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Gas Testing for Confined Space Entry

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Background Information

Even though the federal OSHA Permit Required Confined Space Entry Standard, 29 CFR 1910.146, contains specific requirements for pre-entry and follow-up atmospheric monitoring people continue to die in confined spaces due to oxygen deficiency and / or exposure to hazardous atmospheres. One only has to look at the Weekly Fatality / Catastrophe Reports on the federal OSHA website (OSHA.gov) for evidence. The question is, why? Having worked in the industry for over 30 years I have formulated several ideas as to why and what can be done to prevent such tragedies.

I have and continue to see major problems with companies' Confined Space Entry Atmospheric Monitoring Programs, both in the United States and abroad. The problems generally fall in to one of three categories:

1. Use of defective monitors or ones that have not been correctly calibrated
2. Incorrect use of the equipment
3. Failure to correctly interpret the results of the monitoring

In almost every case the root cause is the lack of training on the part of the monitor users, their supervisors and managers. Let's review a few actual examples:

A leak in the sampling system that yielded incorrect results: In one (1) instance the monitor being used to issue Confined Space and Hot Work Permits had a leak in the sampling hose, but none of the users knew of the need for or how to perform a leak check. The Instrument Technician who was performing calibration checks on the unit had placed a small hole in the bottom of the sampling hose to "drain out" liquid being drawn in to monitor by the users. He did not know he could purchase a line trap assembly to capture liquid.

Failure to correctly perform a Calibration or Bump Check before each use: In one (1) instance the users of the instrument and the Instrument Technicians calibrating the instruments were using a sample of a process chemical to check the operation of the equipment. In another case, the company could not purchase calibration check gas from the equipment supplier due to

the lack of an import permit from the government. The instrument in use could not be adjusted to read 20.9% in fresh air. How accurate were their readings?

Incorrect use of the equipment: In one (1) instance the gas tester correctly performed a leak check and a calibration check then turned the instrument off. He proceeded to the confined space, inserted the sampling hose into the space and turned the unit on. After doing so he adjusted the Oxygen meter to 20.9% and the Combustible Gas Instrument to 0%. In effect, he calibrated the instrument to the atmosphere inside the confined space. The individual running the test was the unit supervisor responsible for issuing confined space entry permits and training others.

In another instance while using a new style detector tube the user correctly broke off the ends of the tube but failed to break the center section of the tube to mix the reagents and allow flow through the tube. He documented that he received a zero (0) reading.

Incorrect Sampling Techniques: Numerous problems of this nature are often seen. In some cases the gas testers only check near the entrance to the space. They neglect to check all levels of the space. Gases that are lighter or heavier than air might be missed.

In other cases, testers fail to check the atmosphere with the ventilation system turned off. In doing so, they don't obtain a true sample of what is in the space.

When using detector tubes the user does not take the required number of strokes on the bellows pump. As a result they don't receive an accurate reading of the atmosphere inside the space. In a similar situation, while using a syringe (piston) pump, the user correctly inserted the detector tube in the syringe, tied the pump to a long broom handle, pulled the handle on the syringe back while outside the space and then inserted the syringe and tube in the space. Again, he did not get an accurate reading. The individual had been trained to do it that way.

Mis-interpretation of the readings: In one (1) case personnel noted high levels of Carbon Monoxide in a section of a commercial bakery where the dough was rising. The contaminant was not Carbon Monoxide but was alcohol being generated from the rising dough. The gas detector needed a carbon filter installed on the inlet of the instrument. Many people do not understand the concept of interfering gasses or the limitations of their instruments.

In another case, a combustible gas indicator was used to check the atmosphere in an old chemical tank. The sludge in the bottom of the tank had a flash point of 55^0 Fahrenheit (F). When the initial gas test was run on the tank the ambient temperature was 34^0F. After lunch when they resumed worked the temperature was 75^0F. No additional tests were performed before the resumption of welding late in the afternoon. The tank exploded. The individual who ran the gas test did not understand the concept of flash point and the need to run another test as the ambient temperature rose.

