Ventilation of Permit-Required Confined Spaces (PRCSs)

Presented by:
Gregg Grubb, CIH
Grubb Industrial Hygiene Services, LLC
Milford, Michigan
Grubb.Gregg@Gmail.com
517-819-5986

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Agenda

The attendee will be able to:

- Identify the difference between using ventilation to control versus eliminate a hazard in a permit space
- Understand the ventilation requirements of Parts 90/490
- Understand the reason why forced air ventilation is better than exhaust air ventilation
- Know how to calculate air changes for a space

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Ventilation of Permit Spaces

May be performed to:

- Control atmospheric hazards…or…
- Eliminate atmosphere hazards

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CONTROL of Atmospheric Hazards

- **Control** of atmospheric hazards through forced air ventilation does not constitute **elimination** of the hazards:
  - Contaminant may continue to evolve in the permit space
  - Ventilation maintains generated air contaminants below acceptable limits
  - Not permitted for reclassified, (c)(7), entries; the hazard must be **eliminated**
- Maintain acceptable air limits for:
  - Alternate, (c)(5), entries: below 50% of PELs and/or 5% of LELs
  - Full permit, (c)(4), entries: as necessary

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ELIMINATION of Atmospheric Hazards

- Performed in permit spaces for the purpose of ensuring that there is no potential to generate further hazardous air contaminant exposures:
  - **Eliminates** the hazardous atmosphere (i.e., dilute/replaces contaminated air such that contaminants concentrations below acceptable limits
  - Would not be used for alternate, (c)(5), entries.
- Acceptable limits for:
  - Reclassified, (c)(7), entries: below PELs and/or 10% of LELs.
  - Full permit, (c)(4), entries: as necessary.

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Permit Space Ventilation Requirements

Full Permit (c)(4) and Reclassified (c)(7) Entries

- Full permit, (c)(4), entries:

  (d)(3)(iv) Purging, inerting, flushing, or ventilating the permit space as necessary to **eliminate or control atmospheric hazards**
- Reclassified, (c)(7), entries:
  - (c)(7)(i) …the permit space **poses no actual or potential atmospheric hazards**…
  - That is, either no atmospheric hazards were present or ventilation was used to eliminate the hazardous atmosphere prior to entry

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Permit Space Ventilation Requirements

Alternate Entry (c)(5)

- Ventilation **CONTROLS the hazardous atmosphere; it does not ELIMINATE** it.
- For alternate, (c)(5), entries:
  - *A. …demonstrate that the **only hazard posed by the permit space is an actual or potential hazardous atmosphere**.*
  - *B. …demonstrate that **continuous forced air ventilation alone is sufficient** to maintain that permit space safe for entry.*
  - *C. …**develop monitoring and inspection data** that supports the demonstrations required by paragraphs* A and B.

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Alternate Entry

(c)(5)(ii)(E) Continuous forced air ventilation shall be used, as follows:

1) *An employee may not enter the space until the forced air ventilation has **eliminated any hazardous atmosphere**;*
2) *The forced air ventilation shall be **so directed as to ventilate the immediate areas where an employee is or will be present** within the space and shall continue until all employees have left the space;*
3) *The air supply for the forced air ventilation **shall be from a clean source** and may not increase the hazards in the space.*

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Forced Air Ventilation

Beware of advertising!

