

 <b>Application Note</b>	<b>Gas Detector Preparation for Monitoring Combustible (LEL/LFL) Levels of Solvent &amp; Liquid Fuel Vapors</b>	Date	27APR2006
		Nº	AN20060427
		By	Jeff Emond

## 1. Statement of purpose

This Applications Note is designed to provide information on the best way to set up and operate gas detectors used primarily to monitor combustible solvent and fuel vapors in the lower explosive limit (%LEL) range, and associated volumetric scales 0-1.00%.

## 2. Combustible materials covered

Materials covered by this application note include, but are not limited to, kerosene and jet fuels JP-8 and Jet A, spirits of turpentine, plus aromatic hydrocarbon solvents and monomers such as toluene, ethyl benzene, styrene, cumene (isopropyl benzene) and xylenes.

The LEL monitoring methods described below may not be used to monitor for benzene since benzene is considered hazardous at levels far below the 1% LEL detection threshold of the standard catalytic “hot bead” type LEL sensor.

Basic physical properties, including health and safety data, for the materials discussed above are given in the appendix at the end of this document.

## 3. LEL Sensor Technology

### 3.1 Overview (details see appendix)

The discussion in this note regards only sensor technology of the catalytic “hot bead” type LEL sensor. This will include not only the standard range type 0-100% LEL in 1% LEL increments, but also the enhanced performance LEL sensor or PPM-HC sensor available in the Cannonball3 (PN 54-25-71), which is capable of 10 PPM resolution in the 0-1% vol. range.

General purpose LEL sensors respond best to lighter gases and vapors such as methane and hydrogen. The materials listed above are heavier, have a higher boiling/flashpoint and produce a much lower response in a general purpose LEL sensor than the equivalent amounts of the lighter gases. The magnitude of difference in response may be as much as a factor of 3, meaning that a detector calibrated directly for methane may only read about 30% of the actual %LEL level for the heavier vapors. Therefore, it is important to select the proper calibration gas/scale to ensure accurate detector readings.

The exception to the situation above is for the application involving Jet Fuel monitoring associated with aircraft wing tank servicing operations. In this case a specialized “kerosene” LEL sensor is available (PN 54-25-83) in selected detectors with high sensitivity to this vapor, but the use of this specific sensor is restricted to this application. The reason is that the “kerosene” sensor catalyst is inactive to methane or natural gas and therefore entirely unsuitable for this purpose or for general purpose use.

For a detailed discussion of LEL sensor performance across a broad spectrum of detectable hydrocarbons, please see Applications Note #AN20010808 – “Use of Equivalent Calibration Mixtures” (Note #19 on the website).

### 3.2 Catalytic Hot-Bead LEL Sensor Limitations

The standard catalytic hot-bead LEL sensor used by Biosystems requires a minimum of 10% oxygen in the sampled atmosphere to obtain accurate readings.

To conduct LEL measurements under oxygen-free/reduced or “inert” conditions, Biosystems offers the Cannonball3 with a dilution pump that automatically mixes the inert sample with fresh air to ensure an accurate response. Please contact Biosystems’ technical department for further information concerning the dilution pump-equipped Cannonball3.

For a detailed discussion of dilution monitoring options, please see Applications Note #AN20010809 – “Dilution Monitoring” (Note #20 on the website).

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### 3.3 Calibration requirement

To ensure accuracy to a specific combustible gas, the LEL sensor must be regularly calibrated with calibration gas that either is the gas that is to be monitored, or produces a sensor response similar to the response of the gas that will be monitored. Depending on the detector model and LEL sensor type, Pentane (C5) equivalent is best for all but heaviest of vapors. JP-8 or JetA surrogate is preferred for Jet Fuels and kerosene.

Routine calibration is important for maintaining sensor accuracy in hazardous conditions. For LEL sensors, routine calibration is particularly important because the LEL sensor can fail suddenly and unexpectedly when exposed to a sensor catalyst poison. In the case of sensor poisoning, neither the instrument nor the operator may be aware that the LEL sensor has been compromised and that the sensor is unresponsive to LEL vapors. The only way to be sure is to physically test the response of the sensor by subjecting it to a known source of calibration gas.

The important point is that, as with all gas detectors, periodic accuracy verification and calibration with the proper calibration gas is paramount to accurate detection.

Biosystems' policy on recommended frequency of accuracy verification is provided in all detector manuals and on our website as Applications Note #AN20010807 – "Frequency for Verifying Sensor Accuracy" (Note #18 on the website).

## 4. Detector Set-up

### 4.1 Applicable equipment

This applications note pertains to portable multi-gas detectors containing at least an oxygen and LEL sensor.

