Steam Distribution System

The first question is 'why use steam?' There are several reasons why steam is still commonly used in process industries: it is a very effective way of transferring energy from a central single point source to various local points of use, the steam's own pressure acts as the motive power to move the steam to the points required, there is a direct relationship between the steam pressure and the temperature which makes it ideal for process control and steam has a relatively high enthalpy so can transfer a large amount of energy relative to the mass flow.

So having established that steam is still a very good medium for transferring and controlling the flow of energy throughout a plant the key is to achieve this as effectively and efficiently as possible.

Steam is distributed in steam pipelines and it is necessary to design the pipework system so as to achieve the required process conditions and to reduce, as much as practical, the losses from the system.

Saturated Steam v Superheated Steam

This is not always a choice. If some equipment on a plant requires superheated steam then there is no choice it has to be superheated. However it is often considered more efficient to distribute the steam superheated because it doesn't generate condensate but superheated steam is hotter than saturated steam (at the same pressure) and therefore the losses from superheated steam will be higher. There is also a potential problem in large plants of the steam becoming saturated as it travels through the plant, if the system has been designed assuming superheated steam.

The main reason for choosing to distribute with superheated steam would be to reduce the losses through steam traps but if the steam traps are working correctly and the condensate is being collected and returned to the boiler house then the recommendation would be to distribute the steam saturated.

Pipework heat losses

Ideally all the energy leaving the boilerhouse would arrive at the process. However since the steam is considerably hotter than the surrounding air temperature there will always be some losses, the key is to reduce them as far a practical. The first step is to insulate the line. There is a huge difference between the heat loss from a bare pipe and a pipe with just 1" on insulation but the general rule is 1" of insulation per 100^{o}F (25mm for 56^{o}C) of steam temperature.

Typical insulation will be glass fiber with stainless steel cladding. Ideally all the ancillaries such as control valves, isolation valves etc should also be isolated but it is a good idea to consider the removable insulation covers for ancillaries that need regular maintenance.

The most important point is to keep the insulation dry. Wet insulation is worse than no insulation. The cladding should be well sealed and pipework should not run in ditches where there is a possibility of the flooding.

Insulation of the condensate pipework if often overlooked but is important too. Even though it is condensate rather than steam any heat loss in the condensate line results in more energy being used in the boiler house.

Pipeline sizes

For saturated steam the velocity of steam in the pipework should be around 30 m/s to 40 m/s for long runs, and 25 m/s for branches and short runs. For superheated steam the velocity range can be increased by 10 m/s.

For condensate return the design velocity depends upon if there is flash steam in the line. If it is pure condensate such a pumped flow after a condensate tank then 1 to 1.5 m/s is typical but if the it is two phase flow with flash steam then the lines should be sized based on the steam flow rather than the condensate flow. For two phase flow the design velocity should be much less at around 15 m/s.

Trapping

Even if the steam is superheated it is recommended to have dirt pockets and steam traps to drain condensate from the lines. In the case of superheated steam the theory is that there is no condensate but this is not always the case. If the line is oversized for the flow then there a stagnant layer can form which loses heat and produces condensate. Also on long runs it is possible to lose all the superheat and start condensing. So the better option, even with superheated steam, is to correctly design the condensate removal system.

For saturated steam the dirt pockets/traps should be located every 30 to 40m. For superheated steam 10m can be added to this range. Larger pipes can also have longer distances between traps. What is essential is to have a trap before every rise and preferably before every bend. It is also important to protect equipment such as flow meters and control valves.

Figure 1 shows the typical arrangement for protection of bends or equipment.

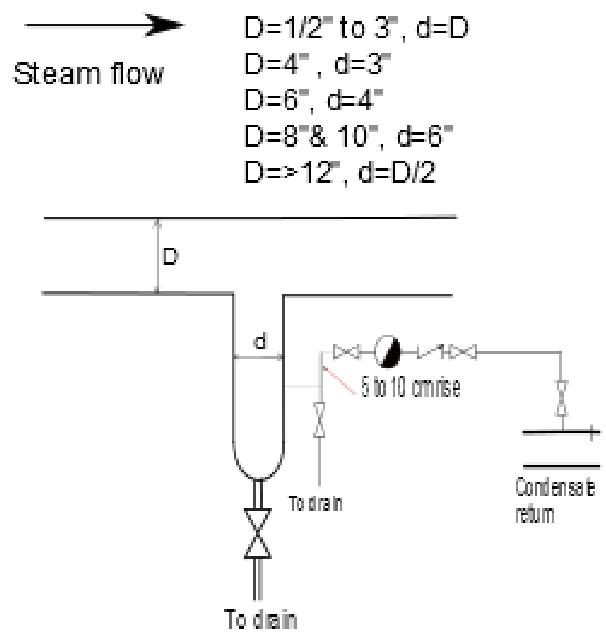

Figure 1 – typical drip leg arrangement

On a long straight run the line should drop be around 1 in 50 (minimum 1 in 100). So if we put a trap at the end of a 50m run then there needs to be a 1 m rise to start again. However if there is an expansion loop required then this should be considered as part of the pipework design and will depend on whether the expansion loop is horizontal or vertically up or down.

Figure 2 shows the ideal arrangement for a long distribution line.

