GESTRA Steam Systems

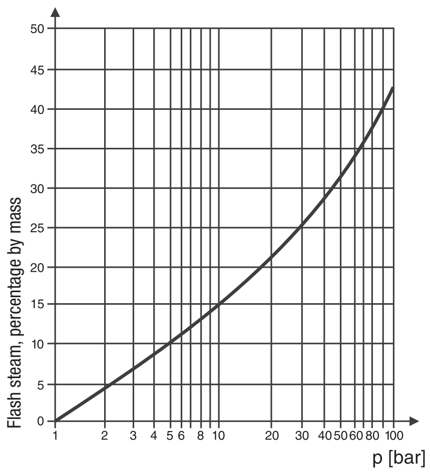
GESTRA Information A 1.1

Physical Basis
for Evaluating Steam-Trap Performance

Monitoring Flow Conditions in Condensate Lines

Flash-steam or live-steam losses?

Quite often the efficiency of a steam trap discharging into the open is judged by the steam clouds at the trap outlet. If large clouds are visible, the steam traps are discarded as unsuitable. However, this judgement of steam trap performance which is due to ignorance of physical phenomena is fundamentally wrong for the following reason: During pressure drop of hot condensate, flashing of part of the condensate into steam is inevitable and must not be confused with live-steam losses. It is impossible to distinguish flash steam from live steam.



Absolute pressure upstream of steam trap

Fig. 1

What is flash steam?

The higher the pressure in a steam plant, the higher the boiling point of the water and consequently the higher the total heat content. If the pressure drops, the saturation temperature (boiling point), and the heat content of the water are reduced to the same extent, viz. when reducing the pressure of boiling hot condensate – as happens during condensate discharge – a fraction of the total heat content is released and its energy leads to the evaporation of part of the condensate. The steam formed is called "flash steam" and the process is known as "flashing".

The amount of flash steam formed (percentage by mass) from condensate at different pressures can be read in **Fig. 1**.

If, for example, the pressure upstream of a steam trap is 10 bara and the pressure downstream of the trap only 1 bara, i.e. if the condensate pressure is reduced from 10 bara to 1 bara, 15 % of the condensate formed are evaporated.

The following experiment provides conclusive evidence of the formation of flash steam (see **Fig. 2**).

A vessel under pressure filled with boiling hot condensate above which is a steam space, is fitted with a GESTRA steam trap Ⓐ, a GESTRA Vaposcope (sightglass) Ⓑ and an isolating valve Ⓒ.

If the valve Ⓒ is opened, a sharp jet of steam intermingled with water droplets is ejected from the trap outlet. However, the Vaposcope Ⓑ fitted upstream of the trap shows clearly that only water is flowing towards the steam trap. This proves that the steam escaping is totally flash steam produced by the pressure drop and consequent flashing of the hot condensate.