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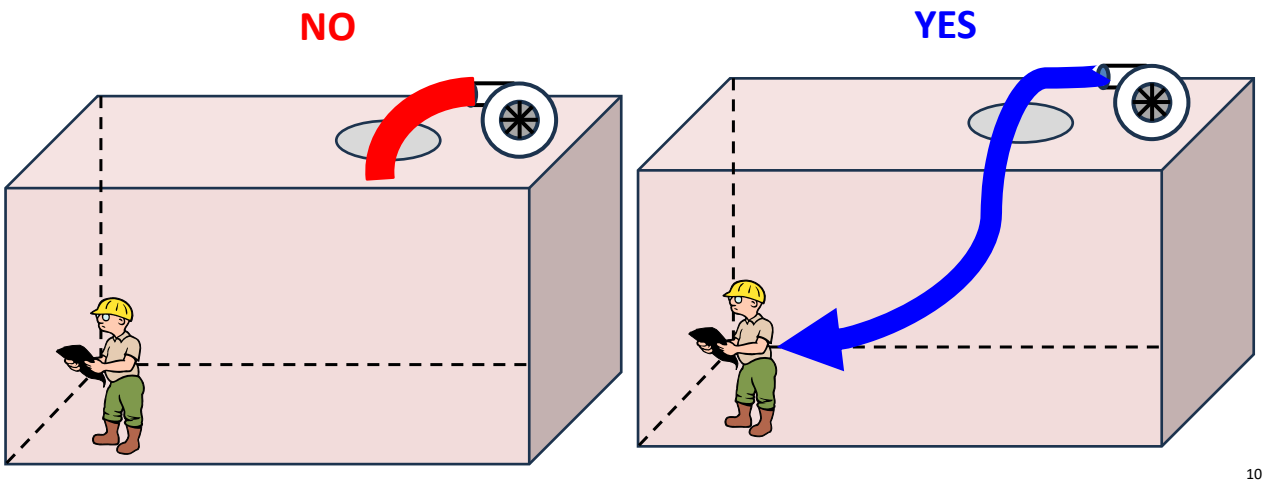
Direct the Supply Air Into the Entrant's Breathing Zone



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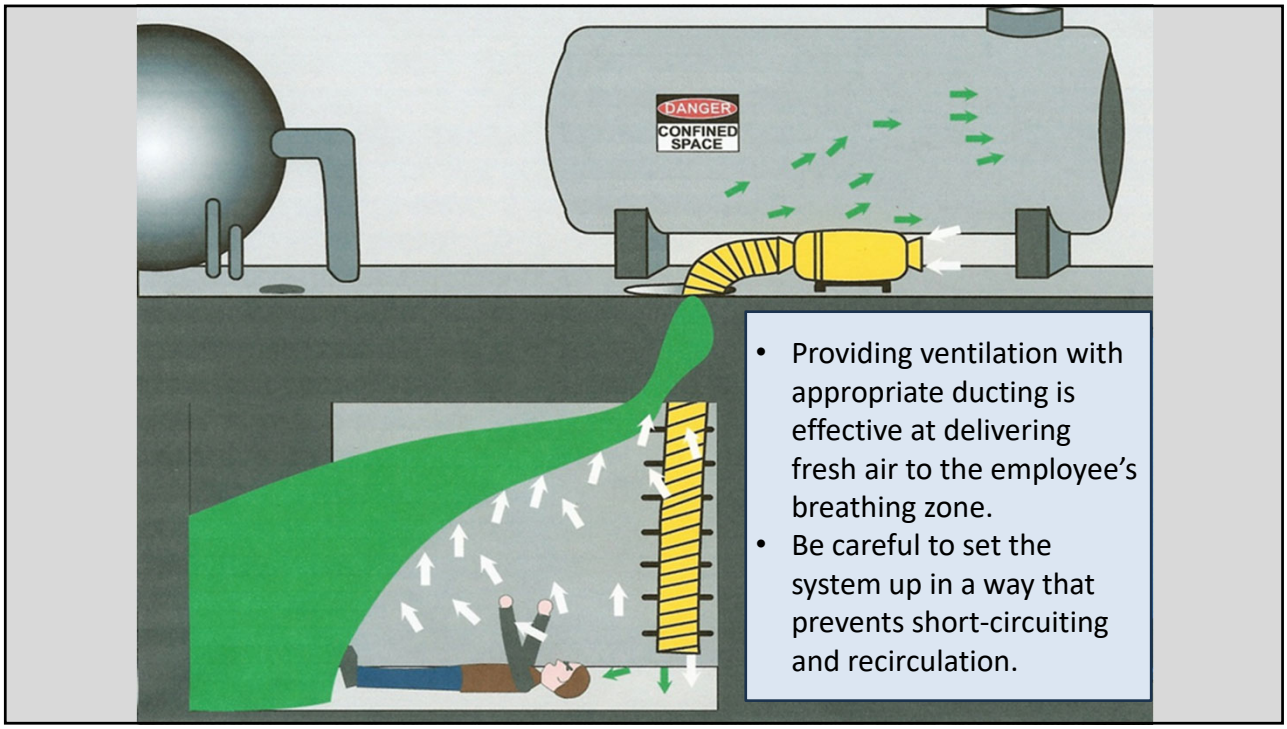
DANGER
CONFINED SPACE
• Providing ventilation with appropriate ducting is effective at delivering fresh air to the employee's breathing zone.
• Be careful to set the system up in a way that prevents short-circuiting and recirculation.