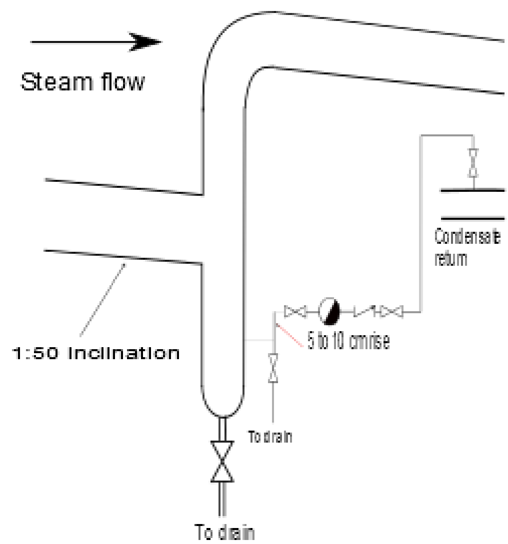

Figure 2 – arrangement for long runs

If the trap is installed on a superheated steam line then there needs to be around 2 to 3 m of bare pipe before the trap. The idea is that the bare pipe will lose heat and become saturated so forming condensate. All types of traps require some condensate to work correctly. Traditional mechanical traps have a very short life expectancy on superheated steam lines where there is no condensate. But the nature of mechanical traps creates a problem in this situation. When the trap opens and closes it invariably passes some live steam (more with age) which results in the line before the trap not being stagnant. The steam in the line before the trap doesn't have time to condensate before the trap opens again and so not condensate is formed. The trap therefore operates dry and the life of the trap is very short.

The only solution to the problem of trapping on superheated steam lines is to use hydrodynamic steam traps. The trap forms a permanent condensate seal that prevents the loss of live steam so that line before the trap is stagnant and forms more condensate hence maintaining the seal.

Branches

Branches should be taken from the top of steam lines and if there is a requirement to isolate the line the isolation valve should be directly on top of the steam line. This might require high level access to open or close the valve but prevents the possibility of condensate building up in front of the valve.

If a branch is feeding a piece of equipment such as a heat exchanger then there should be a valve on the branch directly on the line (as mentioned above) and second valve before the equipment. A trap should be located before the second isolation valve- see Figure 3 below.

If the equipment is isolated temporarily then the local isolation valve can be used but if the equipment needs maintenance or replacing then both valves should be used (double isolation).

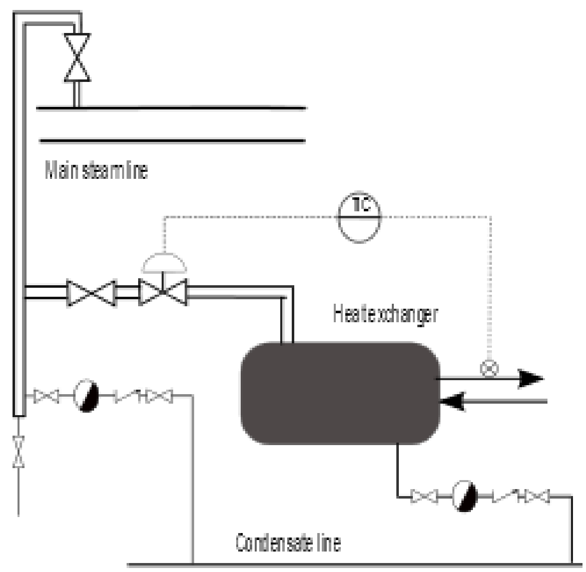

Figure 3 – typical process application

Condensate Return

Ideally all condensate from traps should be returned to the boilerhouse. This is often easier said than done especially on large sites where the steam use can be a long way from the boilerhouse. For small plants there can be a single condensate return line which all traps feed into and this returns to the boilerhouse. The practicality of single condensate return line will also depend on the operating characteristics of the steam users. If there are a number of steam users which can operate at very low pressures e.g. air conditioning heating coils then there could be a problem to raise the condensate into the condensate return line.

A typical ideal arrangement is to have a condensate collection tank for each process area. The condensate from the tanks would be pumped back to the boilerhouse possibly in a common condensate header.

If this system is adopted it is imperative that no traps are fed into the pumped condensate return line. The line will be pressurized by the pumps and can cause a back pressure on the traps. Also a failed mechanical trap will cause a two phase flow in the condensate line which will invariably be designed for single phase condensate flow.

If hydrodynamic traps are used then there is no problem to mix steam traps from different pressures in the same condensate collecting tank. Ideally the condensate collecting tank should be physically located at a low point and all the condensate should discharge down into the tank.

If the condensate return line is at a higher level than the trap then the connection into the line should still be on the top of the line with an isolation valve.

If there is a possibility that steam using equipment will be switched off and the condensate line is either elevated or pressurized then a check valve is required after the steam trap to prevent a back flow of condensate into the equipment.

Figure 3 above shows the typical arrangement for a process heat exchanger. The ideal is to have the condensate return line below the level of the heat exchanger so that the condensate discharging from the steam trap can flow by gravity into the condensate return line. This arrangement would allow the heat exchanger operate down the lowest possible pressure.

In many cases it is not practical to have the condensate return line below the heat exchanger and the condensate return line is positioned some distance above the application. However it is a good idea to minimize as much as possible the elevation of the condensate return line. The higher the condensate return line the higher the minimum pressure in the heat exchanger. If there is a tendency for the heat exchanger to operate at very low pressures e.g. air conditioning heaters, then it maybe that the heat exchanger will be partially flooded if there is too much lift required after the steam trap.

If the trap is a mechanical steam trap then the backing up on condensate in the heat exchanger can cause problems with water hammer in the condensate line due to the intermittent operation of mechanical traps. There is less of a problem with hydrodynamic traps because the flow is continuous so there is less thermal shock.