Compare Two Fixed Orifice Venturi Style Products to a Variable Orifice Free Float® Steam Trap

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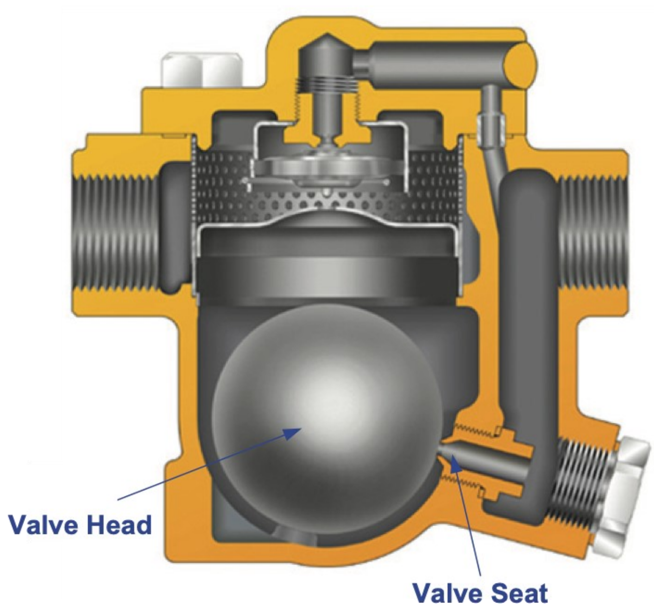
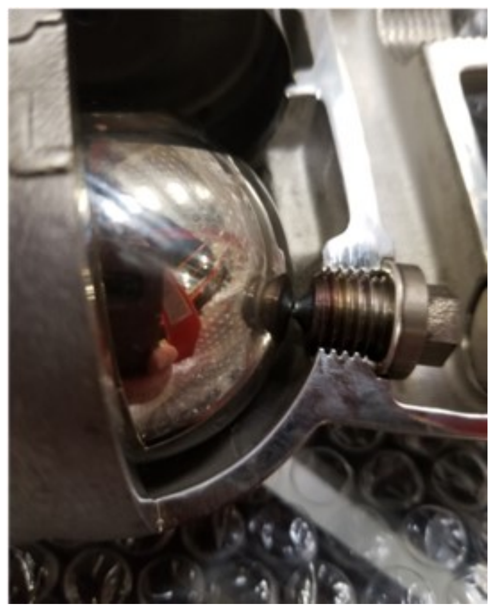
There are multiple choices for steam traps to be used in mains drainage, tracing, or process applications. How do fixed orifice Venturi-style products compare to variable orifice Free Float® models?

When evaluating what products to use for draining condensate, there may be instances where some users consider different steam trapping options. Those might include comparing fixed orifice fitting style products to steam traps with internal mechanisms having both a valve head and a valve seat. Some key determinants in the evaluation might include expectations about functionality, operating cost, safe operation, and reliability.

Fixed and Variable Orifice Products

A fixed orifice product – provided to perform a steam trap function of discharging condensate from a steam system – is sometimes referred to by the provider as being a "Venturi." Another product, a specific style of steam trap that contains a floating ball to operate as the valve head and a fixed orifice as the valve seat, modulates to allow variation of flow through the orifice's opening (**Fig. 1**). One such steam trap, which is sometimes referred to as a variable orifice style product, is represented by the cutaway images below.[1] Some possible characteristics of the differing orifice product styles – fixed or variable – follow.





▲**Fig. 1.** Free Float® steam trap has a ball float valve head and fixed orifice valve seat. The ball float enables variation of the size of the orifice opening, modulating to match flow requirements.

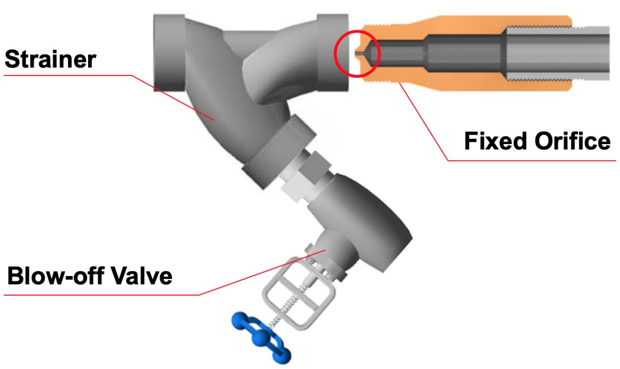
What Makes A Venturi

The Venturi shown can be viewed as a .gif file on the website noted in References and Acknowledgements (**Fig. 2**).[2] Named after Italian physicist, Giovanni Batista Venturi, the wide inlet section is high pressure, low velocity, and the narrow central section is high velocity and low pressure. The reduction in pressure follows the rules of Bernoulli's principle.[3]

A Venturi tube can have different width and length, but the basic design can be the same – consisting of a wide tubular structure with a distinct narrowing between the ends. The narrow section circled in red increases the fluid velocity, which causes a simultaneous drop in pressure at the same point (**Fig. 3**).

Some common uses for a Venturi include suctioning vapors such as air from steam systems or to produce a differential pressure used to measure flow rates (as in a flow meter).

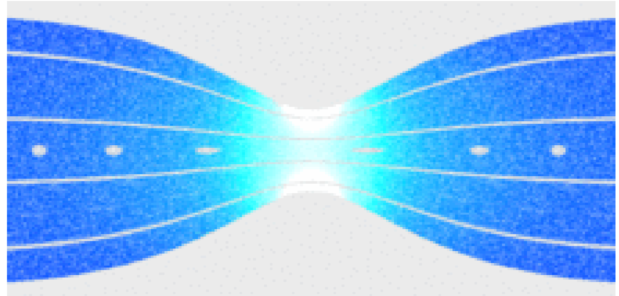
It can be helpful to review a possible assembly structure of a fixed orifice fitting that might be used for condensate drainage (instead of a steam trap). Such a product might include not only the orifice fitting, but also a strainer, blowdown / blow-off valve, and connection piping as shown in a generic graphic (**Fig. 4**). This graphic represents just one possible assembly and does not purport to represent any particular or all orifice fitting assemblies that might be used for steam trap service.



