ADCAMAT PUMP TRAPS
How to select and size

CONSIDERATIONS

When a steam control valve is throttling to meet a reduced heat load, the steam pressure falls inside the heat exchanger.

This steam pressure falling is sometimes considerable for several different reasons and the lack of differential pressure across the steam trap reduces it’s discharge capacity, causing accumulation of condensate inside the heat exchanger, resulting in a stall condition.

In presence of these considerations, it is recommended that before any steam trap selection and sizing for this kind of systems, to determine whether or not stall will occur. The non observance of this procedure may cause serious troubles on the systems, causing malfunction and equipment damage.

Typically most of heat exchangers are selected from a standard production range available and they are often oversized, in other words, after the calculation the designer select the available model which area covers the calculated area, which in addition to other safety factors normally considered during the system design and heat exchanger calculation, results on over sizing.

Over sizing heat exchangers increase the heat transfer capability above the required needs and for that reason the required steam pressure (and correspondent temperature) will be lower when compared with a correctly sized unit. They must be in consequence subject to a specific analysis.

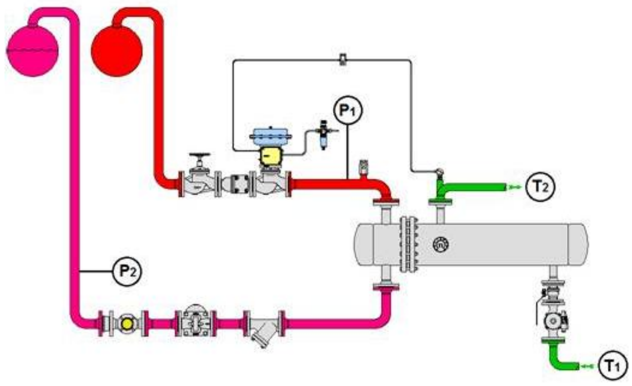


Fig.1

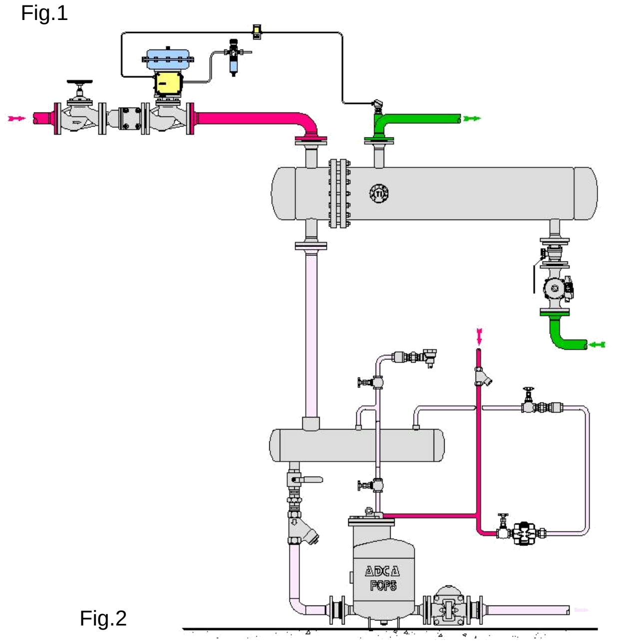


Fig.2

What is stall ?

In a modulating temperature control system as shown in fig.1, when the heat exchanger steam inlet pressure (P1) is equal or less than the back pressure (P2), it can no longer prevent condensate drainage because of insufficient differential pressure causing a stall condition.

The consequence of the stall condition, results, among others, in poor heat transfer (temperature fluctuation), water hammer, corrosion and noise.

The solution

An Adcamat pressure operated pump and steam trap or an automatic pump trap, installed in a closed loop system (fig.2).

Why a pump and steam trap (or a pump trap) ?

Because the system operates with a modulating steam control valve and the pressure may fluctuate, sometimes exceeding, sometimes falling below the system back pressure.

The pump is only required during stall loads and therefore a steam trap is still required to prevent steam from discharging into the return condensate line whenever the supply pressure exceeds the back pressure.

Obviously, if the back pressure always exceed the steam pressure, the steam trap is unnecessary.

A pressure operated pump and steam trap combination in a closed loop system operate in conjunction with each other, however, each component must be analyzed individually since there are specific considerations applied to these systems.

Pump sizing

In a typical closed loop heat transfer system (see fig.2) including a heat exchanger and modulating control valve, the pump need to be sized only for the stall load, which, as a rule, is substantially less than the maximum system load. A small pump can therefore be required.

