Troubleshooting pH/ ORP Controllers

Many industrial processes, such as wastewater treatment require the pH/ORP to be controlled...

By THOMAS H. MARTIN
Consulting Chemist
Delta Chemicals & Equipment, Inc.
Indianapolis, Indiana

pH is the level of acidity or alkalinity of a solution and is measured on a scale of 0 to 14. Water is neutral with a pH of 7. pH less than 7 is acidic, and pH greater than 7 is alkaline. pH measurement uses a logarithmic scale, which means that each time the value moves one full unit away from 7, the strength increases ten times. A pH of 5 is one hundred times more acetic than water. A pH of 10 is one thousand times more alkaline than water.

pH is usually measured electrometrically with a meter. However, pH papers can provide a quick test. pH meters use glass electrodes or probes to determine pH. The probe senses the hydrogen ion concentration and produces a high-impedance potential in millivolts (mv). Since water is neutral and the hydrogen and hydroxyl ions are equal, the mv potential is zero. Each pH unit down from 7 produces a +59 mv potential. For example, the pH of vinegar is about 3, and the mv potential is 7 -3 = 4 x 59 mv = 236 mv. However, when the pH rises above 7, the mv potential changes from positive to negative.

Calibration. Accurate calibration is easy using buffer solutions of a known value that resist changes in pH. First, the probe is immersed in pH 7 buffer solution. The meter or digital display is adjusted to read seven or zero mv. Next, the instrument is "sloped." Usually pH 4 or pH 10 buffers are used for sloping, depending on the solution to be monitored. A buffer solution with pH 10 is best for alkaline solutions, while a pH 4 solution works best for acids. The probe is immersed in the buffer solution and the slope adjusted.

Slope is more easily understood using a graph showing the linear relationship between pH and mv (Fig. 1). The center of the line is like a fulcrum. As one end rises, the other lowers.

ORP (oxidation reduction potential) is the level of an oxidizing or reducing agent. It is also measured in mv. However, unlike pH, the ORP is not a measurement of hydrogen ions. The mv signal is generated when an oxidizing or reducing solution contacts a gold-, silver- or platinum-tipped electrode or probe. Since there is an inverse relationship between pH and ORP, the pH is held constant when measuring ORP.

Given the inverse relationship, as pH increases ORP decreases. The oxidizing potential of a 500 mg/liter solution of hexavalent chromium is +500 to +600 mv. When the pH is held constant at 2.5, the ORP is lowered by slowly adding sodium metabisulfite, a reducing agent. When the ORP reaches +200 to +250 mv, the hexavalent chromium is reduced to the trivalent state. However, if the pH is rises as the reduction takes place, the reaction time increases and more reducing reagent may be required.

Since test papers are not available, ORP is measured electrometrically. Instrument calibration is similar to the procedure used for pH, only standard oxidizing reference solution is used. First, a jumper wire is place between the P+ and P- probe terminals. Then the meter is set at zero mv. Next, standard oxidizing solutions are prepared by saturating pH 4 and pH 7 buffer solutions with quinhydrone. The probe is immersed in the pH 7 buffer solution and should sense a +87 mv potential (±40 mv). The probe is rinsed and immersed in the pH 4 solution. The potential should be +267 mv (±40 mv). Once the probe passes this test, the instrument is calibrated using the pH 7 = +87 mv standard and sloped using the pH 4 = +267 mv standard.

pH/ORP Controllers. An automatic controller precisely adds acid, alkaline, oxidizing and reducing agents. The controller energizes (closes) a relay at the desired pH or ORP setpoint. Usually two relays are used. One is the low alarm, which energizes when the pH or ORP moves below the setpoint. If the setpoint is pH 9, the relay is energized at pH 8.9 or lower. The second relay is the high alarm, which energizes when the pH or ORP moves above the setpoint.

Identifying Problems. Most of the time, pH/ORP controllers operate trouble free. However, problems can occur: Meter inoperative; meter flashing error signal; instrument cannot be calibrated; instrument will not hold calibration; controller does not energize alarm at the set point; or meter is undependable and gives erroneous readings.

Troubleshooting. There are three places problems can occur with pH/ORP controllers: 1) Sensing probe; 2) Control unit; 3) Sensor connecting cable. A bad probe or poor connection is most often the problem. The solution may be as easy as replacing a fuse in the controller or electric panel. The first step is to make sure the controller has the proper electrical power.