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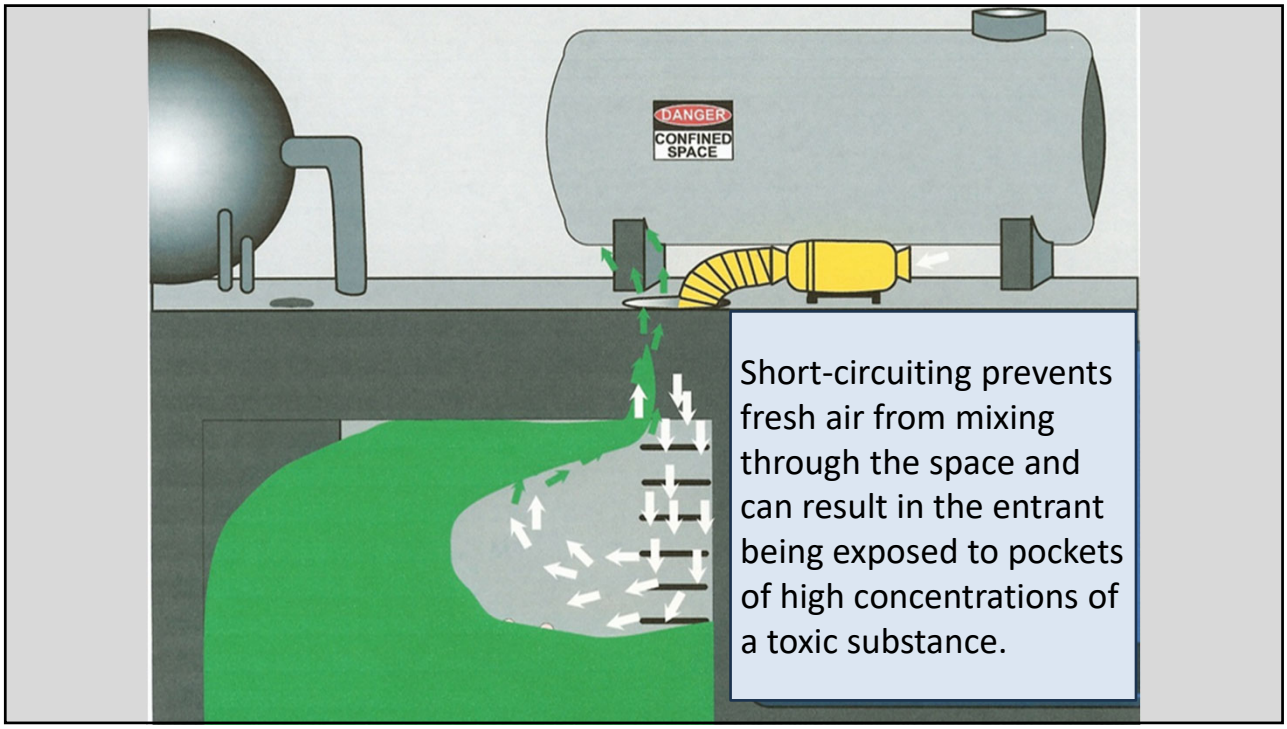
DANGER
CONFINED SPACE
Short-circuiting prevents fresh air from mixing through the space and can result in the entrant being exposed to pockets of high concentrations of a toxic substance.

