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Developing a Training Program for Confined Space Entry Atmospheric Monitoring

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Background Information

Even though the federal OSHA Permit Required Confined Space Entry Standard (PRCS), 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 40 years 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 into one (1) of three (3) 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.

What constitutes an effective gas testing training program? That's a good question. The OSHA PRCS standard is silent on this issue. The ANSI / ASSE Z117.1-2009 Standard[1], "Safety Requirements for Confined Spaces", states, "Training shall include the selection and proper use of appropriate atmospheric monitoring instruments based on a current hazard assessment." The explanatory note further states, "It is important for individuals conducting atmospheric tests to possess adequate knowledge of the proper operation of monitoring equipment as well as its limitations associated with anticipated conditions (such as inaccurate measurement readings for flammable gas when the oxygen level is below 16% for certain equipment). Similarly, these individuals should have information about the related process to anticipate potential atmospheric contaminants, such as a nearby reactor containing a highly toxic substance which could endanger the entry team in the event of a leak or release."

[1] American National Standards Institute (ANSI) Z117.1-2009, Safety Requirements for Confined Spaces.

Companies need to develop and implement a comprehensive training program for personnel who carry out atmospheric monitoring. Let's look at some ways to do this.

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 as shown in Table 1:

Term	Definition
Combustible liquids	Having a flash point above 100^0F (37.8^0C) and below 200^0F (93.3^0C)
Explosion Proof Apparatus (OSHA)	Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor that may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes or explosion of the gas or vapor within, and that operates at such an external temperature that it will not ignite a surrounding flammable atmosphere.
Flammable liquids	Liquid with a flash point below 100°F (37.8°C).
Flash Point	The temperature at which a liquid will give off enough flammable vapor to ignite.
Inerting	The displacement of the atmosphere in a permit space by a noncombustible gas (such as nitrogen) to such an extent that the resulting atmosphere is noncombustible. **NOTE:** This procedure produces an IDLH oxygen-deficient atmosphere.
Intrinsically Safe	Equipment and wiring which is incapable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignited concentration."[2]
Lower Flammable Limit (LFL	The lowest concentration (lowest percentage of the substance in air) that will produce a flash of fire when an ignition source (heat, arc or flame) is present.
Oxygen deficiency	A concentration of oxygen in the atmosphere equal to or less than 19.5% by volume.
Oxygen enrichment	An atmosphere with an oxygen concentration greater than 23.5% by volume.
Permissible Exposure Limit (PEL)	An exposure limit established by OSHA regulatory authority. OSHA may establish PEL's for an eight-hour time weighted average (TWA), a Short Term Exposure Limit (STEL) or a maximum concentration or Ceiling Value (C).
Threshold Limit Value (TLV)	Expression of the airborne concentration of a material to which nearly all persons can be exposed day after day, without adverse effects.
Toxicity	A relative property of a chemical agent and refers to a harmful effect on some biologic mechanism and the conditions under which this effect occurs.
Upper Flammable Limit (UFL)	The highest concentration (highest percentage of a substance in air) that will produce a flash of fire when an ignition source (heat, arc or flame) is present.
Vapor Density	The weight of a vapor or gas compared to the weight of an equal volume of air; an expression of the density of the vapor or gas.
Vapor Pressure	The pressure exerted by a saturated vapor above its own liquid in a closed container.

Table 1. Definition of Terms

[2] American National Standards Institute / International Society of Automation, "Wiring Practices for Hazardous Classified Locations Instrumentation: RP12.6-1995"

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 an international organization of safety and health equipment manufacturers including monitoring instruments. ISEA has published the following definitions[3]:

- **"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 impact changes in temperature may have relative to the flash point of a substance
- 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

Sample Gas Testing Quiz

Circle the letter in front of the most correct answer.

1. The reasons for performing gas testing are:

    a. Detecting hazardous conditions
    b. Assist in the selection of personal protective equipment
    c. Assessing potential health hazards
    d. Issue work permits
    e. All of the above are correct

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

2. Before performing gas tests with a Combustible Gas Indicator (CGI), you should first perform an oxygen test to be sure that there is sufficient oxygen present for the indicator to function properly.

   a. True b. False

3. You checked your CGI earlier in the day and it was functioning properly. It is not necessary to check its operation again before using it two hours later.

   a. True b. False

4. The primary purpose of a Detector Tube Unit, when used with a specific tube, is to _____ a specific substance.

   a. Measure the density of
   b. Detect the presence of
   c. Measure the temperature of
   d. Measure the vapor pressure of

5. A Detector Tube Unit, when used with a specific tube, will also _____ the specific substance if it is present.

   a. Give you the weight of
   b. Measure the temperature of
   c. Measure the concentration of
   d. Measure the vapor pressure of

6. When inserting a detector tube into the pump head, the arrow on the tube should point in which direction?

   a. Away from the pump
   b. Toward the pump
   c. Either direction
   d. There is no arrow

7. Before personnel are permitted to enter an area where hazardous atmospheres may be present, which three types of gas tests should be performed?

   a. Acid, Base & Caustic
   b. Odor, Color & Taste
   c. Oxygen, Flammable Gas, & Toxic
   d. None of the above are correct

8. Can you always rely on your sense of smell to alert you to the presence of a hazardous atmosphere?

   a. Yes b. No

9. Gas testing equipment can be used with a leak in the sample flow system with the understanding that the meter readings will be low.

   a. True b. False

10. Before conducting an oxygen test, the oxygen analyzer's meter should be set so the meter reading is _____% oxygen in fresh air.

a. 0
b. 100
c. 20.8
d. 25

11. Before conducting a flammable gas test, the L.E.L. meter should be set so it reads _____% of the L.E.L. in fresh uncontaminated air.

