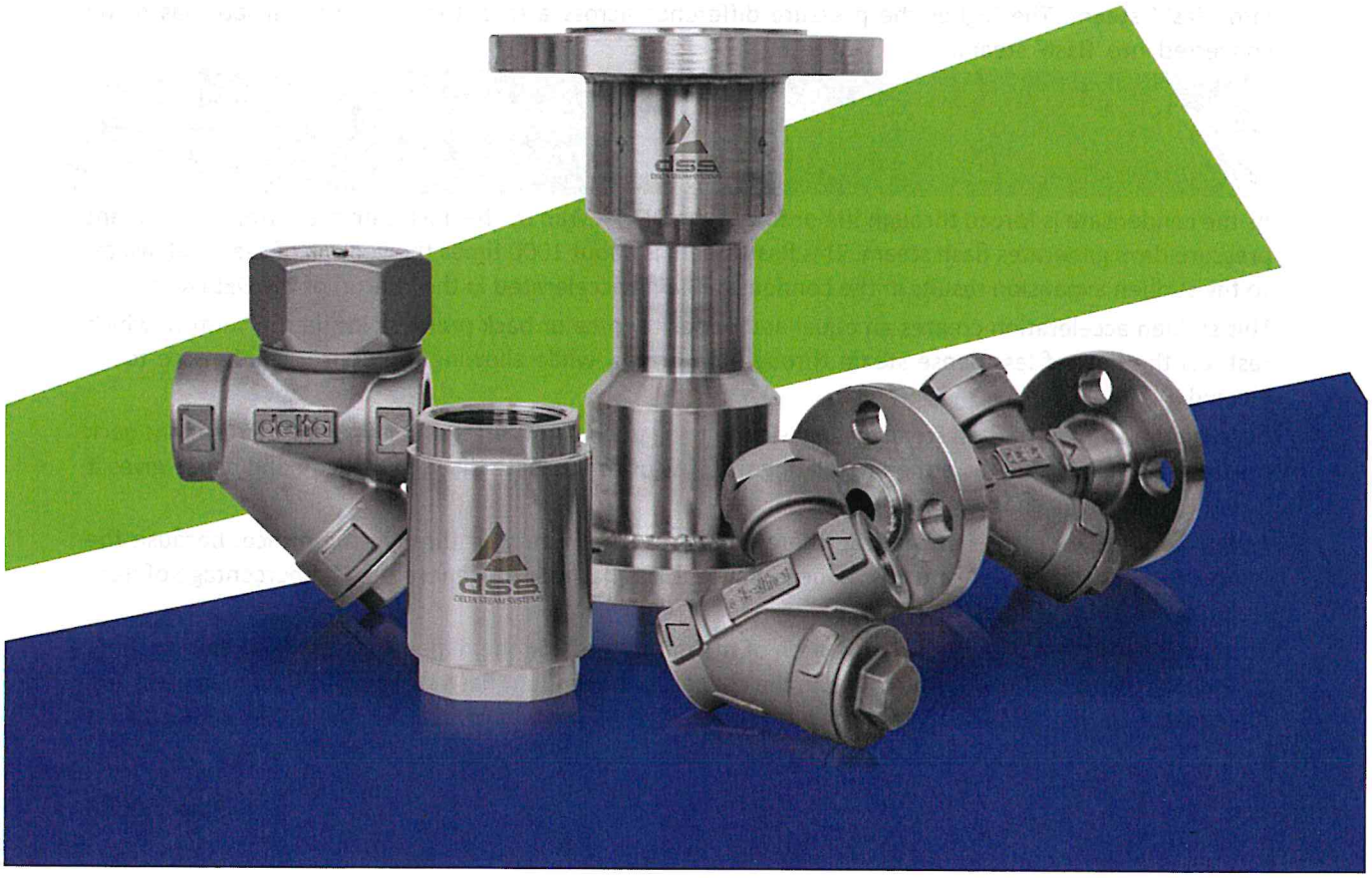
DELTA STEAM SYSTEMS

SECTION I

TECHNICAL MANUAL



SECTION I - TECHNICAL MANUAL

Introduction

The purpose of this manual is to provide guidance and instruction on how to appropriately, efficiently and correctly utilize the DELTA Trap.

In order to do this there is a certain understanding of thermodynamics, steam systems, and various aspects of utility piping and construction required.

