MP&M Compliance Using a Patented Vapor Compression Flash Evaporation System

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A patented vapor compression flash evaporation process can be used to evaporate and then condense clean water from wastewater contaminated with metals and oils. Metals and oils are concentrated to a ratio of 20 to 100:1. In other words, the contaminants are concentrated to 1/20th to 1/100th of the treated volume of wastewater. At the same time, oils can be concentrated for recovery to over 80%. The balance is clean water effluent. Metals in the effluent have proven to be at "non-detect" levels. Effluent can be reused as boiler feed or cooling water makeup, process water or discharged to the local POTW. Currently, four such systems operating at MP&M-designated plants are producing effluents with "non-detect" levels of heavy metals, while at the same time concentrating oils for recovery. Case studies will be presented.

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Overview

MP&M compliance requires facilities under this rule to treat their wastewater to achieve heavy metal contaminant levels to generally less than 0.5 ppm. Each metal has its own limit with some as low as 0.03 ppm (lead). Traditionally, wastewater treatment to remove metals involves raising the pH of the wastewater to the point of minimum solubility with some form of hydroxide (NaOH, KOH, etc.) and thereby precipitating metal hydroxides prior to filtration. In some cases sulfide chemistry is also used. When discharge limits were higher (typically by an order of magnitude), hydroxide precipitation was effective. With the discharge limits being lowered to generally less than 0.5 ppm, precipitation treatments will not yield consistent results, even when followed by microfiltration.

That leaves two processes that will achieve the desired results. The first is reverse osmosis and the second is evaporation. Reverse osmosis will remove heavy metals from the wastewater to the desired level, but requires pretreatment steps to remove suspended solids and oils. Additionally, large volumes of concentrated wastewater are generated. Evaporation techniques will also yield the desired level of treatment while generating significantly less concentrated wastewater. Conventional single-stage or 2-stage evaporation processes have high operating costs, as they do not recover heat efficiently. Typical operating costs are in the $0.04-0.07 per feed gallon range.

A patented vapor compression flash evaporation system* (hereinafter called the system) is well suited to ensure MP&M compliance at a low operating cost ranging from $0.0075-0.015 per feed gallon. Additionally, the system does not require chemistry, pretreatment steps or a full-time operator. Labor required is 2-4 hours per week for preventative maintenance.

The system effluent is, in essence, demineralized water having “non-detect” levels of heavy metals. Most of the time the effluent is suitable for reuse as boiler feed makeup, process water or cooling tower makeup. It can also be discharged to the local POTW. The concentrate from the system can be disposed of in several ways depending on the nature of the contaminants present. If oil is present, the wastewater will be concentrated until the oil is in the 60-80% range. It can then be incorporated in a fuels blending program or recovered. If oils are not present, then the concentrate would have to be disposed of in accordance with state and federal regulations.

System process description

The system bases its operation on the combination of mechanical vapor recompression and externally mounted heat exchangers, which are designed with self-cleaning turbulent flows. Active boiling only occurs in a separate disengagement or flash vessel. The result is a system (vapor compression flash evaporation), which can concentrate further than conventional evaporators at lower operating costs. It is also a system that has proven to be competitive with conventional physical/chemical treatment trains and membrane systems without the maintenance and operator attention required for them. An evaporation process, long accepted as a technically sound solution to oils and metals removal from wastewater, has evolved to compete with conventional processes without the problems associated with fluctuating contaminant loadings. The process diagram is depicted on the following page.