The moment at which stall occurs can be calculated using the chart (fig.3) or mathematical formulas as mentioned ahead.

Steam trap sizing

On the other hand, the steam trap must be sized not only for the full nominal condensate flow, but also sized to accommodate the instantaneous flow rates when the pump discharges at stall condition.

It is recommended to use appropriate safety load factors when sizing the steam trap based on full load as well as sizing it based on instantaneous discharge at the stall condition load calculated, considering at this point a substantial lower differential pressure (the worst scenario should be than chosen).

How to predict stall ?

Using the chart (fig.3), we can determine the percentage of heat load at stall and with that, calculate the condensate load.

The next example is applied to a typical heat transfer system (fig.2) with the following parameters:

-Flow of fluid to be heated (secondary fluid) is constant

-Outlet secondary fluid temperature is constant

-Inlet secondary fluid temperature varying (rising)

-Steam heating fluid controlled by a modulating valve (therefore varying inlet pressure and temperature)

Important: The steam pressure decrease in a heat exchanger can occur as a result of different circumstances.

The example shown in this document covers one of them:

-Inlet secondary fluid temperature rising (less heat load necessary).

Systems with alternate parameters require a different approach and different equations for prediction of stall condition, namely:

-Outlet secondary fluid temperature falling (due to a lower set point)

-Secondary fluid flow rate falling (decrease of heat load needs)

For such applications please consult factory

Practical example

Considering a heat exchanger working with 6 barg steam, designed to heat a constant 15000 kgs/h flow of water from 20ºC to 80ºC.

Condensate lift of 10 meters into a return line at 0,5 barg pressure.

Preliminary calculations

Determine the saturated temperature of steam.

From the steam tables we can obtain 165 ºC at 6 barg

Determine the equivalent saturated temperature of the total back pressure.

The total back pressure is equal to the lift height equivalent pressure, plus the pressure existing in the return line.

(Pipe friction was ignored considering a short and properly sized downstream pipe work)

10 m x 0,0981bar/m + 0,5 bar = 1,481 or 1,5 bar approximately.

Therefore, the total back pressure is 1,5 barg and from the steam tables the correspondent saturated temperature is 127,6 ºC

PERCENTAGE OF HEAT LOAD AT STALL

Summarizing the previous calculations, we have now the following parameters:

-Inlet steam pressure at full load …………………….............6 barg

-Inlet temperature at full load…………………………………...165 ºC

-Outlet temperature of secondary fluid………………………….80 ºC

-Back pressure (lift height plus return line pressure)………...1,5 barg

-Back pressure equivalent saturated steam temperature….127,6 ºC

Graphical solution
On the left vertical axis, mark the following temperatures:
-The steam temperature Ts (165º)
-The temperature of the fluid to be heated T1 (20º)
-The outlet temperature of the fluid to be heated (80º) and plot this point to the right vertical axis T2.
Draw the lines between T2 and T1 and T2 and Ts.
On the right vertical axis plot the back pressure Tb (1,5 bar) and draw a horizontal line to the left vertical axis. From the point of interception (1), draw a vertical line to the bottom horizontal axis (2), where we can determine the percentage of load at which stall occurs: 57%

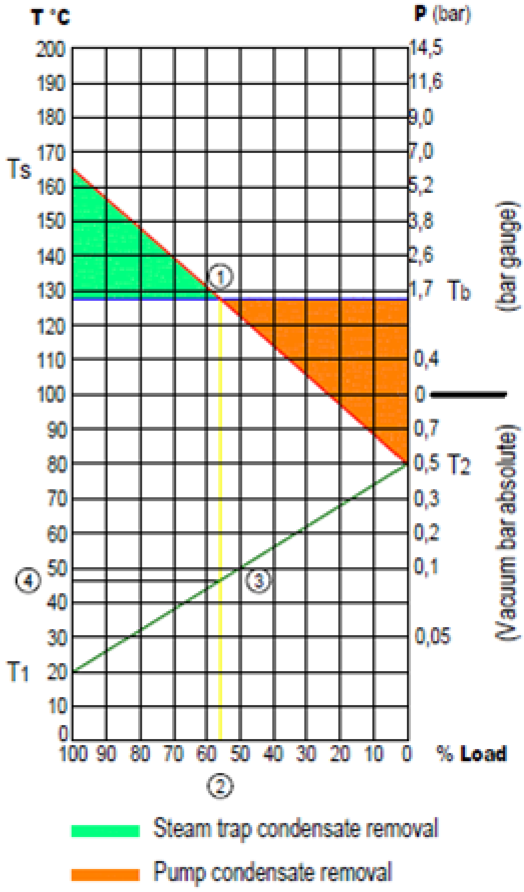


Fig.3

Mathematical calculation
% Stall load = [(Tb-T2) / (Ts – T2)] x 100 [%]