This handbook attempts to provide a guide to entry level as well as experienced users on the aspects pertaining to a steam trap. It is by no means an exhaustive source of information and does not eliminate the responsibility of the user of the product to take full responsibility for the safe installation, maintenance and life cycle of the DELTA Trap.

How our product works

The DELTA Trap works by combining venturi technology with the orifice:

- part of the capacity of the DELTA Trap is related to the size of the orifice
- part is also related to the back pressure that is generated inside the venturi

It is a combination of the pressure drop across the orifice and the back pressure generated in the venturi that gives the DELTA Trap its overall capacity.

As the condensate passes through the tunnel orifice of the DELTA Trap there is a pressure drop. On the upstream side of the orifice (the steam line or process side) the condensate is at the same pressure as the steam and it has a high-energy content. As the pressure drops across the orifice, the temperature and pressure of the condensate reduces, so it contains less energy.

However, energy cannot be created or destroyed, so the transfer of energy between the high pressure upstream side and the low pressure downstream side causes some of the condensate to be converted into 'flash' steam. The higher the pressure difference across a trap, the more condensate has to be converted into 'flash' steam.

The DELTA Trap uses the flash steam to create a back pressure inside the venturi!

As the condensate is forced through the orifice of the DELTA Trap by the upstream pressure, the resultant pressure drop generates flash steam. This flash steam is about 1000 times the volume of the condensate, so the sudden expansion results in the condensate being accelerated in the venturi of the DELTA Trap.

This sudden acceleration creates an equal and opposite force or back pressure inside the venturi, which restricts the flow of less dense steam through the orifice, while allowing the denser condensate to be ejected.

Because the amount of flash steam changes depending upon the operating conditions, the resultant back pressure also changes. This is then regulating the flow of condensate through the trap and hence gives it its variable capacity characteristics.

As less condensate arrives at the trap there is less pressure forcing it through the orifice, because the temperature of the condensate has reduced, there is less flash steam generated. The percentage of flash steam drops and the mass flow reduces.

The capacity of the DELTA Trap is a function of the orifice size and the dimensions of the venturi section. By utilising the natural laws of physics, i.e. the change in the amount flash steam with change in pressure, the capacity of the DELTA Trap can vary with the changes in process conditions. The internal dimensions

of the DELTA Trap are designed in such a way that the capacity of the DELTA Trap changes with the changing capacity of the application.

DELTA traps and varying loads

A question often asked when considering use of the DELTA Trap is:

> ***'how can a trap that has a fixed diameter tunnel orifice with no moving parts, operate on applications with a variable load?'***

This paper attempts to explain the function of the DELTA Trap and in-particular how the use of the flash steam in the venturi section of the DELTA Trap provides the DELTA Trap with a varying capacity.

As previously stated the DELTA Trap works by combining venturi technology with the tunnel orifice, relating the capacity of the trap to the size and length of the orifice as well relating it to the back pressure generated within the venturi.

It is a combination of the pressure drop across the tunnel orifice and the back pressure generated in the venturi that gives the DELTA Trap its overall capacity.

The DELTA Trap works in varying load conditions from the minimum to the maximum capacity!

Why use venturi technology and not a simple orifice plate?

A simple orifice plate type steam trap has been tried on numerous occasions by companies worldwide and has always failed when tested for steam trapping applications.

A simple orifice plate type steam trap has a limited operating range on varying loads. These traps are not able to manage varying loads and therefore the DELTA Trap technology was developed.

Cold start-up

This will be a situation when the plant has been down for some time. In this case, all the pipework is cold including the steam lines, process plant and heat exchangers. When the steam is first 'switched on' there is a massive rush which has to evacuate the air from the system. The cold air is denser than the steam so the lighter steam sits above the air and pushes it out through the trap.

Once the steam starts to come into contact with the cold walls of the steam lines or process surfaces it condenses. Because of the huge temperature difference between the steam and the surfaces, the condensing load can be 2 to 3 times the normal operating load. However, the condensate that forms is not at the saturation temperature of the steam. It is possible to run your hand through the condensate discharging from a trap at start up and it will be cool to the touch.

Because the temperature of the water is below the boiling point of water at atmospheric temperature (below 100˚C), there is no flash steam being generated inside the venturi of the traps. Since there is no flash steam being generated, there is no backpressure being generated either so the condensate can flow at a higher rate through the trap. The capacity of the DELTA Trap for cold start-ups is typically 2 to 3 times 'normal' running conditions. This means that there is no need to use bypass valves for cold start up for low load applications, drip legs and trace heating or for larger process loads.

