Chapter 3

# Industrial Hygiene

# Industrial Hygiene

- Due to civic concern and ethics,
- Sometimes manifested in laws and regulations
- science devoted to the identification, evaluation, and control of occupational conditions that cause sickness and injury
- Projects involving industrial hygiene are
  - monitoring toxic airborne vapor concentrations,
  - reducing toxic airborne vapors through the use of ventilation,
  - selecting proper personal protective equipment
  - prevent worker exposure, developing procedures for the handling of hazardous materials
  - monitoring and reducing noise, heat, radiation, and other physical factors

# Industrial Hygiene

- The four phases in any industrial hygiene project are *anticipation, identification, evaluation,* and *control:*
- **Anticipation**: Expectation of the presence of workplace hazards and worker exposures.
- **Identification**: Determination of the presence of workplace exposures.
- **Evaluation:** Determination of the magnitude of the exposure.
- **Control**: Application of appropriate technology to reduce workplace exposures to acceptable levels.

# Government Regulations

- Laws and regulations are major tools for protecting people and the environment
- Government organizations
  - Environmental Protection Agency (EPA),
  - Occupational Safety and Health Administration (OSHA),
  - Department of Homeland Security (DHS)

**Creating a Law :** three-step process-

  - **Step 1.** A member of Congress proposes a bill. A bill is a document that, if approved, becomes a law.
  - **Step 2.** If both houses of Congress approve the bill, it is sent to the president, who has the option to either approve it or veto it. If approved, it becomes a law that is called an act.
  - **Step 3.** The complete text of the law is published in the United States Code (USC)

- The code is the official record of all federal laws.

# Creating a Regulation

- Authorizes governmental organizations, including the EPA, OSHA, and DHS, to create regulations and/or standards
- Regulations set specific rules about what is legal and what is not legal
- Clean Air Act will specify levels of specific toxic chemicals that are safe
- EPA has the responsibility
  - help citizens comply with the law
  - enforce the regulation
- Creating a regulation and/or standard has two steps:

# Creating a Regulation

- **Step 1.**
  - ✓ Agency decides when a regulation is needed.
  - ✓ The organization then researches, develops, and proposes a regulation.
  - ✓ The proposal is listed in the *Federal Register* (FR) so that the public can evaluate it
  - ✓ Send comments to the organization.
  - ✓ These comments are used to revise the regulation.

- **Step 2.**
  - ✓ After a regulation is rewritten, it is posted in the *Federal Register* as a final rule,
  - ✓ it is simultaneously codified by publishing it in the *Code of Federal Regulations* (CFR).

# Creating a Regulation

- As a result of the OSHAct, sufficient funding was committed to create and support the both
- Occupational Safety and Health Administration (OSHA),
- National Institute for Occupational Safety and Health (NIOSH),

  which conducts research and technical assistance programs
- Examples of NIOSH responsibilities include

  (1) measuring health effects of exposure in the work environment,

  (2) developing criteria for handling toxic materials,

  (3) establishing safe levels of exposure, and

  (4) training professionals for administering the programs of the act.

- NIOSH develops data and information regarding hazards, and OSHA uses these data to promulgate standards.

# Laws from the United States Code (USC) and Regulations from the Code of Federal Regulations (CFR)

| Number | Description |
|---|---|
| 29 USC 651 | Occupational Safety and Health Act (1970) |
| 42 USC 7401 | Clean Air Act (1970) |
| 33 USC 1251 | Clean Water Act (1977) |
| 42 USC 7401 | Clean Air Act Amendments (1990) |
| 15 USC 2601 | Toxic Substances Control Act II (1992) |
| 42 USC 300f | Safe Drinking Water Act Amendment (1996) |
| 40 CFR 280.20 | Underground Storage Tank Leak Tests (1988) |
| 40 CFR 370.30 | Annual Toxic Release Report, SARA 313 (1989) |
| 29 CFR 1910.120 | Training, Hazardous Materials Technician, HAZMAT (1989) |
| 29 CFR 1910.1450 | Exposure to Hazardous Chemicals in Laboratories (1990) |

# Highlights of OSHA's Right of Enforcement

Employers must admit OSHA compliance officers into their plant sites for safety inspections with no advance notice. A search warrant may be required to show probable cause.

