Function and suitability of thermostatic steam traps in SIP applications

For the operation of pharmaceutical and biochemical plants, the cleaning and sterilization of pipes, valves, tanks and reactors is prescribed by law to ensure that the final products are perfectly hygienic. This procedure makes very high demands on the controls and equipment, because reliable operation is essential in safeguarding optimum productivity and therefore rapid amortization of the invested capital.

The aim is to operate the plants at high efficiency over a long period without disturbances, and to ensure absolutely reliable processes. Making the best choices for the valves becomes all the more important. Selecting the optimum steam traps plays a vital role in ensuring the stability of the process as well as in maintaining the required cleaning times. Unfortunately, these valves are not always given the attention they deserve.

The first step in the overall cleaning process is the CIP cleaning; this is generally subdivided into several steps. Parameters such as temperature, speed, concentration of the cleaning medium, and the cleaning duration must be considered.

The subsequent SIP process focuses on the required killing of microorganisms through heating-up of the system. Depending on the kind of germs, the system is heated up to 150 °C for varying times. The SIP process exclusively uses saturated steam from a clean steam generator. This is the only type of steam with a combination of temperature and moisture offering a suitable medium for dependable sterilization. The success of the sterilization procedure then depends on whether the temperature in the system remains constant. Following sterilization, the system must be cooled down; this is done by purging it with sterile air.

The temperature in the SIP process is regulated at a constant value solely by selecting the correct pressure for the saturated steam. Any condensate which is produced reduces the temperature. An important process step is therefore to detect the physical state of the medium and to achieve an adequate response time for the steam trap. Plant components that are poorly accessible and the endpoints of the system are especially critical. These sensitive positions are monitored by temperature sensors and provide the basis for validation of the production plant.

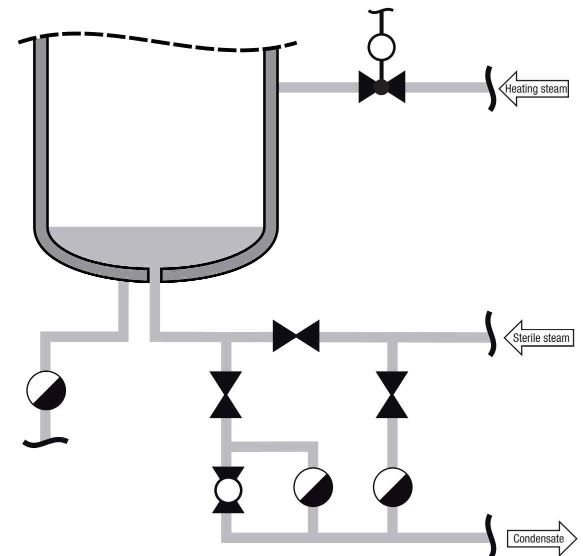


Fig. 1: Example of a SIP process

When selecting a suitable steam trap system, it is necessary to differentiate between the sterilization of pipes and valves and the sterilization of tanks and reactors, since the amount of condensate needed depends on the size of the system. By way of example, the following diagram depicts the condensate flowrates occurring in a heated pipe in comparison to those for a tank.

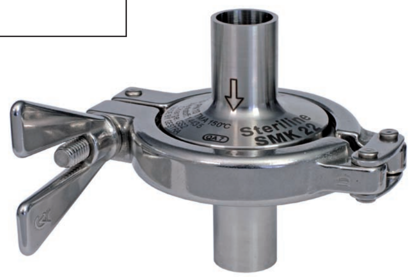


Fig. 2: GESTRA steam trap type SMK 22 for sterile and aseptic applications

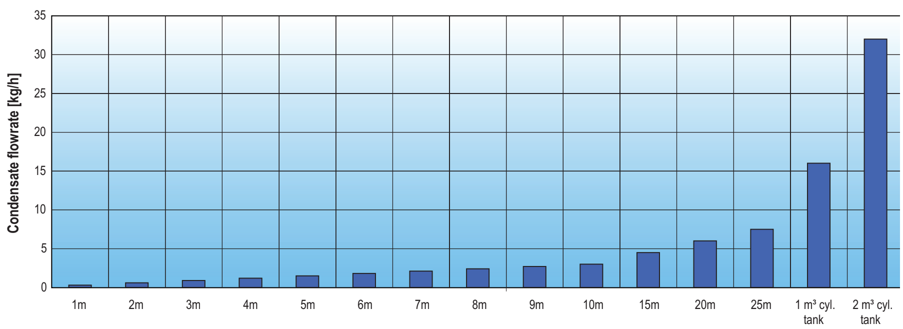


Fig. 3: Condensate produced in a DN 20 pipe of stainless steel during sterilization with saturated steam at 3 bar / 144 °C

