

Steam Traps – Operating Principles and Types

STEAM TRAPS:

Steam Traps are automatic valves designed to remove condensate from steam lines, but prevent steam loss by “trapping” the steam; hence the name, “Steam Trap”. Air is usually present for some period of time in a steam line, either during start-up and/or operation. So, depending on the application, air is another fluid that usually requires removal from a steam line.

Therefore, in order to operate properly, steam traps should be able to sense certain differences between condensate, steam, and air. Based on current designs, there are three basic operating principles of steam traps, which are explained below: **Thermostatic**, **Density**, and **Thermodynamic**.

THREE OPERATING PRINCIPLES OF STEAM TRAPS:

THERMOSTATIC traps sense the temperature difference of entering fluids

These are designed to open for cool fluid and close for hot fluid. The intention is to open for cool condensate or air, and close for hot condensate.

The closure occurs when the fluid, typically hot condensate, has a temperature greater than or equal to a certain threshold value. The hot temperature causes a thermostatic element to move in such a manner that closes a valve head against a valve seat (“valve”). This temperature threshold value is below that of saturated steam, but the actual specific temperature to open/close is different depending on the type of thermostatic trap.

Since air – like cool condensate – has a temperature significantly lower than steam, thermostatic traps are generally very good at venting large amounts of air.

There are three basic types of thermostatic traps that operate according to the temperature principle: **Expansion**, **Balanced Pressure**, and **Bi-Metal**.

- **Expansion** trap elements have an internal filling that expands and contracts with temperature change to actuate the valve, but the filling does not vaporize. There are two basic element designs: **wax** or **petroleum-based liquid**:
 - **Wax elements** are in a congealed state when cool, and expand when heated
 - **Petroleum-based elements** are in a contracted liquid state when cool, and expand when heated

- **Balanced Pressure** trap elements have filling which is a mixture of water and mineral spirits that generally vaporizes or condenses at near-to-steam temperature to actuate the valve. There are five basic element designs: **drum** or **barrel**, **spiral bellows**, **edge-welded bellows**, **encapsulated bellows**, and **encapsulated diaphragms**.
 - **Drum or Barrel** elements are of cylindrical design with soldered ends, usually constructed of copper
 - **Spiral Bellows** elements are of convoluted tube design with soldered ends, usually constructed of copper or monel
 - **Edge-Welded** elements are constructed of alternating inner and outer welds to join stainless steel plates
 - **Encapsulated Bellows** elements are constructed of stainless steel plates; enclosed in a protective stainless steel outer shell
 - **Encapsulated Diaphragm** elements are constructed of either stainless steel or Hastelloy®-equivalent diaphragms; enclosed in a protective stainless steel outer shell

- **Bi-Metal** trap elements are composed of two dissimilar metal strips bonded together so that temperature change causes deflection in one direction or its opposite to actuate the valve. There are four basic element designs: **Circular Plate**, **Irregular Plate**, **Cantilever Strip**, and **Single Strip**.
 - **Circular Plate** elements contain stacked circular discs, centrally surrounding a valve stem. The stacked orientation of the plates is alternating, so that the metal of one disc faces the same metal on the next. Temperature change causes deflection of the opposed discs to actuate the valve open and closed.
 - **Irregular Plate** elements contain stacked plates of irregular, but identical shape, centrally surrounding a valve stem. The stacked orientation of the plates is alternating, so that the metal of one plate faces the same metal on the next. Temperature change causes deflection of the opposed plates to actuate the valve open and closed.
 - **Cantilever Strip** elements contain identical, rectangular-shape, bimetal strips stacked on top of each other. The stack is attached to a fixed mounting point at one end, and surrounding a valve stem at the other. The strips are stacked in like orientation, so that metal of one strip faces the dissimilar metal on the next. Temperature change causes stack deflection to actuate the valve open and closed.
 - **Single Strip** elements contain a single bimetal strip bent into the basic shape of an upper case “C”, with the two ends surrounding a valve stem. Temperature change causes deflection of the strip to actuate the valve open and closed.

DENSITY traps sense the density difference of entering fluids

Also called mechanical traps, these are designed to open for more-dense fluids and close for less-dense fluids. The intention is to open to discharge condensate, and close for steam.

The opening and closing of the valve mechanism occurs by using the buoyancy property of a floating object. The buoyant object might be a sealed round or oblong float, inverted bucket, or open-top bucket.

There are two basic categories of mechanical traps that operate on the density principle: **Float**, and **Bucket**. Within these categories, there are two types each of density traps: **Lever Float**, **Free Float**, **Inverted Bucket**, and **Open Bucket**.