OSHA's right of inspection includes safety and health records.

Criminal penalties can be invoked.

OSHA officers finding conditions of imminent danger may request plant shutdowns.

# Federal Legislation Relevant to Chemical Process Safety

| Date | Abbreviation | Act |
|---|---|---|
| 1899 | RHA | River and Harbor Act |
| 1906 | FDCA | Federal Food, Drug, and Cosmetic Act |
| 1947 | FIFRA | Federal Insecticide, Fungicide, and Rodenticide Act |
| 1952 | DCA | Dangerous Cargo Act |
| 1952 | FWPCA | Federal Water Pollution Control Act |
| 1953 | FFA | Flammable Fabrics Act |
| 1954 | AEA | Atomic Energy Act |

# OSHA: Process Safety Management

- On February 24, 1992, OSHA published the final rule "Process Safety Management of Highly Hazardous Chemicals."
- Process safety management (PSM) was developed after the Bhopal accident (1984)
- PSM standard has 14 major sections
  - employee participation, process safety information,
  - process hazard analysis, operating procedures,
  - training, contractors, prestartup safety review,
  - mechanical integrity, hot work permits,
  - management of change, incident investigations, emergency planning and response, audits,
  - trade secrets.

# Risk Management Plan

- On June 20, 1996, the EPA published the Risk Management Plan (RMP) as a final rule.
- Decreasing the number and magnitude of accidental releases of toxic and flammable substances.
- RMP is designed to protect off-site people and the environment,
- whereas PSM is designed to protect on-site people
- RMP is required for plant sites (the site may have several processes) that use more than a specified threshold quantity of regulated highly hazardous chemicals.
- PSM covers every covered process on the site.

# Risk Management Plan

- The RMP has the following elements:
  - Hazard assessment
  - Prevention program
  - Emergency response program
  - Documentation that is maintained on the site and submitted to federal, state, and local authorities.
- The RMP document is updated when the process or chemistry changes or governmental audit requests

***Hazard assessment:***

- ✓ range of potential hazardous chemical releases
- ✓ A risk matrix can be used to characterize the worst- case and more likely scenarios

# Risk Management Plan

- The EPA requires the following consequence analyses:

(1) A single worst-case release scenario is analyzed, only one flammable substance is analyzed

(2) A single worst case release scenario is analyzed for all toxic substances on the site,

for each toxic substance covered by the rule.

- The worst-case scenario is based on releasing the entire contents in a 10-minute period under worst-case meteorological conditions (1.5 m/s wind speed).
- Passive mitigation measures (for example, dikes) can be used in the calculation process; therefore the release rate for liquid spills corresponds to the evaporation rate.

# Risk Management Plan

- Dispersion model calculations are normally used to estimate downwind concentrations
- The RMP requires only an analysis of the consequence and not the probability
- risk is composed of both consequence and probability.
- The second requirement of the RMP is a prevention program
- The prevention program has 11 elements, compared to the 14 elements of the PSM standard
- EPA made a deliberate attempt to retain the same requirements wherever possible
- EPA and OSHA have different responsibilities

# Comparison of the PSM and RMP Prevention Programs

| PSM program (OSHA) | RMP (EPA) |
| --- | --- |
| Process safety information | Process safety information |
| Process hazards analysis | Hazard evaluation |
| Operating procedures | Standard operating procedures |
| Employee participation | (No equivalence) |
| Training | Training |
| Contractors | (No equivalence) |
| Pre-startup review | Pre-startup review |
| Mechanical integrity | Maintenance |
| Hot work permit | (No equivalence) |
| Management of change | Management of change |
| Incident investigations | Accident investigations |
| Emergency planning and response | Emergency response |
| Compliance audits | Safety audits |
| Trade secrets | (No equivalence) |
| (No equivalence) | Risk assessment |

# Emergency response program

- Establishes procedures for notifying the local community and the appropriate emergency response agencies.
- Include drills to test the plan and to evaluate its effectiveness
- Plan must be revised based on the findings of these drills.
- Coordinated with Local Emergency Planning Committees (LEPCs)
- Similar to OSHA regulations- the Resource Conservation and Recovery Act (RCRA),
- Spill Prevention Control - Clean Water Act,

# DHS: Chemical Facility Anti-Terrorism Standards (CFATS)

- In 2006 Congress passed a law requiring the U.S. Department of Homeland Security (DHS)
- Risk-based performance standards for the security of chemical facilities
- April 9, 2007, DHS issued an interim rule called the **Chemical Facility Anti-Terrorism Standards (CFATS)**
- Purpose of the CFATS rule is to identify to DHS all chemical facilities that are high-risk with respect to terrorism.

