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Occupational Health, Safety & Environmental Consultants

Industrial Ventilation Fundamentals

Presented for:

New England Roundtable

by:

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Introduction

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Topics

- Purpose of Ventilation
- Systems Overview
- Types of Systems
- Air Cleaning Devices
- Returning treated air to the workplace
- Maintenance
- Pictures and Discussion
- Performance of LEV Systems
- Regulations and Standards
- General Ventilation Systems
- Questions

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Purpose of Ventilation

- Remove contaminants from the breathing zone.
- Minimize employee exposures.
  - Primarily Inhalation, but also affects skin, eye, ingestion
- Prevent accumulation
  - Minimize skin contact.
  - Improve housekeeping.
  - Avoid flammable/explosive atmosphere, vapors, and combustible dusts.
  - Minimize migration from one area to another, clean/break areas, off-site.
- Dilute contaminants – less desirable
  - General ventilation (HVAC systems) *vs* Local Exhaust Ventilation (LEV)
  - **Best to capture contaminants at their source before they can be dispersed into the work environment.**
  - **Intercept agents before they reach the breathing zone.**

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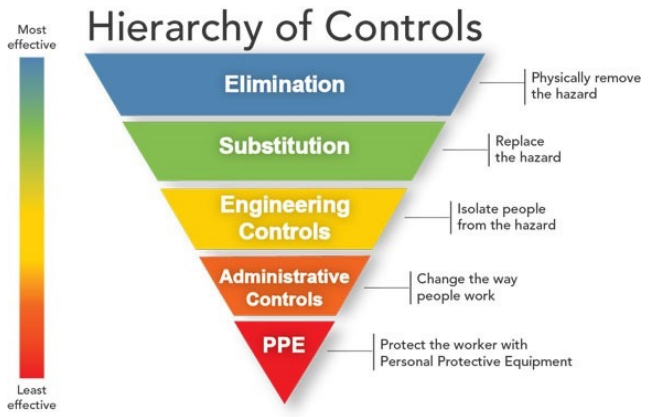
Hierarchy of Controls



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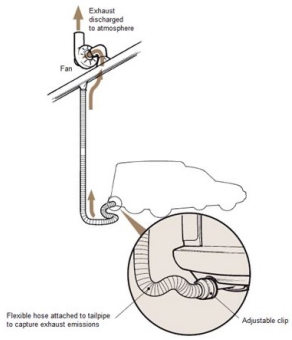
Overview -
Major Categories of Ventilation

Local exhaust Ventilation (LEV)



General Dilution Ventilation

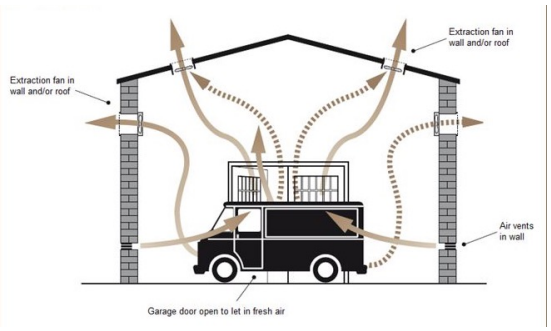


Image source: Government of Canada Labor Program

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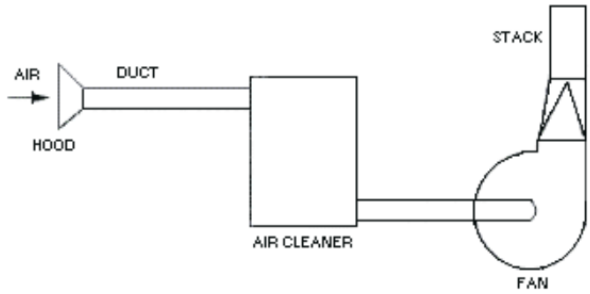
Overview –
Basic Elements of LEV Systems



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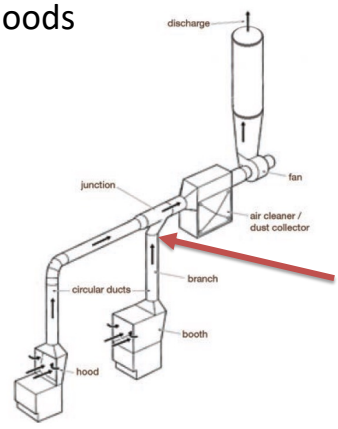
System with multiple hoods

- Requires Balancing



Design of connections is important to reduce losses and prevent settling

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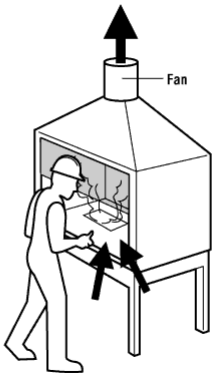
Hood Types – Partially Enclosing Hood



Does not require the operator to do much other than make sure they system is on. They do not need to position the hood manually.

