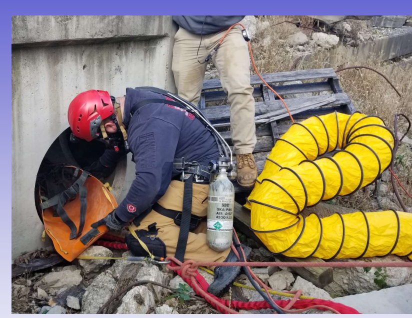
Hazmat Team Role in CSR?

- Specialize in IDLH atmospheres
- Understand chemical & physical properties of products
- Experts in air monitoring & ventilation
- Great partners with tech rescue

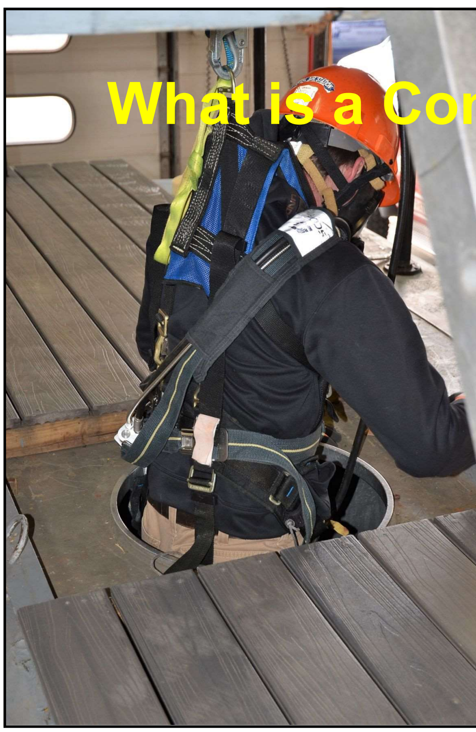


What is a Confined Space?

OSHA 29 CFR 1910.146 defines as:

- **Area large enough to enter to work**
- **Has limited or restricted means for entry and exit**
- **Is not designed for continuous employee occupancy**

What is a Confined Space?



NFPA 1006 3.3.31 defines as:

- **An area large enough and so configured that a member can bodily enter and perform assigned work but which has limited or restricted means for entry and exit and is not designed for continuous human occupancy. (NFPA 1500, 2013 edition)**

Examples of Confined Spaces

- Tunnels
- Sewers
- Tanks
- Tank Cars and Trailers
- Ship Holds and Accesses
- Coffer dams
- Process Vessels
- Reaction Vessels
- Manholes
- Industrial Spaces
- Storm Drains
- Ovens and Furnaces

Other Regulations which may pertain to Confined Space Entry and Rescues

- Respiratory Protection
- Lockout / Tagout / Blockout
- Fall Protection
- Trench Excavation

Confined Space Emergency

- **Any action or event, whether inside or outside the confined space, which could endanger the persons working within the space.**

- **Includes: failure of any hazard control or monitoring equipment used in the space, such as ventilation or atmospheric testers, or unauthorized entries**

Incident

- **An occurrence, either human-caused or a natural phenomenon, that requires action or support by emergency services personnel to prevent or minimize loss of life or damage to property and/or natural resources. [NFPA 1143, 2009]**

Video : Rope Rescue

Confined Space Hazards

All confined space hazards fall into one of four basic categories:

- ✓ **Atmospheric Hazards**
- ✓ **Physical/Mechanical Hazards**
- ✓ **Environmental Hazards**
- ✓ **Psychological Hazards**

Note: All hazards must be identified and controlled (rendered non-hazardous) before entry.

Atmospheric Hazards

Hazardous atmosphere means an atmosphere that may:

- ✓ **Expose employees to the risk of death, incapacitation, impairment of ability to self rescue, injury, or acute illness from one or more of the following causes:**

Atmospheric Hazards (continued)