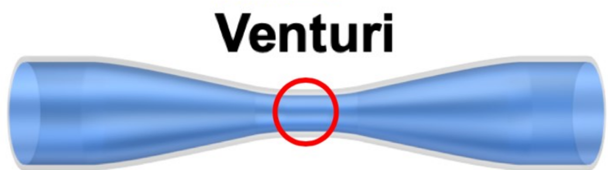
▲**Fig. 4.** A fixed orifice product may use a strainer and blow-off valve in its assembly.

This particular graphic shows a series of varying inside diameters after the circled fixed hole. It is possible that the shape of the Venturi from different orifice manufacturers is intended to drain condensate through a fixed hole without steam leakage.

Using the term, Venturi, may create a kind of mystique about the product. But, does the actual orifice which drains the product closely resemble the Venturi tube shown in Figure 3, or does it more closely resemble a "**half Venturi**" such as shown (**Fig. 5**)?

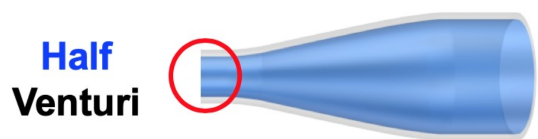


▲**Fig. 2.** A Venturi has high velocity and low pressure at its narrow section.



▲**Fig. 3.** Low pressure at Venturi narrowing is commonly used for suction or differential pressure reading purposes.

Since a narrowed section is circled in the several graphics provided, some might conclude that a fixed orifice or "Venturi" actually more closely resembles a "half Venturi" rather than a full Venturi tube. Then a question might follow as to how the half Venturi orifice compares to some orifice configurations that might be present in some steam traps that have both a valve head and a valve seat.



▲**Fig. 5.** A fixed orifice product may more closely resemble a half rather than a whole of a Venturi tube.

Steam traps that contain both a valve head and valve seat as part of the trim internals must also have an orifice through which condensate flow will pass. Commonly, the orifice is located in the valve seat. Such a valve seat orifice design may also be considered to be a half Venturi by some reviewers.

Orifice Design and Quality

Manufacturers' literature may sometimes show outline images representing their orifice or valve seat design. However, graphic outlines alone may not do an orifice or steam trap product justice. It can be worthwhile for an end user to examine the actual valve seat of a production steam trap which contains full valve trim consisting of both the orifice and a valve head to shut off flow – and compare it to the orifice in a half Venturi product. Users can examine the quality of the manufactured orifices, the size of the orifice opening, and the hardness of the materials used as all of these characteristics may influence product reliability.

▲Fig. 6. Compare differences of actual orifices between manufacturers, not just graphical outlines.

One such valve seat with orifice opening from a manufacturer's variable orifice style product (**TLV's SS1NH-10 Free Float® steam trap**) is provided with its outline graphic for review (Fig. 6). It is useful to note that various steam trap manufacturers may have their own unique valve seat orifice designs, and this image is not intended to reflect the design, materials, diameter, or any other characteristics of any other manufacturer – but rather is just the design used in TLV's SS1NH-10 steam trap. It cannot be stressed enough that if a site is considering to use a half Venturi product in a steam system for drainage, it is hoped that actual orifices of both a variable orifice steam trap and the half Venturi product are reviewed in a visual side-by-side comparison by the end user before making any final decision.

Flashing Condensate

Half Venturi fittings are sometimes promoted for steam applications under the assumption that the orifice structure creates a restriction to flow due to the flashing effect of condensate. Engineers can understand the concept of "**Choked Flow**" as the maximum flow through an orifice, but a question may arise regarding how to effect minimum flow through the same orifice diameter based on design configuration differences.

What may be notable to consider is that some high temperature condensate flashes into steam based on a combination of factors, including pressure drop, heat energy in the condensate while at the high-pressure side, and the sensible heat saturation point on the low-pressure side. So, condensate discharging from a high temperature, high pressure region to a low-pressure line can expect to see flashing when passing through an orifice – whether the orifice is in a steam trap or a half Venturi product. Flash steam mixed in with the discharged condensate may sometimes resemble the lighter, off-white color section in the representation (Fig. 7).[4]

▲Fig. 7. Light color section represents flash steam from condensate.

Measuring Steam Loss

The phrase "**no steam loss**" might be used in description of a steam trap or half Venturi fitting. However, end users should require that the representation be verified by applicable standards, such as "**conducted in strict accordance to globally-recognized steam loss standards ASME PTC39-2005 or ISO 7841**." Those standards created by their respective organizations provide an objective, calorimetric-based method for measuring steam loss through any orifice of a product used as a steam trap.[5,6]

The steam loss during normal operation can also be referred to as **Functional Steam Loss** (FSL).[7] An example of one manufacturer's test apparatus used to measure FSL to the **ASME PTC39-2005 and ISO 7841 standards** is shown in the two photos provided (Fig. 8). Measuring FSL between vendor recommended models may

▲Fig. 8. The test apparatus has been independently validated to comply with ASME PTC39-2005 and ISO 7841 standards.

