Confined Space
Lesson One
Hazard Control

DOMAIN: COGNITIVE / PSYCHOMOTOR

LEVEL OF LEARNING: COMPREHENSION / APPLICATION

MATERIALS

FIRE ENGINEERING Confined Space Rescue; DELMAR Confined Space Rescue; CMC Confined Space Entry and Rescue; WILEY Confined Space Entry and Emergency Response; NFPA 1006, Standard for Technical Rescuer Professional Qualifications; NFPA 1670, Standard on Operations and Training for Technical Rescue Incidents; NC OSHA A Guide to Safety in Confined Spaces; OSHA 29 CFR 1910.146 "Permit-Required Confined Space"; OSHA 29 CFR 1910.147 "Lockout and Tagout Procedures"; ANSI (American National Standard Institute) standard entitled "Safety Requirements for Confined Spaces" (Z117.1-1989), Laptop computer, multimedia projector, and whiteboard or flipchart, and marking pens.

NFPA 1006, 2008 edition JPRs

7.1.1 Conduct monitoring of the environment
7.2.2 Assess the incident
7.2.3 Control hazards

TERMINAL OBJECTIVE

The Technical Rescuer shall correctly identify, describe, and demonstrate the setup, operation, and function of various hazard control measures and devices used during confined space rescue incidents.

ENABLING OBJECTIVES

OBJECTIVE PAGE

1. The Technical Rescuer shall correctly identify OSHA rules and regulations that pertain to confined space entry.

2. The Technical Rescuer shall correctly identify and describe in writing the features of a permit-required confined space as defined by OSHA 1910.146.

3. The Technical Rescuer shall correctly identify and describe in writing the reasons for deaths in a permit-required confined space.

4. The Technical Rescuer shall correctly identify and describe in writing the hazards of a permit-required confined space.

5. The Technical Rescuer shall correctly identify and describe in writing the classifications of a permit-required confined space.

6. The Technical Rescuer shall correctly identify and describe in writing the necessary steps for atmospheric monitoring of a permit-required confined space.

7. The Technical Rescuer shall correctly identify and describe in writing the entry requirements of a permit-required confined space.

8. The Technical Rescuer shall correctly identify and describe in writing the procedures for ventilating a permit-required confined space.

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MOTIVATION

OSHA has established safety requirements, including a permit system, for entry into those confined spaces which OSHA has identified as posing special dangers for entrants due to their configuration or other features. Section 1910.146 of Title 29 of the Code of Federal Regulations (CFR) will require employers in approximately 225,000 work places to adopt procedures that will enable their personnel to work safely in a variety of what will be called "permit-required confined spaces." It is the employer's responsibility to address properly the risks to which workers may be exposed when entering confined spaces. Once the hazards have been identified, appropriate measures must be taken to protect workers. A National Institute for Occupational Safety and Health (NIOSH) study demonstrates that 59% of those killed in confined space accidents were the would-be rescuer. In one NIOSH study, 23 percent of the confined space deaths were in multiple-victim incidents with as many as five fatalities at two separate accidents. OSHA believes that compliance with the new standard will reduce the number of confined space accidents by 80 - 90 percent.

PRESENTATION

ENABLING OBJECTIVE #1

The Technical Rescuer shall correctly identify OSHA rules and regulations that pertain to confined space entry.

1. Discuss the numerous standards OSHA (Occupational Safety and Health Administration) has written addressing problems encountered in a confined space.
    - a) 1910.252 (d) (e) (f) General Industry Standard.
    - b) 1926.21 (b) (g) ii - found in the Construction Industry Standard.
    - c) 1915.2 Maritime Standards for Shipyard Employment.

d) 1917.2 (e) Maritime Standards for Marine Terminals.

NOTE: A Notice of Proposed Rulemaking was published on June 5, 1989. After more than a decade of study and development, OSHA issued its final rule for permit-required confined spaces. The new standard has a direct affect on the training, information and procedures which rescue personnel will need to work with in responding to confined space incidents. The Final Rule added a new paragraph, 1910.146 to subpart j of 29 CFR (Code of Federal Regulations) Part 1910 which addresses the hazards confronting employees who enter "permit-required confined spaces." The standard provides regulations which employers must apply along with the existing 29 CFR Part 1910 standards to protect all those who must enter or work in these spaces. The new standard was published on January 14, 1993, and took effect throughout General Industry on April 15, 1993.

2. Discuss that ANSI (American National Standard Institute) also has published a standard entitled "Safety Requirements for Confined Spaces" (Z 117.1-1989) which was approved October 5, 1989.

NOTE: An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer and the general public. The American National Standards Institute does not develop standards and will in no circumstances give an interpretation of any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute.

3. Describe how NIOSH (National Institute for Occupational Safety and Health) describes a confined space as belonging to one of three categories (Publication # 80 - 106), Class A, Class B, or Class C.

NOTE: NIOSH is not a regulatory agency as is OSHA. NIOSH, much like the NFPA (National Fire Protection Association), is an agency which makes

recommendations and not regulations. These categories contradict the information contained in 29 CFR 1910.146. When in doubt, one would be prudent to follow the information contained within 29 CFR 1910.146.

4. Discuss the numerous standards NFPA standards which would be applicable during a confined space rescue.
    a) NFPA 1404 "Standard for Fire Service Respiratory Protection Training".
    b) NFPA 1983 "Standard on Life Safety Rope and Equipment for Emergency Services".
    c) NFPA 1500 "Standard for a Fire Department Occupational Safety and Health Program".
    d) NFPA 1521 "Standard for a Fire Department Safety Officer".
    e) NFPA 1932 "Standard on, Use, Maintenance and) Service Testing of In-Service Fire Department Ground Ladders".

Reference: Confined Space Entry and Emergency Response, Unit 2, pages 11-27.

PRESENTATION

ENABLING OBJECTIVE #2

The Technical Rescuer shall correctly identify and describe in writing the features of a permit-required confined space as defined by OSHA 1910.146.

1. Define a permit- required confined space as contained in Title 29 of the Code of Federal Register (CFR), section 1910.146:
    a) Under the definition in 29 CFR 1910.146, a "permit-required confined space" is large enough and so configured that an employee can bodily enter and perform assigned work.
    b) Has limited or restricted means for entry or exit. (Doorways and other portals through which a person can walk are not considered to be limited means for entry or exit.)
    c) Is not designed for continuous human occupancy and has one or more of the following characteristics: contains or has known potential to contain a hazardous atmosphere, contains a

material with the potential for engulfment of an entrant, has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls, or a floor which slopes downward and tapers to a smaller cross-section, or has a known potential to contain a hazardous atmosphere.

2. A hazardous atmosphere means an atmosphere which exposes employees to a risk of death, incapacitation, injury or acute illness from one or more of the following causes:
   a) A flammable gas, vapor or mist in excess of 10 percent of its LEL.
   b) An airborne combustible dust at a concentration that obscures vision at a distance of five feet or less.
   c) An atmospheric oxygen concentration below 19.5 percent or above 23.5 percent.
   d) An atmospheric concentration of any substance for which a PEL could result in employee exposure in excess of its permissible limits.
   e) Any atmospheric condition recognized as IDLH.

3. The term "non permit confined space" means that the space has been freed of the potential for atmospheric hazards.
   a) "Acceptable environmental conditions" means confined space workplace conditions in which uncontrolled hazardous atmospheres are not present.

