How to Trap: Pipe Sizing Steam and Condensate Return Lines

Armstrong®

Say energy. Think environment. And vice versa.

Any company that is energy conscious is also environmentally conscious. Less energy consumed means less waste, fewer emissions and a healthier environment.

In short, bringing energy and environment together lowers the cost industry must pay for both. By helping companies manage energy, Armstrong products and services are also helping to protect the environment.

Armstrong has been sharing know-how since we invented the energy-efficient inverted bucket steam trap in 1911. In the years since, customers' savings have proven again and again that knowledge *not* shared is energy wasted.

Armstrong's developments and improvements in steam trap design and function have led to countless savings in energy, time and money. This section has grown out of our decades of sharing and expanding what we've learned. It deals with the operating principles of steam traps and outlines their specific applications to a wide variety of products and industries. You'll find it a useful complement to other Armstrong literature and the Armstrong Steam-A-ware™ software program for sizing and selecting steam traps, pressure reducing valves and water heaters, which can be requested through Armstrong's Web site, **armstrong**international.com.

This section also includes Recommendation Charts that summarize our findings on which type of trap will give optimum performance in a given situation and why.

IMPORTANT: This section is intended to summarize general principles of installation and operation of steam traps, as outlined above. Actual installation and operation of steam trapping equipment should be performed only by experienced personnel. Selection or installation should always be accompanied by competent technical assistance or advice. This data should never be used as a substitute for such technical advice or assistance. We encourage you to contact Armstrong or its local representative for further details.

Instructions for Using the Recommendation Charts

A quick reference Recommendation Chart appears throughout the “HOW TO TRAP” brochures (857-EN - 868-EN).

A feature code system (ranging from A to Q) supplies you with “at-a-glance” information.

The chart covers the type of steam traps and the major advantages that Armstrong feels are superior for each particular application.

For example, assume you are looking for information concerning the proper trap to use on a gravity drained jacketed kettle. You would:

1. Turn to the “How to Trap Jacketed Kettles” brochure, 864-EN, and look in the lower right-hand corner of page 10. The Recommendation Chart located there is reprinted below for your convenience. (Each section has a Recommendation Chart.)

2. Find “Jacketed Kettles, Gravity Drain” in the first column under “Equipment Being Trapped” and read to the right for Armstrong’s “1st Choice and Feature Code.” In this case, the first choice is an IBLV and the feature code letters B, C, E, K, N are listed.

3. Now refer to Chart 3-2 below, titled “How Various Types of Steam Traps Meet Specific Operating Requirements” and read down the extreme left-hand column to each of the letters B, C, E, K, N. The letter “B,” for example, refers to the trap’s ability to provide energy-conserving operation.

4. Follow the line for “B” to the right until you reach the column that corresponds to our first choice, in this case the inverted bucket. Based on tests and actual operating conditions, the energy-conserving performance of the inverted bucket steam trap has been rated “Excellent.” Follow this same procedure for the remaining letters.

Abbreviations

- IB Inverted Bucket Trap
- IBLV Inverted Bucket Large Vent
- BM Bimetallic Trap
- F&T Float and Thermostatic Trap
- CD Controlled Disc Trap
- DC Automatic Differential Condensate Controller
- CV Check Valve
- T Thermic Bucket
- PRV Pressure Reducing Valve

Chart 3-1. Recommendation Chart
(See chart below for “Feature Code” References.)

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

Chart 3-2. How Various Types of Steam Traps Meet Specific Operating Requirements

Feature Code	Characteristic	IB	BM	F&T	Disc	Thermostatic Wafer	DC	Orifice
A	Method of Operation	(1) Intermittent	(2) Intermittent	Continuous	Intermittent	(2) Intermittent	Continuous	Continuous
B	Energy Conservation (Time in Service)	Excellent	Excellent	Good	Poor	Fair	(3) Excellent	Poor
C	Resistance to Wear	Excellent	Excellent	Good	Poor	Fair	Excellent	Poor
D	Corrosion Resistance	Excellent	Excellent	Good	Excellent	Good	Excellent	Good
E	Resistance to Hydraulic Shock	Excellent	Excellent	Poor	Excellent	(4) Poor	Excellent	Good
F	Vents Air and CO_2 at Steam Temperature	Yes	No	No	No	No	Yes	Poor
G	Ability to Vent Air at Very Low Pressure (1/4 psig)	Poor	(5) NR	Excellent	(5) NR	Good	Excellent	Poor
H	Ability to Handle Start-Up Air Loads	Fair	Excellent	Excellent	Poor	Excellent	Excellent	Poor
I	Operation Against Back Pressure	Excellent	Excellent	Excellent	Poor	Excellent	Excellent	Poor
J	Resistance to Damage From Freezing	(6) Good	Good	Poor	Good	Good	Good	Excellent
K	Ability to Purge System	Excellent	Good	Fair	Excellent	Good	Excellent	Poor
L	Performance on Very Light Loads	Excellent	Excellent	Excellent	Poor	Excellent	Excellent	Poor
M	Responsiveness to Slugs of Condensate	Immediate	Delayed	Immediate	Delayed	Delayed	Immediate	Poor
N	Ability to Handle Dirt	Excellent	Fair	Poor	Poor	Fair	Excellent	Poor
O	Comparative Physical Size (7)	Large	Small	Large	Small	Small	Large	Small
P	Ability to Handle“Flash Steam”	Fair	Poor	Poor	Poor	Poor	Excellent	Poor
Q	Mechanical Failure (Open or Closed)	Open	Open	Closed	(8) Open	(9)	Open	NA

(1) Drainage of condensate is continuous. Discharge is intermittent.
(2) Can be continuous on low load.
(3) Excellent when “secondary steam” is utilized.
(4) Bimetallic and wafer traps – good.
(5) Not recommended for low pressure operations.
(6) Cast iron traps not recommended.
(7) In welded stainless steel construction – medium.
(8) Can fail closed due to dirt.
(9) Can fail either open or closed, depending upon the design of the bellows.