# Security Issues of Concern to Chemical Plants

| Security issue | Example terrorist objective |
| --- | --- |
| Intentional loss of containment | Release of chemicals to the atmosphere, resulting in toxic exposure, fire, or explosion. This results in harm to the public, to workers, and to the environment. The chemical plant can also be damaged or destroyed, causing direct or indirect economic damage. |
| Theft of chemicals | Use of the chemicals as primary or secondary[a] improvised weapons against a third party. |
| Contamination or spoilage of a product or process | Immediate or delayed harm to people or the environment, or to cause economic injury. |
| Degradation of the asset | Mechanical or physical damage or cyber disruption. This causes severe direct or indirect economic damages. |
| Acquisition of chemicals under false pretense | Purchase of chemicals through normal purchasing channels by misrepresentation of purpose. Use of the chemicals as primary or secondary[a] improvised weapons against a third party. |

# Chemical Security Assessment Tool

- Chemicals in quantities that exceed the threshold, they are required to complete a Chemical Security Assessment Tool (CSAT) Top Screen is done on-line
- DHS evaluates the Top Screen and makes a preliminary classification whether the facility poses a high risk
- DHS ranks 1 through 4, with tier 1 - highest risk
- Preliminarily tiered chemical conduct a Security Vulnerability Assessment (SVA) and submit it to DHS
- Security vulnerability assessment (SVA) is a process used to identify security issues
- Intentional release of chemicals, sabotage, to theft or diversion of chemicals
- Chemical facilities are required to develop and implement a Site Security Plan (SSP)

# Chemical Security Assessment Tool

- DHS conducts inspections and/or audits at tiered facilities
- Highest-risk inspected more frequently
- The SSP must detail physical, procedural, and cyber measures to reduce or eliminate the vulnerabilities.
- Security strategies involve security threat: deterrence (Obstruction), detection, delay, response, and awareness
- Deterrence prevents breaches by means of fear or doubt
- Security guards, lighting, and barriers are examples of deterrence countermeasures
- Delay is designed to slow the progress of an adversary either coming into or out of a restricted area
- Response includes both
  - Off site responders, police and fire fighters,
  - On-site response capabilities include fire fighting, security, medical response, spill containment, and the capability to quickly reduce inventory

# Industrial Hygiene: Anticipation and Identification

- The identification step requires a thorough study of the chemical process, operating conditions, and operating procedures
- The sources of information include process design descriptions, operating instructions, safety reviews, equipment vendor descriptions, information from chemical suppliers and information from operating personnel.
- Identification step is to collate and integrate the available information to identify new potential problems from the combined effects of multiple exposures

# Identification of Potential Hazard

- list of potential hazards together with the required data for hazard identification is commonly used

| Potential hazards | |
|---|---|
| Liquids | Noise |
| Vapors | Radiation |
| Dusts | Temperature |
| Fumes | Mechanical |
| **Entry mode of toxicants** | |
| Inhalation | Ingestion |
| Body absorption (skin or eyes) | Injection |
| **Potential damage** | |
| Lungs | Skin |
| Ears | Eyes |
| Nervous system | Liver |
| Kidneys | Reproductive organs |
| Circulatory system | Other organs |

# Data Useful for Health Identification

Threshold limit values (TLVs)
Odor threshold for vapors
Physical state
Vapor pressure of liquids
Sensitivity of chemical to temperature or impact
Rates and heats of reaction
Hazardous by-products
Reactivity with other chemicals
Flammable and explosive concentrations of chemicals,
dusts, and vapors
Noise levels of equipment
Types and degree of radiation

# Odor Thresholds for Various Chemicals

- One approach to identify the presence of chemical vapors in the workplace
- Many cases the odor threshold is below the TLV