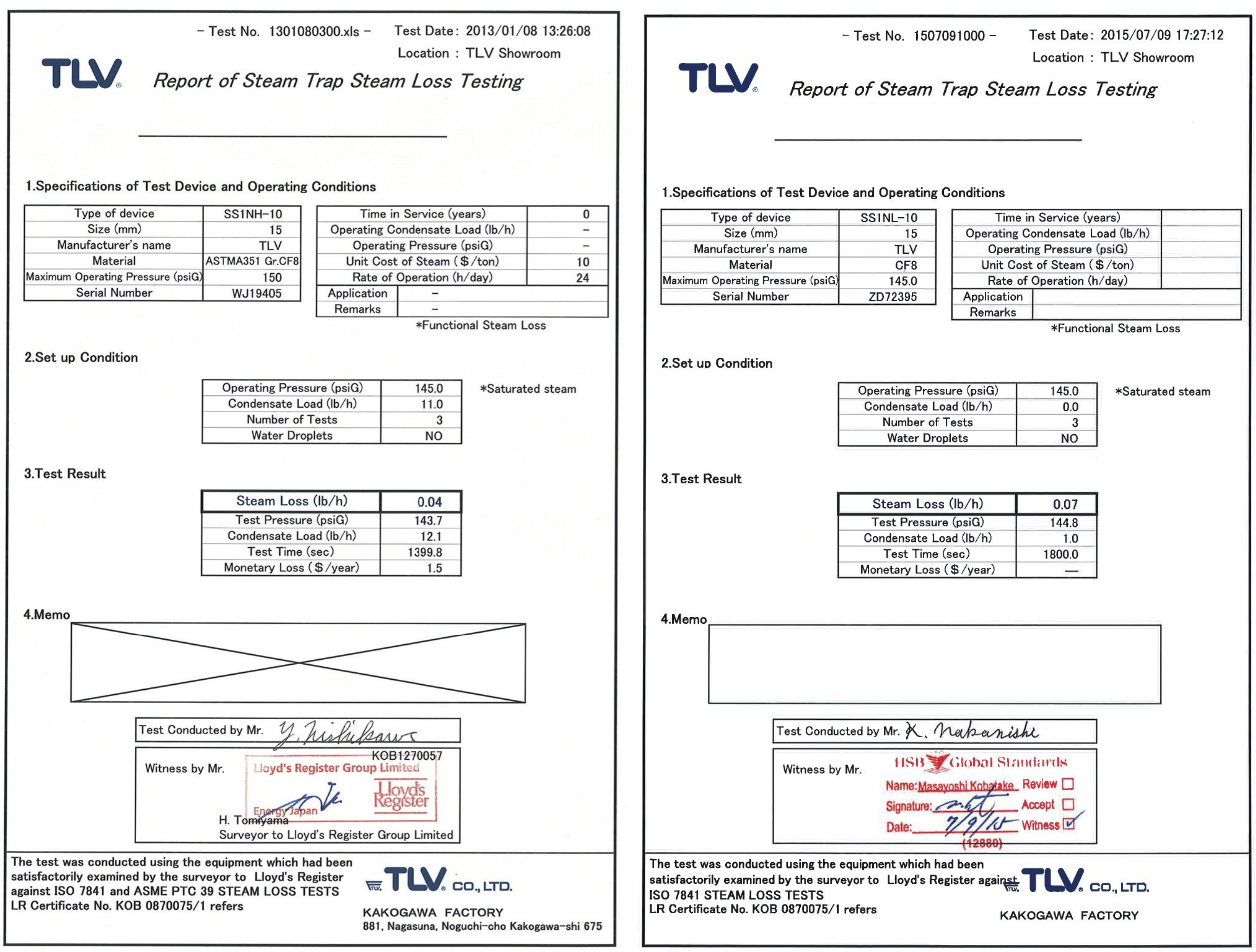
provide useful information to be considered in the selection process.

Tests of two half Venturi products sold by two different orifice providers, both products having 1.5 mm orifices, performed to the **ASME PTC39-2005 and ISO 7841 standards** on a test apparatus validated by 3rd party inspection, provided interesting results for consideration. It is important to note that tests of just two products cannot reflect any other product, but just those two half Venturi products tested under a controlled environment. In accordance with the ASME PTC39-2005 standard's test requirement to use a condensate load of 11#/h (5kg/h for ISO 7841), and at a test pressure of 145 psig, **those two specific half Venturi products had 3rd-party-witnessed steam loss recorded as exceeding 18#/h and 21#/h respectively.**

As a comparison, TLV's Free Float® steam trap containing both a valve head and valve seat having a larger orifice diameter of 1.8 mm **recorded tested steam loss to those same two standards as low as 0.04 #/h (TLV Model 15mm SS1NH-10) (Fig. 9).** The 0.04#/h is not a statement regarding every steam trap, but only the specific TLV 15mm SS1NH-10 model referenced. The main point to consider is the importance of having actual steam loss test values in accordance with the two standards (ASME / ISO) noted above for comparison in the decision-making process. Applications such as trapping instrument enclosures or superheated vertical drops into a steam turbine inlet can have little to no condensate for a significant time of operation. For this reason, **a TLV SS1NL-10 model was tested with condensate load set to 0.0 #/h** – which is less than the load of 11#/h per the ASME PTC39-2005 standard. **Recorded tested steam loss was 0.07 #/h.** Ibid.

