BEST PRACTICE NO. 72

# WHY IT IS NECESSARY TO RECOVER CONDENSATE

## 1. CONDENSATE

Steam consists of two types of energy: latent and sensible energy. When steam is supplied to a process application (heat exchanger, coil, tracer, etc.), the steam vapor releases the latent energy to the process fluid and condenses to a liquid better known as condensate. The condensate contains the sensible energy from the steam vapor. The condensate can contain as much as 16% of the total energy in the steam vapor, depending on the steam pressures.

*Figure 1: New Pressurized Condensate Tank System*

Unfortunately, a large percentage of industrial plants waste the condensate from the steam system and do not proactively return condensate to the boiler plant. Condensate being returned is still losing thermal energy due to uninsulated tanks, condensate pipe, valves, and fittings. The best practice to prevent thermal energy losses is to insulate all devices in the condensate system

One of the highest returns on investment is to return condensate to the boiler plant operation. As fuel costs continue to rise, it is imperative to focus on recovering condensate in all industrial steam operations.

Condensate contains a large amount of energy transferred during the combustion process in the boiler. Therefore, condensate needs to be returned to the boiler to:

- Improve energy efficiency
- Reduce the following:
- Chemical costs
- Make-up water costs
- Make-up water preparation costs
- Boiler blowdown
- Emissions
- Improve the steam system thermal cycle
- Efficiency

If condensate is not returned to the boiler plant, the steam system has to make up the loss with cold, untreated, raw water that has to be prepared for the boiler operation. Preparing the make-up water has a cost, and the make-up water will contain a substantially lower BTU content that has to be raised to the temperatures in the deaerator or atmospheric feedwater heater. The additional energy to increase the make-up temperature adds even more cost to the steam operation.

The make-up water has to be chemically prepared for the boiler operation, which further increases costs. Make-up water introduced into the boiler will increase the boiler blowdown to offset the additional minerals added to the boiler.

# 2. CONDENSATE RETURN BENCHMARK

With today's high energy cost, the plant must return the highest percentage of condensate possible for reuse in the boiler.

The benchmark for the optimal condensate return percentage is 90%. This benchmark is possible if the plant does not require direct steam injection for process applications.

## 2.1. Justification to Return Condensate

**Below is a example of a typical operating steam and condensate system with a capacity of 5,800 lbs. per hour steam to a process. The condensate loss is calculated at $ 73,078.00 dollars per year.**

| Condensate Energy losses | | | | | |
|---|---|---|---|---|---|
| Condensate System Operation | | Gravity System | | | |
| Condensate Tank Operation | | Vented to Atmosphere | | | |
| Lbs. of Condensate-to-Condensate Tank | 5800 | Cost of Steam Energy per MMBtu | | | $9.74 |
| Total Flash Quantity | 521.3 | lbs./Hr. | 505,727 | Btu's/Hr. | |
| Total Quantity of condensate | 5278.7 | lbs./Hr. | 950,945 | Btu's/Hr. | |
| Cost Per Hour (loss condensate) | $9.26 | Steam System Pressure | | 50 | Psig |
| Number of Hours | 7890 | Estimated | | | |
| **Yearly Cost in Energy** | **$73,078.81** | | | | |

The potential savings are based on the amount of energy required to elevate the make-up water energy content (sensible energy) to the energy level of the condensate being returned in a gravity-designed conde nsate system. The calculation does not take into account the savings from chemicals, water, and sewer costs. It also does not consider the effect of bringing back the condensate at higher pressures, resulting in greater savings (See Best Practice 8: High-Pressure Condensate Return Systems).

The above is calculated with no condensate being returned to the boiler, but most industrial plants return at least a small percentage of condensate. Each plant should evaluate the cost of failing to return condensate and establish a roadmap for returning condensate.

# 3. REASONS TO RETURN CONDENSATE

There are many reasons to return condensate from the plant operation.

## 3.1. Reduce Chemical Cost

If condensate is returned, then the need for make-up water is reduced. Lowering the quantity of required make-up water will result in lower requirements for boiler chemicals.

## 3.2. Reduce Make-Up Water Costs

Water costs are rising everywhere, and a high percentage of condensate return will reduce the total make-up water costs.

## 3.3. Reduce Make-Up Water Preparation Cost

The make-up water needs to be prepared for the boiler operation by using water softeners, reverse osmosis, or some other means. Each of these means adds cost to the overall boiler operation.

## 3.4. Reduce Boiler Blowdown

Reducing the quantity of make-up water, which has minerals in the fluid, will reduce surface or bottom blowdown requirements for the boiler.

# 4. WHAT PREVENTS THE CONDENSATE ENERGY FROM BEING RETURNED?

**Plants must understand the issues that prevent the condensate from being returned to the boiler plant so they can choose the right corrective actions.**

## 4.1. Pumping Condensate

It is necessary to select the correct condensate pumps with the proper net positive suction head (NPSH). Several condensate pumping units can only handle condensate temperatures of less than 180°F. Condensate temperatures will be close to the atmospheric saturation temperature of steam, 212°F, and inferior condensate pumps (180°F limit) will have premature failures. Failing to design condensate tanks with the proper NPSH will result in pump cavitation and damage to the seals and impeller in a short period. During the condensate unit failure mode, condensate is allowed to flow to drain and lost.

Therefore, condensate pumps must have the proper NPSH design to pump condensate at 211.9°F.

## 4.2. Steam Trap Issues

The lack of a proper steam trap management program will lead to steam trap failures from undersizing, oversizing, improper installation, water hammer, and other negative operational issues. All too often, plants opt for the short-term solution of allowing condensate to flow to a drainage system. Many steam trap installations open drain valves to remove the condensate from the process, which resolves the steam trap issue and ensures the process is achieving proper temperatures.

## 4.3. Condensate Line Corrosion

Condensate systems experience two types of corrosion, oxygen and carbonic acid, that attack condensate components.

The highest concentration of carbonic acid is in condensate return lines because carbon dioxide dissolves in cooling condensate. The majority of condensate lines are installed with schedule 80 steel pipe and threaded connections. The steel pipe and components will deteriorate from condensate corrosion, but the pipe threads are typically more susceptible to deterioration due to corrosion. Plants should use stainless for condensate pipe and valves and avoid threaded connections to slow the effects of corrosion on the system.

## 4.4. Condensate System Insulation

Industrial steam system components must be insulated to ensure the thermal energy in the condensate is not lost. Everything in the condensate system over 140°F should be insulated. Insulation will also help protect personnel from hot condensate system components, thus improving plant safety.

- Condensate lines
- Condensate tanks
- Condensate pumps
- Valves
- Some steam trap types

## 4.5. Leaks

Plants often have leaks from malfunctioning components in the condensate system, which can contribute to condensate loss.

## 4.6. Flash Steam Losses

Flash steam is lost from condensate tank vents that are venting to the atmosphere. We address flash steam losses in Steam Best Practices 7: Flash Steam.

## 4.7. Summary

Condensate is one of the top five items that must be targeted in a steam and condensate system to reduce energy costs and improve reliability.