Liquid analysis: The key to efficient, economical desalination

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Desalination plants are a major industrial operation throughout Asia Pacific. Two major technologies are used for desalination — membrane separation (reverse osmosis or RO) and distillation. Because distillation is energy intensive, most major markets employ membrane separation. That fact means all water professionals who are concerned with RO, including those who use reverse osmosis in more traditional water plants, must become experts in the "care and feeding" of their costly RO membranes. That, in turn, means they must understand the analytical measurement of water. While conductivity measurement is key to analysing the ongoing condition of the membranes, in fact many other water analytics are required to prepare water for RO and to ensure the water is ready for drinking. Knowing what measurements to use and when will optimise efficiency and compliance in desalination facilities.

THE SENSITIVE MEMBRANE

In the RO process, raw seawater or brackish groundwater is pumped at high pressure against a semi-permeable membrane. The membrane lets water pass through but it blocks and rejects dissolved solids as concentrated brine. Up to 99 per cent of the dissolved solids in the feedwater are separated out by RO membranes. RO membranes, however, can be fouled or degraded by solids in the raw water. Fouled membranes can be cleaned, but irreversible fouling can also occur. Permanently fouled or chemically degraded membranes have to be replaced at a significant investment, so steps need to be taken to protect the membrane.

PRETREATMENT

The first line of defence against fouling and degrading the membrane is in the pretreatment process, which removes harmful chemicals, filters out suspended solids and controls scale formation. Scale forms when slightly soluble salts concentrate and precipitate as the water passes through the RO module. Pretreatment systems typically measure pH and ORP (oxidation reduction potential). In some plants, free chlorine measurement and turbidity may also be included in pretreatment.

RO membranes are highly sensitive to feedwater pH and degrade rapidly in an alkaline environment, particularly in the case of cellulose acetate. The feedwater should be maintained at approximately pH 5 and monitored continuously for cellulose acetate membranes. Aromatic polyamide composite membranes are more resistant to pH, and may tolerate any pH between 2 and 10, however, they are damaged by chlorinated water. While chlorinated water is avoided in systems with polyamide membranes, in some cases, the risk of biological fouling is so high that chlorine has to be added. It must then be removed, usually by treatment with a dechlorinating chemical. A convenient way of monitoring removal of chlorine is to measure ORP, which is a capability on many pH analysis systems. Other plants may choose to use a free chlorine or total chlorine analysis system.

Stopping scale formation is another important goal of pretreatment. There are a number of different control strategies for scale, but in some cases, simply adding acid to lower the pH is effective. This becomes another important reason to perform continuous monitoring of pH to prevent overfeeding or underfeeding of acid.

MAINTAINING MEMBRANE HEALTH

The measurement most associated with the separation process itself is conductivity. Conductivity is a measure of how well a solution conducts electricity. To carry a current, a solution must contain charged particles or ions, and the solids in seawater or brackish water are primarily ionic, so conductivity is an inexpensive and easy way of measuring membrane performance. Typically, the conductivity of both the feedwater and permeate are measured, allowing continuous calculation of percent solids rejection by the membrane. Unexpected changes in performance immediately alert the operators to a problem.

There is more than one type of conductivity measurement, such as contacting (or two

Rosemount™ 400 general purpose contacting conductivity sensor from Emerson

electrodes) and toroidal (or inductive) conductivity. In desalination processes, the preferred method, in most cases, is contacting conductivity. Inductive measurement has several benefits. The sensor does not need to touch the sample, so it can be encased in plastic and used in solutions that would corrode metal electrode sensors and it can tolerate high levels of fouling and be used in solutions containing suspended solids. However, inductive conductivity sensors perform best in higher conductivity samples and therefore, are not recommended for measuring low conductivity solutions such as permeated water, boiler water and so on. Thus, contacting conductivity is ideal for RO permeated seawater measurements.

