**Confined Space: Forced Air Ventilation Lesson Plan**

**Terminal Goal:** Prepare operators of department’s confined space mechanical ventilation equipment (blowers, ducts, elbows, and other accessories) to 1) set up and operate equipment to establish both positive pressure and point-of-operation exhaust ventilation, and 2) evaluate whether the forced air system achieves the necessary air to meet change-of-air requirements.

**Educational Content:**

1. Review ventilation requirements under OSHA’s [General Industry Permit-Required Confined Space Standard](https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.146)
	1. *Acceptable entry conditions* means the conditions that must exist in a permit space to allow entry and to ensure that employees involved with a permit-required confined space entry can safely enter into and work within the space.
	2. *Hazardous atmosphere* means an atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from a permit space), injury, or acute illness from one or more of the following causes:
		1. Flammable gas, vapor, or mist in excess of 10 percent of its lower flammable limit (LFL)
		2. Airborne combustible dust at a concentration that meets or exceeds its LFL;

Note: This concentration may be approximated as a condition in which the dust obscures vision at a distance of 5 feet (1.52 m) or less.

* + 1. Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent;
		2. Atmospheric concentration of any substance for which a dose or a permissible exposure limit is published in subpart G, Occupational Health and Environmental Control, or in subpart Z, Toxic and Hazardous Substances, of this part and which could result in employee exposure in excess of its dose or permissible exposure limit;

Note: An atmospheric concentration of any substance that is not capable of causing death, incapacitation, impairment of ability to self-rescue, injury, or acute illness due to its health effects is not covered by this provision.

* + 1. Any other atmospheric condition that is immediately dangerous to life or health.
		Note: For air contaminants for which OSHA has not determined a dose or permissible exposure limit, other sources of information, such as Material Safety Data Sheets that comply with the Hazard Communication Standard, § 1910.1200 of this part, published information, and internal documents can provide guidance in establishing acceptable atmospheric conditions.
	1. 1910.146(c)(5)

*An employer may use the alternate procedures specified in paragraph (c)(5)(ii) of this section for entering a permit space under the conditions set forth in paragraph (c)(5)(i) of this section.*

*An employer whose employees enter a permit space need not comply with paragraphs (d) through (f) and (h) through (k) of this section, provided that the employer can demonstrate that the only hazard posed by the permit space is an actual or potential hazardous atmosphere; and the employer can demonstrate that continuous forced air ventilation alone is sufficient to maintain that permit space safe for entry*

* 1. 1910.146(c)(5)(ii)(E)

*Continuous forced air ventilation shall be used, as follows:*

* *An employee may not enter the space until the forced air ventilation has eliminated any hazardous atmosphere;*
* *The forced air ventilation shall be 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;*
* *The air supply for the forced air ventilation shall be from a clean source and may not increase the hazards in the space.*
	1. 1910.146(d)(4)

*Under the permit space program required of this section, the employer shall provide ventilating equipment needed to obtain acceptable entry conditions*

1. Confined space ventilation math
	1. Calculating confined space volume
		1. Operators of ventilation equipment should be able to use formulas for the volume of rectangles nd cylinders
		2. This can be omitted if the volume of all confined spaces has been calculated by the department and is available to ventilation equipment operators
	2. Calculating total air volume per hour using department ventilation equipment and different set-ups using available accessories such as elbows, manhole hangers, etc.
	3. Calculating time needed to achieve pre-entry air purge of 5 air changes
		1. OSHA does not specify a number of air changes before a confined space entry. It refers to air testing that meets Acceptable Entry Conditions
		2. ANSI suggests 5 air changes before a confined space entry
	4. Calculating minimum air flow needed per minute to achieve 20 air changes / hour.
		1. OSHA does not specify a rate of continuous air flow or number of air changes per minute.
		2. ANSI recommends 20 air changes per hour.
		3. Your agency may specify their best practice.
2. Specifications & capacities of department ventilation equipment
	1. Ventilation fans (blowers); air flow capabilities and electrical needs
		1. Ventilation fan #1: Make \_\_\_\_\_\_\_\_\_\_\_\_\_\_ Model: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ CFM rating: \_\_\_\_\_\_\_\_
		2. Ventilation fan #1: Make \_\_\_\_\_\_\_\_\_\_\_\_\_\_ Model: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ CFM rating: \_\_\_\_\_\_\_\_
	2. Ventilation ducts, elbows and other accessories
		1. Insert each accessory
3. Positive-pressure forced air ventilation and negative-pressure exhaust ventilation
	1. Definitions

Positive pressure forced air ventilation is a system that forcibly supplies clean, filtered air into a building, creating a higher internal air pressure that pushes stale, moist, or contaminated air out through natural leaks and openings.

Negative pressure general exhaust ventilation uses fans to pull more air out of a space than is supplied to it, creating a lower air pressure inside than outside. This pressure difference causes outside air to flow into the room through intended openings.

