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CO Plus Sensor Performance

1. Overview of CO Plus sensor performance

Carbon monoxide and hydrogen sulfide are the two most common toxic gases associated with confined space entry. In addition to "substance specific" sensors designed to measure these toxic hazards, Biosystems also offers a dual purpose sensor designed to detect both carbon monoxide and hydrogen sulfide. This "CO Plus" sensor is ideal for situations requiring use of a single sensor to monitor simultaneously for both toxic hazards.

The "CO Plus" sensor has been designed to respond to both carbon monoxide and hydrogen sulfide, and can be calibrated for the direct detection of either hazard. Since the sensor has been designed to respond to both hazards at once, it cannot discriminate between or tell which of the two gases is producing the reading. It can't tell which hazard is present in what specific concentrations, but will give an immediate indication whenever conditions become unsafe.

Although the primary purpose of the sensor is to directly monitor for the presence of CO or H_2S, as an added benefit "CO Plus" sensors are also responsive to a variety of other toxic contaminants including gasoline, alcohols, hydrogen, acetylene, ethylene, toluene, nitric oxide and sulfur dioxide.

Although the CO Plus sensor has been designed to respond to many hazards present in the atmosphere, it cannot discriminate between hazards or tell them apart when more than one contaminant is present at the same time. When a specific toxic contaminant is known to be potentially present the best approach is usually to use a direct reading substance specific sensor. The OSHA standard for permit required confined space entry (29 CFR 1910.146) explicitly requires the use of direct reading, substance specific sensors whenever a particular toxic hazard is known to be present. For instance, if chlorine is known to be potentially present, one of the toxic sensors selected should be specifically for the detection of chlorine, and calibrated directly to this hazard. A "broad range" sensor unable to discriminate between chlorine and other contaminants which may also be present should not be used for this purpose.

2. Relative response of the "CO Plus" sensor to carbon monoxide and hydrogen sulfide

Biosystems "CO Plus" sensors may be calibrated to either carbon monoxide or hydrogen sulfide. If the sensor is calibrated to carbon monoxide, the current gas reading display will identify a "CO+" sensor as being currently installed and the PhD Plus or PhD Ultra will automatically use the alarm settings for carbon monoxide. If hydrogen sulfide is chosen as the calibration gas, the display will identify the sensor installed as an "H_2S+" sensor and H_2S alarm settings will automatically be used. A properly calibrated "CO Plus" sensor will be exactly accurate for the gas to which it is calibrated. OSHA has assigned an 8 hour TWA of 35 ppm as the permissible exposure limit for carbon monoxide. If the "CO Plus" sensor is calibrated to carbon monoxide, then exposed to 35 ppm carbon monoxide, the reading will be 35 ppm.

The "CO Plus" sensor will also show a "relative response" to other interfering gases. When calibrated on carbon monoxide the relative response of the "CO Plus" sensor to hydrogen sulfide is a ratio of about 3.5 to 1.0. This means a concentration of 10 ppm hydrogen sulfide would produce a "CO+" sensor reading of 10 X 3.5 or about 35 ppm.

This is a very convenient relative response. The 8 hour TWA permissible exposure limit for hydrogen sulfide is 10 ppm. This means that the "CO+" gas alarms will be tripped any time the concentration of hydrogen sulfide exceeds the permissible exposure limit.

3. Cross sensitivity of the "CO Plus" sensor to other common interfering gases.

"Specificity" in a sensor refers to the degree to which the sensor response is restricted to only the substance the sensor is designed to measure. The higher the specificity the less the sensor is affected by exposure to other interfering gases. When the nature of the toxic contaminant is known it is usually better to use a substance specific sensor. Biosystems uses substance specific sensors in our gas detectors to measure CO, H_2S, SO_2, Cl_2, NH_3, HCN, HCl, NO, and NO_2. We pride ourselves on the "specificity" of these sensors. For instance, a substance specific carbon monoxide sensor really doesn't measure anything else. It is deliberately designed not to respond to other gases which may be present at the same time, such as hydrogen sulfide or methane.

