STEAM LOSS AND INVERTED BUCKET TYPE STEAM TRAPS

A Comparative Study of Energy Loss Using Static Load Testing

ABSTRACT

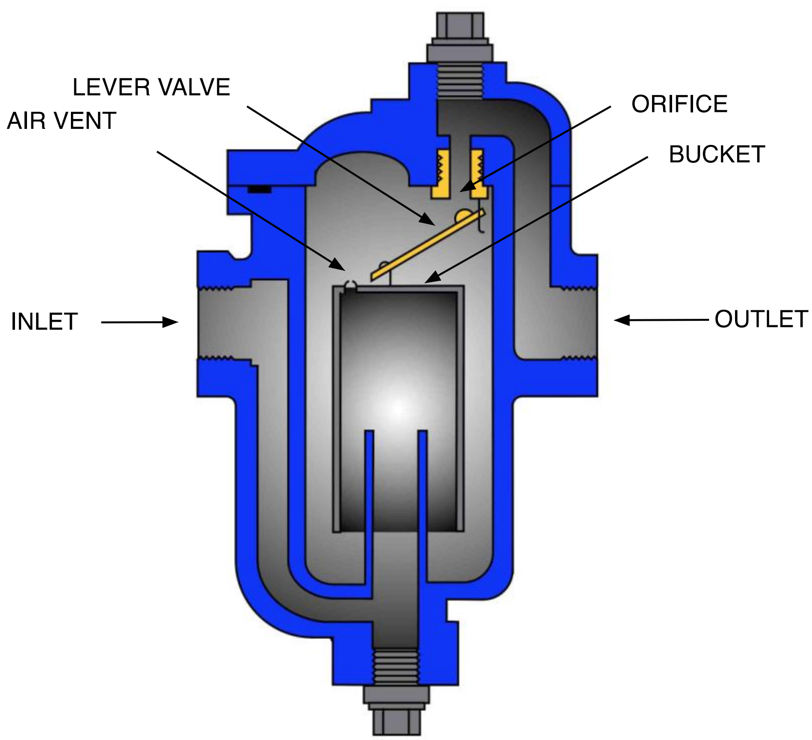
Testing demonstrates that steam loss is a normal and necessary condition for Inverted Bucket Type steam traps containing internal air vents. These testing methods demonstrate how the Inverted Bucket Trap operates and how to measure the amount of steam lost during the normal operation of the trap.

STEAM LOSS AND INVERTED BUCKET STEAM TRAPS: A COMPARATIVE STUDY OF ENERGY LOSS USING STATIC LOAD TESTING

Inverted Bucket type steam traps (IB Traps) are widely used throughout the world for steam tracing and drip leg applications. The advantages of the IB Trap include an ability to operate over a wide pressure range, a fail-open characteristic, and a relatively low price due to body materials typically found in cast iron and welded stainless steel plate. However, these advantages come at a significant price when steam loss is considered. The purpose of this study is to quantify the amount of steam that is lost due to the normal operation of these devices and how it relates to steam consumption of other available steam trap technologies.

INVERTED BUCKET TRAP OPERATION

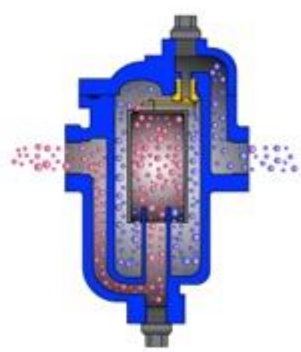
Inverted Bucket traps operate on the difference in density between steam and condensate. The operating parts of the trap include an orifice located in the top of the trap, a lever valve and a bucket.



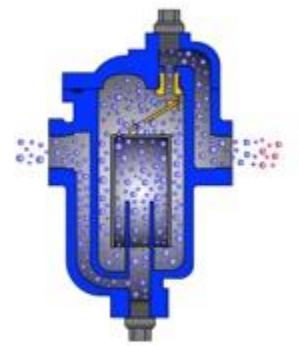
INVERTED BUCKET TRAP

SEQUENCE OF OPERATION

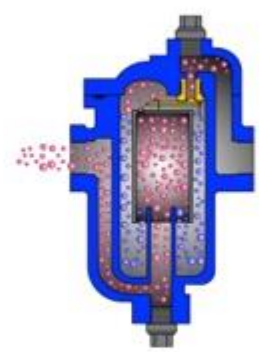
1. Upon startup, the bucket sits at the bottom of the trap body, keeping the valve open and allowing discharge of condensate.



