Heated Regulators for Vapor and Liquid Hydrocarbons

Heated regulators were introduced in the early 1980's. Construction consists of a pressure regulator assembly with a **centrally located heating element** that is uniquely designed to address various ill effects in **vapor** applications. This design remains valid today and found in many brands of heated regulators that provide an inexpensive solution in various applications.

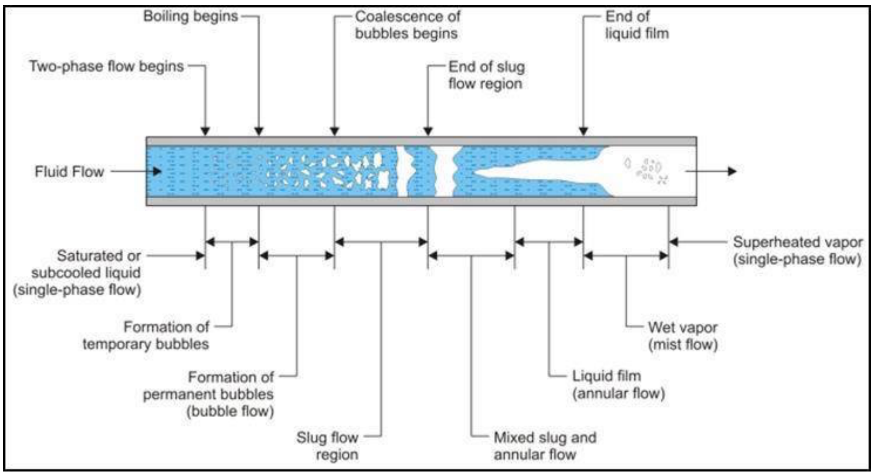
The **heated regulator** transitioned to vaporizing liquid hydrocarbons back in the days when Liquid Sample Injection Valves (i.e. LSV - flash vaporizers) on process gas chromatographs could not handle high pressures or were not as reliable as they are today. As heated regulators found their way into sample handling systems they became a generic solution for many **vapor and liquid** applications including cryogenic installations such as LNG Loading - thus becoming commonly known as the continuous flow **vaporizing regulator.**

As installations evolved, so have many different problems associated with vaporized samples from unstable readings to burned out or plugged vaporizers mostly as a result of misapplication or incorrect settings. Today we know that using existing designs of vaporizing regulators have very limited uses on liquid hydrocarbons. This has led to new innovative developments in **flash vaporizers** (specifically on LNG applications) and improved LSV arrangements on gas chromatographs. It should be noted that, flash vaporizers inject a fixed micro litre of **liquid** sample into fixed volume, temperature-controlled chamber. This attains **instant homogenous vaporization** resulting in highly accurate analysis results and by design are a costly solution.

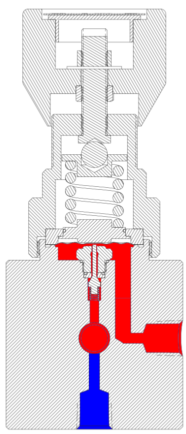
Continuous flow vaporizing regulators operate in a opposite manner yet over time have come to be expected to yield the same performance as flash vaporizers- often with limited success and in many cases become nothing more than **fractionating regulators**.

This discussion re-focuses on understanding the design basis of continuous flow heated regulators and introduces some new developments for liquid applications.

The illustration below shows what happens to a liquid sample as it passes over a heating element inside a commonly found heated regulator. This effect is more evident in liquid samples having a wide boiling point, typically C1 to C4+. Obtaining any reasonable balance of outlet pressure, flow and temperature can be a major challenge.



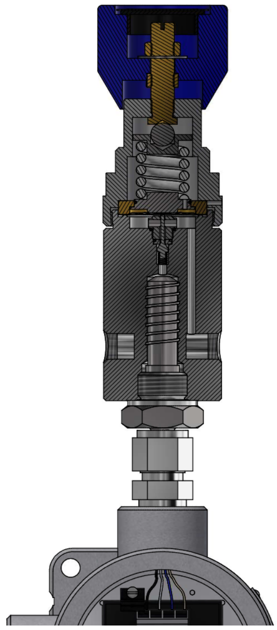
Courtesy: ASaP nl



Courtesy: Pressure Tech UK

Vapor Applications

Heating is achieved by a central electrical heating element within the regulator body. The position of this element allows for a **desired heat conductance path** to the regulator body in a radial manner extending upwards.



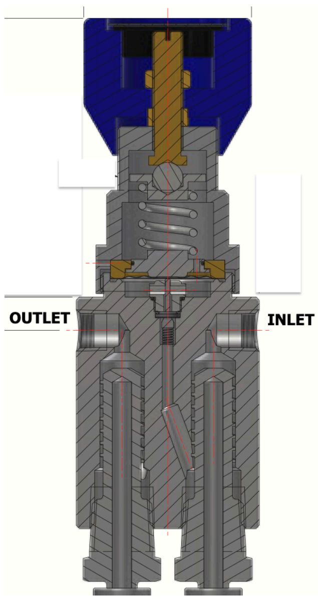
Single central heater

The vapor sample is passed through the inlet towards the heated chamber and **around the heater** to ensure the vapor is kept **above its dewpoint** whilst eliminating droplets or mists. As pressure is reduced via the poppet and seat arrangement a Joule-Thompson (J/T) effect is formed within the upper body.

The heater temperature is adjusted to overcome the J/T effect whilst providing a relative limited amount of heat to keep the whole regulator body above the sample dewpoint under normal flow conditions. The amount of heat required will vary depending on pressure, flow and surroundings for the given application.