Ts-Steam temperature at full load [ºC]
T2-Secondary fluid outlet temperature [ºC]
Tb-Back pressure equivalent steam temperature [ºC]

% Stall load = (127,6 – 80) / (165 – 80) x 100%
% Stall load = (47,6 / 85) x 100% = 56%

LOAD AT STALL
Although the load was not specified in our example, we have enough information for it's calculation, as follows:
Steam pressure……………………. …..6 barg
Latent heat of steam at 6 barg …. 493,8 Kcal/kg (r)
Constant water flow……………......15000 Kg/h (m)
Specific heat of water (Cp=1 Kcal/Kg ºC)
Temperature rise of secondary fluid (△T) (water heating from20ºC (T1) to 80ºC (T2)
So, consulting Adca Training1, the following equation for steam load heat exchanger can be applied:

Q= (m x Cp x △T) / r [kg/h]
Q = [15000 x 1 x (80 - 20)] / 483,8 ; Q=1860,3 kg/h

So, totally open, the steam control valve will provide 1860,3 Kg/h of heating steam. Thus, from previous calculations, stall was determined to occur at 49 % of full load, therefore:

Stall load = 1860,3 x 0,56 = 1041,8 kg/h

Taking in consideration the guide lines mentioned above, we can now select the pump and external steam trap (i.e. POP + FLT) or a compact version pump and steam trap in the same housing (i.e.APST).

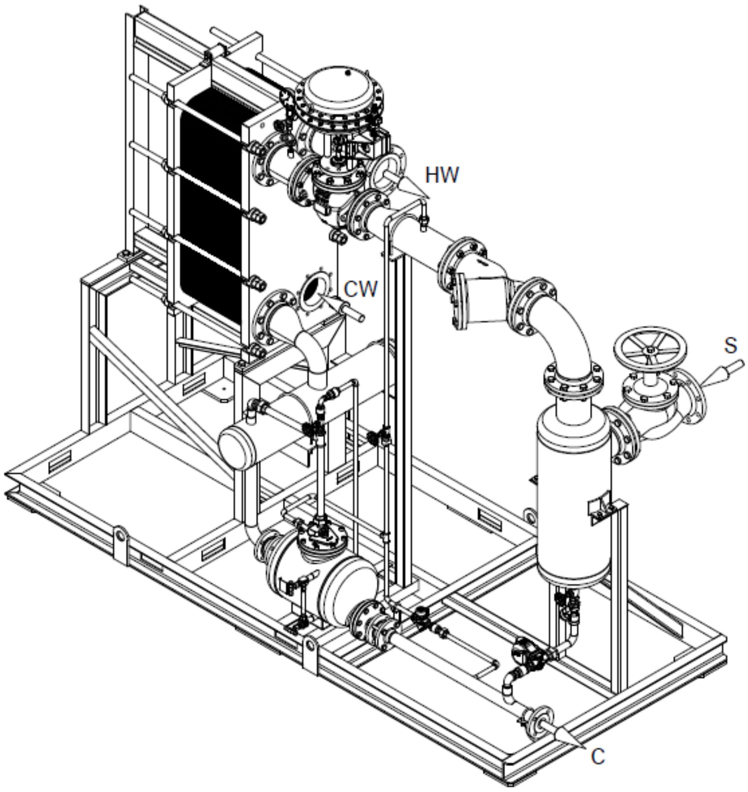
SECONDARY INLET TEMPERATURE AT STALL
From the stall chart we can also extract the inlet temperature at stall (point 4), in this case it is approximately 47 ºC.

Mathematical calculation
T1Lf = [(T2-T1) x (1-Lf)] + T1 [ºC]
T1Lf-Secondary inlet temperature at any load factor Lf [ºC]
T1-Seconday inlet temperature at full load [ºC]
T2-Secondary outlet temperature at full load
Lf-Load factor (0,56 according to the previous example)

T1(0,56) = [(80 -20) x (1-0,56)] + 20 ; T1(0,56) = [(60) x (0,44)] + 20 ; T1(0,56) = 46,4 ºC

SKID MOUNTED HEAT EXCHANGERS WITH APST PUMP TRAP

S – Steam inlet
C – Condensate return
CW – Cold water inlet
HW – Hot water delivery



SKID MOUNTED HEAT EXCHANGER WITH PRESSURE OPERATED PUMP AND STEAM TRAP