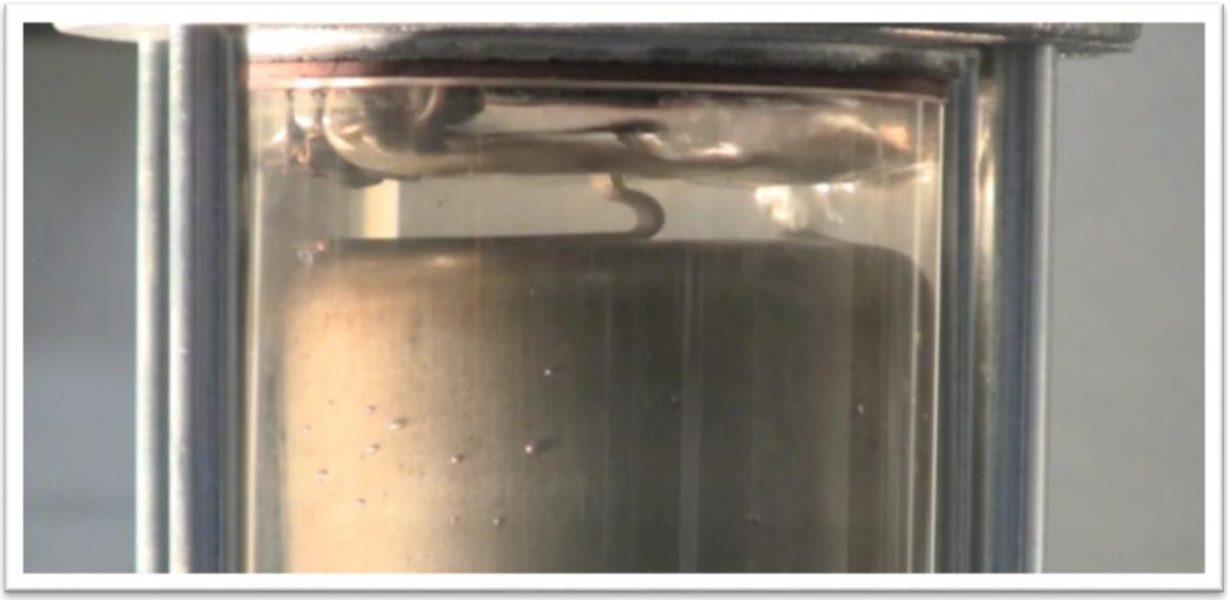
2. When steam or air enters the trap, the bucket floats to the top, closing the lever valve.



3. When the steam inside the bucket condenses, the bucket falls – opening the lever valve and repeating the cycle again.



4. During normal operation, the steam keeping the bucket closed is continually discharged through the air vent, reducing buoyancy of the bucket and causing the lever valve to open.

