

China National Petroleum Corporation

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China National Petroleum Corporation Operates Efficient Seawater Desalination System

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by Invensys Operations Management

Goals

- Maintain the right pressure in each evaporator, control the flow of seawater and vapor through the system, know exactly when the purity level has been reached, and minimize the corrosive effects of the process on the desalination equipment.

Challenges

- Making seawater usable for industry requires removal of salt in a precisely orchestrated distillation sequence and involves accurate measurement.

Solutions and Products

- Foxboro Measurement & Instruments.

Results

- Successfully desalinated thousands of tons of seawater;
- Reduced cost of seawater desalination;
- Reduced maintenance time and cost of desalination equipment.

Beijing, China – China National Petroleum Corporation (CNPC) is China's largest producer and supplier of crude oil and natural gas, and a world leading integrated energy company. CNPC provides operational services and technical support in such areas as geophysical prospecting, well drilling, logging, well testing, downhole operations, oilfield surface facilities construction, pipeline construction, refining and petrochemical projects and manufacturing and supply of petroleum equipment.

Seawater Distillation Challenge

Making seawater usable for industry requires removal of salt in a precisely orchestrated distillation sequence. CNPC faces this challenge every day as it desalinates some 500 tons of freshwater to cool its boilers. They use a time-tested, desalination process called Multi-Effect Distillation (MED), in which the seawater passes through a programmed series of pressure-controlled evaporators.

The MED evaporators, also called 'effects', are arranged horizontally, vertically, or stacked, depending on heating requirements. As the first evaporator receives seawater, the water is heated to boiling and the resulting vapor is piped to a second vessel, where it meets a condenser, which converts the vapor back to water.

Although some salt is removed at this step, the process must be reiterated until a desirable purity level is reached. The beauty of the MED process is that it enables multiple distillations using only the heat that was applied to the first unit. It does this by exploiting two physical principles. The first is that water vapor releases heat as it condenses back into water and it is this heat generated by the condensation that helps boil the water in the second vessel, which in turn condenses into a third vessel and boils the water there.

However, condensation alone does not provide enough heat to boil the water. It needs help from the second principle: reducing the ambient pressure also lowers the boiling point of water. Therefore, by systematically reducing the pressure in each subsequent evaporator, the seawater is boiled, condensed, re-boiled, and condensed as many times as necessary to achieve the desired level of purity.

Adding to the efficiency of the system design, seawater passing through the condensation coils en route to desalination cools them, and lithium bromide acts as a desiccant to facilitate condensation.

Maintaining the right pressure in each evaporator, controlling the flow of seawater and vapor through the system, knowing exactly when the purity level has been reached, and minimizing the corrosive effects of the process on the desalination equipment requires reliable and high performing process instrumentation. CNPC has selected Foxboro® as its primary supplier of pressure, flow, and analytical instrumentation used in this important operation.

Foxboro Pressure, Flow, and Analytical Sensors

CNPC currently uses more than 38 Foxboro pressure, flow, and analytical sensors in its MED desalination operation. For pressure measurement, Foxboro differential and gauge pressure sensors are used at each of its evaporators to balance and regulate pressure in the presence of steam, water, and lithium bromide. Each pressure transmitter uses the same innovative topworks packaging with modular intelligent electronics, which greatly simplifies installation, operation, servicing, and spare parts requirements at CNPC.

To measure flow, CNPC uses ten Foxboro magnetic flow sensors to monitor the passage of seawater through the system and two vortex flowmeters to



Control room.



Foxboro magnetic flow sensors to monitor the passage of seawater through the system.

measure gas and nitrogen. With the ability to withstand the demands of constant exposure to seawater, the Foxboro magnetic flowmeters have proven themselves as the durable solution for reliable, accurate measurement needed for this demanding application.

At CNPC, measuring gas and nitrogen requires precise accuracy and the Foxboro vortex flow meters are the industry standard, with best-in-class accuracy of $\pm 1.0\%$ of reading in gas and steam, and $\pm 0.5\%$ of reading in liquids.

To assure the quality of the desalinated water, CNCP relies on two DolpHin pH sensors to monitor the acidity of the seawater as it passes through the

desalination process, and two Foxboro contacting conductivity sensors to monitor the percentage of salt remaining in the water. Designed specifically for challenging process applications, the DolpHin sensors feature a unique pH glass formulation that provides superior measurement stability and accuracy, and longer service life, which has reduced probe replacements and maintenance calls at CNPC.

The Foxboro conductivity sensors provide CNPC with an economical, reliable solution for monitoring salt content of the water being processed. As the concentration of salt ions in the water changes so does detectable conductivity. The Foxboro conductivity sensors combine advanced sensing technology with durable electrode materials to accurately measure the changes in salt ion concentration, enabling CNPC to monitor and maintain the desired salt content throughout the desalination process.

Successfully Desalinated Thousands of Tons of Seawater

The first phase of the project has been completed, with CNPC having successfully desalinated thousands of tons of seawater. CNPC estimates that the MED process has resulted in substantial cost savings, while contributing significantly to reliable operation of its boilers. A company representative has expressed that they are very pleased with the cost savings and downtime benefits CNPC has enjoyed from MED, and believes that the Foxboro instruments and the after sales support, were a big part of that success.

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