Steam Quality – Plant Operations Require A High Steam Quality

What is Steam Quality?

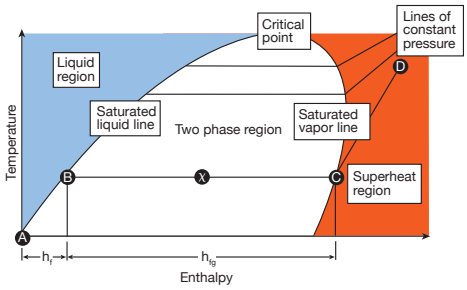
Steam quality is the proportion of saturated steam (vapor) in a saturated condensate (liquid)/ steam (vapor) mixture. A steam quality of 0 indicates 100 % liquid, (condensate) while a steam quality of 100 indicates 100 % steam. One (1) lb of steam with 95 % steam and 5 % percent of liquid entrainment has a steam quality of 0.95.

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.

The boiler operation uses chemical energy from a fuel source to deliver energy to the boiler water. Inside the boiler, liquid gains energy from the combustion process and changes state into saturated steam. Water enters the boiler at point A and the water gains sensible energy (hf) to point B. The change of state is referenced as point B on the chart. As the saturated steam acquires more energy from the boiler combustion process, the steam achieves a high quality, (moving left to right) as represented on the chart, points B to C. The increase in energy gained by the steam from points C to D goes toward the superheat of the vapor.

There exists a directly proportional relationship between temperature and pressure in saturated steam. That is, as the temperature increases so does the pressure. Illustrated by the "Lines of constant pressure" on the graph, more sensible energy (hf) is needed to for water to transition from point A to point B and become a vapor.

When steam enters the process, the energy level goes from right to left as the process absorbs the energy from the steam.



Why Steam Quality is Important

Today's manufacturing techniques of heat transfer, control, and standards are all dedicated to improving and providing the highest quality product to the market place. To attain the highest quality, each manufactured component of the final product is inspected repeatedly, and measured for its quality to ensure that it meets the manufacturer's and consumer's expectations.

Steam is a vital and critical part in producing the final product; therefore steam quality should be one of the main measurable points in producing a product in today's manufacturing facility. All heat transfer components (shell/tube, plate/frame, plate/coil, tracing, etc.) base performance calculations on 100 % steam quality, unless the manufacturer is informed by the end user that the steam quality is lower than 100 %.

Unfortunately, steam quality is typically not monitored closely and is assumed to be 100 % quality. Therefore, issues that arise from poor steam quality are blamed on some other item in the system. Based on field documentation by Swagelok Energy Advisors Inc., a high percentage of steam systems are operating below acceptable steam quality levels.

What are the effects of Steam Quality?

Low steam quality affects steam system operations in many ways.

1. Reduced heat transfer efficiency:
   The major problem with low steam quality is the affect on the heat transfer equipment and process. In some cases, low steam quality can reduce heat transfer efficiency by more than 65 %. The liquid entrained in the steam has sensible energy (16 % estimated – varies with pressure) which has a significantly lower amount of energy than the steam vapor's latent energy (94 %). Therefore, less usable energy is being delivered to the steam process equipment.

   Also, the additional liquid (low steam quality) collects on the wetted surface of the heat exchanger causing an additional build up of a liquid which reduces the ability of the steam's latent energy to be transfer to the product.

2. Premature Valve Failure:
   Liquid passing through steam control valves will erode the internals of the valves causing premature failure.

3. Internal Turbine Component Failures:
   Liquid introduced with the steam in a saturated turbine operation will reduce the life expectancy of the internal components.

4. Waterhammer
   Steam systems are usually not designed to accommodate the additional liquid in steam. Additional liquid creates the chance for waterhammer to occur. Waterhammer is a safety issue, and may cause premature failure in the steam system.

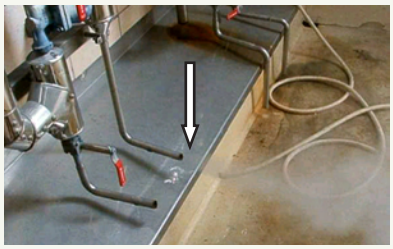
How is Steam Quality measured?

A true measurement of steam quality can be obtained from the use of a throttling calorimeter and Ganapathy's steam plant calculations. Unfortunately, most industrial plants do not have the luxury or capability of doing the testing.

Another way to measure steam quality is relying on the basics of steam. Saturated steam is a dry invisible gas and only becomes visible with the entrained air or liquid. Therefore, opening a steam valve and allowing steam to be released into the atmosphere provides an estimate of the steam quality in the system.

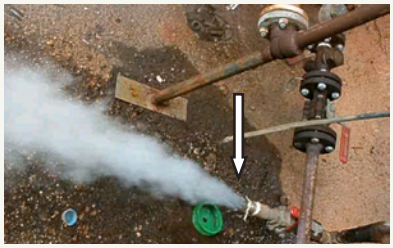
Examples:

Picture number 1 indicates an acceptable steam quality. The discharge from the valve through the tube is almost invisible.



Picture number 2 shows the discharge from the valve off the steam line to be very visible with liquid being discharged with the steam vapor.

Steam quality is not acceptable for the process.



Picture number 3 shows the discharge from the valve off the steam line to be very visible with liquid being discharged with the steam vapor.

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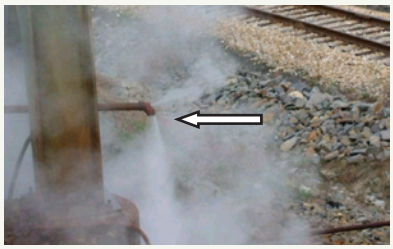

Roadmap to ensure a High Steam Quality.

The following items will ensure a high steam quality.

1.) Insulate steam lines and components.
2.) Establish proper steam line drip leg steam trap stations.
3.) Develop proper startup procedures.
4.) Implement a proactive boiler chemical program.
5.) Implement a proactive steam system management program.
6.) Install steam separators (mechanical coalescing design), if needed.