Condensate will jet out of the Delta Trap and once the trap has ejected the 'cold' condensate and the hotter saturated condensate arrives at the trap, the flash steam then throttles back the flow and starts to regulate the flow.

Batch process with on/off actuated valve

This condition would be a normal ON/OFF start-up such as a batch process. There will always be a small amount of preheating to get all the system back to temperature, but if the batch processes are frequent then the warm up is minimal. Also, there is usually an ON/OFF valve rather than a modulating valve which will open 100% at the start of the batch. In this situation, there is an initial high load as the product heats up and then it will stay at maximum capacity until the end of the batch.

During the heat-up phase the condensate rate is higher due to the higher temperature difference between the steam and the product. This condensate that is formed is sub-cooled and so less flash is generated in the venturi.

Once the product reaches set temperature then the condensate arriving at the trap will be at the saturation temperature. There will be less condensate but it will be at saturation temperature. This will result in an increase in flash steam, and will create an increased back pressure that will restrict the flow of less dense steam through the tunnel orifice, while allowing the denser condensate to be ejected. This will be the design condition that the trap will be specified for.

Control valve with varying load

The final condition is if an application has a control valve, that is regulating the flow of steam to a unit. Below is a model of the function of a DELTA Trap operating on a heat exchanger. The model simulates a heat exchanger (with a $10m^2$ surface area heating water from 20°C to 80°C).

Table 1.1 Function of DELTA Trap operating on a heat exchanger

	FULL LOAD	PART LOAD	LOW LOAD
Water Flow Rate	37 700 kg/hr	30 371 kg/hr	18 900 kg/hr
Energy Required	2 639 kW	2 126 kW	1 323 kW
Steam Flow Rate	4 750 kg/hr @ 10 bar	3 675 kg/hr @ 5 bar	2 165 kg/hr @ 1 bar
Flash Steam Generated	16%	11%	4%
Flash Steam Flow	760 kg/hr	408 kg/hr	83 kg/hr

As less condensate arrives at the trap there is less pressure forcing it through the orifice, but because the temperature of the condensate has reduced, there is less flash steam generated. The percentage of flash steam drops and the mass flow reduces.

The reduction in the flash steam being generated means that there is less back pressure generated so even though there is less pressure forcing the condensate through the orifice of the trap, there is less back pressure holding it back.

The nett result of all this is that as the process conditions change the capacity of the DELTA Trap changes accordingly.

The output characteristic curve of a heat exchanger is not linear, but a curve which starts at the maximum condition (maximum flow and maximum pressure) and regulates down to zero as the control valve closes completely.

The capacity of the DELTA Trap is a function of the orifice size and the dimensions of the venturi section. By utilising the natural laws of physics, i.e. the change in the amount flash steam with change in pressure, the capacity of the DELTA Trap can vary with the changes in process conditions. The internal dimensions

of the DELTA Trap are designed in such a way that the capacity of the DELTA Trap changes with the changing capacity of the application.

Hence the DELTA Trap works on varying loads from minimum through to maximum capacity.

For a visual animation on how the DELTA Trap works, follow this link: CLICK TO VIEW ANIMATION (https://www.youtube.com/watch?v=KUQLQaFBmAA&feature=youtu.be)

Conventional steam traps vs. DELTA Traps

The DELTA Trap varies significantly from the standard traps available, as shown in

Table 1.2 below. These differences, as well as the testing processes the traps underwent, will be elaborated on in this section.

Table 1.2: Conventional steam traps vs DELTA Traps

Conventional Steam Traps	**Delta Venturi Trap**
Commonly of carbon steel construction	Made completely from Grade stainless steel
Have moving parts that wear out	Have NO moving parts to wear out
Needs spare parts on a regular basis	Never requires spare parts
Specialist testing required on regular and ongoing basis	No complicated testing required
Requires ongoing maintenance	Maintenance free
Affected by thermal shock or water hammer	Unaffected by thermal shock or water hammer
Single internal strainers	Dual internal strainers
Specific mounting positions	Can be mounted in any position
Cost over lifespan is 5 times more than DELTA Traps	Cost over lifespan is less than 20% of the cost of conventional steam traps
Average lifespan of 1 - 5 years	Average lifespan of 20 - 30 years
1-year guarantee	10-year guarantee

Energy savings with DELTA Trap

When compared to a conventional steam trap that has internal moving parts, the DELTA Trap can save your customer anywhere between **€250 and €3,500 per trap annually**. DELTA Traps have a life expectancy that is **10 – 20 times that of a conventional steam trap** due to its unique venturi design that has no moving parts.