4. Review the types of confined spaces as defined in the Incident Planning Lesson Plan.
   a) Tanks / vessels.
   b) Silos / elevators.
   c) Storage Bins / hoppers.
   d) Utility Vaults / pits.
   e) Aqueducts / sewers.
   f) Cistern / wells.
   g) Coffer Dams.

Reference: Guide to Safety in Confined Spaces, pages 1-32.
Available at: http://www.cdc.gov/niosh/pdfs/87-113.pdf

PRESENTATION

ENABLING OBJECTIVE #3

The Technical Rescuer shall correctly identify and describe in writing the reasons for deaths in a permit-required confined space.

1. Review the most common mistakes in failing to identify a confined space.
    a) Review with the candidates the information published by NIOSH in its 1986 "Alert" (Reference 16) that indicates that "rescuers" account for approximately sixty percent of all fatalities associated with confined space deaths (this is not to imply that this sixty percent is made up entirely of emergency service personnel, this indicates that poorly trained co-workers constitute an especially important "group at risk").
    b) They trust their senses - they think that if a confined space looks safe, it is safe.
    c) They fail to realize that most hazardous atmospheres are invisible - you cannot see, smell, or taste most toxic gases.
    d) They think they can affect a rescue before they themselves become overcome by the toxic atmosphere.
    e) Compassion - it is human nature to try and rescue someone who is in danger (indeed in some cases, the unsuccessful rescuer dies, while the initial entrant recovers).
    f) The likelihood that good intentions and poor preparation will lead to tragedy has led OSHA to establish criteria for rescue procedures to protect co-workers from accidental injury or death (an unplanned rescue will probably be your last).

2. Review OSHA’s determination, based on its review of accident data, that asphyxiation is the leading cause of death in confined spaces, and that atmospheric hazards cause most confined space asphyxiation fatalities.

Reference: Guide to Safety in Confined Spaces, pages 1-32.
Available at: http://www.cdc.gov/niosh/pdfs/87-113.pdf

PRESENTATION

ENABLING OBJECTIVE #4

The Technical Rescuer shall correctly identify and describe in writing the hazards of a permit-required confined space.

1. Every confined space has certain actual or potential hazards within it. These hazards may be created in a number of different ways and may take a variety forms. Most of the hazards will fall into on of the three major categories: atmospheric, physical, or environmental.

2. Atmospheric hazards within a confined space can be created in a number of different ways and may take different forms. The potential for the existence of an atmosphere hazard makes it critically important that the atmosphere within the space be sampled with properly calibrated instruments prior to entry. These hazards consist of:
   a) Oxygen Deficiency.
   b) Oxygen Enrichment.
   c) Oxygen Displacement.
   d) Flammability.
   e) Toxicity.

3. An "oxygen deficient atmosphere" is defined in 29 CFR 1910.146 as "an atmosphere containing less than 19.5 percent oxygen by volume.
   a) The atmosphere within a confined space is considered oxygen – deficient whenever the percentage of oxygen drops below 19.5%.
   b) Oxygen deficiency can result from biological activity such as in fermentation, fire, other oxidation, or by being displaced by another gas being intentionally or unintentionally introduced into the space.
   c) Ambient air has oxygen content of 21% (20.9%).
   d) When the oxygen level drops below 17%, the first sign of hypoxia is a deterioration of night vision, which is usually not noticeable.

e) Between 14% and 16% physiologic effects are increased breathing volume and accelerated heartbeat, poor muscular coordination, rapid fatigue, and intermittent respiration.
f) Between 6% and 10%, the effects are nausea, vomiting, inability to perform, and unconsciousness.
g) At concentrations less than 6%, there is rapid loss of consciousness, and death in minutes.

4. Discuss the common causes of oxygen deficiency.
   a) Oxidation of metals - scaling and sandblasting operations in a metal tank can expose rust and alter an environment that has been tested as safe.
   b) Combustion - oxygen deficiency can continue long after a fire has been extinguished.
   c) Displacement by inert gases - the original atmosphere may intentionally have been wholly or partly purged using such gases as helium, nitrogen, or carbon dioxide without ventilating the confined space with breathing quality air.
   d) Bacterial action - is a condition that is particularly prevalent in sewage treatment plants, manholes and sewers where sufficient aerobic bacteria are present to consume enough oxygen to create a serious hazard.
   e) Simple asphyxiants – these physiologically inert substances cause asphyxiation by displacing air and creating an oxygen deficiency such as methane is a highly combustible gas that is also asphyxiants.

5. An "oxygen enriched atmosphere" is defined in 29 CFR 1910.146 as "an atmosphere containing more than 23.5 percent oxygen by volume."
   a) ANSI Z 117.1 1989 also defines it as an atmosphere containing more than 23.5 percent oxygen by volume.
   b) Any atmosphere within a confined space that exceeds 23.5 percent oxygen is defined as an oxygen-enriched atmosphere.
   c) This can be created by oxygen leaking into the space or by the space inadvertently being purged with oxygen instead of air or an inert gas.

   d) Too much oxygen greatly increases the fire hazard.

6. Define the term oxygen displacement.
   a) Simple asphyxiants will displace oxygen and may result in an atmosphere unable to support respiration.
   b) The ambient or normal atmosphere is composed of approximately 21% oxygen, 78% nitrogen, and 1% argon with small amount of other various gases.
   c) If 100% nitrogen - a non-toxic, colorless, odorless gas is used to inert or displace oxygen in a confined space. It will cause immediate collapse and death to the worker or rescuer if the confined space is not adequately ventilated before entry is made.
   d) Other examples of simple asphyxiants which have claimed lives in confined space include carbon dioxide, argon, and helium.

7. Define flammable or explosive atmospheres.

8. OSHA defines the term "flammable or explosive atmosphere" as an atmosphere which poses a hazard because flammable gases, vapors or dusts are present at a concentration greater than 10 percent of their lower explosive limit. (29 CFR 1910.146 and ANSI Z 117.1 - 1989 both list 10 percent of the LEL as the point an atmosphere is explosive".)
   a) If the atmosphere within a confined space contains a flammable gas, vapor, or mist in excess of 10% of its lower flammable limit, it is considered hazardous.
   b) This will mostly likely result from residual flammable product remaining in the space.
   c) It can also result from a volatile flammable liquid seeping in from a contaminated aquifer.
   d) A flammable atmosphere does not have to be related to either flammable gases or flammable liquids.
   e) When grain dust or fine dust from woodworking is stirred up and suspended in the air, a very flammable or even explosive atmosphere can be created.

f) The regulations say that the lower flammable limits of airborne combustible grain dust can be approximated by a condition in which the dust obscures vision at a distance of 5 feet or less.

9. In the case of gases or vapors which form flammable mixtures with air or oxygen, there is a minimum concentration of vapor-in air or vapor-in-oxygen below which propagation of flame does not occur on contact with a source of ignition. There is also a maximum proportion of vapor or gas in air above which flame propagation does not occur. These boundary-line mixtures of vapor or gas with air, which if ignited will just propagate flame are known as the "lower flammable limit / lower explosive limit" (LFL / LEL) and "upper flammable limit / upper explosive limit" (UFL / UEL). No attempt is made to differentiate between the terms "flammable" and "explosive" as applied to the lower and upper limits of flammability**.**

10. Review the following key points to consider for flammable gases and vapors.
    a) When a vapor-in-air mixture is below the LEL, we say that it too lean to burn.
    b) When a vapor-in-air mixture is above the UEL, we say that it is too rich to burn.
    c) Vapor-in-air mixtures between the LEL and UEL are said to be within the flammable range.

