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Options for recarbonation, remineralisation and disinfection for desalination plants

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Abstract

Un-treated desalinated water produced by seawater reverse osmosis and thermal processes differ in product water salinity. The water produced by thermal distillers, is usually, characterized by very low salinity and high aggressiveness and corrosivity. Post treatment of seawater reverse osmosis permeate is discussed, with particular emphasis on carbon dioxide (CO_2), acid dosing and boron issues. A number of chemical factors influence the aggressiveness and corrosiveness of water produced by reverse osmosis and thermal distillation plants. Stabilisation of the distillate by recarbonation to a level that is non-aggressive, non-corrosive and palatable to consumers is therefore required. Langelier saturation index and Larson Indices are commonly used indicators of the aggressiveness and corrosiveness of potable water. The "quality goals" for remineralisation will depend on factors such as nature of distribution pipework materials, palatability and client preference. An important factor influencing palatability, and which can strongly influence client preference, is the total dissolved solids content of the water. Blending remineralised desalinated water with treated brackish groundwater or treated seawater are frequently the cheapest options for increasing the dissolved solids content of desalinated water, if there is a requirement to provide a total dissolved mineral content of 150 mg/l or above in the final product water. The choice between the different processes is frequently project specific and depends on issues such as: installed capital and operating costs; volume of distillate to be treated; availability, quality and cost of locally available chemicals; issues associated with carbon dioxide such as ease and quantity recoverable from thermal desalination processes, feed water pH and resultant carbon dioxide present within SWRO permeate. Additionally boron has become an important issue associated with SWRO plants, feed water pH can influence boron removal efficiency and therefore the optimum and boron removal options associated with SWRO desalination. Additionally the simplicity of the competing processes; client experiences, whether good or bad with the competing processes. Disinfection of desalinated water can be undertaken by utilising various forms of chlorine/hypochlorite, the cost of which will vary depending upon size of plant, client preference and availability of chemicals. Remineralisation can be distinguished, for the purpose of this paper, into four treatment processes: 1) chemical addition — excluding lime or limestone; 2) carbon dioxide addition followed by limestone

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or dolomitic dissolution; 3) carbon dioxide addition followed by lime dosing; 4) blending with a water containing high mineral content. The methods available for recarbonation and remineralisation offer varying economic and technical merits and disadvantages. The paper explores the economic and technical differences of the various processes.

Keywords: SWRO; Thermal desalination; Post treatment; Process economics; Boron; Influence of pretreatment on boron removal; Economics associated with carbon dioxide use

1. Introduction

The quality of water produced by the different desalination processes such as seawater reverse osmosis (SWRO) or thermal processes such as multi stage flash (MSF) or multi effect distillation (MED) can differ quite significantly between the processes. The actual detailed design or operation of the different processes can also control the quality of water produced, for example inclusion of a second pass within the SWRO or demister height above the brine surface at a particular brine temperature can strongly influence permeate/distillate salinity. The numerous issues associated with SWRO and thermal plant design are outside the scope of this paper; however SWRO pretreatment and its influence on post treatment will be discussed further.

The quality of the water produced from desalination processes and intended for human consumption, should meet all relevant standards and/or guideline values. In the Gulf States for example these are the Gulf Drinking Water quality Standards [1] and the World Health Organisation (WHO) Guidelines for Drinking Water Quality [2]. Values for selected parameters are shown in Table 1.

In addition to meeting drinking water standards, *the desalinated water should be non-aggressive and non-corrosive.* Aggressive water, for the purpose of this paper shall be defined by a negative *Langelier saturation index* (LSI) and its resultant attack of cement mortar lined pipes. Corrosive water can be defined as water which will corrode any pipe material.

The fundamental reaction in the saturation index developed by Langelier is:

$$CaCO_3 + H^+ \leftrightarrow Ca^{2+} + HCO_3^-$$

The LSI is equal to the measured pH minus the pH_s where pH_s is the equilibrium pH value for the equation above. If the LSI is negative the water is aggressive to calcium carbonate. If the LSI is zero the water is in balance and is neither aggressive nor depositing. If the LSI is positive, the water will deposit calcium carbonate. Aggressive water can be treated to obtain a slightly positive LSI in order to produce a protective scale of calcium carbonate in pipelines conveying the water. Another frequently used measure of corrosion potential is the *Larson–Skold index.* This index provides an indication of the corrosivity of water towards mild steel and other ferrous containing materials. The index is the ratio, in moles per litre of sulphate (SO_4^{2-}) and chloride (Cl^-) to alkalinity (in the form bicarbonate plus carbonate):

$$\text{Larson}-\text{Skold index} = [Cl^-] + 2\cdot[SO_4^{2-}]/[HCO_3^- + CO_3^{2-}]$$

The Larson–Skold index has been correlated to observed corrosion rates and to the type of corrosion in a study of for example Great Lakes waters. The Larson–Skold index can be interpreted by utilising the following guidelines:

- Index << 0.8 chlorides and sulfate probably will not interfere with natural film formation.
- 1.0 << index << 1.2 chlorides and sulfates may interfere with natural protective film formation. Some corrosion can be anticipated.
- Index >> 1.2 a tendency towards high corrosion rates can be expected as the index increases.