Ozonation System is Critical to Product Quality

To assure a sanitized water supply for their new production operations, a large high-quality filter manufacturer installed an ozonation system monitored by THORNTON instrumentation.

A challenging system design
Providing cartridge filtration products for the diversity of pure water users is a challenge demanding the utmost attention to quality. When the manufacturer expanded their operations and required new filter integrity testing equipment within their facility, they contracted with an experienced water consulting and service organization. After setting stringent specifications for the system and its instrumentation, the consultant then worked with the system fabricator to finalize the design. The system design specified ranges and limits for ozone, conductivity and dissolved oxygen as well as recognizing the need to monitor temperature.

THORNTON instrumentation selected
Despite the fact that other instrumentation had been used for these kinds of measurements in older parts of the facility, they selected THORNTON conductivity, ozone and dissolved oxygen instrumentation based on its excellent reputation and broad acceptance across the pure water industries. They also recognized the benefits of measuring all these parameters with a single instrument platform.

Two 770MAX for five parameters
In fact, just two 770MAX Instruments measure and provide output signals for all the required points: 5 of ozone, 2 of conductivity, 1 of dissolved oxygen (DO), plus 2 temperatures. Another factor in the choice of instrumentation was the simple
maintenance for ozone and dissolved oxygen sensors which have cartridge type membranes that are especially easy to replace. They also recognized that the efficient packaging of these measurements provided a very cost-effective instrumentation system while maintaining high quality.

Measurements at important points

The distribution system provides a total recirculation flow rate of 200 GPM (760 LPM) around two large loops, each with numerous points of use. Ozone measurements are made after the ozonator, at the outlet of the storage tank, and after the ozone destruct UV unit which assures that no ozone reaches the points of use in normal operation. Periodically the points of use are shut down and the entire distribution loops are ozonated for system sanitization.

Two additional measurements are made at the ends of these loops to verify that sanitization levels of ozone have reached the entire system.

No residual ozone passes UV unit

Ozone measurement is of great importance to the distribution system design as it employs a membrane degasifier, which can be damaged by oxidizing agents such as dissolved ozone. The ozone measurement after the ozone destruct UV unit continuously monitors the flow path to ensure no residual ozone passes the UV unit during normal operation. A measurement above zero triggers valves in the system that bypasses water around the membrane degasifier as automatic protection.

Low DO values are quality key for final products

Dissolved oxygen is another critical parameter. Final product test specifications require levels of dissolved oxygen well below saturation. Accurate monitoring of this variable is a key factor that contributes to the manufacturer’s guarantee of quality and performance for their product.

Conclusion

THORNTON instrumentation once again demonstrates the value of a versatile multiparameter measurement platform providing accurate and reliable monitoring. The manufacturer in this article is now considering the use of more THORNTON instrumentation to monitor flow rate, total flow volume, conductivity and temperature on other distribution loops and treatment equipment throughout their facility.

Whether a system is for ozonation or for other upstream water treatment functions such as filtration, dechlorination, reverse osmosis, deionization or deaeration, THORNTON instrumentation has the flexibility to measure any combination of associated parameters. These include conductivity/resistivity, pH, ORP, TOC, dissolved oxygen, ozone, temperature, flow rate, pressure and level. Additional measurements may be needed at the points of use and these can be handled with similar instrumentation.
Instrument Predicts
Deionization System Exhaustion

The exchange capacity of a deionization system is the total load of ionic materials that can be removed before regeneration is required. Instrumentation can monitor this accumulated load and accurately predict resin exhaustion.

In operation, deionization resins eventually reach their capacity and need to be regenerated. The costs of regeneration including acid, caustic, rinse water and labor are very substantial. Anything that can be done to extend run cycles, regenerate more efficiently, or accurately determine the need for resin treatment or replacement can bring significant operating savings.

Detecting resin exhaustion
When exchange capacity is reached, the resin begins to leak the most weakly held ions. Conventional monitoring for resin exhaustion uses sodium measurement at the outlet of a cation exchanger and uses conductivity and/or silica at anion and mixed bed exchanger outlets. An accurate and precisely temperature compensated conductivity measurement provides reliable, low cost, fast responding and continuous means of detecting exhaustion.

These are all sensitive measurements but detect exhaustion only after breakthrough has occurred. The process downstream begins receiving contamination at the same time the measurement detects it. In many situations it is desirable to predict when exhaustion will occur beforehand to allow coming off-line and regenerating before breakthrough, but not so much ahead of time that a large portion of exchange capacity is wasted.

Predicting resin exhaustion
Predicting resin exhaustion has a number of benefits. It can help avoid reaching capacity during an inadequately staffed shift or weekend. It can allow more reliable scheduling of operations. In some situations this can reduce overtime labor costs or wasted chemicals. With more confidence in the amount of exchange capacity remaining, it can allow running longer and can avoid premature regeneration. Early regeneration wastes time, system capacity, and most importantly, expensive caustic and acid used for regeneration, plus the additional chemicals needed to neutralize the wastewater produced by the unneeded regenerations.

