Flash Steam Recovery from Non-Modulating Steam Applications

With today's energy pricing, a plant's steam/condensate systems can't afford to vent flash steam into the atmosphere. The non-modulating steam system's operational design allows the condensate and flash steam to be recovered in a flash tank system.

This flash steam recovery system differs from a modulating steam system as discussed in Best Practice No. 26.

1.0 Flash Steam Recovery Systems (Non-modulating steam conditions)

Reviews the non-modulating processes

Condensate/flash steam (two-phase flow) discharging from a non-modulating steam system process can be recovered in a flash steam system or high-pressure condensate return system. Non-modulating steam condition means there is no control valve modulating steam flow to the process. If there is a control valve, the steam control valve always maintains a steam pressure to the process above the pressure in the condensate recovery system. A non-modulating process steam system provides a constant steam pressure to the process, thus providing a constant pressure differential across the steam traps or condensate discharge control valve. (Figure 1)

The two-phase flow (flash/condensate) from the process discharge can be directed to the pressurized flash tank for separation. The flash/condensate separation process separates the flash steam and condensate, leaving no entrainment of condensate into the flash steam. The flash steam can then be delivered to a lower-pressure steam line. This method is referred to as a cascading flash steam system. In a high-pressure condensate return system, the percentage of flash steam is greatly reduced by the high pressure in the condensate return line, and typically the flash steam is used for the deaerator steam consumption.

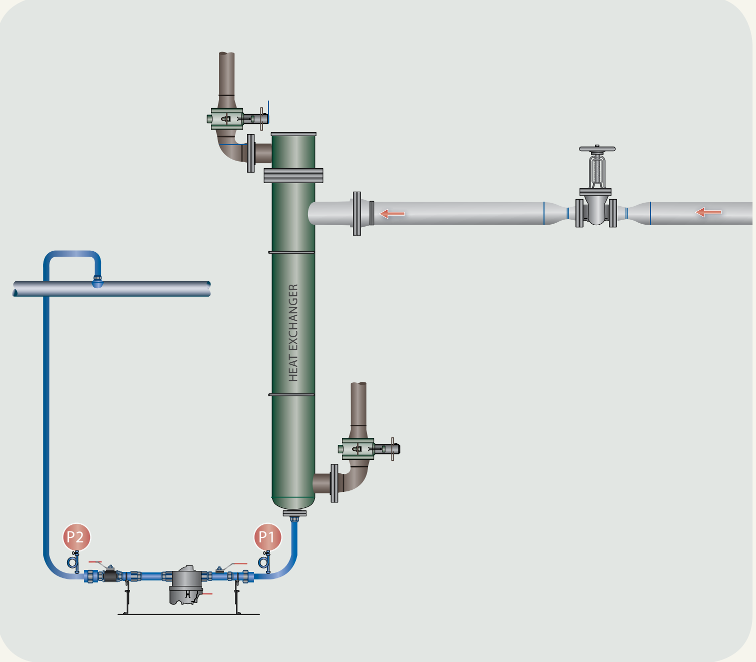

Figure 1

1.1 Examples of Non-Modulating Steam Processes:

- Steam tracing
- Drip leg steam traps
- Unit heaters
- Process heater
- Reboilers
- Corrugators

2.0 Flash Recovery System

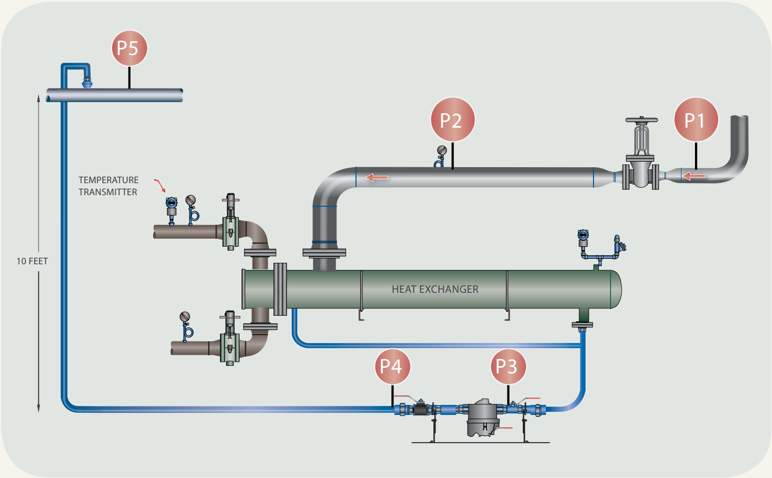

Figure 2

How to recover

The steam systems don't have a modulating steam control valve for the process, or if there is a control valve, the steam control valve always maintains a steam pressure to the process above the pressure in the condensate recovery system. There is always a higher steam pressure to the process than the condensate return line, which will provide a constant pressure differential across the steam traps or condensate control valve. (Figure 2)