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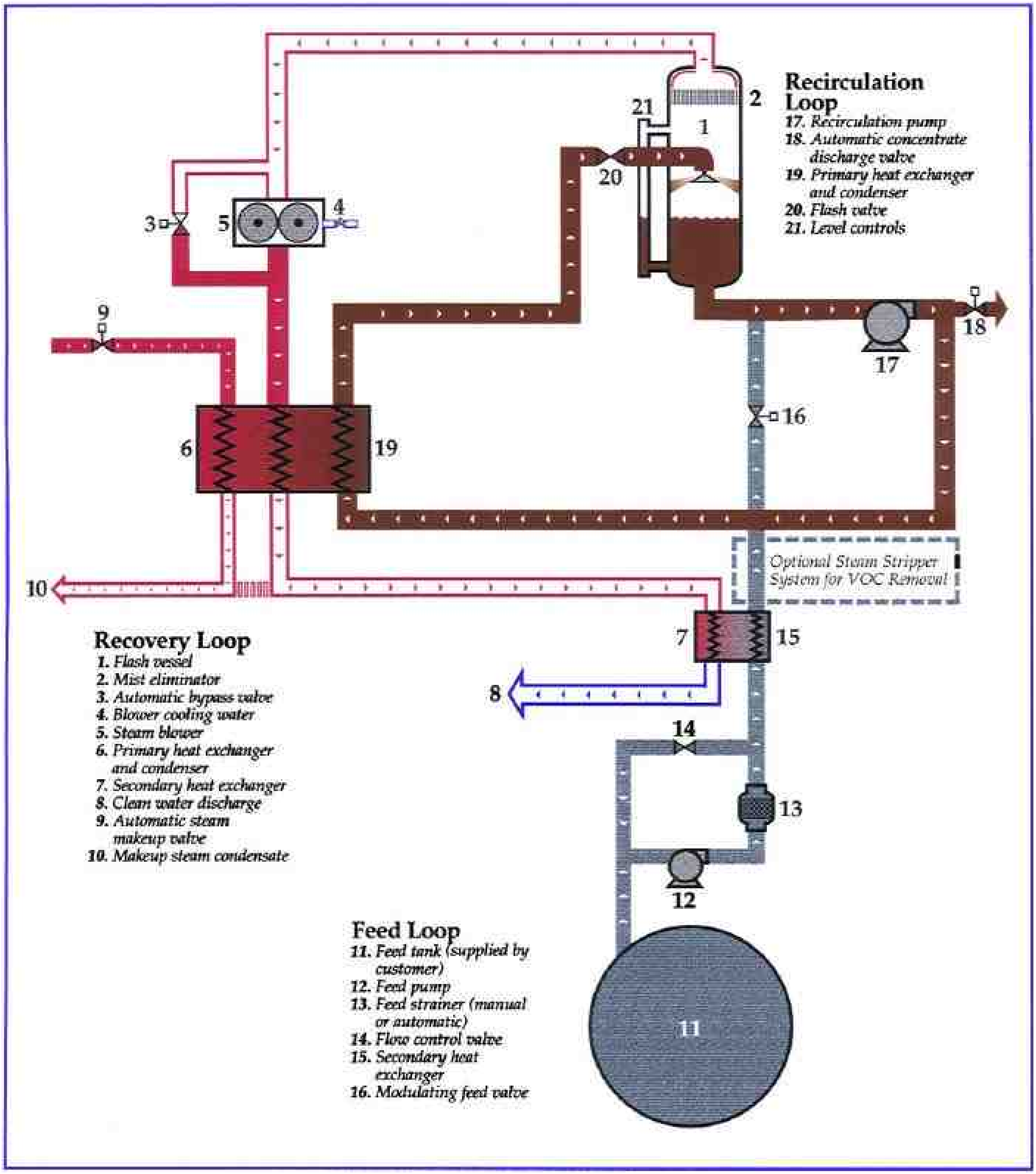

Schematic of vapor compression flash evaporation system.

Wastewater is pumped from a storage tank thru a filtration device. The filtration device can be either a manual basket strainer or an automated filter. From the filtration device, the wastewater enters a secondary heat exchanger (plate and frame or shell and tube) for preheating prior to entering the primary recirculation loop. Within the primary recirculation loop, the temperature is elevated to create separation of steam generated from the liquid. The wastewater is continuously pumped out of a “flash” vessel thru a primary heat exchanger (plate and frame) and back into the vessel across a flash diffuser located above the liquid level in the vessel. Flows and velocities within the primary recirculation loop are designed to create turbulent self-cleaning action within the primary heat exchanger. The system is also designed to eliminate evaporation within the primary heat exchanger and create a steam separation or “flash” zone within the vessel only.

