WHY DO WE NEED STEAM TRAPS?
In order to operate economically and efficiently, all steam systems must be protected against 3 factors:

* CONDENSATE
* AIR
* NON-CONDENSIBLES

Condensate is formed in a system whenever steam gives up its useable heat. And, since condensate interferes with the efficiency of the operation of a steam system, it must be removed.

Air, one of natures finest insulators, when mixed with steam, will lower its temperature and hinder the overall effectiveness of an entire system. For example: A film of air 1/1000th of an inch thick offers as much resistance to heat transfer as 13" of copper or 3" of steel. For that reason, air MUST be continuously bled from a system by steam traps to have it operate efficiently and to conserve energy.

Non-condensibles, such as carbon dioxide promote corrosion and other deterioration of equipment and inhibit their function.

WHAT IS A STEAM TRAP?
A steam trap is basically an automatic valve which discharges condensate, undesirable air and non-condensibles from a system while trapping, or holding in, steam. They fall into 4 major categories: Thermostatic, Mechanical, Thermodynamic and Drain Orifice. Each type will be discussed in detail in this section.

In every steam system, there are four phases of operation in which traps play a vital role:

1) Start-up – During “start-up”, when the system is initially activated, air and non-condensibles must be discharged.
2) Heat-up – During “heat-up”, as the system works to achieve the desired temperature and pressure, condensate is discharged.
3) At Temperature – “At temperature”, when the desired levels are reached, the valve must close to retain the steam.
4) Using Heat – At the “using heat” level, the valve’s job is to stay closed unless and until condensate occurs; then the valve must open, discharge the condensate and close quickly and positively, without allowing valuable steam to escape.

WHAT ARE THE QUALITIES OF A GOOD STEAM TRAP?
A good steam trap should:

• Discharge condensate, air and non-condensibles.
• Be equal to the load over a wide range of pressures and temperatures.
• Be freeze-proof where necessary.
• Be simple and rugged.
• Have few moving parts.
• Require low maintenance and spare parts inventory.
• Have a long life.

A good steam trap should not:

• Discharge live steam.
• Fail or malfunction if pressure changes.
• Respond slowly or hesitantly.
• Open too often, too briefly or for too long.
• Require constant adjustment or frequent repair.
• Require a wide variety of models, spare parts or orifice sizes for different pressures.
Thermostatic Steam Traps

Thermostatic steam traps, as their name implies, operate in direct response to the temperature within the trap. There are two primary types: BELLOWS and BIMETALLIC.

BELLOWS TRAPS

Of all actuating devices, the bellows trap most nearly approaches ideal operation and efficiency and is most economical. It is positive in both directions, is fast acting and does not require adjustment. Bellows traps employ only one moving part - a liquid filled metal bellows - which responds quickly and precisely to the presence or absence of steam.

During startup and warmup, a vacuum in the bellows keeps it retracted, with the valve lifted well clear of the seat permitting air and non-condensibles to be freely discharged (Figure 13).

Next, condensate is discharged (Figure 14). Then heat from arriving steam will cause the liquid in the bellows to vaporize and close the valve (Figure 15). At temperature, the valve will remain closed indefinitely opening only when condensate, air or other non-condensibles cause it to retract and open. When live steam re-enters the trap housing, the bellows extends immediately, trapping the steam (Figure 15).

The bellows, unlike a disc trap, is a temperature sensitive rather than a time cycle device. There is no way that air can be mistaken for steam and cause binding, since bellows react to temperature only. And unlike bucket traps, bellows traps do not require a variety of sizes for valves and seats for various pressures.

BIMETALLIC TRAPS

Bimetallic traps work like the differential metal strip in a thermostat, using the unequal expansion of two different metals to produce movement which opens and closes a valve.

Figure 16: When the cooler condensate contacts the bimetallic discs, the discs relax. Inlet pressure forces the valve away from its seat and permits flow.

Figure 17: When steam enters the trap and heats the bimetallic discs, the discs expand forcing the valve against its seat preventing flow. Bimetallic traps are simple and positive in both directions. However, they have a built-in delay factor which makes them inherently sluggish. Moreover, they do not maintain their original settings because the elements tend to take a permanent set after use, which requires repeated adjustment to maintain efficiency.

MECHANICAL STEAM TRAPS

There are two basic types of mechanical steam traps:

1) FLOAT & THERMOSTATIC
2) INVERTED BUCKET

Inverted bucket traps, as their name suggests, operate like an upside down bucket in water.

