Workplace Health and Safety Bulletin

WORK SAFE ALBERTA

Misuse of Combustible Gas Meters

An incident investigation raised concerns that users of combustible gas meters may be greatly underestimating fire and explosion hazards. Errors result when meters calibrated on a specific gas are used to measure other explosive gases or vapours. In one case 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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The problem has its basis in the way the meters were designed to operate. Most combustible gas detectors literally measure the contaminant by combustion at a catalytic detector. The heat produces 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. As you can see from the table, there are wide variations in meter response as the compound and heat of combustion vary.

Combustible gas meters can only then 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

Alberta Human Resources and Employment | Building Alberta's Workforce 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 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	15.80	107
Methane	20.00	213
n-Hexane	54.20	995
Biphenyl	80.00	1494

For instance, these instruments can not be relied upon to:

1. 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 operators failure to consider the work environment.

However, the instruments can be a valuable tool if used by operators fully knowledgeable of their limitations.

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For highly toxic gases the danger to health is usually of much greater concern than explosivity. Hydrogen sulphide has an immediately hazardous to life level of 300 ppm, while its lower explosive limit is 43,000 ppm. A meter designed to measure explosivity can not be expected to have the sensitivity required to evaluate the toxic hazard.

Oxygen concentrations in air, other than those normally occurring in the atmosphere (i.e. 20.9%), may result in underestimating the 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 then would read 0% LEL, even if high levels of combustible gas were present.

Since it is quite common for the meter sensors to fail, calibration before use is required to prevent inadvertent entry into an explosive or oxygen deficient atmosphere. Furthermore, exposure of the sensor to moisture, lead compounds, silicon compounds, or chlorinated hydrocarbons may result in instrument failure during use. Calibration after the measurement has been taken is also required to validate instrument function.

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It is recommended that the use of combustible gas meters be limited to those people with in-depth training in their use. Training should be bases 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 443311

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

The Use of Correction Factors

Various means of correcting for different meter response have been employed 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 your meter. The following are examples of two of the more common methods used.

Method A:

One manufacturer has provided "K-factors" for their combustible gas meters:

e.g. 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:

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

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

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 gross fire control applications it is useful to correct the meter reading 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: We 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:

e.g. 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 however the gas or vapour with the poorest instrument response is the one with the highest correction factor.

e.g. A leak from a pressure vessel containing a mixture of methy elthyl 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:

Corrected % LEL = 1.52 x 35 = 53%

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