Calculating and Monitoring Percentage Condensate Return

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Boiler Systems
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The Value of Condensate
Condensate is essentially hot, distilled water. Since it is typically hotter than the makeup water, returning more condensate can significantly reduce fuel requirements. Because properly treated condensate is very pure, returning more improves the feedwater quality. This allows the boiler to be successfully operated with less blowdown, which reduces fuel, water, and treatment costs. The more condensate returned for reuse as boiler feedwater, the lower the operating costs.

The table to the right illustrates how valuable condensate is. It shows the excess fuel and water costs associated with a boiler system returning less than its maximum amount of condensate return. Since condensate is so valuable, it is important to routinely monitor how much is returned. A decline in the condensate return rate indicates previously recovered condensate is being lost and money is being wasted. Possible causes include a leaking heat exchanger, feedwater tank, or condensate receiver.

Calculating the Percentage Condensate Return (%CR)
The %CR is typically defined as condensate flow rate divided by feedwater flow rate. The most practical way to estimate the %CR is to compare the relative chloride, silica, or conductivity levels in the feedwater and makeup water.

\[
%\text{CR} = 1 - \frac{\text{Feedwater Chloride Level}}{\text{Makeup Chloride Level}} \approx 1 - \frac{\text{Feedwater Silica Level}}{\text{Makeup Silica Level}} \approx 1 - \frac{\text{Feedwater Conductivity}}{\text{Makeup Conductivity}}
\]

**Example**
Feedwater Chlorides = 25 ppm    Feedwater Silica = 4 ppm    Feedwater Conductivity = 100 umhos
Makeup Chloride = 100 ppm       Makeup Silica = 16 ppm        Makeup Conductivity = 400 umhos

\[
%\text{CR} = 1 - \frac{25}{100} = 1 - 0.25 = 0.75 = 75\%
\]
By Relative Chloride Levels

\[
%\text{CR} = 1 - \frac{4}{16} = 1 - 0.25 = 0.75 = 75\%
\]
By Relative Silica Levels

\[
%\text{CR} = 1 - \frac{100}{400} = 1 - 0.25 = 0.75 = 75\%
\]
By Relative Conductivity Levels

This calculation is only valid where all condensate is returned to a common feedwater system and is only indicative of operating conditions at the time of testing. Also, the calculated condensate return rate will not be accurate if boiler water carryover is present in the feedwater. In theory, the ratio of each parameter should give the same %CR. However, in practice, one is usually more accurate than the others. For example, the chloride levels are not an especially good indicator if they’re too low for accurate measurement (<10 ppm). Conductivity is not a particularly good indicator where the makeup conductivity is low, the %CR is high, and/or where chemicals are added to the feedwater. The relative silica levels are often the best indicator for determining the %CR, especially if a spectrophotometer is used for testing. However, if the silica levels are too low for accurate measurement with conventional test methods (<2.0 ppm), an ultra low silica test method should be considered. Your water treatment professional can provide advice regarding the best test parameter to use for monitoring the %CR in each situation.

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**High Cost of Lost Condensate**

<table>
<thead>
<tr>
<th>Actual %CR</th>
<th>Target %CR</th>
<th>Excess Annual Fuel Cost</th>
<th>Excess Annual Water Cost</th>
<th>Total Excess Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>85</td>
<td>$112,797</td>
<td>$29,063</td>
<td>$141,861</td>
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<tr>
<td>55</td>
<td>85</td>
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<td>85</td>
<td>$15,917</td>
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<td>$20,047</td>
</tr>
</tbody>
</table>

Based on a 1,000-HP boiler operating at 50% average load, 180°F condensate, $10.00/MCF gas cost, $4.00/Mgal water cost.