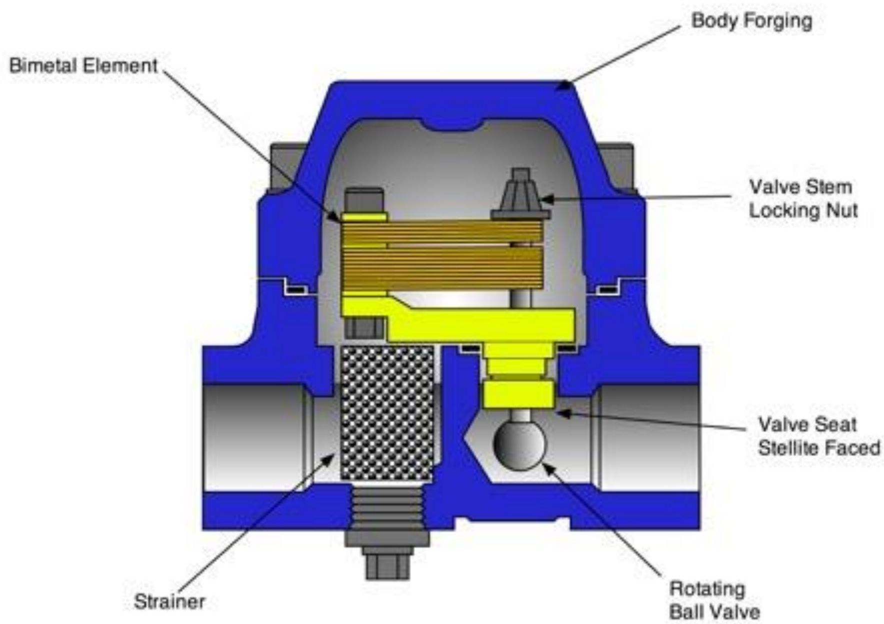


STEAM LOSS AND INVERTED BUCKET TRAPS

Inverted bucket traps require a mechanism for venting air and non-condensable gases from inside of the bucket. This mechanism consists of an orifice drilled into the top of the bucket, allowing for continuously venting, eventually purging the system of entrained gases. However, after all non-condensable gases are rid from the system, the orifice continues to pass steam, causing the bucket to lose buoyancy and the lever valve to open and close, releasing this steam to the outlet side of the trap.

THE VELAN MULTI-SEGMENT BIMETALLIC STEAM TRAP

The Velan Multi-Segment Bimetallic Steam Trap was developed in Canada in 1950 for the primary purpose of reducing operational energy loss. The Velan Steam Trap uses a unique bimetal technology to ensure proper drainage of condensate without the loss of live steam. The Velan Steam Trap operates on a thermostatic principle, assuring that live steam does not pass beyond the outlet orifice. This feature brings many advantages including 100% energy efficiency as well as a significant improvement in service life due to a reduction of wear on internal parts.

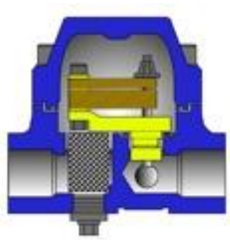


Velan Bimetallic Steam Trap

OPERATING PRINCIPLE OF VELAN STEAM TRAPS

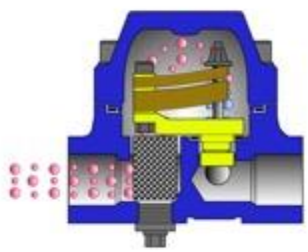
The Velan steam trap operates on a heat/pressure principle, using the heat from the steam and hot condensate to cause a stack of bimetal plates to close the valve in the trap. At all times, the line pressure is opposing the closing force of the bimetals. The result is a steam trap that fully discharges air and cool condensate until the system is sufficiently warm, then closes tightly on steam.

SEQUENCE OF OPERATION



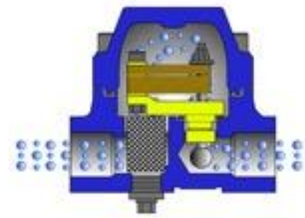
1. STARTUP

At ambient temperatures, the discharge valve is wide open, allowing air and cold water to pass quickly.



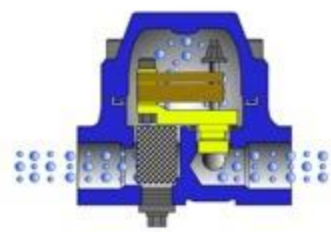
2. STEAM TRAPPING

Incoming steam contacting the bimetallic element causes the bimetal to deflect and develops a thermal power of the bimetal acting on the valve stem, which overcomes the steam pressure and closes the valve. This thermal pull seats the ball valve tightly, preventing loss of live steam. This thermal power increases or decreases as a function of temperature in the same relation, as temperature and pressure of saturated steam.



3. CONDENSATE DISCHARGE

When cooler condensate and air collects in the trap, the thermal pull of the bimetal is gradually reduced until the line pressure overcomes the closing force of the bimetal and the valve opens, discharging the condensate.