Delta's extensive experience performing plant retrofits has produced decreases in steam consumption plant wide averaging over **60,000 kg of steam per trap annually**.

Cost savings with DELTA Trap

For a typical process plant with a population of 500 conventional steam traps, a total plant retrofit will save an average of **29 million kilograms of steam per year**. At current energy costs, this is approximately **€450,000 per year of steam savings**.

Factoring in the energy savings and long life expectancy of the DELTA Trap, **the DELTA Trap has the lowest total life cycle cost** compared to any conventional steam trap on the market.

Average Service Life for Various Mechanical Steam Traps at 14 bar Steam Pressure

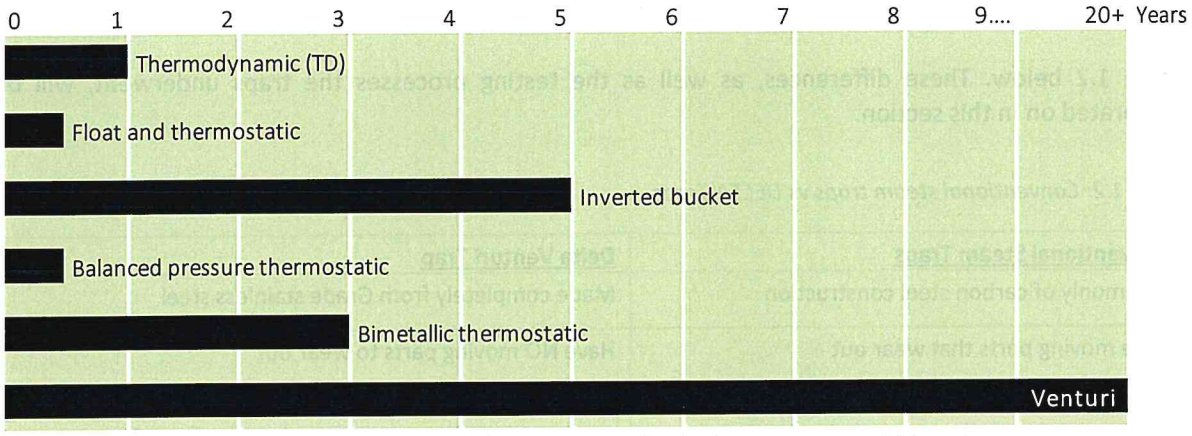


Figure 1: Diagram to show service life for various mechanical steam traps at 14 bar steam pressure

Conclusion

The DELTA Trap has proven itself to be highly efficient, long lasting, and a better choice for improving and maintaining plant efficiency.