What They Are…How to Use Them

The heat quantities and temperature/pressure relationships referred to in this section are taken from the Properties of Saturated Steam table.

Definitions of Terms Used

Saturated Steam is pure steam at the temperature that corresponds to the boiling temperature of water at the existing pressure.

Absolute and Gauge Pressures
Absolute pressure is pressure in pounds per square inch (psia) above a perfect vacuum. Gauge pressure is pressure in pounds per square inch above atmospheric pressure, which is 14.7 pounds per square inch absolute. Gauge pressure (psig) plus 14.7 equals absolute pressure. Or, absolute pressure minus 14.7 equals gauge pressure.

Pressure/Temperature Relationship (Columns 1, 2 and 3). For every pressure of pure steam there is a corresponding temperature. Example: The temperature of 250 psig pure steam is always 406°F.

Heat of Saturated Liquid (Column 4). This is the amount of heat required to raise the temperature of a pound of water from 32°F to the boiling point at the pressure and temperature shown. It is expressed in British thermal units (Btu).

Latent Heat or Heat of Vaporization (Column 5). The amount of heat (expressed in Btu) required to change a pound of boiling water to a pound of steam. This same amount of heat is released when a pound of steam is condensed back into a pound of water. This heat quantity is different for every pressure/temperature combination, as shown in the steam table.

Total Heat of Steam (Column 6). The sum of the Heat of the Liquid (Column 4) and Latent Heat (Column 5) in Btu. It is the total heat in steam above 32°F.

Specific Volume of Liquid (Column 7). The volume per unit of mass in cubic feet per pound.

Specific Volume of Steam (Column 8). The volume per unit of mass in cubic feet per pound.

How the Table Is Used

In addition to determining pressure/temperature relationships, you can compute the amount of steam that will be condensed by any heating unit of known Btu output. Conversely, the table can be used to determine Btu output if steam condensing rate is known. In the application portion of this section, there are several references to the use of the steam table.

Table 4-1. Properties of Saturated Steam
(Abstracted from Keenan and Keyes, THERMODYNAMIC PROPERTIES OF STEAM, by permission of John Wiley & Sons, Inc.)

	Col. 1 Gauge Pressure	Col. 2 Absolute Pressure (psia)	Col. 3 Steam Temp. (°F)	Col. 4 Heat of Sat. Liquid (Btu/lb)	Col. 5 Latent Heat (Btu/lb)	Col. 6 Total Heat of Steam (Btu/lb)	Col. 7 Specific Volume of Sat. Liquid (cu ft/lb)	Col. 8 Specific Volume of Sat. Steam (cu ft/lb)
Inches of Vacuum	29.743	0.08854	32.00	0.00	1075.8	1075.8	0.016022	3306.00
	29.515	0.2	53.14	21.21	1063.8	1085.0	0.016027	1526.00
	27.886	1.0	101.74	69.70	1036.3	1106.0	0.016136	333.60
	19.742	5.0	162.24	130.13	1001.0	1131.0	0.016407	73.52
	9.562	10.0	193.21	161.17	982.1	1143.3	0.016590	38.42
	7.536	11.0	197.75	165.73	979.3	1145.0	0.016620	35.14
	5.490	12.0	201.96	169.96	976.6	1146.6	0.016647	32.40
	3.454	13.0	205.88	173.91	974.2	1148.1	0.016674	30.06
	1.418	14.0	209.56	177.61	971.9	1149.5	0.016699	28.04
PSIG	0.0	14.696	212.00	180.07	970.3	1150.4	0.016715	26.80
	1.3	16.0	216.32	184.42	967.6	1152.0	0.016746	24.75
	2.3	17.0	219.44	187.56	965.5	1153.1	0.016768	23.39
	5.3	20.0	227.96	196.16	960.1	1156.3	0.016830	20.09
	10.3	25.0	240.07	208.42	952.1	1160.6	0.016922	16.30
	15.3	30.0	250.33	218.82	945.3	1164.1	0.017004	13.75
	20.3	35.0	259.28	227.91	939.2	1167.1	0.017078	11.90
	25.3	40.0	267.25	236.03	933.7	1169.7	0.017146	10.50
	30.3	45.0	274.44	243.36	928.6	1172.0	0.017209	9.40
	40.3	55.0	287.07	256.30	919.6	1175.9	0.017325	7.79
	50.3	65.0	297.97	267.50	911.6	1179.1	0.017429	6.66
	60.3	75.0	307.60	277.43	904.5	1181.9	0.017524	5.82
	70.3	85.0	316.25	286.39	897.8	1184.2	0.017613	5.17
	80.3	95.0	324.12	294.56	891.7	1186.2	0.017696	4.65
	90.3	105.0	331.36	302.10	886.0	1188.1	0.017775	4.23
	100.0	114.7	337.90	308.80	880.0	1188.8	0.017850	3.88
	110.3	125.0	344.33	315.68	875.4	1191.1	0.017922	3.59
	120.3	135.0	350.21	321.85	870.6	1192.4	0.017991	3.33
	125.3	140.0	353.02	324.82	868.2	1193.0	0.018024	3.22
	130.3	145.0	355.76	327.70	865.8	1193.5	0.018057	3.11
	140.3	155.0	360.50	333.24	861.3	1194.6	0.018121	2.92
	150.3	165.0	365.99	338.53	857.1	1195.6	0.018183	2.75
	160.3	175.0	370.75	343.57	852.8	1196.5	0.018244	2.60
	180.3	195.0	379.67	353.10	844.9	1198.0	0.018360	2.34
	200.3	215.0	387.89	361.91	837.4	1199.3	0.018470	2.13
	225.3	240.0	397.37	372.12	828.5	1200.6	0.018602	1.92
	250.3	265.0	406.11	381.60	820.1	1201.7	0.018728	1.74
		300.0	417.33	393.84	809.0	1202.8	0.018896	1.54
		400.0	444.59	424.00	780.5	1204.5	0.019340	1.16
		450.0	456.28	437.20	767.4	1204.6	0.019547	1.03
		500.0	467.01	449.40	755.0	1204.4	0.019748	0.93
		600.0	486.21	471.60	731.6	1203.2	0.02013	0.77
		900.0	531.98	526.60	668.8	1195.4	0.02123	0.50
		1200.0	567.22	571.70	611.7	1183.4	0.02232	0.36
		1500.0	596.23	611.60	556.3	1167.9	0.02346	0.28
		1700.0	613.15	636.30	519.6	1155.9	0.02428	0.24
		2000.0	635.82	671.70	463.4	1135.1	0.02565	0.19
		2500.0	668.13	730.60	360.5	1091.1	0.02860	0.13
		2700.0	679.55	756.20	312.1	1068.3	0.03027	0.11
		3206.2	705.40	902.70	0.0	902.7	0.05053	0.05