- **Lever Floats** contain a spherical or oblong float attached to a lever mechanism. The mechanism uses the buoyancy of the float, magnified by the lever arm length and fulcrum point to open the valve and discharge condensate. They close by the combination of lever mechanism weight and net system pressure acting over the valve head.
- **Free Floats** contain a spherical float that uses its buoyancy to open by cantilevering off the top ledge of the valve block. They close by combination of float weight, condensate level, net system pressure, and a mechanical stop mechanism in some models.
- **Inverted Buckets** contain an inverted, cylindrically-shaped bucket which is open on the bottom side. It gains buoyancy to close the valve when steam or air enters the bucket's inner chamber. They open by a combined effect of levering the bucket weight and cantilevering off the valve block.
- **Open Buckets** contain a cylindrically-shaped bucket that is open on the top side. The mechanism uses the buoyancy of the float to keep the valve shut. Condensate fills the bucket to remove buoyancy, thereby opening the valve.

Since air – like steam – is less dense than water, density traps tend to close in the presence of air and are generally not suited for venting large amounts of air.

For this reason, density traps may contain a separate thermostatic air vent mechanism to handle significant amounts of air. Those combinations are in two categories: **Float & Thermostatic**, and **Bucket & Thermostatic**.

Within these categories, there are two types each of density & thermostatic combination traps: **Lever Float & Thermostatic**, **Free Float & Thermostatic**, **Inverted Bucket & Thermostatic**, and **Open Bucket & Thermostatic**.

- **Lever Float & Thermostatic traps** operate in the same manner as above, but contain a separate balanced pressure or bimetal thermostatic element to remove air.
- **Free Float & Thermostatic traps** operate in the same manner as above, but contain a separate balanced pressure or bimetal thermostatic element to remove air.

- **Inverted Bucket & Thermostatic** traps operate in the same manner as above, but contain a separate bimetal thermostatic element to remove air.
- **Open Bucket & Thermostatic** traps operate in the same manner as above, but contain a separate balanced pressure element to remove air.

THERMODYNAMIC traps sense the velocity difference of entering fluids

Also called disc, piston, or impulse traps; these are designed to discharge condensate, a relatively slow-moving fluid, and close for flash steam, a relatively high velocity fluid.

When condensate enters the trap body, it moves slowly relative to steam - and is freely discharged. When flash or live steam moves across the underside of the disc, its velocity is much higher than water, and the high speed creates a pressure drop which closes the valve head. The valve stays shut until the control chamber steam pressure above the valve head drops, thereby allowing the valve to open.

There are two basic categories of thermodynamic traps that work on the velocity principle: **Thermodynamic Disc** and **Thermodynamic Piston**.

- **Thermodynamic Disc** traps contain a disc which reacts to differences in velocity of steam or condensate. Velocity under the disc creates a drop in static pressure which closes the disc. Subsequently, control chamber steam above the disc condenses due to heat loss, enabling the valve to open.
- **Thermodynamic Piston** traps operate similarly to disc models, but contain a piston which has a centrally located pilot hole which constantly bleeds some combination of air, condensate, or steam to actuate the valve open.

Since air – like steam – moves much faster than water; thermodynamic disc traps tend to close in the presence of air and are generally not suited for venting large amounts of air. (Thermodynamic piston traps can vent some air, but they can also bleed steam).

For this reason, thermodynamic disc traps may contain a separate thermostatic air vent mechanism to handle significant amounts of air. This combination is called a **Thermodynamic Disc & Thermostatic**.

- **Thermodynamic Disc & Thermostatic** traps operate in the same manner as disc traps above, but contain a separate bimetal thermostatic element to remove air.

BASIC VALVE DESIGNS:

Valves can be made with either of two basic designs: Inlet Valve Head or Outlet Valve Head.

- **Inlet Valve Head** design is sometimes called an “**upstream**” valve head, or “**steam-to-close**” valve. The valve head is on the inlet side of the seat, and uses steam pressure to close or help close the valve.
- **Outlet Valve Head** design is sometimes called a “**downstream**” valve head, or “**steam-to-open**” valve. The valve head is on the outlet side of the seat, and steam pressure can exert continuous force to open the valve.

PILOTED VALVE COMBINATIONS:

Some companies combine the various principles and types in different way, other than just adding thermostatic portions for air venting. The following are two piloted valve combinations used for high capacity flow capability: **Float-actuated Piston, Thermostatic-actuated Piston.**

- **Float-actuated Piston** traps use a float as a pilot valve to release steam pressure which in turn loads a piston to actuate the main valve. Condensate causes the float to rise, which load steam onto a piston valve to actuate the main valve open.
- **Thermostatic-actuated Piston** traps use a balanced pressure thermostatic element as a pilot valve to release steam pressure which in turn loads a piston to actuate the main valve. Condensate causes the balanced pressure capsule to open, which load steam onto a piston valve to actuate the main valve open.

Steam traps have different characteristics. Understanding their various operating principles and types can help users make trap selections that are appropriate for various steam applications.

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