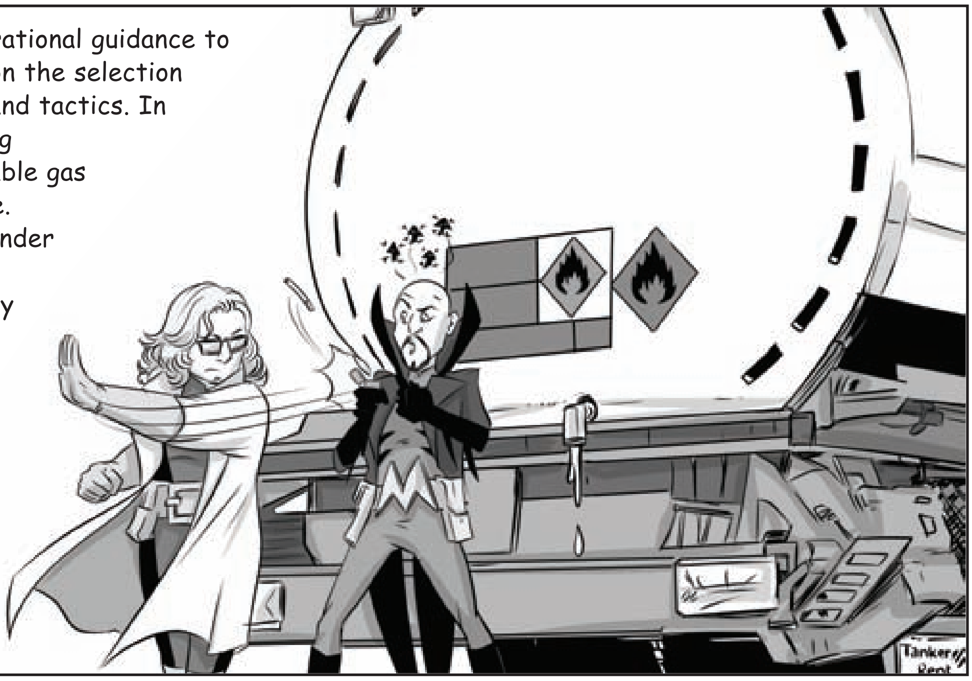
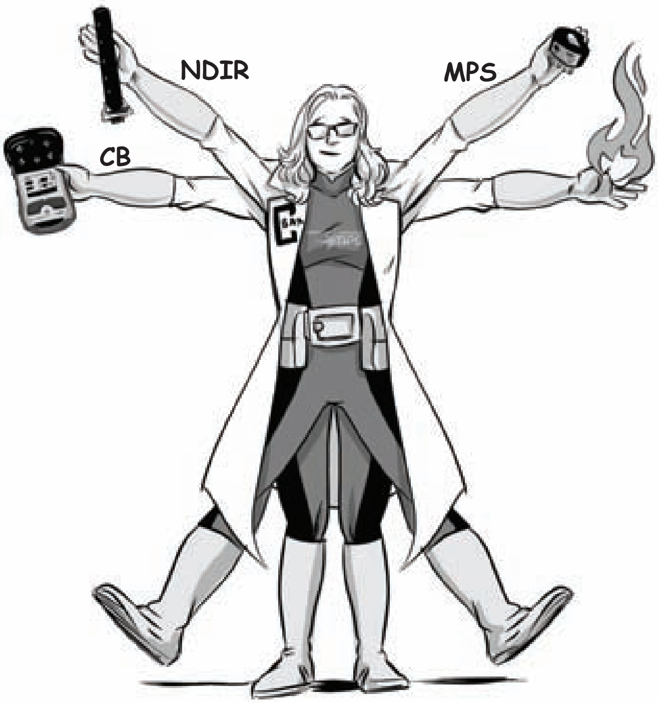
Dr Christina Baxter, of EmergencyResponseTIPS.com and Hazard3.com, offers helpful advice for first responders

Keeping you safe!

The column aims to provide operational guidance to the hazmat/CBRNE community on the selection and performance of equipment and tactics. In this issue, we focus on measuring flammability, that is the flammable gas concentration in the atmosphere. History reveals that most responder deaths linked to hazardous materials are due to flammability or explosions, not toxicity. Terrorists have also shown interest in using these materials to cause mass casualties. It is, therefore, essential that all hazmat/CBRN responders understand these concepts and how to measure them..