With proper sizing and installation of a flash tank, the flash steam may be used for the heat exchanger device to heat air, water, or any other liquid, or it may be used directly in processes with lower-pressure steam requirements. Flash steam can be generated directly by discharging high-pressure condensate to a lower-pressure steam system. This practice is very seldom used in industrial applications. The best practice is to use a flash tank to:

- *a. Separate condensate and flash steam*
- *b. Control the flashing process*
- *c. Allow enough space for flash steam to be released*
- *d. Reduce the velocities of the flash steam to ensure no condensate carryover with the flash steam*

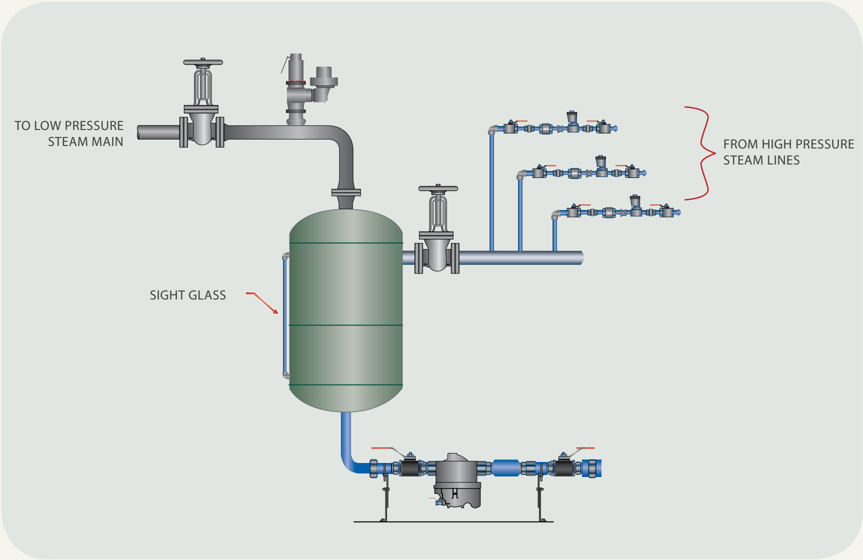

Figure 3

Flash tanks can be mounted either vertically or horizontally, but the vertical arrangement shown in Figure 3 is the preferred method because it provides better separation of steam and condensate and results in the highest possible flash steam quality. The most important dimension in the design of vertical flash tanks is the internal diameter, which must be large enough to ensure a low discharge velocity of flash steam to minimize condensate carryover. Also, the tank sizing requires sufficient surface area for the release of the flash steam from the condensate. If the condensate return line is properly sized, the condensate will release the flash steam in the condensate line; therefore, the flash tank becomes a separator tank (flash and condensate). Outlet velocities from the flash tank should not exceed 3,000 feet per minute. Unfortunately, most condensate lines found in industrial operations are not properly sized; therefore, the flash tank has to provide the proper area for the condensate to release the flash steam.

In Figure 3, the flash steam is being used in a cascade steam system; that is, the flash steam is being delivered to the lower-pressure steam system. The steam demand must always be greater than the amount of flash steam available to prevent the low-pressure steam system from becoming over pressurized. A safety relief valve should always be installed at the top of the flash tank or steam line piping to preclude an over pressurized situation in the steam line. In a typical cascade flash steam system, the flash steam generated is generally less than the demand for a low-pressure steam system. A pressure-reducing valve or makeup steam valve is added to the system to ensure the low-pressure steam system maintains the correct operating pressure.

A large number of plants do not have a need for low-pressure steam; therefore, the cascade steam system is not a benefit. Another method to recover the flash steam is to use a thermocompressing system. (Figure 4) Thermo-compressing takes the low-pressure steam and produces a higher, usable steam pressure. The thermocompressor is a very simple device that has been in existence for many years. It has a nozzle where high-pressure steam is accelerated into a high-velocity fluid. The high velocity entrains the low-pressure steam from the flash tank by momentum transfer and then recompresses it in a divergent venture. The result is an intermediate steam pressure that is useful to the plant operation.

Flash tanks are considered pressure vessels and must be constructed in accordance with ASME and local codes.

3.0 Road Map:

1. Define all the non-modulating steam processes.
2. Determine whether cascade or thermocompressing is the best method.
3. Recover the flash steam.