Steam generated from the boiling wastewater is recycled and the heat recovered by evacuating the steam off the flash vessel thru a blower. The blower imparts a pressure and temperature rise to the steam. The steam is blown back into the primary heat exchanger where it transfers all of its latent heat of vaporization and completely condenses. Pressures and temperatures within the flash vessel and primary heat exchanger are automatically controlled.

Steam that is evacuated from the flash vessel passes thru a mist eliminator. Below the mist eliminator is a spool section, which confines the boiling pool and also allows for enough headspace to disengage froth or foam, developed during active boiling, from the liberated steam.

The condensate from the primary heat exchanger is pressurized by the blower and then passes thru a secondary or pre-heat exchanger. The secondary exchanger is used to recover heat from the condensate by preheating the incoming wastewater. Condensate, now effluent, exits the system after the secondary heat exchanger at approximately 95-100 degrees Fahrenheit.

Heat losses of 2-5% are expected. Make-up heat for heat losses and heat required for initial start-up need to be supplied in the form of low pressure (15-25 PSIG) steam. Make-up steam is introduced thru a control valve, which is automated via a temperature controller, and introduced indirectly into the primary exchanger.

The wastewater feed stream excess (the feed pump is sized at 1.25 times the feed rate) is continuously recirculated back to the head of the feed pump. The feed rate to the system is controlled to match the evaporation rate via level controls housed in an external standpipe attached to the flash vessel. The level controls are used to measure the liquid level within the flash vessel, indicate high and low level alarm functions, and automatically shut the system down should an alarm function occur and to control the feed/recirculation modulating valve. As the wastewater evaporates, the liquid level drops. The modulating valve controls the quantity of feed entering the recirculation loop.

Contaminants are continuously recirculated and concentrated within the vapor compression flash evaporation system. These concentrates are periodically purged from the system by actuating a discharge valve located on the primary recirculation loop. The valve is controlled from a timer, within the PLC, set to achieve the ratio of concentration relative to the volume required for the application. As the valve opens, the recirculation pump pumps concentrates from the system. The concentrate valve can also be controlled automatically via on-line concentrate analytical devices depending on the application.

A proprietary stripper system can be provided to remove contaminant compounds (VOC’s) that have a boiling point equal to or less than water. That will ensure the ability to meet the oil and grease (O&G) requirement of the MP&M regulation.

The system is designed for unattended operation and controlled with a programmable logic controller (PLC).

Testing

Bench testing is advisable on all applications and mandatory on some applications. In addition to testing on the bench, thermal studies can be conducted to determine heat and mass transfer properties. Bench testing of a representative sample will determine process feasibility, concentration ratio, effluent quality and concentrate physical properties (viscosity, specific gravity, % oil, etc.).

Case Histories

1) Tier I supplier to the automotive industry. Plant manufactures metal parts. Wastewater contains oil, coolant compounds and heavy metals.
   - Flow – 20,000 GPD
   - Influent – 2% oils, coolant compounds and heavy metals
   - Concentration ratio – 40/1
   - Concentrate volume – 500 GPD
   - Effluent – discharged to POTW – below detectable limits on heavy metals
   - Energy operating cost - $0.01/feed gallon
   - Concentrate post treated to yield 90%+ oil and collected by an oil recycler

2) Manufacturer of forklifts. Contaminants are oils, heavy metals, coolant compounds and grinding swarf.
   - Flow – 6,000 GPD
   - Influent – 1-4% oils, coolant compounds, heavy metals and grinding swarf.
   - Concentration ratio – 20/1
   - Concentrate volume – 300 GPD
   - Effluent – discharged to POTW – below detectable limits on heavy metals
   - Energy operating costs - $0.01/feed gallon
   - Concentrate post treated and collected by an oil recycler

Summary

The vapor compression flash evaporation system will enable all MP&M designated plants to meet compliance with effluent heavy metals below detection limits. Plants with oil and heavy metals can possibly go zero discharge with effluent reuse and concentrate recycling. Operating costs are minimal at $0.01 per feed gallon and operator attention is low at 2-4 hours per week.