SENVA

Application Solution

Understanding Cross-Sensitivities

SUMMARY

Toxic gas sensors, when used appropriately, can ensure a safe response to elevated levels of toxins in the environments we live and work. While the proper installation of these sensors is imperative, it is also important to understand causes of inaccuracies, such as misapplication and cross-sensitivities.

Toxic gases come from many sources and can impose varying levels of danger to those who come in contact with them. Choosing the appropriate gas sensor for an application can ensure safety. The first section provides a brief overview of where some typical toxic gases come from and the dangers they may introduce.

A toxic gas may have similar properties to another toxic or innocuous gas, causing a sensor to give erroneous readings. This is called cross-sensitivity and it is inherent in the way gas sensing elements work. Unfortunately, a perfect gas sensor does not exist today. Cross-sensitivities can lead to confusion and inaccuracy if ignored. Understanding how they work and which gases to look out for is the best way to ensure safety.

TOXIC GAS SOURCES AND APPLICATIONS

Carbon Monoxide (CO) and Nitrogen Dioxide (NO2) are potentially toxic airborne gases resulting from an incomplete combustion processes from gasoline and diesel engines. Due to their shared source, CO and NO2 elements are often paired into one sensor for ease of installation and monitoring.

Propane and Natural Gas (Methane) are common fuel sources. A leaking tank or pipeline can be dangerously combustible. Methane is also a byproduct of some agriculture, landfills, and the burning of biomass fuels. Hydrogen is used in refineries as well as in some fuel-cell applications and is extremely flammable. It is also known to be released when batteries charge, making Hydrogen sensors a necessary precaution in battery rooms.

Oxygen is prevalent in the air we breathe but can be deadly at particularly high or low concentrations. In processes that require Oxygen or medical treatments, there is a dangerous potential for elevated levels. Oxygen sensors may also be utilized for general air quality monitoring.

Historically, almost all refrigerants were flammable, toxic, or environmentally harmful. While less toxic, more environmentally

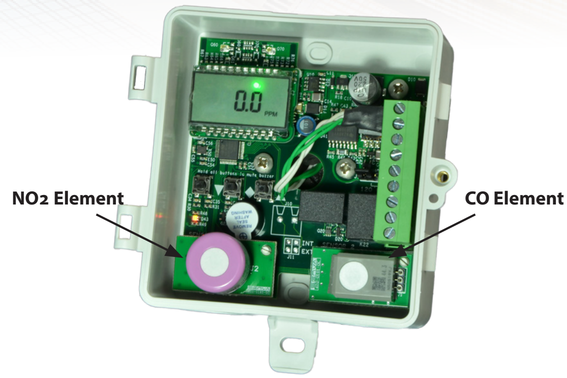

Figure 1: Typical Toxic Gas Sensor with NO2 and CO elements

friendly alternatives are becoming more common, they still pose a threat to safety. Refrigerant sensors are common in air cooling applications as well as commercial and industrial refrigeration applications.

A properly applied gas sensor can ensure safety in our environments.

CROSS-SENSITIVITIES IN ELECTROCHEMICAL SENSORS

Many toxic gas sensors available today utilize electrochemical sensing elements. Electrochemical sensors deploy a positive and negative electrode that generate current, much like a battery, only when a particular chemical reaction occurs with the specified gas. The level of conduction is proportional to the concentration of gas present and can be electrically measured to provide a gas concentration reading.

For example, a CO sensor works when CO reacts with water. An electrolyte has excess hydrogen atoms which it releases to bond with Oxygen in the sensor cell to form water. Then that water molecule (which consumed 2 hydrogen atoms to create) reacts with the CO that has entered the cell to further break apart:

$$CO + H_2O \text{ --> } CO_2 + 2H^+ + 2e^-$$

The outcome of this equation is Carbon Dioxide (CO2) which leaves the cell, 2 hydrogen atoms (H+) which will re-bond with the electrolyte, and 2 free electrons (e-) which are now flowing to generate current through the electrodes. This current can be measured to determine a concentration of CO.

As Hydrogen is a key part of this chemical equation, its presence can affect the reading the sensor provides. In many instances, there are also other gases that will create a similar reaction, causing a false reading.

The electrochemical elements used in the Senva TG product line and their cross-sensitivities are as follows (sensitivities with greater than 5% cross-sensitivity are highlighted yellow).

