

Environmental Effects of Equipment-Use During the Rescue of Entrapped Patients.

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Environmental Effects of Equipment-Use during the Rescue of Entrapped Patients

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INTRODUCTION

- Many workers are injured and killed (approximately 90 in the US) each year while working in confined spaces. It is estimated that [3]:
 - 90% of fatalities are due to asphyxiation
 - 60% of the fatalities are the would-be rescuers.
- Confined spaces are small areas with limited entry or restricted exits that are not designed to be continuously occupied [3].
 - Includes areas such as storage tanks, silos and sewers.
 - Hazardous due to the materials being stored, activities carried out and the environment in which they create.
- Technical rescues involve the use of tools and specialized skills to remove trapped victims. Some tools can potentially create hazardous atmospheric environments when being used, putting both the rescuer(s) and victim(s) at greater risk.
- The purpose of the study is to trend and track the rescue practices that can provide a patient with the least amount of exposure to potentially harmful environments and gases while observing the atmospheric conditions rescue tools can create.

CARBON MONOXIDE POISONING

- Carbon monoxide (CO) is a colorless, odorless, poisonous gas produced during incomplete combustion of an organic compound.[4]
 - Common sources of CO include engine fumes and motor vehicle exhaust, smoke from fire
- CO is inhaled, displaces O₂ attached to hemoglobin in the blood stream and forms carboxyhemoglobin (COHb).
- The bond of CO to hemoglobin is 210 times stronger than the bond of O₂ to hemoglobin, making it difficult for the body to eliminate CO from the blood.[2]
- COHb hinders oxygen from being delivered to the rest of the body causing hypoxia and if prolonged, death.[4]

Effects of Carbon Monoxide Exposure [1]

CO in Air (ppm)	CO in Air (%)	Effect and Symptoms	Comments
35	0.0035	No effect	8-hour average permissible exposure limit (PEL)
100	0.01	Slight headache, fatigue, shortness of breath, errors in judgment	-
200	0.02	Headache, fatigue, nausea, dizziness	Short Term Exposure Limit (STEL)
400	0.04	Severe headache, fatigue, nausea, dizziness, confusion, can be life-threatening after 3 hours	-
800	0.08	Headache, confusion, collapse, death if exposure is prolonged	-
1,500	0.15	Headache, dizziness, nausea, convulsions, collapse, death within 1 hour	Levels greater than 1,500 ppm are considered "immediately dangerous to life or health" (IDLH). This is the ceiling limit.
3,000	0.3	Death within 30 minutes	-
6,000	0.6	Death within 10-15 minutes	-
12,000	1.2	Nearly instant death	-

METHODS

Test Area and Setup

- Lehigh County Special Operations technical rescue team provided the tools, ventilation system, confined space and operational personnel for the experiment.
- Atmospheric Detector:**
 - MSA Waterstop Sample Probe with 5 foot tubing was attached to an MSA ALTAIR 5x Multi Gas Detector and placed in the middle of the confined space
 - monitored the lower explosive limit percentage (LEL%), volume concentration of oxygen (O₂ % vol.), and amounts of carbon monoxide (CO), hydrogen sulfide (H₂S), and hydrogen cyanide (HCN) measured in parts per million (ppm).
- Confined Space:**
 - 25in x 137in x 66in space surrounded by 5in. walls of concrete with one open end
- Ventilation System:**
 - Systems International Blower SVB-E8EXP ventilation system
 - Placed above empty space and tubing fitted through closed end
- Tools:**
 - electric powered DEWALT heavy-duty SDS Max demolition hammer
 - gas powered Stihl K-12 Concrete Saw
 - gas powered generator

Fig. 1. Ventilation system (top left), demolition hammer (top right), K-12 (bottom left), confined space (bottom right)



Running Trials

- One tool was operated at a time and was used for a period of 10 minutes.
- Demolition hammer and K-12 were operated on the concrete outside of the confined space by personnel while the generator was left running inside the confined space without personnel.
- The atmospheric conditions were measured and recorded at the start of each run and every 2.5 minute interval.
- After runs, the tools were turned off and the confined space was vented until initial starting atmospheric conditions returned.
- One run for each tool was preformed without ventilation and then repeated with continuous positive pressure ventilation by leaving on the ventilation system.