11. Discuss flammable range and the relationship of LEL by using the following example:
    a) The LEL for natural gas is 5.0%.
    b) A vapor-in-air mixture is 2.5% natural gas and 98% air.
    c) The above mixture would indicate a 50% LEL. (5.0 divided by 2 is equal to 2.5% by volume or 50% of the LEL.)
    d) A vapor-in-air mixture of 1% natural gas and 99% air would indicate a LEL of 20%.

12. Display the following examples of flammable limits. (Percent by volume.)

a)	Methane (CH_4)	5.0% - 15.0%
b)	Hydrogen sulfide (H_2S)	4.0% - 44.0%
c)	Carbon monoxide (CO)	12.5% - 74.0%
d)	Propane	2.1% - 9.5%

e) Toluene 1.2% - 7.1%

13. Define the term toxic atmosphere.
    a) The term 'toxic atmospheres" refers to atmospheres containing gases, vapors or fumes known to have poisonous physiological effects. The toxic effect is independent of the oxygen concentration, which may in fact be greater than 20 percent.
    b) In confided spaces, toxic gases and vapors that might otherwise dissipate harmlessly into the atmosphere are maintained at harmful concentrations.
    c) Whether the source is a liquid residue that is off-gassing, a biological activity such as in a sewer trunk, or an intentionally introduced substance such as a fumigant, rescuers must be careful to not add themselves to the list of victims.
    d) Toxic gases which have been reported to cause death in workers in confined spaces include: carbon monoxide, hydrogen sulfide. Methane, carbon dioxide, hydrogen cyanide, arsine, chlorine, sulfur dioxide, ammonia, phosgene, and oxides of nitrogen.

14. Discuss with the Technical Rescuers the following definitions:
    a) PEL - the permissible exposure limit is the maximum level of a toxic substance to which an individual may be safely exposed.
    b) TWA - the time weighted average is the amount a person can be safely exposed to for 8 hours a day, 40 hours a week.
    c) STEL - the short term exposure limit is defined as a 15 - minute time-weighted average exposure which should not be exceeded at any time during a work day even if the 8 - hour time-weighted average is within the TLV. (Exposures at the STEL should not be repeated more than four times per day and there should be at least 60 minutes between successive exposures at the STEL.)
    d) IDLH - immediately dangerous to life or health means any condition which poses an immediate threat of loss of life; may result in irreversible or immediate health effects; may result in eye

damage; irritation or other conditions which may impair escape from the permit space.

e) TLV- threshold limit values - three categories of threshold limit values are generally indicated.

f) TLV-TWA - threshold limit value-time weighted average - the time-weighted concentration for a normal 8 - hour day and a 40 - hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effects.

g) TLV-STEL -threshold limit value-short term exposure limit - the concentration to which workers can be exposed continuously for a short period of time (15 minutes) without adverse effects.

h) TLV-C - threshold limit value-ceiling the concentration that should not be exceeded during any part of the working exposure. (May also be referred to as IDLH.)

15. List the potential effects of carbon monoxide (CO) exposure.

a) Emergency Overview - Inhaled Carbon Monoxide binds to the blood hemoglobin, greatly reducing the red blood cell's ability to transport oxygen to body tissue. Effects may include headaches, dizziness, convulsions, loss of consciousness and death. Extremely flammable gas.

b)	PEL - OSHA	50 PPM
c)	LC50	1807 PPM (rat)
d)	IDLH	1200 PPM
e)	Odor / Appearance	Odorless; colorless gas
f)	LEL %	12.5
g)	UEL %	74.0
h)	Vapor Density	Same as Air
i)	UN Number	1016
j)	CAS Number	630-08-0

16. List the potential effects of hydrogen sulfide (H2S) exposure.

a) Emergency Overview - Irritating to the eyes, mucous membranes and respiratory system. Inhaled gas reacts with enzymes in the bloodstream and inhibits cellular respiration resulting in pulmonary paralysis, sudden collapse and death. Extremely Flammable.

b)	PEL - OSHA	20 PPM – Ceiling

c) LC50 444 PPM (rat)
d) IDLH 100 PPM
e) Odor / Appearance Colorless; rotten egg odor
f) LEL % 4.0
g) UEL % 44.0
h) Vapor Density 1.21
i) UN Number 1053
j) CAS Number 7783-06-4
k) Continuous inhalation of low concentrations may cause olfactory fatigue or paralysis of the sense of smell. Thus, detection of hydrogen sulfide by its odor is not effective.

17. List the potential effects of methane (CH_4) exposure.
a) Emergency Overview - Simple asphyxiants - maintain oxygen levels above 19.5 %. Extremely Flammable.
b) PEL - OSHA Simple Asphyxiants
c) LC50 N/A
d) IDLH N/A
e) Odor / Appearance Odorless; colorless gas
f) LEL % 5.0
g) UEL % 15.0
h) Vapor Density 0.61
i) UN Number 1971
j) CAS Number 74-82-8
k) Effects of oxygen deficiency resulting from simple asphyxiants may include: rapid breathing, diminished mental alertness, impaired muscular coordination, faulty judgment, depression of all sensations, emotional instability, and fatigue. As asphyxiation progresses, nausea, vomiting, prostration, and loss of consciousness mat result eventually leading to convulsions, coma, and death.

18. List the potential effects of carbon dioxide (CO_2) exposure.
a) Emergency Overview - Oxygen levels below 19.5% may cause asphyxia. Carbon Dioxide exposure can cause nausea and respiratory problems. High concentrations may cause vasodilatation leading to circulatory collapse.
b) PEL - OSHA 5000 PPM
c) LC50 N/A
d) IDLH 40,000 PPM

e) Odor / Appearance — Odorless; colorless gas
f) LEL % — None
g) UEL % — None
h) Vapor Density — 1.53
i) UN Number — 1013
j) CAS Number — 124-38-9

19. List the potential effects of arsine exposure.
    a) Emergency Overview - Arsine inhalation may cause headache, delirium, nausea, vomiting, general malaise, tightness in the chest, and pain in the abdomen and loins. Exposure may destroy red blood cells and can cause widespread organ injury. Highly flammable.
    b) PEL - OSHA — 0.05 PPM
    c) LC50 — 390 mg/m^3 (rat)
    d) IDLH — 3 PPM
    e) Odor/Appearance — Colorless; slight garlic
    f) LEL % — 5.1
    g) UEL % — 78
    h) Vapor Density — 2.67
    i) UN Number — 2188
    j) CAS Number — 7784-42-1

20. List the potential effects of chlorine (CL2) exposure.
    a) Emergency Overview - Corrosive and irritating to the eyes, skin and mucous membranes. Inhalation may result in chemical pneumonitis and pulmonary edema. Nonflammable. It hydrolyzes very rapidly yielding hydrochloric acid. Oxidizer may explode or accelerate combustion if contacting reducing agent.
    b) PEL - OSHA — 1 PPM - Ceiling
    c) LC50 — 293 PPM (rat)
    d) IDLH — 10 PPM
    e) Odor / Appearance — Greenish-yellow
    f) Odor / Appearance — Liquid is amber colored
    g) LEL % — None
    h) UEL % — None
    i) Vapor Density — 2.47
    j) UN Number — 1071
    k) CAS Number — 7782-50-5

