KEEP YOUR WORKERS SAFE & HEALTHY – A GUIDE TO INDUSTRIAL VENTILATION

Concerned about worker safety and air quality in your facility? Discover the power of ventilation.

Industrial ventilation aims to control heat and airborne pollutants. This 6-hour course provides you with the skills needed to establish safe, healthy, and efficient work environments across various industrial settings. It covers dilution ventilation technique, which regulate temperature and maintain air quality by introducing fresh air. Additionally, it addresses the local exhaust ventilation (LEV) technique to eliminate contaminants at the source.

Embedded within the course are essential metrics, practical tips, and handy rules of thumb to help you make well-informed decisions.

Let's get started with essential metrics and rules of thumb.

DILUTION VENTILATION SYSTEMS

	Dilution Ventilation (DV)	***Rules of Thumb***
👍	Principle of DV	***Fresh air in = Hot & contaminated air out*** *The effectiveness depends on the volume of outside air, mixing with room air and air movement.*
👍	Design modes	*Can be designed in any of the three modes:* *a. Supply mode: Fresh air forced into workspace using fans. Dilutes contaminants, lowering concentration.* *b. Exhaust mode: Contaminated air extracted using exhaust fans. Creates slight negative pressure, replaced by fresh air.* *c. Combined mode: Combines supply and exhaust ventilation.*
👍	Contamination control criteria	***Dilute & remove:*** *Fresh air + exhaust clear pollutants and heat, keeping them below safe limits (PEL, TLV, LEL).* *a. PEL: Permissible exposure limits defined by OSHA enforces an 8-hour exposure limit.*

	Dilution Ventilation (DV)	***Rules of Thumb***
		b. TLV: Threshold limit value by ACGIH, prescribes safe concentrations of various contaminants in workspace. *c. LEL: Lower explosive limit (LEL) is the minimum ignitable concentration; target alarms below 10% and shut down below 25%.*
	Airflow rate for heat dissipation	*Calculate Airflow (CFM) ventilation needs based on heat load (BTU/h) and acceptable temperature rise (ΔT):* $CFM = \frac{BTU/h}{1.08\ x\ \Delta T\ (°F)}$
	Air changes per hour (ACH)	*Number of times the room air is replaced with completely new air in an hour. An air change rate of 6 means that a room's entire volume of air is replaced six times each hour.*
	Calculating ACH	*Calculate Airflow (CFM) into the space based on ACH and the volume of space (V in ft^3):* $CFM = \frac{ACH\ x\ V\ (ft^3)}{60}$
	Airflow rates for contaminants control	*Determine ventilation needs through air changes per hour (ACH) based on contaminant type and concentration.* *Air changes for Contaminant Control:* *a. Low toxicity, high TLV (> 100 ppm+): 4 - 6 ACH* *b. Moderate toxicity, moderate TLV (10-100 ppm): 6 - 8 ACH* *c. High toxicity, low TLV (<10 ppm): 8 - 12 ACH* *d. Flammable gases/vapors (LEL concern): Typically, >12 ACH*
	Applications	*Ideal for large areas with widespread contaminant dispersion.*

LOCAL EXHAUST VENTILATION (LEV)

	Local Exhaust Ventilation (LEV)	***Rules of Thumb***
	Principle of LEV	*Capture contaminants at the source before they spread.*
	Estimating airflow rates	*Calculate airflow rates based on contaminant type and concentration or use ACH for effective contamination control.*
	Capture velocity	*Maintain a minimum of 100 feet per minute (fpm) capture velocity at hood opening, but heavier contaminants may need 200+ fpm.*
	Applications	*Ideal for capturing welding fumes, vapors, dust, or hazardous contaminants generated by machinery/process equipment.*

COMPARISON OF LEV Vs DILUTION VENTILATION

	Features	***LEV (Local Exhaust Ventilation)***	***Dilution Ventilation***
	Target	*Contaminants at the source.*	*Overall air quality of the entire space.*
	Capture Method	*Hoods, enclosures positioned close to the emission point.*	*Strategically placed supply and exhaust fans to mix and remove contaminated air.*
	Airflow	*High velocity, low volume.*	*Lower velocity, higher volume.*
	Efficiency	*More efficient in capturing concentrated contaminants.*	*Less efficient for strong contaminants, but good for general air quality.*
	Energy Consumption	*Lower energy consumption due to lower airflow requirements.*	*Higher energy consumption due to larger volume of air movement.*
	Applications	*Welding fumes, soldering, grinding dust, spray painting booths.*	*Paint booths (general), chemical storage areas, warehouses.*
	Suitability	*Ideal for potent contaminants or when worker exposure*	*Ideal for moderate contaminants or large spaces requiring overall*