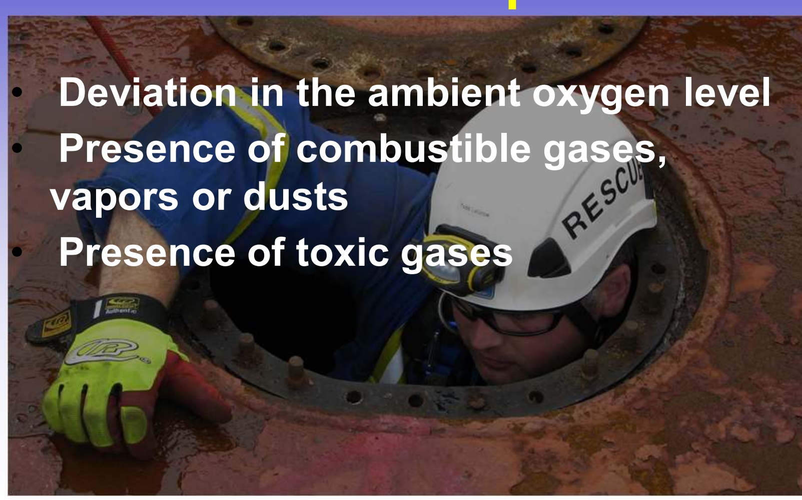
- **Flammable gas, vapor, or mist >10% LEL**
- **Airborne combustible dust at a concentration that obscures visions at 5' or less**
- **Oxygen concentration <19.5% or >23.5%**
- **Radiation or radioactivity**
- **Any substance at or beyond its PEL**
- **Any other Immediately Dangerous to Life or Health atmosphere (IDLH)**

Immediately Dangerous to Life or Health (IDLH)

Any condition that poses an immediate or delayed threat to life, that would cause irreversible health effects or that would interfere with an individual's ability to escape unaided from a permit space

IDLH

Common Atmospheric Hazards in Confined Spaces



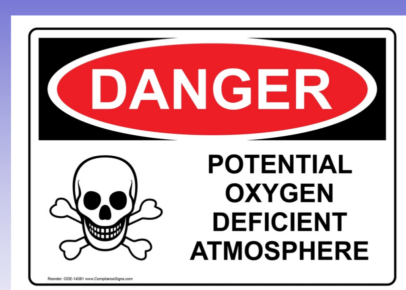
- Deviation in the ambient oxygen level
- Presence of combustible gases, vapors or dusts
- Presence of toxic gases

Oxygen Deficient Atmospheres

20.9%	Normal Oxygen Concentration in air
19.5 %	Minimum acceptable oxygen level.
17%	First signs of hypoxia, degraded night vision
16%	Disorientation. Impaired judgement
14%	Faulty judgement, rapid fatigue.
8%	Mental failure. Fainting.
6%	Difficulty breathing. Death within minutes.

Causes of Oxygen Deficient Atmospheres

- Consumption
  - ✓Combustion
  - ✓Decomposition
  - ✓Oxidation of Metals
- Absorption
  - ✓The vessel itself
- Displacement
  - ✓Intentional Purging with Inert Gasses
  - ✓Unintentional Purging (Engine Exhaust)

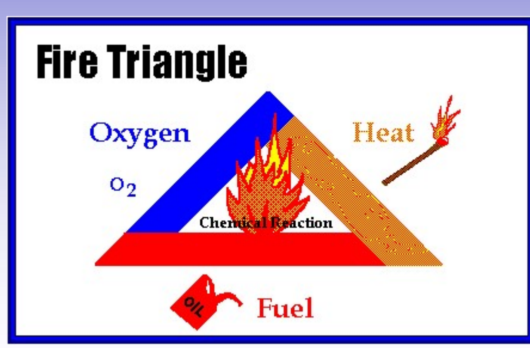


Oxygen Enriched Atmospheres

- Oxygen level above 23.5%.
- Causes flammable and ordinary combustible materials to burn violently when ignited.
- Never use pure oxygen to ventilate.
- Never store or place compressed tanks in a confined space.

Presence of Combustible Gases

- For fire to occur, three components must be present simultaneously



Flammable Ranges

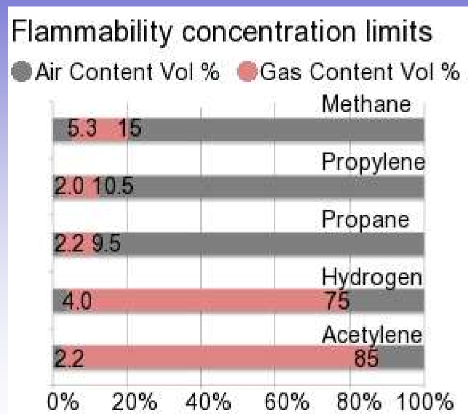
- Between the LEL and UEL in order to burn
- Every chemical has a different LEL