(Chlorine: odor threshold of 0.05 ppm, TLV is 0.5 ppm)

(Ethylene oxide: odor threshold of 851 ppm, TLV is 1 ppm)

| Chemical species | Odor threshold (ppm) |
|---|---|
| Acetaldehyde | 0.186 |
| Acetic acid | 0.016 |
| Acrolein | 0.174 |
| Acrylic acid | 0.4 |
| Acrylonitrile | 16.6 |
| Ammonia | 5.75 |

# Material Safety Data Sheets

- Important references used for toxic chemicals is the material safety data sheet (MSDS)
- The MSDS lists the physical properties of a substance to determine the potential hazards of the substance
- Most companies use their own MSDS format

MATERIAL SAFETY DATA SHEET S-210 31:9203

**Material Safety Data Sheet**
May be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Standard must be consulted for specific requirements.

**U.S. Department of Labor**
Occupational Safety and Health Administration
(Non-Mandatory Form)
Form Approved
OMB No. 1218-0072

| | |
|---|---|
| IDENTITY *(As Used on Label and List)* | *Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that* |

**Section I**

| | |
|---|---|
| Manufacturer's Name | Emergency Telephone Number |
| Address *(Number, Street, City, State, and ZIP Code)* | Telephone Number for Information |
| | Date Prepared |
| | Signature of Preparer *(optional)* |

**Section II — Hazardous Ingredients/Identity Information**

| Hazardous Components (Specific Chemical Identity; Common Name(s)) | OSHA PEL | ACGIH TLV | Other Limits Recommended | % *(optional)* |
|---|---|---|---|---|

# Material Safety Data Sheets

**Section III — Physical/Chemical Characteristics**

| | | | |
|---|---|---|---|
| Boiling Point | | Specific Gravity ($H_2O$ = 1) | |
| Vapor Pressure (mm Hg.) | | Melting Point | |
| Vapor Density (AIR = 1) | | Evaporation Rate (Butyl Acetate = 1) | |
| Solubility in Water | | | |
| Appearance and Odor | | | |

**Section IV — Fire and Explosion Hazard Data**

| | | | |
|---|---|---|---|
| Flash Point (Method Used) | Flammable Limits | LEL | UEL |
| Extinguishing Media | | | |
| Special Fire Fighting Procedures | | | |
| | | | |
| Unusual Fire and Explosion Hazards | | | |
| | | | |

(Reproduce locally) OSHA 174, Sept. 1985

# Material Safety Data Sheets

31:9204 REFERENCE FILE

**Section V — Reactivity Data**

| | | | |
|---|---|---|---|
| Stability | Unstable | | Conditions to Avoid |
| | Stable | | |

Incompatibility (*Materials to Avoid*)

Hazardous Decomposition or Byproducts

| | | | |
|---|---|---|---|
| Hazardous Polymerization | May Occur | | Conditions to Avoid |
| | Will Not Occur | | |

**Section VI — Health Hazard Data**

Route(s) of Entry: Inhalation? Skin? Ingestion?

Health Hazards (*Acute and Chronic*)

Carcinogenicity: NTP? IARC Monographs? OSHA Regulated?

Signs and Symptoms of Exposure

Medical Conditions
Generally Aggravated by Exposure

Emergency and First Aid Procedures

# Material Safety Data Sheets

## Section VII — Precautions for Safe Handling and Use

Steps to Be Taken in Case Material Is Released or Spilled

Waste Disposal Method

Precautions to Be Taken in Handling and Storing

Other Precautions

## Section VIII — Control Measures

Respiratory Protection *(Specify Type)*

| | | |
|---|---|---|
| Ventilation | Local Exhaust | Special |
| | Mechanical *(General)* | Other |

| | |
|---|---|
| Protective Gloves | Eye Protection |

Other Protective Clothing or Equipment

Work/Hygienic Practices



* USGPO [illegible]

- MSDSs are available from
  - (1) Chemical manufacturer
  - (2) Commercial source
  - (3) Private library developed by the chemical plant
-