21. List the potential effects of sulfur dioxide (SO2) exposure.

a) Emergency Overview - Corrosive to exposed tissues. Inhalations of vapors are irritating to the upper and lower respiratory tract and all mucous membrane. Initial symptoms of exposure include nose and throat irritation, becoming steadily worse, suffocating and painful. The irritation extends to the chest causing a cough reflex, which may be violent and painful and may include discharge of blood or vomiting with eventual collapse. Inhalation of vapors may result in pulmonary edema. Nonflammable. Reacts with water to produce sulfuric acid.

b)	PEL - OSHA	5 PPM
c)	LC50	2520 PPM (rat)
d)	IDLH	100 PPM
e)	Odor / Appearance	Colorless gas; pungent
f)	LEL %	None
g)	UEL %	None
h)	Vapor Density	2.26
i)	UN Number	1079
j)	CAS Number	7446-09-5

22. List the potential effects of ammonia (NH3) exposure.

a) Emergency Overview - Irritating or corrosive to exposed tissue. Inhalation of vapors may result in pulmonary edema. Depending on concentration inhaled, it may cause burning sensations, coughing, wheezing, shortness of breathe, headache, nausea, with eventual collapse. Slightly flammable.

b)	PEL - OSHA	50 PPM
c)	LC50	2000 PPM (rat)
d)	IDLH	300 PPM
e)	Odor / Appearance	Colorless gas; pungent
f)	LEL %	15.0
g)	UEL %	28.0
h)	Vapor Density	0.62
i)	UN Number	1005
j)	CAS Number	7664-41-7

23. List the potential effects of phosgene exposure.

a) Emergency Overview - Corrosive to exposed tissues. Inhalation of vapors may result in pulmonary edema. Nonflammable. Reacts violently and decomposes to toxic compounds, including chlorine, on contact with moisture.

b) PEL - OSHA 0.1 PPM
c) LC50 800 PPM (human)
d) IDLH 2 PPM
e) Odor / Appearance Colorless; sweet odor
f) LEL % None
g) UEL % None
h) Vapor Density 3.41
i) UN Number 1076
j) CAS Number 75-44-5

24. Discuss the relationship of STEL and PEL by using the following example:
    a) An individual is exposed to a level of 70 PPM of carbon monoxide (which does not exceed the STEL) for a period of four hours.
    b) For the next four hours he is not exposed to any carbon monoxide.
    c) The total amount of carbon monoxide this individual has received for this eight hour period of time is 280 PPM.([70 PPM x 4 hrs.] plus [O PPM x 4 hrs.] = 280 PPM)
    d) The TWA for this individual is 35 PPM which does not exceed the PEL. (280 PPM divided by 8 hrs. = 35 PPM).

25. Using a flipchart, list the potential effects of hydrogen sulfide (H_2S) exposure.
    a) 1 0 PPM - PEL for 8 hours.
    b) 15 PPM - STEL for 15 minutes.
    c) 500 - 700 PPM - unconsciousness and death by pulmonary paralysis after a fifteen minute exposure.
    d) Has a distinctive and suffocating odor which causes olfactory fatigue. (Its paralyzing effect on the sense of smell renders victims insensitive to its characteristic rotten egg odor.)

26. Define and discuss vapor density.
    a) The weight of a pure vapor or gas compared with the weight of an equal volume of dry air at the same temperature and pressure. The molecular weight of air is 29. If the vapor density of a gas is less than one, the material is lighter than air and may rise, If the vapor density is greater than one, the material is heavier than air and will collect in low or enclosed areas.

b) An easy way to remember those gases which are lighter than air is the acronym HA HA MICEN, where: H = Hydrogen, A = Anhydrous Ammonia, H = Helium, A = Acetylene, M = Methane, I = Illuminating Gas, C = Carbon Monoxide, E = Ethylene, and N = Nitrogen.

c) This is a significant property for evaluating exposures and where gas and vapor will travel.

27. Review the following examples of vapor density (air = 1, e.g., 0.5 = lighter than air, 1.0 = same weight as air and 1.5 heavier than air).

a)	Methane	0.6
b)	Hydrogen sulfide	1.2
c)	Carbon monoxide	1.0

28. List and define physical hazards generally found in confined spaces.

a) The physical hazards in confined spaces may be created by the lack of structural integrity of the space.

b) They may also be created by hazardous object within the space.

c) Physical hazards include structural instability, debris, and engulfment.

29. Engulfment refers to situations where a confined space entrant is trapped or enveloped, by dry bulk materials, flow able product and atmospheric conditions. The engulfed entrant is in danger of asphyxiation, either through filling of the victim's respiratory system as the engulfing material is inhaled, or through compression of the torso by the engulfing material.

30. List and define environmental hazards generally found in confined spaces.

a) The environmental hazards of confined spaces are those that are created by conditions within the space but not by the physical or structural condition of the space.

b) The environmental hazards can be combined to make rescue slower and more difficult and to heighten the victim’s anxiety and feelings of claustrophobia.

c) Environmental hazards include darkness, moisture, dust, noise, and temperature extremes.

31. Review the following key points to consider for mechanical hazards.

32. OSHA has determined from its review of accident data that accidents have occurred in confined spaces when employers failed to isolate equipment from sources of mechanical or electrical energy.
    a) The correct preventive action is to secure the equipment so that it will not be inadvertently activated while employees are in the confined space.
    b) In a confined space, it may be very hard to separate the employee from the sources of hazardous energy.
    c) The close quarters in which the employee works increases the likelihood of the injury. The activation of electrical or mechanical equipment and the release of material through lines connected to the confined space are major causes of injury.
    d) A lockout/tag out program is required. (See 29 CFR 1910.147, The Control of Hazardous Energy, and 29 CFR 1910.333(b), working on or near Exposed De-energized Parts).
    e) Specific procedures to lockout/tag out specific pieces of equipment are required before entering the space.
    f) It is essential to de-energize and lock out all electrical circuits and physically disconnect mechanical equipment prior to any work in the confined space. All lines must be physically disconnected, blanked off, or isolated using a double block and bleed system.

33. Discuss with the candidates the following key points to consider for limited entry and egress.
    a) Locking Out - electrical sources, preferably at disconnect switches remote from the equipment.
    b) Securing - mechanical moving parts within confined spaces with latches, chains, chocks, blocks, or other devices.
    c) Blanking and Bleeding - pneumatic and hydraulic lines.

d) Disconnecting - belt and chain drives and mechanical linkages on shaft-driven equipment where possible.
e) Confined space configurations can hinder rescuers in obtaining air monitor samples.

34. Explain points of consideration for limited entry and egress.
    a) Restricted entry and exit means physical impediment of the body. (e.g., use of the hands or a contortion of the body to enter into or exit from the confined space)
    b) OSHA has a definition for the term ”entry” in order to indicate exactly when OSHA considers a person to have entered a permit space. Under the definition, entry begins as soon as any part of the body crosses the plane of the permit space’s opening and the entrant is breathing the atmosphere of that permit space.

35. Describe and discuss factors contributing to contamination of confined spaces.
    a) Confined space can become contaminated in a number of ways.
    b) Rescuers need to be aware pf these mechanisms in order to know how to protect themselves and others during the incident.

36. Absorption – would usually result from a concrete underground tank allowing the contaminant to pass from a contaminated aquifer through the tank walls and into the tank.
    a) Most often gasoline or other petroleum products.

37. Adsorption – occurs when the product formerly contained within the vessel clings tenaciously to the tanks interior surfaces after the product has been offloaded.
    a) One example of evidence of adsorption is an empty tank that still has product fumes because of some of the product clinging to the tank walls.