Personnel are frequently found using a conventional combustible gas indicator to check equipment that has been purged with Nitrogen to allow the performance of hot work. In every case, they did not understand that most conventional Combustible Gas Indicators require a minimum amount of oxygen for the instrument to yield a correct reading.

As you can see from these examples the personnel assigned to perform these critical tests were not adequately trained. In my experience this is a very common problem.

An effective atmospheric monitoring program requires the following:

- An adequate supply of properly calibrated monitoring equipment selected for the type of contaminants likely to be encountered
- The correct attachments for the instruments such as, but not limited to, line trap assemblies if moisture is problem, sampling pumps and hoses or wands and battery chargers
- The capability of and requirements for pre-use bump or calibration checks
- A preventive maintenance program
- A comprehensive training program for gas testers
- A written policy and procedure governing the selection, care, use and limitations of the gas testing equipment including training and auditing.

Developing a Comprehensive Gas Testing Training Program

A comprehensive Gas Testing Training Program typically includes the following:

1. A detailed review of chemical terminology relative to gas testing
2. Principles of operation of Combustible Gas Indicators, Oxygen Meters and Direct Reading Colorimetric Indicator Tubes
3. The purpose of and how to use typical attachments such as pumps, hoses, wands, line trap assemblies and calibration or bump check equipment and supplies
4. Instruction on the care, use and limitations of each type of instrument including how to perform a leak check, calibration or bump check, replace and / or recharge batteries
5. Open book quizzes using the instrument operating manuals and detector tube instruction sheets
6. Practical demonstrations of the equipment and attachments by the instructor
7. Proper sampling techniques
8. Practical student demonstrations on the use of the instruments including how to perform leak checks, calibration or bump checks and all attachments
9. A written quiz
10. Refresher training at least every two (2) years.

Personnel who perform gas testing need a thorough understanding of the following terms:

- Oxygen deficiency
- Oxygen enrichment
- Flammable liquids
- Combustible liquids
- Upper Flammable Limit (UFL)
- Lower Flammable Limit (LFL)
- Flash Point
- Vapor Density
- Vapor Pressure

- Inert gas
- Threshold Limit Value (TLV)
- Permissible Exposure Limit (PEL)
- Toxic Substance

The training should clearly explain the purpose of and how to perform a Bump or Calibration check before each use. The International Safety Equipment Association (ISEA) is a national organization of safety and health equipment manufacturers including monitoring instruments. ISEA has published the following definitions[1]:

- **"Bump Test** (Function Check): A *qualitative* function check where a challenge gas is passed over the sensor(s) at a concentration and exposure time sufficient to activate all alarm indicators to present at least their lower alarm setting. The purpose of this check is to confirm that gas can get to the sensor(s) and that all the alarms present are functional."

- **"Calibration Check:** A *quantitative* test utilizing a known traceable concentration of test gas to demonstrate that the sensor(s) and alarms respond to the gas within manufacturer's acceptable limits."

- **"Full Calibration:** The adjustment of the sensor(s) response to match the desired value compared to a known traceable concentration of test gas."

In addition, the training should focus heavily on:

- The need for daily Bump or Calibration Checks in accordance with the equipment manufacturer's requirements
- Sampling techniques including the need to check all levels of the space from top to bottom
- The need to shutdown the ventilation systems for at least 15 minutes before performing the test. Additional tests may be performed with the ventilation system switched on to verify the ventilation system is functioning as intended.
- The need for continuous or periodic monitoring to verify that atmospheric conditions remain safe for entry
- The potential for interfering gases
- The need to consult equipment manufacturer's operating instructions for guidance on evaluating readings when the contaminant being sampled for is different from the gas used to calibrate the instrument

Guidelines for Purchasing Gas Testing Equipment

Up to this point we have discussed common problems and the need for a comprehensive gas testing training program. It is also important to have the correct type and amount of equipment on hand when needed. To the extent possible companies should standardize on the types and

[1] International Safety Equipment Association, "ISEA Statement on Validation of Operations for Direct Reading Portable Gas Monitors", Arlington, VA, www.safetyequipment.org, March 5, 2010

brands of gas testing equipment to minimize training issues and avoid possible errors in use. It also reduces the need for and cost of multiple types of calibration equipment and spare parts.