Flammable Ranges

- OSHA prohibits entry into a space which is at or above 10% of the LEL (IDLH)

10% of LEL is IDLH

Flammable Range Examples



Toxic Atmospheres

- **Product stored in a confined space:**
  - ✓**Gases released when cleaning.**
  - ✓**Materials absorbed into walls of confined space.**
  - ✓**Decomposition of materials in the confined space.**
  - ✓**Migration or accidental injection**
- **Work performed in a confined space:**
  - ✓**Welding, cutting, brazing, soldering.**
  - ✓**Painting, scraping, sanding, degreasing.**
  - ✓**Sealing, bonding, melting.**

Permissible Exposure Limit (PEL)

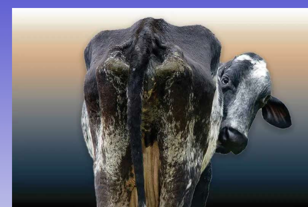
- **Maximum amount or concentration of a chemical that a worker may be exposed to without respiratory protection under OSHA regulations.**
- **Usually as a time weighted average**
- **Found in NIOSH PG, NFPA and on Safety Data Sheets**

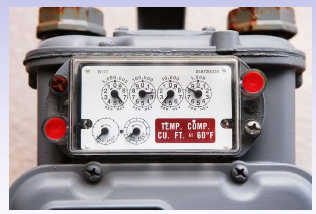
5 Common Toxic Gases found In Confined Spaces

- **Methane**
- **Carbon Monoxide**
- **Carbon Dioxide**
- **Hydrogen Sulfide**
- **Sulfur Dioxide**

Methane

- Odorless, Colorless, Non-Toxic Combustible Gas
- Made by decomposition of organic materials
- Lighter than air
- Explosive Range 5.3%-15%





Carbon Monoxide

- Colorless, odorless, flammable and toxic gas
- Widely encountered in almost every industry
- Has 200-300 times the affinity for Hemoglobin that oxygen has
- Wide flammable range 12.5% – 74%
- Vapor density – 0.968
- Inhalation hazard

Carbon Monoxide

Percent CO in Blood	Typical Symptoms
<10	None
10-20	Slight headache
21-30	Headache, slight increase in respirations, drowsiness
31-40	Headache, impaired judgment, shortness of breath, increasing drowsiness, blurring of vision
41-50	Pounding headache, confusion, marked shortness of breath, marked drowsiness, increasing blurred vision
>51	Unconsciousness, eventual death if victim is not removed from source of CO

Carbon Monoxide

Signs and Symptoms

- Headache
- Nausea
- Shortness of breath
- Irritability, confusion, loss of judgment
- Lethargy and stupor
- Skin color initially pale to cyanotic and then cherry red
- Coma, convulsions and death

Carbon Dioxide

- Colorless, odorless–nonflammable gas
- Vapor density = 1.527
- Displaces oxygen
- Inhalation hazard as an asphyxiant
- Increases heart rate & respirations
- Increases acid level in blood
- PEL - 5,000 PPM
- IDLH - 40,000 PPM

Hydrogen Sulfide (H2S)

- Toxic, colorless, combustible gas
- Rotten egg odor
- Flam Range = 4.5% - 45.5%
- Vapor density = 1.19
- Generated by decomposition of organic materials by bacteria
- Collects in the bloodstream then paralyzes the nerves in the brain that control breathing

Hydrogen Sulfide (H2S)

- May paralyze olfactory
- PEL - 10 PPM
- IDLH - 100 PPM
- 800 ppm = single breath unconsciousness

HYDROGEN SULFIDE (H2S)

- Signs and symptoms of exposure
  - ✓Headache
  - ✓Loss of appetite
  - ✓Dizziness
  - ✓Muscle fatigue and cramps
  - ✓Low blood pressure
  - ✓Loss of consciousness
  - ✓Respiratory paralysis and death

Sulfur Dioxide

- Toxic, colorless, non-flammable gas
- Strong irritating pungent odor
- Vapor density = 2.264
- Soluble in water and irritating to skin, eyes, nose and throat
- Causes burns and pulmonary edema
- PEL = 2 ppm IDLH = 100 ppm