Flash Steam (Secondary)

What is flash steam? 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.

Why is it important? This flash steam is important because it contains heat units that can be used for economical plant operation—and which are otherwise wasted.

How is it formed? When water is heated at atmospheric pressure, its temperature rises until it reaches 212°F, the highest temperature at which water can exist at this pressure. Additional heat does not raise the temperature, but converts the water to steam.

The heat absorbed by the water in raising its temperature to boiling point is called "sensible heat" or heat of saturated liquid. The heat required to convert water at boiling point to steam at the same temperature is called "latent heat." The unit of heat in common use is the Btu, which is the amount of heat required to raise the temperature of one pound of water 1°F at atmospheric pressure.

If water is heated under pressure, however, the boiling point is higher than 212°F, so the sensible heat required is greater. The higher the pressure, the higher the boiling temperature and the higher the heat content. If pressure is reduced, a certain amount of sensible heat is released. This excess heat will be absorbed in the form of latent heat, causing part of the water to "flash" into steam.

Condensate at steam temperature and under 100 psig pressure has a heat content of 308.8 Btu per pound. (See Column 4 in Steam Table.) If this condensate is discharged to atmospheric pressure (0 psig), its heat content instantly drops to 180 Btu per pound. The surplus of 128.8 Btu re-evaporates or flashes a portion of the condensate. The percentage that will flash to steam can be computed using the formula:

$$\text{\% flash steam} = \frac{SH - SL}{H} \times 100$$

SH = Sensible heat in the condensate at the higher pressure before discharge.
SL = Sensible heat in the condensate at the lower pressure to which discharge takes place.
H = Latent heat in the steam at the lower pressure to which the condensate has been discharged.

$$\text{\% flash steam} = \frac{308.8 - 180}{970.3} \times 100 = 13.3\%$$

Chart 5-3 shows the amount of secondary steam that will be formed when discharging condensate to different pressures. **Other useful tables will be found in brochure 873-EN (Useful Engineering Tables).**

Chart 5-3.
Percentage of flash steam formed when discharging condensate to reduced pressure.

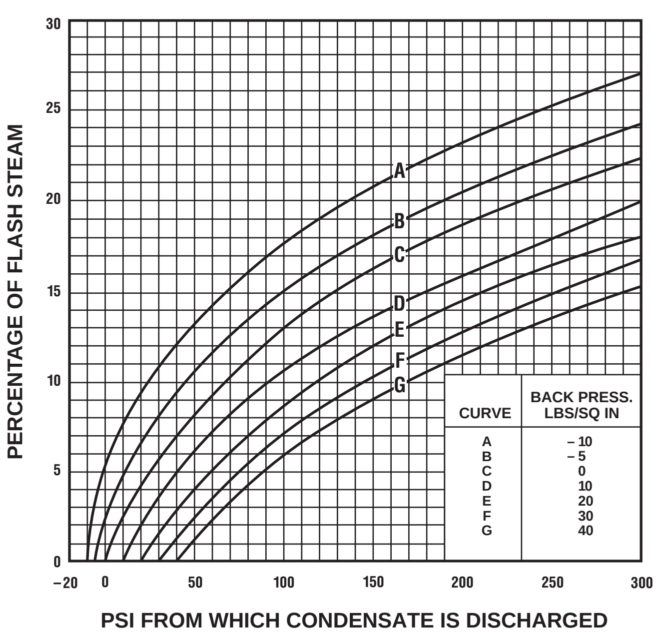
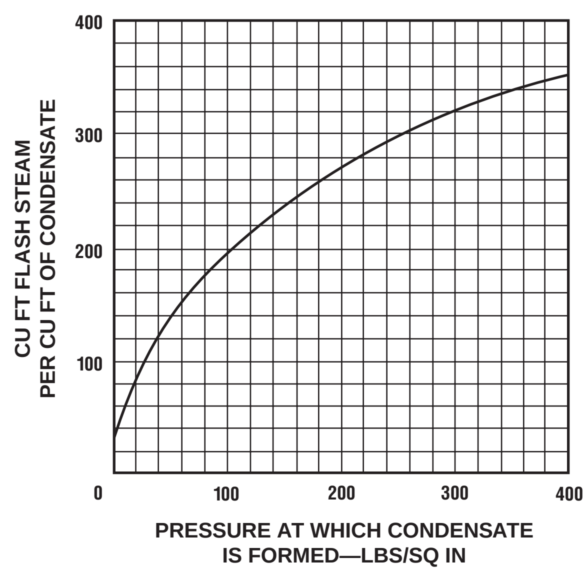


Chart 5-4.
Volume of flash steam formed when one cubic foot of condensate is discharged to atmospheric pressure.