Without the means for monitoring resin capacity remaining, it is much like operating a car without a fuel gage. You must be constantly vigilant to avoid running out of fuel and even then, there is no real assurance. Extra, precautionary stops for fuel are needed.

Common methods for predicting exhaustion are to monitor elapsed time or total flow. If the flowrate is nearly constant over the run cycle, then a consistent run time before regeneration should give adequate prediction, but only if the water composition is also constant. If the flowrate varies through the run of the exchanger, then a total flow measurement can accurately account for this, but again, only if the feedwater composition is constant.

In the missing fuel gage analogy above, using total flow as the criteria for regeneration is like using the odometer of the car to monitor mileage to determine when to refuel. It can be used. However, if the driving involves mountainous terrain, strong headwinds or long waits in heavy traffic, the odometer reading will not correlate well with the amount of fuel consumed. Likewise, if the water composition changes for any reason, then a total flow value will not be a good predictor of the time to regenerate.

Deionization unit.
In today’s environment of scarcer water supplies, raw water comes from multiple sources, recycled and reclaimed water, and with variable pretreatment processes ahead of deionization. Seasonal variations also are significant. As a result, variable composition in deionization feedwater is becoming commonplace. There really is a need to account for the varying ionic load on a deionization bed due to both flowrate and composition.

**More accurate prediction of exhaustion**

The capability to predict exhaustion that accounts for variations in both flowrate and composition has been implemented in the THORNTON 770MAX Multiparameter Analyzer/Transmitter. It includes the unique DI-Cap™ deionization capacity monitoring algorithm. The accompanying figure illustrates how this method is implemented. Feedwater conductivity is measured and converted to TDS (total dissolved solids). Flowrate is also measured and multiplied by the TDS value. The product of these is integrated over time to produce a measure of ionic load entering the deionization system as illustrated by the accompanying equation. The direct readout allows a choice of units of equivalents, grains or ppm-gallons.

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\text{Ionic load} = \int \text{Flow} \times \text{TDS} \, dt
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With this system, an accounting is made for both variable flowrate and variable water composition to give a very close measure of ion loading. Display, output signals, setpoints and relays can be assigned to this computed parameter to enable continuous monitoring and control. The total ionic load measurement can be reset manually or automatically by a remote contact closure at the beginning of each run. The 770MAX has additional channels that allow it to measure, alarm and provide output signal for effluent conductivity as well as other measurements.

**Assessing resin health**

Another benefit from deionization capacity monitoring is to track resin bed working capacity over the long term to warn of capacity loss. Lowered working capacity can be due to incomplete regeneration, loss of resin, channeling, fouling with organics or silica, etc. which leaves many areas to examine when a problem occurs. If a DI bed is run to exhaustion as detected by effluent conductivity or other means and the total ionic load for each run cycle are logged, a good historical record of performance can be developed. This record will be much more useful than a record of just total gallons since it will be corrected for changing feedwater composition.

With this technique, even a gradual deterioration in performance can be detected and corrective action can be taken before a major loss of efficiency occurs. This represents a real improvement in DI system troubleshooting and maintenance since the first loss of capacity will be more visible and will allow more timely diagnosing of the problem. Problems that continue undetected become harder to pinpoint and more damage and inefficient operation can result.

**Conclusion**

Deionization capacity monitoring with the THORNTON 770MAX provides a significant contribution to the efficient operation and troubleshooting of large DI systems. Whether deionizing raw water, reverse osmosis permeate, or condensate, most systems can benefit from this water treatment monitoring tool.
Self-Contained Controller – a Problem Solver

When a water or wastewater treatment system is widely separated from other process controls, a pH transmitter with built-in PID control capability can provide a very efficient solution.

Water and wastewater pH control requirements vary widely, especially with the increasing efforts at reclaiming and recycling this valuable commodity. Variations in flowrate, pH range, requirements for acid and/or base, and the variety of valves and pumps delivering those chemicals place a range of demands on the control system. Stand-alone instrumentation flexible enough to handle these variations can be very helpful in meeting treatment system requirements.

Often, control functions are provided with a process control system, programmable logic controller or other centralized control system. However, when a remote location requires high resolution control but does not have a control system available, a pH transmitter with internal proportional control capability, such as the THORNTON M300, can greatly simplify the installation.

**On-off control**
Simple on-off control at a setpoint turns reagent flow on or off depending on whether the measurement is above or below the setpoint, much like a room thermostat. For very small systems and batch treatment, this can be adequate. However, for pH control in most applications, on-off control produces significant over and under treatment which is unacceptable.

**PID control action**
Proportional, Integral and Derivative control can provide smooth regulation of a process. Instead of abrupt on-off action, PID provides a more continuous and gradual change in reagent feed rate and accounts for changing demand while minimizing over or under treatment. It does this using the three standard modes of control action which are summed together to provide the ultimate control of the reagent feed rate.

