Lifespan and Shelf Life of Electrochemical Gas Sensors

Electrochemical (EC or Echem) gas sensors are used for a wide range of applications, such as industrial safety, air quality monitoring, and IoT-powered systems.

For general applications in industrial safety, the most popular EC sensors are carbon monoxide (CO) and hydrogen sulfide (H2S) sensors. Based on the highly accelerated life testing data, SemeaTech CO and H2S sensors are expected to have a service life of 2 years. The oxygen (O2) sensor is another popular one, and the SemeaTech Lead-Free O2 sensor is designed for a service life of 5 years.

In industrial applications, there are many other types of toxic gas sensors, so-called exotic gas sensors (or exotics in short), such as chlorine (CL2) sensors and ammonia (NH3) sensors. These sensors can be grouped into two major categories: consumptive and non-consumptive (also known as depleting and non-depleting) as listed in the table below.

Non-Depleting EC Sensors			Consumptive EC Sensors
Hydrogen (H2)	Methyl Mercaptan (CH3SH)	Formaldehyde (CH2O)	Ammonia (NH3)
Nitric Oxide (NO)	Nitrogen Dioxide (NO2)	Phosphine (PH3)	Hydrogen Fluoride (HF)
Sulfur Dioxide (SO2)	Long-Life Ammonia (NH3)	Ethylene (C2H4)	Hydrogen Cyanide (HCN)
Ethylene Oxide (ETO)	Tetrahydrothiophene (THT)	Arsine (AsH3)	Hydrogen Chloride (HCL)
Chlorine (CL2)	Chlorine Dioxide (CLO2)	Acetylene (C2H2)	Vinyl Chloride (C2H3CL)
Ozone (O3)			

Non-consumptive means these sensors don't need to convert an element to create the electrical output for readings. In general, the lifespan of non-consumptive EC gas sensors is expected to be a minimum of 12 months, but in different applications, it can be longer or shorter. In harsh environments, the lifespan can be reduced significantly in contrast to in a clean environment with temperature and humidity controls, where these EC gas sensors can work continually for several years.

The consumptive or depleting EC gas sensors are also designed to work for 12 months or longer. However, the catalyst is consumed by the chemical reaction while the target gas is being measured. The lifespan of these sensors not only depends on the environmental conditions but also on the concentration of the ambient target gas and the duration of time the sensor has been exposed to the target gas. A typical depleting ammonia sensor with a capacity of 10,000 PPM-Hours will only last 42 days if it is deployed in a chicken farm with constant ammonia concentrations of 10 ppm.

Under ideal conditions, that is, the temperature and humidity are maintained at around 20°C and 60%RH, respectively, and there is no contaminant invasion, some EC gas sensors are known to work for more than 10 years. Periodic exposure to the target gas does not limit the sensor lifespan, and good quality EC gas

sensors are usually equipped with sufficient catalysts and durable materials that are not easily depleted by chemical reactions.

Shelf Life

EC gas sensors usually have a shelf life or storage period of six months in an ideal storage condition of 20°C and 60%RH before initial use after production. Beyond this period, the sensor performance is likely to deteriorate, such as with longer response time and lower sensitivity.

Sensors with filtration layers

Some EC gas sensors are embedded with chemical filters to remove interference gases. These filtration layers have a limited lifespan. When a filtration layer is saturated, the degree of cross-reaction between the target gas and the interference gas becomes more severe, so users cannot tell whether the signal detected by the sensor is from the target gas or the interference gas. Some filtration materials are sensitive to humidity, and the filtration effectiveness will be reduced at high humidity levels.

Factors affecting sensor lifespan

- Temperature: Extreme temperatures affect the EC gas sensor lifespan significantly. The majority of these sensors are designed to operate between -30°C and +50°C. The high-quality ones can withstand temperatures beyond this range for a short period of time. For example, well-designed and manufactured H2S or CO sensors can withstand 1 to 2 hours of exposure at 60°C. However, repeated exposure to such a high temperature can lead to electrolyte drought and cause baseline shifting and delay responses. Some EC gas sensors can work at a temperature as low as -40°C, but the sensitivity will be greatly reduced, and the response time will be increased. In addition, when the temperature falls below -35°C, the electrolyte has the risk of freezing.
- Target gas concentration: If the target gas concentration is too high, the EC gas sensor performance will be degraded. It is important to prevent a sensor from being exposed to the target gas at a concentration exceeding five times its designed maximum load. Sensors using high-quality catalysts might be able to withstand such conditions without damaging their long-term performance, but sensors using poor-quality catalysts will stop functioning in this case.
- Humidity: The ideal working environment for EC gas sensors is around 20℃, 60%RH. When ambient humidity is extremely high, the electrolyte gets diluted by the absorption of moisture. In extreme cases, electrolyte volume can increase by 2 to 3 times, which is likely to cause electrolyte leakage. If ambient humidity drops very low, say below 20%RH, the electrolytes can become dehydrated, and the sensor response time will be significantly prolonged. By weighing the sensor, electrolyte dilution and dehydration can be determined quickly and easily. Compared with the factory weight, when the change in sensor weight is more than ±250mg, it indicates that the performance of the sensor is likely to be affected. The dilution or dehydration of the electrolyte is reversible by exposing the sensor to the opposite extreme of humidity. It takes about 5 to 25 days to restore the sensor electrolyte, and the sensor performance can be restored as well.
- Organic gases: Ambient air containing organic gases may be absorbed by the EC gas sensor catalyst or react with the catalyst to produce by-products that inhibit the catalyst and damage the sensor electrode.

- Vibration: Strong vibration and mechanical shock can damage the interconnections of the electrodes and connecting strips (platinum wires) of an EC gas sensor.

It is important to note that the sensitivity of the sensor may vary with the surrounding environment. A sensor that is insensitive and has a long response time may improve as ambient humidity changes. This situation is more prominent in areas with distinct seasonal climate changes. The sensitivity and response time of the sensors in fixed gas detectors are likely to change within two to three weeks of being adjusted and stabilized according to local temperature and humidity. This is especially common when the sensor is stored in a very dry environment prior to installation in the field.

Prediction of the service life of EC gas sensors

In practical applications, it is difficult to predict the service life of EC gas sensors accurately. The service life of the sensor can be affected by many of the factors mentioned above. The situation is quite different for various applications. In practice, the user can replace the sensor according to the manufacturer's recommended life cycle, or according to their own historical data, for example, every year. When the sensitivity of the sensor is significantly reduced or the response time is too long, the sensor needs to be replaced immediately.