4. 100% BACK-FLOW CONTROL

In the event of a sudden drop in upstream pressure, the valve and seat act as a check valve – preventing reverse flow in the system.

MEASURING STEAM LOSS USING STATIC LOAD METHOD

One method of establishing the operational steam losses through steam traps is to employ the static load method. The static load test subjects a steam trap to a constant condensate load at a fixed pressure such that the total volume of discharge (liquid and vapor) can be condensed, captured and recorded. These results are compared against other steam traps to estimate differences in operational steam loss. Precautions are taken to ensure that condensate load produced by the test rig are constant and do not vary either during the test or between subsequent tests. These precautions include the following:

1. Each steam trap is warmed up for 10 minutes prior to collecting discharge so that condensate accumulation between test heats will not become part of the sample.

2. The boiler steam pressure is regulated prior to the test rig such that the normal pressure swings caused by burner cycling will not change the steam pressure during the test.

3. Ambient temperature is monitored to ensure that test heats are not subject to changes in condensate production.

4. All condensate producing equipment such as fan coils are shut down to ensure consistency of load at the test rig.

Test rig with condenser on steam trap discharge

TEST ARRANGEMENT

Figure 1 shows the piping arrangement for conducting a static load steam trap test.

This test configuration consists of a drip leg arrangement with probes installed at the following locations:

PEN 1 T_1records temperature at steam trap inlet.

PEN 2 T_2records temperature at a point 12 linear inches ahead of the trap inlet

PEN 3 T_3records steam temperature

PEN 4 P_1pressure transducer records upstream steam system pressure

PEN 6 L_1 liquid level transmitter records condensate accumulation ahead steam trap