Performance Considerations for Widely Varying Loads

In real world site applications, condensate loads may fluctuate significantly. Consider the possible load variation on outdoor applications – summer to winter, and



– Test No. 1301080300.xls – Test Date: 2013/01/08 13:26:08
Location : TLV Showroom

TLV Report of Steam Trap Steam Loss Testing

1.Specifications of Test Device and Operating Conditions

Type of device	SS1NH-10
Size (mm)	15
Manufacturer's name	TLV
Material	ASTMA351 Gr.CF8
Maximum Operating Pressure (psiG)	150
Serial Number	WJ19405

Time in Service (years)	0
Operating Condensate Load (lb/h)	–
Operating Pressure (psiG)	–
Unit Cost of Steam ($/ton)	10
Rate of Operation (h/day)	24
Application	–
Remarks	–

*Functional Steam Loss

2.Set up Condition

Operating Pressure (psiG)	145.0
Condensate Load (lb/h)	11.0
Number of Tests	3
Water Droplets	NO

*Saturated steam

3.Test Result

Steam Loss (lb/h)	0.04
Test Pressure (psiG)	143.7
Condensate Load (lb/h)	12.1
Test Time (sec)	1399.8
Monetary Loss ($/year)	1.5

4.Memo

Test Conducted by Mr. Y. Nishikawa

Witness by Mr. KOB1270057 Lloyd's Register Group Limited Lloyd's Register Energy Japan
H. Tomiyama
Surveyor to Lloyd's Register Group Limited

The test was conducted using the equipment which had been satisfactorily examined by the surveyor to Lloyd's Register against ISO 7841 and ASME PTC 39 STEAM LOSS TESTS
LR Certificate No. KOB 0870075/1 refers

TLV CO., LTD.
KAKOGAWA FACTORY
881, Nagasuna, Noguchi-cho Kakogawa-shi 675

– Test No. 1507091000 – Test Date: 2015/07/09 17:27:12
Location : TLV Showroom

TLV Report of Steam Trap Steam Loss Testing

1.Specifications of Test Device and Operating Conditions

Type of device	SS1NL-10
Size (mm)	15
Manufacturer's name	TLV
Material	CF8
Maximum Operating Pressure (psiG)	145.0
Serial Number	ZD72395

Time in Service (years)	
Operating Condensate Load (lb/h)	
Operating Pressure (psiG)	
Unit Cost of Steam ($/ton)	
Rate of Operation (h/day)	
Application	
Remarks	

*Functional Steam Loss

2.Set up Condition

Operating Pressure (psiG)	145.0
Condensate Load (lb/h)	0.0
Number of Tests	3
Water Droplets	NO

*Saturated steam

3.Test Result

Steam Loss (lb/h)	0.07
Test Pressure (psiG)	144.8
Condensate Load (lb/h)	1.0
Test Time (sec)	1800.0
Monetary Loss ($/year)	—

4.Memo

Test Conducted by Mr. K. Nakanishi

Witness by Mr. HSB Global Standards
Name: Masayoshi Kobatake Review ☐
Signature: Accept ☐
Date: 7/9/15 Witness ☑
(12880)

The test was conducted using the equipment which had been satisfactorily examined by the surveyor to Lloyd's Register against ISO 7841 STEAM LOSS TESTS
LR Certificate No. KOB 0870075/1 refers

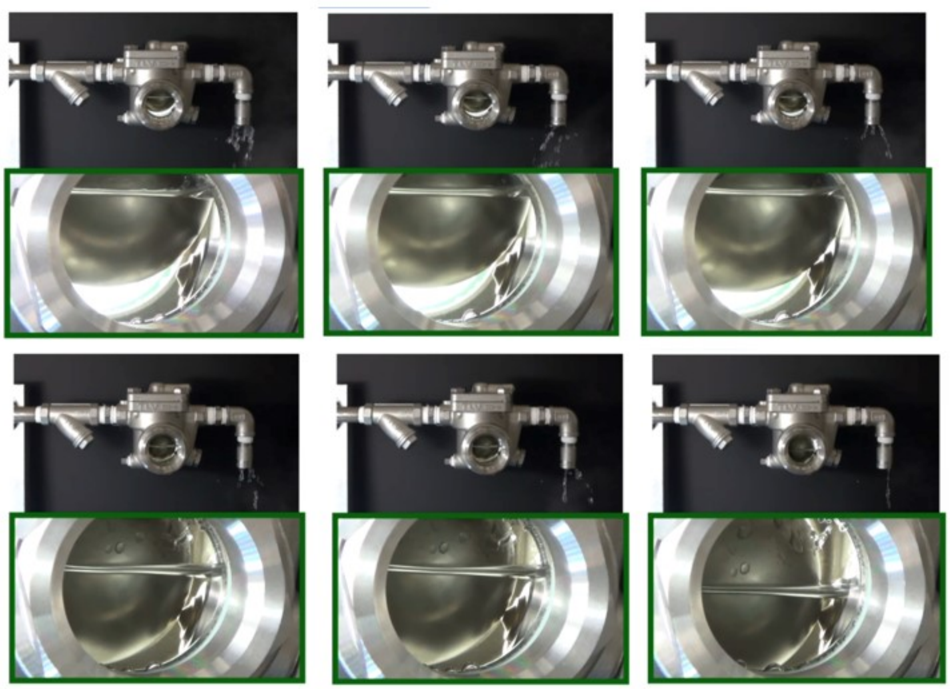
TLV CO., LTD.
KAKOGAWA FACTORY

▲**Fig. 9.** The test on left had condensate load set to 11.0#/h, whereas he test on right had condensate load set to 0.0#/h. "No-load" conditions are considered by some to be highly challenging on steam traps.

sunny to rainy conditions. Cold weather, wind, rain, or snow can greatly impact condensate load, ***"especially when these weather conditions contact uninsulated sections of pipe, valves, flanges or other fittings."*** [8] The condensate load on an outdoor condensate drainage point may be more than double on a rainy day compared to a sunny day condition.

Due to some applications' need for an ability to adjust to load changes, various manufacturers or providers of steam traps may provide images of their products as cutaways or in operation at condensate loads that are a percentage of their full rated capacity. A purpose could be to demonstrate the ability of the products offered to operate over a wide range of flow conditions without experiencing condensate back-up, or significant steam loss.

