Session No. 770

Documentation Beats Confrontation in Gas Detection

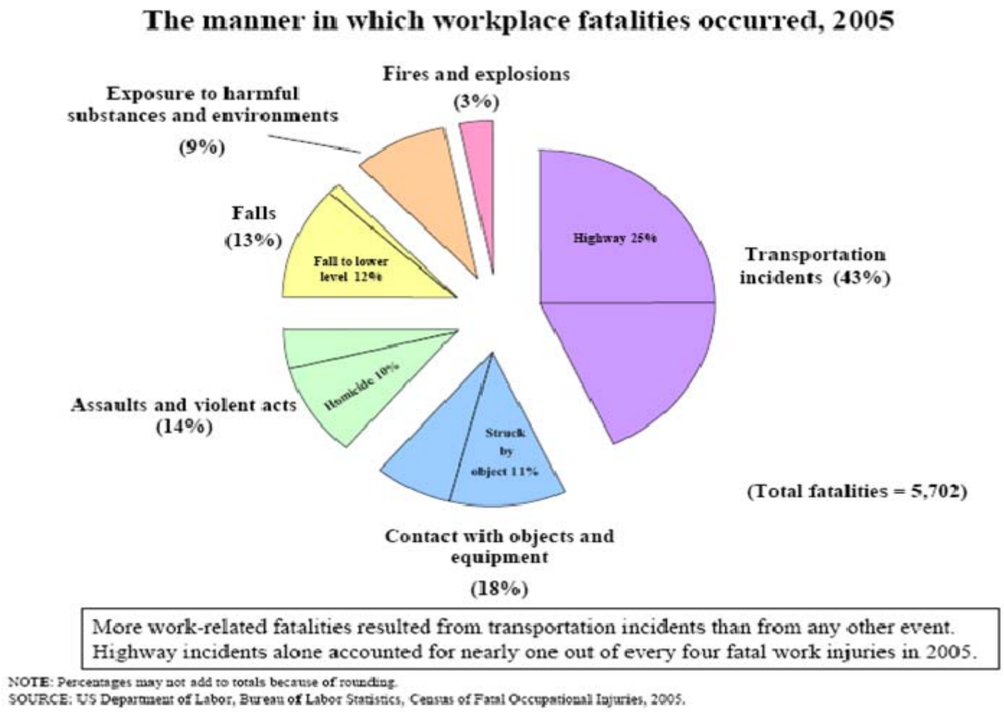
Andrew Saunders, CQT
Applications and Training Specialist
BW Technologies by Honeywell

Introduction

Deaths of workers in confined spaces are a recurring occupational tragedy. According to NIOSH (National Institute for Occupational Safety and Health), approximately 60% of deaths involve would-be rescuers. With the proper equipment and training, the vast majority of these fatalities can be prevented.

The danger of toxic gas hazards is a very real and daily threat that people face in numerous occupations. In the state of Kentucky, one police officer and two sewer workers died in an attempt to rescue a third sewer worker who had been overcome by H_2S gas at the bottom of an underground pumping station. All four were pronounced dead upon their removal from the station.

In the state of Georgia, a plumbing contractor and two co-workers were laying out a new sewer line for an industrial building under construction when a fatal accident occurred. The contractor entered the manhole and descended 15 feet into the sewer to measure a stub out location for the new line. Co-workers were unsuccessful in their rescue attempts and the contractor was removed by the fire rescue squad. He was pronounced dead on arrival at a local hospital. Atmospheric tests revealed the oxygen level in the sewer to be six percent.



In all tragic events any gas monitoring equipment is seized and the investigation begins. How prepared are you for the questions that will follow? Accurate record keeping provides evidence of the event as well as the proper testing and maintenance of the gas monitor. The due diligence of data collection and retention may help avoid a long and costly litigation. Even when gas monitoring prevents a tragic event, loss of time, money and productivity may have to be justified.

While this paper will focus on multi-gas monitors used primarily in confined space entry, the principles as it pertains to documentation can be used for all applications of gas detection. This includes event and data logging retrieved from the gas monitor as well as data retrieved form bump testing and calibration devises.

Know the dangers that lurk below!