# Industrial Hygiene: Evaluation

- Determines the extent and degree of employee exposure to toxicants and physical hazards
- Likelihood of large and small leaks must be considered.
- Sudden exposures to high concentrations, through large leaks, may lead to immediate acute effects
  - such as unconsciousness, burning eyes, fits of coughing
- Chronic effects, arise from repeated exposures to low concentrations, mostly by small leaks or volatilization of solid or liquid chemicals
- compare actual exposure levels to acceptable health standards, TLVs, PELs, or IDLH concentrations

# Evaluating Exposures to Volatile Toxicants by Monitoring

- continuous concentration data $C(t)$

  TWA (time-weighted average):

$$\text{TWA} = \frac{1}{8} \int_0^{t_w} C(t)\, dt$$

  $C(t)$ is the concentration (in ppm or mg/m$^3$)

  $tw$ is the worker shift time in hours

  The integral is always divided by 8 hours

- Case is for intermittent samples

$$\text{TWA} = \frac{C_1 T_1 + C_2 T_2 + \cdots + C_n T_n}{8 \text{ hr}}.$$

# Evaluating Exposures to Volatile Toxicants by Monitoring

- If more than one chemical is present in the workplace

$$\sum_{i=1}^{n} \frac{C_i}{(\text{TLV-TWA})_i}$$

*n* is the total number of toxicants,

$C_i$ is the concentration of chemical *i* with respect to the other toxicants

$(\text{TLVTWA})_i$ is the TLV-TWA for chemical species *i*.

If the sum exceeds 1, then the workers are overexposed

- Mixture TLV-TWA can be computed

$$(\text{TLV-TWA})_{\text{mix}} = \frac{\sum_{i=1}^{n} C_i}{\sum_{i=1}^{n} \frac{C_i}{(\text{TLV-TWA})_i}}.$$

# Evaluating Exposures to Volatile Toxicants by Monitoring

- sum of the concentrations of the toxicants in the mixture exceeds this amount, then the workers are overexposed.
- For mixtures of toxicants with different effects

  (such as an acid vapor mixed with lead fume)

  **TLVs cannot be assumed to be additive**
-

# Exposures to Dusts

- Toxicological theory: greatest hazard to the lungs are particle size range of 0.2–0.5 μm
- Larger than 0.5 μm : unable to penetrate the lungs,
- Smaller than 0.2 μm : exhaled with the air
- Dust evaluation calculations identical to volatile vapors. Instead of ppm as use unit, $mg/m^3$ or mppcf

# Exposures to Noise

- Noise levels are measured in decibels. A decibel (dB) is a relative logarithmic scale used to compare the intensities of two sounds
- sound is at intensity I and Io, then the difference in intensity levels in decibels by

$$\text{Noise intensity (dB)} = -10 \log_{10}\left(\frac{I}{I_o}\right).$$

# Exposures to Noise

- dBA: absolute decibels

    hearing threshold is set at 0 dBA

**Sound Intensity Levels for a Variety of Common Activities**

| Source of noise | Sound intensity level (dB) |
|---|---|
| Riveting (painful) | 120 |
| Punch press | 110 |
| Passing truck | 100 |
| Factory | 90 |
| Noisy office | 80 |
| Conventional speech | 60 |
| Private office | 50 |
| Average residence | 40 |

