Maximizing Sensor Performance in Demanding Applications

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For maintenance and plant operations, one device that can often represent significant cost is the sensor, particularly in harsh applications such as chemical and petrochemical processing. Often exposed to or immersed in highly corrosive solutions and subjected to extremely high operating temperatures and other severe conditions, pH sensors are the critical front-line probes that gather and deliver key data. The proper selection, installation and maintenance of pH sensors, combined with new sensing technology can extend sensor life, thus reducing costs and improving performance.

Selecting a sensor

Maximizing pH sensor performance starts with selecting the right sensor, which is predicated on knowing your application. The more demanding the application, the more critical it is to consider process operating conditions and expectations of the sensor.

Selecting the appropriate pH sensor requires a basic understanding of sensor construction. The five main components are the sensor body, measuring electrode, reference junction, temperature sensing element, and reference electrolyte. When selecting a sensor body housing, two key considerations are material and mounting configuration. Choose a body material that is compatible with the process chemistry, temperature and physical parameters of the installation. Sensor bodies, made of polyphenylene sulfide (PPS) are suitable for most general-purpose applications. For more demanding applications, polyvinylidene fluoride (PVDF) is suitable because of its pressure, temperature and mechanical properties, including resistance to chemical attack.

Regarding mounting configurations, existing mounting arrangements will dictate what should be specified. The traditional problem has been specifying, ordering, stocking, providing training for, and maintaining an extensive variety of sensors to accommodate the different types of mounting configurations throughout a plant. To alleviate this, single-body sensors have been developed that can be installed to a variety of different mounting options. The one-sensor-fits-all design provides adaptability for valve insertion, threaded universal bushings, tees, flow chambers, and tri-clamp flanges. Standardizing on single-body sensors simplifies ordering, inventory and storage, while reducing maintenance and material costs.

Another factor to consider is disposable versus rebuildable sensor bodies. Disposable sensors are more widely used because of their ease of use; specifically, they are easy to install, replace, calibrate, and maintain. However, convenience has its cost. Ongoing cost containment has renewed interest in rebuildable sensor bodies, particularly in harsh environments that require frequent sensor replacement. With rebuildables, new electrodes, reference junctions and reference electrolyte are inserted into reusable sensor bodies. Rebuild kits are less costly than replacement disposable sensors. However, rebuildables do require inventorying internal spare parts and skilled technicians that can assemble the sensors.

The measuring electrode is the "business" area of the sensor and includes glass that comes in contact with the media being measured. The three most popular types of glass configurations available are domed glass bulb with a protective guard, domed glass, and flat glass. The domed glass bulb with a protective guard is best suited for severe applications where breakage is a concern while in service or handling during installation and maintenance. The domed glass bulb accommodates applications where the process stream contains a high level of solid material that might get caught on the protective guard. The user must take special precautions while handling this electrode during installation and maintenance. The flat glass electrode is especially well suited for applications with solids that coat or wear on the electrode. The smooth sensing surface is self-cleaning by the action of the process flow. This design is also well suited to minimize breakage from handling.

New technology

Advancements in materials and sensing technology open new avenues for extending pH sensor service and cost savings. For instance, a pH glass formulation is now available that provides measurement stability and accuracy, and longer service life in high temperature applications, up to 250 degrees F. The glass also increases response speed up to five times and allows longer duty cycles compared with conventional sensors. By switching to pH sensors incorporating this new technology, a leading chemical company increased pH sensor life from two weeks to six months. Equipment and maintenance costs were eight times lower than with the previous sensors. The new sensors also provided more accurate pH readings, ensuring that control operators could use the on-line pH measurements to optimize the efficiency of their process.

Installation

Industrial pH sensors can be installed in the process piping, immersed in a tank or basin, or placed in a sidestream sample. In a sidestream, a portion of the process liquid is continuously removed from the main process and directed to the sensor. Sidestream systems are necessary when the temperature and pressure of the process liquid exceed the sensor rating. If the sensor is to be inserted directly into a pipe, choose a location that is always flooded. If that is not possible, pay attention to how far the sensor extends into the pipe. If the liquid level varies, the sensor may become uncovered and render inaccurate readings.

Also, consider that pH sensors need regular calibration and, in some applications regular cleaning. If possible, install sensors to allow easy access and removal. If the sensor is installed in the process pipe or inserted through a vessel wall, the process might have to be shut down and at least a portion of the system drained before the sensor can be removed. In these situations, a retractable sensor may be the solution.