Video 1: ***Key Largo, FL***

Video 2: ***Key Largo, FL***

Physical/Mechanical Hazards

- Engulfment
- Mechanical
- Corrosive
- Radiation
- Falls
- Falling Debris

Purpose of Air Monitoring

- Air monitoring is an essential part of confined space rescue operations
- Prior to entry, all atmospheres should be tested to:
  - Determine the survival profile of the subject
  - Select PPE
  - Determine areas where protection is needed
  - Assess the potential health affects of exposure
  - Determine the need for specific medical monitoring
  - Determine effectiveness of ventilation

Gas Monitoring Instruments

- Single gas monitors vs. Multiple gas monitors

Gas Monitoring Instruments

- To be useful in the field, these instruments should be
  - Portable and Durable
  - Reliable
  - Sensitive and Selective
  - Intrinsically safe
  - Few Cross Interference

4 Gas Monitors

- Most common gas monitor
- Measures
  - Oxygen
  - Carbon Monoxide
  - LEL
  - H2S or other gas

Atmospheric Monitors

- Must be:
  - Used by qualified individuals
  - Must be up to date and calibrated
- Limited value when contaminants are unknown
- A reading of zero should be reported as “no response” rather than “clean”

Gas Monitoring Instruments

- Can be damaged by exposing the sensors to certain products
- Are calibrated to, or have sensors for, certain hazards

Atmospheric Monitors

- Will not be precise when using in atmosphere other than what the instrument has been calibrated to
- Use multiple monitors when available
- When monitoring unknown atmospheres, utilize several different detection systems

Monitoring for Oxygen

- First monitoring priority
- Reads in percent of oxygen
- Most instruments are calibrated for concentrations between 0% - 25%
- 19.5% - 23.5% acceptable range for entry unless respiratory protection is used
- Uses an electrochemical cell

Monitoring for Flammable Atmospheres

- Second monitoring priority
  - Check oxygen level first since oxygen is required to burn the combustible gas
  - Most instruments will not give an accurate reading in atmospheres of less than 10% oxygen
- Accomplished by using an instrument capable of measuring flammable/combustible atmospheres

Monitoring for Flammable Atmospheres

- Readings are relative to the calibrated gas
  - Different gases require a response curve
- On a combustible gas indicator, combustible gases are heated and burned inside the sensor
  - This combustion heats a filament which changes the resistance and causes an imbalance in the Wheatstone Bridge
  - This resistance change is translated into an atmospheric monitoring reading

Video 3: Phoenix, AZ

Monitoring for Toxics

- Third priority for atmospheric monitoring
  - Toxic gas Monitors
    - ✓ Contains an electro chemical sensor designed to give an accurate response to specific gases
    - ✓ Variety of detectors available for different toxic substances

Colormetric Tubes

- Colorimetric detector tubes
  - ✓ Glass tube filled with chemical reagent
  - ✓ Specific volume of air is drawn through the tube
  - ✓ Concentration of the contaminate is determined by observing the length of stain in the reagent
  - ✓ Useful for measuring the concentration of a known gas or vapor gas

Photo Ionization Detector

- **Ionizes a sample of gas with a UV lamp**
- **Works well for many toxics and flammables**
- **Measures in PPM**

Application of Detection Devices

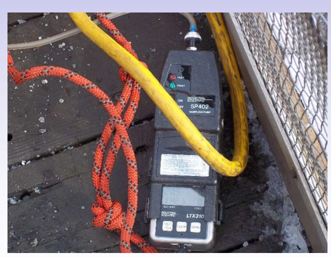
- **No one Atmospheric Monitor can detect all hazards**
- **Monitors must be calibrated, maintained and operated by qualified persons**
- **Factors that directly affect readings**
  - ✓ **Proper equipment operation**
  - ✓ **Proper calibration**
  - ✓ **Equipment detection range**
  - ✓ **Device relative response**
  - ✓ **Response time**
  - ✓ **Inherently safe**
  - ✓ **Nature of the hazard**
  - ✓ **Environmental conditions**

Application of Detection Devices

- Key points on monitor use
  - ✓ Calibrate or zero monitor prior to use
  - ✓ Use the appropriate instrument
  - ✓ Never assume only one hazard
  - ✓ Use one instrument to confirm another
  - ✓ Monitor continuously
  - ✓ Establish action levels
  - ✓ Use conservative judgment in interpreting atmospheric monitor readings