For consideration, images of **a specific Free Float® steam trap model J3S with 1.4 mm orifice** – outfitted with an inspection window – follow. These photos show operation under condensate loading of 100% of full rated capacity, then 80%, 50%, and 10% respectively at steam pressure of 14.5 psig. The steam pressure is low to enable safe operation with the glass aperture (Fig. 10).[9,10]



▲Fig. 10. A water seal is maintained as the orifice opening varies from modulation. Steam remains in the body keeping the trap hot, which can be useful for process, mains, and tracers.

There are several important items in the photos to consider.

The first is that for each percentage of load shown – from 100% to 10% – the Free Float® steam trap orifice is covered by a liquid condensate seal that can mitigate against steam loss over a wide condensate load range.

The second is that the trap body has steam above the condensate level in each photo. This enables both a high internal trap body temperature – to help mitigate against freeze-ups, and also provides drainage capability without back-up. Such characteristics can be useful in many steam trap applications.

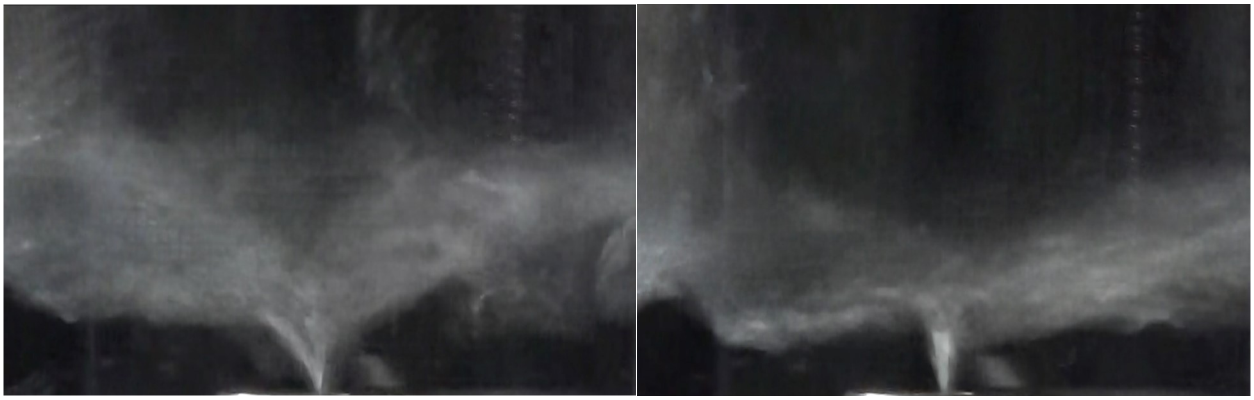
One possibility of steam loss through an orifice under a load condition less than 100% of the rated condensate load is shown in the single test case photos of one specific half Venturi product with a 1.5 mm orifice diameter under testing. These two photos do not purport to represent every half Venturi orifice – nor every test condition, but only to show the test of one specific product at one specific condensate load. The actual half Venturi fitting tested is cropped out in the photos, **but the steam loss can be seen by the off-white, vertical funnel as steam makes its way through the orifice even though there is a condensate level above the orifice** (Fig. 11).

To check potential for steam blow-through or steam loss for half Venturi fitting or steam trap products under consideration – end users may want to install their own visual measurement apparatus, or request steam loss reports conducted in strict accordance with either of the ASME or ISO standards referenced above, and witnessed by appropriate 3rd party validation entities.

Some of the main uses for steam traps include draining condensate from steam tracer lines (tracer traps), steam mains (drip traps), or steam process equipment (process traps). It may be useful to consider potential load and pressure changes in those applications.

Steam Tracers

Tracers represent a high percentage of steam trapping



▲**Fig. 11.** The vertical funnels show condensate surges and steam leakage through condensate and the half Venturi fitting.

applications in many industrial plants. **Table 1** shows possible estimations of tracer condensate loads, ranging from 5#/h to 25#/h. The load variance in the table ranges by 500%. It can lead to several items to consider relative to the selected trapping products; 1. Capacity, 2. Orifice diameter, 3. Ability to adjust over full load range.

If the needed capacity is only 5#/h, then even when applying a **sizing factor** (referred to by some as a "safety factor"), a trapping product for a load requirement of only 8#/h or 10#/h may be needed. **If a half Venturi product is selected, what is its; 1. Capacity, 2. Orifice diameter, 3. Rangeability? If a Free Float® steam trap is provided, the same questions can be asked – and it may be useful to compare those steam trap specifications to the half Venturi in a side-by-side table.**

Estimated Tracer Condensate Loads					
	Distance to Trap (ft)	Pipe Size (in)	Steam Pressure (psig)	Ambient Temperature (ºF)	Condensate Load (#/hr)
Tracers	**75**	**3/8"**	**75**	60	5
	75	3/8"	**150**	60	11
	75	**1/2"**	**75**	60	15
	75	1/2"	**150**	60	25
	Condensate Load Variance (%)				500%

▲**Table 1.** Typical tracer loads are small but can have wide variance.

Steam Mains

Draining steam mains from dangerous condensate is a key requirement to optimize system reliability and safety. There are multiple examples of severe header damage from water hammer events, and a common cause of hammer can be when traps become blocked or "**cold**" (**Fig. 12**).[11,12,13] Also, excess condensate in the steam supply can severely damage equipment.[14] Cold traps can occur when the internal orifice is blocked, sometimes from debris or precipitate deposits. One of the considerations for a site user may be to decide potential importance of the orifice diameter of the product selected. **For example, does the user feel that a large or smaller orifice may be more resistant against blockage, and what is the priority of the orifice diameter in the selection process?**

Another consideration may be the ability to handle the variations and fluctuations of condensate loads from **superheated** to highly "**wet**" mains. How different can condensate loads be relative to wetness, insulation efficiency, or just simply distance? **Table 2** provides an estimation of condensate loads for 2" through 12" steam headers with 150 psig steam pressure, subject to changes in outdoor temperature from 10 ° F to 90 ° F.