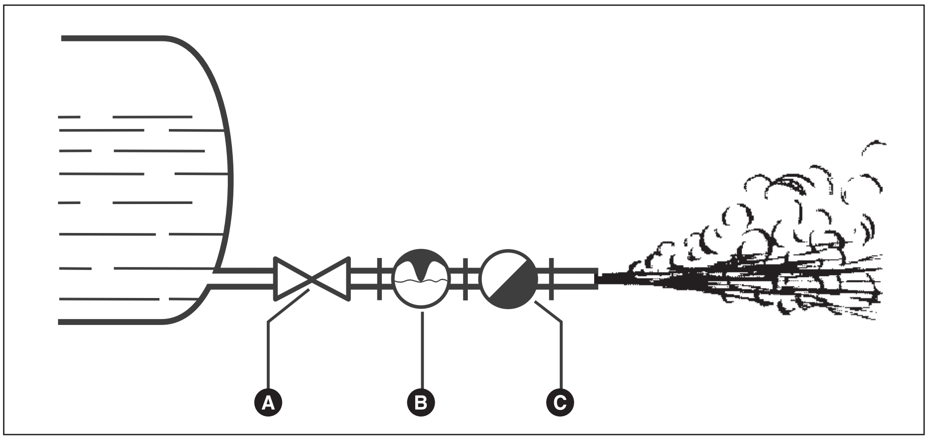


Fig. 2 *Test arrangement*

Volume increase during flashing

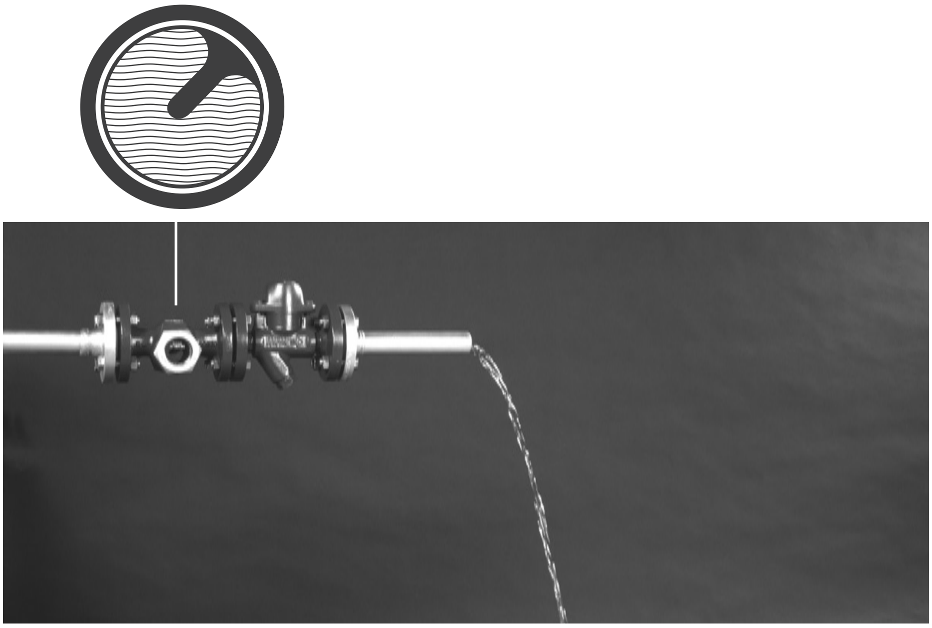


Fig. 3

Example 1: Cold water
(Fig. 3)

Only cold water is admitted to steam trap Ⓐ (test arrangement as per **Fig. 2**). The water enters and leaves the trap in the same condition. No change in volume occurs. **(Fig. 6).**

This is confirmed by the graph, **Fig. 9**.

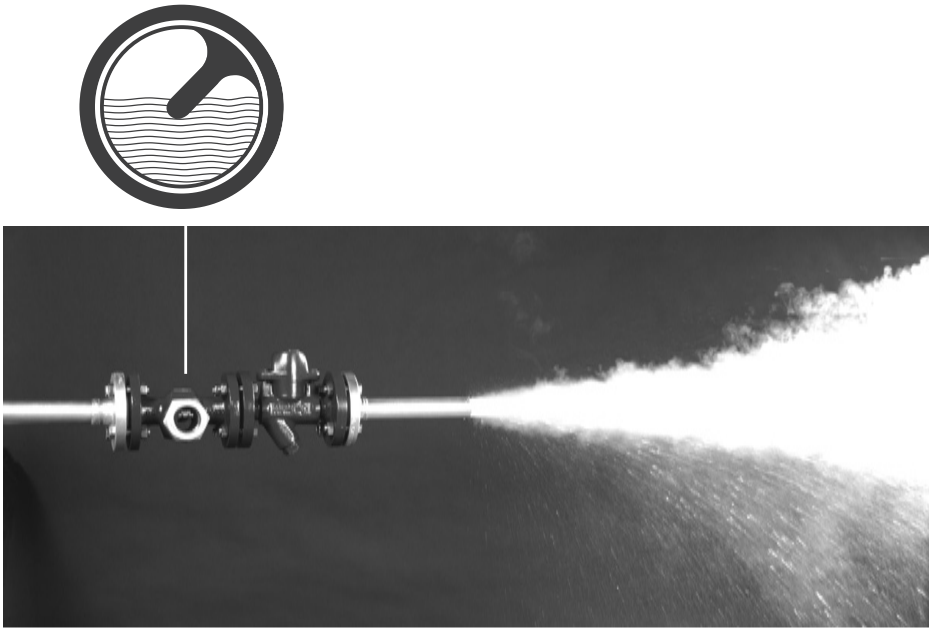


Fig. 4

Example 2: Hot water
(Fig. 4)

Boiling hot condensate at a pressure of 5 barg is fed to the steam trap. As is confirmed by the Vaposcope no steam is entering with the water. At the trap outlet, however, only steam, i. e. flash steam, is visible. The graph, **Fig. 7**, clearly shows the large volume increase caused by the expansion of the boiling hot condensate.