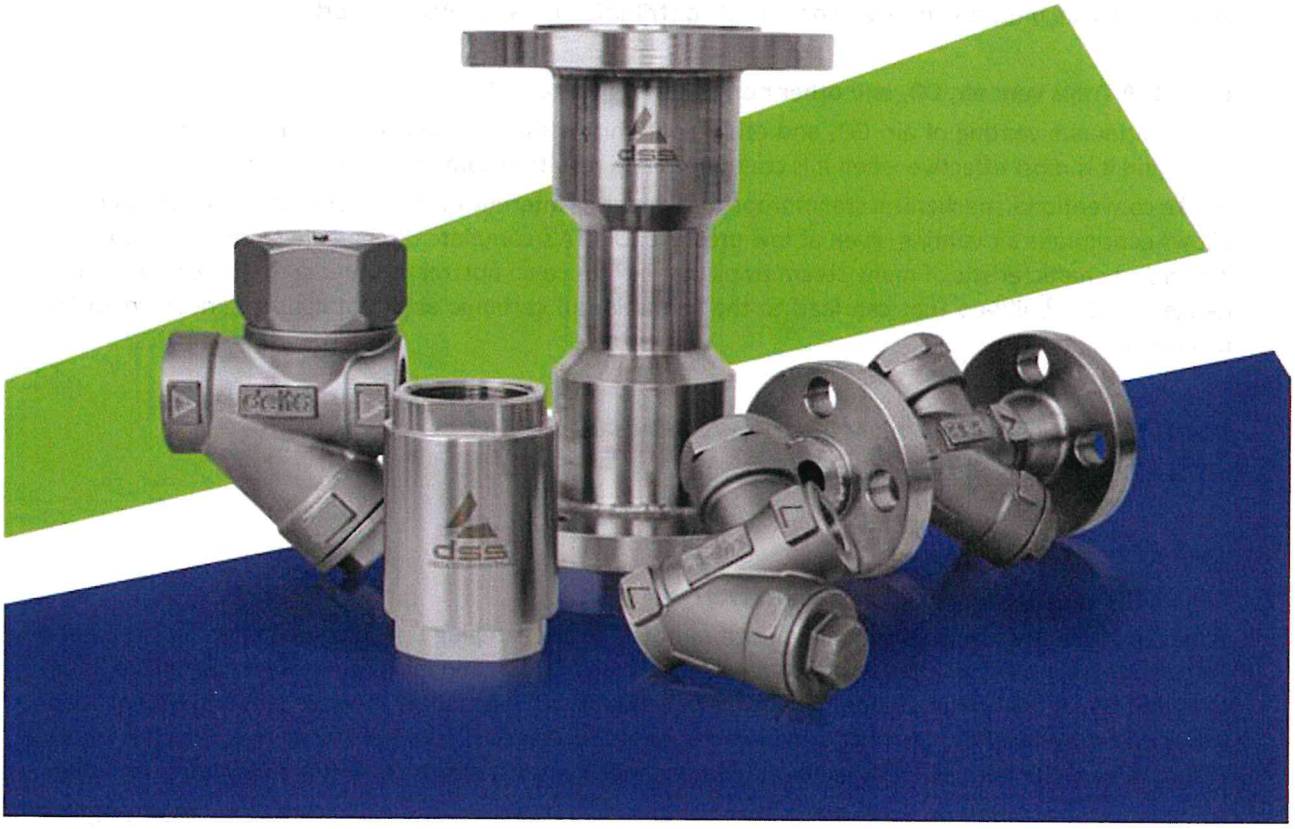
Moving away from the use of conventional steam traps such as inverted bucket, thermodynamic and thermostatic steam traps, and toward more efficient technologies such as the DELTA Trap will improve overall plant efficiency and substantially lower maintenance costs.

When considering the normal operating costs associated with the use of conventional steam traps, converting your facility to the DELTA Trap will typically be cost justified within a period of one year.

DELTA STEAM SYSTEMS

SECTION III

FREQUENTLY ASKED QUESTIONS



SECTION III – FREQUENTLY ASKED QUESTIONS

DELTA Traps in application

Where can DELTA Traps be used?

DELTA Traps can be used virtually anywhere steam is used. DELTA Traps can be used on a variety of applications in many different types of facilities, including saturated steam distribution lines; superheated steam distribution lines; steam tracing; tank heating; radiators/convectors; plating coils/degreasers/embossed coils; steam heated dry cans/cylinders; humidifiers; flash tanks; sterilization equipment; and cooking kettles.

DELTA Traps also can be used on applications that utilise a modulating control valve: Air handling coils; shell/tube heat exchangers; water heating tanks; instantaneous water heaters; batch process tanks; steam absorption chillers; and process heating equipment.

Delta Steam Systems supplies DELTA Traps to more than 22 countries worldwide for applications within refineries, chemical companies, pharmaceuticals, hospitals, hotels, colleges & universities, government facilities, and other manufacturing plants. Our customers continuously rely on the DELTA range of steam traps for significant steam system improvements and trouble free steam trapping.

Will a trap replacement program require a large number of different DELTA Trap models?

No. Even though DELTA Traps are engineered for each specific application, our application experience has proven that many large facilities require a surprisingly limited number of DELTA models. A major local oil refinery standardised on only two different DELTA models to complete a 680 trap conversion of its existing steam traps.

Can DELTA Traps be used on a distribution line when ambient conditions change?

Yes. DELTA Trap units are in service on outside distribution lines all over the world.

Do DELTA Traps vent air, CO_2 and other non-condensable gases?

Yes. Continuous venting of air, CO_2 and other contaminants is an important requirement of any steam trap - and it is most effective when it is continuous and results in complete condensate removal.

Unlike conventional mechanical steam traps that operate "intermittently", DELTA's continuous discharge allows continuous air venting, even at low pressure. DELTA's complete discharge also results in no "sub-cooling", a characteristic of many steam traps that introduce an upstream water seal. This can result in a dangerous CO_2 build-up that can lead to the formation of carbonic acid that causes serious corrosion problems.

