Tech Sheet #ST 101

Some Usage Consequences with Orifice Drain Devices
(Valuable Design Considerations for Engineers, Designers, and Steam Users)

Engineers, designers and steam users may want to consider the potential consequences to a steam system where orifice devices are utilized for condensate discharge.

An orifice device drains condensate through a fixed hole or a series of fixed holes. The orifice opening does not vary during operation; therefore, it allows for a single flow rate at a specific differential pressure. The amount of condensate flow rate within the steam system, however, will vary, sometimes significantly. The load changes can have dramatic effects on process temperature-controlled applications; therefore, orifice devices are generally not recommended for this type service. Similar issues may be experienced to some extent on expected "steady state" applications, such as mains drainage or tracing, or when changes in ambient temperature or system back pressure occur as well.

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 device will normally be at least slightly to moderately oversized for the largest load condition. 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 load factor (SLF). In this case, however, startup of the steam main cannot be accomplished with a running load orifice. A second orifice in a bypass line may be required and can be closed manually after the startup phase has been completed to prevent excessive steam loss after the warm-up is reached. This second orifice possibility requires additional expense and is generally not done.

To understand further, selecting an orifice device according to the typical selection practices may cause the device to lose steam during some operating periods. This is because such devices are usually sized with a safety load factor of approximately 1-1/2 times the actual load for safety reasons. The amount of steam loss will vary with the amount of safety load factor applied and load variation during operation. Additionally, the amount of steam loss can increase over time as erosion of the orifice diameter increases.

If a large quantity of orifice devices discharge condensate and steam flow into a common return, the additional steam loss plus the flash steam tend to increase system backpressure and become an important critical consideration for proper return line sizing. This can require larger return pipe sizes. In contrast, steam traps usually operate with the smallest size return line because they are designed to close and prevent the loss of steam.

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The comparative result is that a return line in a steam trap system must only be sized for the condensate and flash steam loads, whereas a return line in an orifice-drained system must be sized for condensate and flash steam loads, ***plus*** the additional live steam loss.
A potentially acceptable application for an orifice device is where relatively constant condensate load and pressure and clean steam conditions exist, and where the condensate is discharged to a lower pressure condition (cascade), and not at atmospheric pressure. Under this application the unit can be sized with adequate safety load 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).

Orifice devices use the smallest hole diameters since the intention is to have constant flow with no flow interruption. In steam systems, the tiny holes used (0.020" to 0.075" are typical on drip service), tend to block shut. For this reason, it is advisable that orifice drain devices be limited to clean systems where dirt will not block the hole in a short period of time. 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 the flashing occurs. (This actions tends to block the small orifices of such devices).

In contrast, steam traps typically have much larger openings because their operation is intermittent 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.

For further process information, orifice devices generally should not be utilized on virtually any process applications that are on/off batch-type or with modulating control. The possible exception would be a process which runs without a control valve at a constant pressure, although even in this case, some steam loss would 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 would be expected to cause slower startup, poor or lessened temperature control and possible waterhammer due to backup.

Most heat exchange applications require relatively infinite turndown capability. An orifice has limited turndown characteristics, and it would need very specific load conditions for it to work correctly with heat exchange equipment. Because the pressure in process equipment typically varies to some extent 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, resulting in an orifice that is over-sized at operating conditions. This oversizing would 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 orifice drain devices installed in a given system.

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

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