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Calibration Requirements for Confined Space Gas Detectors

Manufacturers and regulatory agencies agree the safest and most conservative approach is to perform a functional test by exposing the instrument to known concentration test gas before each day's use.

Oxygen deficiencies, explosive atmospheres, and exposure to toxic gases and vapors injure or kill hundreds of workers every year during confined space entry procedures. The atmospheric conditions that lead to these accidents and fatalities are usually invisible to the workers who are involved. The only way to ensure atmospheric conditions are safe is to use an atmospheric monitor. The only way to know that a gas detector's readings are accurate is to expose the instrument to known concentration test gas. Exposing the instrument to known concentration test gas verifies both the accuracy of the readings, as well as the proper performance of the instrument's alarms. Failure to periodically test and document the performance of your confined space gas detectors can leave you open to regulatory citations or fines, as well as increased liability exposure in the event that a worker is injured in an accident.

There has never been a consensus among manufacturers regarding how frequently confined space gas detectors need to be calibrated. However, manufacturers do agree that the safest and most conservative approach is to verify the performance of the instrument by exposing it to known concentration test gas before each day's use. This functional "bump test" is very simple and takes only a few seconds to accomplish. It is not necessary to make a calibration adjustment unless the readings are found to be inaccurate. The regulatory standards that govern confined space entry procedures are in agreement with this approach.

What causes an instrument to lose accuracy?

Confined space gas detectors usually include several different types of sensors. The atmosphere in which the instrument is used can have profound effect on the sensors. Each type of sensor uses a slightly different detection principle. Sensors may be poisoned or suffer degraded performance if exposed to certain substances. The kinds of conditions that affect the accuracy of sensors vary from one type of sensor to the next.

While the electrochemical sensors used to measure toxic gases like carbon monoxide and hydrogen sulfide are not worn out or consumed by exposure to CO or H_2S, they still eventually need to be replaced when they are no longer able to detect gas. Although CO and H_2S sensors may last for years without significant loss of sensitivity, the loss of sensitivity at the end of life may be sudden. Incidental exposure to other substances may also reduce sensitivity. For instance, many electrochemical sensors can be permanently affected by exposure to organic solvents and alcohols. Exposure to methanol is well known to affect the performance of CO and H_2S sensors.

Combustible sensors are particularly prone to damage due to exposure to poisons

or substances that inhibit the sensor's response to combustible gas. Combustible sensors may be affected by exposure to silicone containing substances, chlorinated solvents, sulfides (including H_2S), or even exposure to high concentrations of combustible gas. Sensors may also suffer loss of sensitivity due to aging or desiccation, mechanical damage due to dropping or immersion, or loss of sensitivity due to other causes.

What do the regulations say?

OSHA 1910.146 "permit-required confined spaces" paragraph (c)(5)(ii)(C) explicitly states (in part) that, "Before an employee enters the space, the internal atmosphere shall be tested, with a calibrated direct-reading instrument". OSHA Compliance Directive CPL 2.100, "Application of the Permit-Required Confined Spaces (PRCS) Standards, 29 CFR 1910.146" explains what is meant by "calibrated":

> "A testing instrument calibrated in accordance with the manufacturer's recommendations meets this requirement. The best way for an employer to verify calibration is through documentation."

In other words, instrument users are held accountable to calibrating and / or testing the performance of their instruments in accordance with the manufacturer's instruction manual. OSHA expects instrument users to be able to document that their procedures match the requirements listed. The instructions, cautions and warnings listed in the owner's manual are governed not by OSHA, but by the standards to which the instrument is Classified, Listed or Marked by Nationally Recognized Testing Laboratories such as Underwriters Laboratories® or the Canadian Standards Association (CSA).

Instruments used in environments characterized by the potential presence of flammable or explosive gases usually carry a classification for intrinsic safety. 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. The instrument should carry the logo of the testing laboratory that conducted the evaluation, as well as the specific hazardous location groups for which the classification applies.

Most manufacturers whose confined space instruments are sold in North America have submitted their designs for testing in accordance with both United States and Canadian performance criteria. A small "c" included in the classification mark indicates compliance with Canadian performance criteria.

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. Section 5.3, "Instruction Manual" lists the minimum information and warnings that must be included in the owner's manual of gas detectors that are compliant with this standard. Paragraph (k) requires that the manual include the following statement:

CAUTION: BEFORE EACH DAY'S USAGE SENSITIVITY MUST BE TESTED ON A KNOWN CONCENTRATION OF _____ (SPECIFY GAS) EQUIVALENT TO 25-50% OF FULL SCALE CONCENTRATION. ACCURACY MUST BE WITHIN -0-+20% OF ACTUAL.

In other words, to comply with Canadian requirements, the performance of the combustible sensor must be verified by exposure to known concentration combustible gas before each day's use. The manufacturer is free to specify the type and concentration of combustible gas to be used, and is free to specify a tighter performance tolerance if desired. The standard does not require that the instrument be adjusted before each day's use, only that it is found to be capable of detecting combustible gas according to the tolerances listed in the instruction manual. The standard is mute regarding the verification of performance of other types of sensors that may be included in the instrument. The only requirements are for the verification of performance of the combustible sensor.

Instrument users who operate and maintain their instruments in accordance with US rather than Canadian requirements have more latitude in determining the interval between calibration checks.

