TECHNICAL
rescue
EMS, Fire, SAR, Aquatic, Rope & Special Rescue

An idiot's guide to Gas Detection

For people who should know better than to volunteer for Confined Space Rescue !

Gas detection in Fire Department and Fire Services around the world is often either absent or present only on Major Incident or Special Response Units. This is because the wearing of SCBA is mandatory for any unidentifiable entry and therefore the presence of toxic gas or a lack of oxygen should not be an issue to the individual rescuers. However, the composition of the atmosphere you are about to enter can impact directly on the way you equip for and carry out a rescue not the least of which is the status of your casualty. Continual atmospheric monitoring of all confined spaces both prior to and during an entry rescue is sound practice even in the presence of full breathing apparatus because your progress will need to be far more measured in say a 12 ppm H_2S or 10% LEL methane atmosphere than one with intermittent high CO_2 pockets. The difference is not only that your life could be endangered should you lose your air supply but also that particular actions that you might take - eg. accidentally dropping a metal component onto a metal or concrete surface - may be enough to cause an explosion or to ignite a flammable pocket of gas. It is assumed that any rescue service routinely dealing with confined space rescues will use intrinsically safe equipment but don´t forget that harness fittings, rope rescue hardware, portable ladders, extension poles etc. would need to be all stainless steel rather than steel and alloys for true intrinsic compliance and this is rarely the case, indeed for most multi-role teams and services this wouldn´t even be plausible.

So, knowing the status of your atmosphere AT ALL TIMES during an entry is worthwhile information because it will dictate how fast you carry out the required operation, what equipment you can and can't use to make life easier, whether your casualty is a possible rescue (or most likely a body recovery) and your general stress levels. There will come a time when the ADSU (Automatic Distress Signaling Unit) worn by most firefighters will incorporate multi-gas detection and temperature alarm for no size and weight penalty and eventually not much of a cost penalty either. But this is some way off and as usual would only be available to those with an amenable budget and therein lies the problem with acquiring even the technology currently available to rescuers - its expensive. A multi gas detector capable of simultaneously sampling 4 types of gas (for instance: Oxygen, H_2S (toxic), CO (toxic), CH_4 (flammable/explosive)) normally costs around one or two thousand pounds or dollars and personal issue at those rates may not possible. But don't forget we are only talking about rescuers likely to make a confined space entry and this will either be relatively few or at worst relatively few at any one time. A number of monitors now available have brought prices down by close to half of those previously available - the BW Defender featured here for example costs around $800 and weighs about a pound (half a kilo) with battery and sampling pump. There now can´t be any excuse for statutory rescue services using single-gas detectors unless they are completely sure that the risks on their patch are wholly limited to one particular gas in each particular location in which case the latest generation of miniature single gas monitors represents a huge improvement on the old ¯car battery¯ dimensioned monitors. But those charged with the responsibility of rescue have a duty to be properly equipped and in this respect ¨properly equipped¨ must mean the best quality multi-gas that your service can afford. It is just not acceptable to have an entry team, even with BA donned, unaware of the presence of hydrogen sulphide or methane because they have been issued only with an Oxygen monitor.

TROUBLE IN THE ATMOSPHERE

(There are 3 states of a substance - solid, liquid and gaseous. Solids can cause problems where they are able to engulf a rescuer but are not a common consideration in terms of atmospheric contamination. Liquids on the other hand can often be the catalyst for or direct cause of dangerous fumes. Even the most innocuous looking of confined spaces can cause problems for workers (and therefore rescuers) - oxidation of corroding steel - (rust) depletes the air of oxygen and this can easily reach dangerously low levels, vegetation and faecal matter in sewer and drainage pipes can release hydrogen sulphide and/or methane when disturbed - this means that the atmosphere could be 100% safe until you walk through one particular section of pipe and cause a rapid change in circumstances. Oxygen is present in air at around 20.9% of the total air volume. Any less than about 16% and you're in trouble. 19% to 19.5% is the normal lower limit for work - too much lower than this and breathing apparatus is called for. Even more dangerous for those at the scene is too much oxygen because it can be a trigger for spontaneous combustion/ignition of certain substances such as grease. 23%(UK) to 23.5%(US) is usually the upper limit for oxygen and this would be regarded as an enriched atmosphere. The concentration of a gas is given in various units - ppm.%. %LEL etc..

