Understanding Gas Detector Performance Specifications

GAS DETECTION

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Manufacturer specifications for gas detectors can be both a blessing and a curse when purchasing an instrument. Understanding the vocabulary used by the manufacturer to describe performance is critical. The most prudent approach includes field evaluation prior to purchase.

Performance specifications published by manufacturers are a valuable tool for would-be purchasers. Unfortunately, it sometimes takes a practiced eye to interpret specifications when comparing one instrument design to another. The most significant problem is the terminology used by a particular manufacturer. While some terms are straightforward and fully accepted throughout the industry, other terms have specific meanings to a particular manufacturer. Conservative firms tend to minimize performance capabilities in written specifications, preferring to err on the side of caution. Less conservative specifications may be based on "best case" performance. The best advice is to conduct a field trial prior to purchase! There is no substitute for hands-on experience.

• Battery Life

A good example of this kind of "specsmanship" can be found in the way that different manufacturers present the "run time" for their portable gas detectors when equipped with a fully-charged battery pack or, (depending on the design), fresh set of disposable batteries. Of course, all manufacturers base the performance specification on the highest quality disposable alkaline batteries permissible for use with the instrument design. If you use a cheap or "industrial grade" disposable battery, all bets are off concerning duration. In point-of-fact, only batteries listed in the instrument owner's manual or on the instrument label should ever be used to power the instrument. Use of non-listed batteries may violate the instrument's IECEx or ATEX Classification for Intrinsic Safety. But even when the proper batteries are used to power the instrument, the way the operation duration is defined differs from manufacturer to manufacturer.

Let's say a manufacturer tests a population of 20 instruments equipped with fresh batteries with the following results. Ten of the instruments run for a full 10-hours. Four instruments run for 12-hours, while four other instruments only run for eight hours. One instrument runs for 14-hours, while one only runs for six hours.

The most conservative approach would be to list the "minimum" operation duration when the instrument is equipped with a fresh set of batteries as six hours, since that is the "worst case" operation duration among the instruments tested. But clearly, most instrument users will obtain better results. A less conservative, but more realistic approach, would be to list a "normal" or "expected" run time as a range of between eight and 12-hours. Another common approach would be to list the "average" run time of ten hours. The least conservative approach would be to list the duration as "up to" 14-hours based on the performance of the single, best case example. Thus, from the same data set, depending on the manufacturer's approach to writing specifications, the "duration" could be anywhere between six and 14-hours. To make it worse, many specifications do not explain what is meant by "duration". Listing a "duration" of 10-hours without an explanation doesn't provide the complete picture. Also, some manufacturers rate duration as the time from initially turning the instrument on to the time when the low battery alarms are first activated. Other manufacturers base the duration rating on the total time of operation – including while the instrument is in low battery alarm – until the instrument finally shuts down due to lack of power. Manufacturers are free – in good conscience – to use any of these methods to define duration. The important thing for potential customers is to ask for clarification whenever the terms used in the specification are undefined or ambiguous.

• Sensor Performance Specifications

Many gas detector manufacturers use sensors obtained from the same suppliers. However, the sensor performance specifications listed on the data sheet may vary widely even between manufacturers who use the same brand of sensor in their products.

As an example, most manufacturers publish measuring ranges for the electrochemical sensors used in their instruments. Electrochemical sensors are widely used to measure toxic gases such as hydrogen sulphide (H_2S) and carbon monoxide (CO). These sensors have a "nominal range" in which they may be continuously used without harm or damage, and over which they are capable of accurate readings. Electrochemical sensors can be used discontinuously or for short periods above the nominal range as long as they are not exposed to conditions that exceed the "maximum overload" concentration. While prolonged exposure to concentrations above the nominal range may saturate the electrolyte or create other conditions that prevent the sensor from providing accurate readings, short exposures should not do any long-term damage to the sensor. Exposure to concentrations above the maximum overload concentration may permanently harm the sensor, however.

Some manufacturers differentiate between nominal and maximum overload concentrations. Others list the maximum overload concentration as the upper range limit. Still others take the far more conservative nominal range as the upper range limit. They all may be using the same sensor obtained from the same manufacturer in their designs! Of course, instrument electronics and performance characteristics may also limit performance. That means the same sensor installed in a different brand of instrument may provide substantially different performance. So customers who expect exactly the same performance from different manufacturers who happen to use the same sensor may or may not find this to be the case.

Another source of ambiguity in the specification is the way that sensor "response time" is defined. Figure 1 shows the response of a typical electrochemical H_2S sensor when it is exposed to gas. The 25 ppm H_2S test gas was initially applied to the sensor at 1 minute and 56 seconds into the test run. Electrochemical sensors typically show an "S" shaped response curve. They respond very rapidly to about 90% of their final stable readings. The last little bit of stabilization occurs more slowly. In the case of the sensor in Figure 1, it took about 106 seconds after the initial application of the test gas for the sensor to reach 100% of its final stable reading of 25 ppm. This is referred to as the "T-100" time.