RESULTS

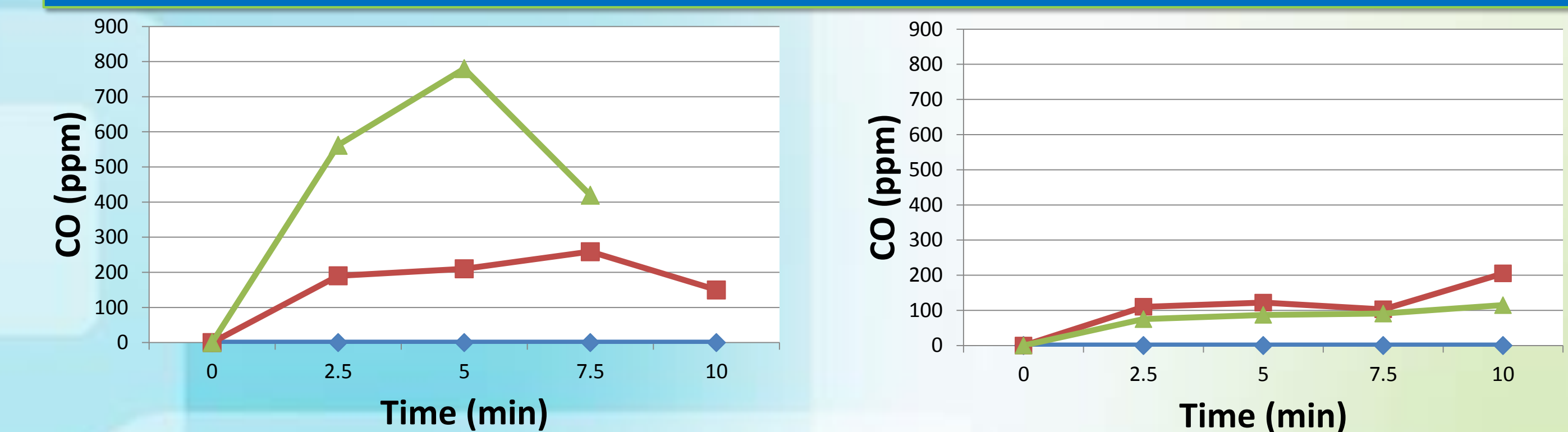


Fig 2. Amount of carbon monoxide detected in confined space during use of a rescue tool. Left shows without ventilation, right shows with positive pressure ventilation. Blue diamonds represent operating the demolition hammer outside the confined space. Red squares represent operating the K-12 outside the confined space. Green triangles represent operating the generator inside the confined space.

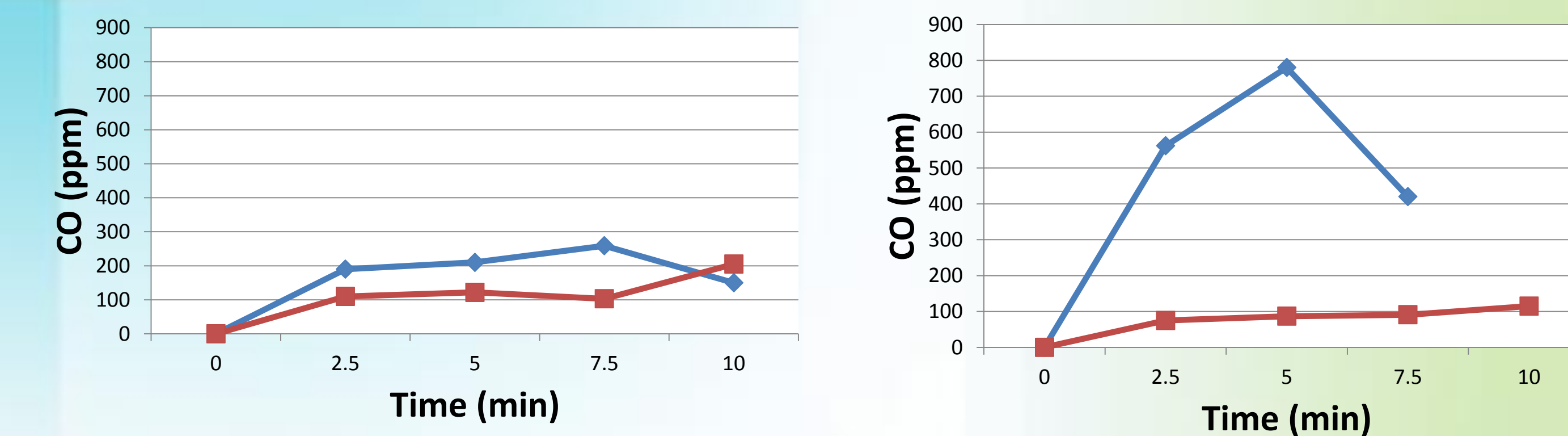


Fig 3. Comparison between the two types of ventilation used. Each line represents the amount of carbon monoxide detected during the use of the K-12 operated outside the confined space (left) and of the generator operated inside of the confined space (right). The blue diamonds represent the trial run without ventilation. The red squares represent the trial run with positive pressure ventilation.