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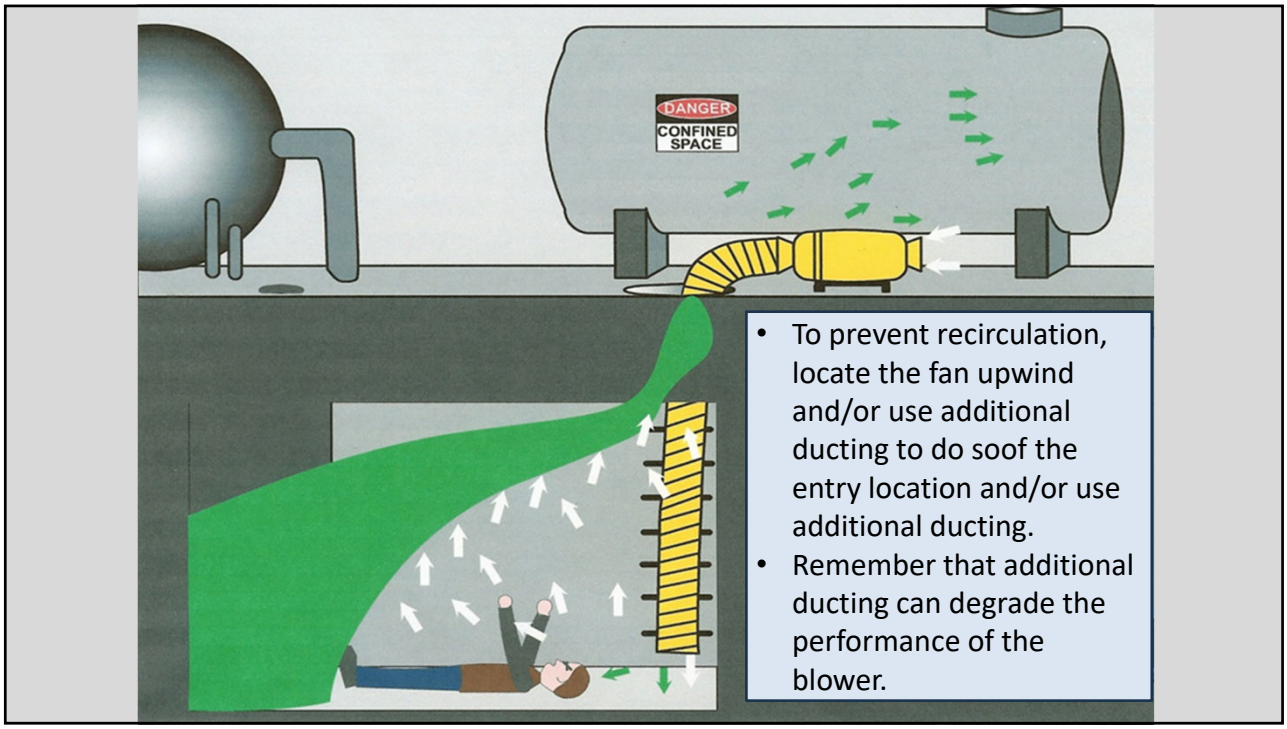
DANGER
CONFINED SPACE
• To prevent recirculation, locate the fan upwind and/or use additional ducting to do soof the entry location and/or use additional ducting.
• Remember that additional ducting can degrade the performance of the blower.