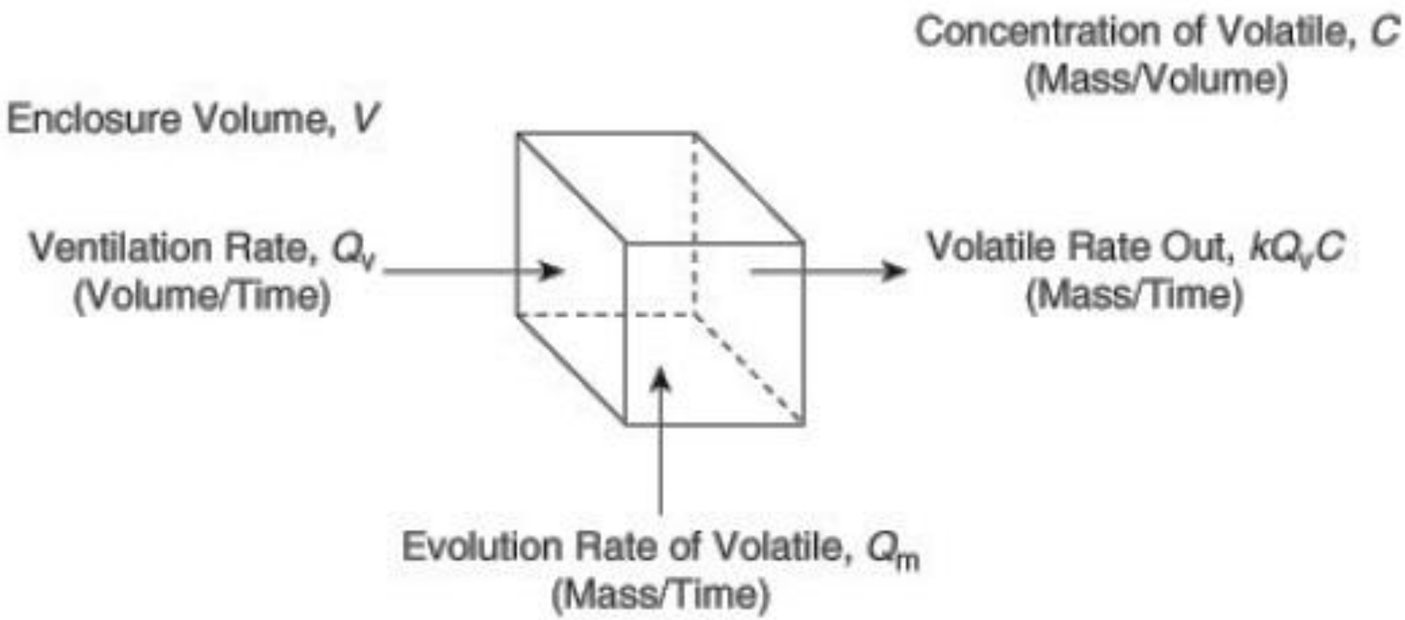
# Permissible Noise Exposures

| Sound level (dBA) | Maximum exposure (hr) |
|---|---|
| 85 | 16 |
| 88 | 10.6 |
| 90 | 8 |
| 91 | 7 |
| 92 | 6 |
| 94 | 4.6 |
| 95 | 4 |
| 97 | 3 |
| 100 | 2 |
| 102 | 1.5 |
| 105 | 1 |
| 110 | 0.5 |
| 115 | 0.25 |

Noise evaluation calculations identically to vapors, except that dBA is used instead of ppm and hours of exposure is used instead of concentration.

# Exposures to Toxic Vapors

- Estimates of vapor concentrations are frequently required in enclosed spaces




Conc. Can be find out

$$C_{ppm} = \frac{Q_m R_g T}{k Q_v P M} \times 10^6$$

# Exposures to Toxic Vapours

- C: concentration of volatile vapour in the enclosure (mass/volume),
- V: volume of the enclosure (volume),
- Qv: ventilation rate (volume/time),
- K: nonideal mixing factor (unitless), and
- $Q_m$: evolution rate of volatile material (mass/time)
- Total mass of volatile in volume = VC,

$$\text{Accumulation of mass of volatile} = \frac{d(VC)}{dt} = V\frac{dC}{dt},$$

- Mass rate of volatile material resulting from evolution = $Q_m$,
- Mass rate of volatile material out = kQvC

$$V\frac{dC}{dt} = Q_m - kQ_vC$$

$$C = \frac{Q_m}{kQ_v}$$

# Exposures to Toxic Vapors

$$C_{\text{ppm}} = \frac{V_v}{V_b} \times 10^6 = \left(\frac{m_v/\rho_v}{V_b}\right) \times 10^6 = \left(\frac{m_v}{V_b}\right)\left(\frac{R_g T}{PM}\right) \times 10^6,$$

$$C_{\text{ppm}} = \frac{Q_m R_g T}{k Q_v P M} \times 10^6$$

## Estimating the Vaporization Rate of a Liquid

vaporization rate is proportional to the difference between the saturation vapor pressure and the partial pressure of the vapor in the stagnant air

$$Q_m \alpha (P^{\text{sat}} - p)$$

vaporization rate is available

$$Q_m = \frac{MKA(P^{\text{sat}} - p)}{R_g T_L}$$

# Exposures to Toxic Vapors

- Qm is the evaporation rate (mass/time),
- M is the molecular weight of the volatile substance,
- K is a mass transfer coefficient (length/time) for an area A,
- Rg is the ideal gas constant, and
- TL is the absolute temperature of the liquid

