WHAT DOES IT MEAN WHEN A GAS DETECTOR DISPLAYS NEGATIVE READINGS?

Although it is physically impossible for the atmosphere to contain a negative quantity of a substance, it is not uncommon for a gas detector to display a negative reading on the LEL, PID or toxic measurement channels.

While each type of sensor uses a different method to detect gas, all gas detecting sensors produce an electrical output that is proportional to the amount of gas detected. In general, the greater the output, the higher the reading. However, the electrical output is not as simple as "gas in = signal out". The changes in current flow produced by the sensor must be interpreted by the instrument before the readings can be displayed. A very important point is that even if the sensor is not detecting gas there is still a current flowing through the sensor. In other words, even when the sensor is located in an atmosphere with "zero contaminants" the sensor is still producing a signal.

Whenever you "Auto Zero" or fresh air adjust a sensor you are telling the instrument that the electrical signal at the time the sensor is adjusted is what the instrument should expect the sensor to produce while it is located in fresh air. The output signal in fresh air is used as the point of comparison for subsequent readings. A higher output signal is interpreted by the instrument as indicating a higher concentration of gas. However, if the signal drops below the output at the time the sensor was last fresh air adjusted, the comparison point is now negative with respect to the actual readings.

• Do all instruments display negative readings?

Most instruments eventually display negative readings or sound a "downscale" or "negative alarm" if the negative difference with the fresh air output value becomes significantly large.

However, different manufacturers have different ideas about what constitutes a "significant" negative reading. For instance, to avoid raising concerns with their users because of "minor" fluctuations in readings near zero, manufacturers often include a "dead band" in the instrument's programming. Until the signal exceeds the limits of the dead band, readings remain locked on zero.

In some designs the dead-band can be quite substantial. For instance, some brands of instruments equipped with miniaturised pellistor type LEL sensors have a dead-band that stretches all the way from -3% to +3% LEL. In other words, in the presence of a rising concentration of gas, the first reading displayed is 4% LEL. At 3% LEL the instrument reading is still"locked" on zero. Similarly, until the output signal reaches a value of -4% LEL, the display shows a reading of zero.

Figure 1: Always allow all of the sensors installed in your instrument to stabilise completely in fresh air BEFORE making a fresh air zero adjustment.

Sometimes the manufacturer may simply make the readings a littlemore "sticky"close to zero, to proportionally reduce fluctuation as the signal gets closer and closer to zero. Whether or not to include a dead-band is a manufacturer decision based on the instrument design and the stability and resolution of the senso.

Dead-bands may reduce user concerns because of trivial fluctutions in the instrument readings, but they may also leave the user unaware of changes as the instrument initially begins to respond to increasing concentrations of gas. Even worse, when the instrument starts out from a negative output level, it takes that much more gas before the instrument reaches the alarm concentration. For instance, if the LEL alarm is set at 10% LEL, when instrument starts out at -3% LEL it will take 13% LEL gas to cause the instrument to go into alarm. When the display is digitally locked on zero the user is unaware of the need to fresh air zero adjust the instrument.

Figure 2: Changes in humidity as well as exposure to certain contaminants can affect the output of gas detecting sensors in fresh air.

• How can I avoid negative readings?

The best way to reduce or avoid negative readings is simply wait a little longer BEFORE making an Auto Zero adjustment after initially turning the instrument on (Figure 1). Many types of sensors, especially PID and pellistor type LEL sensors, start out with an initially higher output signal, then "count down" as the sensors finish warming up in fresh air. To avoid problems make sure the instrument is located in fresh air that does not contain measurable contaminants, and give the sensors time to stabilise completely before using the instrument or making a fresh air adjustment.

Remember that stabilisation can sometimes take quite a bit of time. While pellistor type LEL sensors usually stabilise completely within 6 - 8 minutes, electrochemical sensors that have been exposed to certain interfering contaminants can sometimes take an hour or longer to clear completely. For instance, CO sensors are equipped with an internal filter to prevent or limit the sensor's response to VOC contaminants. However, once the filter is saturated, the sensor responds very strongly to solvents and VOCs such as methanol, MTBE (methyl tert-buytyl ether) and toluene. CO sensors are also very responsive to acetylene. Figure 3 shows the clearing time for a CO sensor that was exposed to a 500 ppm (2% LEL) concentration of acetylene (C_2H_2). Even after 30 minutes in fresh air the reading is still a few ppm above zero. If the instrument is fresh air adjusted before clearing is complete, readings will drop below zero as the sensor continues to stabilise.