What properties should a steam trap offer to be suitable for such sensitive processes?

All parts in contact with the fluid are ideally made of stainless steel type 316L. However, this American material designation covers an entire palette of European grades of stainless steel. There is a fundamental principle that special requirements are best served by a more precise definition of the desired properties, since a variety of materials in this “material group” may be used, depending on the manufacturer. Body gaskets are usually made of PTFE, EPDM or FPM and normally meet all the requirements of the FDA.

With regard to the surface roughness (Ra) for the wetted parts, a roughness value of $R_a \leq 0.8$ µm has become standard. As an option, some manufacturers offer values down to < 0.4 µm. In some cases, electro-polished surfaces are requested, with a view to preventing deposits and soiling from the very start.

If these details receive due consideration, malfunctions of the production process as a consequence of product residues and dirt and foreign matter in the system can frequently be avoided entirely.

The most important functional unit of the steam trap is its control element. With the thermostatic steam traps, a differentiation is made between the bimetallic, membrane and bellows types **(Fig. 4)**.

The opening and closing operations of the bimetallic regulator are controlled by the interaction of the temperature sensor (consisting of Duo stainless steel plates) and the stage nozzle. Owing to its susceptibility to soiling, however, it is not suitable for use in pharmaceutical plants. This type is only mentioned here for the sake of completeness, and will not be considered any further. The same applies to the bellows regulator, although this type is very similar in function to the membrane regulator.

The membrane regulator offers a decisive benefit. Owing to its small surface area, it can respond very quickly to changes in the temperature and other operating conditions.

When condensate flows through the trap, the control medium in the capsule is completely liquid, as a result of the low ambient temperature. The pressure within the capsule is lower than the surrounding pressure (service pressure); the membrane with the valve disc is pushed in the opening direction **(Fig. 5, left)**. When the condensate temperature rises, the liquid filling starts to evaporate. The internal pressure of the capsule rises, the membrane is pressed in the closing direction **(Fig. 5, right)**. The function is not affected by a fluctuating upstream pressure or by back pressure.

