

Workplace Health and Safety Bulletin



Use of Combustible Gas Meters at the Work Site

Combustible gas meters are frequently used at Alberta work sites to evaluate and assess fire and explosion hazards. It is critical that this equipment be properly used and calibrated so that these hazards are not underestimated. The instruments can be a valuable tool if used by operators fully knowledgeable of their limitations.

It is common practice to use meters to measure for a variety of gases. Errors result when meters calibrated on a specific gas are used to measure other explosive gases or vapours. In one case investigated by Alberta Employment and Immigration, a methane calibrated meter was used to measure gasoline vapours; the meter gave a reading of 14% LEL (Lower Explosive Limit) while the actual concentration in the tank was 73% of the LEL.

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Most combustible gas detectors measure the contaminant by combustion at a catalytic detector. The heat produced is used as a measure of the “explosivity” of the contaminant in air. Different compounds produce different amounts of heat when they are burned. So the meters respond differently to different chemical mixtures in air. Table 1 compares the actual percent LEL of four different compounds required to produce a meter reading of 20% for a typical combustible gas meter. There are wide variations in meter response as the compound and its heat of combustion vary.

Combustible gas meters can only be expected to respond accurately to the gas for which they were calibrated. To measure other gases with the same meter, consideration must be given to the specific properties of the gas and of the detector. Some manufacturers have responded to

the need to estimate more accurately the concentration of other gases by providing correction factors which allow calculation of percent LEL from the measured level. A guide to their use is provided in Appendix A. Even when these factors are used, interpretation of the reading must be made by someone who has training and experience to understand how different factors at the work site may affect results.

Table 1: Variation in Meter Response with Chemical Compound and Heat of Combustion

Compound	Actual Vapour Concentration Required to Produce a 20% LEL Meter Response (%LEL)	Heat of Combustion Kcal/mol
Ammonia	15.8	107
Methane	20.0	213
n-Hexane	54.2	995
Biphenyl	80.0	1494

Combustible gas meters can not be relied upon to:

1. accurately measure highly toxic gases such as hydrogen sulphide.
2. respond accurately in atmospheres which do not contain 20.9% oxygen in air.
3. provide a reliable indication of the degree of explosive hazard when meters are not calibrated before and after each use.
4. compensate for poor field sampling technique or an operator failure to consider the conditions of the work environment (for example temperature).


For highly toxic gases the danger to health is usually of much greater concern than explosivity. For example, hydrogen sulphide has an IDLH (immediately dangerous to life and health) level of 100 ppm, while its LEL is 43,000 ppm. A meter designed to measure explosivity cannot be expected to have the sensitivity required to evaluate the hazard to health.

Oxygen concentrations in air, lower than those normally occurring in the atmosphere (20.9%), may result in underestimating an explosive hazard. The response of the meter depends on its ability to burn the combustible gas. If there is not enough oxygen to support combustion, the meter will read a lower or even 0% LEL, even if high levels of combustible gas are present.

Since it is common for meter sensors to fail, calibration, or function testing, is required to ensure that a hazardous atmosphere is properly detected. Furthermore, when the sensor is exposed to moisture, lead compounds, silicon compounds, or chlorinated hydrocarbons, it may fail. Drift may also occur if the instrument is not allowed to acclimate to the environment in which it will be used, (for example an instrument is used outdoors during the winter). Calibration after the measurement has been taken is also used to validate instrument function.

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Combustible gas meters must only be used by those people who are competent in their use. Training should be based on a comprehensive guide of practice such as:

 Manual of Recommended Practice for Combustible Gas Indicators and Portable, Direct Reading Hydrocarbon Detector
American Industrial Hygiene Association
475 Wolf Ledges Parkway
Akron, Ohio 44331

In addition, the manufacturer's operating manual or technical representative should be consulted to supply more detailed information or training for the use of a particular combustible gas meter.

Function testing of combustible gas meters

A variety of conditions can affect the reliability of a combustible gas meter. These conditions include:

- *moisture condensing on sensor filaments* — this may cause filaments to short circuit or fracture
- *exposure to high concentrations of combustible gases* — this will shorten the effective life of the sensor
- *exposure to high concentrations of dust* — gas sensor filters can be slowed or blocked
- *exposure to catalytic sensor poisons* — substances such as silicone compounds e.g. WD-40, sulphur compounds, or chlorine

can coat, corrode or inactivate sensor filaments

- *mechanical damage* — sensors can stop working if a meter is dropped
- *immersion in water* — sensors can stop working if a meter is immersed in water.

The only way to ensure that a combustible gas meter is accurate and fully functional is to complete a function or “bump” test before use.

A function or bump test is a field test that is done at the start of each shift or before the meter is used. The test is usually done in a clean location at the site where the instrument is to be used. The test makes sure that the meter is working properly and has not been damaged during transport. During a function test, the meter is exposed to a known concentration of calibration gas. If the monitor responds within predetermined limits defined by the manufacturer, the instrument is ready for use. No attempt is made to re-calibrate the meter during a function test. A meter that fails the function test must immediately be taken out of service and returned to a qualified person or facility for a complete inspection and recalibration.

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Equipment Certification and Electrical Code requirements

The Canadian Standards Association (CSA) is one of the many Certification Bodies which provides “Certificates of Compliance” to manufacturers of combustible gas meters that meet all the requirements of CSA Standard C22.2 No. 152-FM1984 (R2006), *Combustible Gas Instruments*. This Standard describes the function testing and calibration requirements for a combustible gas meter. Meters that have received Certificates of Compliance bear a certification mark and may be used in the appropriate Class 1 hazardous locations as defined by the Canadian Electrical Code.