• Why do sensor readings go negative?

The potential causes of negative readings are different for each type of sensor.

Standard (pellistor type) LEL sensors detect combustible gas by catalytically oxidising (burning) the gas on an active bead in the sensor. Along with warm-up issues; mechanical damage due to banging or dropping, exposure to sensor poisons and exposure to high concentrations of combustible gas can all affect the zero ofset and lead to negative readings.

Electrochemical sensors used to measure CO, H_2S and many other substance-specific toxic gases detect gas by means of a chemical reaction between the gas and materials in sensor. The chemical reaction causes a change in the electrical output of the sensor that is proportional to the concentration. The most common causes of negative readings are fresh air adjusting the sensor while it is in the presence of measurable contaminants (especially common with CO sensors that are zeroed in areas contaminated with engine exhaust or where people have been smoking), or fresh air adjusting the sensor before it has finished stabilising after exposure to an interfering contaminant.

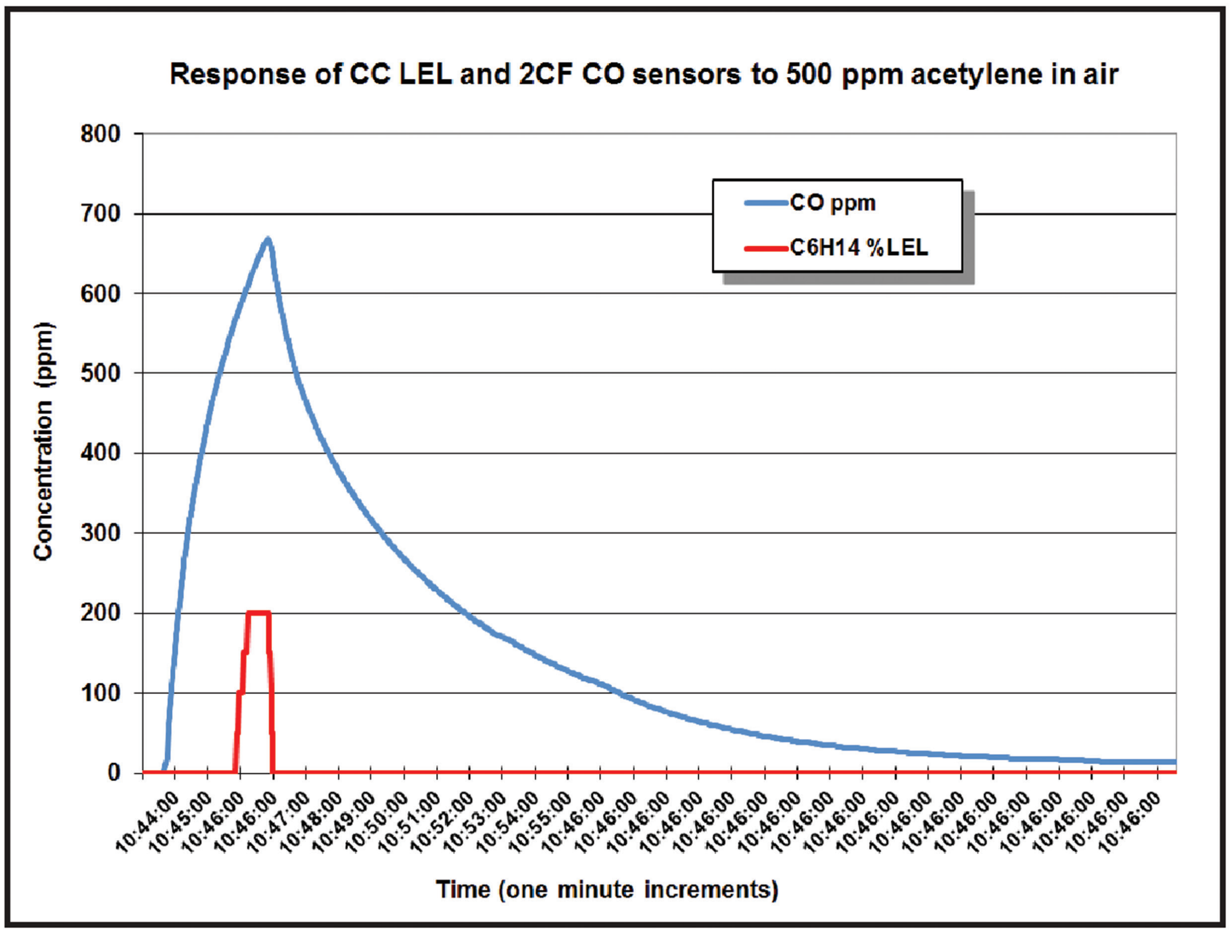

Figure 3: Electrochemical CO sensors can take a long time to clear after exposure to certain interfering contaminants such as acetylene.