Steam is an invisible gas generated by adding heat energy to water in a boiler. Enough energy must be added to raise the temperature of the water to the boiling point. Then additional energy—without any further increase in temperature—changes the water to steam.

Steam is a very efficient and easily controlled heat transfer medium. It is most often used for transporting energy from a central location (the boiler) to any number of locations in the plant where it is used to heat air, water or process applications.

As noted, additional Btu are required to make boiling water change to steam. These Btu are not lost but stored in the steam ready to be released to heat air, cook tomatoes, press pants or dry a roll of paper.

The heat required to change boiling water into steam is called the heat of vaporization or latent heat. The quantity is different for every pressure/temperature combination, as shown in the steam tables.

Steam at Work... How the Heat of Steam Is Utilized

Heat flows from a higher temperature level to a lower temperature level in a process known as heat transfer. Starting in the combustion chamber of the boiler, heat flows through the boiler tubes to the water. When the higher pressure in the boiler pushes steam out, it heats the pipes of the distribution system. Heat flows from the steam through the walls of the pipes into the cooler surrounding air. This heat transfer changes some of the steam back into water. That's why distribution lines are usually insulated to minimize this wasteful and undesirable heat transfer.

When steam reaches the heat exchangers in the system, the story is different. Here the transfer of heat from the steam is desirable. Heat flows to the air in an air heater, to the water in a water heater or to food in a cooking kettle. Nothing should interfere with this heat transfer.

Condensate Drainage... Why It's Necessary

Condensate is the by-product of heat transfer in a steam system. It forms in the distribution system due to unavoidable radiation. It also forms in heating and process equipment as a result of desirable heat transfer from the steam to the substance heated. Once the steam has condensed and given up its valuable latent heat, the hot condensate must be removed immediately. Although the available heat in a pound of condensate is negligible as compared to a pound of steam, condensate is still valuable hot water and should be returned to the boiler.

Definitions

- **The Btu.** A Btu—British thermal unit—is the amount of heat energy required to raise the temperature of one pound of cold water by 1°F. Or, a Btu is the amount of heat energy given off by one pound of water in cooling, say, from 70°F to 69°F.
- **Temperature.** The degree of hotness with no implication of the amount of heat energy available.
- **Heat.** A measure of energy available with no implication of temperature. To illustrate, the one Btu that raises one pound of water from 39°F to 40°F could come from the surrounding air at a temperature of 70°F or from a flame at a temperature of 1,000°F.

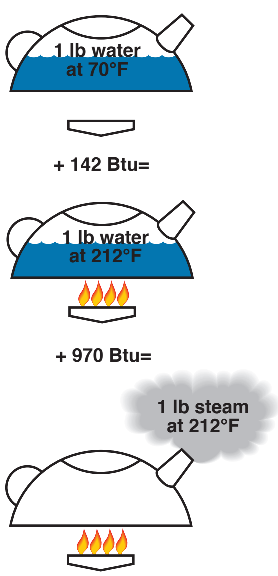


Figure 6-1. These drawings show how much heat is required to generate one pound of steam at atmospheric pressure. Note that it takes 1 Btu for every 1°F increase in temperature up to the boiling point, but that it takes more Btu to change water at 212°F to steam at 212°F.

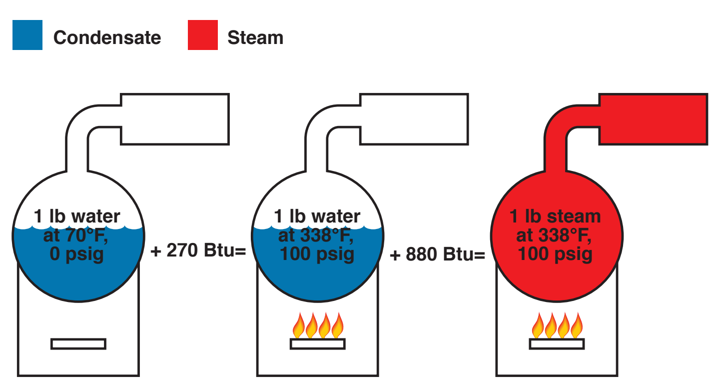


Figure 6-2. These drawings show how much heat is required to generate one pound of steam at 100 pounds per square inch pressure. Note the extra heat and higher temperature required to make water boil at 100 pounds pressure than at atmospheric pressure. Note, too, the lesser amount of heat required to change water to steam at the higher temperature.

The need to drain the distribution system. Condensate lying in the bottom of steam lines can be the cause of one kind of water hammer. Steam traveling at up to 100 miles per hour makes “waves” as it passes over this condensate (Fig. 7-4). If enough condensate forms, high-speed steam pushes it along, creating a dangerous slug that grows larger and larger as it picks up liquid in front of it. Anything that changes the direction—pipe fittings, regulating valves, tees, elbows, blind flanges—can be destroyed. In addition to damage from this “battering ram,” high-velocity water may erode fittings by chipping away at metal surfaces.