The table presents condensate loads for both "**Start-up**" and "**Running**" conditions, and the drainage needs (without sizing factor) vary from a low of 4#/h to a high of 205#/h.[15,16] **It is notable**

▲**Fig. 12.** Significant blow-out of a steam pipe due to a water hammer event (BP Grangemouth, 2000).

that the load on the 12” line varies almost 19x from low to high, and even the 2” line load varies >5x.

Applying even just a 1.5x sizing factor requires the minimum trap drainage capability as 6#/h and 308#/h respectively. If the sizing factor is 2x, then the selected trap capability needs to be a minimum of 8#/h and 410#/h respectively, which is used in the example below.

Minimizing storeroom item numbers for steam traps can be important for site users, and it can be useful to consider that **a single SS1NH-10 Free Float® steam trap model with a 1.8 mm orifice diameter has a published capacity of 385#/h for a 150-psi differential pressure.**[17] As a result, the TLV SS1NH-10 steam trap can handle all of the Table 2 loads with a 1.5x sizing factor, and all loads except the 200’ run on a 12” header when a 2x sizing factor load of 410#/h is required. Using a single product for both 150 psig steam main and tracer applications can help mitigate against improper selection of products in some installations. Furthermore, capacities should be rated according to global standards such as **ASME PTC39-2005 or ISO 7842.** [5,18]

But what if a half Venturi product is chosen for the 12” line’s 410#/h load, but no model has exact capacity? In such an instance, what if the next model in the orifice provider’s range – perhaps having a 467#/h capacity – is selected?

Then, that Venturi product could be >42x oversized for the estimated 11#/h running load.

Environmental Influences

By comparison to some variable orifice models, some half Venturi (or even other steam trap) products may not be able to adjust for a wide range of condensate loads, and they may not be recommended for use when the low load falls below a certain percentage of the product’s published full capacity. How many different half Venturi products are needed for the same load variations, and what are the diameters and rangeability of those models? It might be useful to ask any half Venturi provider under consideration to provide specific model selections, capacity chart data, rangeability, and specific orifice diameter specifications of the selected products for the same steam main conditions, – and to compare those specifications to the SS1NH-10 model or other steam traps in a side-by-side table.

Perhaps enough consideration is not always given to other environmental effects such as heavy rain. Whenever wide load fluctuations occur from changes in the environment (or for other reasons), it is important that a

Estimated Actual Condensate Loads

	Distance Between Drip Traps (ft)	Steam Pressure (psig)	Ambient Temperature (°F)	Insulation Thickness (in)	3 Hr. Start-up Load (#/h)	Running Load (#/hr)
Drip on 2" Line	75	150	10	2	8	5
	75	150	90	2	6	4
	100	150	10	2	11	7
	100	150	90	2	9	6
	200	150	10	2	22	14
	200	150	90	2	17	11
	Condensate Load Variance (%)					521%
Drip on 3" Line	75	150	10	2	14	7
	75	150	90	2	11	6
	100	150	10	2	19	9
	100	150	90	2	15	7
	200	150	10	2	39	18
	200	150	90	2	30	15
	Condensate Load Variance (%)					700%
Drip on 4" Line	75	150	10	3	18	6
	75	150	90	3	14	5
	100	150	10	3	24	8
	100	150	90	3	19	7
	200	150	10	3	48	16
	200	150	90	3	37	13
	Condensate Load Variance (%)					963%
Drip on 6" Line	75	150	10	3	30	8
	75	150	90	3	23	7
	100	150	10	3	40	11
	100	150	90	3	31	9
	200	150	10	3	79	21
	200	150	90	3	61	18
	Condensate Load Variance (%)					1201%
Drip on 8" Line	75	150	10	3	43	10
	75	150	90	3	33	8
	100	150	10	3	57	13
	100	150	90	3	44	11
	200	150	10	3	115	26
	200	150	90	3	89	22
	Condensate Load Variance (%)					1435%
Drip on 10" Line	75	150	10	3	59	12
	75	150	90	3	46	10
	100	150	10	3	79	15
	100	150	90	3	61	13
	200	150	10	3	158	31
	200	150	90	3	122	26
	Condensate Load Variance (%)					1649%
Drip on 12" Line	75	150	10	3	77	13
	75	150	90	3	60	11
	100	150	10	3	103	18
	100	150	90	3	79	15
	200	150	10	3	205	35
	200	150	90	3	159	29
	Condensate Load Variance (%)					1867%

▲**Table 2.** Condensate loads on steam mains can vary widely from temperature or other environmental changes, insulation efficiency, and length between traps.

drainage product, steam trap or half Venturi product, have the capability to adapt automatically.