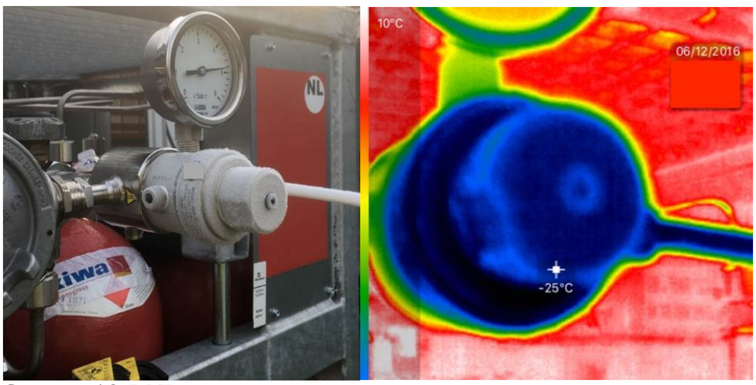
The sample exits from around the diaphragm towards the outlet which is in close proximity to the heated chamber ensuring the sample remains warm. After a while, an overall equilibrium temperature is reached which may require further optimization during commissioning stages.

Certain high pressure vapor applications can exhibit a significant amount of J/T effect during pressure reduction where there is simply not enough heat available to overcome icing during operating conditions. This leads to vapor samples condensing to liquids at the outlet as well as internal mechanical failures resulting in gas releases through the bonnet. These problems cannot be overcome via a single heating element but may require flash vaporizers, multi-stage pressure reduction or a dual element heated regulator whilst maintaining minimal flow rates.



Dual heaters

Courtesy: Pressure Tech UK



Courtesy: ASaP NL

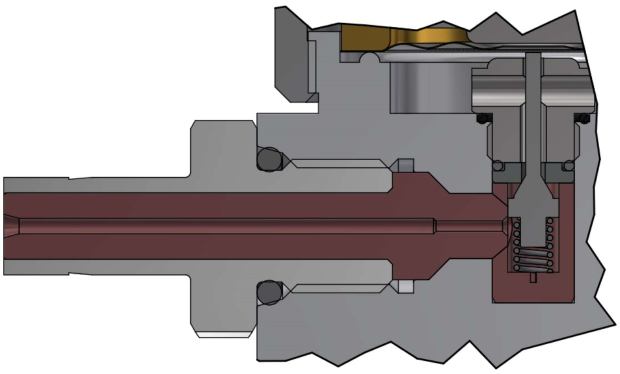
200 Barg Natural Gas Sample reduced to 5 Barg

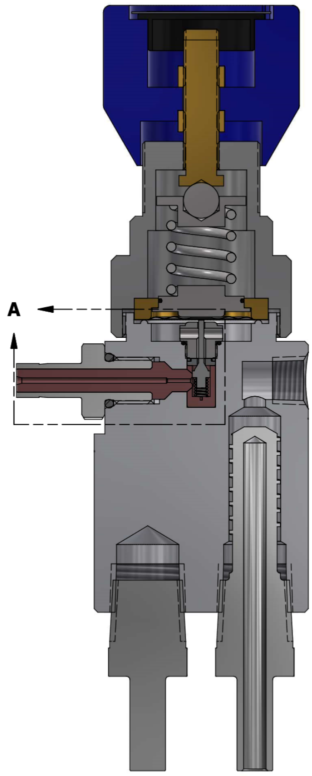
Liquid Applications

Liquids need to be kept **below their bubble point and away from any heat source** requiring a different approach.

This following design incorporates an insulated inlet made from Polyimide having a low thermal conductivity of 0.12 W/(mK) compared to that of 16.3W/(mK) for SS316.

The polyimide insulation provides thermal insulation of the liquid sample from point of entry into the vaporizer through to the **vena contracta** where the pressure drop is lowest and fractionation is greatest. By ensuring the integrity of the insulation is maintained up to this point, the liquid sample is transformed to gas state in supercritical conditions so that the sample flashes directly from liquid to gas rather than fractionate.



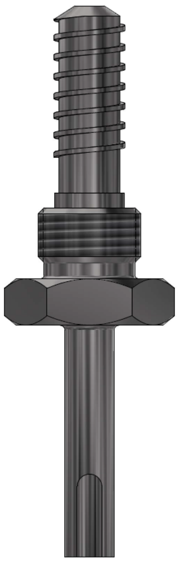


Heated Regulator for Liquids

Images courtesy: Pressure Tech UK

Bore and CV sizes can be made to suit specific liquid densities and flow requirement. Various sized Service Kits are available for easy retrofit.

The offset outlet heater is biased towards applying heat in the post pressure reduction area. A heater cartridge sits within a solid spiral sheath having a large surface area to promote good heat transfer to the outward flowing sample. By using the spiral insert, the electrical power density is increased by 11.4% to 4.93 W/cm^2 on a 100w heater, allowing for greater heat transfer to the sample.



Spiral Sheath housing heater element

Typical applications: Refinery, NGL's, liquefied propane, butane, ethylene plants and limited cryogenic samples.

Summary
Process analyzers are an expensive investment but can only deliver valid results if presented with a representative sample during calibration and online use. In instances where heated regulators are deployed in liquid applications it is critical to recognize the possible presence of sample fractionation / evaporation /condensation and how cumulative errors can impact the final result.

In such cases, an expensive analyzer installation can be held hostage to an in-expensive heated regulator. Today our understanding of these problems coupled with modern manufacturing techniques has allowed for a design more suitable for liquid hydrocarbons than previously available whilst maintaining the same familiar packaged product.

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No ChatGPT or AI was used in the production of this paper ☺