Instrumentation and Air Monitoring

1. **Overview**
    a. Identify atmospheric hazards
    b. Identify sources of atmospheric hazards
    c. Identify testing equipment (instrumentation & air monitoring)
    d. Understand the usage characteristics of testing equipment
    e. Identify control practices
    f. Look at case studies

2. **Atmospheric Hazards**
    a. Hazardous atmosphere means an atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from a permit space), injury, or acute illness from one or more of the following causes:
        i. Flammable gas, vapor or mist in excess of 10% of its Lower Flammable Limit (LFL);
        ii. Airborne combustible dust at a concentration that meets or exceeds its LFL;
        iii. Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent;
        iv. Atmospheric concentration of any substance for which a dose or a permissible exposure limit is published in Subpart D—Occupational Health and Environmental Control, or in Subpart Z—Toxic and Hazardous Substances, of this part and which could result in employee exposure in excess of its dose or permissible exposure limit; or
        v. Any other atmospheric condition that is immediately dangerous to life or health.
    b. Three Main Types of Hazardous Atmospheres
        i. Unsafe Oxygen levels, either an oxygen deficient below 19.5% or oxygen enriched above 23.5%
        ii. Flammable gases
        iii. Toxic vapors and/or toxic dust particulates
    c. Calibration
        i. Common mistakes
            1. Test instruments not calibrated at all
            2. Equipment calibrated with wrong gases
            3. Meter is zeroed in an area where gases are present giving the meter a false zero
            4. Permit does not identify toxic gases to test
            5. Tester cannot be identified

3. **Atmospheric Hazard Sources**
    a. Types of atmospheric hazards
        i. Flammables
            1. Flammable gas, vapor or mist in excess of 10% of its Lower Flammable Limit (LFL);
        ii. Combustible dust

1. Airborne combustible dust at a concentration that meets or exceeds its LFL

iii. Oxygen
1. Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent

iv. Atmospheric concentration
1. Atmospheric concentration of any substance for which a dose or a permissible exposure limit is published in Subpart D—Occupational Health and Environmental Control, or in Subpart Z—Toxic and Hazardous Substances, of this part and which could result in employee exposure in excess of its dose or permissible exposure limit

v. Any other atmospheric condition that is immediately dangerous to life or health.

4. Characteristics of testing equipment

a. Types of instruments
i. Real time
ii. Alarm only devices

b. Monitor characteristics
i. Easily operated
ii. Readable in both light and dark conditions
iii. Easily calibrated or standardized
iv. Equipped with a peak-hold feature to record the highest concentration encountered
v. Equipped with audible and visual alarms for a preset concentration
vi. Explosion-proof
vii. Equipped with fully charged batteries at all times
viii. Easily protected against contamination
ix. Equipped with a remote probe for non-entry testing
x. Reliable, rugged, and dependable

5. Understand the usage characteristics of testing equipment

a. Where do you test
i. Top middle and bottom
1. Texting at every level is important to ensure proper readings of all gasses within the confined space
2. Good air at the opening does not mean good air at the bottom.

ii. Vapor density
1. Hydrogen: 0.07
2. Methane: 0.55
3. Ammonia: 0.59
4. Carbon Monoxide: 0.96
5. Nitrogen: 0.97
6. Air: 1.00

7. Hydrogen Sulfide: 1.19
8. Argon: 1.38
9. Carbon Dioxide: 1.52
10. Toluene: 3.20
11. Gasoline: 3.0-4.0
12. Jet Fuel, JP-8: 4.70

6. Identify control practices

a. Hazard Assessment
   i. A hazard assessment should be done in order to assess what hazardous atmosphere (including chemicals) is likely to be present and what sensors are need to be in the air monitor to identify the presence of those hazardous atmosphere (including chemicals)

b. Sensors
   i. The responsiveness of sensors will vary with workplace environmental conditions, such as temperature and humidity.
   ii. Therefore, to the degree possible, operators should calibrate sensors in environmental conditions that are the same as (or similar to) the actual workplace conditions.
   iii. Follow the manufacturer's guidelines for proper calibration.

c. Evaluation testing
   i. Meant to evaluate the atmosphere inside a confined
      1. What chemical hazards are present or may become present
      2. How to best deal with hazards and perform tasks at hand

d. Air Monitoring
   i. Must conduct atmospheric testing before entry into the confined space
   ii. The reason for testing is to ensure atmosphere is safe to enter
   iii. Test every time before reentering the confined space
   iv. Testing Frequency
      1. The atmosphere within the space must be continuously monitored unless the entry employer can demonstrate that equipment for continuous monitoring is not commercially available or periodic monitoring is sufficient.
   v. Order of testing for Atmospheric hazards
      1. Oxygen
      2. Combustible gases and vapors
      3. Toxic gases and vapors
      4. Or test for all simultaneously
   vi. Lower Explosive Limits