38. Desorption – occurs when a container within a vessel leaks or leaches the contaminant out of its containment and into the confined space where it is housed.

a) This is the reverse of the absorption/adsorption mechanism.

39. Inerting – confined spaces may be contaminated by the intentional introduction of an inert gas such as argon, nitrogen, or carbon dioxide into the space.
    a) This is often done to purge the space of flammable vapors or gases, but in doing so the level of O2 within the space is also reduced below acceptable levels.

40. Inserting – the insertion of a product into a tank can contaminate the tank in terms of its suitability for human occupancy.
    a) Flammable liquids and many other products that are routinely inserted into tanks and other confined spaces render them uninhabitable until the tanks have been emptied, cleaned, and ventilated.
    b) Until contamination has been mitigated, entrants should wear special protective clothing and respiratory protection.

41. Combustion – is a complex sequence of chemical reactions between a fuel and an oxidant accompanied by the production of heat or both heat and light in the form of either a glow or flames.
    a) A fire in a confined space can produce some extremely hazardous conditions.
    b) It will consume all or most of the oxygen.
    c) If the oxygen is depleted and a rescuer opens a hatch before the area has cooled, a back draft could occur.

42. Biological activity - Microbial agents presenting a risk or potential risk to the well-being of humans through inhalation, ingestion, skin absorption, or injection.
    a) Most common form of biological activity is fermentation.
    b) In this process organic matter consumes oxygen and gives off carbon dioxide.
    c) Without ventilation the atmosphere within a fermentation tank or silo is likely to be below 19.5% O2.
    d) Another source of biological contamination in confined spaces is untreated sewage.

l) Raw sewage produces hydrogen sulfide.

43. Chemical reaction – happens when a chemical that is introduced into the vessel reacts with residue from another chemical that was formerly contained within the space.
    a) Unless tanks are properly cleaned between uses, a chemical reaction can occur.
    b) Chemical reactions most often occur by mixing chemical in the liquid form, but mixing incompatible dry chemicals can produce a similar result.

Reference: Confined Space Entry and Rescue, Unit 6, pages 1 - 24.
Reference: Confined Space Entry and Emergency Response, Unit 3, pages 29-53.

PRESENTATION

ENABLING OBJECTIVE #5

The Technical Rescuer shall correctly identify and describe in writing the classifications of a permit-required confined space.

1. Discuss with the National Institute for Occupational Safety and Health (NIOSH Publication # 80 - 106) assigns confined spaces to one of three categories: Class A, Class B, or Class C.

2. Class A - is a confined space that is IDLH that has the following criteria:
    a) An oxygen concentration of less than 16% or greater than 25%.
    b) Combustible gases or vapors in concentrations exceeding 20% of the LEL.

3. Class B - a confined space that has the potential for causing injury and illness if preventive measures are not used, but not IDLH with the following criteria:
    a) An oxygen concentration between 16.1 % and 19.4%.
    b) Combustible gases or vapors in concentrations between 10% - 19% of the LEL.

4. Class C - a confined space in which the potential hazard does not require any special modification of the work procedure with the following criteria:
   a) An oxygen concentration between 19.5% and 21.4%.
   b) Combustible gases or vapors in concentrations less than 1 0% of the LEL.

NOTE: The above information was included only because of its widespread familiarity within North Carolina. As was mentioned earlier in this outline, this information is contradictory to that which is contained in 29 CFR 1910.146. As one can see, the Class B confined space meets the requirements for a "permit required confined space" with regards to the oxygen concentrations and LEL. Again, when in doubt, one would be prudent to follow the information contained within 29 CFR 1910.146.

5. Discuss the classification for entry portals to confined spaces as defined in NFPA 1670.
   a) Entry portals are classified as either vertical or horizontal, round, oval, or square, and either less than or more than 24 inches in size.
   b) Diagonal portal – plane of man-way or portal is at an angle somewhere between perpendicular and parallel to the ground.
   c) Elevated portal – bottom of passageway is 4 feet or higher from the ground level.
   d) Manway or portal – an internal or external opening large enough for a person to pass through.
   e) Rectangular / square portal – a four sided opening with four right angles. The opening size is determined by measuring the shortest side of the opening.
   f) Round / Oval portal – a circular or elliptical opening; also any polygon not having exactly for sides. Opening size is determined by measuring the smallest inside diameter.
   g) Horizontal entry – access passageway is entered traveling parallel to ground level through a vertical portal.
   h) Vertical entry – access passageway is entered traveling perpendicular to ground level through a horizontal portal.

i) CS Type 1 / 1E (elevated): portal size: less than 24”, configuration: round / oval, and accessibility: horizontal entry (vertical portal).
j) CS Type 2 / 2E (elevated): portal size: 24” or larger, configuration: round / oval, and accessibility: horizontal entry (vertical portal).
k) CS Type 3 / 3E (elevated): portal size: less than 24”, configuration: square / rectangle, and accessibility: horizontal entry (vertical portal).
l) CS Type 4 / 4E (elevated): portal size: 24” or larger, configuration: square / rectangle, and accessibility: horizontal entry (vertical portal).
m) CS Type 5 / 5E (elevated): portal size: less than 24”, configuration: round / oval, and accessibility: vertical entry (horizontal portal).
n) CS Type 6 / 6E (elevated): portal size: 24” or larger, configuration: round / oval, and accessibility: vertical entry (horizontal portal).
o) CS Type 7 / 7E (elevated): portal size: less than 24”, configuration: square / rectangle, and accessibility: vertical entry (horizontal portal).
p) CS Type 8 / 8E (elevated): portal size: 24” or larger, configuration: square / rectangle, and accessibility: vertical entry (horizontal portal).
q) CS Type 9 / 9E (elevated): portal size: less than 24”, configuration: round / oval, and accessibility: vertical bottom entry (horizontal portal).
r) CS Type 10 / 10 (elevated): portal size: 24” or larger, configuration: round / oval, and accessibility: vertical bottom entry (horizontal portal).
s) CS Type 11 / 11E (elevated): portal size: less than 24”, configuration: square / rectangle, and accessibility: vertical bottom entry (horizontal portal).
t) CS Type 12 / 12E (elevated): portal size: 24” or larger, configuration: square / rectangle, and accessibility: vertical bottom entry (horizontal portal).
u) Explain the importance of considering the internal configuration; both congested and non-congested.

Reference: NFPA 1670 Standard on Operations and Training to Technical Rescue Incidents, 2004 edition.

PRESENTATION

ENABLING OBJECTIVE #6

The Technical Rescuer shall correctly identify and describe in writing the necessary steps for atmospheric monitoring of a permit-required confined space.

1. The AHJ should develop SOG's and/or Protocols for all monitoring equipment carried by responding apparatus.

2. Discuss the ways to confirm calibration of air monitoring equipment.

3. Explain the cardinal rule for any systematic approach to entering and working in confined spaces is to assume a hazard exists.
    a) Most atmospheric hazards are invisible.
    b) Atmospheric hazards can develop while you are in a confined space.
    c) Testing should be done continuously throughout the work in a confined space.
    d) Conditions may change the atmosphere after the initial test. Humidity and temperature can drastically affect the dispersal of gaseous contaminants within an enclosed space.
    e) There should be an initial testing of atmospheric conditions and subsequent tests after a job has been stopped or after the space has been vacated for a significant period of time.
    f) If testing reveals oxygen deficiency, or the presence of toxic gases or vapors, the space must be ventilated and re-tested before workers enter.
    g) If ventilation is not possible and entry is necessary workers must have appropriate respiratory protection
    h) Further testing should be conducted with ventilation systems turned on to ensure that the contaminants are removed and that the ventilation system is not itself causing a hazardous condition.