a. 0
b. 100
c. 20.8
d. 25

12. In some cases where the oxygen is less than 20.8% it means that some other gas has displaced some of the air or some process has consumed a part of the available oxygen.

a. True
b. False

13. Not enough gas or fuel in relation to the amount of oxygen in the air for the mixture to support combustion is considered to be the

a. Flash point
b. Rich region
c. Oxygen deficient region
d. Lean region

14. The right combination of gas or fuel and oxygen to form a combustible or explosive mixture is within the flammable or explosive range.

a. True
b. False

15. The flammable limits are the same for all gases but vary for different liquids.

a. True
b. False

16. When selecting the proper detector tube for a specific test you must know:

a. The color of the substance
b. The molecular weight of the substance
c. The substance you wish to detect
d. The melting point of the substance

17. In general, when reading the scale on the detector tube, the longer the stain the of the detected substance.

a. Lower the concentration
b. Higher the concentration
c. Higher the temperature
d. Lower the temperature

18. If you conducted a leak test with the pump and there were no signs of leakage, it would not be necessary to test the pump together with the extension hose if you used the extension hose later in the day.

a. True
b. False

19. The lower explosive limit is the minimum amount of a gas or fuel required to produce an explosive mixture in air.

    a. True
    b. False

20. The hazard of an atmosphere being above the UEL (the rich region) is:

    a. Ventilating the area may bring the levels into the explosive / flammable range
    b. There is no hazard because the mixture is too rich to burn
    c. Toxicity
    d. None of the above are correct

21. When entering an area with a personal CGI or oxygen analyzer and the alarm sounds you should:

    a. Reset the alarm
    b. Continue working
    c. Immediately leave the area
    d. Finish the job and then leave

22. Most CGIs measure:

    a. Percent of the LEL
    b. Vapor pressure of the gas
    c. Density of the gas
    d. Temperature of the gas

23. Liquids, silicones, and leaded gasoline vapors can damage gas testing equipment, therefore it is important that filters and line traps be used.

    a. True
    b. False

24. Although most CGIs and oxygen analyzers operate using similar technology, it is essential that you read the manufacturer's instructions and know company policies and procedures before using the equipment.

    a. True
    b. False

25. Normal oxygen content in air is:

    a. 19.5 %
    b. 25 %
    c. 20.8 %
    d. 23.5 %

26. An oxygen **deficient** atmosphere contains less than _____ oxygen.

    a. 19.5 %
    b. 25 %
    c. 20.8 %
    d. 23.5 %

27. An oxygen **enriched** atmosphere contains more than _____ oxygen.

    a. 19.5 %
    c. 20.8 %

b. 25 %

d. 23.5 %

28. Sampling points when gas testing should be:

    a. High points for materials lighter than air
    b. Low points for materials heavier than air
    c. It doesn't matter where you sample
    d. Both a and b are correct

29. It is important to read the detector tube instruction sheet before you begin sampling.

    a. True

    b. False

Match the letter of the correct answer with the number of its definition.

30. ____ Vapor Density

31. ____ Vapor Pressure

32. ____ Threshold Limit Value (TLV)

33. ____ Permissible Exposure Limit (PEL)

34. ____ Immediately Dangerous to Life and Health (IDLH)

35. ____ Flash Point

36. ____ Oxygen Deficient

37. ____ Oxygen Enriched

38. ____ (LEL) Lower Explosive Limit or (LFL) Lower Flammable Limit

39. ____ (UEL) Upper Explosive Limit or (UFL) Upper Flammable Limit

A. The lowest temperature at which a liquid gives off enough vapor to form an ignitable mixture.

B. Atmosphere with greater than 23.5% oxygen.

C. Used to describe very hazardous atmospheres where employee exposure can cause serious injury or death within a short time or serious delayed effects.

D. The weight of a gas or vapor in relation to air. Air = 1

E. The **OSHA** legally enforced exposure limit for a substance.

F. Atmospheres with less than 19.5% oxygen.

G. **Highest** concentration of gas in air to form an explosive mixture.

H. The pressure exerted by a liquid in a closed container at a specified temperature.

I. **Lowest** concentration of gas in air to form an explosive mixture.

J. The maximum airborne concentration of a material to which nearly all workers can be exposed day after day without adverse health effects.

Sample Practice Session Using a Multi-Gas Detector Tube

Review the attached tube information sheet on the Ammonia 5/a Drager tube and answer the following questions.

1. The scale on this tube is calibrated in _____.

   A. percent volume
   B. degrees F
   C. degrees C
   D. parts per million (ppm)

2. What is the color of the indicating layer?

   A. green
   B. orange
   C. white
   D. pink

3. Ammonia turns the indicating layer what color?

   A. yellowish-orange
   B. pink
   C. green
   D. brown

4. What other chemical would indicate on the tube with the same sensitivity as chlorine?

   A. oxygen
   B. nitrogen
   C. bromine
   D. acetylene

5. What color is the pre-layer on this tube?

   A. pink
   B. yellow
   C. Orange
   D. White

Conclusion

Personnel who perform atmospheric monitoring for confined space entry need to demonstrate competency on:

- The care, use and limitations of the equipment including all attachments
- Interpretation of the results relative to the spaces being tested

You may want to perform a training needs assessment. In doing so consider:

- Who needs to be trained and to what level?
- What is the education and experience level of the target audience?
- Previously identified problems with atmospheric monitoring and the solutions
- Type(s) and brand(s) of instruments

- Training resources needed and availability
- Subject matter experts
- Instructors or instructor credentials

In addition to training, an effective atmospheric monitoring program needs to be rigorously audited for 100% compliance. Anything else could be life threatening. How good is your program? Would you bet a life on the quality of your program?