Carbon Monoxide, CO

Gas	Concentration	Typical response of CO sensor (ppm)
Carbon Monoxide	400 ppm	400
Hydrogen	100 ppm	17
Ozone	5 ppm	<1
Chlorine	10 ppm	<1
Nitrogen Dioxide	10 ppm	<1
Sulfur Dioxide	20 ppm	<1
Hydrogen Sulfide	25 ppm	<1
Ammonia	100 ppm	<1
Isopropyl Alcohol	200 ppm	1.3
Acetone	200 ppm	<1
Toluene	200 ppm	<1
N-Heptane	500 ppm	<1
Methane	3,000 ppm	<1
Carbon Dioxide	5,000 ppm	<1

Nitrogen Dioxide, NO_2

Gas	Concentra-tion	Typical response of NO_2 sensor (ppm)
Nitrogen Dioxide	20 ppm	20
Chlorine	1 ppm	1
Nitric Oxide	50 ppm	<10
Hydrogen Sulfide	20 ppm	<-8
Toluene	50 ppm	<1.5
Ammonia	100 ppm	<-1
Ethanol	100 ppm	<1
Hydrogen	500 ppm	<-5
Carbon Monoxide	400 ppm	<-4
Sulfur Dioxide	30 ppm	<-0.3

Oxygen, O_2

Oxygen sensors have no cross-sensitivity with toxic gases at low levels. Highly oxidizing gases, such as Ozone or Chlorine, at very high concentrations could interfere with the element. It is not recommended to sense O_2 in areas where high concentrations of other gases will be in continuous use, as the cell may become saturated over time.

CROSS-SENSITIVITIES IN CATALYTIC SENSORS

Catalytic type sensors contain a catalytic material which encourages reaction with a combustible gas. When a combustible gas is present, it burns, causing a rise in temperature and resistance. This resistance can be measured and compared to a non-catalytic element to determine a relative concentration of gas. Catalytic sensors are sensitive to all combustible gases to different degrees.

The Senva TG product line uses the same element for all combustible gas detection, but the element is calibrated specifically for Methane, Propane, or Hydrogen. The sensors may be field calibrated to sense any of the gases listed. For the Methane calibrated option, estimated cross sensitivities are as follows (Senva Pre-calibrated options are highlighted in gray).

Methane, CH_4

Gas	Relative sensitivity (%LEL gas/%LEL reading)
Methane	100
Hydrogen	84
Ethylene	80
Ammonia	80
Iso-butane	65
Propane	65
Carbon monoxide	65
Methanol	60
N-pentane	60
Cyclo-hexane	55
N-butane	55
Propylene	55
Cyclo-pentane	50
N-heptane	50

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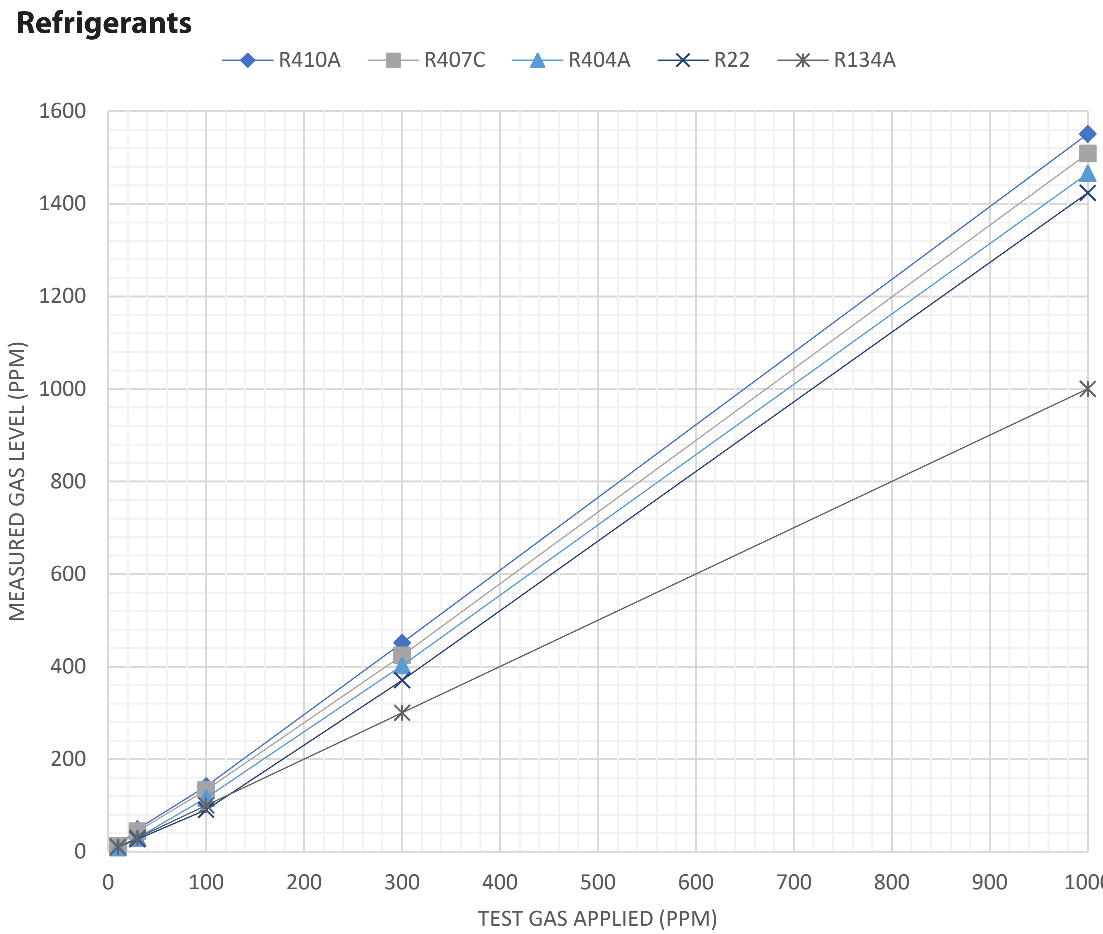
Gas	Relative sensitivity (%LEL gas/%LEL reading)
N-hexane	50
Ethanol	45
Iso-octane	45
Iso-pentane	45
N-propanol	40
Xylene	40
Acetone	35
Iso-butyl alcohol	35
Iso-propanol	35
Toluene	35
N-octane	35
Ethyl acetate	30
Styrene	30
Butyl acetate	20
Acetic acid	5