$$P^{sat} \gg p \qquad Q_m = \frac{MKAP^{sat}}{R_g T_L}$$

In terms of ppm

$$C_{ppm} = \frac{KATP^{sat}}{kQ_v PT_L} \times 10^6.$$

- most situations $T = T_L$

$$C_{ppm} = \frac{KAP^{sat}}{kQ_v P} \times 10^6.$$

- gas mass transfer coefficient

$$K = aD^{2/3},$$

Determine the ratio of the mass transfer coefficients between the species of interest *K* and a reference species *K*o

$$\frac{K}{K_o} = \left(\frac{D}{D_o}\right)^{2/3}$$

Gas-phase diffusion coefficients are estimated from the molecular weights *M* of

$$\frac{D}{D_o} = \sqrt{\frac{M_o}{M}}$$

$$K = K_o\left(\frac{M_o}{M}\right)^{1/3}$$

# Industrial Hygiene: Control

- Application of appropriate technology for reducing workplace exposures
- Newly designed control technique provides the desired control
- New control technique itself does not create hazard
- Two major control techniques are

    1. Environmental controls 2. Personal protection

    - **Environmental control**: reduces exposure by reducing the concentration of toxicants in the workplace environment
    - local ventilation, dilution ventilation, wet methods, and good housekeeping

-

| | |
|---|---|
| **Good housekeeping** | |
| Keep toxicants and dusts contained. | Use dikes around tanks and pumps.<br>Provide water and steam connections for area washing.<br>Provide lines for flushing and cleaning.<br>Provide well-designed sewer system with emergency containment. |

# Industrial Hygiene: Control

- **Personal protection: worn by the worker**

prevents or reduces exposure by providing a barrier between the worker and the workplace environment.

| | |
|---|---|
| **Personal protection** | |
| As last line of defense. | Use safety glasses and face shields.<br>Use aprons, arm shields, and space suits.<br>Wear appropriate respirators; airline respirators are required when oxygen concentration is less than 19.5%. |

| Type | Description |
|---|---|
| Hard hat | Protects head from falling equipment and bumps |
| Safety glasses | Impact-resistant lenses with side shields |
| Chemical splash goggles, gas-tight | Suitable for liquids and fumes |
| Steel-toed safety shoes | Protects against dropped equipment |
| Wraparound face shield | Resistant to most chemicals |

# Chemical Plant Industrial Hygiene Methods

| Type and explanation | Typical techniques |
|---|---|
| **Inherently safer** | |
| Eliminate or reduce hazard | Eliminate chemical entirely.<br>Reduce chemical inventories, including raw materials, intermediates, and products.<br>Replace chemical with less hazardous chemical.<br>Decrease temperature and pressure of chemical.<br>Reduce pipeline size to reduce hold-up inventory. |
| **Enclosures** | |
| Enclose room or equipment and place under negative pressure. | Enclose hazardous operations such as sample points.<br>Seal rooms, sewers, ventilation, and the like.<br>Use analyzers and instruments to observe inside equipment.<br>Shield high-temperature surfaces. |
| **Dilution ventilation** | |
| Design ventilation systems to control low-level toxics. | Design locker rooms with good ventilation and special areas or enclosures for contaminated clothing.<br>Design ventilation to isolate operations from rooms and offices.<br>Design filter press rooms with directional ventilation. |
| **Wet methods** | |
| Use wet methods to minimize contamination with dusts. | Clean vessels chemically vs. sandblasting.<br>Use water sprays for cleaning.<br>Clean areas frequently.<br>Use water sprays to shield trenches or pump seals. |

# Respirators

- Respirators should be used only on a temporary basis, until regular control methods can be implemented
- As emergency equipment, to ensure worker safety in the event of an accident
- A worker with a respirator is unable to perform or respond
- OSHA and NIOSH have developed standards for using respirators

| Exposure | Type | Example of a commercial brand | Limitations |
|---|---|---|---|
| Dust | Mouth and nose dust mask | MSA Comfo Classic half-mask | $O_2 > 19.5\%$<br>N- and R-series filters<br>Less than 8 hours usage<br>Total dust loading <200 mg<br>Concentrations less than IDLH<br>Exposure limits must be known for chemicals |