Checking the sensing probe. Inspect the glass tip to make certain the bulb is clean and unbroken. If necessary, gently scrub the tip with warm soapy water and a soft toothbrush. Scale is easily removed by dipping the tip in a solution of 25 pct by volume hydrochloric acid.

Two-wire probe. Disconnect the probe at the junction box. If the connecting cable is short (10 to 15 ft), with one junction, disconnect it at the controller unit. Connect the probe to a portable pH/ORP meter. Usually there is a male connector on the probe and a female connector on the meter. Calibrate the probe with standard pH buffer or oxidizing potential solutions. The meter response should be fast and accurate over the full range of the test. If the probe fails to respond properly, check to make certain the connector is clean and tight. If the connection is good, then the probe probably needs to be replaced.

Five-wire probe. These probes are more sophisticated. The probe has a built-in pre-amp to increase the signal strength and a thermocouple to sense temperature. The fastest way to test the probe is to replace it with a new one; however, some pre-amps are in the junction box. It may be possible to disconnect the pre-amp and connect the sensing tip to a portable pH/ORP meter, then follow the procedure for checking a two-wire probe.

Checking the controller module. The pH controller, which consists of a meter or digital display and alarm relays, is usually controlled by a microprocessor. A pH signal generator is required to test a meter. The pH signal generator produces a 59 mv output for each pH unit. It acts like an electronic probe, since only a specific pH value can be selected.

Disconnect the sensing probe from the pH controller. If the probe has five wires, usually the black and shield (outer braided wire) are used for the pH signal. The terminals may be marked P+ and P- or shield. Also, the P- and shield terminals may have a jumper wire. Connect the pH signal generator to the controller. It is important to make certain the polarity is correct. The wire from the center of coaxial cable must go to the P+ terminal. Make sure the pH signal generator and pH controller are turned on and pH 7 is selected. Calibrate the pH controller for 7. Then select pH 10 and slope the controller.

After calibration, check the controller for pH 4. Once calibration is complete, check the pH controller over the full range of 0 to 14. The meter or digital display should read the pH value selected on the signal generator. If the controller does not read correctly or will not hold calibration, the module needs repair.

The pH signal generator can also check an ORP controller. Most test instruments generate signals of zero, 10, 100 and 1,000 mv. The testing procedures are similar to checking a pH controller, and the module should give accurate mv readings over the full range.

Cables and connections. The signal from the pH sensing probe must reach the pH controller without interruption or distortion. Often problems result from poor connections or faulty cable. Modern 75-ohm coaxial cable conducts a pH signal up to 100 ft without using a pre-amp. However, triaxial cable, containing three conductors, is best. The center conductor is connected to the glass electrode in the probe and P+ terminal on the controller. The braided shield is used for a ground and is connected to a grounding rod immersed in the solution being tested and the ground terminal on the controller.

Even though shielded cable is designed to prevent interference from AC power, cables connecting sensing probes and controllers should be isolated. The cables should be run in a separate conduit with no wires that conduct AC current. Electricity from the nearby pumps and wires can induce false signals or voltage spikes in pH controllers.

Also, poor connections, especially at the probe, can pose problems. Usual BNC connectors are used because they have good corrosion resistance and are easy to disconnect. Check to make certain that the connectors on the cable are tight and the mating surfaces clean and dry. Also, when all else fails, run a continuity check on the cable to make certain it is not broken and is making good contact.

Groundloop is a condition where the probe senses stray current in the solution. To test for groundloop, fill a plastic container with the solution and immerse the probe. If the pH reading is steady and accurate, the problem is caused by a groundloop, indicating faulty grounding at the controller and/or process tank.

First, use a digital volt meter to check for AC voltage between the common (neutral) wire and ground on the controller. Then, check for AC voltage between the ground on the controller and true earth ground. Neither reading should be greater than 15 to 20 mv.

If no stray AC current is found, the problem may be in the process tank. Both static electricity and stray current produce a false pH or ORP reading. A copper rod grounded to true earth and placed in the process tank eliminates this problem.

Now that many of the mysteries of pH and ORP have been revealed, keeping automatic controllers working properly should be easier. Remember these steps: 1) Inspect the probe to see if the tip is dirty or broken. 2) Test the probe with a portable meter and buffer solutions to see if the signal is correct. 3) Check the connections on the cable between the probe and controller, making sure they are tight, clean and dry. 4) Check the controller module, making sure the unit is properly calibrated and has a good earth ground. 5) Test the meter with a signal generator to see if the readings are correct. 6) Check for a groundloop. The problem may be caused by improper grounding, induced AC current from nearby pumps and mixers or even stray currents in the process tank. **PF**