CROSS-SENSITIVITIES IN METAL OXIDE SEMICONDUCTOR (MOS) SENSORS

MOS sensors typically have a surface of tin oxide, or some other reactant which, when heated, causes gas particles in the air to bond with the reactant surface of the MOS sensor. More gas bonding with the surface of reactant results in more current conducting across the sensor which can be measured ot determine a gas concentration.

MOS sensors, unlike Catalytic or Electrochemical sensors, do not product a linear response. Due to the nature of this reaction, MOS sensors produce an exponential response to the gas applied. Therefore, to understand cross-sensitivity, a curve is needed for an accurate comparison.

A sensor calibrated to R134A responds more drastically to other refrigerant types as shown in the following graph. Thus, R134A sensors may be used for general purpose refrigerant leak detection. Additionally, an R134A sensor may also be field calibrated to any refrigerant gas for maximum accuracy.



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SOLUTION

Senva TG Series sensors can be ordered as individual sensors or as any dual combination of sensors in a shared enclosure. Senva's dual CO/NO2 sensor is the complete package for garage applications. Now you can also detect Methane/Propane leaks and monitor for elevated CO levels, all in one unit.

The analog output model features 2 outputs that support daisy chain wiring - multiple sensors may be used in a parallel sequence (0-10V) for cost effective coverage of large areas. The unit can also act as a stand alone controller, utilizing the relay for exhaust fan operation or the output for direct control of a VFD.

The BACnet/Modbus model supports BACnet MS/TP & Modbus network communication in one unit. Standard features include network auto-configuration, programmable fan and alarm relays, LED indicators,

Visit Senvainc.com for more great features or call your Senva sales rep today at 1-866-660-8864.

WANT TO LEARN MORE?

Check out Senva's Application note on the physics behind detecting CO and NO2.

Warning: *Application notes contain installation ideas and tips. Although developed by engineers and installers, Senva disclaims any liability for injury or losses due to information provided. This information does not supersede codes and/or ordinances or regulatory standards. Application notes do not comprehensively cover safety procedures for working with live electrical equipment. Refer to installation instructions that accompany products and heed all safety instructions.* *Copyright © 2020 by Senva Inc. All rights reserved.*

ORDERING INFO

TG [Pkg] - [Out] [Gas1] [Gas2] [Temp] [Lid]

Package
- W = Wall Mount
- D = Duct Mount
- M = Metal

Output Type
- A = Analog
- B = BACnet/Modbus

Gas Type 1*
- C = Carbon Monoxide (CO)
- N = Nitrogen Dioxide (NO2)
- M = Methane (CH4)
- P = Propane (C3H8)
- H = Hydrogen (H2)
- O = Oxygen (O2)
- 3 = R134A (Multi-Refrigerant)
- 4 = R410A

Gas Type 2*
- X = No second gas
- N = Nitrogen Dioxide (NO2)
- M = Methane (CH4)
- P = Propane (C3H8)
- H = Hydrogen (H2)
- O = Oxygen (O2)
- 3 = R134A (Multi-Refrigerant)
- 4 = R410A

Temperature Output
- A = None
- C = 100Pt RTD
- D = 1000Pt RTD
- E = 10K Type 2
- F = 10K Type 3
- G = 10k w/11k
- H = 3k
- I = 2k2
- J = 1k8
- K = 20k

Enclosure Lid
- Blank = Clear/Tinted
- S = Solid/Opaque
- W=White/Solid

*Refrigerant sensors may only be paired with CO or NO2