The need to drain the heat transfer unit. When steam comes in contact with condensate cooled below the temperature of steam, it can produce another kind of water hammer known as *thermal shock*. Steam occupies a much greater volume than condensate, and when it collapses suddenly, it can send shock waves throughout the system. This form of water hammer can damage equipment, and it signals that condensate is not being drained from the system. Obviously, condensate in the heat transfer unit takes up space and reduces the physical size and capacity of the equipment. Removing it quickly keeps the unit full of steam (Fig. 7-5). As steam condenses, it forms a film of water on the inside of the heat exchanger. Non-condensable gases do not change into liquid and flow away by gravity. Instead, they accumulate as a thin film on the surface of the heat exchanger—along with dirt and scale. All are potential barriers to heat transfer (Fig. 7-3).

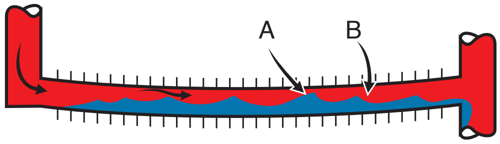


Figure 7-4. Condensate allowed to collect in pipes or tubes is blown into waves by steam passing over it until it blocks steam flow at point **A**. Condensate in area **B** causes a pressure differential that allows steam pressure to push the slug of condensate along like a battering ram.

The need to remove air and CO_2. Air is always present during equipment start-up and in the boiler feedwater. Feedwater may also contain dissolved carbonates, which release carbon dioxide gas. The steam velocity pushes the gases to the walls of the heat exchangers, where they may block heat transfer. This compounds the condensate drainage problem, because these gases must be removed along with the condensate.

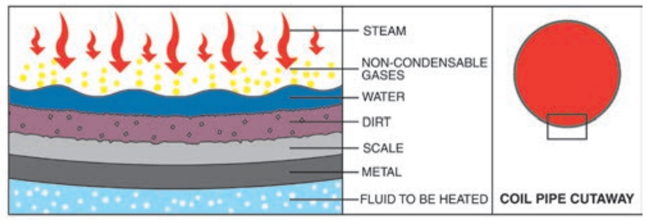


Figure 7-3. Potential barriers to heat transfer: steam heat and temperature must penetrate these potential barriers to do their work.

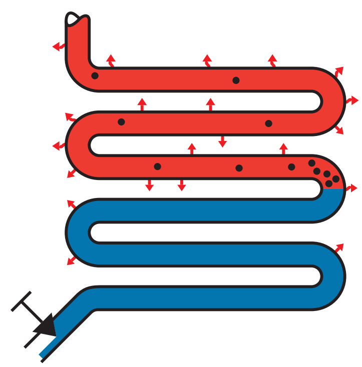


Figure 7-5. Coil half full of condensate can’t work at full capacity.

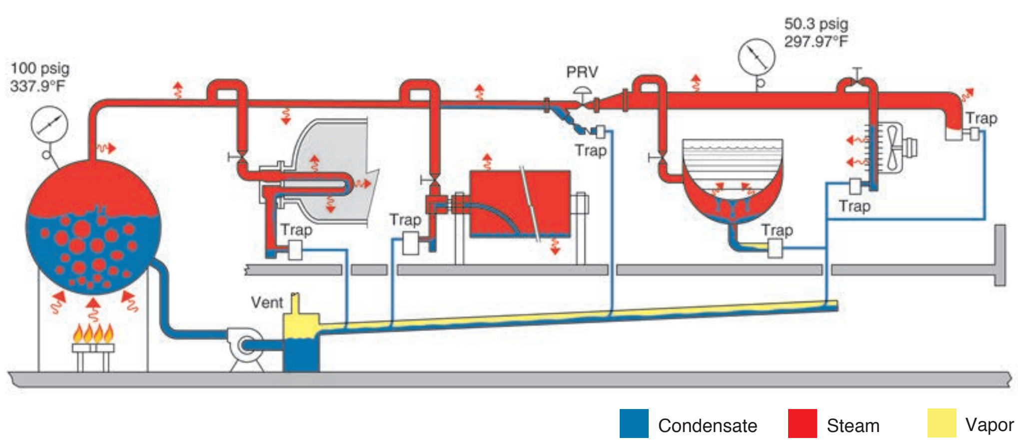


Figure 7-6. Note that heat radiation from the distribution system causes condensate to form and, therefore, requires steam traps at natural low points or ahead of control valves. In the heat exchangers, traps perform the vital function of removing the condensate before it becomes a barrier to heat transfer. Hot condensate is returned through the traps to the boiler for reuse.

Effect of Air on Steam Temperature

When air and other gases enter the steam system, they consume part of the volume that steam would otherwise occupy. The temperature of the air/steam mixture falls below that of pure steam. Figure 8-7 explains the effect of air in steam lines. Table 8-2 and Chart 8-5 show the various temperature reductions caused by air at various percentages and pressures.

Effect of Air on Heat Transfer

The normal flow of steam toward the heat exchanger surface carries air and other gases with it. Since they do not condense and drain by gravity, these non-condensable gases set up a barrier between the steam and the heat exchanger surface. The excellent insulating properties of air reduce heat transfer. In fact, under certain conditions as little **as 1/2 of 1% by volume of air in steam can reduce heat transfer efficiency by 50% (Fig. 9-8).**

Table 8-2. Temperature Reduction Caused by Air

Pressure (psig)	Temp. of Steam, No Air Present (°F)	Temp. of Steam Mixed With Various Percentages of Air (by Volume) (°F)		
		10%	20%	30%
10.3	240.1	234.3	228.0	220.9
25.3	267.3	261.0	254.1	246.4
50.3	**298.0**	**291.0**	**283.5**	**275.1**
75.3	320.3	312.9	304.8	295.9
100.3	338.1	330.3	321.8	312.4

When non-condensable gases (primarily air) continue to accumulate and are not removed, they may gradually fill the heat exchanger with gases and stop the flow of steam altogether. The unit is then “air bound.”

