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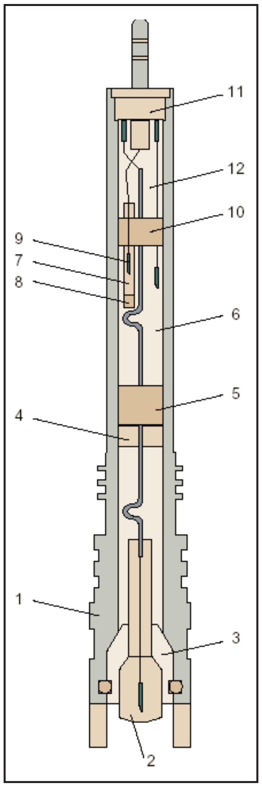
Tracking Sensor Deterioration To Prolong Useful Lifecycles

To date, standard maintenance techniques for electrochemical sensors only demonstrate that the instrument is providing accurate (or inaccurate) measurements and the degree of inaccuracy. Without a means to track the level of contamination of the electrode, process engineers may not know their process is at risk until it is too late. Further, since most electrochemical sensors cannot be tested without removing them from a line, many engineers prefer to replace electrodes, regardless of their remaining useful life. “This preemptive maintenance approach is costly in terms of parts and manpower, as well as disruptive to the process," says Larry Berger, president of Electro-Chemical Devices, Inc. (ECD; Yorba Linda, CA; www.ecdi.com).

Electrochemical sensors are typically made up of two cells – a measurement cell sensitive to the specimen ion or ions to be measured, and a reference cell that maintains a common electrical potential with the specimen fluid. The reference consists of an internal element such as a metal-metal salt bridge (e.g., Ag/AgCl), an electrolyte that surrounds the reference electrode with an electrochemically stable environment and a liquid junction through which the electrolyte contacts the specimen to be measured. When mixing occurs between the electrolyte and the specimen – the onset of electrode poisoning – there is a change in reference cell potential, which causes inaccurate readings and results in sensor failure.

Cross-sectional view of a Sentinel sensor:

1. Sensor housing; Primary measurement cell;
2. Ion-specific membrane;
3. Semi-permeable liquid junction;
4. Barrier salt;
5. Second liquid junction defining an electrolyte chamber for reference cells (RCs);
6. Chamber filled with electrolyte forming diagnostic reference half-cell;
7. Primary RC (PRC) placed in diagnostic RC chamber;
8. Liquid junction within the PRC;
9. Half-cell forming the PRC;
10. Inert plug to hold PRC within diagnostic half-cell;
11. Connector at back of sensor;
12. Electronics embedded in epoxy communicate with transmitter.



ECD has commercialized a technology that alerts process engineers when sensor degradation begins so they can manage the replacement process proactively. Designated the T23 Sentinel electrode system, it centers around a self-diagnostic sensor with a multi-chambered reference cell that determines when the interaction between the reference cell electrolyte and the process fluid has impacted the measurement of pH, ORP or specific ions, such that the error is no longer within the preset limits.

To perform this diagnostic function, each Sentinel sensor contains two or more reference cell chambers, separated from each other by a salt bridge, shown by a double horizontal line in the figure. One electrode generates a standard reference cell potential called, el (7), while an additional electrode (not shown on the drawing) penetrates below the salt bridge where mixing between the electrolyte and process fluid takes place and generates another reference cell potential, el* (6). The difference between el and el* provides the error signal that quantifies reference cell degradation. The Sentinel transmitter receives the potentials e1 and e1* from the two electrodes in the multi-chambered reference cell and compares the difference between them with a setpoint chosen by the operator that specifies the measurement error that can be tolerated. This error is displayed as a simple bar graph in the top right-hand corner of a liquid crystal display. When the error setpoint is reached, the display flashes, alerting local personnel to the sensor failure, while sending a signal to the control to alert an operator.

Other transmitters in use accept two-wire sensors. In contrast, the Sentinel sensor has three wires and cannot yet be used with other commercially available transmitters. The money saved in replacement sensors using Sentinel systems is application-dependent, but can be substantial. For example, if a sensor required replacement once a week but, by using Sentinel sensors, its life were extended by one extra day, the savings would be 15%. On the other hand, if the replacement cycle is once a month, and a Sentinel sensor lasted for two months or more before it alerted an operator for replacement, the saving would be at least 50% or more. Even more importantly, chemical engineers would know that all sensors in their processes were operating accurately at all times, and would never have to throw away defective product produced by measurement errors, Berger points out.

Each Sentinel sensor includes built-in electronics that allow process engineers to locate the transmitter up to 3 miles away from the measurement electrode. When it is time to replace the degraded measurement elements, users can simply plug new electrodes, complete with liquid junctions, into the sensor assembly.

The T23 family of Sentinel transmitters has a base cost of $945-$1,295, depending on the ion to be measured and accessories. “This is 8-10% more than the cost of transmitters currently on the market, due to diagnostic programming and electronics that enable remote monitoring of the sensors,” says Berger. However, the cost of each sensor is competitive. Electrode cartridges range from $325, for a pH monitoring device to $700, for more-complex specific ion measuring electrodes (also 10% more than conventional equipment).