Procedure for calculating the target pH for corrosion control with Lime, Soda Ash, or Caustic Soda

In order to calculate the target pH, you need to collect the calcium and total alkalinity number from the latest well pChem and measure and record the pH of the effluent water from the aerator. If the same treatment plant treats more than one well, then it is up to the surveying engineer to decide which well pChem should be used.

The measured and recorded pH of the aerator effluent will be used to calculate the amount of residual CO$_2$ using the following equation:

\[
[CO_2] = \frac{[Alk]}{(3.2 \times 10^{-7}) \times 10^{\text{pH}}}
\]

where
- pH = pH of the aerator effluent
- Alk = Alkalinity (T) from the selected well pChem as CaCO$_3$
- CO$_2$ = concentration of carbon dioxide in mg/L

The $3.2 \times 10^{-7}$ is a calculated constant based on an average temperature (66.5 °F) of the water in the plumbing.

If a residual CO$_2$ is calculated to be less than 10 mg/L from the effluent aerator pH, then the amount of CO$_2$ that must be used in the further calculations is 10. Ideally, aerators are not efficient enough to produce a CO2 residual of less than 10 mg/L.

Next determine the amount of Hardness and/or Alkalinity that is added to the water from the addition of lime, soda ash, or caustic soda using the residual CO$_2$ that was calculated above:

**For lime addition:**

Calcium Hardness added = $1.351 \times [CO_2]$
Alkalinity added = $1.615 \times [CO_2]$

**For soda ash addition:**

Alkalinity added = $2.5 \times [CO_2]$

**For caustic soda addition:**

Alkalinity added = $1.894 \times [CO_2]$
Then take the added Hardness and/or Alkalinity that is calculated above and add it to the Ca+Mg Hardness as CaCO3 and Alkalinity (T) as CaCO3 numbers from the results of an MSDH Physical and Chemical (pChem) report of the raw water from the well and use these values in the equation below to determine the target pH.

Lime adds Calcium Hardness so Total Hardness after lime addition is:

\[
\text{Total Hardness} = \text{Ca+Mg Hardness off the pChem report} + \text{Calcium Hardness added}
\]

Soda Ash and Caustic Soda do not add Calcium Hardness so for treatment with these chemicals the Total Hardness is:

\[
\text{Total Hardness} = \text{Ca+Mg Hardness off the pChem Report}
\]

Lime, Soda Ash, and Caustic Soda (all three chemicals) add Alkalinity to the water when added so the Total Alkalinity after addition is:

\[
\text{Total Alkalinity} = \text{Alkalinity (T) off the pChem Report} + \text{Alkalinity added}
\]

For Total hardness > 10 mg/l as CaCO3

\[
\text{Target pH} = 9.7 + 1.85 - \log[\text{Total hardness}] - \log[\text{Total Alkalinity}]
\]

For Total hardness ≤ 10 mg/l as CaCO3

\[
\text{Target pH} = 9.7 + 1.85 - 1.0 - \log[\text{Total Alkalinity}]
\]

Total Hardness and Alkalinity as CaCO3 after chemical addition
Example Calculation using Lime:

Raw water p-chem:
Ca+Mg Hardness as CaCO3 = 13
Raw CO2 = 56
Total Raw Water alkalinity = 13

Analysis of the aerator effluent by the field engineer is as follows:
pH = 6.3

The treatment plant is using lime for corrosion control treatment

Step one – Calculate the residual CO2

The residual CO2 can be calculated from the following equation using the alkalinity from the pChem and the measured pH of the aerator effluent

\[
[CO_2] = \frac{[Alk]}{(3.2 \times 10^{-7}) \times 10^{pH}} = \frac{13}{(3.2 \times 10^{-7}) (10^{6.3})} = 20.30
\]

Note the significant decrease in the amount of CO2 from what is reported in the well pChem. There was a decrease from 56 to 20.3. Thus from a calculation standpoint, the engineer can see that the aerator is doing its job and removing the CO2.

Step two – Calculate the Calcium hardness and the Alkalinity added to the water after Lime or Soda Ash addition

It is given that this treatment plant is using lime for corrosion control purposes so both Calcium and alkalinity is added to the system and can be calculated from the equations below:

Calcium hardness added = 1.351 x residual CO2 = 1.351 x 20.3 = 40.4
Alkalinity added = 1.615 x residual CO2 = 1.615 x 20.3 = 45.8

Step three - calculate the total calcium hardness after lime and soda ash addition:

Total hardness = raw water Hardness + Ca hardness added from lime addition = 13 + 40.4 = 53.4
Total Alkalinity = raw water alk + Alk added from lime addition = 13 + 45.8 = 58.8

Step 4 - calculate the target pH

Since the total hardness after lime addition > 4 (53.4 > 4), then the following equation is used:

\[
pH = 9.7 + 1.85 - \log[total hardness] - \log[total alkalinity]
\]
\[
pH = 9.7 + 1.85 - \log[53.4] - \log[58.8] = 8.28
\]

Conclusion:

The target pH for this treatment plant while they are using lime for corrosion control is 8.3
Example Calculation using Soda Ash:

Raw water p-chem numbers taken from the above pChem analysis result:
Ca+Mg Hardness as CaCO3 = 13
Raw CO2 = 56
Total Raw Water alkalinity = 13

Analysis of the aerator effluent by the field engineer is as follows:
pH = 6.3

The treatment plant is using soda ash for corrosion control treatment

**Step one – Calculate the residual CO2**

The residual CO2 can be calculated from the following equation using the alkalinity from the pChem and the measured pH of the aerator effluent

\[
[CO_2] = \frac{[Alk]}{(3.2 \times 10^{-7}) \times 10^{\text{pH}}} = \frac{13}{(3.2 \times 10^{-7})(10^{6.3})} = 20.30
\]

Note the significant decrease in the amount of CO2 from what is reported in the well pChem. There was a decrease from 56 to 20.3. Thus from a calculation standpoint, the engineer can see that the aerator is doing its job and removing the CO2.

**Step two – Calculate the Calcium hardness and the Alkalinity added to the water after Lime or Soda Ash addition**

It is given that this treatment plant is using soda ash for corrosion control purposes so only alkalinity is added to the system and can be calculated from the equation below:

Alkalinity added = 2.5 x residual CO2 = 2.5 x 20.3 = 50.75

**Step three - calculate the total calcium hardness after soda ash addition:**

Total hardness = raw water Hardness = Ca+Mg Hardness as CaCO3 = 13
Total Alkalinity = raw water Alk + Alk added from soda ash addition = 13 + 50.75 = 63.75

**Step 4 - calculate the target pH**

Since the total hardness after soda ash addition > 10 (13 > 10), then the following equation is used:

\[
pH = 9.7 + 1.85 - \log[\text{total hardness}] - \log[\text{total alkalinity}] \\
pH = 9.7 + 1.85 - \log[13] - \log[63.75] = 8.63
\]

**Conclusion:**

The target pH for this treatment plant while they are using soda ash for corrosion control is 8.6