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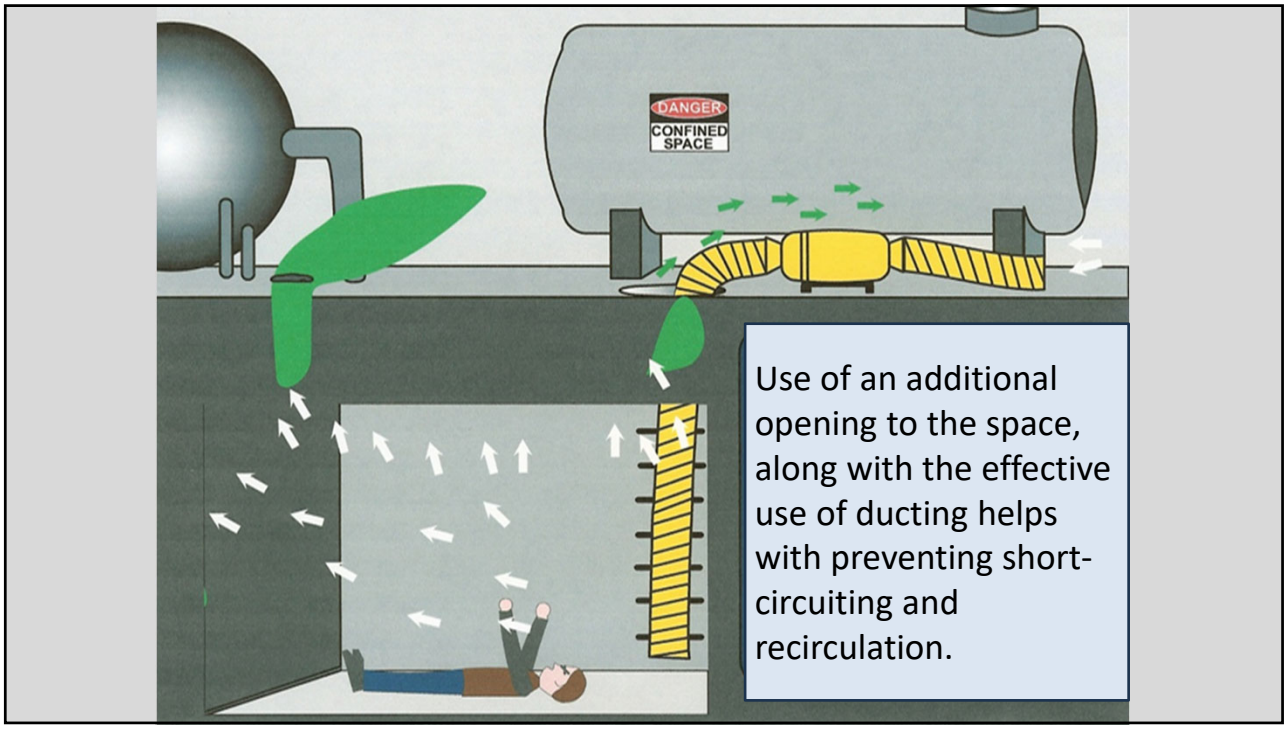
DANGER
CONFINED SPACE
Use of an additional opening to the space, along with the effective use of ducting helps with preventing short-circuiting and recirculation.

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Types of Ventilation Equipment

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Saddle Vents

- Designed to permit entry into manholes while ventilating the space
- Possess a “no-loss” design that does not decrease the effective blower capacity (EBC)

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Ventilation Concerns

- How much is needed?
  - Air flow rate
  - Number of air changes
- Little published information
- Factors impacting ventilation:
  - Size of the space
  - Nature of the hazard(s)
  - Mixing conditions in the space

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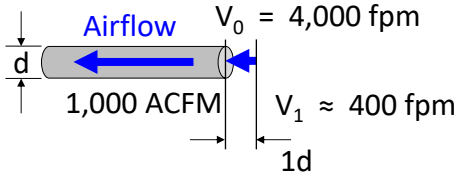
Why Forced Air Ventilation?

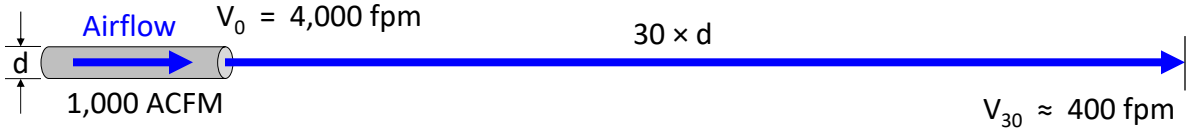
Supply (Forced Air) Versus Exhaust Ventilation

Do you "blow" out or "suck" out your birthday cake candles?