Generally speaking, a confined space is any space that is large enough for an employee to enter and perform work. The space has limited means of entry or exit, and is not designed for continuous occupancy. A permit-required confined space has one or more of the following characteristics:

- A hazardous atmosphere (oxygen deficiency, toxic gases or explosive gases) is present or has the potential to be present.
- Material with the potential for engulfment is present.
- The space has inwardly sloping walls or dangerously sloping floors.
- The space contains any other serious safety hazard.

Many occupations such as sewer workers are typically very knowledgeable when entering and working in confined spaces. Unlike other occupations where confined space entry is an infrequent event, sewer workers' typical work environment is a permit required space. They must understand that the atmosphere may suddenly become lethally hazardous from causes beyond their control. They have been using multi-gas monitors long before the Occupational Safety and Health Administration (OSHA) put the Permit-Required Confined Spaces Final Rule (29 CFR 1910.146) into effect on April 15th, 1993. OSHA also specifies the requirements of a non-permit required confined space.

Non-permit required confined spaces are generic in nature and require the employer to develop and maintain data supporting this determination. Therefore, workers must be prepared for atmospheric monitoring at any given time. Confined spaces include, but are not limited to, trenches, storage tanks, compartments of ships, process vessels, pits, silos, vats, degreasers, reaction vessels, boilers, ventilation and exhaust ducts, sewers, tunnels, vaults, and pipelines.

Monitors with event and datalogging capability may provide supporting documentation for CS declassification. The bottom line: When in doubt…take it out…and turn it on.

Selecting a Multi-gas Monitor

Today’s gas monitoring equipment has come a long way from the miner’s canary. Workers need to have a personal multi-gas monitor to perform the required atmospheric pre-testing and continuous monitoring. The monitor needs to be easy to use, rugged and reliable to work in some of the adverse conditions that can exist in these environments.

At a minimum, the device should monitor several hazards simultaneously:

- Oxygen deficiency; occurs in an atmosphere containing oxygen at a concentration of less than 19.5 percent by volume.
- Oxygen enrichment; defined as an atmosphere containing more than 23.5 percent oxygen by volume. An oxygen enriched atmosphere, even by a few percent, considerably increases the risk of fire.
- The lower explosive limit (LEL) of a combustible gas or vapor; the concentration at which in air will ignite if a source of ignition is present. The alarm is usually set at 10% LEL.
- Carbon monoxide (CO); an odorless, colorless and toxic gas. The alarm is usually set at the permissible exposure limit of 25 – 35 ppm.
- Hydrogen sulfide (H2S), distinguishable at low levels by its distinct odor of rotten eggs. Although a person can smell less than 1 part per million (ppm), the nose quickly becomes anesthetized and can no longer detect the smell. The alarm is typically set at the permissible exposure limit of 10 ppm.

In addition to these gases, a Photo Ionization Detector (PID) sensor can be employed in some of today’s multi-gas monitors for protection against a broad range of volatile organic compounds (VOC) such as benzene, xylene and toluene. The airline industry is using this technology for detection of jet fuel at very low levels.

Today, the best performance comes from a gas monitor equipped with an internal pump and external hose with a hydrophobic filter. The internal pump allows for easy pre-testing of the confined space and limits the amount of accessories involved in the process. Diffusion monitors are still very popular for their small size and cost. Hand motorized pumps are now a commonly available option. Well equipped workers often carry a confined space gas monitor kit. A common kit could include a multi-gas monitor with pump and 10 foot sampling hose for pre-testing (longer lengths available), spare batteries (rechargeable or alkaline), quad-gas cylinder for bump testing and calibration with gas regulator.

Gas Monitor Event Logging

Type of Exposure	Time Alarm Started	Time Alarm Ended	Peak Exposure
Peak Exposure	4/22/04 13:36:56	4/22/04 13:37:27	94 ppm CO
Peak Exposure	4/22/04 13:38:09	4/22/04 13:38:26	80 ppm CO
Peak Exposure	4/22/04 13:40:42	4/22/04 13:42:37	95 ppm CO

Event logging can record a set number of alarm events. When the memory in the monitor becomes full, the oldest event is replaced by the newest event. The typical number of events that a monitor can store is between 10 and 30. This information recovered from the monitor includes but is not limited to: serial number, type of exposure, alarm duration and peak readings.

Even some of the low-cost single-gas monitors are now available with this feature as standard. The more sophisticated the devise, the more information provided per event. Computer hardware such as a USB cable with IR interface is required. Software is provided by the manufacturer and updates are made available on their website.