Slide Source: CCOHS

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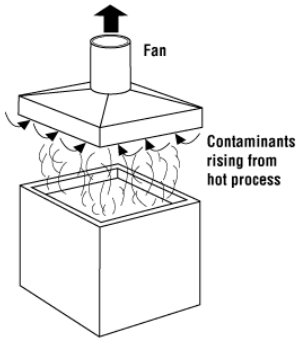
Receiving Hood



Slide Source: CCOHS

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Capturing Hood

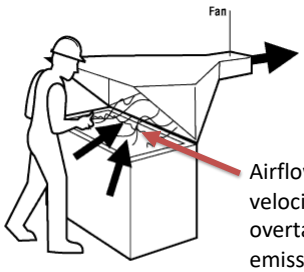

Figure 3
Capturing Hood

Slide Source: CCOHS

Airflow (capture velocity) must overtake emissions and overcome interferences (cross-drafts).

Worker must position hood properly.

Slide Source: Donaldson Filtration Solutions

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Air Cleaning Devices

Particulates

- Filters (fabric, bag house)
- Centrifugal collectors
- Electrostatic precipitators
- Wet scrubbers/collectors

Vapors and Gases

- Adsorption: Charcoal beds, alumina, silica gel
- Catalytic conversion
- Thermal destruction: combustion, oxidation, incineration, after burner

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Combustible Dust

Image Source: Nederman.com

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Returning Treated Air to the Workplace

- Consider the degree of health hazard associated with the contaminant.
  - Returning airflow from treatment systems removing particularly hazardous agents such as carcinogens is discouraged.
- Incorporate a monitoring system (sensor) that would alarm if the air cleaner fails.
- Safety Factor - Target exposure reduction to at least 10% of the occupational exposure limit.
- Consider agents that may not be removed by air cleaning devices (e.g., gases from hot processes not filtered).
- See recommendations from ACGIH (Industrial Ventilation Manual, 31st edition, pages 11-26), and ANSI/AIHA Z9.7.
- **Maintenance becomes very important.**

American National Standard for **Recirculation of Air from Industrial Process Exhaust Systems**

ANSI/AIHA Z9.7–2007

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Maintenance Considerations

- Inspection, visual walkthrough
- Cleaning (hoods, slots, ductwork)
- Troubleshooting problems (pugged ducts, noise, leaks)
- Balancing
  - Dampers
  - Modifications – management of changes
- Performance Evaluation / Validation
  - Airflow visualization – smoke generation
  - Pressures and differentials
  - Industrial Hygiene Exposure Monitoring?
- Components
  - Housings and ductwork (can wear out if they convey abrasives)
  - Bearings (lubrication)
  - Shafts
  - Motors
  - Belts
  - Electronics and sensors for more complex systems.
  - Duct connectors (sometimes flexible and wear out)

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Laboratory "Fume" Hood

Alarm? An indicator to the operator that hood is on and operating properly.

Sash Height is important. Should be marked at validated height.

Avoid Obstructing Air Inlet Slot.

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Glove Box Enclosure

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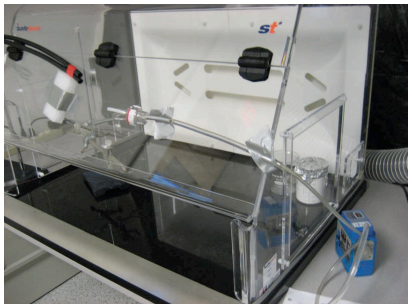
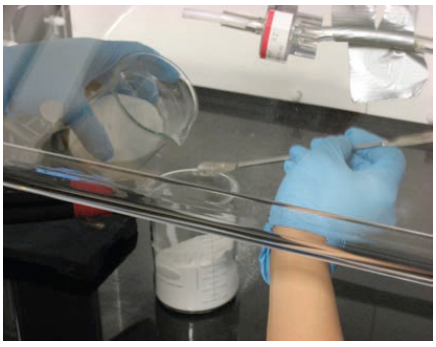
Powder Handling Semi Enclosure





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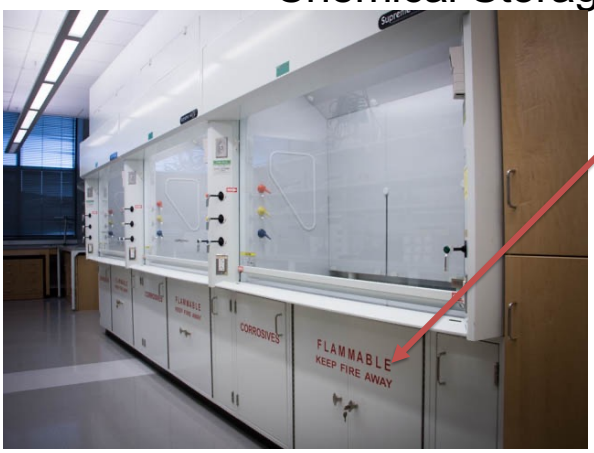
Chemical Storage



Must be designed as flammable storage cabinet.

