Water Recovery Technology – Reverse Osmosis v De-Ionisation

The use of Reverse Osmosis (RO) plant for water recovery , as opposed to De-Ionisation (DI), with the view to being able to do away with the need for hazardous regenerant chemicals is a popular concept. However there are a number of problems associated with the use of RO for water recovery, the main problems being as follows:-

Organic Fouling

RO membranes can be considered "molecular sieves" and as such provide a barrier to ionic species. The membranes are operated very nearly "dead ended", with very little cross flow, the result being that the membranes are very susceptible to particulate and organic fouling.

Organic foulants are typically very large molecules and as such can create "plug fouling" of the membrane pores. This leads to increased pressure loss across the membrane and reduced flux rates. If the organic fouling is not too heavy then membranes can normally be recovered by carrying out a Clean-In-Place (CIP) using an alkaline pH cleaning solution.

Although organics are sometimes present in towns water supplies and require pre-treatment for removal prior to reaching the RO membranes, in water recovery systems, particularly on waste streams from surface finishing applications, organics are often present, deriving from pressing oils which are often found in rinses post cleaners and brighteners etc. found in rinses post plating solutions.

In order to prevent against organic fouling a considerable degree of pre-treatment is often required. This might include use of an organic scavenger which employs an anionic ion exchange resin and requires regeneration on brine, or sometimes a combination of brine and caustic solution. In order to improve cleaning efficiency the combined brine and caustic solution in also sometimes warmed. Activated carbon can also be used for organics removal, although contact time is often quite long. As it is unusual to carry out reactivation of the carbon on site, care must be taken to monitor organics removal efficiency and to ensure the carbon is replaced upon exhaustion.

De-Ionising systems (DI) employed for water recovery often utilise anion resins which offer some degree of protection against organic fouling (e.g. macroporous resins). Regeneration with higher levels of caustic on resin exhaustion also help prevent against organic fouling.

Particulate Fouling

The construction of RO membranes with little space between membrane sheets and the low cross flow operation means that RO membranes are very susceptible to particulate fouling. Typically a 5 µm filter is employed immediately prior to the membranes to provide protection. Where the level of suspended solids in the incoming water is particularly high and the pre-filter becomes blocked on a regular basis it may be necessary to employ additional filtration such as is offered by multi-media filtration.

Conventional DI systems employing twin beds (i.e. separate cation and anion columns) and operated co-currently (i.e. regeneration in same direction as service flow) typically have the facility for backwashing of the resin beds as the first stage of regeneration. Although this does not make the resin beds immune from particulate fouling and additional pre-filtration will be required where

incoming suspended solids levels are high, it does afford some protection and helps prevent build-up, with increase in pressure losses resulting from bed fouling tending to build up over a period of time. As a result fouling from particulates tends to take longer to manifest itself on DI systems than on RO systems, where it can be more immediate.

Metal Precipitation on Concentration

Ionic species present in the incoming water are concentrated up on the surface of the RO membrane. Where heavy metals such as Copper (Cu) or Nickel (Ni) are present at low levels this can lead to concentration reaching saturation point with the result being precipitation at the RO membrane surface. The resultant particulates then lead to fouling of the RO membrane.

This phenomenon does not occur in DI systems where most metals are removed by the cation resin and the high strength of acid used for regeneration ensures that metals regenerated from the resin remain in solution.

Iron (Fe) Fouling

Large, trivalent ionic species such as Fe and Aluminium (Al) can cause fouling of RO membranes.

Fe is often present in towns waters which originate from borehole supplies and that is why this phenomenon is more widely recognised as “Fe fouling”.

Where Al is present, such as in rinse waters resulting from Al surface treatment processes, a similar fouling problem occurs. The fouling leads to increased pressure losses across the membrane and reduced flux rates. If fouling is not too pronounced the membranes can normally be recovered by carrying out a CIP using an acidic pH cleaning solution.

Although a similar fouling problem occurs with ion exchange resins where the trivalent metals become strongly bound to the cation resin, regeneration with higher levels of acid on resin exhaustion help prevent against loss of capacity from irreversible exchange.

Lack of Redundancy

RO membranes tend to perform better when in constant operation and do not require downtime for regeneration. For this reason RO systems are typically designed with a single stream whereas DI systems are often “duplex”, offering both duty and standby streams, to accommodate for regeneration. This can create problems where RO is employed if there is the need for unscheduled downtime for corrective maintenance. This can often be more easily accommodated where a duplex DI system is employed.