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Methods & Calculation Required for Ventilation in Confined Spaces

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Abstract

Current standards and guidelines are not enough for the required ventilation in confined space nor do they sufficiently accentuate need for ventilation nor provide guidance on how to ventilate confined spaces based upon area, volume etc. Ventilation is optimistic engineering control that can usually be taken and that will reduce the hazards of adverse atmospheric conditions inside a confined space. Many accidents, exposures, fatalities, injuries, in confined spaces could have been prevented by ventilating the space prior to and during the entry as well as while at work Much information has been written about ventilation systems by various organizations, However with the many variables in confined space work, there is only limited information on confined space ventilation practices. Information should need to progress & increase related to hazards and their preventive controls so as to reduce the likelihood & severity of accidents by means of engineering techniques.

Introduction

Confined Space: it can be any space of enclosed nature where there is a risk of death, serious injury, hazardous substances [or] dangerous conditions

Characteristics:

- poor natural ventilation
- Poor natural lighting
- Likely oxygen enrichment/deficiency
- Likely presence of flammable gases/vapors
- Likely presence of toxic gases/vapors

Fairly easily to identity: Storage tanks, Manholes, Boilers, Furnaces, Sewers, Silos, Hoppers, Vaults, Pipes, Trenches, Tunnels, Ducts, Bins, Pits, Reaction vessels, converted drains etc.

Less obvious but equally dangers: open topped chambers, vats, trenches, combustion chambers, dust work, sump etc.

Classification of confined space hazards:

1. Physical hazards

- Mechanical hazards with machinery & equipment's
- Slip, trip, falls
- Drowning
- Fall from height
- Thermal hazards
- Electrical hazards
- Engulfment hazards
- Hazards passed by welding & cutting
- Noise hazards

2. Atmospheric hazards

- Oxygen deficiency
- Oxygen enrichment
- Presence of flammable substances
- Presence of toxic substances [H_2S, NH_3, CO, Hydrocarbon Vapors, C_6H_6, Vinyl Chloride, Lead, Mercury, Solvents etc.]

Elements to Prevent & Control of Confined Spaces:

1. Hazards Identification [Identify & Access/Real/ Potential Hazards]
2. Risk Evaluation [severity * likelihood, Rank Risk]
3. Risk Control [Eliminate, control methods & procedures]
4. Permit to Work
5. Specialized Equipment's [flame proof, Gas detectors, ventilation equipment's, non-sparking tools, PPE etc.]
6. Employee Designation [specially designated persons, Entrants, Attendants, Supervisors, Rescuers etc.]
7. Testing & Monitoring [Test Atmospheric Conditions, oxygen level, flammable & toxic

gases, noise, radiation, temp, illumination, Ventilation etc.]

8. Out Side Contractors
9. Emergency Procedures [Rescue team, Rescue equipment's etc.]
10. Information & Training

Methods

Purging: It is the first step in adjusting the atmosphere in a confined space to acceptable standards

- flammable mixtures should be less than 10% of the LEL [for nontoxic gases]
- flammable mixtures should be less than 1% of the LEL [for toxic gases]
- Concentrations of toxic contaminants should be below the permissible exposure levels [PEL]
- Purging is accomplished either by displacing the atmosphere in the confined space with inert gas [e, g, nitrogen] water or steam, or by forced air ventilation
- Continuous forced ventilation is often required as part of the operating procedure to maintain the contaminant concentration level as low as possible
- Local exhaust ventilation. LEL could be provided when general or when high local concentrations of contaminants may occur during work activities such as welding and chemical cleaning.

Proper testing and correct interpretations of the test results are very important; for example the air tested and found safe at the top of a tank may not reflect the condition of the air at the bottom.

Type of Mechanical Ventilation

Supplied or forced ventilation: Using blowers to disperse widespread contaminants e.g. during tank cleaning

For forced ventilation: the fresh air should be supplied as near to the site of work as possible.

Exhaust ventilation: Using exhaust hoods to suck out localized sources of contamination e.g. welding

For exhaust ventilation, the exhaust hood should be positioned as close as

Types of Air Moving Devices

Fans-axial or centrifugal

- A fan can be used as a blower or an exhauster depending on whether it is used in a supply system or an exhaust system. (Fig.1)

Pneumatic air mover

- This is a venture tube through which compressed air is used to induce a larger amount of outside air. (Fig.2)
- The air movers can be used for either supply or exhaust ventilation depending on whether suction or discharge end.

Ducting

- Collapsible-plastic tubing – this can only be used at the discharge side of the fan i.e. for supplied [forced] ventilation. (Fig.3)
- Non-collapsible tubing e.g. flexible metal hose – this can be used for either suction side or discharge end of the fan. I.e. for supplied or exhaust ventilation.
- The ducts should be as short as possible and the number of elbows or bends in duct should be kept to a minimum to reduce friction loss.

