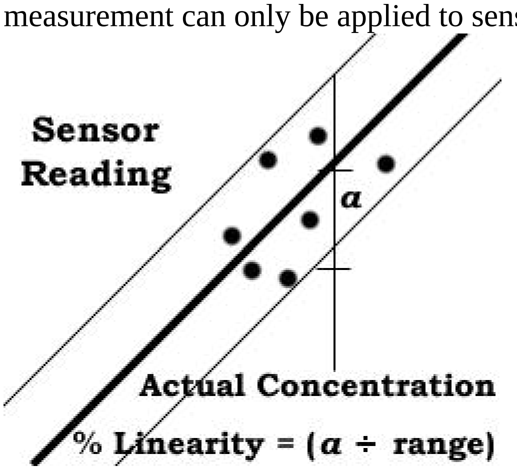
Sensor Performance: Accuracy, Repeatability, Linearity, Sensitivity, and Drift

The words "accuracy," "repeatability," "linearity," "sensitivity," and "drift" are among the most misused terms in the gas detection business. This Tech Tip provides some clarification on what they really mean.

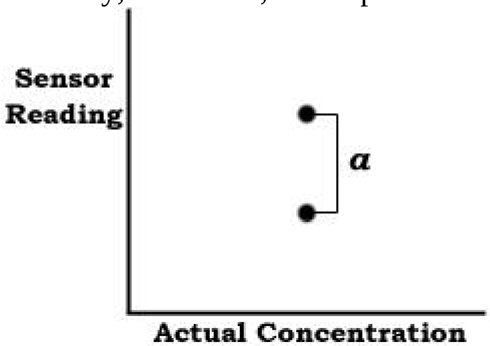
Also provided in this Tech Tip are some comparisons of EIT's stated repeatability and linearity versus those of competitors (where published). Across its entire line of gas sensors, EIT stands out as one of the better performers. And, many of the published specs should be viewed skeptically -- assumptions and measurement techniques vary widely, and some companies are not as rigorous as others.

Accuracy
The term accuracy is generally not meaningful when applied to gas detectors. Once a sensor has been calibrated, its accuracy is constrained by the accuracy of the zero air and span gas used. In other words, accuracy only has meaning in relation to the calibration gas used and the ambient conditions -- gas detectors have no "absolute" accuracy.
ISA Standards do exist that provide a common vocabulary for some gases, namely H_2S and combustibles. In these cases, "accuracy" is defined in relation to tests involving calibration gases of specified concentrations (H_2S: ISA S12.15 Part I, paragraph 7.9; combustibles: ISA S12.13 Part I, paragraph 7.8).

Linearity
When people say "accuracy," they often mean linearity. Calibration creates a linear relationship between zero and the span gas value. If sensor readings are taken at additional known gas concentrations, linearity is defined as the maximum percent error between the expected value (the zero-span line) and the actual sensor reading, compared to the range. Obviously, this measurement can only be applied to sensors that generate linear output.



Repeatability Repeatability is another measure that compares expected to actual sensor performance. Calibration establishes a "benchmark" sensor reading at a known gas concentration. Following a complete calibration and application of zero gas (to stabilize the sensor response at zero), repeatability is defined as the percent error between the reading generated by a second application of calibration gas and the benchmark value, compared to the range. Obviously, both readings must be taken with constant temperature, humidity, flow rates, and exposure times.



% Repeatablity = (a ÷ range)

Sensitivity Sensitivity, the minimum concentration of gas that is detectable, is the third main measure of sensor performance. As a good rule of thumb, it is typically a concentration of gas that results in an output two to three times the inherent background noise of the system.

Drift While drift has little to do with the measurement performance of a sensor, it is certainly an important component of operational performance. There are several different factors that can cause apparent sensor "drift:"
Zero drift. This refers to the tendency of electrochemical sensors to shift their zero point over time
Span drift. This relates to a change in sensor sensitivity, in many cases caused by changes in temperature.
Interferences. These are environmental factors which give sensor readings the appearance of moving or drifting, and include interferent gases, temperature changes, and pressure changes.
In many cases, a user may believe a sensor is experiencing zero drift when the problem is really caused by interferences.

Zero drift is generally a long-term phenomenon -- it is rare to see output fluctuations on an hourly or daily level. If this type of sensor behavior is observed, the problem is typically an interferent gas or (in the case of chlorine sensors) a sudden temperature change. An easy test is to expose the sensor to a reliable source of zero air. True zero drift is present only if the reading doesn't return to zero -- otherwise, an interferent is the cause. It should be remembered that interferent gases can cause both negative and positive readings. And, as always, it is important to have used pure zero air during initial calibration unless the ambient air is known to be free of interferences.
Span drift is generally not visible to the user. This type of drift behaves according to known patterns identified by EIT research, and is compensated for in EIT gas transmitters' software and hardware.

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