TERMINOLOGY

(PPM means Parts Per Million and is used for the so-called toxic gases such as Hydrogen Sulphide and Carbon Monoxide. These two gases require separate sensors because their lethal concentrations are so different - H2S is deemed dangerous above 10ppm (UK) or 15 ppm (US)whilst CO may be survivable at over 200ppm although most monitors will alarm at only 35ppm (US) 50ppm (UK). The gases which seem to cause most confusion are the combustible or explosive gases (which is a misnomer in itself since H2S and CO amongst others are combustible themselves whilst methane at 90% concentration is not explosive but will asphyxiate) because they are usually quoted as a %LEL or a percentage of their Lower Explosive Limit. It is surprising to many to learn that a fundamental gas like methane will not explode in the presence of a flame until it reaches a very specific concentration - below a certain level the gas is deemed too lean to burn and above a certain limit the gas may be too rich to burn rather like smothering a fire with too much wood. But within what may be a narrow band, between the Lower Explosive Limit (LEL) and the Upper Explosive Limit (UEL) such gases will ignite with only the faintest whiff of a Zippo. Because multi-gas and so-called 'explosi-meters' or combusti-meters' are monitoring a number of combustible gases of which methane is just one the %LEL is usually set at 10 to 20. This means that at only 10% to 20%of methane's Lower Explosive Limit or 10% to 20% of the level at which the gas will easily ignite when exposed to an ignition source the alarm sounds and decisions have to be taken about evacuation of the space. Of course 10% or 20% may sound like an overly cautious figure but remember that in other gases the

LEL may be much lower - in real terms a less common gas could have an LEL 50% higher than methane and you would therefore be sailing much closer to the wind by the time the alarm sounds - you generally will not know whether the gas which has triggered the alarm is methane at a relatively safe level or petroleum vapours at more hazardous levels. Other gas related terms are:

TLV

(Threshold Limit Value) & TWA (Time Weighted Average) both are referring to the duration of exposure to a particular atmosphere. TWA usually refers to an 8 hour working day over a 40 hour week. TLV will include this definition but also defines two other exposure limits - Short term or 15minute exposure and an absolute limit or ceiling which is the most that an individual should ever be exposed to.

PEL

is the Permissible Exposure Limit and this is a figure defined by the OSHA (US equivalent of HSE in the UK) as the legal limit of exposure for an employee. This means that they may be knowingly exposed to a known hazardous gas for no longer than a legislated maximum time. Any exposure beyond the PEL for that particular gas and the bereaved relatives can presumably sue.

STEL

is a UK term meaning Short Term Exposure Limit and refers to a maximum concentration or percentage exposure over a 15 minute period (similar to TLV-Short Term above)

IDLH

means Immediately Dangerous to Life or Health and is not something you want to see next to a low number on a Permit before making an entry. This is because IDLH given as a percentage or PPM represents the maximum exposure level at which you could survive for 30 minutes without breathing apparatus and without incurring debilitating symptons which would hinder your escape or even irreversibly damage your health. Thus if a gas is given an IDLH of 1ppm or .000001% you know that it´s a nasty one and if your SCBA packs up when your monitor is showing 10ppm its Goodnight Vienna.

The GAS MONITOR - MULTI OR SINGLE?

(We have already stated that any rescue service charged with confined space rescue should be equipped with MULTI-GAS monitors or should carry all four of the standard single-gas monitors simultaneously which even for devices as small as MSA´s Cricket monitors, seems a bit daft. There are models such as the Draeger PAC III which uses a single monitor costing around $800 into which can be fitted one of a selection of 10 small sensors which can be changed anywhere. In terms of bulk and initial purchase cost this design makes a lot of sense although functioning is obviously not as convenient as a true multi-gas monitor. Nevertheless, it is not sufficient for rescuers to carry a single-gas monitor even if that monitor is an explosive gas monitor and your rescuers are wearing full breathing apparatus despite the fact that this is a relatively safe practice which would serve you well through the majority of incidents. The key word here is ¯majority¯. Rescue services should always cater for the worst case scenario and in this case a multi-gas rather than single-gas monitor is a simple expedient in covering a worst case scenario - perhaps an entrapment or a breathing apparatus failure in which identifying a pocket of breathable air for the rescuer or casualty with no breathing air would have made the difference between life and death.