- Values for all other atmospheric components monitored were constant:
LEL% = 0% O₂ % Vol. = 20.8% H₂S = 0 ppm HCN = 0 ppm

Discussion

- Electric powered tool produced no CO accumulation and therefore no hazardous environment.
- Amount of CO in the confined space generally increased both with positive pressure ventilation and no ventilation during the use of tools with combustion engines
- Trend observed: greater increase and amount of CO detected without ventilation compared to positive pressure ventilation.
- Highest amount of CO detected at 780 ppm due to generator operated inside of the confined space at T = 5 min. without ventilation.
 - During exposure, this produces symptoms such as headache, confusion, collapse, and death if exposure is prolonged.
 - Positive pressure ventilation decreased this amount to 87 ppm.

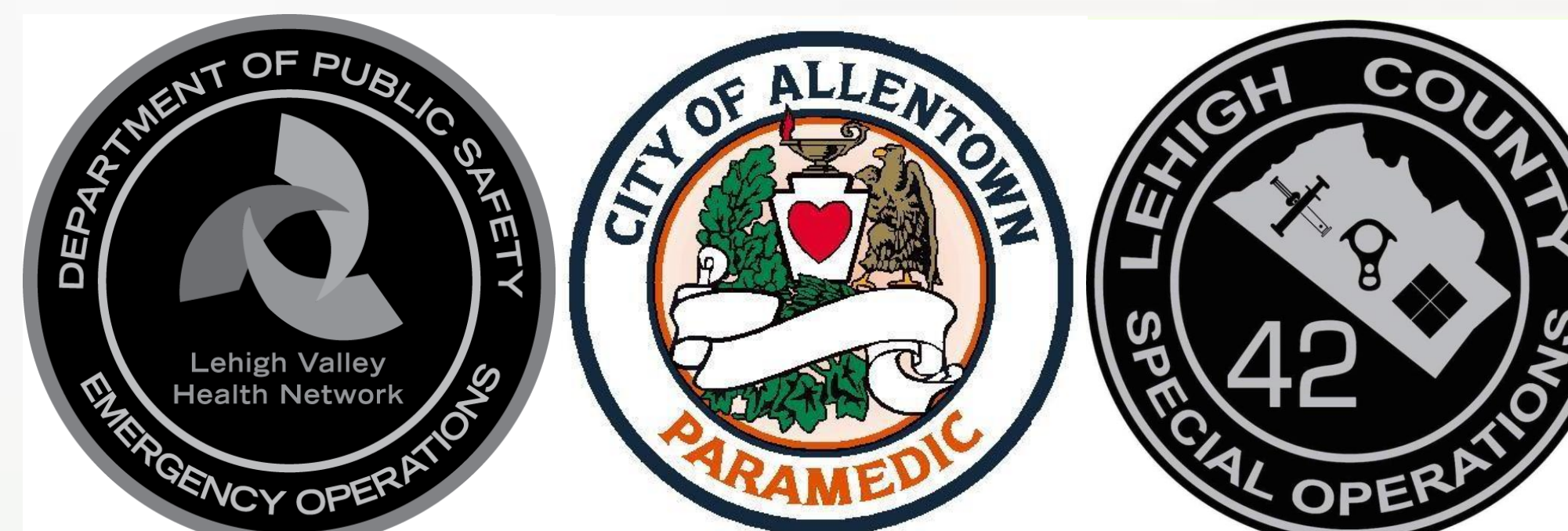
Limitations:

- Statistical analysis unavailable
- Equipment malfunctions
- Limited time period

Conclusion:

- Electrical power tools are the safest means of extraction during a technical rescue of a confined space since it produces no atmospheric hazards.
- If combustion engine tools are used, positive pressure ventilation decreases the amount of hazards produced by the tools, however it may not stop them from building up.

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