When using flammability detectors, it's important to know what's being measured. This may be the parts per million of a specific chemical, a percentage of its lower flammable limit (LFL) or lower explosive limit (LEL), or the percentage of the chemical in the atmosphere. Every flammable or combustible gas has a specific concentration range over which it is flammable. The lower limit of the flammable range is usually called the LEL or LFL, while the upper limit of the flammable range is the UEL or UFL. These limits are reported as a percentage of the flammable gas in air.



The three common types of flammable gas sensors used in the emergency response community are catalytic bead (CB), non-dispersive infrared (NDIR), and molecular property spectrometers (MPS). Most of them display readings as a percentage of the LEL (%LEL). The instruments are generally calibrated against methane and the %LEL readings must be converted for the gas being measured, if it is known, using published correction factors. For example, when measuring the flammability of an ammonia atmosphere using a Honeywell QRAE 3 incorporating a catalytic bead sensor, an instrument reading of 4%LEL (methane) is equivalent to 5.2%LEL (ammonia) because this instrument's correction factor is 1.3.

CB sensors operate by burning the chemical on a catalyst-coated bead and measuring the resistance difference between the coated bead and a non-coated bead. CB sensors respond quickly (15 seconds) and measure all flammable gases and combustible liquid vapours (albeit less sensitively). They are only accurate for the calibration gas measured (correction factors required for other gases), have dead bands up to 3% of LEL, require at least 11% oxygen to perform accurately, and are poisoned by heavy hydrocarbons, materials containing sulphur and phosphorous, and silicones.

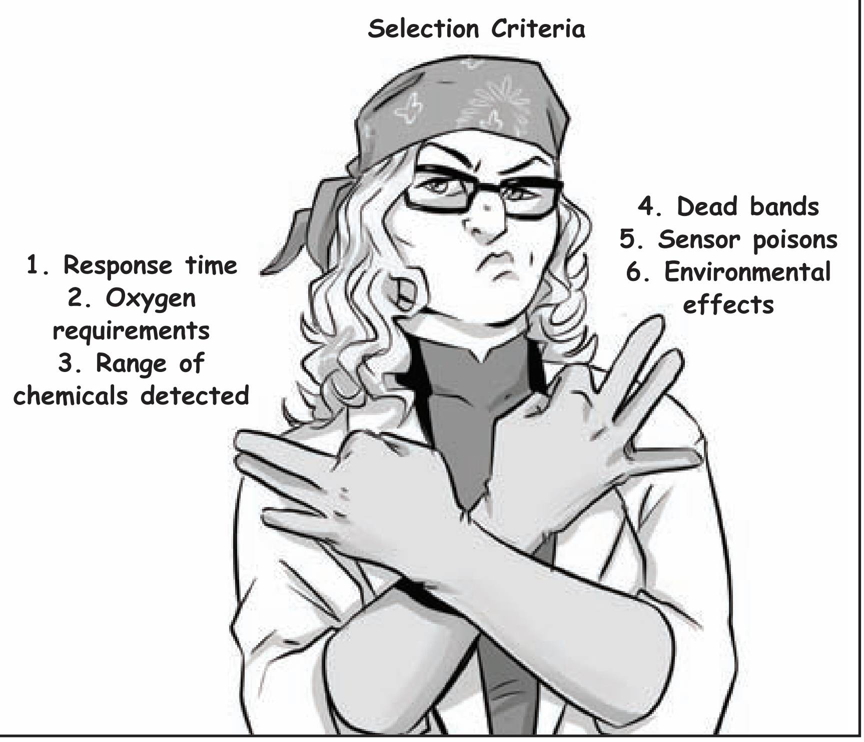
NDIR sensors operate using the infrared absorption wavelength of hydrocarbons. Infrared light is transmitted at two wavelengths, one being specific to hydrocarbons and another reference wavelength. The decrease in light intensity at the hydrocarbon specific wavelength is used to indicate the presence of flammable gases. NDIR sensors respond more slowly (30 seconds) and do not require oxygen to operate, but they can only measure hydrocarbons. Hydrogen, ammonia and other non-hydrocarbon gases or vapours are not detected. They have dead bands up to 3% of LEL and can be affected by extreme changes in temperature and humidity.

MPS sensors heat the gases and vapours rapidly, while monitoring the ambient temperature, pressure and humidity. The energy required to heat the sample is measured, corrected for environmental conditions, and an algorithm applied which classifies the gases into six classes, based upon the corrected energy, molecular weight, and density. MPS sensors respond relatively quickly (20 seconds), measure all flammable gases and vapours, and provide highly accurate data for 14 gases, but data is not available for many other flammable gases. Dead bands are 5% of LEL, high altitude may affect results, and other gases like carbon dioxide can be read as a flammable gas, although it does not poison the sensor.