Do DELTA Traps leak steam when there is no condensate present?

No. See DELTA Traps and varying load in section I.

Operation of the DELTA Trap

Will DELTA Traps plug up if my system is dirty?

While any type of steam trap or condensate removal device can plug up, "plug up" rates on the DELTA Traps are a fraction of similar rates with mechanical traps. DELTA minimises plugging through its unique, patented DSV model which comes standard with a primary and secondary 40 mesh strainer system. Also, the drain nozzle in all DELTA units is manufactured with a staged discharge. This design, which is totally different from the "simple" orifices found in many mechanical steam traps and orifice plates, facilitates

the continual discharge of contaminants usually found in condensate. This continual discharge allows CO_2, air and non-condensable gases to be passed continually, unlike "sub-cooling" or "intermittent discharging" traps.

What is the difference between an orifice steam trap and the DELTA Trap?

Orifice plate steam traps are subject to several limitations. Sharp edged orifices are subject to "wire draw effect", particularly at higher pressures; this causes the orifice to distort in the direction of flow and become larger. Orifice plate steam traps are subject to plugging due to eddy currents present on the backside of the orifice. The eddy currents allow contaminants in the steam to settle on the back of the orifice and eventually plug the flow. See figure 3.1.

The DELTA Trap uses two-phase flow technology enables the denser condensate to throttle the inlet to the tunnel orifice to keep steam from escaping. Condensate is being created continuously, so the DELTA Trap continuously chokes the nozzle to prevent steam loss while continuously removing condensate.

Because of its long tunnel orifice there is no chance of wire draw happening therefore eliminating the chance of steam leakage.

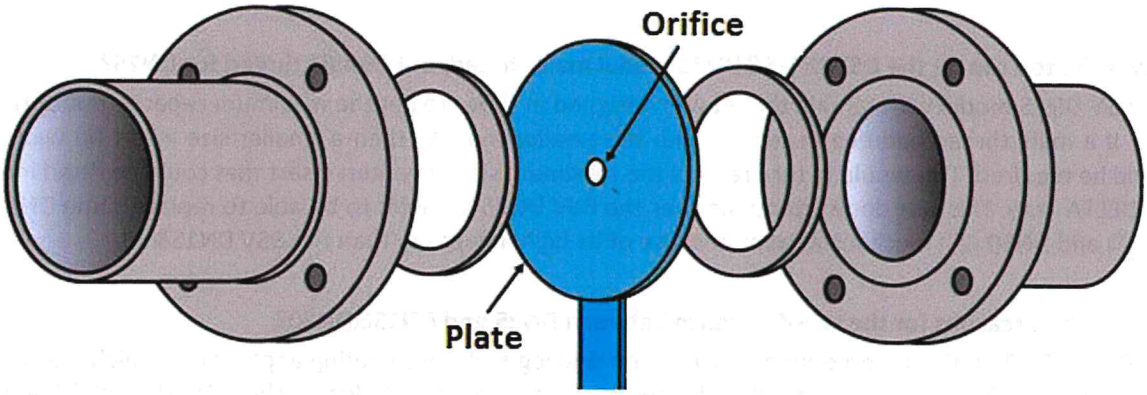


Figure 3.1: Conventional orifice trap

Why use venturi technology and not a simple orifice plate?

A simple orifice plate type steam trap has been tried on numerous occasions by companies worldwide and has always failed when tested for steam trapping applications.

As explained above, a simple orifice plate type steam trap has a limited operating range on varying loads. These traps are not able to manage varying loads and therefore the DELTA Trap technology was developed.

Can DELTA Traps be applied in a return system that is experiencing back pressure problems?

Yes, as long as any back pressure is made clear to Delta engineers prior to sizing

What is the maximum drain output (per/hour) for each orifice?

The maximum drain output is dependent on the pressure differential over trap. In other words, at 0.1 mPa it will be far lower than at 1 mPa. As the pressure changes so does the maximum output of the venturi. Also, this varies with the amount of water steam mixture there is upstream of the venturi.

Because the upstream side is two-phase flow (liquid and gas) which is changing as the loads for the plant change, the output of the venturi changes too. See model capacity ranges in Section IV for further information.

Will it be difficult to select the correct DELTA model sizes?

No. Selecting the appropriate DELTA models requires a basic knowledge of the lines and equipment to be trapped. Proper sizing is imperative and our field engineers gather appropriate sizing information for each application. See Section IV for product catalogues as well as Section V for sizing information.