Don't store incompatible materials (e.g., acids and organics).

Slide Source: University of Washington EHS

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Performance
Capture Velocity and Hood Design

Four times more airflow needed to maintain capture velocity when distance is doubled.

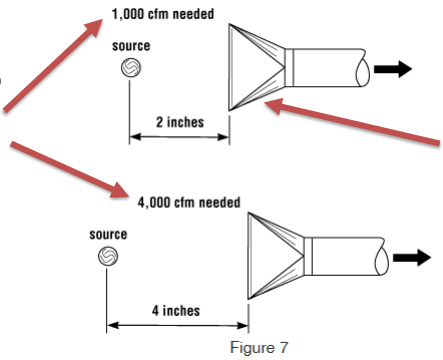

Figure 7

Capturing Hood

Hood shape and flanges are important

Slide Source: CCOHS

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Lab Hood Performance Criteria

- Laboratory hoods are generally designed to provide 100 feet per minute (fpm) average airflow.
- A range of 80 to 120 average fpm is preferred.
- Results from 60-80 fpm may be acceptable with optimum room conditions, containment characteristics, and operator technique.
- Airflow rates above 120 fpm and up to 150 fpm are not recommended due to increased operation cost.
- Airflow rates above 150 fpm are not recommended due to increased operation cost and decreased effectiveness due to turbulence.

Airflow measured at face of opening with sash positioned at operating height.

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Don't forget about the need for make-up air

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Capture Hood Performance Criteria

Condition of Dispersion of Contaminant	Example	Capture Velocity (fpm)
Released with practically no velocity into quiet air	Evaporation from open tanks, drums, or vessels.	50 – 100
Released at low velocity into moderately still air	Manual material transfer; spray coating, palletizing.	100 – 200
Active generation into zone of rapid air motion	Keg filling; discharging blenders	200 – 500
Released at high initial velocity into zone at very rapid air motion	Grinding	500 – 2,000

fpm – feet per minute

These are general criteria, based on ACGIH's ventilation manual, which also contains design and performance criteria for specific operations.

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Performance - No LEV

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LEV Present but Not Used Properly

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LEV Effective

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Fixed System – Poor Design and Placement

Contaminant is being drawn through the employee's breathing zone.

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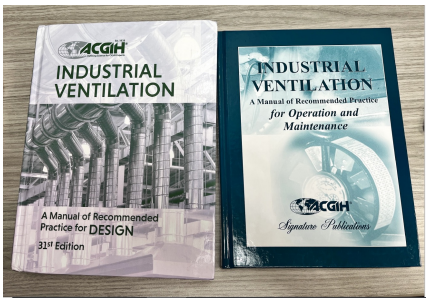
Regulations and Standards

Ventilation systems are not highly regulated by OSHA regulations. OSHA has permissible exposure limits. Criteria are typically specified by engineers based on consensus standards and building codes in place at construction date.

- American Conference of Governmental Industrial Hygienists (ACGIH).
  - Industrial Ventilation Manual for Design, 31st Edition (2023)
  - Industrial Ventilation Manual for Operations and Maintenance (2007)



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Regulations and Standareds

- American National Standards Institute (ANSI).
  - Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI/ASSP Z9.2-2018
  - Portable Ventilation Systems, ANSI/ASSP Z9.9-2021
  - Recirculation of Air from Industrial Process Exhaust Systems. ANSI/AIHA/ASSE Z9.7-2007.
  - Fundamentals Governing the Design and Operation of Dilution Ventilation Systems in Industrial Occupancies, ANSI/ASSE Z9.10-2017.

General Ventilation

- American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE).
  - Ventilation for acceptable indoor air quality (ANSI/ASHRAE 62).

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OSHA

- Occupational Safety and Health Administration (OSHA).
  - 29 CFR 1910.94 - Ventilation addresses specific operations:
    - Abrasive blasting
    - Abrasive cut-off wheels
    - Spray Finishing operations – Contains airflow criteria to control explosion hazard
    - Grinding, polishing, and buffing operations
    - Incorporates old ANSI standards by reference
- Guidance
  - OSHA: "Ventilation Investigation," Section 3, Chapter 3 of *OSHA Technical Manual*.