Exhaust Ventilation:



Supply (Forced Air) Ventilation:



d = duct diameter

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Blower Capacity

- "Free Air Delivery": the actual air flow rate provided at the blower outlet with no attachments in actual cubic feet per minute (ACFM)
- "Effective Blower Capacity": the flow rate with a segment of flex duct (e.g., 25 feet in length) attached to the blower
- The blower's capacity to move air is reduced due to the resistance of air moving through attachments connected to the blower caused by:
  - Friction as the air moves through the ducting
  - Dynamic losses associated with changing the direction of the air (e.g., through an elbow)
- Blower example:
  - Free air delivery = 980 ACFM
  - With one, 90-degree elbow and 25' of duct = 722 ACFM
  - With two, 90-degree elbows and 25' of duct = 614 ACFM

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Air Changes

- Strictly a calculated parameter
- Not a complete displacement of contaminated air with fresh, replacement air
- Are a process of continuous dilution by the mixing of contaminated and fresh air
- How well the air mixes in the space plays a large part in the successful ventilation of the space
- Poor blower setup may yield poorer than calculated results

$$N_{changes} = [(60)(Q) / (V_r)]$$

Where:

- $N_{changes}$ = number of air changes in a given space in one hour
- 60 = conversion from minutes to hours
- Q = blower airflow rate , ACFM
- V_r = volume of the permit space

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How Much Ventilation is Enough?

- Study of telecommunication vault performed by Bell Telephone Laboratories, 1970s
- $T = 7.5 [(V_r) / (Q)]$
  - T = purge time, minutes
  - V = volume of the permit space, cubic feet (ft^3)
  - Q = effective blower capacity, cubic feet per minute (cfm)
  - Equation determines the time necessary to provide 7.5 air changes
- Formula was applied to conventional manholes found in the Bell system

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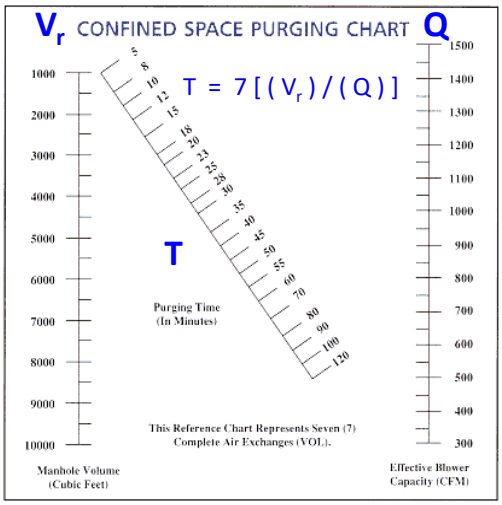
Approximate Determination of Ventilation Time

Use of Nomographs to Determine Air Changes

- Plot a line connecting the space volume with the EBC.
- Where the plotted line crosses the Purge Time line indicates the time to complete 7 air changes (in this case).
- Note that this says nothing about how well the air will mix during those 7 air changes!



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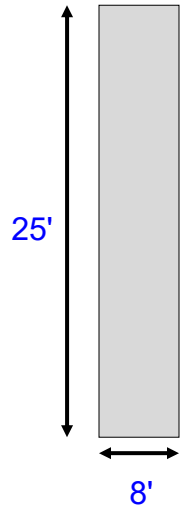
Example Problem

Sewage Lift Station

- Lift station: 45' deep × 8' diameter
- Permit space volume, $V_r = h\pi r^2$, where:
  - V_r = permit space volume, cubic feet (ft^3)
  - h = cylinder height, ft
  - r = cylinder radius, ft
- Lift station volume:

  $V_r = h\pi r^2$

  $= (25\ ft) \times (3.1415) \times (4\ ft)^2 =$ **1,257 ft^3**



- Blower capacity (Q; with 1 elbow and 25 feet of duct): **875 ACFM**
- $N_{changes} = [(60)(875) / (1,257) \approx$ **41.8 air changes per hour**

