Auto Blowdown Savings Calculations

For Process Boiler Measure #2 Conductivity-Based Blowdown & Deaerator Settings

Conductivity-Based Blowdown Energy Savings Calculations

Savings were calculated based on the decreased energy loss down the drain due to excessive blowdown.

The energy of the blowdown water was calculated using the following equations:

$$Blowdown\ Energy\ \left(\frac{Btu}{hr}\right) = \dot{m}_{bdn} * (H_{bw} - H_{mw})$$

$\dot{m}_{bdn} = blowdown\ flow\ rate\ in\ (\frac{lbs}{hr})$
$H_{bw} = Enthalpy\ of\ boiler\ water$
$H_{mw} = Enthalpy\ of\ makeup\ water$

The mass flow of the blowdown water was calculated from the cycles of concentration determined by boiler water and feedwater conductivity values:

$$\dot{m}_{bdn} = \frac{Steam\ flow}{(COC-1)}$$

$$COC = \frac{C_b}{C_{fw}}$$

$COC = Cycles\ of\ Concentration$
$C_b = conductivity\ of\ boiler\ water$
$C_{fw} = conductivity\ of\ feedwater$

Assumptions for calculating COC (Cycles of Concentration)

- C_b = 2,500 µΩ
- C_{fw} = 345 µΩ

Automatic blowdown energy was estimated using the same equations with the following change:

- C_b = 3,000 µΩ

Annual Therm Usage = average blowdown energy (Btu/hr) * Hours/100,000/BE

1. BE = boiler efficiency

Savings = Annual Therm Usage with manual blowdown – Annual Therm Usage with automatic blowdown

Assumptions:

Consistent between baseline and measure case:

1. Annual hours of operation: 6,500
2. Condensate conductivity: 20 µΩ
3. Make-up conductivity: 440 µΩ
4. Feed water conductivity: 345 µΩ

Unique to baseline case:
1. Boiler water conductivity setpoint: 2,500 µΩ

Unique to proposed measure case:
1. Boiler water conductivity setpoint: 3,000 µΩ

Deaerator Settings Energy Savings Calculations

To estimate the natural gas savings from improved deaerator control, the CASE team will calculate the mass flow (lbs/hr) of steam lost to over-pressurization when the deaerator setpoint is greater than 5 psig.

$$\frac{(p_1-p_2)}{p_1} < F_\gamma * x_T \rightarrow m_s = 63.3 * C_v * \left(1 - \frac{\frac{p_1-p_2}{p_1}}{3 * F_\gamma * x_T}\right) * \sqrt{(p_1 - p_2) * \rho}$$

$$\frac{(p_1-p_2)}{p_1} \geq F_\gamma * x_T \rightarrow m_s = 0.66 * 63.3 * C_v * \sqrt{F_\gamma * x_T * p_1 * \rho}$$

p_1: Primary Pressure (psia)
p_2: Secondary Pressure (psia)
C_v: Secondary Valve Cv Value (Cv (US))
m_s: Secondary Steam Flow Rate (lb/h)
ρ: Density of steam (lb/ft^3)
F_γ: Specific heat ratio factor (=Specific heat ratio/1.4)
x_T: Pressure differential ratio factor (=0.72)

Assumptions:

Baseline case:
1. Deaerator pressure setpoint: 8 psig

Proposed measure case:
1. Deaerator pressure setpoint: 5 psig

Note: Energy benefits for deaerators set inadvertently under 2 psig are not calculated since this is typically a deaerator issue after installation and they are estimated to make up <5% of newly installed boiler systems.