The CO Plus sensor is designed to do just the opposite of these highly specific toxic sensors. The CO Plus sensor is designed to respond to as many different toxic gases as possible. Although the CO Plus sensor does not respond to all potential toxic contaminants (no currently available "broad range" sensor does) it does respond to a number of commonly encountered contaminants such as gasoline, alcohols, hydrogen and sulfur dioxide. Assuming that the sensor is calibrated to carbon monoxide, and that the alarm is set at 50 ppm, here are some approximate gas concentrations which would set off the alarm:

Gas Present Concentration

Gas Present	Concentration
Carbon monoxide	50 ppm
Hydrogen sulfide	15 ppm
Gasoline	50 ppm
Methyl alcohol	50 ppm
Acetylene	50 ppm
Ethylene	55 ppm
Sulfur dioxide	77 ppm
Toluene	78 ppm
Hydrogen	83 ppm

There will be almost no response to very high concentrations of methane, propane, and other combustible gases of the "alkane" family. That's good! Monitoring for these non-toxic but highly explosive gases should be through use of a specific sensor for the detection of combustible range (percent LEL) gases and vapors.

4. Calibration gas recommendations:

Some manufacturers use MOS sensors in their equipment to measure both combustible gases and toxic gases, and suggest toluene (100 ppm) as a calibration standard. Although it is possible to calibrate the CO Plus sensor to 100 ppm toluene, Biosystems usually recommends calibrating the sensor to 50 ppm carbon monoxide (in which case the display indicates "CO+" as the type of sensor installed, or 25 ppm hydrogen sulfide (in which case the display indicates "H 2S+"). There are three main reasons for this recommendation:

(i) Carbon monoxide and hydrogen sulfide are the two most common toxic gases associated with confined space entry. We feel the CO Plus sensor should be calibrated to the gas it is the most likely to see while "on the job". Although it is important that the CO Plus sensor respond to substances such as toluene and gasoline, it is much more likely to encounter carbon monoxide or hydrogen sulfide.

(ii) Biosystems cross sensitivity testing for the CO Plus sensor is done with the sensor "characterized" to 50 ppm carbon monoxide.

(iii) Carbon monoxide and hydrogen sulfide mixtures are readily available in small, stable, reasonably priced cylinders that offer the most cost effective choice for calibration gas.

5. Broad range sensor limitations

No "broad range" sensor can discriminate between hazards or tell them apart when more than one contaminant is present at the same time. This is true for the CO Plus sensor as well. In addition, the relative response of both the CO Plus and other broad range sensors can vary a little from sensor to sensor, and with time.

The CO Plus sensor is only precisely accurate for the measurement of the specific gas used to calibrate the sensor! (This basic limitation is true of all broad range sensors.) For other detectable gases, the CO Plus sensor provides only a general indication that conditions are dangerous, not specific information as to which hazards are present in what specific concentrations.

Whenever specific hazards are known to be potentially present, substance specific sensors calibrated directly to the hazard to be measured should be used. In other words, if hydrogen sulfide is a hazard known to be potentially present, your PhD Plus or PhD Ultra should be equipped with a sensor directly calibrated to this hazard.

6. Comparison of the CO Plus sensor to MOS type sensors

Most of the sensors marketed as "broad range" detectors are based on the use of a Metal Oxide Semiconductor or MOS element to detect hazards. Biosystems feels strongly that design limitations associated with these sensors make them inappropriate for use in our instruments. The electrochemical CO Plus sensor has been designed to eliminate the drawbacks associated with these older types of non-specific sensors. The following chart lists some of the most important differences between these two types of sensors:

Effect	CO Plus	MOS
Warm-up	None	Warm up may require 30 minutes (or longer!) before use. Sensor must be allowed to stabilize in the same temperature and humidity conditions in which it will actually be used.
Water-vapor	None	Very strong. As humidity increases, the sensor output increases. As an example, changing from 0% relative humidity to 65% relative humidity at room temperature can cause a 20 ppm increase in the sensor output.
Linearity	Excellent	Terrible. MOS sensor output is logarithmic. MOS sensors tend to be highly inaccurate at concentrations which vary from their calibration set points. A sensor calibrated at 100 ppm Toluene will be highly inaccurate when exposed to either 20 ppm or 200 ppm vapor.
Intrinsic Safety	The PhD Plus and PhD Ultra designs (and the City Technology sensors used by Biosystems to monitor for combustible and toxic gases) are Classified by Underwriters Laboratories and the Canadian Standards Association for intrinsic safety for Class 1, Division 1, Groups A, B, C, and D explosive environments.	May be an issue! The power requirements and operating temperatures for the sensing element in MOS sensors may make it hard to obtain an approval for intrinsic safety. Verify that any design which uses an MOS sensor has an approval for intrinsic safety prior to purchase!
Power consumption	Low	High. Power consumption may lead to shortened operational times. Verify that any design which uses an MOS sensor is capable of operation for at least a full eight hour shift between battery replacement or recharging.