4. Explain gases and the characteristics as related to vapor density.

a) It is important to understand that some gases or vapors are heavier than air and will settle to the bottom of a confined space.
b) Some gases are lighter than air and will be found around the top of the confined space.
c) Therefore, it is necessary to test all areas, top, middle, and bottom, of confined space with properly calibrated testing instruments to determine what gases are present.

5. Explain that rescuers should never trust your senses to determine if the air in a confined space is safe and if you cannot see or smell many toxic gases and vapors, nor can you determine the level of oxygen present.

6. When confined spaces are tested, the three hazard classes should be tested for in the following order:
   a) Oxygen deficiency - a combustible gas indicator (CGI) needs an oxygen concentration of 5 - 1 0 percent to operate properly.
   b) Combustibility / flammability.
   c) Toxicity.

7. Point out that testing for one of the possible hazards is not much better than performing no test at all.
   a) A worker may determine that the confined space contains enough oxygen and no toxic contaminants, only to have static electricity create a spark which ignites the combustible gas present.

8. Explain the importance of testing all areas of the confined space.
   a) Heavier-than-air vapors tend to form pockets in ground depressions or low areas of tanks and spaces.
   b) If access to a confined space is from the top, a cursory check near the top may fail to detect a pocket of heavier-than air gas or vapor.
   c) Lighter-than-air contaminants are particularly hazardous when entry must be made from the top of a confined space.
   d) Special attention should be given to any lines, ductwork, vents, or pipes within the space, the restricted air movement results in a non-homogeneous atmosphere.

e) Confined spaces which are deep, have odd shapes, or remote areas may require the entrants to take the sampling equipment into the confined space. This sampling should be done progressively so that personnel are aware of any deteriorating conditions as they move to remote areas.

9. Explain the following considerations for determining acceptable limits for confined space entry.
   a) Whenever testing of the atmosphere indicates that levels of oxygen, flammability or toxicity are not within acceptable limits, entry should be prohibited until appropriate controls are implemented or appropriate personal protective equipment is provided.
   b) There is the possibility that the confined space atmosphere can become unacceptable while the work is in progress. The entry task or even the entry itself may “stir up" contaminants so that the ambient air concentrations may raise and the PEL is exceeded.
   c) If the source of the contaminant cannot be determined, precautions should be adequate to deal with the worst possible condition which the contaminant could present in the confined space.
   d) Explain the importance of considering the internal configuration; both congested and non-congested. As it relates to obtaining air monitoring samples.

10. Discuss and demonstrate the various types of atmospheric testing equipment.

11. Discuss and demonstrate oxygen detection equipment.
   a) Some offer semi-continuous monitoring; others detect and monitor combustibles as well as oxygen deficiency.
   b) Several contaminants, including acid gases and carbon dioxide, seriously shorten the life of the sensor cells in oxygen detection equipment.
   c) They usually have an alarm, both audio and visual, that sound when the oxygen level falls below 19.5%.

d) Many include a remote sensor for probing manholes and tanks.

e) Most units that can measure both combustible gas and oxygen have a builtin pump that draws the sample to the instrument. (oxygen and combustibles are measured simultaneously)

f) Low or high oxygen concentrations can affect flammability readings, so test oxygen levels first.

NOTE: Never use equipment designed for one condition to test for another. Each sensor in a piece of equipment works in a different way and is designed for a specific purpose. Do not use an oxygen sensor to test for flammability or a standard flammability sensor to test for toxic atmospheres. If you lower your instrument in a space, make certain that you can see or hear it's alarm clearly while it is inside the space. One of the biggest mistakes you can make is to ignore or not believe your instruments. If an alarm sounds, you should leave the space immediately and then try to determine what actions might be necessary to make the space safe again before re-entry. Instruments will be preset to alarm at different percents of the LEL and different concentrations of oxygen, be sure you know the particular data supplied by the manufacturer. Make sure you understand the capabilities and limitations of the test equipment. Instruments are only as good as the care and maintenance they receive.

12. Discuss and demonstrate combustible gas indicators (CGI) are portable instruments for quick determination and measurement of combustible gases or vapors.

    a) The unit can sample the immediate environment or, by use of sampling lines and probes, can draw samples from remote areas.

    b) A built-in filter chamber is normally fitted with a cotton filter to prevent dust and moisture from entering the system.

    c) An illuminated indication meter provides a direct reading of gas concentrations from 0 to 100% LEL.

    d) Leaded gasoline vapors can poison detector filaments quickly when such vapors are present, an inhibitor filter should be used to nullify their effect.

e) Even minute traces of compounds containing silicon can rapidly poison the filament so that it will not respond accurately when there is suspicion that such materials are present, the instrument must be checked frequently, at least once after every five tests.

13. Discuss and demonstrate portable combustible gas and oxygen alarms.
    a) The battery-powered pump draws the sampled atmosphere into a manifold, where it diffuses into the sensing heads.
    b) Most are not capable of measuring the percentage of vapors in steam or inert atmospheres because of a lack of oxygen which is necessary to support combustion in the filament chamber.

NOTE: The only way to be sure an instrument is performing properly is to check the calibration. Any instrument used to test confined spaces should be calibrated regularly, and calibration should be checked at the start and finish of each job. Additional checks should be made if there is any possibility that the equipment has been contaminated. The calibration may be checked by introducing into the instrument a known concentration of gas (e.g., pentane) in air. The response may then be compared to the standard response data supplied by the manufacturer.

14. Discuss and demonstrate electronic gas detectors.
    a) They are available in a variety of models with testing for up to around 30 pre-calibrated hazardous gases.
    b) Most test for presence of carbon monoxide, oxygen deficiency, flammability and toxicity.
    c) Have the ability to record events for incident and safety documentation.
    d) Have the ability to download information on compatible computers.
    e) Are intrinsically safe.
    f) Simplistic in their operation, once unit is turned on it will monitor certain factory pre-calibrated hazardous gases. (e.g., carbon monoxide)
    g) Proper maintenance is critical. Detectors should have fully charged batteries, be properly

calibrated by trained technicians according to manufacturer's specifications, and field tested before and after each use.

Reference: Confined Space Entry and Rescue, Unit 5, pages 1 - 18.
Reference: Confined Space Entry and Emergency Response, Unit 4, pages 55-77.

PRESENTATION

ENABLING OBJECTIVE #7

The Technical Rescuer shall correctly identify and describe in writing the entry requirements of a permit-required confined space.

1. Discuss the entry requirements and points of consideration for permit required confined spaces (PRCS).

2. Responsibilities of the employer with regards to the identification of permit spaces.
   a) If an employer finds upon their investigation, that the workplace contains no permit spaces, the proposed standard imposes no further responsibility, except to ensure that any changes which create the potential for a permit space hazard can be detected.
   b) If an employer determines that a permit space is present, then they have additional responsibilities depending upon the potential action of their employees.
   c) The employer could satisfy the standard by permanently shutting off the permit space and ensuring that no one could enter.
   d) Where the workplace contains permit spaces, and where the employer determines that their employees will enter those spaces, the employer would ensure that any work in a permit space is performed in compliance with an appropriately protective entry permit program.