Listed herein are some things to consider when purchasing gas testing equipment. **Before purchasing equipment you should answer the following questions:**

1. What contaminants do you want to detect and measure?

    - Oxygen deficient or enriched atmospheres
    - Flammables / Combustibles
        - Hydrogen
        - Acetylene
    - Toxics: (specify)
    - Radioactive

2. Instrument Specifications:

    - Sensitivity
    - Accuracy and range of measurement
    - Temperature and humidity range
    - Direct reading vs. Detector Tubes
    - Electrical or magnetic field interference shields

3. Do you need remote sampling equipment?

    - How much sampling line will you need?
    - Is there a possibility of drawing liquid into the instrument?
    - Do you need dielectric equipment?
    - Do you need a rigid extension rod?

4. What are the general environmental conditions?

    - Hot
    - Cold
    - Dusty
    - Mists or aerosols

5. Do you need personal monitors?

    - What types of alarms are needed? (Visual and / or audible)
    - Are earphones needed?

6. Do you need carrying cases or straps?

7. Who will use the equipment?

8. Who will repair the equipment?

9. Who will calibrate the equipment?

10. How many instruments are required for normal operation?

11. In an emergency or major shutdown how many units would be needed?

12. How many units are needed for off site emergency response?

13. How many units are needed to keep on hand as spares?

14. How many units are needed for training?

Questions to ask of the supplier or vendor:

1. Is your equipment UL Listed or FM Approved as Explosion Proof or Intrinsically Safe?

2. Are there any interfering gases or contaminants that can cause problems? What limitations does your equipment have?

3. Where is the nearest service center, and what is the turnaround time for repairs?

4. What spare parts do you recommend be kept on hand?

5. How frequently should the equipment be calibrated?

6. What calibration equipment is needed?

7. What repairs can be made on site?

8. Do the batteries need to be exercised to keep them from developing a memory?

9. How long will the instrument operate before it needs to be recharged? What is the recharging time? Can I charge a battery separately from the instrument?

9. Do you have any audiovisual training programs?

10. Will your Factory Representative train our personnel?

11. Are there any special training requirements?

Conclusion

Based on the issues discussed up to this point, would you feel comfortable entering a confined space at one of your facilities if the pre-entry gas tests were performed by someone else and not

witnessed by you? What if you are a contractor relying on a host employer's employee to run the pre-entry tests?

The OSHA Permit Required Entry Confined Space Entry Standard, 29 CFR 1910.146, allows employees and / or their representative to observe pre-entry and any subsequent testing. This is a concept I wholeheartedly endorse and encourage.

Take a look at your existing confined space entry gas testing procedures and instruments. Are there any potential problems? How well trained are your gas testers? What about your confined space entrants who rely on others to perform gas tests for them? Have you trained them on the questions to ask and what to look for? If not you may want to do so. You may wish to have your personnel perform their own verification tests using your equipment.

Would you bet your life, or those of your employees who enter confined spaces, on the reliability and accuracy of the gas tests run by your personnel and those who run the tests for your employees? Why not conduct a comprehensive audit of your gas testing program?

Using the information discussed herein, prepare and administer a written quiz for personnel currently performing your gas tests. Accompany your personnel in the field to verify they are:

- Performing a pre-use leak check on the equipment and component parts
- Performing a pre-use bump or calibration check
- Turing off the ventilation system for at least 15 minutes prior to the initial test
- Sampling the space from top to bottom
- Drawing the correct amount of flow through direct reading colorimetric indicator tubes
- Correctly interpreting the readings

Don't take your gas testing program for granted. Conduct regular audits of all facets of your gas testing program. Remember: **Management gets not what it expects, but what it inspects and measures.**