ACTIVATION

(Most gas monitors will switch on with a single push of a button but will only switch off with consistent pressure or consecutive pressing of a button or simultaneous pushing two buttons. This is to ensure that the monitor cannot be accidentally switched off during use. Once activated the monitor will go through a series of self tests possibly indicating date and time, temperature, battery level, calibration status (which, if overdue could stop you using the monitor) and in some cases the settings which have been programmed into the monitor for the various gases. These can be altered to suit your own circumstances but you must be absolutely sure of the regulations regarding exposure to the range of gases you are altering and if you are making the entry you must take notice of the levels at which the monitor is going to alarm. It is possible for somebody to have altered the settings without your knowledge thus putting you into a life threatening situation. For this reason many monitors have a security lock function which requires a password to change the settings. Most monitors have a peak exposure reading which shows the highest (or for oxygen the lowest) levels of each gas that were encountered during the entry. Such information and indeed readings throughout the duration of the entry can often be downloaded to a computer for future analysis hence the need for date and time. Temperature is important because it can affect the way in which liquids, solids and gases react in a space - at low temperatures a liquid may be inert but may start to give off lethal vapours once the temperature increases.

READING THE MONITOR

(Most monitors have an LCD display - often just a single line which scrolls through its various gases continuously. In the case of the BW Defender illustrated here there is a large 1 ½¯ LCD screen which displays all 4 gases at one time as well as battery status and an indication that the sampling pump is activated (because you would not hear its quiet motor with BA donned.) This provides one of the most user-friendly and easily read screens on the market at the moment. Typically, many of the ¯pocket¯-sized models provide a single line display with continual scrolling through the gases being monitored. But Oxygen % can look like the date or a calibration date since the ¯2¯ is displayed as ¯O2¯ using a full size 2 rather than drop case. Nevertheless in the event of an activation the relevant gas is illuminated by its own red LCD so it is immediately obvious what you are dealing with. There are normally two alarm stages - low and high or simply stage-1 and stage-2. These represent an activation at the first and lowest level deemed to be risky and culminate in a more intense beep and warning light display as the readings pass the high and therefore extremely dangerous level for each gas. Be sure that you are familiar with the various alarm tones that your monitor may have - low battery for instance but all supplementary alarms will be overridden by the 2 levels of gas alarm - the first is a warning that your status may need to be reviewed (eg. Don BA or begin evacuation) but the second is a full blown, kick in the behind reminder to get the hell out of Dodge or if suitably equipped , proceed with the utmost caution and maybe speed things up (or forget about it!) if you haven´t yet rescued your casualty. Low or first stage alarms may switch off automatically once levels regain acceptable limits or they may require an acknowledging push of a button on the part of the rescuer. High or second stage alarms however are often impossible to switch off other than by turning off the gas monitor and this is to ensure that everyone is well aware that the situation is very dangerous since switching off the monitor requires a very positive action. If your entry environment is noisy you may need to invest in an ear-piece for the monitor assuming your particular model has this facility - if not you've made an incorrect purchase because the monitor is not functioning adequately in the environments in which you are working.