Gas Monitor Data Logging

Date + Time	Serial Number	Gas Typ	Reading (ppm/%vo	STEL (ppn	TWA (ppn	Sensor Status	Unit Status	Pass Prote	STEL Perio	Confidence Beep
4/22/2004 13:27:15	J304-M123456T	CO	35	0	0	TWA Alarm Setpoint		No	15	No
4/22/2004 13:27:15	J304-M123456T	CO	200	0	0	STEL Alarm Setpoint		No	15	No
4/22/2004 13:27:15	J304-M123456T	CO	35	0	0	Low Alarm Setpoint		No	15	No
4/22/2004 13:27:15	J304-M123456T	CO	200	0	0	High Alarm Setpoint		No	15	No
4/22/2004 13:27:15	J304-M123456T	CO	0	0	0		Calibration Due	No	15	No
4/22/2004 13:27:15	J304-M123456T	CO	1023	0	0		Last calibration	No	15	No
4/22/2004 13:27:15	J304-M123456T	CO	0	0	0		Manual shutdown	No	15	No
4/22/2004 13:27:57	J304-M123456T	CO	35	0	0	TWA Alarm Setpoint		No	15	No
4/22/2004 13:27:57	J304-M123456T	CO	200	0	0	STEL Alarm Setpoint		No	15	No
4/22/2004 13:27:57	J304-M123456T	CO	35	0	0	Low Alarm Setpoint		No	15	No
4/22/2004 13:27:57	J304-M123456T	CO	200	0	0	High Alarm Setpoint		No	15	No
4/22/2004 13:27:57	J304-M123456T	CO	0	0	0		Calibration Due	No	15	No
4/22/2004 13:27:57	J304-M123456T	CO	1023	0	0		Last calibration	No	15	No
4/22/2004 13:27:57	J304-M123456T	CO	0	0	0			No	15	No
4/22/2004 13:27:58	J304-M123456T	CO	0	0	0			No	15	No
4/22/2004 13:27:59	J304-M123456T	CO	0	0	0			No	15	No
4/22/2004 13:28:00	J304-M123456T	CO	0	0	0			No	15	No
4/22/2004 13:28:01	J304-M123456T	CO	0	0	0	Auto-zeroing		No	15	No

Data logging is much more comprehensive than event logging. It constantly records instrument and sensor status. This feature is often used similar to a “black box” in an airplane. If the unfortunate were to happen, the monitor could be downloaded and its activity revealed.

The gas monitor records key points of information such as:

- Turning the unit on and off
- Date and time
- Monitor configuration
- STEL, and TWA and peak readings
- Sensor status
- Calibration and bump test compliance

Total memory can vary but most gas monitors can be set up to record all sensor readings every second and still provide days, weeks or even months of data.

Monitor Testing and Verification

Advancement in sensor technology has allowed for longer intervals between calibrations of the monitor (up to 180 days). A functional test prior to each day’s use ensures that the sensors provide an adequate response to gas and generate the appropriate alarms throughout this interval. The two methods used today are:

a) Bump Test – (qualitative) a functional check involving the passing of a challenge gas over the sensors sufficient enough to activate audio, visual and other alarms.

b) Calibration check – (quantitative) a bump test utilizing a known concentration of a challenge gas to demonstrate that an instrument’s response to the gas is within acceptable limits.

If the monitor fails the test, it cannot be used until it is successfully calibrated.

Increasing in popularity is the use of a docking station that will do the functional test, calibrate, record data and charge the monitors. In case of an event where evidence of proper maintenance and care of a gas detector must be given, docking stations provide objective proof that procedures are being followed.

Docking stations are arguably the best method for recording test, calibration and activity status. Safety managers and industrial hygienists will often be required to show evidence of up to date monitor calibration bump test history. Docking stations cannot only record these events, they can automatically perform them.

Although some do not require a computer to operate, they can be remotely connected to a network and regularly downloaded for management of an entire fleet of gas monitors. The software package allows users to:

- import event logs, bump test and calibration results, and data logs from detectors and base stations,
- generate bump test certificates, calibration certificates, and detector status reports,
- manage users and base stations,
- configure detectors, and
- archive and save the database.

In 2005 a construction company had a death in a confined space. In reviewing their confined space program they decided to upgrade their gas detection equipment. Understanding the need for documentation, they would not even look at a system that did not include a docking station.