Lengthening the interval between calibration checks

The International Safety Equipment Association (ISEA) is the leading national organization of manufacturers of safety and health equipment, including environmental monitoring instruments. The ISEA is dedicated to protecting the health and safety of workers through the development of workplace standards and the education of users on safe work practices and exposure prevention. In May 1996 the ISEA published a protocol to clarify the minimum conditions for lengthening the interval between calibration checks for direct reading portable gas monitors used in confined spaces. The complete text of the protocol can be downloaded from the ISEA website at: **www.safetyequipment.org**

The protocol is designed to reemphasize to OSHA and other standards writing bodies the importance of verifying the calibration of instruments used to monitor the atmosphere in potentially hazardous locations, to clarify the differences between a functional (bump) test and a full calibration, to clarify the circumstances when daily bump tests are needed and when less frequent tests may be appropriate. The protocol applies to all of the sensors installed in the confined space gas detector, not just the combustible sensor. The ISEA protocol has been widely adopted by the gas detection equipment manufacturing community, even by manufacturers who are not members of the Association.

The ISEA protocol begins by clarifying the difference between a functional (bump) test and a full calibration:

a. A functional (bump) test is defined as a means of verifying calibration by using a known concentration of test gas to demonstrate that an instrument's response to the test gas is within acceptable limits.

b. A full calibration is defined as the adjustment of an instrument's response to match a desired value compared to a known concentration of test gas.

The protocol goes on to recommend the frequency for verification of calibration:

a. A functional (bump) test or full calibration of direct reading portable

gas monitors should be made before each day's use in accordance with the manufacturer's instructions using an appropriate test gas.

b. Any instrument that fails a functional (bump) test must be adjusted by means of a full calibration procedure before further use.

c. If environmental conditions that could affect instrument performance are suspected to be present, such as sensor poisons, then verification of calibration should be made on a more frequent basis.

The protocol goes on to identify the circumstances under which it may be appropriate to lengthen the interval between verification checks. If conditions do not permit daily testing of the gas detector to verify calibration, the ISEA protocol permits less frequent verification of calibration only if the following criteria are met:

a. During a period of initial use of at least 10 days in the intended atmosphere, calibration is verified daily to be sure there is nothing in the atmosphere which is poisoning the sensor(s). The period of initial use must be of sufficient duration to ensure that the sensors are exposed to all conditions that might have an adverse effect on the sensors.

b. If the tests demonstrate that it is not necessary to make adjustments, then the time interval between checks may be lengthened but should not exceed 30 days.

c. The history of the instrument since last verification can be determined by assigning one instrument to one worker, or by establishing a user tracking system such as an equipment use log.

Any conditions, incidents, experiences, or exposure to contaminants that might adversely affect the calibration should trigger immediate reverification of calibration before further use. Most importantly, if there is any doubt about the calibration of the sensors, expose them to known concentration test gas before further use.

Calibration procedures

Calibration is usually a two-step procedure. In the first step the instrument is taken to a fresh air environment, and "zeroed" so that the readings equal those expected in clean air; 20.9% for oxygen, 0% LEL for combustible gas, and 0 PPM for toxic gas. The second step is to expose the instrument to calibration gas that contains known concentrations of the contaminants the sensors are designed to measure. The readings are then adjusted to match these values.

In most cases, confined space gas detectors automatically adjust their readings to match the concentrations in the calibration gas being applied. Follow the manufacturer's instructions carefully. Different manufacturers use different concentrations during automatic span calibration adjustment procedures. Be especially careful to verify that the values used by the instrument to adjust the readings of the sensors are the same as the concentrations listed on the label of the calibration gas cylinder. Using the wrong concentration calibration gas can result in dangerously inaccurate readings. Be careful also to use the correct regulators and fittings to supply calibration gas to the instrument.

Incorrect flows produced by an improperly set regulator or improvised fittings can produce inaccurate readings.

Given the requirement for documentation, the capability of instruments to log or automatically retain calibration information is highly desirable. Most datalogging confined space instruments automatically update and store dates and other calibration information. Even non-datalogging instruments usually include the date, or number of days since the last time the instrument was calibrated.

Docking stations make CS instruments even easier to use and maintain

Most leading manufacturers of confined space gas detectors now offer automatic calibration or "docking" stations that can automatically calibrate and store instrument calibration records. Docking stations that include fully automatic calibration are redefining the way that users with large numbers of confined space instruments deal with maintenance and calibration issues. Instead of technicians or instrument specialists laboriously calibrating instruments one at a time, instrument users simply drop the gas detector into the docking station. The docking station automatically bump tests or calibrates the instrument, then updates and stores the test results. Use of automatic calibration stations makes it possible to verify the accuracy of confined space instruments on a much more frequent basis.

The prices for automatic calibration stations are beginning to drop in the same way that prices for confined space instruments have been dropping. In the past, it might take forty or more instruments to justify the expense of investing in a docking station. As prices continue to drop, customers with only a few instruments are finding that investing in an automatic calibration station makes very good sense.

Confined space gas detectors are designed to help keep workers safe in potentially life threatening environments. Verifying the proper performance of your gas detectors is a mandatory part of every confined space entry program. But more importantly, it's an essential part of keeping your workers safe.