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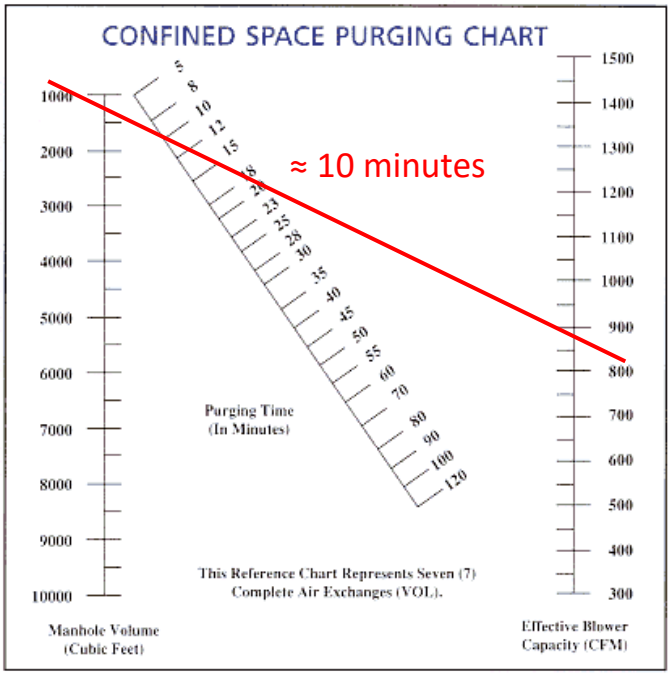
Use of a Nomograph

- Plot a line connecting the space volume with the EBC.
- Where the plotted line crosses the Purge Time line indicates the time to complete 7 air changes.
- Note that this says nothing about how well the air will mix during those 7 air changes!
- Using the example information, 7 air changes will occur in approximately 10 minutes.



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Ventilation in Confined Spaces

- American Industrial Hygiene (AIHA) Journal:
  - Volume 52, Issue 12, 1991
  - Richard Garrison, et al, University of Michigan
  - *Contaminant Reduction by Use of Ventilation in a Confined Space Model – Toxic Concentrations Versus Oxygen Deficiency*
- Conclusion:
  - After about 6 air changes, the concentration was reduced to less than 1% of the initial concentration
  - Supply ventilation is better than exhaust ventilation

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ACGIH®, Industrial Ventilation, A Manual of Recommended Practice for Design, 31st Edition, Chapter 10

- When the generation of the contaminant has ceased (i.e., G = 0) **AND** good mixing of fresh air into the PRCS is developed, the time required to provide seven (7) air changes to the space can be determined by:

$$t_{7AC} = 7\left(\frac{V_r}{Q}\right)$$

- Where generation of the contaminant continues, a combination of local exhaust and dilution ventilation is recommended.
- Again, air monitoring is essential!

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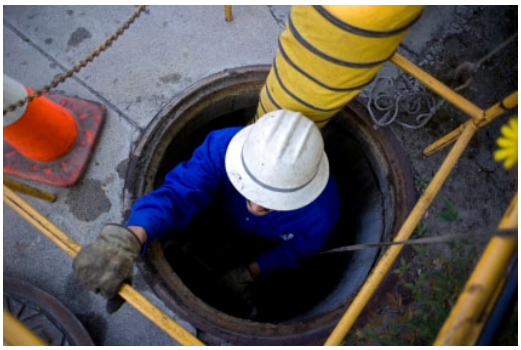
Permit Space Ventilation Summary

- Use forced air – required with all (c)(5), alternate entries
- Provide where employees are or will be working
- Provide continuously for all (c)(5), alternate entries
- It is a primarily means of **Hazard Control** … that may sometimes be used as a means of **Hazard Elimination**



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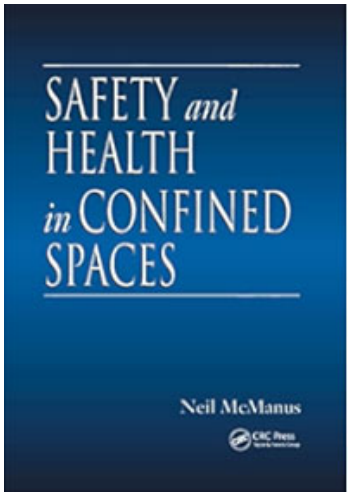
A Useful Resource on Confined Spaces

- *Safety and Health in Confined Spaces*
- Neil McManus
- 1999



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Any questions?

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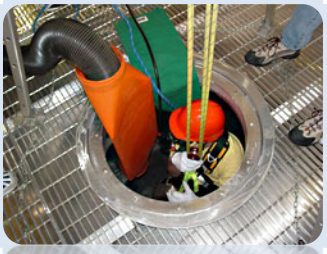

Thank you for attending this presentation!

Gregg Grubb, CIH
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