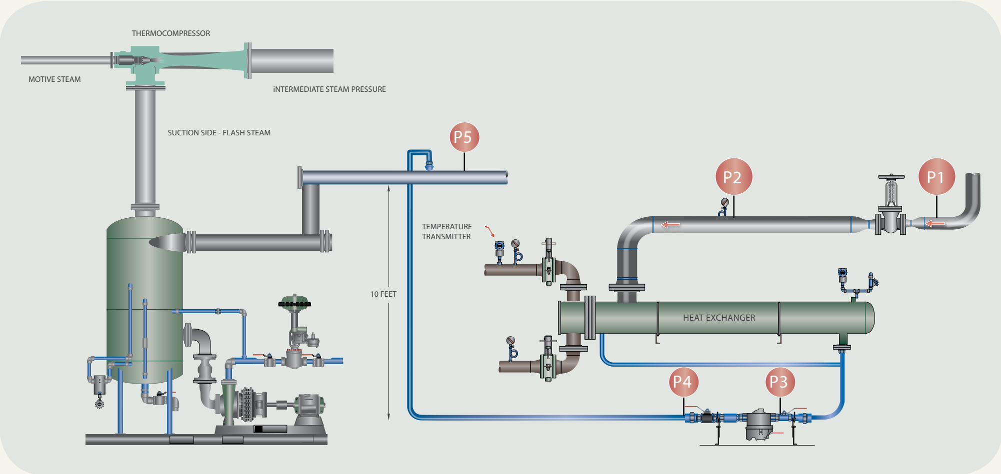

Figure 4

4.0 Steps to Designing a Flash Tank

1. Calculate the amount of condensate entering the flash tank.

The amount of condensate entering the tank will be the sum of the steam-consuming capacity of all equipment discharging into the condensate return line that is going to the flash tank. This could be only one component or multiple components.

Example: 25,000 lbs per hour (11.3 ton/hr)

2. Determine the process pressure and flash tank pressure.

Example: Process pressure: 150 psig (10.3 bar)
Flash tank pressure: 10 psig (.7 bar)

3. Calculate the condensate that flashes to steam.

Formula:

$$\%\ \text{Flash} = \frac{\text{High "150 psig (10.3 bar)" Sensible Heat } (-) \text{ Low "10 psig (.7 bar)" Sensible Heat}}{\text{Low "10 psig (.7 bar)" Latent Heat}}$$

$$\%\ \text{Flash} = \frac{338.4 \text{ Btu's @ "150 psig (10.3 bar)"} - 207.9 \text{ Btu's @ "10 psig (.7 bar)"}}{952.6 \text{ Btu's @ "10 psig (.7 bar)"}}$$

Example:

$$13.7\ \% = \frac{338.4 - 207.9 \text{ Btu's}}{952.6 \text{ Btu's}}$$

25,000 lbs per hour (11.3 ton/hr) divided by 13.7% = 3,425 lbs/hr (1.7 ton/hr) Flash Steam

4. Size the steam space

If the condensate line is adequately sized; a high percentage of the steam flashing will occur in the condensate line. So, the steam section of the tank need only be sized to take care of the instantaneous flash. Unfortunately, a high percentage of the condensate lines in the industrial plants are undersized for a number of reasons.

Therefore, the following example should be followed to size the steam section of the flash tank.

$$\frac{3{,}425 \text{ lbs./hr} \times 16.5 \text{ (specific volume of steam @ 10 psig) cu. ft./lb.}}{3600 \text{ sec./hr}} = 15.7 \text{ cu. ft./sec. Flashing}$$

To accommodate steam system malfunctions which introduce additional steam to the system, to add a sizing factor of 1.5.

1.5 x 15.7 cu. ft./sec. = 23.55 cu. Ft.

42 in. Tank is capable of 9.65 cu. ft per 12 in.; – therefore, 23.55 divided by 9.65* 12 in. = 29.3 inches

Answer: 29.3 in. length on a 42 in. diameter tank for the steam section

5. **Size the condensate section**

25,000 lbs per hour (total volume) - 3,425 lbs/hr (flash steam volume) = 21,575 lbs/hr liquid or condensate
21,575 divided by 8.33 lb/gal = 2,590 gallons/hour
2,590 divided by 60 = 43.2 gpm (gallons per minute)

To provide stability of flow from the flash tank, at least five minutes of water should be provided.
43.2 gpm x 5 minutes = 216 gallons
42 in. tank gallon capacity per 12 in. = 72 gal.

216 divided by 72* 12 in. = 36 in.

Answer: 36 in. length on a 42 in. diameter tank for the condensate section

6. **Size the tank**

29.3 in. length on a 42 in. diameter tank for the steam section
36 in. length on a 42 in. diameter tank for the condensate section

65.3 in. length on 42 in. diameter tank

5.44 feet length on 42 in. diameter tank

7. **Size the flash vent line off tank**

Tank outlet flash steam velocities should not exceed 3,000 feet per minute.

$$\text{V (fpm)} = \frac{2.4 \times \text{Flow (lb/hr)} \times v \text{ (cu ft/lb)}}{\text{A (sq in)}}$$

$$\text{V (fpm)} = \frac{2.4 \times 3{,}425 \text{ (flash steam)} \times v\ 16.5 \quad = \quad \mathbf{2712.6\ fpm}}{50 \text{ (8'' vent line)}}$$