Monitoring Strategies

- General Site Monitoring
- Perimeter Monitoring
- Confined Space Monitoring
- Personal Monitoring



Monitoring Strategies

- General site monitoring
  - ✓All areas around confined space
  - ✓Start upwind
  - ✓Wear PPE for any suspected hazards
  - ✓ Utilize appropriate PPE with respiratory protection in unknown atmospheres

Monitoring Strategies

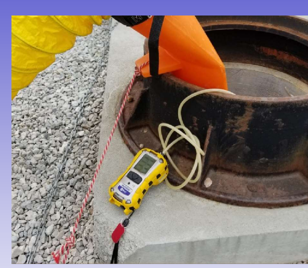
- Perimeter monitoring
  - ✓Area around operation
    - Measures contaminant migration from within space
- Confined space monitoring
  - ✓Starts outside the space
  - ✓Identify source of possible contaminant generation
  - ✓Atmospheric monitoring must be performed prior to entry
  - ✓If possible perform prior to ventilation

Monitoring Strategies

- Sample around opening
- Sample inside opening
  - If possible, perform atmospheric monitoring without opening
  - Use probe or hose through "pick" holes or cracks
  - If necessary to open
    - ✓Test all areas within spaces

Monitoring Strategies

- ✓Vertical spaces
  - Top, bottom, middle
  - Remember response delays caused by hose
    - Typically at least two seconds per foot of hose
- ✓Horizontal spaces
  - Tape hose to probe (pipe, pike pole, etc) and reach into space



Monitoring Strategies

- If entry is necessary to perform atmospheric monitoring it must be conducted as permit required entry
- Personal Monitoring
  - First entrant into confined space
  - Entrant furthest into confined space

Stratification of Atmospheres

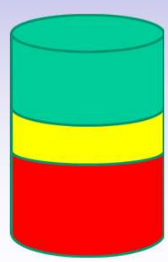
- Atmospheres are made up of a combination of gases
- Each gas has its own weight (vapor density)
- Vapor density
  - ✓ A vapor density of less than one is lighter than air
  - ✓ A vapor density of more than one is heavier than air

Vapor Density

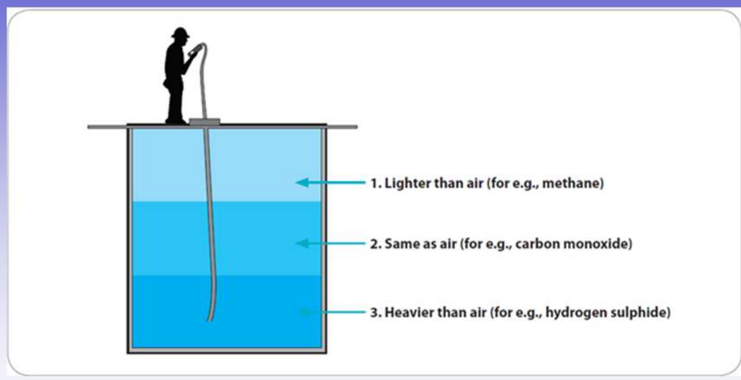
- Lighter than air gases
  - Hydrogen
  - Helium
  - Hydrogen Cyanide
  - Hydrogen Fluoride
  - Methane
  - Ethylene
  - Diborane
  - Illuminating Gases
  - Carbon Monoxide
  - Acetylene
  - Neon
  - Nitrogen
  - Ammonia

Stratification of Atmospheres

- Gases will tend to seek their own level within a space or “Stratify” based upon vapor density
- Relying heavily on a suspected gas to be “lighter” or “heavier” than air to determine its location within a space can be a fatal mistake
  - ✓ Gases can be found at any location within a confined space



Stratification of Atmosphere



Vapor Density of Gases

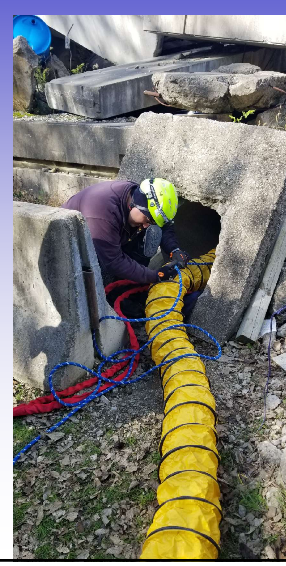
Hydrogen	H_2	0.0695
Methane	CH_4	0.5540
Carbon Monoxide	CO	0.9660
Air		1.0000
Hydrogen Sulfide	H_2S	1.1912
Carbon Dioxide	CO_2	1.5291
Sulfur Dioxide	SO_2	2.2638

Hazards Control

- Once you have identified the hazards, you must control them.