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OSHA's Lead Standard - General Industry

- 1910.1025(e)(4)(i)
  - When ventilation is used to control exposure, measurements which demonstrate the effectiveness of the system in controlling exposure, such as capture velocity, duct velocity, or static pressure shall be made at least every 3 months. Measurements of the system's effectiveness in controlling exposure shall be made within 5 days of any change in production, process, or control which might result in a change in employee exposure to lead.
- 1910.1025(e)(4)(ii)
  - ***Recirculation of air***. If air from exhaust ventilation is recirculated into the workplace, the employer shall assure that:
    - 1910.1025(e)(4)(ii)(A)
      - the system has a high efficiency filter with reliable back-up filter; and
    - 1910.1025(e)(4)(ii)(B)
      - controls to monitor the concentration of lead in the return air and to bypass the recirculation system automatically if it fails are installed, operating, and maintained.

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Other

- National Fire Protection Association (NFPA)
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

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Laboratory Hoods

- ANSI/ASSP Standard Z9.5-2022 *Standard for Laboratory Ventilation.*
  - *Contains performance criteria including capture/face velocity.*
- American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) publication 110-2016 "*Methods of Testing Performance of Laboratory Fume Hoods.*"
- NFPA 45. Standard on Fire Protection for Laboratories Using Chemicals

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Photos

- Totes held hot caustic.
- Canopy (receiving) hood
- Note vapor plume vs the location of the canopy hood. Effective?

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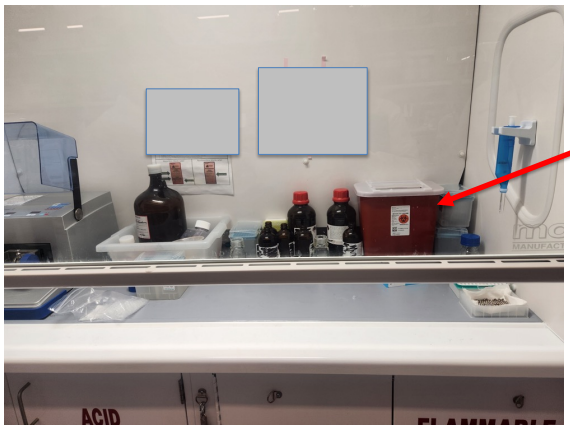
Photos



Objects blocking airflow through slot at rear bottom of hood.

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Photos

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Photos

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Photos

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General Ventilation - What can it do?

- Remove odors and contaminants
  - Exhaust some air outdoors and introduce fresh air
  - Filter
- Reduce the concentration of contaminants.
  - Dilute contaminants into existing space volume.
    - Reduces potential dose
    - Avoid accumulation in dead air space.
  - Add fresh outdoor air for additional dilution.
- Improve general air quality and comfort
  - Odor reduction
  - Temperature control

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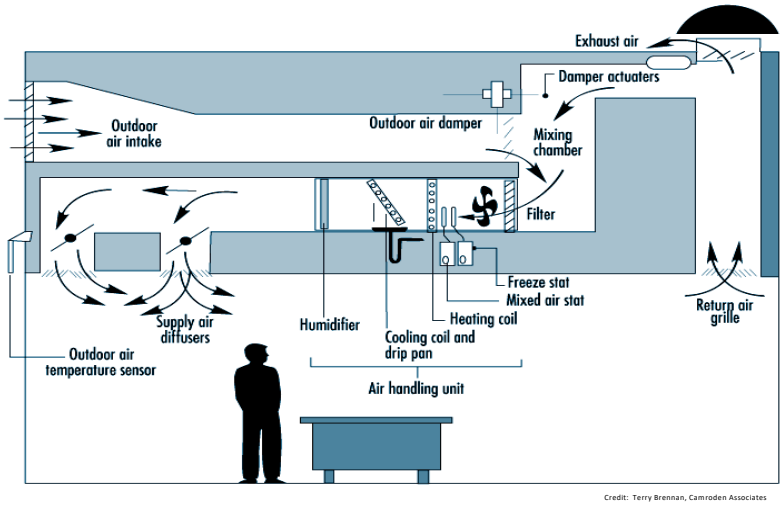
Typical Heating, Ventilation, and Air-Conditioning (HVAC) System



Credit: Terry Brennan, Camroden Associates

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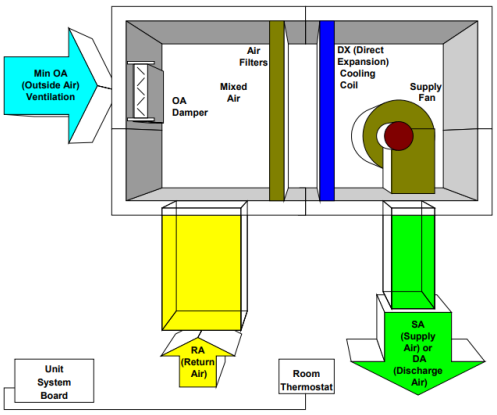
Rooftop Unit (RTU)



Credit: U.S. Department of Energy Building Energy Codes Program

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Questions?

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