Cross-Contamination of Sensors by Other Gases and the Influence on Detector Accuracy

Introduction

Most gas detectors contain a sensor that is designed to register the presence of a particular gas. There are some singular sensing elements capable of distinguishing multiple gases, but the majority of them are selective to one gas. In a perfect world, that would be the end of this discussion. However, real sensors are subject to cross-contamination from other gases that have the potential to interfere with both sensitivity and accuracy.

The following information will detail what kinds of symptoms to look for and how to understand the influence of interfering gases on detector accuracy.

Sensor Operation

In order to better understand cross-sensitivity, it is helpful to know the basics of sensor operation. When it comes to monitoring toxic gases, the most popular sensor type is electrochemical.

Electrochemical sensors have two main sensing components: electrodes and an electrolyte. When gas reaches the electrodes, a chemical reaction occurs and generates an electric current through the electrolyte that is proportional to the amount of gas at the electrodes. The more gas present at the electrodes, the more reaction occurs and the more current is generated.

While greatly simplified, this is the basic concept of turning gas into electrical signals that can be interpreted by gas detectors and dealt with accordingly.

Cross-Sensitivity

Cross-contamination occurs when other gases cause a chemical reaction at the sensor's electrodes. Since the sensors are exposed to the outside air, any gases in the detection area will be able to reach the electrodes. Some of those gases will cause the same chemical reaction as the target gas, thus tricking the sensor into a false positive reading.

Many electrochemical sensors incorporate a filter into the housing to limit the exposure from interfering gases. These filters have a limited capacity that is typically rated in ppm-hours. Figure 1 shows the filter capacity from one particular carbon monoxide sensor.

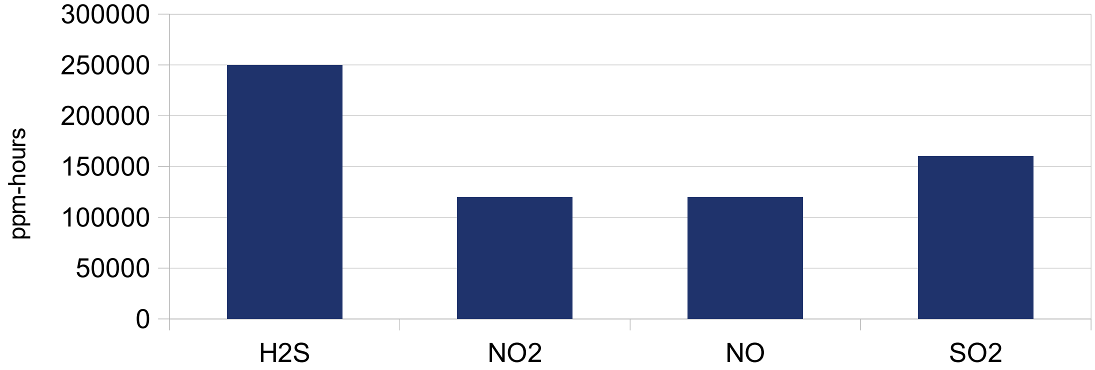

Figure 1: Filter Capacity in ppm-hours
Source: Alphasense: (http://www.alphasense.com/WEB1213/wp-content/uploads/2013/07/COBF.pdf)

The greater the exposure to the interfering gas, the weaker the filters will get and the quicker they will wear out. This increases the effect of cross-contamination as a sensor ages.

Even with a brand new filter, a sensor is still susceptible to false readings from these other gases. The response of the sensor to the chemical reaction from these gases other than the target gas is called its cross-sensitivity. Figure 2 shows the cross-sensitivity of one carbon monoxide sensor to other gases both with and without a filter and after the sensor has been allowed to age.