Reasons to Ventilate

- Replaces contaminated air
- Decreases possibility of explosion
- Reduces/Eliminates toxic atmosphere
- Increases survival profile of victim
- Reduces temperature inside space



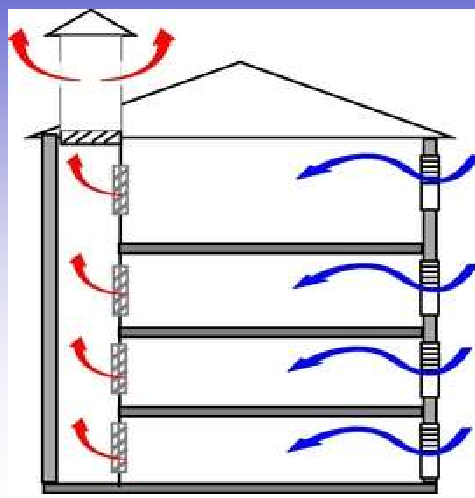
Ventilation

- Types
  - Natural
  - Mechanical
- Determined by the
  - Configuration of the space
  - Type of product you are dealing with
  - The number and type of ventilators you have

Ventilation

- Natural ventilation
  - Slow process
  - Not generally useful in rescue situations
- Mechanical
  - Positive pressure ventilation (supply ventilation)
    - Air forced in diffuses contaminants
    - Increases oxygen in space
    - Can create new hazards by agitating contaminants in the space or by bringing a flammable atmosphere into its explosive range
  - Negative Pressure (exhaust ventilation)
    - Draws contaminates out of the space
    - Can control the direction of the exhaust

Natural Ventilation



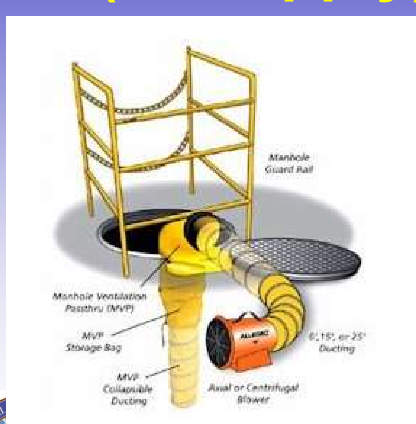
Exhaust Ventilation

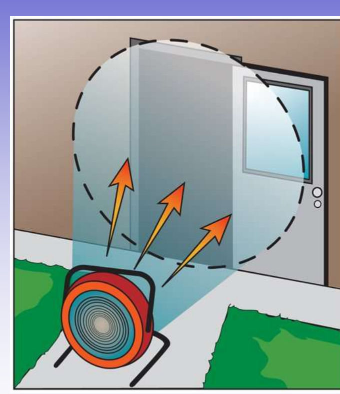
- Draws contaminates out of the space
- Can control the direction of the exhaust
- Can draw more contaminants into the space from other connecting areas
- Can contaminate ventilation equipment
- Use caution where contamination is exhausted
- Combination ventilation
  - One blower to supply air and one to exhaust it
  - Increased efficiency

Local Exhaust

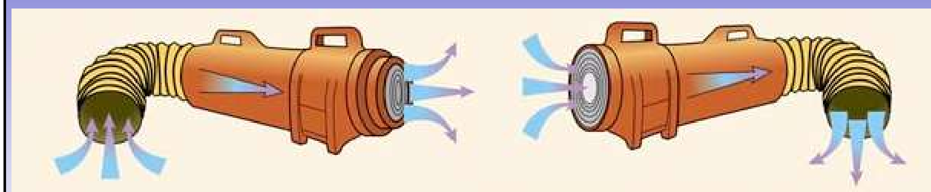
- Ventilation placed close to the source of contamination
- Pulls contaminates out before they spread
- Useful in diffusing flammables from a fixed source