The volume increase across a range of pressures is indicated in the chart, **Fig. 9.**

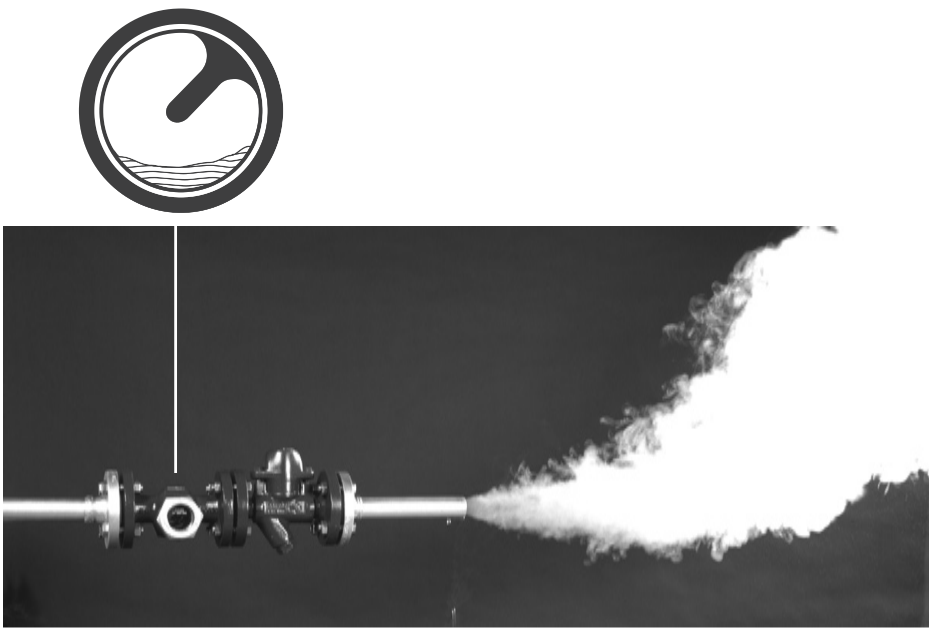


Fig. 5

Example 3: Saturated steam
(Fig. 5)

Saturated steam at a pressure of 5 barg is fed to the steam trap. The cross-sectional flow area of the trap was adjusted to admit live steam loss, contrary to example 2. At the trap outlet only a moderate steam cloud is visible.

The relatively slight volume increase of the steam is shown in **Fig. 8.**

No change of volume

Fig. 6 When reducing the pressure of **cold** water, the volume remains unchanged.

Increase of volume caused by expansion of condensate

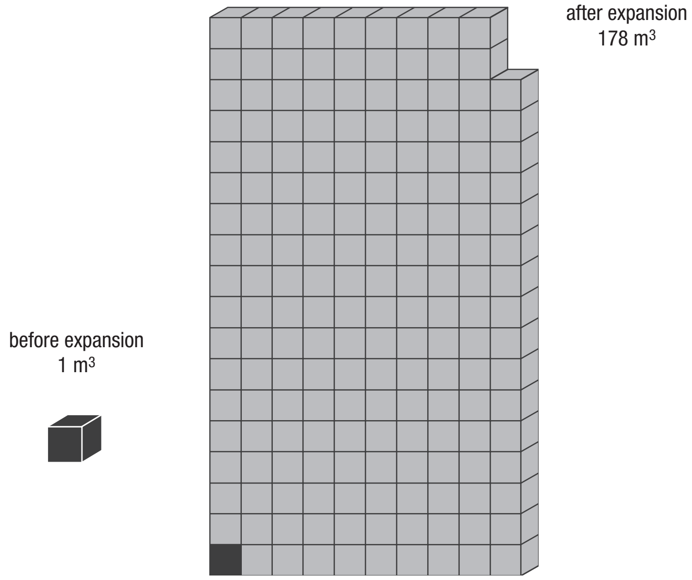


Fig. 7 When reducing the pressure of boiling **hot** condensate from 5 barg to 0 barg, the volume (flash steam and residual water) is increased 178 times.

Increase of volume caused by expansion of saturated steam

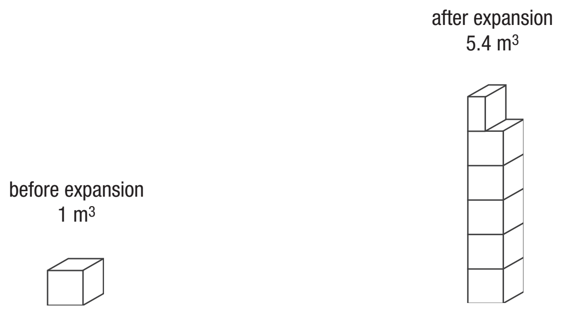
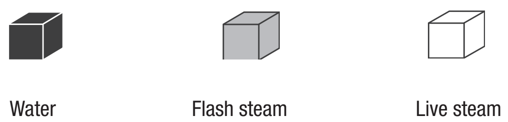


Fig. 8 When reducing the pressure of **saturated steam** from 5 barg to 0 barg, the volume is increased 5.4 times.