Local exhaust ventilation (LEV) is a system designed to remove airborne contaminants like dust, fumes, and vapors at their source before they spread into the workplace.

* 1. Set-up, advantages and limitations of each

Positive pressure forced air ventilation

Positive pressure ventilation (PPV) provides crucial safety benefits in confined spaces by rapidly clearing hazardous air, improving visibility, and creating a controlled environment. It pushes fresh air into a space, forcing stagnant, hot, or contaminated air and smoke out, which enhances safety for workers and rescue personnel and speeds up operations by making conditions more breathable and visible. This method is effective in quickly ventilating microenvironments like tanks, pipelines, and tunnels, replacing the hostile atmosphere with fresh, cool air. The mechanically created positive pressure prevents outside air from entering through other openings, which is crucial in controlling air quality

Negative pressure general exhaust ventilation

Negative pressure general exhaust ventilation in confined spaces prevents contaminants like hazardous gases or dust from spreading by drawing contaminated air out of the space, filtering it, and exhausting it outdoors. This creates a controlled inflow of fresh air, effectively containing hazards and protecting workers and nearby areas by ensuring a constant inward flow of clean air into the contaminated zone.  The primary benefit is the prevention of airborne contaminants (fumes, dust, pathogens, gases) from escaping the confined space and spreading to adjacent areas.

Local Exhaust Ventilation



Local Exhaust Ventilation offers crucial benefits in confined spaces by capturing and removing hazardous airborne contaminants at their source, thereby protecting workers from respiratory illnesses, [heat stress](https://www.google.com/search?sca_esv=b874bfd7680df073&cs=0&q=heat+stress&sa=X&ved=2ahUKEwjLr6Cs66-PAxXUN2IAHbtLFYIQxccNegQIBBAB&mstk=AUtExfCHqoEjwTDKan7Nb1TeVojYytP5WGWhM3CgVV6ya7NnGY295PCMcHOh2_m77KhDSRvXS3lB2tYlRXbOEJ08F9MZ9iqnLOY7nZGDf1fiwDadGrzGn3TWTNFS2Iqa9lNTB40&csui=3), and fire/explosion risks. Key advantages include reduced worker exposure to toxins, compliance with health and safety regulations, improved air quality, higher productivity due to a better work environment, and energy savings compared to general ventilation.

1. Skill demonstration:
	1. Set up a typical ventilation operation for a vertical (below grade) confined space entry
	2. Set up a typical ventilation operation for a horizontal (tank) confined space entry

**Training resources**:

Equipment Owners’ Manuals

Many equipment manufacturers have YouTube training videos

 Allegro <https://www.youtube.com/watch?v=FOpoARz3k1I>

 Ecko <https://www.youtube.com/watch?v=HRVWON1TyNE>

General confined space training YouTube training videos

 Rescue Methods: Confined Space Ventilation series <https://www.youtube.com/watch?v=kCdKBV_myvU>

 Hurco Technologies <https://www.youtube.com/watch?v=dzcp5aoWCzU>

**Math for Confined Space Ventilation**

**Calculating the volume of a confined space**

To figure out the volume of a confined space, think of the space as one or more rectangles and one or more cylinders. Calculate the volume each rectangle and each cylinder in cubic feet and add them together to get the total volume in the confined space.

Volume of cube = length x width x height

 Volume of cylinder = π (approx. value is 3) x radius2 x height (*Radius is ½ the diameter of the cylinder*)

Example:

What is the volume of the confined space vault pictured below?



Volume of space = 30 ft. x 20bft. x 10 ft. = 6,000 cubic feet (ft3)

Volume of entrance = 3 x 5 ft. x 5 ft. x 20 ft = 1,500 ft3

Total volume = 6,000 ft3 + 1.500 ft3 = 7,500 ft3

**Calculating the time to achieve the recommended pre-entry purge of 5 air changes**

To calculate the minimum time it will take to change the air in a confined space 5 times before the first Entrant enters the space, multiply the space’s total volume by 5 and divide by the air flow at the end of the forced air positive ventilation system.

Time in minutes = Volume in ft3 x 5 / air flow in ft3 / min. (cfm)

Example:

If your ventilation fan’s owners manual gives the air flow at the end of the integral 10 ft duct with a single 90 bend as 1,500 cfm, how long would it take to change the air in the above space 5 times?

Time = (7,500 ft3 x 5) / 1,500 cfm = 25 minutes

**Calculating minimum air flow to achieve the recommended continuous 20 air changes per hour**

To calculate CFM for a confined space, first determine the space's volume in cubic feet and the required number of air changes per hour (ACH) based on regulatory requirements.

MinimumCFM = (Volume of Space in cubic feet x Air Changes per Hour) / 60 (minutes in an hour)

Example:

What is the minimum air flow needed to maintain 20 air changes per hour in the above confined space?

Minimum CFM = (7,500 ft3 x 20) / 60 = 22,500 cfm

This calculation gives you the minimum CFM required for the space, but it's always recommended to select a blower with a higher CFM to provide a safety margin.