Tech Sheet #ST 101

Is an Orifice a Steam Trap?
Some Usage Consequences with Orifice Drain Fittings

Valuable Design Considerations for Engineers, Designers, and Steam Users

A steam trap is an integral, self-actuated valve which automatically vents air in the steam system and drains condensate from a steam containing enclosure while remaining tight to live steam. Most steam traps will also pass non-condensible gases while remaining tight to live steam. (FCI 69-1, Paragraph 2.1).

Engineers, designers and steam users should consider the potential consequences to a steam system where an orifice drain fitting "orifice" is utilized for condensate discharge in lieu of a steam trap. An orifice is not considered to be a steam trap because it does not have the capability to remain tight to live steam.

An orifice (sometimes incorrectly referred to as a venturi) drains condensate through a fixed hole (there may be a series of varying inside diameters before and after the fixed hole). The orifice diameter is fixed and cannot vary during operation; therefore, it is used for a single flow rate at a specific differential pressure. The condensate flow rate within the steam system varies, sometimes significantly. The load changes can have dramatic effects on process temperature-controlled applications; therefore, an orifice is generally not recommended for this type service. Similar issues may be experienced on expected “steady state” applications, such as draining steam mains or tracing, or when changes in ambient temperature or system backpressure occur. Weather conditions such as cold weather, wind, rain, or snow can increase system load requirements when these weather conditions contact un-insulated sections of pipe, valves, flanges or other fittings.

Sizing an orifice on expected “steady state” applications, such as steam main drip, must be performed carefully, so neither undersizing nor gross oversizing occurs. Undersizing must be avoided to prevent dangerous condensate back up and flooding of equipment or steam mains. So, the orifice will normally be at least slightly to moderately oversized for the largest load condition. Undersizing can create dangerous water hammer conditions leading to safety and reliability issues, including serious personal injury and equipment damage. The oversizing is aggravated when the load decreases through the fixed orifice.

To keep the steam loss to a minimum, the orifice may be sized for the worst-case running steam load condition and a small safety factor. Startup of the steam system cannot be accomplished with a running load orifice. A second orifice in a bypass line may be required. Some orifices can be closed manually after the startup phase has been completed. This procedure could help reduce the level of excessive steam loss after the warm-up is reached. This second orifice possibility requires additional expense and is generally not done. In most cases, when using an orifice for drainage, only a supervised startup procedure should be done. Supervised startup requires a manual valve be opened to remove both condensate and air during the warm-up process. When full steam pressure is achieved, the valves are closed.

Selecting an orifice according to the typical selection practices may cause the fitting to lose steam during some operating periods. This is because such fittings are typically sized with a safety factor of approximately 1-1/2 times the actual load. The amount of steam loss will vary with the size of the safety factor applied and load variation during operation. In some cases, engineers require a 3 to 1 safety factor at very low-pressure differentials on process equipment. This large safety factor could lead to large steam losses at full operating pressures. Additionally, the amount of steam loss can increase over time as erosion of the orifice diameter increases.
A return line in a traditional steam trap system is usually sized for the condensate and flash steam loads. However, a return line in an orifice-drained system should be sized for condensate and flash steam loads, ***plus*** additional live steam loss.

If a large number of orifices discharge condensate and steam flow into a common return, the additional steam loss plus the flash steam tend to increase system backpressure. This becomes an important critical consideration for proper return line sizing and can lead to larger return pipe sizes. If orifices are installed in existing systems, the possibility of condensate line water hammer can occur. When an orifice is used in vacuum return systems, excess steam can cause problems with the vacuum pump system. In contrast, actual steam traps usually operate with the smallest size return line. They are designed to close and prevent the loss of steam and can perform well in vacuum return systems.

Orifices typically use very small diameter holes (0.020” to 0.075” are common on drip service), since the intention is to have constant flow with no flow interruption. In steam systems, these tiny holes may tend to block shut. For this reason, it is advisable that orifice drain devices be limited to clean steam systems where dirt may not block the hole in a short period of time. Clean steam is created from a demineralized, deionized or RO water source and often is accompanied by the use of stainless steel piping. Orifice products had been used years ago on some naval vessels where steam is not created from mineral laden water. A fine mesh strainer may help filter the largest particles, but this will not stop fine deposits that precipitate out of the condensate when the condensate flashes at the orifice. Minerals, iron oxide and boiler chemicals cannot remain in the solution and they drop out when flashing occurs. The fine mesh strainer often also becomes a location experiencing plugging issues.

In contrast, steam traps can have much larger openings and they can shut off in the presence of live steam while opening wide for condensate drainage. Although steam traps can also plug, this occurrence is significantly reduced due to the larger opening of the discharge port.

A potentially acceptable application for an orifice is where the following conditions exist:

- relatively constant condensate load and pressure
- clean steam
- condensate is discharged to a lower pressure condition (cascade), not at atmospheric pressure, however, such lower pressure lines should have steam traps with variable load drainage capability.

Under these conditions, the unit can be sized with an adequate safety factor, and any steam which is lost through the orifice will be recovered in the next lower pressure level. (This is a relatively safe economic consideration provided there is not an excessive amount of low pressure steam that is vented).

Orifices generally should not be utilized on any process applications that are on/off, batch-type or with modulating controls. The possible exception would be a process application, which runs without a control valve at a constant pressure. But even in this case, some steam loss could still be expected to occur. Both modulating, and especially on/off, processes require larger startup capability and air removal capacity. An orifice sized for the running load could be expected to cause slower startup, poor or reduced temperature control and possible water hammer due to condensate backup.

Most heat exchange applications require relatively infinite turndown capability. An orifice has limited turndown characteristics and requires very specific load conditions for it to work correctly with heat exchange equipment. Because the pressure in process equipment typically varies with load changes, it can be expected that the orifice inlet would be subject to pressure changes. Ensuring that the orifice has sufficient capacity at the minimal pressure requirements, however, would cause the orifice to be larger than needed when the pressure is high. The result is an orifice that is oversized at operating conditions. This oversizing could lead to excessive steam loss and overall steam system imbalance. To understand the impact on the system, multiply the expected steam loss by the number of orifices installed in a given system.

All steam trap manufacturers publish capacities to ANSI / ASME PTC 39.1 performance test codes. However, some orifice manufacturers publish no capacity data. The customer and consulting engineers may have no way to compare the orifice capacity to the system requirements. As such, there may be no recognizable standard to ensure the proper sizing for the equipment in the system. In these instances, orifices may not meet accepted national industry standards such as ASTM F1139 or ANSI / ASME PTC39.1.

For further information, refer to the technical paper on the Department of Energy website: http://www.oit.doe.gov/bestpractices/steam/pdfs/orificetraps.pdf