Thermal Conductivity sensors are also used to detect flammable gas and vapour leaks. They rely on heat transfer to the surrounding environment. As non-specific sensors, these are highly sensitive, measuring in parts per million (ppm), but have significant cross-sensitivities. Metal Oxide sensors (MOS) are another highly sensitive device for gas and vapour leak detection, measuring in the ppm range. MOS tend to be low cost and do not require oxygen in the environment but have high power draw and poor sensor stability and repeatability.

Selection

When selecting a flammable gas sensor, consider the response time, oxygen requirements, range of chemicals detected, dead bands, sensor poisons, environmental effects, etc. For responder safety, catalytic bead sensors are used for most flammable gases while NDIR sensors are used for flammable, vapour forming hydrocarbons as they may poison catalytic bead sensors. MPS sensors have broad applicability across flammable gases and vapours but are currently most useful in the petrochemical industry due to limited availability of information. Thermal conductivity sensors and MOS are generally used to pinpoint the location of the leak whereas the others are used to classify the environment.



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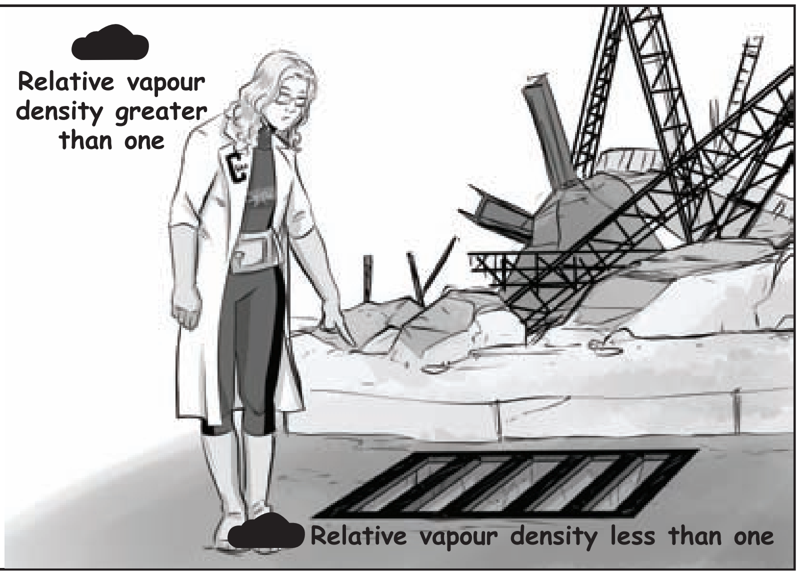
Sampling

It is critical to ensure that sampling for flammable gases and vapours is performed properly. Gases with a relative vapour density less than one (air = 1) will rise, while those with a relative vapour density greater than one will be found in low lying areas. Flammable gases with a relative vapour density under that of air include hydrogen (0.07), methane (0.55), ammonia (0.60), acetylene (0.90), hydrogen cyanide (0.94), carbon monoxide (0.97), and ethylene (0.98). Consider this fact when sampling, especially within structures, doorways, confined spaces, low lying areas and drains.



Operational Applications

While LEL sensors cannot identify specific materials, they can detect the presence of something and have an additive response for flammable mixtures. If the identity of the material is determined, it can be used quantitatively. These values can also be viewed as action levels for operators, who should consider the gas and its correction factor when monitoring.

This enables the operator to apply the instrument to:

- Identify Control Zones. Hot zone identification often uses greater than 10% of LEL while warm zones use greater than 3% of LEL. This means the operator is always erring on the side of safety, even if the largest correction factor is required. For example, using a MultiRae catalytic bead sensor, the highest correction factor (naphthalene, CF=6.5) results in an actual % LEL of 65%.
- Deny Entry. Most agencies use 5% of LEL as the turnback for confined space entry while regular spaces generally use 10% of LEL as the turnback.
- Select PPE. Traditional chemical protective garments provide minimal flame resistance and no flash protection, therefore many teams use a 3% of LEL reading to dictate a move towards flash protection garments. Note that some programmes recommend 1% of LEL for this transition, but the reading is not attainable on most commercially available instruments.
- Estimate Chemical Concentration. The % of LEL readings can be used along with the manufacturer's published correction factors and the flammable range of the chemical of interest to calculate concentration. Remember, always calibrate sensors following the manufacturer's guidelines and apply correction factor data specific to the manufacturer and model of the detector you are using.

Images are courtesy of Phil Buckenham *https://philbuckenhamart.wixsite.com/philbuckenham*