1. Ammonia	15.00%	28.00 %
2. Carbon Monoxide	12.50%	74.00 %
3. Methane	5.00 %	15.00 %
4. Proplyene	2.40 %	11.00 %

e. Calibration
    i. “Calibration" refers to an instrument's measuring accuracy relative to a known traceable concentration of test gas.
    ii. Best way to verify that a Direct Read Portable Gas Monitors (DRPGMs) is reading accurately and reliable, is to compare the sensor's response to a known concentration of the test gas.
    iii. To confirm the validity of this comparison, it is important to ensure the calibration gas has not expired (always check the expiration date of the gas before usage).
    iv. The instrument's response to the calibration gas serves as the reference point
    v. The primary reason for proper, regular instrument calibration is to provide accurate gas-concentration readings that could prevent worker illness, injury, or death. Correctly calibrating an instrument helps to ensure that the DRPGM will respond accurately to the gases it is designed to detect, thereby warning users of hazardous conditions before the conditions reach dangerous levels.
    vi. Always calibrate per the manufacturers’ specifications.

f. Calibration Drift
    i. When an instrument's reference point shifts, the reading will shift accordingly and be unreliable. This is called "calibration drift," and it happens to all sensors over time. An instrument that experiences calibration drift can still measure the quantity of gas present, but it cannot convert this information into an accurate numerical reading.
    ii. Causes of calibration drift
        1. Degradation caused by exposure to phosphates
        2. Degradation of phosphorus-containing components
        3. Degradation of lead-containing components
        4. Gradual chemical degradation of sensors and drift in electronic components that occur normally over time.
        5. Use in extreme environmental conditions, such as high/low temperature and humidity, and high levels of airborne particulates.
        6. Exposure to high concentrations of the target gases and vapors.
        7. Exposure of catalytic hot-bead LEL sensors in the instruments to volatile silicones, hydride gases, halogenated hydrocarbons, and sulfide gases.
        8. Exposure of electrochemical toxic gas sensors to solvent vapors and highly corrosive gases.
        9. Handling/jostling of the equipment causing enough vibration or shock over time to affect electronic components and circuitry.

g. Bump Testing
    i. This is a qualitative function check in which a challenge gas is passed over the sensor(s) at a concentration and exposure time sufficient to activate all alarm settings.
    ii. The purpose of this check is to confirm that gas can get to the sensor(s) and that all the instrument's alarms are functional.

iii. The bump test or function check does not provide a measure of the instrument's accuracy.
iv. When performing a bump test, the challenge gas concentration should trigger the DRPGM's alarm(s).

h. Bump test vs full calibration
    i. A bump test or calibration check of portable gas monitors should be conducted before each day's use in accordance with the manufacturers' instructions
    ii. If an instrument fails a bump test or a calibration check, the operator should perform a full calibration on it before using it. How often you should calibrate the meter depends on how much its used, always refer to the manufacturers' recommendations. If the instrument fails the full calibration, the employer should remove it from service.

i. Calibration
    i. Follow the manufacturers' guidelines for proper calibration
    ii. Only use a certified traceable test gas, and do so before its expiration date
    iii. Train DRPGM operators on the proper methods of calibration. Most instruments are designed to be field calibrated with detailed instructions provided in the manufacturers' user manual, training videos, or computer-based training modules

7. Case Study

a. Case Study 1
    i. Company laying sewer pipe & manholes for a new housing development 6 employees onsite. City codes require a vacuum test – must maintain 10 inches of mercury for a specific time based on depth of manhole. If vacuum test fails, then sections of the manhole must be grouted to get a better seal. After vacuum test failure, employee reportedly was assigned the grouting task Grouting is done by hand and takes about 1 hour. The employee was working alone.
    ii. The employee was found at the bottom of the manhole unconscious

b. Findings Case Study 1
    i. OSHA issued two serious violations and one other than serious violation:
        1. – 5(a)(1) – Develop and Implement a confined space entry program
        2. – 29CFR1926.21(b)(6)(i) – Training
        3. – 29CFR1904.39(a) – Employer to report a workplace fatality within 8 hours

8. Outline employee rights

a. Employee rights and responsibilities
    i. To assure safe and healthful working conditions for working men and women
    ii. By authorizing enforcement of the standards developed under the Act
    iii. By assisting and encouraging the States in their efforts to assure safe and healthful working conditions

iv. By providing for research, information, education, and training in the field of occupational safety and health

b. A right to
    i. A safe and healthful workplace
    ii. Know about hazardous chemicals
    iii. Information about injuries and illnesses in your workplace
    iv. Complain or request hazard correction from employer
    v. File a confidential complaint with OSHA to have their workplace inspected.
    vi. Receive information and training about hazards, methods to prevent harm, and the OSHA standards that apply to their workplace. The training must be done in a language and vocabulary workers can understand.
    vii. Get copies of their workplace medical records.
    viii. Participate in an OSHA inspection and speak in private with the inspector.
    ix. File a complaint with OSHA if they have been retaliated or discriminated against by their employer as the result of requesting an inspection or using any of their other rights under the OSH Act.
    x. File a complaint if punished or discriminated against for acting as a "whistleblower" under the additional 20 federal statutes for which OSHA has jurisdiction.

c. Whistleblower Protection
    i. OSHA's Whistleblower Protection Program enforces the whistleblower provisions of more than twenty whistleblower statutes protecting employees who report violations of various workplace safety.