POST-TREATMENT

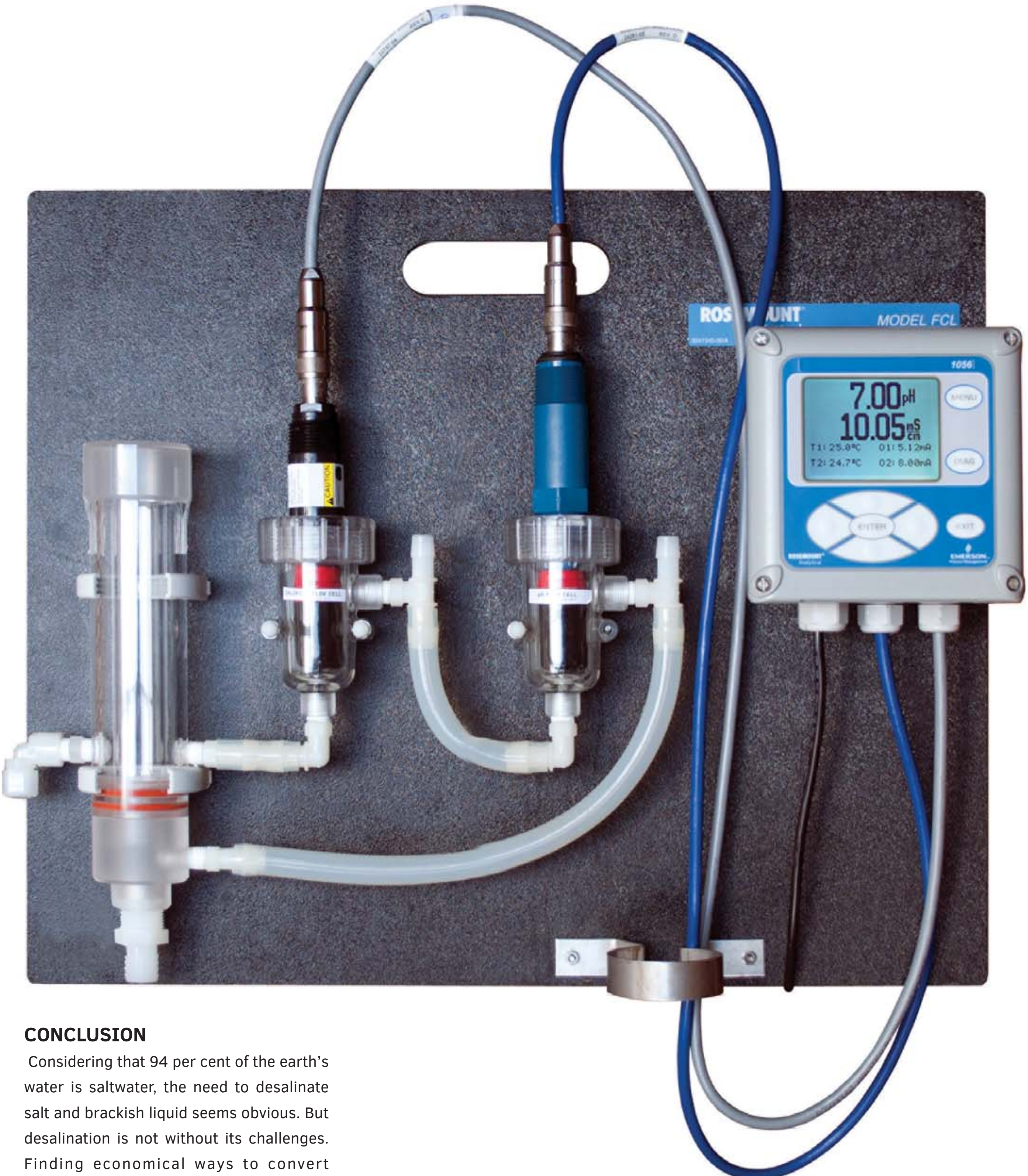
Since desalinated water is widely used in both municipal and industrial applications, post-treatment of water from RO systems is dependent on the application. Generally, however, post-treatment consists of disinfection and conditioning (i.e., blending and remineralisation) to reduce the aggressive nature of the treated water. These processes have the potential to introduce microbial and chemical contaminants into the water, so this has to be taken into consideration.

Disinfection in desalinated water is relatively straightforward because of the low total organic carbon and particle content, low microbial loads, and minimal oxidant demand after desalination treatments. While most biological contaminants are removed during pretreatment, some viruses can pass through RO membranes, and potential damage to the membrane can allow passage of both biological and chemical contaminants, therefore plants use chlorination as secondary disinfection in the final treatment step. Today, chlorine is added as chlorine gas (Cl_2), sodium hypochlorite (NaOCl), or chlorine dioxide (ClO_2) as the secondary disinfection agent. Secondary disinfection prevents the re-growth of certain pathogens that may enter the treatment plant or be introduced by back-flow contamination. When chlorine is added to water, free chlorine forms a mixture of hypochlorous acid (HOCl) and hypochlorite ion (OCl^-). The relative amount of each is dependent on the pH, and the total of HOCl and OCl^- is defined as free chlorine. For disinfecting water, HOCl is not only more reactive than OCl^-, but is also a stronger disinfectant and oxidiser. HOCl is 80 to 100 times more effective than OCl^-.

The use of chlorine and/or monochloramine in disinfection creates a need for free chlorine or monochloramine analysers in post-treatment. Turbidity analysis is also required because lime is often used to improve water quality, especially for water softening and arsenic removal.

CONSIDER BENEFITS OF WIRELESS

A key trend in water treatment plants in general around the world is the use of wireless analytical technologies. In some areas, such as western Australia, other protocols have been standardised for desalination that may make the use of the WirelessHART® protocol inappropriate, but for many desalination plants, wireless is a cost saving option. Wireless pH and conductivity transmitters can be integrated into a plant's network, making the adoption of wireless easy and painless. New adaptor technologies allow wireless technologies to be added to HART®-enabled analysers without the need for software upgrades, batteries, or additional hardware, making the move to wireless systems cost-effective, scalable and simple. This approach reduces installation costs for plants by up to 90 per cent. In addition, the wireless analysers can transmit both process variables and diagnostic data back to the central system, reducing the workload of field personnel and maintenance. New systems feature onboard data logging capabilities, permitting the transfer of process data and events to a USB memory device for PC analysis, making the systems even more flexible for desalination plants.



CONCLUSION

Considering that 94 per cent of the earth's water is saltwater, the need to desalinate salt and brackish liquid seems obvious. But desalination is not without its challenges. Finding economical ways to convert saltwater without excessive cost in energy needs a careful application of technology. Virtually all of that involves the appropriate use of liquid analytical instrumentation. WWA

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