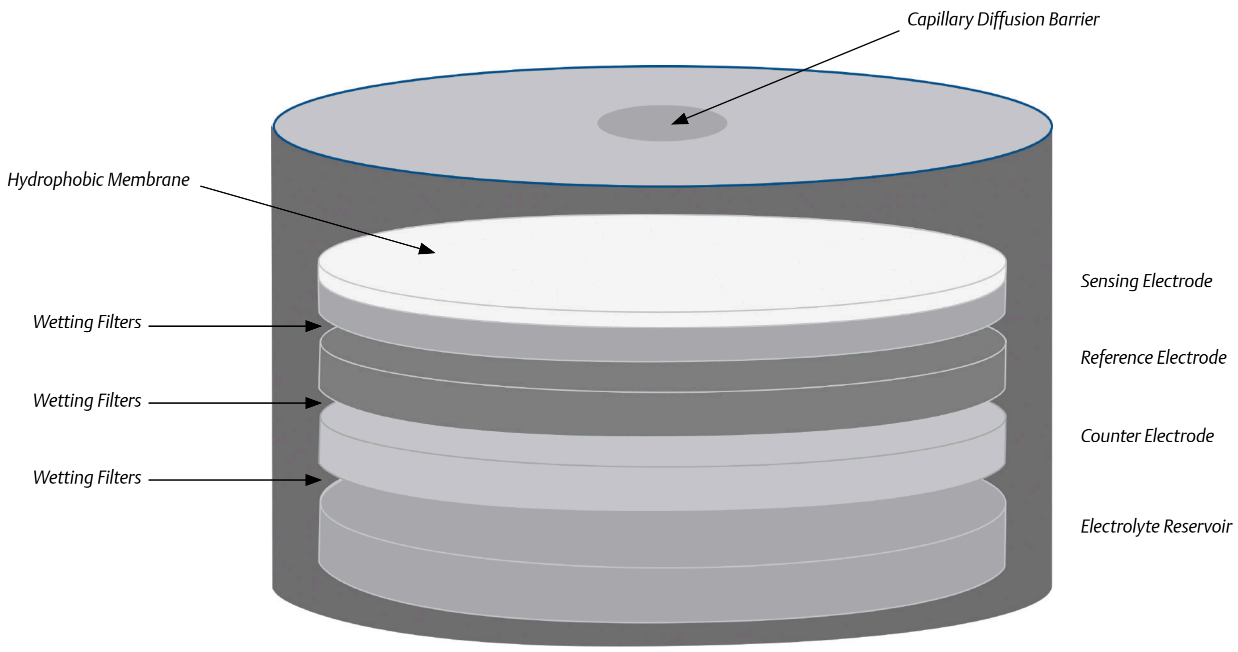
Gas Testing for Electrochemical Gas Detectors

Background

Electrochemical sensors used for fixed point toxic gas detection have advanced considerably over the last years. New designs are more compact, resilient to adverse environments, and reliable. Novel designs are also revealing more failure types and providing information on sensor health well before the device can no longer perform its protective function. Such diagnostics are prompting end users to consider maintenance routines in a new light; most evident perhaps in the extension of periodic inspections and tests. In some instances, operators are forgoing periodic gas testing in favor of monitoring parameters that correlate with sensor health. Nonetheless, such complete reliance on leading indicators of sensor health is risky. As end users modify maintenance protocols to better take advantage of predictive health intelligence diagnostics, they should consider the role of periodic gas testing and diagnostics in electrochemical devices.

Electrochemical sensors respond to gas accumulations by reacting to the target gas and producing an electrical signal proportional to the gas concentration. A typical electrochemical sensor consists of a sensing electrode (or working electrode), a reference electrode, and a counter electrode separated by a thin layer of electrolyte (typically hydrochloric or sulfuric acid; see Figure 1). The electrolyte provides ionic electrical contact between the electrodes with the aid of hydrophilic separators. Gas that comes into contact with the sensor first passes through a small capillary opening and diffuses through a hydrophobic barrier to reach the sensing electrode. The gas then reacts at the surface of the sensing electrode oxidizing or reducing the gas to be measured. A high surface area catalyst is used to optimize sensor performance. All electrochemical sensors for fixed gas detectors operate in the amperometric mode, meaning they generate a current that is linearly proportional to the fractional volume of target gas.

Figure 1 – Schematic of Electrochemical Cell



Because high availability is essential for safety devices, most gas detector manufacturers make provisions for circuitry that monitors sensor health. A voltage or resistance across the sensor can be indicative of an incipient failure provided the signal and allowable variance in parameters for a "good sensor" are understood. Deviations from a baseline beyond certain tolerances or patterns of the signal can therefore suggest degradation in sensor performance. Such diagnostics have contributed to the wider acceptance of electrochemical gas detectors in the process sector, where devices must operate continuously in low demand conditions for several years. The advent of predictive health diagnostics has also contributed to a more robust and efficient management of detector installations. As work orders for repair are issued only to those devices that need attention, the risk of inadvertently damaging well-running equipment is minimized.

Although the benefits of improved diagnostics must be recognized, they cannot be taken to suggest periodic testing should be reduced or eliminated. Like periodic testing, diagnostics are imperfect and it is unrealistic to assume they will detect all failures. Consider a detector may fail to detect gas if its membrane or sinter is blocked by dirt. Even a small amount of impacted dirt can have a significant effect on the membrane's permeability and access of gas through the capillary diffusion barrier, reducing the device's effective response speed. Prolonged exposure to silicone vapors can also have a similar effect. In both instances, the inhibition of sensitivity may not be revealed through diagnostics.

Invariably, periodic gas testing must be part of a maintenance regime. For point gas detectors, periodic gas testing involves applying a well-known gas concentration to the device. If the device reports a reading that is within tolerance of the applied gas concentration and responds within an adequate amount of time, it can be said to operate as specified. The test is simple and easy to implement. One advantage of gas testing that is often overlooked is that it serves as a forcing mechanism for visual inspections. A visual inspection can reveal signs of exposure to alkaline metals, which form salts and can cause sensor drift. Excessive rust around the sensor may also be indicative of exposure to corrosive materials like chlorine, hydrochloric acid, and hydrogen sulfide. Additionally, a damaged diffusive barrier – a splash guard, insect guard – can be quickly detected by visual inspection. Equally important, the gas test is an enabler for a full test of the safety loop. Such holistic tests ensures sensor activation and fire and gas system response, including alarms and isolation of equipment, are consistent with fire and gas system design.

It is not often that a detection technique can be as improved for long unattended operation. End users have responded to new advances in electrochemical cell design with higher rates of product usage. Nonetheless, the adjustments of maintenance practices as a result of new diagnostics must be measured. Diagnostics cannot test the permeability of gas across a membrane or diffusive protective barrier. The intent should be to increase the percentage of failures that are revealed from testing and diagnostics. In an imperfect world, the combination ensures device availability is maximized.

References

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