3-4. Solubility Product Calculations

To determine the scaling potential, the ion product IP_c of a sparingly soluble salt in the concentrate stream should be compared with the solubility product K_{sp} of the salt under conditions in the concentrate stream (K_{sp} is a function of temperature and ionic strength). If $IP_c < K_{sp}$, no scale control is necessary.

The concentration of ion species in the concentrate stream is usually not known unless measured experimentally, but can easily be estimated from the concentration in the feed stream by multiplication with the concentration factor $CF = \frac{1}{1-Y}$. Where Y is fraction of recovery ratio (expressed as a decimal).

The ionic strength of the feed water is :

$$I_f = \frac{1}{2}\sum (m_i \times Z_i^{\,2})$$

Where m_i = molar concentration of ion i (mol/kg)
Z_i = ionic charge of ion i

Where the water analysis is not given in molar concentrations, the conversion is as follows :

$$m_i = \frac{1000 \times C_i}{MW_i}$$

where C_i = concentration of ion i in mg/L
MW_i = molecular weight of ion i

The ionic strength I_c of the concentrate stream is obtained from :

$$I_c = I_f \times \frac{1}{1-Y}$$

With the ionic strength of the concentrate stream, the solubility product K_{sp} of the sparingly soluble salt can be obtained.

To make sure that scaling will not occur, the IP_c for $CaSO_4$, $BaSO_4$, $SrSO_4$ and CaF_2 should be less than 0.8 K_{sp} of the corresponding salts, respectively. If $IP_c > 0.8K_{sp}$, one of the scale preventing methods discussed in the previous section must be used.

If proper scale inhibitors are used, IP_c could be greater than K_{sp} as shown in the following equation.

$IP_c \leq 2.0\ K_{sp}$ for $CaSO_4$ if PAA or organophosphonates are employed
$IP_c \leq 1.5\ K_{sp}$ for $CaSO_4$ if SHMP is used
$IP_c \leq 50\ K_{sp}$ for $BaSO_4$
$IP_c \leq 10\ K_{sp}$ for $SrSO_4$
$IP_c \leq 100\ K_{sp}$ for CaF_2

Barium sulfate is the most insoluble of all alkaline-earth sulfates. In most natural waters, barium is present at a level close to precipitation in the concentrate stream. The critical feed concentration of $BaSO_4$ may be as low as 15 μg/L in sea waters, 5 μg /L in brackish waters or even 2 μg/L if sulfuric acid is added to brackish waters.