NOTE: In areas where emergency service personnel are subject to state occupational safety and health regulations, the Incident Commander (officer-in-charge)

at the scene of an emergency may be viewed the same as any other employer. If that person fails to make the workplace safe for their employees (emergency service personnel), they too, may be subject to the same penalties of any other employer who allows their employees to work in an unsafe environment. In addition, OSHA has repeatedly cited employers under the general duty clause of the OSHA Act for confined space workplace conditions which the Agency determined violated the basic requirement that employers provide their employees with workplaces free from recognized hazards.

3. Identify and discuss employer requirements for the entry permit program.
    a) Identify and evaluate each hazard of the permit space, including the determination of the severity.
    b) Establish the means, procedures and practices by which the permit spaces can be entered safely.
    c) Establish a written permit system for the proper preparation, issuance and implementation of entry permits.
    d) Post signs near the permit spaces to notify employees what hazards might be present and that only authorized entrants may enter the permit space.
    e) Prevent unauthorized employee entry through such measures as posting barriers as necessary.
    f) Train employees so they can work safely in and around the permit spaces.
    g) Provide, maintain, and ensure the proper use of the equipment necessary for safe entry, including testing, monitoring, communication and personal protective equipment.
    h) Ensure that the procedures and equipment necessary to rescue entrants from permit spaces are implemented and provided.
    i) Ensure that all barriers necessary to protect entrants from external hazards (e.g., vehicles) are provided.
    j) Ensure that an employer provides a host (e.g., contractors, emergency service personnel) who plan to enter a space with all available information on the hazards present.

4. List the components of a permit system required by OSHA for permit-required confined spaces.

5. Discuss why an employer should prepare a permit in a standardized format which identifies all conditions which must be evaluated to ensure safe entry.

NOTE: According to the Notice of Proposed Rulemaking issued by OSHA (June 5, 1989), "OSHA would not require employers to prepare a permit when the personnel entering a space are members of a rescue team summoned in compliance with this standard." This should not imply that an emergency service organization is exempt from "providing their employees with workplaces free from recognized hazards."

6. Point out that employers who intend to authorize entry into a permit space shall include information in the checklist portion of a permit:
   a) The hazards of the permit space.
   b) The measures for isolation of the permit space.
   c) The measures, such as lockout / tag out, equipment and procedures for purging, inerting, ventilating and flushing, used to remove or control potential hazards.
   d) Acceptable environmental conditions which must be maintained during entry.
   e) Testing and monitoring equipment and procedures by which acceptable environmental conditions can be verified.
   f) The rescue and other services that would be summoned in the event of an emergency.
   g) Rescue equipment to be provided on-site, if necessary such as ropes, harnesses and hardware.
   h) The communication procedures and equipment used by authorized entrants to maintain contact.
   i) The personal protective equipment to be used in order to ensure employee safety.

7. Unless the individual who authorizes an entry assumes direct charge of the entry for its duration, they should provide the following information in addition to the above named checklist items.

a) The identity of the permit space.
b) The purpose of the entry.
c) The date of the entry and the authorized duration. A permit may be valid for up to one year, so long as all conditions under which the permit was issued are maintained.
d) A list of the authorized entrants.
e) A list of eligible attendants.
f) A list of individuals eligible to be in charge of the entry.
g) The signature along with the name printed of the individual authorizing the entry, verifying that all actions and conditions necessary for safe entry have been performed.
h) Any special work to be performed (e.g., grinding, sandblasting, welding, etc.) should prominently be noted on the permit or a special permit should be attached.

8. Point out that any properly trained person such as an entry supervisor, who has the authority to sign an entry permit authorizing the entry of others, may enter that space during the term of the permit provided the attendant is informed of that entry.

9. Point out that "Authorized entrants" are those employees authorized to enter a permit required confined space who have received the appropriate training to perform their assigned duties as follows:
   a) Recognition of the signs and symptoms of exposure to a hazard.
   b) Understand the consequences of exposure to a hazard.
   c) Maintain contact with the attendant.
   d) Authorized entrants may rotate duties, serving as attendants if the entry permits.

10. Note the importance of entrants to understand that they must exit the space under any one of three conditions:
    a) When ordered by the attendant.
    b) If an evacuation alarm sounds.
    c) If they perceive that they are in danger.

11. Point out the training requirements and duties of an attendant.

a) The primary duty is to monitor and protect the authorized entrants.
b) An attendant must know the hazards of the confined space.
c) The attendant must continuously maintain an accurate count of entrants in the permitted space.
d) They must remain outside the permitted space until relived by another attendant or everyone is out of the confined space.
e) They must maintain communication with the entrants.
f) If an entrant needs assistance, the attendant must summon rescue or other emergency services.
g) The attendant must take the appropriate action when unauthorized persons approach or enter a permitted confined space.
h) Attendants must meet the same training requirements as the entrants.

NOTE: One of the requirements of 29 CFR 1910.146 is that an attendant must be present on all permit-required confined spaces. OSHA notes that the provisions covering authorized entrants and attendants are very similar. This reflects the Agency's perception that the two positions have complementary responsibilities. It is hoped that this responsibility will not be taken lightly where the lowest paid employee will be placed in this position, due to what appears to be lost productivity from an employee. For the purposes of nomenclature, the term attendant will be used in this outline, when in fact this person would more appropriately be referred to as the Safety Officer within the organizational structure for an emergency service organization.

12. Point out that an attendant is someone who is stationed outside the permit space at all times during entry operations who has received appropriate training in order to perform their assigned duties as follows:
    a) The attendant should continuously maintain an accurate account of all persons in the space in the event of an emergency, the attendant needs to know the number of entrants so that there are neither any entrants needing help left in the space, nor are there any useless search and rescue entries conducted for persons who have already left the space.

b) Be able to recognize potential permit space hazards.
c) Monitor activities both inside and outside the space that would significantly increase the likelihood that a hazard could be detected in time for successful escape or rescue.
d) Assure continuous and effective contact with those in the space by whatever means are furnished. Methods of contact include voice, visual, portable radio, or rope.

Note: A rope signaling system may be employed to maintain contact with entrants who may be in a remote space where no other means of communications are possible. The acronym "OATH" is used to remember the number of pulls on a rope that correspond to the respective commands. “O” means "OK" (one pull), "A" stands for "advancing" (two pulls), "T" is for "take-up slack" (three pulls) and the "H" (four pulls) stands for "HELP."

e) The attendant should be trained in the techniques of properly using emergency equipment to affect a rescue without entering the space such as using a winch to haul entrants out.
f) The attendant should be empowered with the authority both to fend off unauthorized intruders and to order entrants out at will.
g) The attendant should order the entrants to immediately evacuate the confined space should any of the following conditions be present.
h) If they see any condition not allowed on the permit such as hot work, abrasive grinding, sandblasting, solvent usage, or any unauthorized work procedures.
i) If they detect behavioral changes like euphoria (due to oxygen starvation).
j) If they detect situations on the outside of the space that could endanger those on the inside such as a vehicle idling near the ventilation intake.
k) If they detect an uncontrolled hazard such as an exposed, energized circuit or a leaking fluid line in the space.

l) If the attendant is monitoring more than one space, (perhaps two side-by-side), and has to divert attention exclusively to one.
m) If they have to leave their station for any reason.