Reports and certificates

Calibration Test Certificate

2007-11-29 16:07:42

Device			
Serial Number:	KA107-0010332	Device Type:	GasAlertMicroClip
Manufacturer:	BW Technologies	Next Cal Due:	2008-04-06

Test Result	Pass

Sensors				
Type:	H2S	CO	LEL	O2
Result:	Pass	Pass	Pass	Pass
Final Reading:	25.0 ppm	100.0 ppm	50.0 %	20.9 %
Next Calibration Due:	2008-04-06	2008-04-06	2008-04-06	2008-05-27

Set Points				
Type:	H2S	CO	LEL	O2
High Alarm:	15.0 ppm	200.0 ppm	20.0 %	23.5 %
Low Alarm:	10.0 ppm	35.0 ppm	10.0 %	19.5 %
TWA Alarm:	10.0 ppm	35.0 ppm		
STEL Alarm:	15.0 ppm	50.0 ppm		

Options			
Datalog Interval:	15 seconds	Unit Programmed:	N/A
H2S STEL Period:	15 minutes	CO STEL Period:	15 minutes

Test Station					
Dock Serial Number:	Z207-001572	Dock Location:	Home		
	Inlet 1:	Inlet 2:	Inlet 3:	Inlet 4:	Inlet 5:
Used:	Yes	Yes	No	No	No
Concentration:	20.9 %	25.0	25.0	20.9 %	20.9 %
Type:	Purge	4 Gas Mixture 2.5% vol CH4	Custom 2 Gas	Purge	Purge
Notes:					

The software program for the gas monitor is quite dynamic today and provides custom reports as well as certificates of bump testing and calibration. Safety managers will often be required to show evidence of up-to-date monitor calibration and periodic testing.

Success Story

A 250 MW power generation station was in the process of putting hydrogen back into the generator. The hydrogen gas is used to cool the generator during operation. As the operators filled the generator they noticed the generator hydrogen pressure decaying by about 2 lbs per hour. This rate is usually less than 1/10 of a pound per hour. The operations department notified the site safety specialist that they were getting a CO alarm on their BW Micro 5 monitor when they walked out of the control room. The Safety Specialist grabbed a second BW Micro 5 gas monitor and went to investigate the high CO levels. When the specialist got to the generator his BW Micro 5 monitor overloaded on the CO sensor and started reading 15% on the LEL sensor. The Safety Specialist had the area barricaded and called BW Technologies by Honeywell to ask about the CO reading. By extracting the information from the monitor they were able to show the Safety Specialist that Hydrogen would affect the CO sensor and with the % of LEL they felt certain the monitor was picking up Hydrogen. The high CO reading coincided with the reading on the LEL sensor each time.

The Safety Specialist then went back to the generator and found that the monitor was picking up 100% LEL of hydrogen in the area around the generator. He requested that the generator be purged of hydrogen until the leak could be found.

The operations department found the hydrogen leak on a hydrogen cooling system on the generator in the exact location the BW Micro 5 was reading its highest levels of LEL. The leak was fixed and the unit was started without further incident. The response of BW Technologies by Honeywell gave the Safety specialist the knowledge he needed to prevent a potential Hydrogen explosion. This hazard could have resulted in hundreds of thousands of dollars worth of damage to the generator, more importantly, the potential for multiple losses of life were averted. He told them later: “You guys saved lives that day!!!!!”

Conclusion

Datalogging monitors may cost a bit extra, but, imagine if the end result went the other way. A simple spark from any number of sources could have ignited this atmosphere and the cost would have been a million times higher. In a tragic event a seized monitor may have stored the data of this event, but what about its accuracy?

- Was the monitor calibrated in accordance per manufacturer’s recommendations?
- Who has the certificate of calibration?
- Was it bump tested prior to that day’s use?
- Were the operators trained to use and maintain the monitor properly?
- Where is the documentation of these events?

Event and data logging as well as computer software able to create and store key information provide objective evidence for the investigation teams (both internal and external). For most investigators, if it wasn’t documented…it wasn’t done! Avoid confrontation with documentation.

Bibliography

UD Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2005

National Institute for Occupational Safety and Health (NIOSH) www.cdc.gov/niosh/

Occupational Safety and Health Administration (OSHA) put the Permit-Required Confined Spaces Final Rule (29 CFR 1910.146) www.osha.gov