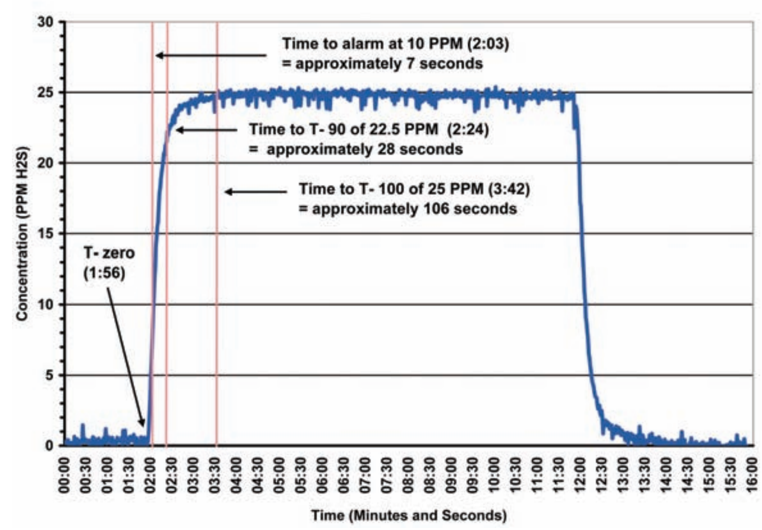

Figure 1: Response of H_2S Sensor When Exposed to 25 PPM Gas

Many H_2S detector users set the "LOW" instantaneous alarm at 10 ppm. Even a momentary excursion above this concentration should be enough to trigger the alarm. As can be seen from Figure 1, the "Time to Alarm" when the sensor is exposed to 25 ppm H_2S test gas is about seven seconds. "Time to alarm" is one way to define the speed of response of the instrument and sensor. Many instrument manufacturers prefer to define the response time as the time it takes for readings to reach 90% of their final stable value. This is referred to as the "T-90". For the sensor in Figure 1, the T-90 when the sensor was exposed to 25 ppm gas is about 28 seconds. Some manufacturers choose a different time value, such as T-85, T-80 or even T-60. This can dramatically change the way the speed of response appears on the technical specification. When evaluating alternative instrument designs it is important to verify that manufacturers are using the same measurement technique.

• Classification for intrinsic safety

One of the best ways to verify performance is by having a look at the instrument label. Figure 2 explains what all of those small numbers and letters signify.

Devices classified as "Intrinsically Safe" prevent explosions in hazardous locations by employing electrical designs that eliminate the possibility of ignition. Classification for intrinsic safety is based on performance of the instrument when tested in a specific flammable atmosphere. However, not all instruments carry exactly the same classification. Learning to read the meaning of the specific letters and numbers included on the instrument label is very important. For instance, a typical CE Marked confined space instrument might include the following ATEX classification as to intrinsic safety:

EEx ia d IIC T4 Tamb – 40 to + 50ºC

The first "E" indicates the instrument complies with the relevant harmonized European standards. The "Ex" indicates that the instrument is for use in potentially explosive atmospheres. The "ia" indicates the protective concept, in this case, intrinsically safe per ATEX. The "d" indicates the design incorporates design elements, in this case the combustible sensor, that carry an additional "flameproof" classification. The "IIC" indicates the specific combustible gas groups to which the classification applies, in this case atmospheres containing hydrogen, or gases of an equivalent (or lesser) hazard in environments other than mines. The "T4" indicates the temperature code rating

Commonly Used Terms in Instrument Specifications Include:

- **Accuracy** is the percentile agreement between the instrument reading and the true concentration. Accuracy may be expressed as a function of the full-scale reading, a percentage of the actual reading, or a specific unitary value. For instance, consider a carbon monoxide instrument with a full-scale range of 0 - 500 ppm that is exposed to a concentration of 50-ppm calibration gas. If the published accuracy of the instrument is + 10 % of the actual reading, the expected reading in a properly calibrated instrument should fall within 45 - 55 ppm. On the other hand, if the accuracy is + 10 % of the full scale, the reading could fall anywhere within 0 - 100 ppm and still be within tolerance! The most straightforward approach is to use a unitary value. A unitary approach to the accuracy of a carbon monoxide sensor might be + 2 ppm over a range of 0 - 250 ppm.
- **Precision** characterizes the degree of mutual agreement among a series of individual measurements, values, or results.
- **Accuracy vs. precision:** An archery target makes a good (and commonly used) analogy to explain the difference between accuracy and precision. Accuracy describes the closeness of the arrows to the center of the target. Precision describes how close the arrows are to each other. You can have a high level of precision even though all of the arrows are stuck in the outer ring – as long as they are grouped closely together.
- **Resolution** is the lowest concentration of the substance being measured that can be reliably detected by the instrument.
- **Increment of measurement** is the least significant measurement unit used to display readings. The increment of measurement can sometimes exceed the resolution of the instrument. For instance, some confined space instruments can provide toxic readings in either 1.0 or 0.1 ppm increments. A sensor that shows poor resolution below 1.0 ppm should not be used to obtain 0.1 ppm readings.
- **Response time** is the time from initial exposure for the sensor to reach its final stable reading when exposed to gas. Response time is usually given as a T-90 value (time to 90 % of final stable reading). Some manufacturers use T-95, T-85, T-80 or other values in their specifications. Make sure the specification is clear as to the method used!
- **Recovery time** is the time necessary for the sensor to recover after exposure to a step-change in concentration.
- **Repeatability** is the maximum percentage variation between repeated, independent readings on a sensor, (using a gas mixture within the nominal range and under identical conditions).
- **Linearity** is the measure of how well the concentration response curve of an instrument fits the equation for a straight line. It's important to note that it is not necessary for the sensor output to be exactly linear in order to provide linear readings. As long as the sensor output is mathematically predictable, instrument electronics may be able to linearize the readings.
- **Linear range** is that portion of the concentration range over which the instrument's concentration response matches (or approximates) a straight line.
- **Noise** is random fluctuation in signal that is independent of the concentrations being measured.
- **Drift** refers to slow or long-term changes in the instrument reading that are not caused by immediate changes in the concentration of the substance being measured.

for the instrument. The temperature code rating is one of the most frequently overlooked specifications when evaluating an instrument for purchase.

Temperature code groupings correspond to the range of autoignition temperatures in which a particular gas belongs. The autoignition temperature (or AIT) is the temperature, in °C, at which a gas will ignite spontaneously without another source of ignition. Gases with low autoignition temperatures are the ones most easily ignited by increasing the temperature once the gas is present in explosive concentrations. A T4 rating means that the instrument is classified as intrinsically safe for gases with autoignition temperatures greater than 135 °C. The AIT for propane is 470 °C. Using an instrument with a T4 rating to monitor for the presence of propane would be well within the scope of its ATEX classification. Similarly, using the instrument to monitor for methane (AIT = 595 °C), hydrogen (AIT = 560 °C), or hexane (AIT = 240 °C) would all be within the scope of the classification. The instrument would not be intrinsically safe for carbon disulphide, however, which has an autoignition temperature of only 95 °C.

The final part of the classification explains the ambient operating temperature range over which the classification applies. In this case from – 40 °C to + 50 °C. The ATEX classification for intrinsic safety only applies while the instrument is used within this operating temperature range.

Although it is not technically necessary for sale in Europe, don't overlook the North American Classifications carried by the instrument. Instruments that are sold in North America generally carry the "mark" of a "Nationally Recognized Testing Laboratory" such as CSA or UL® that indicates that the instrument has been tested by one of these independent testing laboratories as to intrinsic safety. The mark includes an indication to which national requirements the instrument has been tested. The small "c" in the c-UL-us® or c-CSA-us mark indicates the instrument conforms with Canadian as well as United States requirements. Canadian Standards Association C22.2 NO. 152-M1984 (R2001), "Combustible Gas Detection" is the CSA standard that covers the details of construction, performance, and test procedures for portable instruments used to detect or measure combustible gases in hazardous locations characterized by the known or potential presence of combustible gas. CSA C22.2 includes rigorous performance testing of the combustible sensor not included in ATEX criteria.

Figure 2: Specifications between gas detector manufacturers may vary widely even though the sensors inside the instrument come from the same supplier.

Evaluate Before Purchase!

No matter what performance criteria you decide on beforehand, nothing replaces actually trying out the instrument in the field. Most leading instrument manufacturers, or their distributors, have evaluation instruments available for this purpose. But even if you have to rent an instrument, you will be better off in the long run if you try it out under circumstances similar to the ones in which it will be actually used prior to purchase. The best instrument in the world is the one that's the best for your own individual conditions of use.

About the Author:

Robert Henderson is Vice President, Business Development for BW Technologies by Honeywell. Mr. Henderson has been a member of the American Industrial Hygiene Association since 1992. He is 2006 Chair of the AIHA Gas and Vapor Detection Systems Technical Committee. He is also a current member and past chair of the AIHA Confined Spaces Committee. He is also a past chair of the Instrument Products Group of the Industrial Safety Equipment Association.