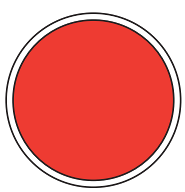
Corrosion

Two primary causes of scale and corrosion are carbon dioxide (CO_2) and oxygen. CO_2 enters the system as carbonates dissolved in feedwater and, when mixed with cooled condensate, creates carbonic acid. Extremely corrosive, carbonic acid can eat through piping and heat exchangers (Fig. 9-9). Oxygen enters the system as gas dissolved in the cold feedwater. It aggravates the action of carbonic acid, speeding corrosion and pitting iron and steel surfaces (Fig. 9-10).

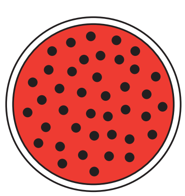
Eliminating the Undesirables

To summarize, traps must drain condensate because it can reduce heat transfer and cause water hammer. Traps should evacuate air and other non-condensable gases because they can reduce heat transfer by reducing steam temperature and insulating the system. They can also foster destructive corrosion. It’s essential to remove condensate, air and CO_2 as quickly and completely as possible. A *steam trap*, which is simply an automatic valve that opens for condensate, air and CO_2 and closes for steam, does this job. For economic reasons, the steam trap should do its work for long periods with minimum attention.

Figure 8-7. Chamber containing air and steam delivers only the heat of the partial pressure of the steam, not the total pressure.



Steam chamber 100% steam
Total pressure 100 psia
Steam pressure 100 psia
Steam temperature 327.8°F



Steam chamber 90% steam and 10% air
Total pressure 100 psia
Steam pressure 90 psia
Steam temperature 320.3°F

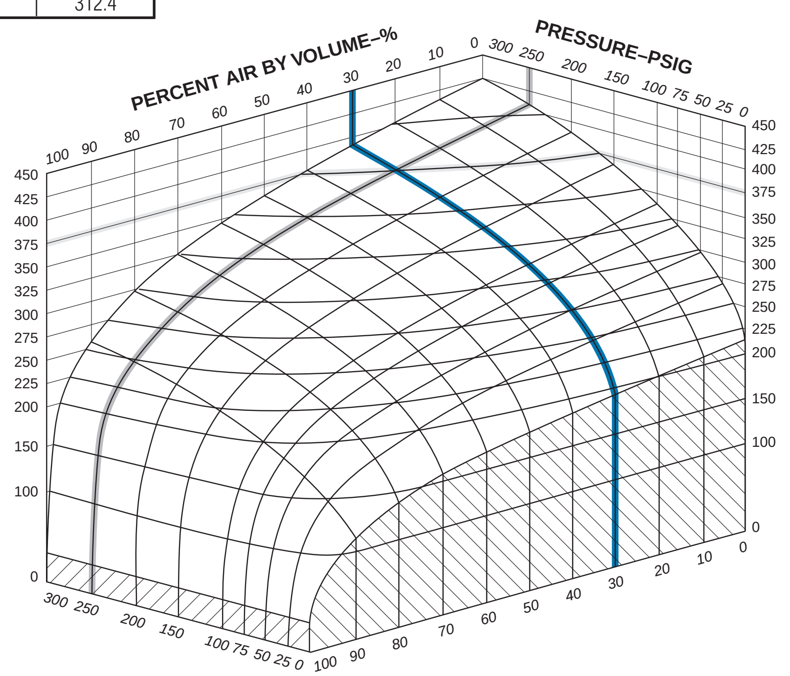


Chart 8-5. Air Steam Mixture
Temperature reduction caused by various percentages of air at differing pressures. This chart determines the percentage of air with known pressure and temperature by determining the point of intersection between pressure, temperature and percentage of air by volume. As an example, assume system pressure of 250 psig with a temperature at the heat exchanger of 375°F. From the chart, it is determined that there is 30% air by volume in the steam.

What the Steam Trap Must Do

The job of the steam trap is to get condensate, air and CO_2 out of the system as quickly as they accumulate. In addition, for overall efficiency and economy, the trap must also provide:

1. **Minimal steam loss.** Table 9-3 shows how costly unattended steam leaks can be.

2. **Long life and dependable service.** Rapid wear of parts quickly brings a trap to the point of undependability. An efficient trap saves money by minimizing trap testing, repair, cleaning, downtime and associated losses.

3. **Corrosion resistance.** Working trap parts should be corrosion-resistant in order to combat the damaging effects of acidic or oxygen-laden condensate.

4. **Air venting.** Air can be present in steam at any time and especially on start-up. Air must be vented for efficient heat transfer and to prevent system binding.

5. **CO_2 venting.** Venting CO_2 at steam temperature will prevent the formation of carbonic acid. Therefore, the steam trap must function at or near steam temperature since CO_2 dissolves in condensate that has cooled below steam temperature.

6. **Operation against back pressure.** Pressurized return lines can occur both by design and unintentionally. A steam trap should be able to operate against the actual back pressure in its return system.

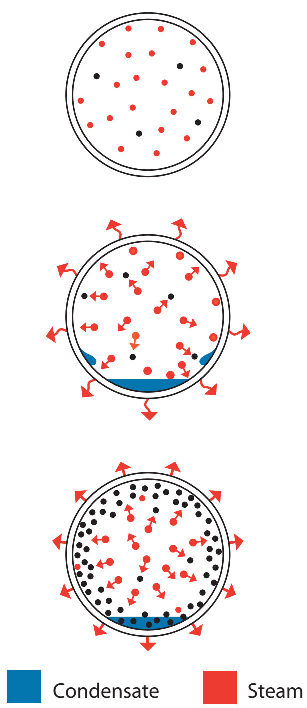
7. **Freedom from dirt problems**. Dirt is an ever-present concern since traps are located at low points in the steam system. Condensate picks up dirt and scale in the piping, and solids may carry over from the boiler. Even particles passing through strainer screens are erosive and, therefore, the steam trap must be able to operate in the presence of dirt.