### 4.2 O2/LEL – incidental presence of toxic gas types

Note that although toxic gas sensors may also be present in detectors used for incidental monitoring of fuel & solvent vapors, it is generally considered poor practice to chronically expose electrochemical toxic gas sensors – i.e. sensors designed for PPM detection of CO, H<sub>2</sub>S, SO<sub>2</sub>, etc., to detectable LEL concentrations of these vapors. Solvent vapors can eventually pollute the electrochemical toxic gas sensor catalyst/electrolyte, which can lead poor performance, including an elevated and/or drifting baseline. Chronic exposure of the electrochemical sensor to LEL concentrations of fuel & solvent vapors can also lead to premature sensor failure.

### 4.3 Diffusion vs Directed Flow / Remote Sampling -Manually Aspirated vs Motorized Pump

Biosystems gas detectors are available with a wide variety of sampling accessories that are able to draw a gas sample into the detector at a faster rate than would occur by diffusion alone. The vapors of the materials discussed above are heavy and tend to diffuse slowly. Relying on simple diffusion when sampling tanks and other confined vessels will result in slow response times and an increased likelihood of erroneously readings. Diffusion is not the recommended method when sampling for these vapors under these conditions.

### 4.4 Directed Flow Sampling

The manual sample draw pump with hand-operated squeeze bulb provides highest gas sample flow rates to the detector sensors, and therefore the most rapid sensor response. The drawback to manual sample draw systems is that they require constant hand pumping to keep readings accurate if conditions change.

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Motorized sampling pumps provide lower overall flow rate than hand-operated pumps, but they offer the advantage of providing a constant flow with “hands free” operation. As such they are normally the preferred sampling method for this application.

#### 4.5 Replacement Components: Sensor Cover, Sampling Line, Probe/Filters

For all remote sampling systems it is important to only use OEM replacement components when the need arises. The use of untested detection components, including tubing, probes and filters, can cause erroneous readings. As an example, commercially available grades of tubing differ widely in their compatibility with fuel and solvent vapors. Biosystems tubing has been tested and has proven to have minimal interaction with fuel and solvent vapors. The substitution of components not authorized by Biosystems can lead to longer response and recovery times and in the worst case erroneously low readings.

### 5. Sampling Method

#### 5.1 Physical behavior of vapors

The lightest vapor in this class – toluene, has a vapor density more than 3X heavier than air. Therefore in deep vessels or spaces under static conditions the vapor will stratify, collecting at the lowest level. In this case it is especially important to sample the space at varying levels **and** to wait for the sensor response to level off completely when sampling at any particular location. The general rule for obtaining an accurate reading through a sample draw system, either motorized or manual, is to allow 1 second per foot of tubing for the vapor to reach the sensor plus an additional 45 seconds for the sensor to fully respond to the sampled atmosphere.

When heavier fuels and other distillate materials, such as spirits of turpentine, VM&P naphtha, etc., are stored in vessels, they tend to form a film on surfaces and in some cases of long term storage to leave a tarry residue. It should be considered that hot work performed on associated surfaces with varying states of cleanliness can result in a rapid release of significant quantities of combustible vapor leading to a localized combustible atmosphere. It is especially important to monitor these areas continuously while hot work operations are being performed, as well as those operations – mucking, etc., which can result in a change in ambient vapor levels.

#### 5.2 Sense of smell unreliable indicator

It should be noted that all of these vapors have a distinct odor, but that the sense of smell is an unreliable indicator of amount with regards to combustibility of these materials.

The threshold of odor for many aromatic solvents is in the range of 1-10 PPM. A strong odor would be on the order of TWA values, in the range of 100-200 PPM.

The lower explosive limit in air for these materials is on the order of 1%/vol, which is 10,000 PPM. A standard detector with an appropriately calibrated catalytic “hot bead” LEL sensor has a resolution threshold of 1% of the LEL, which in this case would be about 100 PPM. Therefore it is quite possible to have a strong smell of vapor in a space and yet have it not register a response on the LEL sensor channel. Given the prior comment about the heaviness of the vapor, it is often the case that an appreciable response is not detected in a vessel until sampling close to the liquid/lowest level.

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## Appendix\*\*

Material	Formula	Boiling Point / Range	Flash Point	PEL OSHA	8 hr TWA OSHA	8 hr TWA ACGIH	IDLH NIOSH
Toluene	C7H8	110°C	40°F	300 PPM	200 PPM		500 PPM
Xylene(s)	C8H10	137-140°C	77°F		100 PPM	100 PPM	
Styrene	C8H8	145-146°C	87°F	200 PPM	100 PPM	20 PPM	700 PPM
Cumene	C9H12	152-153°C	102°F		50 PPM	50 PPM	900 PPM
"Spirit" or Oil of Turpentine	C10H16 Var.	154-170°C	95°F		100 PPM	20 PPM	800 PPM
Kerosene	C10-C16 Var.	175-325°C	110-150°F			100 mg/m3*	
Jet Fuel A or JP-8	C10-C16 Var.	145-300 °C	>107 °F			200 mg/m3	

\* NIOSH, 10-hour TWA limit

\*\* Exposure value limits as of 2006.