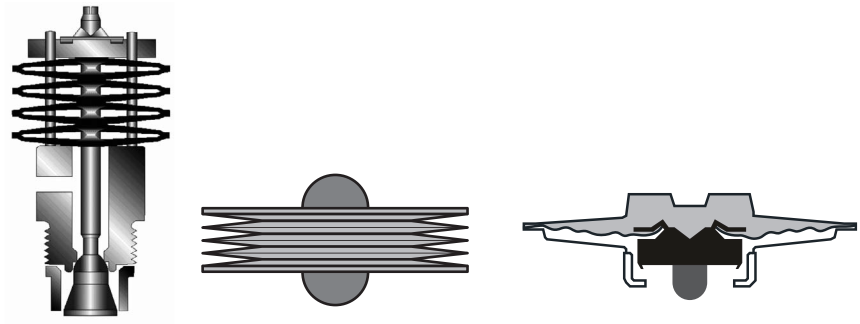


Fig. 4: *The various types of thermostatic steam traps*

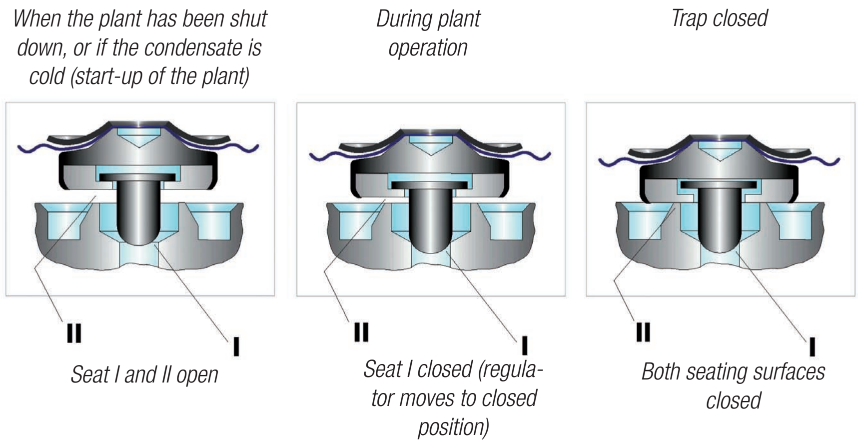


Fig. 5: *Functional principle of the GESTRA thermostatic capsule*

Fig. 6: *Structure of the GESTRA steam trap type SMK 22-81*

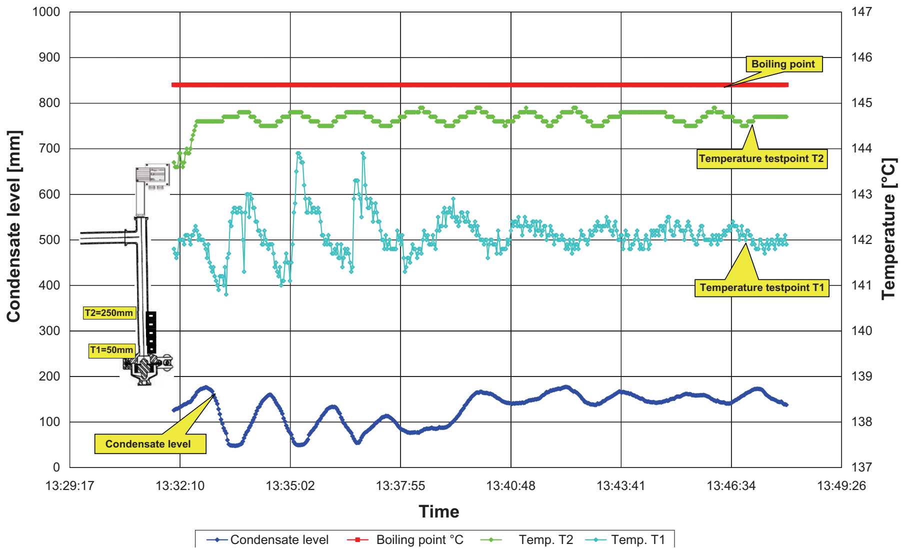
Since the membrane regulator very quickly detects the change of the medium's physical state from steam to condensate and discharges the condensate without delay, it can be ensured that the SIP process to be validated yields reproducible measurement curves at all times.

Another aspect in favour of the membrane regulator is to be found in its structural design. Since it has almost no crevices, the regulator offers little possibility for soiling or the accumulation of dirt and foreign matter. This permits a long service life and also a reliable and safe SIP process. Outages and maintenance downtimes can be reduced to a minimum.

Nevertheless, it is necessary to take steps during the planning phase to ensure good accessibility of these valves. In order to minimize the need for gaskets, butt-weld ends are frequently used for the connections to pipework. There are also body versions which allow a rapid and easy exchange of the regulator (i.e. the functional unit). Only two gaskets are required in this case **(Fig. 6)**. With the correct selection and sizing of the steam trap system, sterilization becomes a safe and reliable process. Temperature fluctuations, and hence the risk of unkilled microorganisms, need not jeopardize efficient production and high plant availability.

Fig. 7: Functional test of the GESTRA capsule 5H1
Upstream pressure = 3.2 bar / TS = 145.4 °C
10% heat exchanger = 11.7 kg/h condensate

Practically constant plant temperature T2 with minimal banking-up of condensate through use of a capsule when sterilizing a 30 m section of pipe with the nominal size DN 20.



Technical terms:

CIP:	cleaning in place
SIP:	sterilization in place
Saturated steam:	Steam containing the maximum possible amount of moisture that it can just hold for that steam pressure without condensing
FDA:	Food and Drug Administration

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