BATTERIES

(Rechargeable is pretty much the name of the game right across the board. There is often a standard dry cell (battery) option and there may be some specialist monitors around specifically designed to use low temperature tolerating/long shelf life Lithium cells but for the most part rechargeable monitors are favoured. Some like the OldhamMX2000, Sabre MGM400 and Draeger Multi-Pac have an integral cell and either the whole monitor is placed in the charger when required or the charger plugs in to the monitor - this has the advantage that there is no chance of an accidental battery exposure during changing and that there is no separate battery compartment which can detach from the main body and disable the monitor whilst in use. The second type is a uniform rechargeable battery pack servicing a number of different sensing units - as with the single gas Sabre PM200 series. This means that a number of batteries can be rotated on charge at all times for the same head and that components are interchangeable. However make sure that the battery compartment is securely fastened in place since if the two components should part company during use you will not only lose your gas detection (possibly unbeknown you) but the separation of power supply and host may constitute an explosion risk though this is apparently not the case with the PM200. The BW Defender uses Black & Decker´s Versatech batteries - readily available at any hardware store and convenient to carry and charge but again be sure that the battery lock switch is engaged. To overcome any risk of inadvertent battery disengagement or monitor malfunction always use the confidence bleep option present on every gas monitor. This is usually in conjunction with a bright LED indicator (green for confidence, red for alarm according to the latest European standards) and lets you know every 30 seconds or so that the monitor is functioning Ok.

SAMPLING

(The all important part of this article because it is the part of the rescue operation most often mismanaged. There are two stages of sampling - Pre-entry and continuous during entry. Pre-entry sampling is undertaken during the set up phase of a rescuer. The person tasked with identifying the risks, at least at the entrance and area immediately adjacent to the space, will switch on a multi-gas monitor well away from the area and wait for pre-checks to be complete. If the space is a known hazard, breathing apparatus should be donned even at the pre-entry sampling stage before moving towards the space with the sensor ports exposed and facing the suspected risk area. Sampling must be done at ground level, mid-height and above head height when entering an ante-chamber to the entry location - taking account of light and heavy gases. This will establish your 'clean' area but remember that this will probably be the location for entry Control Officer/comms and airline control panel or cylinder staging and should also be continuously monitored for multiple gases during the operation. Once adjacent to the entry "hole", hatch or door a sampling tube may be used for remote monitoring- this is particularly the case with vertical entries. All sampling tubes should incorporate a filter somewhere along their length to stop liquids and dust from being drawn into the sensor. Some tubes use a simple hand aspirator bulb whilst some have a pump built into the monitor to actively draw in air. Because any worthwhile monitor has a peak reading facility many services opt to lower the monitor into the space and check the peak reading once it has been pulled back up. You will need to perform checks at regular heights down to and including the ground but remember that not many monitors will appreciate being lowered into several inches of liquid at the bottom of the space.

Monitor **ALL AREAS** of a space both prior to and during the entry. Many gases form isolated pockets which can be hard to locate until you stick your head into it or disturb it with your boots. The rest of the space may be perfectly breathable so "safe" readings can lead to a fall sense of security. Be ever vigilant and be diligent in your sampling of the space. The location of the monitor on your body is an important decision. Ideally it should be chest mounted with the option to sample by hand at every opportunity. If it is waist mounted and you are crawling through a confined space you will only be sampling a few inches above the ground and may be missing a complete strata of toxic gas above you. Worst still, if you have chosen not to don BA your head may be "sampling" a different gas to that of your monitor being dragged beneath you!

CONCLUSION

Rescuers should use multi-gas monitors capable of simultaneously sensing three or four types of gas.

Every entrant should be issued with a monitor. If budgets do not allow this then at the very least every team should have a monitor and all team members must operate in close proximity to the monitor.

The Entry Control area should be monitored for multiple gases throughout the operation to ensure that it remains a ¯clean¯ and therefore safe staging area.

Check the monitor frequently and take readings in all parts of the space - ground, middle and top and in corners and offset holes. (However, be realistic, this is a rescue and time may be of the essence).

Never dismantle a monitor or change the batteries in a hazardous atmosphere. (Some models may be safe)

Establish ground rules for rescuer evacuation of the space prior to entry eg. Evacuate on low alarm, high alarm, loss of monitor function, loss of comms etc.

Ensure that all electrical equipment meets appropriate intrinsic requirements (lighting, radios, tools, pagers, etc), and that plastic components such as airline are anti-static.

Be aware that any hardware not manufactured in stainless steel may cause a spark when knocked against another metal or stone surface.

Thanks to:

Brian Robinson

Tony Pickett - Protector Sabre

BW Technologies

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