A trap delivering anything less than all these desirable operating/design features will reduce the efficiency of the system and increase costs. When a trap delivers all these features the system can achieve:

1. Fast heat-up of heat transfer equipment
2. Maximum equipment temperature for enhanced steam heat transfer
3. Maximum equipment capacity
4. Maximum fuel economy
5. Reduced labor per unit of output
6. Minimum maintenance and a long trouble-free service life

Sometimes an application may demand a trap without these design features, but in the vast majority of applications the trap which meets all the requirements will deliver the best results.

Figure 9-8. Steam condensing in a heat transfer unit moves air to the heat transfer surface, where it collects or "plates out" to form effective insulation.



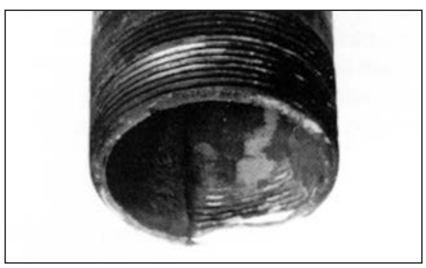


Figure 9-9. CO_2 gas combines with condensate allowed to cool below steam temperature to form carbonic acid, which corrodes pipes and heat transfer units. Note groove eaten away in the pipe illustrated.

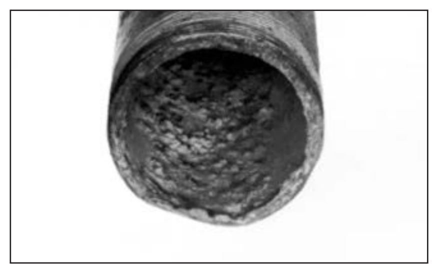


Figure 9-10. Oxygen in the system speeds corrosion (oxidation) of pipes, causing pitting such as shown here.

Figs. 9-9 and 9-10 courtesy of Dearborn Chemical Company.

Table 9-3. Cost of Various Sized Steam Leaks at 100 psi
(Assuming steam costs $10.00/1,000 lbs)

Size of Orifice		Lbs Steam Wasted Per Month	Total Cost Per Month (USD)	Total Cost Per Year (USD
1/2"	12, 7 mm	553,000	$5,530.00	$66,360.00
7/16"	11, 2 mm	423,500	4,235.00	50,820.00
3/8"	9, 5 mm	311,000	3,110.00	37,320.00
5/16"	7, 9 mm	216,000	2,160.00	25,920.00
1/4"	6, 4 mm	138,000	1,380.00	16,560.00
3/16"	4, 8 mm	78,000	780.00	9,360.00
1/8"	3, 2 mm	34,500	345.00	4,140.00

The steam loss values assume typical condensate load for drip trap applications.
Armstrong methodology for steam trap management and condensate return is sanctioned by the Clean Development Mechanism of the United Nations Framework Convention on Climate Change.

Armstrong®

Pipe Sizing Steam Supply and Condensate Return Lines

Sizing Charts

Chart 11-25, page 11, is the basic chart for determining the flow rate and velocity of steam in Schedule 40 pipe for various values of pressure drop per 100 ft, based on 0 psig saturated steam. Using the multiplier chart (Chart 10-24), Chart 11-25 can be used at all saturation pressures between 0 and 200 psig (see Example).

These Charts are based on the Moody Friction Factor, which considers the Reynolds number and the roughness of the internal pipe surfaces.

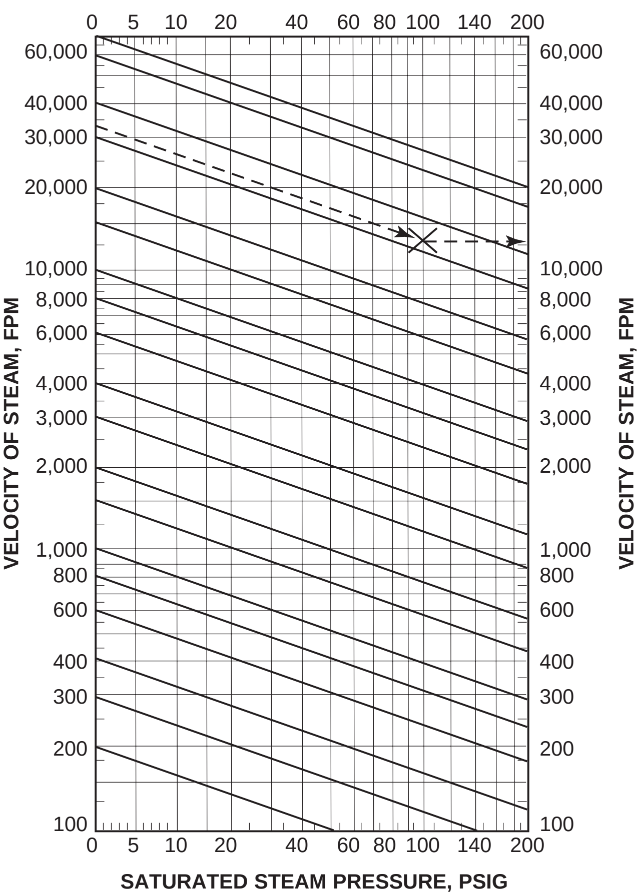
Notes: Based on Moody Friction Factor where flow of condensate does not inhibit the flow of steam. See Chart 10-24 for obtaining flow rates and velocities of all saturation pressures between 0 to 200 psig: see Example.