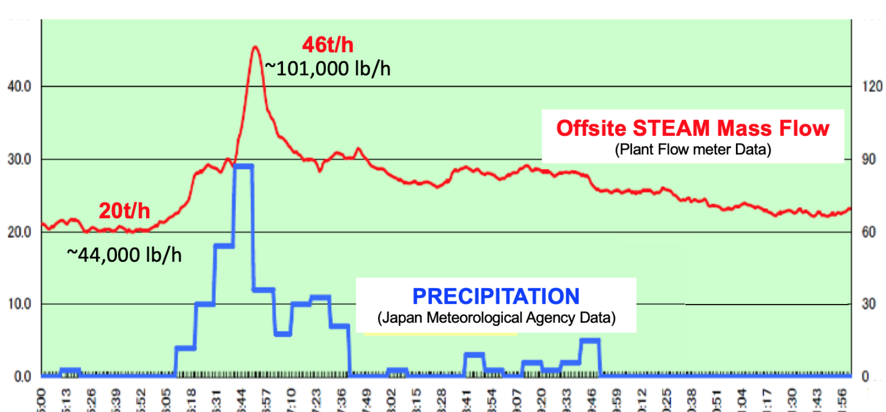
Consider the correlation of rain to a singular site's steam use data in an offsites area with more than 3,000 steam traps. Chart 1 shows the overlay of precipitation data onto the steam use chart for a given time period – to determine if there was the possibility of any correlation, steam load to precipitation. **The peak steam load rose to a high of 46t/h – a 2.3x increase – in a similar time period as the increase in rain.**

Dirt and Debris

In steam systems, debris and precipitate may cause blockage in tiny holes, even when strainers with fine mesh screens are provided (Fig. 13). Debris may be the result of heavy corrosion, and precipitate can occur from fine particles in solution falling out when condensate flashes, depositing on downstream surfaces until blockage occurs. Because of such deposits in steam systems, one of the topics reviewed is relative size of orifice diameters for selected models from different product suppliers – so that users can decide which may be better to resist against blockage.

Consider that on a light load application, a vendor-recommended half Venturi product may have a small 0.7 mm orifice diameter. **Evaluating a 0.7 mm half Venturi orifice diameter to an SS1NH-10 Free Float® steam trap with a 1.8 mm orifice can provide an interesting comparison.**

The area of a 0.7 mm diameter hole represents only 15% of the area of a 1.8 mm hole.



▲**Chart 1.** Overlaying precipitation onto a steam chart shows potential correlation of a rise in precipitation to a 230% increase in steam use for a >3000 trap area.

▲**Fig. 13.** A steam trap may experience a lot of debris.

A relative difference between 15% to 100% area is shown in the enlarged graphic (Fig. 14).

One possible consideration of which product to use as a reliable steam trap may be directly related to which orifice does the user feel may plug sooner – or resist plugging longer?

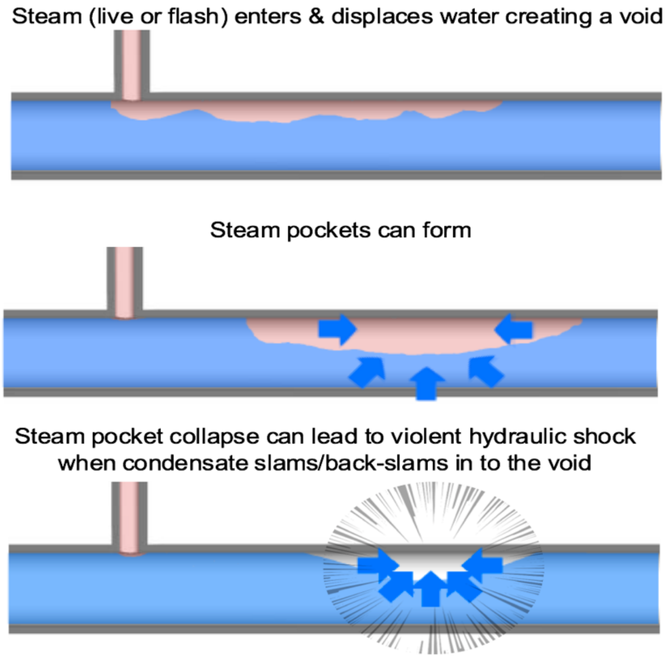
Concern for possible plugging may be the reason that at least one provider of a half Venturi fitting offers a ***"servicing tool designed to efficiently remove any possible build-up of debris at the orifice."*** [19], and also states, ***"Each servicing tool component can be replaced where necessary, and additional sizes of cleaning rods are available upon request."*** [Ibid.]

One alternative to small holes in some half Venturi products is to select models with larger diameters. But, if employing a "large orifice" opening strategy, it may be important to research the product's rangeability without significant steam loss. This is because reducing or eliminating steam blow-through can be crucial to mitigate water hammer in condensate return lines. **When excessive steam is discharged into condensate headers, vapor pockets can form and ultimately collapse with violent shock (Fig. 15).** [20,21]

In contrast, Free Float® steam traps can have larger openings and they can shut off in the presence of live steam – yet open to drain condensate quickly. Although these steam traps can also block, such issues may be reduced significantly due to the discharge port's relatively large diameter orifice.

Steam Process

One of the possible concerns regarding use of half Venturi products on process applications may be if the prod-



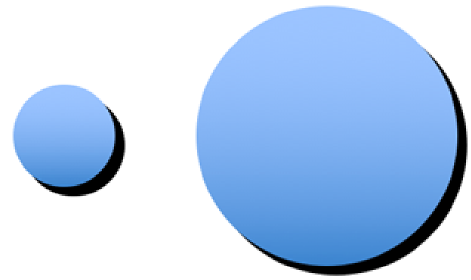
▲**Fig. 15.** Steam in the condensate return can collect in a pocket. Cooler condensate can collapse the pocket, creating violent shock waves directed to a pipe wall and water hammer as a result.

ucts can adjust to load or pressure changes without condensate back-up or large steam loss. It can be useful to approximate the potential changes to inlet steam pressure, "**P3**," at the Free Float® steam trap or half Venturi product – by studying the steam pressure profile in the **Extended Stall Chart.**

Chart 2 shows 55% heat exchanger over-surfacing, loads of 100% and 70% respectively, and considers the effect of fouling on exchanger steam pressure.[22]

The heat demand of a process can be calculated by the formula, $Q_d = M * C_p * \Delta T$. The heat supply of the exchanger can be estimated by the formula, $Q_s = U * A * LMTD$.

