PREDICTING SCALE FORMATION

Precipitation of soluble salts leads to scale formation. As scale forming ions concentrate within the flow passages of RO systems, a point may be reached in which the solubility of one or more of these salts is exceeded.

Fortunately, calculation procedures exist for predicting the likelihood of scale formation.

Use of these predictors depends upon an up-to-date water analysis and knowledge of system design parameters. At a minimum, the water analysis must include the
following parameters:

Aluminum	Potassium
Barium	pH
Calcium	P and Mo alkalinity
Chloride	Silica
Fluoride	Sodium
Iron	Strontium
Magnesium	Sulfate
Manganese	Temperature
Phosphate	TDS

While the monovalent ions listed do not enter directly into
precipitation reactions, they do contribute to the total ionic strength of the feed water, and the solubility of virtually all of the scale formers is a function of ionic strength.

Since the ions contained in the feedwater concentrate through the RO system, the point of maximum scale potential is the concentrate stream. Antiscalant dosage is therefore based upon the mineral analysis at this point, which is calculated from the feedwater analysis and the system recovery factor.

In general, the concentrate value for any individual ion is calculated by the following equation:

$$Cbi = \frac{(Cfi - SP*Cfi)}{(1-R)}$$

Where,

Cfi = Concentration of ion in the feedstream.

Cbi = Concentration of ion in the concentrate stream.

SP = Salt passage through the membrane of ion as a decimal.

R = System recovery as a decimal.

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Calcium carbonate scale potential:

Calcium carbonate scale potential is generally based upon the Langelier Saturation Index (LSI) when the TDS of the concentrate stream is below about 6000 ppm. Above 6000 ppm an extension of the LSI known as the Stiff Davis Index is generally applied.

It is beyond the scope of this technical bulletin to give details on how these indices are calculated, but both depend upon the calculation of a saturation pH (pH_s). For given values of temperature, TDS, calcium, and alkalinity, saturation pH is defined as that pH in which calcium carbonate just becomes saturated. LSI or Stiff Davis index is LSI or Stiff Davis Index = Actual pH - pH_s.

When the LSI or Stiff Davis Index is positive, it indicates a tendency for calcium carbonate to precipitate. A negative value indicates a scale dissolving tendency. A zero value indicates that calcium carbonate will neither precipitate nor dissolve. When concentrate LSI or Stiff Davis indices are positive, some form of scale control must be applied.

Sulfate scales:

For specific conditions of temperature and ionic strength, there is a specific solubility value for each of the sulfate scales. This value is the solubility product, abbreviated K'sp.
The degree of saturation is expressed as the mole product of sulfate times the balancing cation (calcium, barium, or strontium) divided by the K'sp. Multiplying by 100 converts this expression to percent saturation.

$$\frac{(Cation)\ (Sulfate)*100}{K'sp}$$

Values greater than 100 percent indicate a tendency for precipitation. Values less than 100 percent indicate that the solution is undersaturated with the sulfate salt.

Silica:

Silica forms an amorphous precipitate unlike that of calcium carbonate or the sulfate scales. Silica solubility is a function of both temperature and pH. At pH of 7 and 25 degrees Centigrade, silica solubility is 125 ppm. At pH 5 and 9, solubility increases to 150 and 238 ppm, respectively.

With an increase in temperature from 25 to 35 degrees Centigrade, silica solubility increases from 125 to 145 ppm. Silica saturation is generally expressed as the ratio of silica actually present in the concentrate stream to the theoretical solubility at the actual concentrate pH and temperature.