Positive Pressure (or Supply) Ventilation

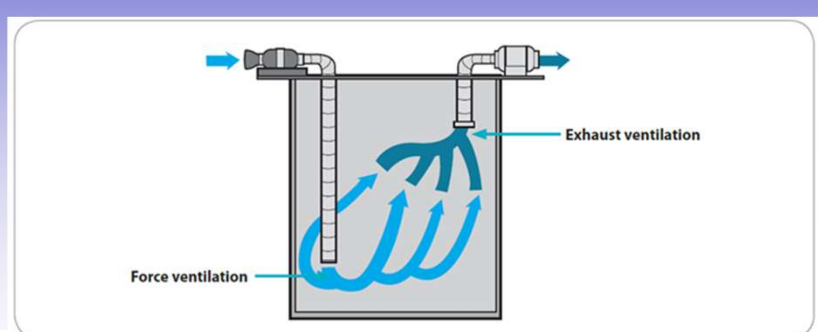




Supply and Exhaust Ventilation



Combination Ventilation



Ventilation Devices

- Fan
- Ductwork
- Saddle
- Elbow

Ventilation Considerations

- Volume of Air to Move
  - Cubic Feet Per Minute (CFM)
  - Height x Width x Depth = Volume
  - Cubic Feet ÷ CFM rating of blower = Minutes per air exchange
  - Each “device” added reduces CFM by about 20%

Specific Ventilation Procedures

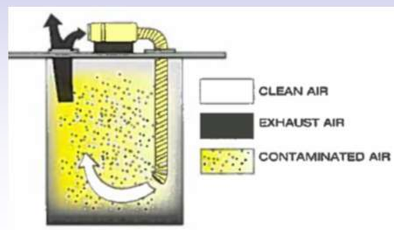
- Important safety considerations when ventilating
  - Secure a second power supply to ensure continuous ventilation should the original power be lost
  - Continually monitor the atmosphere
  - Use "TELLTALE" to monitor air flow

Ventilation Considerations

- Length of Time?
  - Ventilation goal = 7 air exchanges
  - Monitor exhaust air
-

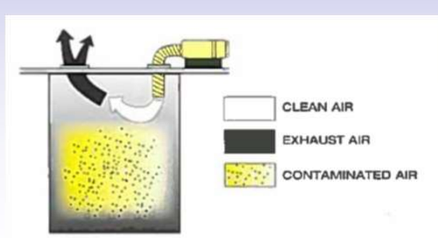
Ventilation Problems

- Recirculation
  - Recirculation of contaminated exhausted air back in to space
  - Keep ventilator intake at least five feet away and upwind from confined space entry portal



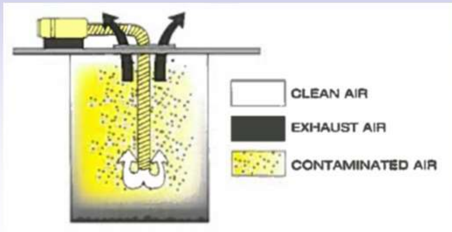
Ventilation Problems

- Short circuiting
  - Air is exhausted prior to ventilating the entire space
  - Extend duct work further into space
  - Use alternate exhaust port



Ventilation Problems

- Chimney effect
  - Caused by duct work hanging vertically in the space
  - Direct duct towards wall or corner of space



Specific Ventilation Procedures

- Important safety considerations when ventilating
  - Fans are compatible with the environment
    - Intrinsically safe
    - Explosion proof
  - Vehicles and generators positioned downwind away from opening
  - Begin ventilation far enough in advance to allow sufficient number of air exchanges
  - Only ventilate with air
    - Never oxygen

Intrinsically Safe

- Class I, II and III
  - ✓Class 1 – Flammable Vapors
  - ✓Class 2 – Combustible Dusts
  - ✓Class 3 – Ignitable Fibers
- Division 1 and 2
  - ✓Div 1 – Generation and/or release likely
  - ✓Div 2 – Generation only from leak in closed system

Explosion Proof

- Sealed to prevent the hazardous atmosphere from reaching the ignition source in the equipment.

Video 4: Scottsdale, AZ

Summary

- Hazmat Team Personnel can add expertise to Confined Space Rescue Incidents
- Joint Operations can be beneficial if Tech Rescue and Hazmat train together and establish joint SOGs