Section 18, Hazardous Locations, of the Canadian Electrical Code Part I, Safety Standards for Electrical Installations, lists many rules that apply to hazardous locations. Specifically, battery-powered equipment that may be carried into or located within a hazardous location must be “approved”. This applies to equipment such as flashlights, paging receivers, vibration monitors, tachometers, battery-

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powered telephones, portable test equipment and combustible gas meters.

In all cases, “approved” means that the combustible gas meter bears a certification mark. The certification marks of all Certification Bodies may be obtained from the Alberta Municipal Affairs website at:

 www.municipalaffairs.alberta.ca/documents/ss/STANDATA/electrical/330-LEG-ECR-2unsigned.pdf

Whatever the certification mark, the meter must meet all the requirements of CSA Standard C22.2 No. 152.

Clause 5.3.1(k) of CSA Standard C22.2 No. 152 states that instruction manuals for intermittent duty and continuous duty portable gas detection instruments must contain the following warning:

“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. ACCURACY MAY BE CORRECTED BY _____ (SPECIFY ADJUSTMENT PROCEDURE):

Note: Tighter tolerances on accuracy may be stated if desired. (See clause 3.6)”

Function testing required

Section 12 of the Alberta *Occupational Health and Safety(OHS) Regulation* requires that an employer ensure that all equipment used at a work site will safely perform the function for which it is intended. If an employer has not conducted function testing prior to use, they will not know whether the instrument is operating properly. This is particularly important where the instrument is to be used in emergency conditions or as part of an emergency response. The emergency response plan required by Sections 115 and 116 of the OHS Code must include whether a combustible gas meter is required and the procedures for calibrating and using the instrument at the work site.

Further, Section 12(d) of the Alberta OHS Code requires equipment to be used and calibrated according to the manufacturer's specifications. Failure to perform the required testing and/or calibration means that the requirements of Section 12(d) are not being met. This may result in workers being exposed to unsafe and potentially dangerous conditions because of a meter that may not be functioning properly.

For more information, the US Occupational Safety and Health Administration has a bulletin available titled "Verification of Calibration for Direct-Reading Portable Gas Monitors" available online at:

 <http://www.osha.gov/dts/shib/shib050404.html>

The International Safety Equipment Association (ISEA) has issued a position statement about verification for direct-reading instruments. They state that the instrument should be function (bump) tested or fully calibrated using the appropriate test gas in accordance with the manufacturer's instructions each day that it is used. If the instrument fails a function test, then it must be adjusted by a full calibration. More frequent function testing may be required if there are environmental conditions that could effect the performance of the sensor. Function testing may be done less frequently under some conditions, and recommendations are provided for the circumstances when they may apply. The policy statement from ISEA can be obtained from their website at:

 <http://www.safetyequipment.org>

Appendix A

The Use of Correction Factors

Various means of correcting for different meter response are used by a number of manufacturers. In each case, however, the correction factors given are specific to the model of meter and the gas/vapour being measured. Individual suppliers must be contacted to obtain the appropriate correction factors for the meter used at the work site. Examples are given below for two of the more common methods used.

Method A:

A manufacturer provides "K-factors" for their combustible gas meters:

In a tank used to store ammonia an operator records a reading of 18% LEL using a meter calibrated for methane gas. What is the actual % LEL in the tank?

Given: Observed reading: 18% LEL
gas/vapour: ammonia, K-factor = 141.7
Calibration gas: methane, K-factor = 112.0

Then: Corrected % LEL = $\frac{\text{K-factor (calibration gas)} \times \text{observed LEL}}{\text{K-factor (measured gas/vapour)}}$

$$= \frac{112.0 \times 18}{141.7} = 14\%$$

A more complex problem is posed by chemical mixtures. It becomes difficult to extrapolate correction factors for a single chemical to multi-component mixtures. However, for overall fire control applications, the meter reading can be corrected based on the correction factor for the component with the poorest meter response. If the total corrected reading indicates that there is less than 10% LEL even when many gases are being measured, this may be enough information to decide whether work should continue:

e.g. A reading of 6% LEL was found in a tank previously containing natural gas which had a composition of 83% methane, 12% ethane, 3% propane and 2% butane. Determine an estimate of the actual % LEL if the meter was originally calibrated for methane (K-factor = 112.0).

Given: K-factors: Methane = 112.0 Propane = 61.8
 Ethane = 75.8 n-Butane = 65.5

Then: Assume all of the vapour present is propane, since this will give the greatest margin of safety when correcting the measured % LEL.
(i.e. it has the lowest K-factor)

$$\text{Corrected \% LEL} = \frac{112.0 \times 6}{61.8} = 11\%$$

Method B:

In another method, K-factors are combined into a single correction factor that can be multiplied by the meter reading to give a corrected value:

The area around a leaking tank car gives a reading of 56% LEL on a meter calibrated with methane. The tank car is believed to contain propane. What is the actual % LEL in the area?

Given: Observed reading = 56% LEL
Correction factor (propane) = 1.1

Then: Corrected % LEL = correction factor x observed
% LEL = 1.1 x 56 = 62%

Mixtures can also be treated in a manner similar to that used in Method A. The gas or vapour with the poorest instrument response is the one with the highest correction factor.

A leak from a pressure vessel containing a mixture of methyl ethyl ketone (correction factor = 1.52) and tetrahydrofuran (correction factor = 1.23) produces a 35% LEL reading on a methane calibrated meter. Give an estimate of the corrected % LEL.


Given: Methyl ethyl ketone has the poorest instrument response (i.e. it has the highest correction factor = 1.52)


Then: Assume all of the gas present is methyl ethyl ketone since this will give the greatest margin of safety:

$$\text{Corrected \% LEL} = 1.52 \times 35 = 53\%$$

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<http://employment.alberta.ca/whs-ohs>

Call any Government of Alberta office toll-free
Dial 310-0000, then the area code and telephone number you want to reach

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