Pipe Sizing

Two principal factors determine pipe sizing in a steam system:

1. The initial pressure at the boiler and the allowable pressure drop of the total system. The total pressure drop in the system should not exceed 20% of the total maximum pressure at the boiler. This includes all drops—line loss, elbows, valves, etc. Remember, pressure drops are a loss of energy.

Chart 10-24. Velocity Multiplier Chart for CG-25.



2. Steam velocity. Erosion and noise increase with velocity. Reasonable velocities for process steam are 6,000 to 12,000 fpm, but lower pressure heating systems normally have lower velocities. Another consideration is future expansion. Size your lines for the foreseeable future. If ever in doubt, you will have less trouble with oversized lines than with ones that are marginal.

Use of Basic and Velocity Multiplier Charts

Example.

Given a flow rate of 6,700 lb/hr, an initial steam pressure of 100 psig, and a pressure drop of 11 psi/100 ft, find the size of Schedule 40 pipe required and the velocity of steam in the pipe.

Solution: The following steps are illustrated by the broken line on Chart 11-25 and Chart 10-24.

1. Enter Chart 11-25 at a flow rate of 6,700 lb/hr, and move vertically to the horizontal line at 100 psig.

2. Follow inclined multiplier line (upward and to the left) to horizontal 0 psig line. The equivalent mass flow at 0 psig is about 2,500 lb/hr.

3. Follow the 2,500 lb/hr line vertically until it intersects the horizontal line at 11 psi per 100 ft pressure drop. Nominal pipe size is 2-1/2 in. The equivalent steam velocity at 0 psig is about 32,700 fpm.

4. To find the steam velocity at 100 psig, locate the value of 32,700 fpm on the ordinate of the velocity multiplier chart (Chart 10-24) at 0 psig.

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

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

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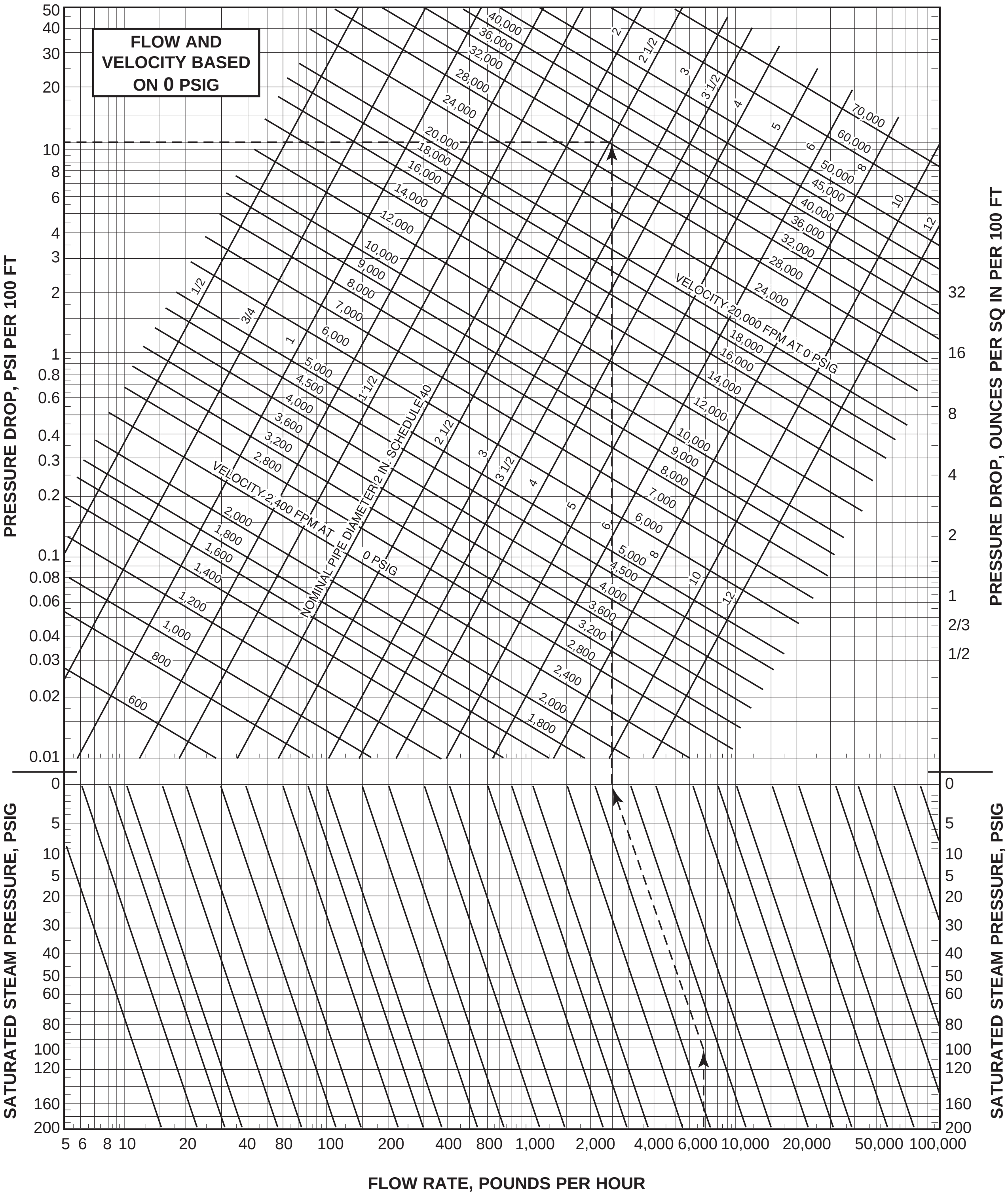
Chart 11-25. Flow Rate and Velocity of Steam in Schedule 40 Pipe at Saturation Pressure of 0 psig



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