Proportional control action responds to the amount of pH deviation from the setpoint. It adjusts the reagent feed rate in direct proportion to the difference between the measured pH and the setpoint. The proportional GAIN tuning parameter adjusts the sensitivity of this action: higher gain produces more reagent feed for the same deviation.

As implemented in the THORNTON M300, the proportional action can also be modified by a non-linear characteristic which mirrors the non-linearity of a pH titration curve. It has flexibility to establish a deadband close to the setpoint, an area of relatively low gain further out, and an area of higher gain at the extremes, as shown. With this enhancement, the proportional action can be more accurate across the entire pH range.

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**Controller with corner points**
Enhanced nonlinear pH control is available in the THORNTON M300 Transmitter by setting deadband, corner points and proportional limits.
Integral control action responds to a combination of the amount of the pH deviation and the length of time it continues: it integrates the deviation over time. Integral action (also called reset) is needed to bring a continuous process all the way to the setpoint because proportional action by itself turns off reagent feed when the setpoint is reached even if there is a continuing demand for reagent. Integral action, on the other hand, causes an increasing output as long as the pH is away from the setpoint. Only when the pH goes to the other side of the setpoint does the integral action start decreasing its contribution to the control signal. The INTEGRAL TIME tuning parameter adjusts how long it takes to duplicate the proportional control action for the existing deviation.

Derivative control action responds to the speed and direction of pH change. It minimizes over treatment by “heading-off” a growing deviation of pH as an operator would do instinctively by anticipating the need for additional corrective action. The reagent feed rate is changed by an additional amount in proportion to the rate-of-change in the measured pH. Derivative control is also called rate action. The DERIVATIVE TIME tuning parameter adjusts how far ahead the control action will anticipate, based on the present rate of change. Very low or zero settings of derivative action are used to maintain stability, especially if the measured pH is noisy.

THORNTON M300 transmitter with PID control activated.
Control output types

Various reagent feeders require various types of control signals. Pulse metering pumps require a relay pulse frequency, solenoid valves require a relay pulse length, and proportioning valves require an analog signal. All THORNTON M300 Transmitters include the hardware and software for all three control output types so the user can choose the type of output to use. A pictorial representation of the three types of control signals conveys the type of action they provide.

**Pulse frequency** control output provides short rapid relay contact closures, suitable for pulse-type electronic metering pumps. Each relay contact closure causes the metering pump to pulse and deliver a small fixed volume of reagent. Pulse frequency is adjusted by the PID control action with output from one or two relays for acid and/or base as selected. Pulses of reagent are smoothed by the turbulent mixing of a stirred volume of the process.

**Pulse length** control output provides switching of relay contact(s) to control acid and/or base solenoid valves. The percent “on” or “valve open” time is regulated by the PID control action. The overall period of the pulses is fixed by a one-time setting in the controller. This type of control action requires substantial mixed process volume to smooth out the pulses.

**Analog** control output provides a 4 to 20 mA (or 0 to 20 mA) control signal for acid and/or base feeders. This type of signal can be used with electro-pneumatic converters for pneumatic control valves, electrically actuated control valves, current input proportioning metering pumps or current input proportioning lime feeders.

**Convenient operation**

For routine operation of PID control, the THORNTON M300 uses the bottom display line to provide the control status: manual or automatic control, % output, and whether feeding acid or base, if both reagent feeders are configured. In addition, when in manual control for sensor calibration or maintenance, the Up and Down arrow keys provide manual manipulation of the control output. For a stand-alone transmitter/controller, the M300 provides outstanding value.
New Developments in Process Analytics

METTLER TOLEDO delivers powerful solutions to optimize your processes and reduce maintenance costs. Recently, we introduced new intelligent technologies that allow you to improve handling and optimize maintenance thus addressing your most pressing needs.

ISM – the next generation of intelligent process analytics!
With the groundbreaking ISM technology METTLER TOLEDO provides another milestone in process analytics measurement! Dissolved oxygen sensors and pH electrodes with integrated preamplifier are using a new technology with “Plug and Measure” and intelligent diagnostics functionalities. The Intelligent Sensor Management (ISM) technology simplifies all maintenance operations of the sensor. Process interruptions are shorter or even avoided, leading to enhanced productivity.

iSense – the key to maximize the benefits of the ISM technology
iSense ISM Asset Suite allows efficient and easy verification and calibration of METTLER TOLEDO digital ISM pH and DO sensors in an instant with an intuitive software application that includes advanced analysis and documentation functionalities to support your sensor management.

Digital transmitter line M300
The digital M300 transmitter represents an easy-to-use version of the M300 transmitter line. Its unique “Plug and Measure” features enable a fast start-up and robust measurements for digital pH/ORP and dissolved oxygen sensors. Its versatility and reliability make this instrument the ideal choice for a wide range of applications.

If you want to take advantage of these advanced products ask your local METTLER TOLEDO representative or visit www.mt.com/ISM.