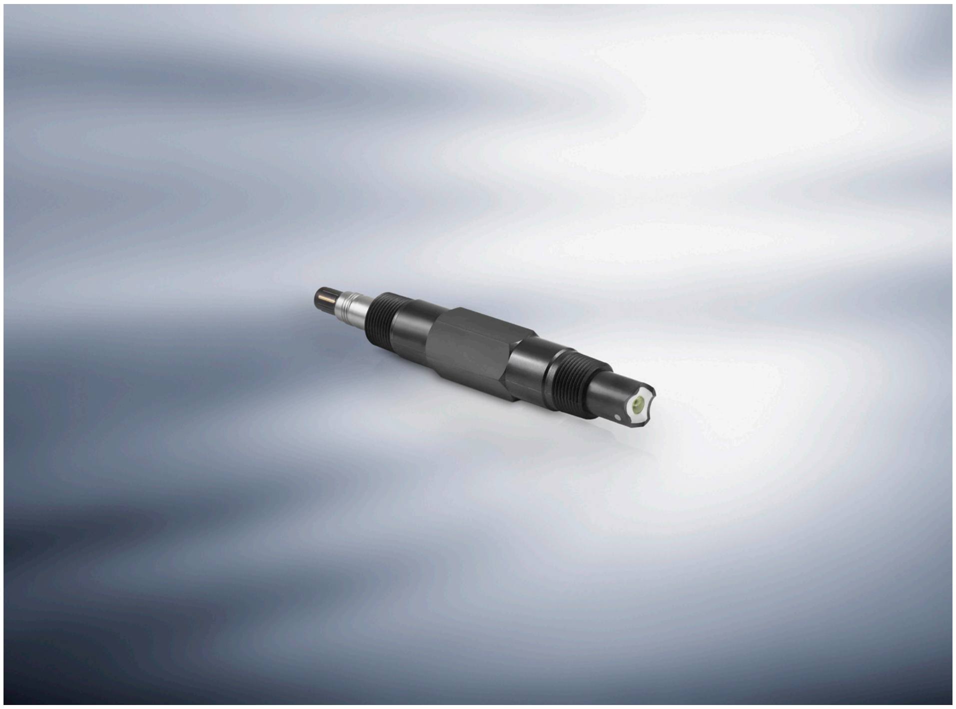
A Sense Of What's Next: Digital, Integrated pH Measurement



Taking pH measurements may be the most common water quality testing performed around the world. From backyard pools to treatment plants serving millions, it has long been a reliable method of detecting red flags in water quality. But with rapid developments in sensor technology, is there room to innovate on such a routine practice?

Water Online spoke with Thomas Roemer, the business development manager for KROHNE about the company's efforts to do just that. By applying the edicts that have dictated the evolution of our cell phones, watches, and other gadgets, KROHNE has ushered in the next phase of pH sensors: the SMARTPAT.

What factors affect the pH levels of water? Why is it used to monitor water and wastewater?

The "natural" pH value of water is seven, which is called neutral, however chemicals like acids and caustics as well as biological activity in the water can change this pH value either to the acidic range of less than seven or caustic range of greater than seven. The pH value is therefore an important indicator for the quality and purity of the water and if potentially harmful substances are contained in the water or wastewater. The pH measurement is widely used in drinking water as well as wastewater as a quality parameter to control the treatment process as well as a safeguard to monitor if potentially harmful substances are either coming into the plant (mainly in wastewater) or are contained in the effluent.

What would you consider to be the "worst case scenario" resulting from irregular pH levels in drinking water, wastewater, and/or industrial water?

As it pertains to drinking water, most important is the negative effect of too low or too high pH values on human health. However, especially low and acidic pH values can also have a negative effect on plant equipment and the water distribution system. Low pH values can cause corrosion of pipes and can promote precipitation of calcium carbonate which causes scaling.

When it comes to wastewater, pH values that are too high or too low in wastewater treatment plants (WTTPs) can potentially kill the bacteria in the biological stage of a WWTP and therefore need to be monitored at the inlet of the plant. Contaminated water needs to be diverted and separately treated. Throughout the treatment process it is important to control the pH value for the very same reason: to only promote growth of the bacteria you need for your treatment and not create an environment for bacteria which do not work as efficiently. With regard to effluent, it is important that the treated water leaves the plant "neutral" so that impact to the environment is minimized.

For industrial wastewater, many plants have to pretreat water and run WWTPs. They need pH measurement at the inlet as well as throughout the process for the same reasons that municipal plants do, "protection" of the biological stage and control of the treatment process. However, even plants without wastewater treatment are mostly required to have a pH measurement at their outlet. This is to monitor the effluent for any harmful material contained in the water and to detect product losses. Many municipalities require such pH monitoring and set limit values for the plant. Exceeding those limit values can cause higher effluent charges or even penalty payments.

What are some common challenges for taking accurate pH measurements?

A pH sensor is an electrochemical sensor which ages over its lifetime. The pH glass changes and the reference electrodes drift due to loss or poisoning of the internal electrolyte. The pH transmitter that converts the measuring signal coming from the probe into the pH value therefore has to be frequently adjusted to the changed characteristics of the sensor. The calibration is done by using two calibration liquids with known pH value (usually four and seven), which are called "buffer solutions." The pH sensor needs to be put into these buffer solutions and then the new slope and offset can be adjusted at the transmitter.