When the exchanger tube bundle is clean, the large surface area results in the steam pressure adjusting down to achieve supply side equilibrium with the demand for heat ($U * A * LMTD = {}_sQ_d = M * C_p * \Delta T$). As the bundle becomes fouled, the steam pressure is increased to deliver higher temperature to the process to balance heat sup-



▲**Fig. 14.** A large orifice may be more resistant to plugging that one of 15% area.

ply to heat demand. Accordingly, the pressures estimated for loads of 100% and 70% are shown in Chart 2 at points "c" and "d" for a clean tube set, and points "e" and "f" for a heavily fouled bundle. Table 3 **shows those pressures to be 19 psig, -1 psig, 108 psig, and 28 psig respectively.**

The estimated pressure variance from 70% load in a clean exchanger, and 100% load in a fouled exchanger represents a possible 109 psi P3 steam pressure difference. This leads to the question, ***"Which of these four inlet-to-trap steam pressures should be used to size a half Venturi product for the exchanger?"***

Consider the possible effects if the half Venturi product is sized for full load capacity at very low differential from hydraulic head (to overcome a "-1 psig" pressure). For a small driving pressure through the orifice, the half Venturi's hole diameter could be considerably large. Additionally, this negative to low pressure could actually cause a "Stall" condition if there is not sufficient height / hydraulic head to create necessary positive pressure differential to discharge the condensate. [Ibid.,23]

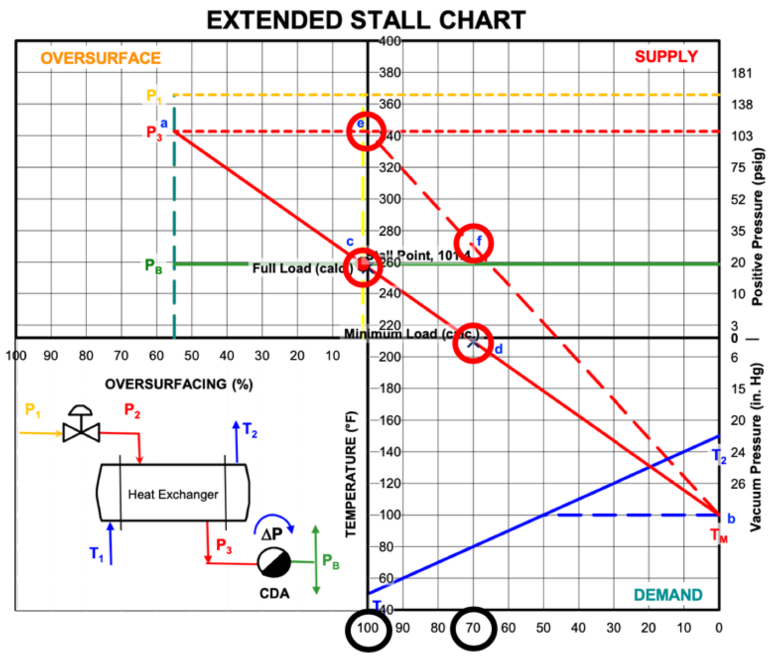
The result could be that condensate backs up into the exchanger, potentially causing corrosion, thermal stress, hydraulic shock, and control swings. Also, condensate back-up could cause premature channel head gasket failure in horizontal exchangers.

What happens when the exchanger's tube bundle becomes heavily fouled and the P3 steam pressure rises to 108 psig to provide the necessary heat transfer? **Does the half Venturi product with a large hole adjust for no steam loss at such a high-pressure differential, or does it bleed some or a lot of steam into the condensate return line?** It can be an important consideration because excess steam in the return header could cause severe water hammer.

Alternatively, if the half Venturi product is originally chosen for the high P3 pressure of 108 psig, or even the lower P3 pressure of 28 psig – what happens when the exchanger is cleaned and the pressure drops to 19 psig, or even lower to -1 psig?

A Free Float® steam trap for the same application can adjust throughout the pressure range and discharge condensate without significant steam loss provided that sufficient positive differential pressure from hydraulic head exists.

An exception for both variable orifice steam traps or half Venturi products is that if the -1 psig pressure condition cannot be overcome by hydraulic head, then a combination pump/trap product, such as a **TLV PowerTrap®** condensate recovery pump with integral trap, may need to be employed.[24]



Δ Chart 2. P3 steam pressures are estimated for the 100% and 70% process loads when effective exchanger surface area is either 155% or 100%.

Capacity Data

Another consideration for engineers is the ability to cross check vendor recommendations with site engineering practices. **Steam trap manufacturers commonly publish capacities to globally recognized ASME PTC 39-2005 or ISO 7842 rating standards.**[5,18]

However, published capacity data for half Venturi fittings may be more limited, with some half Venturi fitting manufacturers providing no such capacity data on easily access forums such as the world-wide-web.

If no capacity data is readily available, end users may not be able to confirm or justify the selection of half Venturi fitting products as meeting the system requirements – which could incur potential safety ramifications.

Estimated Process Condensate Loads

	Process % of Full Load	Steam Pressure (psig)	% of Needed Surface Area	Condensate Load (#/hr)
Process	100% **(c)**	19	155	5,000
	70% (d)	**-1**	**155**	**3,500**
	100% (e)	**108**	**100**	**5,000**
	70% **(f)**	28	100	3,500
	High - Low Pressure Range Variance (psi)			**109**

▲Table 3. Estimated P3 steam pressures from Chart 1 show significant pressure variance (assumes no pressure drop in heat exchanger).

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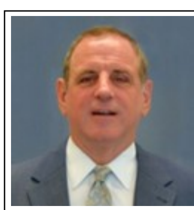

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