Figure 1: During startup, the trap is filled with water, with the bucket (A) at the bottom and the valve (B) fully open to allow condensate to flow out freely.

Figure 2: Air trapped in the bucket escapes through a vent hole (C).
some buckets, an additional vent hole is controlled by a bimetallic strip which is kept closed by the steam. Therefore, the vent only operates during startup. This limits bucket trap air handling capacity.

**Figure 3:** At temperature, steam enters under the bucket and causes it to float up and close the valve (B). During heat use, any condensate entering the line is forced up into the bucket. The bucket loses buoyancy and drops down, reopening the valve and discharging the condensate. (see Figure 1)

Bucket traps are rugged and reliable, however, air building up in the bucket can bind them closed causing condensate to back up in the line. Also, they can waste steam if they lose their prime force, the weight of the bucket, discharge orifices must be sized by pressure. For example, a trap sized to operate at 50 PSIG will not open at 150 PSIG.

Float traps are manufactured in a variety of sizes, shapes and configurations. The most commonly used (for steam service) is the float and thermostatic, or F & T. F & T traps combine the excellent air venting capabilities of a thermostatic trap with the liquid level controlling capabilities of a float trap.

**Figure 5:** During startup, before condensate reaches the trap, the thermostatic element is fully open to discharge air. The float rests on the lower seat.

**Figure 6:** As hot condensate and steam reach the trap, the thermostatic element expands, closing the air vent. Condensate lifts the float, allowing condensate to flow out of the trap.

**Figure 7:** As the condensing rate decreases, the float lowers, reducing flow through the trap. The buoyancy of the float will maintain a liquid level seal above the lower seat ring, preventing the escape of steam. As with inverted bucket traps, float and thermostatic traps rely on a fixed force (the buoyancy of the float). Discharge orifices must be sized by differential pressure. Placing a low pressure float and thermostatic trap in high pressure service will result in the trap locking up. A contrasting characteristic of both the float and thermostatic and inverted bucket is the discharge cycle. A float & thermostatic trap tends to continuously discharge condensate while the inverted bucket trap discharges condensate in cycles.

(see Figure 4). Bucket traps require priming water in the trap which makes them vulnerable to freeze up unless expensive insulation is added. Because bucket traps rely on a fixed
THERMODYNAMIC STEAM TRAPS

Essentially, a thermodynamic steam trap is a time cycle device which responds to imbalances of pressure applied to a valving device, usually a disc.

Figure 9: Pressure caused by air or condensate lifts the disc permitting flow through the trap.

Figure 10: When steam arrives at the inlet port, blowby at a high velocity creates low pressure under the disc. Some of the flashing condensate is blown past the disc into the upper chamber, forcing the disc downward.

Figure 11: Further flow is stopped when sufficient pressure is trapped in the chamber above the disc. During operation, a decrease in chamber pressure permits inlet pressure to lift the disc and open the trap (Figure 9).

The decrease in the chamber pressure should only be caused by the presence of cooler condensate. Due to the design of most thermodynamic traps, especially in cold or wet conditions, the chamber may be prematurely cooled causing improper or frequent cycling as well as steam loss and increased wear. Advanced TD designs have a steam jacket which surrounds the chamber and prevents ambient conditions affecting the operation of the disc.

This type of trap is also subject to water binding. If water pressure is trapped above disc, trap will fail closed.

ORIFICE STEAM TRAPS

Orifice type traps are engineered continuous flow devices. Orifice traps discharge air, condensate and all other non-condensible gases with minimal live steam loss.

The fixed orifice size is calculated, for a given application, to discharge the condensate load at maximum thermal efficiency. Approximately 10 to 25 percent of discharging hot condensate flashes to steam at the downstream side of the orifice, at a constant pressure drop. This flashing effect further restricts the flow of saturated steam. In actual conditions, a minimum percentage of steam, by weight, is discharged with condensate, since the specific volume of steam is relatively large compared to that of the condensate.

The velocity through the orifice is highly turbulent. The initial calculated steam loss can be expected to remain relatively constant over the expected trap life of 10 plus years.

The major factor for energy efficient performance is based on initial orifice sizing for the application. Properly sized, thermal efficiencies of 98 percent plus can be attained.

While Orifice Traps can be applied at all pressures, they are ideally suited for use on saturated or superheated steam 250 PSIG or greater.