Photo-ionization detector (PID) sensors use photons of highly energetic ultraviolet light to ionise VOC molecules present in the atmosphere being sampled. The detection reaction produces a current flow of electrons "stripped" from the ionised molecules that is proportional to concentration. Like LEL sensors, PID readings often start high, then count downwards while the sensor is warming up. PID sensors can sometimes take up to 15 or 20 minutes to fully warm up. Once again, it is very important to wait until the readings have stabilised completely before fresh air adjusting and using the PID to measure gas.

The output of PID sensors in fresh air can also be influenced by the ambient temperature and humidity. Water vapour molecules can absorb photons of ultraviolet light without being ionised. The more humid the atmosphere the more the signal of the PID in fresh air can be "quenched" by the presence of the water vapour molecules. Fresh air adjusting the PID zeroes out this quenching effect. Changes in humidity from one day to the next, or from one area to another can be the cause of negative readings. The best approach is to fresh air zero PID equipped instruments in the same humidity as the air in which the instrument is used to obtain readings.

Non-dispersive infrared (NDIR) sensors detect gas by measuring the absorbance of infrared light by chemical bonds in the molecules of interest. Just like PID sensors, the output of NDIR sensors can be influenced by changes in humidity. While NDIR sensors warm-up and stabilise completely within a few minutes, differences in the humidity between one day and the next can cause negative readings.

• What should I do to correct negative readings?

Correcting negative readings is extremely easy. Almost all instrument designs include a simple procedure to make an automatic fresh air zero adjustment (Figure 4).

Make sure the instrument is located in fresh air, that the sensors are fully warmed up, and that the readings are stable. Continue to pay attention to the fresh air readings. If readings continue to count downwards it may be necessary to repeat the fresh air zero procedure.

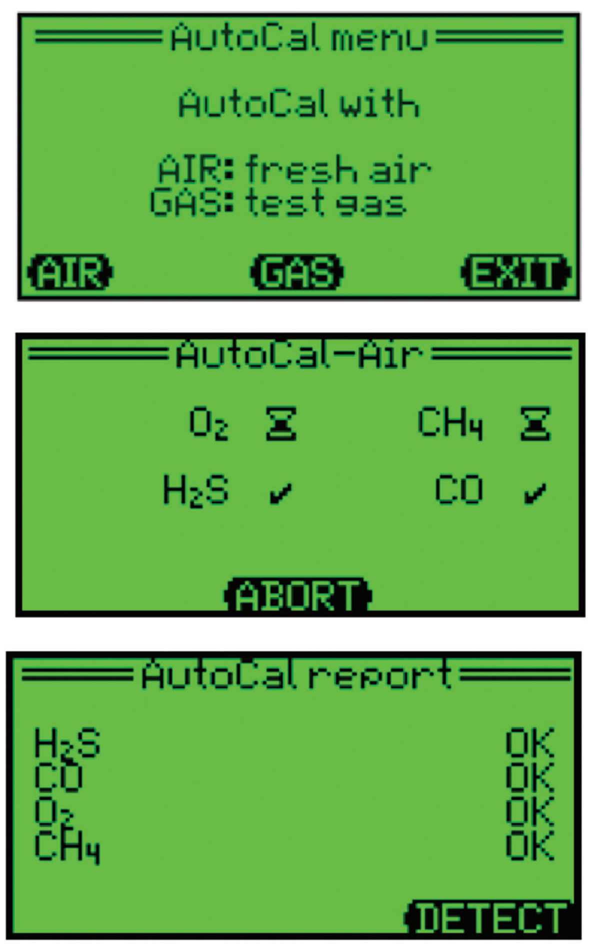

Figure 4: GfG instruments can be automatically fresh air zeroed or calibrated by means of a simple "AutoCal©" procedure, (press "Air" to make an automatic fresh air zero adjustment, "Gas" to make a span calibration adjustment, or "Exit" to return to normal operation)

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