**Liquid level gauge allows for visual monitoring of liquid level in piping upstream of the trap inlet

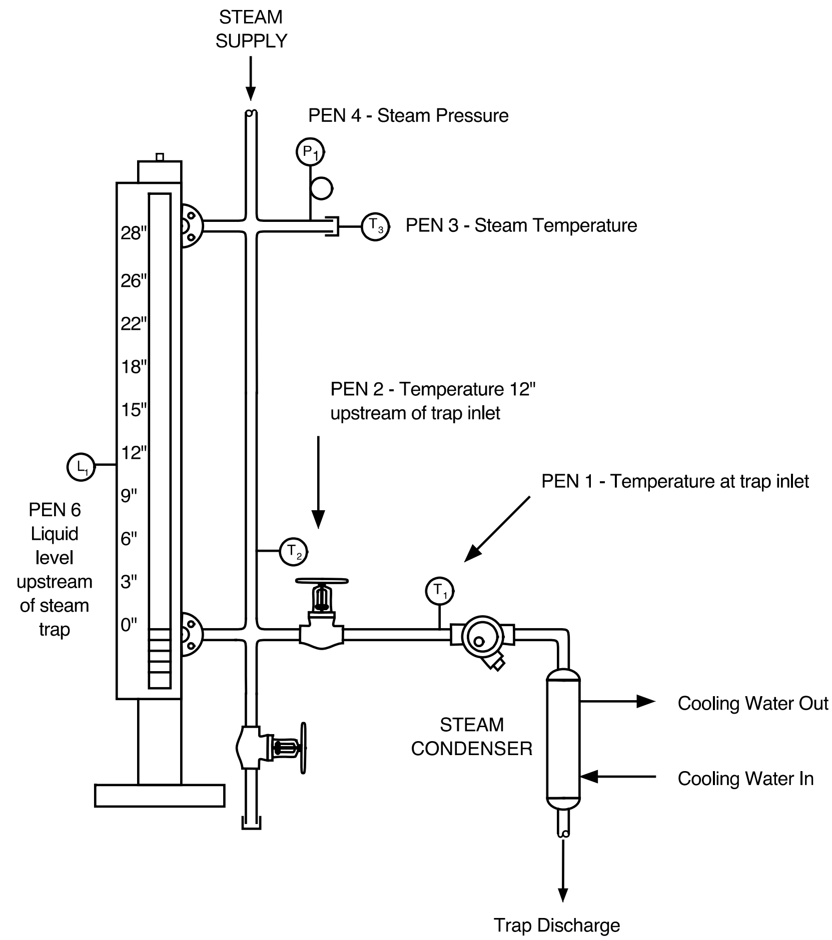


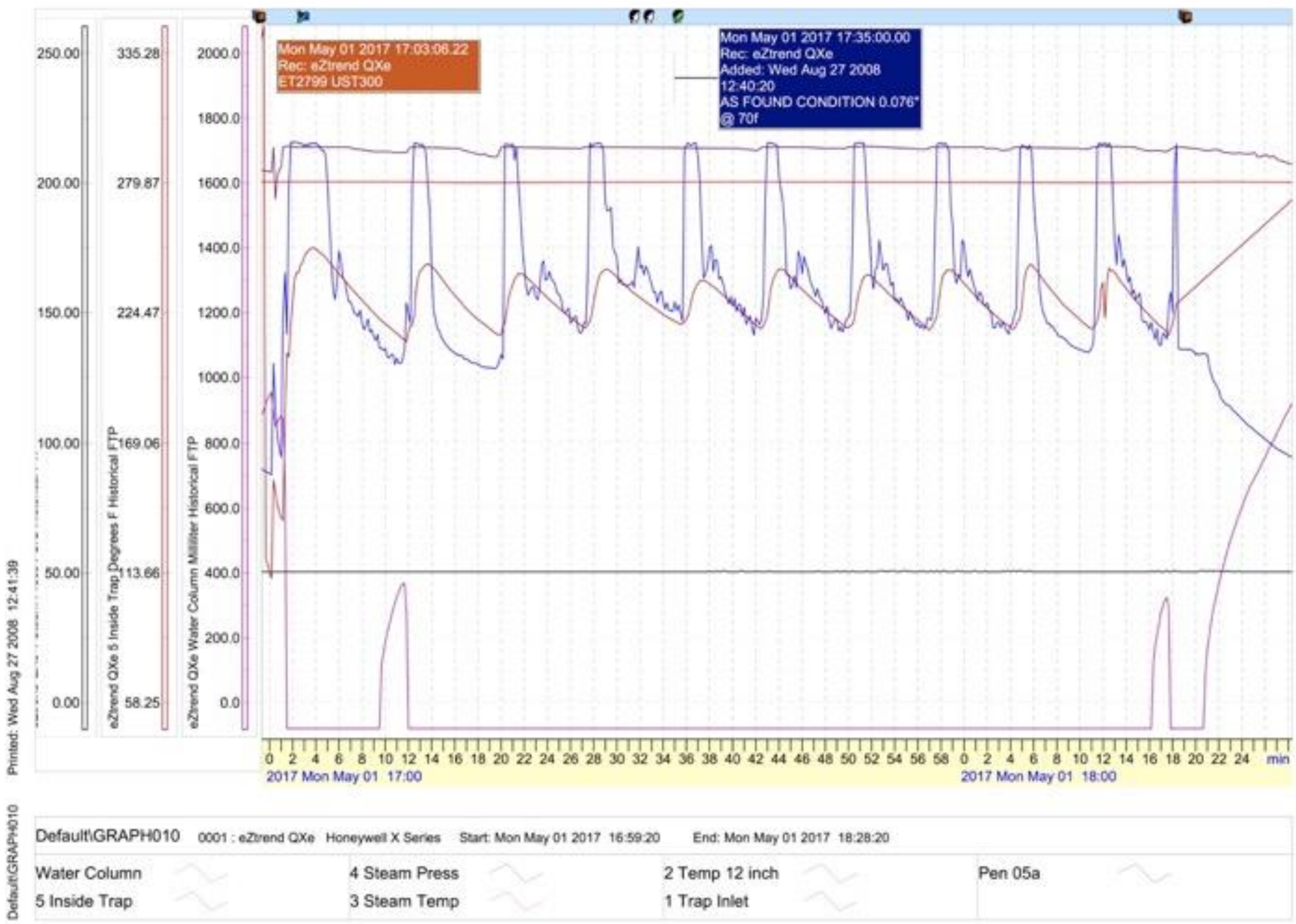
Figure 1

TEST PROCEDURE

1. Start boiler and allow the system to warm up and stabilize sufficiently.
2. Open the inlet valve to the trap and allow to warm up sufficiently (10 minutes minimum).
3. Empty and weight collection vessel.
4. Engage the condenser cooling water to ensure full recovery of all vapor.
5. Begin collection of trap discharge.
6. After test period is complete (minimum 10 minutes), close inlet valve to trap.
7. Weigh the condensate collection vessel and subtract the weight of the vessel to determine total condensate weight.

CHART RECORDING

Chart recordings are used to provide a visual representation of the internal workings of the trap. Temperature readings at different pen locations can show the presence of condensate prior to the trap orifice, establishing the existence of a liquid seal which prevents steam loss. Additionally, the liquid level transmitter records the presence or absence of condensate upstream of the trap during the test, establishing whether the steam trap is adequately draining condensate from the line and precluding condensate backup as a reason for discharge variations during the static load test.



TEST DATA – INVERTED BUCKET vs. MULTI-SEGMENT BIMETALLIC

TEST DATA				Velan UST-300 TEST DATA			ARMSTRONG 2011-200 TEST DATA			RESULTS
Date	Test #	Duration	Weight of Collection Container oz	Total Weight ounces	Net Weight ounces	Discharge Rate lb/hr	Total Weight ounces	Net Weight ounces	Discharge Rate lb/hr	Difference in discharge Armstrong - Velan lb/hr
8/15/17	1	10 min	2.4	17.4	15	5.625	26.4	24	9	3.375
8/15/17	2	10 min	2.4	18.8	16.4	6.15	28.2	25.8	9.675	3.525
8/15/17	3	10 min	2.4	18.6	16.2	6.075	27.2	24.8	9.3	3.225
8/15/17	4	10 min	2.4	18.2	15.8	5.925	26.2	23.8	8.925	3