Will DELTA Traps operate efficiently over varying loads?

Yes. DELTA Traps work on fluctuating as well as constant load applications. See Section I of the Technical Manual for DELTA Traps and various loads.

Can DELTA Traps replace ordinary steam traps?

Yes.

Why is the top cap on the DSV DN15&DN20 model male thread, but female thread for DN25?

The DSV DN25 model with female thread was designed in order to get the maximum capacity out of the trap. If a male thread had been used, as with the smaller models, then a smaller size insert (in width) would be required. This would in turn restrict the maximum size of venturi insert that could be fitted into the DELTA Trap. This was done intentionally as the DSV DN25 model is to be able to replace some DN40 ($1\ ^1/_2$") and DN50 (2") mechanical traps because of its higher capacity than the DSV DN15&20.

What are the reasons for the size difference between DN25 and DN15&DN20?

The DN15&DN20 units are predominantly used on drip leg and trace heating applications which are very low condensate loads, whereas the DN25 is used for higher condensate loads. These DN15 & DN20 units are designed to replace the most common steam trap used worldwide, the thermodynamic (TD) steam trap, and has virtually the same outer dimensions.

Does it make sense to make interchangeable venturi inserts for the larger traps like DN40 and above?

Yes, often it is even more difficult to get the sizing exact on the larger steam traps, and the insert may need to be changed. If these were not removable, the complete unit would need to be changed if over or undersized.

Manufacturing and Maintenance

What is the lead time for manufacturing for each DELTA Trap?

Lead time varies according to current production volumes. For threaded and socket weld DN15, DN20 and DN25 traps can generally be shipped within a few days, but for the other models it takes a bit longer. While there is a standard length shown on the flanged models catalogues, not many of these are kept in stock. This is due to the fact that these traps often need to be specially manufactured according to the customer's requirements. There are so many various lengths of flanged traps amongst the various manufacturers, which will require added lead time. Any variations made by the client may lead to added lead time, which should be confirmed with the manufacturer on order.

Why are DELTA Traps more efficient than conventional steam traps?

The DELTA Traps are more efficient than conventional steam traps due to the constant condensate removal over varying loads. This means that at no point will condensate be backing up in the line, nor would the pressure on the system drop every time the trap discharges as with the convention steam traps. See Section I of the Technical Manual for a full explanation.

Why are DELTA Traps more reliable than conventional steam traps?

The DELTA Traps have no moving parts, this means they cannot become locked in an open or closed position during use. This also means that they do not need to be replaced, and maintenance on the trap is extremely low. See Section I, table 1 for a detailed comparison.

What maintenance is needed for DELTA Traps?

The DELTA Traps do not require maintenance if the steam plant is operating efficiently. Please see Section II for an explanation of steam trap maintenance and what may cause blockages in the steam traps. If the trap does become blocked, see section VI for a detailed explanation of insert unblocking procedures.

Do DELTA Traps require spare parts?

No, DELTA Traps require no spare parts.

Do the DELTA Traps undergo any testing?

Yes, the DELTA Traps undergo pressure testing, and various non-destructive testing procedures. Any specific tests required by the client must be stipulated on order of the DELTA Trap.

Steam Trap Surveys

Why do we perform steam trap surveys?

Steam trap surveys are done to ensure the traps are not blocked or blowing steam. It is very important that surveys are done in order to protect the steam line from damage caused by condensate, as well as from a financial point of view. Loss of steam means loss of money.

What is required to do a steam trap survey?

An accurate ultrasonic tester such as Dr Trap is best to have during a survey, as well as a Flir thermal imaging camera. The understanding of plants is also important, along with knowledge of steam traps and general knowledge about thermodynamic principles.

It is very important to be equipped with the correct PPE to ensure ones' safety.

A clipboard with print outs for recording trap tag numbers, trap types, and readings from the ultrasonic tester and thermal imaging camera will be convenient for the surveyor.

Warranty

What is the replacement warranty of all delta traps?

The replacement warranty is valid for 10 years from the date of purchase on all the DELTA Trap models

Do Delta Steam Systems give out product warranty certificates?

Each trap has a unique serial number which is recorded when the trap is supplied. This enables Delta Steam Systems to keep track of the date supplied, customer and model. Because of this and the attached guarantee, there is no need to supply specific order guarantees as the traps supplied are recorded and covered.