorption Machines

An absorption refrigeration machine chills water for air conditioning or process use by evaporating a water solution, usually lithium bromide. Steam provides the energy for the concentration part of the cycle and, except for electric pumps, is the only energy input during the entire cycle.

A steam trap installed on a steam absorption machine should handle large condensate loads and purge air at low pressure, modulated conditions.

Trap Selection and Safety Factor
Determine the condensate load produced by a low pressure (normally 15 psig or less) single-stage steam absorption machine by multiplying its rating in tons of refrigeration by 20, the amount of steam in lbs/hr required to produce a ton of refrigeration. This represents consumption at the rated capacity of the machine.

EXAMPLE: How much condensate will a single-stage steam absorption machine with a rated capacity of 500 tons produce?

Multiply the 500-ton machine capacity rating x 20 lbs/hr to get the condensate load—10 000 lbs/hr.

A 2:1 safety factor should be applied to the full capacity condensate load, and the steam trap must be capable of draining this load, at a 1/2 psi differential. In other words, the machine in the example would require a trap capable of handling 20 000 lbs/hr of condensate at 1/2 psi, and the capability of functioning at the maximum pressure differential, usually 15 psi.

In comparison, two-stage absorption machines operate at a higher steam pressure of 150 psig. They have an advantage over single-stage units in that their energy consumption per ton of refrigeration is less (12.2 lbs steam/hr/ton of refrigeration at rated capacity).

EXAMPLE: How much condensate will a two-stage steam absorption machine with a rated capacity of 300 tons produce?

Multiply the 300-ton machine capacity rating x 10 lbs/hr to get the condensate load—3 000 lbs/hr.

Chart CG-23. Recommendation Chart (See Page CG-4 for "Feature Code" References.		
Equipment Being Trapped	**1st Choice and Feature Code**	**Alternate Choice**
Steam Aborption Machine	F&T A, B, G	*IB

NOTE: Vacuum breaker and standby system should be provided.
*With external thermostatic air vent.

On two-stage steam absorption machines, a 3:1 safety factor should be used. Therefore, the example requires a steam trap with a capacity of 9 000 lbs/hr. At pressures above 30 psig, the trap capacity must be achieved at 1/2 maximum pressure differential, which in the example is 75 psi. At pressures below 30 psig, trap capacity must be achieved at 2 psi differential pressure. However, the trap must still be capable of operating at a maximum inlet pressure of 150 psig.

The F&T trap with an integral vacuum breaker is ideally suited for draining both single- and double-stage steam absorption machines. It provides an even, modulated condensate flow and energy-conserving operation. An inverted bucket trap with an external thermostatic air eliminator may also be acceptable.

Installation

Mount the steam trap below the steam coil of the absorption machine with a drip leg height of at least 15" (Fig. CG-59). This ensures a minimum differential pressure across the trap of 1/2 psi. Whichever trap is used, a standby trapping system is recommended for this service. In the event that a component in the drainage system needs maintenance, the absorption machine can operate on the standby system while the repairs are being made. This ensures continuous, uninterrupted service.

In some cases, very heavy condensate loads may require the use of two traps operating in parallel to handle the normal load.

Figure CG-59. Generally approved method of piping steam absorption machine with standby trapping system.