8/15/17	5	10 min	2.4	17.8	15.4	5.775	25.4	23	8.625	2.85
8/14/17	6	10 min	2.4	16	13.6	5.1	25.4	23	8.625	3.525
8/14/17	7	10 min	2.4	19	16.6	6.225	25.4	23	8.7	2.475
8/14/17	8	10 min	2.4	17.2	14.8	5.55	23.6	21.2	7.95	2.4
8/14/17	9	10 min	2.4	17.2	14.8	5.55	23.6	21.2	7.95	2.4
8/14/17	10	10 min	2.4	16	13.6	5.1	25.6	23.2	8.625	3.525
Average Values			2.4	17.62	15.22	5.7075	25.7	23.3	8.7375	3.03

CONCLUSION

Under static load conditions the Armstrong 2011 was found to consistently discharge a greater volume of steam/condensate than the Velan UST-300. This difference in the discharge rate of the two traps averaged 3.03 pounds per hour. Neither steam trap produced a measurable backup of condensate at any point during the test, demonstrating that the difference in discharge volume can be attributed to the Armstrong 2011 losing steam during the test. This steam was condensed through the outlet condenser and added to the total weight of the condensate being passed through the trap.

COST SAVINGS WITH THE VELAN STEAM TRAP

When compared to the Inverted Bucket Trap, the Velan Steam Trap will consume on average 3 pounds of steam less per hour. At energy costs of $10.00 USD per 1,000 pounds, this is a financial savings of $250.00 per year per steam trap

For a typical process plant with a population of 1000 inverted bucket traps, a total plant retrofit will save an average of over 2 million pounds of steam per year. At current energy cost, this represents and annual cost savings of $250,000.

CONCLUSION

When considering the normal and necessary steam losses associated with inverted bucket traps, significant opportunities for cost avoidance and energy reduction exist by retrofitting facilities to the multi-segment bimetallic steam trap design. Typically, return on investment can be recouped within a period of 24 months, taking into account both the cost of material and labor. and it is prudent to look toward other designs of steam traps to increase plant efficiency.