	Features	*LEV (Local Exhaust Ventilation)*	*Dilution Ventilation*
		needs to be minimized.	*air quality improvement.*
	Cost	*Generally higher initial cost due to hoods, ducts, and fans.*	*Generally lower initial cost for fans, but ongoing energy costs might be higher.*

FAN SELECTION GUIDELINES

	Type of Fans	***Rules of Thumb***
	Fan selection	*Use axial fans for low-pressure systems and centrifugal fans for higher pressure requirements.*
	Propeller/axial fans	*Mostly used in dilution ventilation system.*
	Centrifugal fans	*Generally used in local exhaust ventilation (LEV).*
	Radial fans	*Radial centrifugal fans for heavy dust exhaust, though less efficient and noisier.*
	Forward curved	*Forward-inclined centrifugal fans for moderate resistance.*
	Backward inclined	*Backward-inclined centrifugal fans for high static pressure, light dust, fumes, or moisture.*
	Inline fans	*Inline fans for space-restricted duct installations.*
	Roof ventilators	*Roof ventilators for roof exhaust.*
	Fire safety fans	*Spark-resistant, explosion-proof construction for flammable materials (e.g., battery rooms). Fan construction should comply with National Fire Protection Association (NFPA) and UL standards.*
	Corrosion resistant fans	*Corrosion-resistant materials or coatings for handling corrosive contaminants.*
	High temperature resistant fans	*High-temperature-resistant materials for high-temperature exhaust.*

FAN PERFORMANCE

	Parameters	***Rules of Thumb***
	Flowrate and static pressure	*Airflow (Q) and static pressure (SP) generally have an inverse relationship; higher airflow may mean lower static pressure and vice versa.*
	Flowrate and fan speed	*Flowrate (CFM) varies directly with fan speed.*
	Pressure and fan speed	*Pressure varies with square of fan speed.*
	Horsepower and fan speed	*Horsepower varies with cube of fan speed.*
	Power consumption	*Fan power consumption is approximately 1 brake horsepower (bhp) for 4000 CFM at 1 inch-water pressure, with an efficiency of 60-65%.*
	Direct drive fans	*Direct drive fans are economical for low volume (2,000 CFM or less) and low static pressure (0.50" or less).*
	Belt drive fans	*Belt drive fans are better suited for air volumes above 2,000 CFM or static pressures above 0.50.*

DUCT SIZING

Ducts in LEV systems efficiently transport captured pollutants away from the hood. Here's what matters for optimal performance:

	Duct Sizing	**Rules of Thumb**
	Duct size	***Affects airflow velocity and pressure drop.*** *Higher velocity leads to lower cross-sectional area of duct, but higher pressure drops.*
	Velocity criteria	*Aim for an air velocity of 3000 - 4000 fpm (feet per minute) in the ducts to keep contaminants in suspension. Specific guidelines are as under:* *a. Vapor, Gases: 1000 – 2000 fpm.* *b. Smoke, fume: 2000 fpm.* *c. Fine dry dust: 2500 fpm.* *d. Dry dusts and powders: 3000 fpm.* *e. Average industrial dust: 4000 fpm.* *f. Heavy dusts: 5000 fpm.*

	Duct Sizing	Rules of Thumb
👍	Friction loss criteria	*Size ducts for friction loss as below:* *a. Low Pressure: 0.10" W.G /100 ft. length @ 1500 – 1800 fpm maximum velocity* *b. Medium Pressure: 0.20" W.G /100 ft. length @ 2500 - 3000 fpm maximum velocity* *c. High Pressure: 0.50" W.G /100 ft. length @ 4000 fpm maximum velocity.*
👍	Air resistance	*More bends, elbows, transitions, and obstructions increase resistance, reducing airflow. Aim for smooth, gradual transitions.*

HOODS

	Types of Hoods	***Rules of Thumb***
👍	Type of Hoods	*a. Enclosing Hoods: Used for containing contaminants at the source.* *b. Receiving Hoods: Designed to receive pollutants from a broader area.* *c. Capturing Hoods: Intended to capture contaminants emitted from a specific source.*
👍	Hood Efficiency	*Size, shape, and distance from source all affect capture effectiveness.*
👍	Hood Geometry	*Match the hood size and shape to the plume (wider hood for wider plume). Flanges/baffles on hood enhance capture around the opening.*
👍	Hood Placement	*Closer is better: Position hoods as close to the contaminant source as possible. Doubling the distance will increase the airflow four times.*
👍	Capture Velocity	*Typical Range: 100-200 fpm* *Higher for more dispersive contaminants (grinding) and lower for less (tanks).*
👍	Ductwork	*Diameter: Sized appropriately to maintain airflow velocity and minimize pressure drop.* *Material: Constructed from corrosion-resistant materials compatible with the contaminant properties.*