One of the main issues with this calibration method is that you need to do this onsite, since the sensor has to be connected to the transmitter throughout the procedure. The pH measurement is temperature-dependent and the sensor and buffer should be exactly at the same temperature (ideally at 25 degrees Celsius) during the calibration. This is almost impossible to achieve in the field, or it takes a long time since either the sensor comes out of a cold media and then gets put into a warm buffer or the buffer comes out of the fridge and the sensor is at a higher temperature. In any case you would need to wait quite some time for all the temperatures to be at equilibrium. Additionally, you have uncontrolled environmental conditions like wind, rain, and snow if you do that in the field, which can be another source of error. Low temperatures, for instance, make the electrolyte in the reference cell flow very slowly and the response time of the pH probe can be up to several minutes. In most cases, it is impossible to calibrate a pH sensor outside if temperatures are below five degrees Celsius.

On top of this, you usually do not have enough time or the suitable environment to properly clean the pH sensor and especially the junction. If biofilm and other coatings are not properly removed on a regular basis, the pH sensor soon will become unusable.

Last but not least, the signal generated by a pH sensor is very small and has an extremely high impedance. Therefore special high impedance cables and connectors have to be used to transport the signal from sensor to converter and the cable length is limited to approximately 30 feet. The cable cannot be cut or spliced and if any water or even moisture gets into the connector, the pH signal gets damped to zero.

What makes a digital sensor a better way for operators to measure pH?

With digital sensors, those calibration and sensitivity issues are in the past. Since the calibration results — the changed slope and offset — are stored in the sensor head, the sensor does not need to remain connected to the transmitter during calibration. You can bring the sensor into the workshop or lab and calibrate it under controlled environmental conditions and sensor and buffer at the same temperature. This so-called "offline" calibration gives much better calibration results, leading to more accurate measurement results. Additionally, you have a better chance to properly clean the sensor and junction and therefore extend the lifetime of the sensor. It also saves time since you can just go outside, collect all probes, bring them inside, and calibrate them one after the other with the same equipment instead of carrying the calibration solutions and beakers around the plant, setting up the calibration equipment again and again at each station, and waiting for the temperatures to adjust. Remote locations can be more easily serviced as well. If one pH electrode fails, you just make one ready in your workshop and send it out already calibrated. All that needs to be done on site is plugging it in.

Besides the advantages of digital sensor in regards to the offline calibration, the problem with the high impedance signal is gone as well. Since the sensitive analog signal gets converted into a robust digital signal right in the sensor head, the issues with moisture as well as limitation in cable length are more or less gone as well.

What is a SMARTPAT sensor capable of which previous analog and digital sensors are not?

With SMARTPAT, we not only have a digital sensor which is capable of offline calibration and digital communication, we also have the complete transmitter functionality, including the diagnostics, built right into the sensor. In contrast to all other digital sensors, SMARTPAT can be directly connected to the control system and uses the widely accepted and open HART Protocol, instead of a proprietary protocol for which the customer still requires a transmitter or protocol converter from the manufacturer.

SMARTPAT is loop-powered, which means the power supply, measuring signal, and digital communication run over the same twisted pair of wires, which cuts wiring cost to a minimum. The signal cables can be run over more than 1,000 feet without amplification and can be cut and spliced as needed. Most of the other digital sensors on the market still require special cables (some of them even have electronics built into the connector) and that means higher cabling costs.

If a local indicator for the display of the measuring value is needed, the customer can simply use any 4–20 mA indicator and connect it into the same loop as the SMARTPAT sensor instead of buying an expensive display, which needs, in most cases, additional cabling to power it.

Calibration of SMARTPAT sensors is done using any HART handheld capable of HART 7 protocol or a laptop and HART modem in conjunction with a free-of-charge open protocol FDT frame software, such as PACTWARE.

What technology makes the integrated transmitter possible? What other applications might this technology have in the water treatment space?

The integrated transmitter technology is the next logical step from a digitalized sensor to a fully integrated compact pH analyzer. By using modern microprocessor technology and extreme miniaturization on the verge of nanotechnology, it is possible to integrate all the analog circuits as well as the computing power of a digital transmitter into a pH sensor head the size of a thumb. The same concept whereby cell phones, cameras, and watches get smaller and smaller, they also get smarter.

A modern digital sensor like SMARTPAT has built in more diagnostic functions and transmits more information about the process and status of the sensor than most of its "big brothers" from the analog world. By reading the measuring signal of the SMARTPAT sensor via the HART protocol, you don't just get the pH value. You also get the process temperature, the glass resistance of the pH glass, and the mV voltage, including the status of each parameter. The status messages follow the guidelines of Namur NE 107, a guideline set by the chemical industry, and allow advanced, real-time diagnostics of your process and sensor status.

SMARTPAT is a real intelligent sensor, a trend in all industries to gather more detailed information about your process while allowing for advanced diagnostics and more efficient and failsafe operation of your plant.

What motivated you to innovate on such a standard measuring method?

KROHNE believes that intelligent sensors are the future in any industry, to further enhance efficiency and safety of the operations. In conjunction with modern, open protocol communication technologies, a higher integration of sensors, actuators, and control systems can be reached which enables monitoring and control on much deeper levels than before. All KROHNE devices are therefore following a common device architecture and feature advanced diagnostic functions and common communication interfaces. The KROHNE instruments for the physical parameters like flow, level, pressure, and temperature are already following this philosophy.

However, in the field of analytical sensors this is fairly new; and since pH is one of the most important parameters, especially in the water and wastewater industries, we decided to start with pH measurements first. Another reason is that the issues with common pH measuring loops explained above, like on-site calibration, cleaning, and costly cables make pH measurement loops very maintenance- and cost-intensive. With SMARTPAT technologies, those costs are dramatically reduced due to off-line calibration, the use of common cables, and no need for external transmitters. The customer therefore benefits twice by switching from an analog pH measuring loop to SMARTPAT. ■