Ventilation Systems:

Single Units: These introduce outside fresh air to the confined space by blowers (Fig.4)

Tandem Units: These consists of two units which introduce air (by blower) to, and extract air (by extractors) from the space (fig.5)

Effective Ventilation:

For along confined space: Fresh air is blown in at one end of the space and the contaminated air is being exhausted at the other end. If necessary, use of fans (don't connect them) to move air through them (Fig.6)

For Deep Confined Space: The fresh air is blown into the bottom, and the contaminated air is being exhausted near the top (fig.7)

To prevent short circuiting: In a confined space that has only one opening, use a powerful blower to blow clean air into the entire space

To prevent re-circuiting: In a confined space that has only one opening, use duct work to direct fresh air to the inlet of the blower

To remove lighter than air contaminants: From a confined space that has two openings at the top of the space, use a blower and duct work to introduce fresh air to the bottom of the space. Place an exhaust fan at the other opening to draw the contaminated from the top (fig.8)

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To remove heavier than air contaminants: From a confined space that has two openings at the top of the space, use an exhaust fan and duct work to capture the low-lying contaminants. Place a blower at the other opening to provide fresh to the space (fig.9)

Guidelines for Welding In Confined Spaces

Local Exhaust Ventilation

- A portable local exhaust ventilation system should be used to remove welding fumes at the source of generation
- The LEV system either be mechanical fume extractor or a pneumatic air mover
- The minimum air flow rate per welding point is **10 m^3/min**
- The exhaust fumes should be discharged into the open air or passed through an air cleaner if recirculation is required
- Filter respirator should be worn unless the fumes can be effectively removed by LEV

Dilution or Forced Ventilation

- If LEV system is not practicable, a dilution ventilation system should be used
- The minimum dilution air should be 30 m3/min per welder and the dilution air should be supplied as near to the welder as possible
- The air blowers should be located outside the confined space
- There should be adequate venting the dilution air
- Supplied air respirators should be used if LEV is not provided. (The concentration is above PELs)

Guidelines for Painting in Confined Space

- Dilution or forced ventilation should be provided to dilute the flammable vapor to below 10% of its LEL
- The blowers should be located outside the confined space
- Supplied air respirators should be worn
- Dilution or forced ventilation should be provided to dilute the solvent vapors to below their PEL
- The blowers should be located outside the confined space
- The air should be supplied at or near the persons carrying out the work
- There should be adequate opening for venting the dilution air
- The required air flow rate depends on the amount of paint used and the % of solvents in the paint

% of solvents in the paint	Volume (m3)of air required per liters of paint used
30	600
40	800
50	1000
60	1200
70	1400

Figures

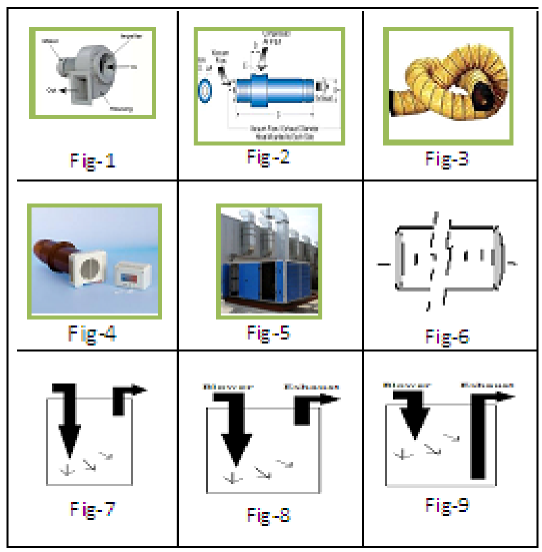
Fig-1 Fig-2 Fig-3
Fig-4 Fig-5 Fig-6
Fig-7 Fig-8 Fig-9

Contaminant Free Conditions:

The maximum fresh air supply is **1.4 m3/ minute per person** if there is no toxic air borne contaminants in the confined space

Contaminant Generation Conditions:

1. Saturation Concentration.
   --Maximum Concentration
2. Static Concentration
   – One Time Release
3. Dynamic Conditions
   --Continuous Release

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Calculations

Saturation Concentration (Maximum Concentration)

Cs = VP/700*1000,000 ppm

Static Concentration (One Time Release)

Static Conditions Ventilation Requirements

Q(l/m)	= V/T*log (Co/C)
Co	= Static Concentration
C	= Concentration after time 't'
V	= Volume of the space

Example: Toluene (Assume)

V	= $18.849*10^3$
t	= 15 min
Co	= 100 ppm
C	= 60 ppm
Q(l/m)	= (18.849*103/15)*log(100/60)
	= 7889.47 lpm or 278.783 cfm

Dynamic Conditions (Continuous Release)

Dynamic Conditions Ventilation Requirements

Q(l/m)	= E(g/min)*24.5*106 / MW*C (ppm)
E	= Rate of Contaminant
MW	= Molecular Weight of Contaminant
C	= Concentration of Contaminant

Example: Xelene (Assume)

E	= 50 g/min
C	= 82 ppm
Q(l/m)	= 50*24.5* 106 / 106*82
	= 140,934 lpm (or) 4974.9 cfm

Conclusion

There are varieties of method for controlling hazards. The best approach is to eliminate them through ventilation. Coming to which is the best way to ventilate, blow in air & exhaust out, sufficient air exchanges and arrangement of ventilation equipments to obtained maximum efficiency are the questions. Many of the confined space accidents occurred because of poor procedures, practices and lack of technical knowledge. The aim of the paper is to increase awareness on OHS by way of engineering control on required ventilation in confined spaces. Those who are working in confined spaces not only must they possess sufficient, specialized professional knowledge and have the required experience, but they must also possess technical tactics in the concern based on engineering concept

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References

1. NTUC Learning Hub, Ministry of Manpower's, Singapore.
2. Complete Confined Space Hand Book by John.F.Rekus.
3. National Electric Code