In-line and in-tank installation can also be accomplished using a ball-valve insertion assembly that allows the sensor to be inserted and removed from the process without draining the tank or shutting down the line. Always consider the velocity and density of the liquid flowing past the sensor. A dense liquid moving at a high flow rate can deform the insertion shaft, particularly if it extends some distance into the stream. If a retractable sensor becomes bent or distorted it might not be possible to safely remove it.

Removing sensors with screw-in (pipe thread) connections can be a problem. To prevent twisting the cable and breaking wires and shielding, the cable must be disconnected before unscrewing the sensor. Consider replacing standard cables with quick-disconnect versions for improved sensor access.

Maintenance maximizes sensor life

As the critical front line probes that gather and deliver key data, pH sensors need regular maintenance for peak performance and extended service life. When using intelligent sensors and transmitters, let the automatic sensor diagnostics help guide sensor maintenance. For example, the "coating" diagnostic automatically tells you to schedule sensor cleaning. Also, when removing a sensor from a very hot or very cold process, avoid thermally shocking the sensor. Do not blast it with water that is significantly hotter or colder than the process fluid. Allow the sensor to moderate its temperature first.

While maintenance involves mostly cleaning and calibrating, and eventually sensor replacement, the frequency of sensor service calls can be determined only by experience. Though cleaning methods will vary by application, all follow general guidelines. For instance, never scratch or aggressively scrub the sensing elements. These are delicate glass electromechanical electrodes and can break easily by force. To remove oil and grease, wash the glass bulb with mild detergent and rinse thoroughly with water. For loose scale or debris, use a stream of water from a wash bottle to rinse away solids from the tip of the sensor. If water does not work, gently wipe the glass bulb and liquid junction with a soft cloth, tissue, cotton-tipped swab, or a soft bristle brush.

Hard scale (oxides, carbonates and other corrosion products) requires more aggressive cleaning. If wiping the sensor tip with a tissue does not remove the scale, soak only the glass in a solution of 5% hydrochloric acid. Be sure to keep the acid away from the liquid junction and any stainless steel part of the sensor. Some scales, such as calcium sulfate, cannot be removed easily with acid. Soaking the glass bulb in a 2% solution of disodium EDTA for five minutes should be helpful. However, be careful not to soak too long, since EDTA solutions can attack glass.

Calibration is key

Experience will also determine the frequency at which sensors should be calibrated. Sensors installed in dirty or corrosive process streams usually require more frequent calibration than sensors in clean water. Sensors measuring extreme pH values, particularly high pH, also require more frequent calibration. The width of the pH control range and the consequences of an out-of-limits condition have a significant impact on calibration frequency. Also, if monitoring data are reported to regulatory agencies, the agency may dictate the frequency of calibration.

The following procedure can help you determine how often a pH sensor should be calibrated:

1. Calibrate the sensor with a two-point buffer and record the date of calibration, pH reading and temperature reading in each buffer.
2. Install the sensor in the process stream.
3. After the appropriate period two weeks for a clean process, three days for a dirty or aggressive process check the sensor's performance in buffers. Record pH and temperature readings.
4. If the calibration is acceptable, do not recalibrate the sensor. Return it to the process. Continue checking the calibration at the same, or slightly longer interval.
5. If the calibration is not acceptable, recalibrate the sensor, check the sensor response in buffers and record the results.
6. Return the sensor to service and recheck it at a shorter period than what was first selected.
7. After a short time, it will be apparent how long the sensor holds calibration. The minimum calibration frequency can then be determined.
8. Check the calibration of the sensor several times during the regular calibration interval. Interim checks verify the sensor is still in calibration and validate the process measurements.

Storage

The standard shelf life for most pH sensors is one year from date of shipment. Sensors should be stored wet, in pH 4 buffer solution or dilute solution of potassium chloride, with the sensor tip down. Do not store sensors in deionized water or alkaline buffers. If a sensor dries out during storage, soaking it overnight in a pH 4 buffer will usually restore the hydrated glass layer and the reference junction.

Sensors are a common and critical component used throughout process industries to support reliable and safe operation, provide regulatory monitoring and validation, and ensure quality control, process efficiency and optimization. Based on industry statistics, it is estimated that by maximizing sensor performance, a medium-sized chemical plant can realize savings of $20,000 per year attributable to fewer probe replacements, and maintenance calls.

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