13. Define and discuss the considerations for entry into non permit confined spaces.
    a) Non-permit confined spaces are those spaces which do not contain, or with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.
    b) When employers determine, based upon documentation, that the permit spaces that they plan to have employees enter are non-permit confined spaces, the employer may authorize entry into a permit space without providing an attendant by complying with the following provisions as applicable.
    c) Authorized entrants who periodically enter non-permit confined spaces on a routine basis to inspect equipment should neither take anything into the permit space nor take any action which could cause a hazard to arise.
    d) In permit spaces with a potential for an atmospheric hazard, the atmosphere should be tested prior to each entry and as the entry proceeds using appropriate monitoring equipment.
    e) Confined spaces may be entered without the need for an entry permit or attendant provided that the space is determined not to be a permit-required confined space or the space can be maintained in a safe condition for entry by mechanical ventilation alone. All spaces shall be permit-required confined spaces until the pre-entry procedures demonstrate otherwise.
    f) When unacceptable conditions have arisen in a permit space, any subsequent entry is made with an attendant stationed outside the permit space.

Reference: Guide to Safety in Confined Spaces, pages 1-32.
Available at: http://www.cdc.gov/niosh/pdfs/87-113.pdf

PRESENTATION

ENABLING OBJECTIVE #8

The Technical Rescuer shall correctly identify and describe in writing the procedures for ventilating a permit-required confined space.

1. Point out the considerations for natural ventilation.
   a) The process of natural ventilation can be driven by, or affected by, different forces.
   b) Natural air currents or wind alone may effect ventilation by forcing good air into a space and forcing bad air out.
   c) Differing densities between contaminated air within a space and uncontaminated air outside the space may cause the bad air to flow out of the space and be replaced with, or diluted by, good air from the outside.
   d) Thermal updrafts caused by solar heating of a container may affect the process.

2. Describe how natural ventilation is done by removing roof and side covers and allowing the natural air currents to remove the gases or vapors.
   a) Due to the unpredictable direction in which the vapors may drift, no work should be done in the area until tests show that the area is free from the hazard.
   b) Natural ventilation is generally insufficient to achieve an adequate exchange between the contaminated air inside the space and fresh air outside the space (particularly true in confined spaces with limited-access openings).

3. Describe how/when steam is used to ventilate a space, it should be introduced through a connection at or near the bottom of the space.
   a) Covers should remain open during the steaming process.
   b) To be effective, the temperature of the atmosphere should be raised to at least 170 degrees Fahrenheit.
   c) Steam ventilation is not considered advisable for large tanks or during cold weather.

d) The steam nozzle should be bonded to the space to prevent static electricity buildup, and all parts of the space should be grounded.

e) Vessels that contained materials that have a potential to build static electricity such as butadiene or carbon disulfide, should not be purged with steam. The condensation might generate a spark that could ignite any combustibles.

f) After a space has been purged with steam or any other inert gas such as nitrogen, the space should be ventilated with fresh air prior to entry.

NOTE: Pure oxygen should NEVER be used to ventilate a confined space, since oxygen concentrations in excess of twenty-one percent may significantly increase the combustibility of other substances in the space. An oxygen enriched atmosphere will cause flammable material, such as clothing and hair, to burn violently when ignited and may cause some "nonflammable" materials to ignite.

4. Point out considerations for mechanical ventilation.
   a) Mechanical ventilation is driven by difference in air pressure between contaminated air within a space and uncontaminated air from outside.
   b) Eductors, fans, or some other types of machinery are required; thus the name mechanical.

NOTE: Any confined space, regardless of its contents should be ventilated to eliminate oxygen deficiency and accumulated combustibles or toxic substances. The space should be sufficiently ventilated so that levels of combustibles do not exceed 10 percent of their lower explosive limit (LEL), toxic substances levels should not exceed their respective threshold limit values (TLV). (Plant Engineering, Volume 36, No. 9, April 29,1982). There are certain sources that would suggest that a space not be ventilated when the flammable range is above the upper explosive limit (UEL), or that we should not positively ventilate a space that contains flammable or toxic atmospheres. The alternative to not ventilating a space that contains a flammable atmosphere that is above the UEL is to risk an uncontrolled dilution of that atmosphere by the movement of personnel into and out of the space to a

point where the mixture is within the flammable range. It is the considered opinion of most rescue tacticians that intentionally trying to keep a mixture "too rich" is an unacceptable risk.

5. Describe how the most effective means of ventilating a confined space is by introducing fresh air near the bottom of the space and discharging it near the top.
   a) Any system of positive ventilation must maintain a constant flow of fresh air through all areas of the confined space.
   b) Tanks or vessels constructed of lightweight metal could collapse during ventilation; therefore air flow should be carefully controlled.
   c) You can positively ventilate a space thirty times more efficiently than you can negatively ventilate one.
   d) Each 90 degree bend in a trunk hose reduces the flow of air by 50%.
   e) As the length of the trunk hose increases, the air movement will decrease due to the friction loss.

6. Describe that when combustible atmospheres are ventilated, the following guidelines should be carefully adhered to.
   a) All equipment used should be intrinsically safe / explosion proof. Even replacing an electrical plug will cause a unit to no longer be considered intrinsically safe.
   b) Any spark source outside the space, such as an electric or combustion motor should be kept away from the discharge vapors.
   c) Adjacent areas may be contaminated as the positive ventilation will result in an expulsion of the flammable atmospheres from the space through any openings.
   d) Any time combustible vapors may be released, ventilation lines and equipment should be grounded to discharge any buildup of static electricity
   e) Ideally, semi continuous monitoring instruments should be set up in the space to ensure that combustibles remain below 10 percent of the LEL.

7. List and discuss the principles of ventilation positive pressure ventilation.

a) Positive pressure ventilation fans (PPV) can be fitted with a plastic shroud that narrows at the opening that can be used to ventilate a manhole type confined space such as sanitary sewers or storm drains.
b) An exhaust fan can be inverted over a manhole type opening to positively ventilate it.

8. Point out the two options that the standard allows for is to either have an in-plant rescue team, or an arrangement in which an outside rescue team will respond to a request for rescue services.

9. Describe how if an employer decides to use an in-plant rescue team, the employer shall ensure that personnel assigned to an in-plant rescue team are provided with and trained to use properly the equipment necessary to perform the assigned rescue functions.
   a) At least once every 12 months, each member of the rescue team must practice making permit space rescues, by means of simulated rescue operations in which they remove dummies, manikins, or actual persons from the actual permit spaces or from representative permit spaces.
   b) Each member of the rescue team must be trained in basic first-aid and CPR. Also, at least one of the members on site during rescue operations must hold current certification in both of these areas.

10. Describe how if the employer chooses to use outside rescue services, the employer shall ensure that the designated rescuers are aware of the hazards that they may confront so they may train and equip themselves accordingly.

Reference: Confined Space Rescue, pages 96-106.

APPLICATION

Create various confined space rescue scenarios. Divide the class into two groups. Develop enough information for your scenario that Group A can ascertain enough information to adequately fill out an entry permit, which is provided, and Group B can begin addressing tactical considerations for the rescue operation. Play the role of a job site foreman. Only give out information that is requested by either group. Continue rotating through the scenarios until the objectives of this lesson have been enforced for the candidates to operate safely at a confined space rescue incident.

SUMMARY

Emergency service personnel who are required to enter confined spaces confront definite risks to health and life. However, if established rules and guidelines for safety are followed, including those regarding respiratory equipment, the risks can be significantly reduced. A confined space rescue can quickly exceed some departments' capacity and capabilities. However, all emergency services can be competently trained to execute a confined space rescue. Students must understand their limitations and those of others while operating in a confined space. If departmental responsibility is accepted and asserted, proper equipment provided and emergency service personnel comprehensively trained many deaths in confined space accidents can be prevented each year. This lesson introduces the student to characteristics specific to confined space rescues.