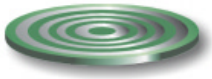
SCOTT/BACHARACH
Gas Detection Products

# What You Should Know About Electrochemical sensors…

Most electrochemical toxic gas sensors are based on the same principles. However, key differences exist between various manufacturers' makes and models. Given the importance of gas detection systems to your facility, it is a good idea to understand these differences, as well as the general limitations of the technology.



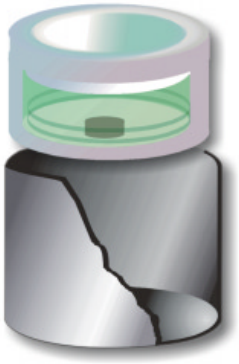
## How Sensors Work

An electrochemical sensor generally has three main components: electrodes (one or more of which is coated with a catalyst), electrolyte, and a membrane. Gas diffuses through the membrane and reacts at the electrolyte-catalyst interface, which creates a current. For example, the reaction for HCl is:

$$2HCl + H_2O \rightarrow Cl_2 + 4H^+ + 4e^-$$

$$4H^+ + O_2 \rightarrow 2H_2O$$

The instrument measures the current and translates it into gas concentration. Since the number of electrons given off is proportional to gas concentration, sensor output is linear.



## Lifetime

Sensor lifetime is determined by many factors, including heat, humidity, dirt, and cumulative gas exposure. Under normal operating conditions, sensors should last for at least one year, and in many cases two years. Brief exposures to high concentrations of gas can reduce sensor performance in the near term — gas that has worked its way into the sensor (response time) needs time to work its way out (recovery time).

## Response

Although sensor output is linear, response time is a logarithmic function. The first molecules of gas to diffuse through the membrane cause a very rapid change in response; as the sensor's output approaches the actual ambient gas concentration, the rate of change of response slowly decreases. The response curve of the best sensors looks very much like a step function; that of the worst looks more like a straight line. The inverse of the response curve determines a sensor's recovery time after being exposed to gas.

Manufacturers typically define some length of time, such as 10 minutes, as the point at which a sensor reaches its maximum output. A sensor's $T_{90}$ is the time in which it reaches 90% of this value; $T_{50}$ is the time to reach 50%. The lower these two numbers, the better the sensor's performance.

## Warm-Up Period

Most electrochemical sensors require a fixed bias to be maintained across the sensor electrodes. This bias is one of the key determinants of sensor performance; after it is applied, the electrolyte typically needs time to reach equilibrium. For most sensors this warm-up period is 4-8 hours. However, some Scott-Bacharach provide sensors with a built-in battery that maintains bias, thus eliminating warm-up time.

## Accuracy

Because electrochemical sensors are typically calibrated to standards that cannot be traced back to a primary standard, "accuracy" is a misleading term. Linearity, repeatability, and sensitivity are much more commonly used (and better) performance measurements. Sensor linearity and repeatability follow the standard definitions. Sensitivity, also known as minimum detectable level (MDL), is generally defined as three times the sensor's inherent background noise.

## Drift and Interferences

All electrochemical sensors experience zero drift. However, typically this is a long-term phenomenon, and quarterly calibration is generally adequate to compensate for it. Interferents, gases other than the target gas that cause the sensor to respond, are a nearer-term concern; their effects are often mistaken for drift. Since they are related to electrolyte composition, interferents cannot be eliminated. However, in many applications (e.g. gas cabinets) they are not an issue — interferents are simply not present. For other applications, some manufacturers provide filters to block specific interferents (e.g., $H_2S$ on HCl). Careful positioning of gas detectors during design and installation can also prevent interference problems.

## Humidity

Sensor electrolytes are generally hygroscopic, meaning the amount of water in the electrolyte tends to reach equilibrium with that in the surrounding air. Because water is a key part of the electrochemical reaction, in very dry (and very hot) areas sensor lifetime will be diminished. Similarly, in environments with very high continuous relative humidity, sensors will have a shortened life. Some manufacturers have addressed these problems by providing sensors formulated specifically for dry or humid environments.

## Air Flow

Rapid air flow past a sensor's face (typically greater than 1 liter per minute) can change gas diffusion characteristics, which can affect sensor performance. In addition, high air velocities can reduce sensor lifetime by drying out the sensor more rapidly than normal. Some manufacturers provide systems that solve these problems by regulating the flow of air past the sensor face.

## Key Questions to Ask

Gas detection typically is a "mission-critical" application, and sensors are the heart of the system. A small number of questions should enable you to compare different manufacturers' sensor performance:

• What is the sensor's $T_{50}$? What is its $T_{90}$? What length of time (to maximum sensor output) are these based on?

•Does the sensor have a warm-up period, or is there a built-in battery?

•What is the sensor's Minimum detection limit (MDL)?

•Does a low/high humidity version of the sensor exist?

•What are the sensor's typical interferences, and what level of response do these cause? Can any of these be filtered out?

As with any instrument, regular maintenance is needed to keep your gas detection system operating at its peak performance. Costs associated with calibration, spares, etc. represent the majority of your investment over the lifetime of the instrumentation — often twice the initial cost of the equipment. The most important questions to ask any vendor, therefore, center around lifetime ownership costs: how long calibration takes, how often sensors need to be replaced, and what lifetime ownership costs are.

## Rock Solid Sensor Technology

In addition Scott/Bacharach's Research and Development team has produced an advanced sensor technology called Rock Solid®. The Rock Solid sensor line is a collection of high performance gas specific sensors that drastically reduce response and recovery times when exposed to gas. Ask you sales representative for more information on Rock Solid sensors.