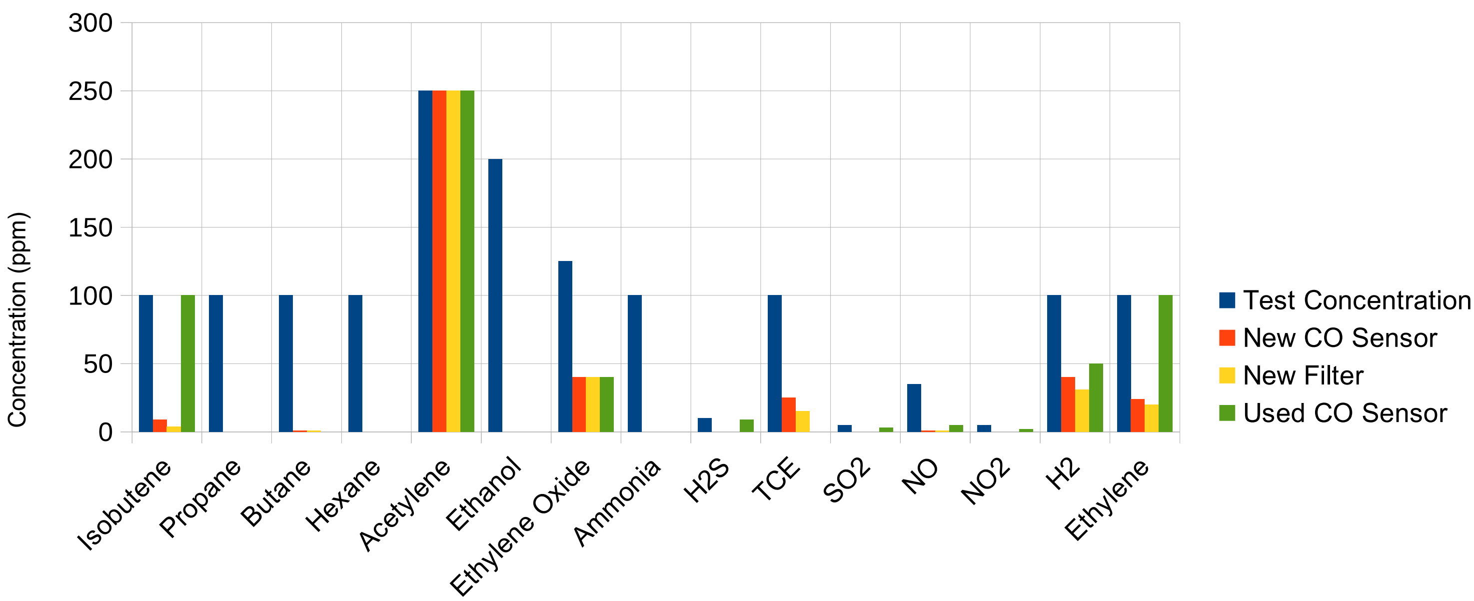

Figure 2: Cross-Sensitivity of Common Gases
Source: RAE Systems: (https://safety.honeywell.com/content/dam/his-sandbox/products/gas-and-flame-detection/documents/Technical-Note-121_CO-Sensor-Cross-Sensitivity-and-Removal-With-a-Charcoal-Filter_11-05.pdf)

Most gases like propane, butane, ammonia, and nitrogen dioxide have very little effect on the readings of this carbon monoxide sensor. However, it is very susceptible to interference from gases like isobutene, ethylene oxide, hydrogen, and ethylene.

Sensor Poisons

While there are numerous gases that can cause unintended reactions in a sensor, most of these will not have any lasting effects. These gases can temporarily create false readings both above and below the actual level of the target gas, but once the interfering gas source is removed and the gas has dissipated, the sensor will continue to operate as normal. Normal conditions, including those with an assortment of gases present, will see the sensor degrade over time and increase its cross-sensitivity characteristics as evidenced by Figure 2.

Conversely, some gases are extremely poisonous to the sensor and can ruin its accuracy in a matter of minutes. Gases that absorb onto the catalyst (e.g., acetylene for CO sensors) or gases that react and inhibit the catalyst (e.g., NO_2 for H_2S sensors) will prevent proper reactions from occurring and irreversibly alter the sensitivity characteristics.

Common Causes

From cleaning chemicals and paint supplies to welding equipment and vehicle exhaust, interfering gases are everywhere. Basically anything besides the intended target that contains a gas, gives off fumes, or evaporates is a potential cross-contaminator. In fact, one of the most commonly overlooked causes of cross-contamination is smoking products. Burning a simple cigarette releases a host of poisons into the air including ammonia, benzene, butane, carbon monoxide, formaldehyde, hydrogen, hydrogen cyanide, hydrogen sulfide, lead, methanol, nitric oxide, and toluene to name a few. Many of these compounds are commonly monitored hazardous gases. This means that anyone smoking, or anyone that has recently smoked, in the vicinity of a detector could be influencing the detector's readings. It is important to remember that inaccurate readings can be the result of interfering gases, but unexpected readings may be the result of accidental exposure to the target gas.

Conclusion

Under most circumstances, the influence of interfering gases on a detector's accuracy will be relatively small. Normal sensitivity drift over time has a much greater effect on accuracy than temporary sensitivity drift caused by cross-contamination. Still, a detector may read slightly higher or lower as a result of other gases being present, not to mention wearing out the filters and depleting the available reactants. Proper detector maintenance, especially sensor recalibration, will help mitigate these effects, ensuring the best detector operation and the most accurate readings. When in doubt, contact the detector manufacturer to obtain more information about the sensor or sensors inside.

Note: This bulletin contains general information with respect to the topic and is not intended to be an instructional guide. Only qualified personnel should perform actions described. All details are accurate as of the publish date below.

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