Correct Steam Separation to Ensure Proper Steam Quality

The efficiency of any steam system depends largely on the quality of steam that is delivered to the process equipment. All end users or process applications require the steam quality be at or near 100%; anything less will negatively affect the process. A steam separator, sometimes called a moisture separator, improves steam quality by separating water droplets from steam.

Definition of Steam Quality
Steam quality is the proportion of saturated steam (vapor) in a saturated condensate liquid/steam mixture. A steam quality of 0 indicates 100% liquid (condensate), while a steam quality of 100 indicates 100% steam (vapor). For example, one pound of steam with 95% steam and 5% percent liquid entrainment has a steam quality of 95. The measurements needed to obtain a steam quality measurement are temperature, pressure, and entrained liquid content.

A high percentage (88% or more) of industrial steam systems use saturated steam for process applications. Saturated steam (meaning steam that is saturated with energy) is completely gaseous and contains no liquid.

High steam quality is needed to minimize equipment issues and sustain/improve efficiency. In a steam turbine operation, for example, entrained moisture will erode the internal parts. In heat-transfer units, entrained moisture will increase the condensate film on the heat-transfer surface which can reduce heat-transfer performance efficiency by 14% or more.

When Are Steam Separators Unnecessary?
Steam separators are rarely required when a steam system is properly designed, specified, installed, operated, and maintained. The “ideal” steam system that doesn’t require a steam separator will have the following:

1. Proper steam-line sizing
2. Steam line velocities below 10,000 fpm
3. Insulated steam lines and components, with the insulation being 95% efficient
4. Proper steam line drip leg steam trap stations
5. Proper standard operating procedures in use throughout the plant

A properly sized steam line may operate like a gravity separator. Here, proper steam velocities will allow the moisture to drop out of the steam vapor to the bottom of the pipe, where a functional drip leg steam trap station will remove it.

When Are Steam Separators Required?
But, there are cases where proper steam system design parameters and procedures are not followed and the steam has moisture entrainment. Here, a separation device needs to be installed because the presence of water in steam can, and will, cause problems, including:

1. Wiredrawing
2. Corrosion
3. Erratic operation of control valves and flow meters
4. Failure of system components
5. Reduced efficiency
6. Lower productivity

All steam separators produce a pressure drop across the device. The design of the separator determines the amount of pressure drop that occurs in the steam line. Therefore, a steam separator should only be used where necessary because a pressure drop in the steam system can affect efficiency and end user performance.

Information Needed to Begin Proper Selection

A steam line separator takes advantage of the inertia difference between condensate (liquid) and steam (vapor). The design of the separator will determine the required pressure drop across the separator, and it’s that pressure drop that creates the velocities required to separate the moisture from the steam flow. Here are nine important items to consider when selecting a separator:

1. Maximum steam flow rate
2. Minimum steam flow rate
3. Pressure drop across the separator
4. Steam quality (inlet)
5. Steam quality desired (outlet)
6. Horizontal or vertical installation
7. ASME construction
   a. Maximum steam pressure
   b. Maximum steam temperature
8. Materials of construction
   a. Typically, internal components are constructed of stainless steel
9. Steam trap station installation off the separator

Three Types of Steam Separators

Plant personnel have a choice of steam separator types, each employing a unique design. They include the baffle type, centrifugal type, and mechanical coalescence type. Often, a combination of two different types of separators is used to achieve higher efficiencies.

Type 1 -- Baffle Separator

The baffle-type separator is the simplest to design and manufacture. It consists of one or more internal baffles that redirect the steam in one or more different directions. This redirection of the steam flow allows the heavier condensate droplets to be removed from the steam. The condensate is then removed by a drain device (control valve or steam trap station). The efficiency of the baffle separator is lower than the other two types.

Type 2 -- Centrifugal Separator

Here the entrained condensate is separated from the steam flow by means of centrifugal force. The steam enters the separator and is directed into a centrifugal steam-flow pattern that creates a force resembling a spinning cyclone. The inertia of the heavier entrained
condensate in the steam causes the condensate to be expelled to the wall of the separator then drained by gravity to the condensate collection point.

Centrifugal separators are not designed to be sized according to the size of the steam line. It is essential that accurate steam flows and pressures be obtained for proper centrifugal separator sizing. The steam pressure drop across this type of separator tends to be larger than in the other types because the velocity required for operation (generating the centrifugal force) is larger. Less centrifugal action will decrease the performance or efficiency of this separator. During the selection process, the plant should determine the effect a pressure drop might have on end users.

**Type 3 -- Mechanical Coalescing Separator**

The coalescing steam separator uses a two-stage separation process.

The first stage features a coalescing effect, where the steam is introduced to a stainless steel mesh that makes the steam flow change directions. Fine water particles combine (increasing their size and mass), fall by gravity to the bottom of the separator, and are removed through a drain device (control valve or steam trap station). Any droplets that are not removed are directed to the second stage, which is the centrifugal stage.

The second stage uses profiled deflector blading, which imparts powerful centrifugal forces to separate all the condensate droplets from the steam flow. The condensate exits the separator from a volute contoured drain and is removed by a drain device (control valve or steam trap station). The result is high steam quality.

The mechanical coalescing separator is the preferred method of steam separation because the unit is not flow dependent and has a high efficiency factor. The pressure drop is typically much less than with the centrifugal separator.