Key



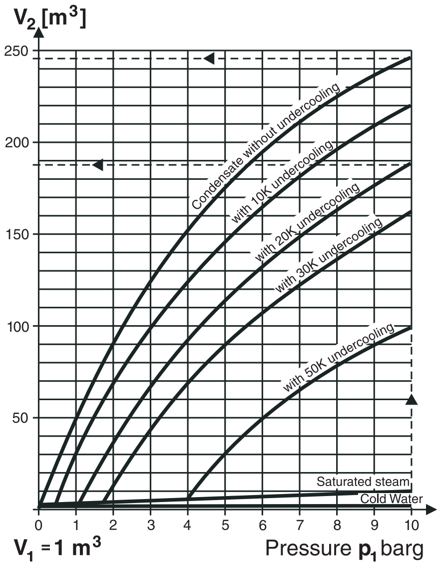


Fig. 9 *The chart shows the volume increase of 1 m³ saturated steam or 1 m³ water for an expansion from 10 barg to atmospheric pressure.*

Example:

At an expansion from 10 barg to 0 barg, the volume of cold water remains practically the same; that of saturated steam increases from 1 m³ to 9.55 m³; that of boiling hot condensate from 1 m³ to 245 m³; that of hot condensate at 20 K below saturation temperature increases from 1 m³ to 189 m³.

Visual monitoring

The GESTRA Vaposcope allows observation of flow conditions in condensate lines upstream of steam traps. The Vaposcope is a double-sided sightglass for efficient checking. In addition to **Figs. 3, 4** and **5** on page 2 the schematic representations below and opposite demonstrate the operating principle of Vaposcope.

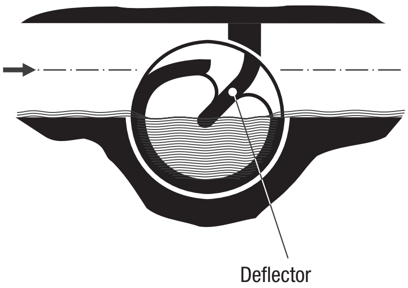


Fig. 10 *Schematic representation of GESTRA Vaposcope*

The conditions in the condensate line are revealed by the different water levels in the Vaposcope water seal.

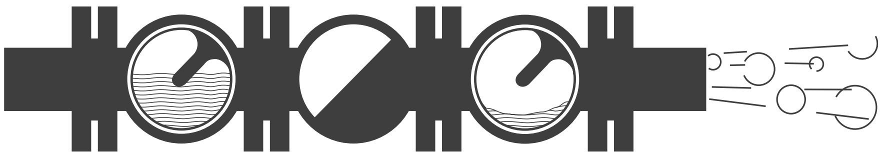


Fig. 11a

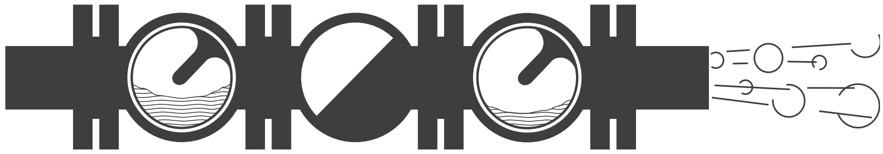


Fig. 11b

Fig. 11 As live steam and flash steam cannot be distinguished it is impossible to determine what type of steam is escaping from the trap outlet, i.e. a defective steam trap losing live steam cannot be detected by a sightglass fitted downstream of the trap. Checking is only possible **upstream** of the trap with a device which can discriminate the passage of live steam. A demonstration is given by the schematic diagram above: In both cases a and b the checking device fitted downstream of the trap would show approximately the same picture although the conditions in the trap are completely different. Such errors occur with all sightglasses fitted downstream of the trap which do not permit the detection of live steam losses.

Fig. 11a The Vaposcope shows that the trap is operating without live steam loss. The deflector tip is just immersed in the water level.

Fig. 11b The Vaposcope clearly shows live steam losses. The passing live steam depresses the water level and forces its way underneath the deflector.

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