Steam Tables
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, armstronginternational.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.

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

<table>
<thead>
<tr>
<th>Equipment Being Trapped</th>
<th>1st Choice and Feature Code</th>
<th>Alternate Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jacketed Kettles</td>
<td>IBLV B, C, E, K, N</td>
<td>F&amp;T or Thermostatic</td>
</tr>
<tr>
<td>Gravity Drain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syphon Drain</td>
<td>DC B, C, E, G, H, K, N, P</td>
<td>IBLV</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Feature Code</th>
<th>Characteristic</th>
<th>IB</th>
<th>BM</th>
<th>F&amp;T</th>
<th>Disc</th>
<th>Thermostatic Wafer</th>
<th>DC</th>
<th>Orifice</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Method of Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Energy Conservation (Time in Service)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Resistance to Wear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Corrosion Resistance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Resistance to Hydraulic Shock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Vents Air and CO₂ at Steam Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Ability to Vent Air at Very Low Pressure (1/4 psig)</td>
<td></td>
<td></td>
<td>(5) NR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Ability to Handle Start-Up Air Loads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Operation Against Back Pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>Resistance to Damage From Freezing</td>
<td></td>
<td></td>
<td>(6) Good</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Ability to Purge System</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>Performance on Very Light Loads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Responsiveness to Slugs of Condensate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Ability to Handle Dirt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>Comparative Physical Size (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>Ability to Handle “Flash Steam”</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>Mechanical Failure (Open or Closed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(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.

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
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>
<thead>
<tr>
<th>Pressure (psig)</th>
<th>Absolute Pressure (psia)</th>
<th>Steam Temp. (°F)</th>
<th>Heat of Sat. Liquid (Btu/lb)</th>
<th>Latent Heat (Btu/lb)</th>
<th>Total Heat of Steam (Btu/lb)</th>
<th>Specific Volume of Liquid (ft/lb)</th>
<th>Specific Volume of Steam (ft/lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>265</td>
<td>387.89</td>
<td>361.91</td>
<td>837.4</td>
<td>1199.3</td>
<td>0.018470</td>
<td>3.20</td>
</tr>
<tr>
<td>200</td>
<td>215</td>
<td>360.50</td>
<td>338.5</td>
<td>861.3</td>
<td>1194.6</td>
<td>0.018121</td>
<td>3.92</td>
</tr>
<tr>
<td>150</td>
<td>165</td>
<td>335.33</td>
<td>312.8</td>
<td>886.0</td>
<td>1188.8</td>
<td>0.017775</td>
<td>4.52</td>
</tr>
<tr>
<td>100</td>
<td>115</td>
<td>300.00</td>
<td>286.0</td>
<td>911.6</td>
<td>1182.5</td>
<td>0.017325</td>
<td>5.00</td>
</tr>
<tr>
<td>50</td>
<td>65</td>
<td>274.44</td>
<td>243.6</td>
<td>936.2</td>
<td>1176.2</td>
<td>0.016870</td>
<td>5.75</td>
</tr>
<tr>
<td>1.3</td>
<td>16.0</td>
<td>216.32</td>
<td>184.4</td>
<td>966.7</td>
<td>1170.2</td>
<td>0.016425</td>
<td>6.40</td>
</tr>
</tbody>
</table>

Designs, materials, weights and performance ratings are approximate and subject to change without notice. Visit armstronginternational.com for up-to-date information.
Steam Tables

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:

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

Where:

- **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.

% 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.
Armstrong provides intelligent system solutions that improve utility performance, lower energy consumption, and reduce environmental emissions while providing an "enjoyable experience."