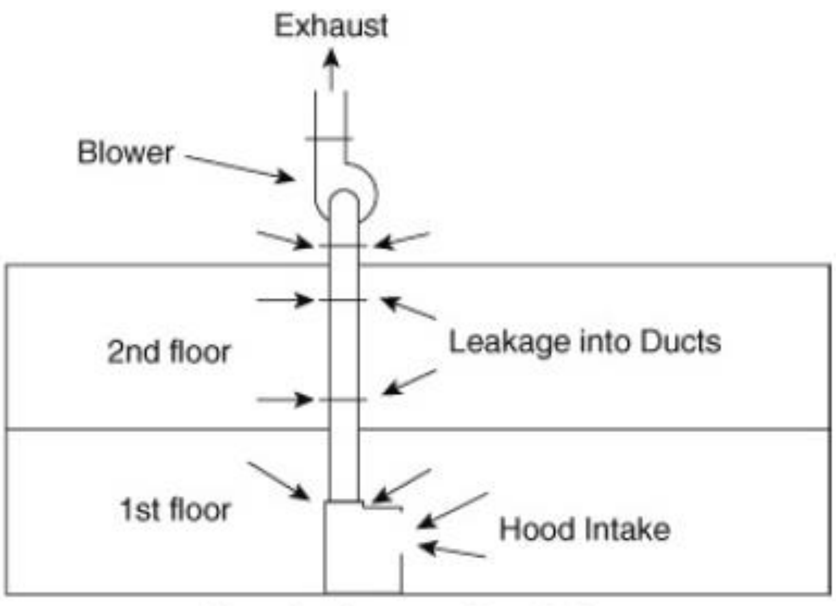
# Ventilation

- For environmental control of airborne toxic material the most common method of choice is ventilation, for the following reasons:
  - Ventilation can quickly remove dangerous conc. of flammable and toxic materials
  - Ventilation can be highly localized
  - Ventilation equipment is readily available and can be easily installed.
  - Ventilation equipment can be added to an existing facility.

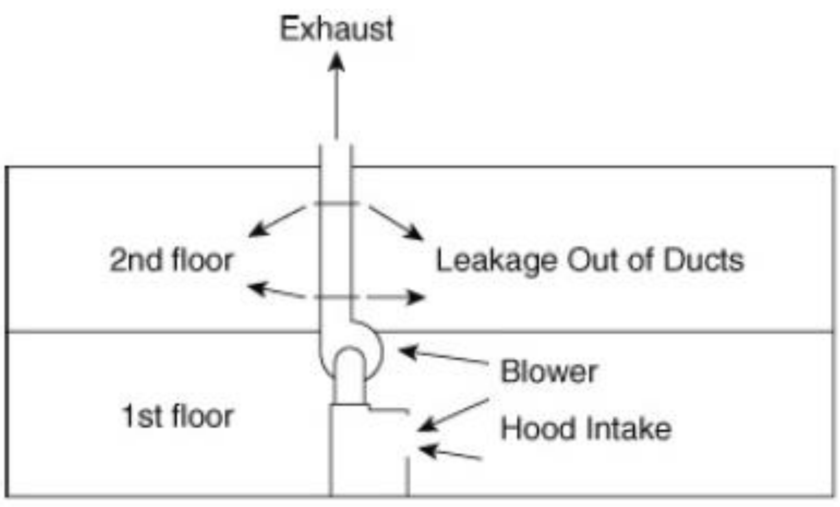
- The major disadvantage is the operating cost. Substantial electrical energy may be needed to drive the potentially large fans

# Ventilation

- Ventilation is based on two principles:
  - (1) Dilute the contaminant below the target concentration
  - (2) Remove the contaminant before workers are exposed
- Best system is a negative pressure system
- With the fans located at the exhaust end of the system
- Draw air, from the workplace



Negative Pressure Ventilation



Positive Pressure Ventilation

# Local and Dilution ventilation

- Two techniques: local and dilution ventilation

**Local Ventilation**

- The most common example hood.
- completely encloses the source of contaminant and carry the contaminant to an exhaust device.

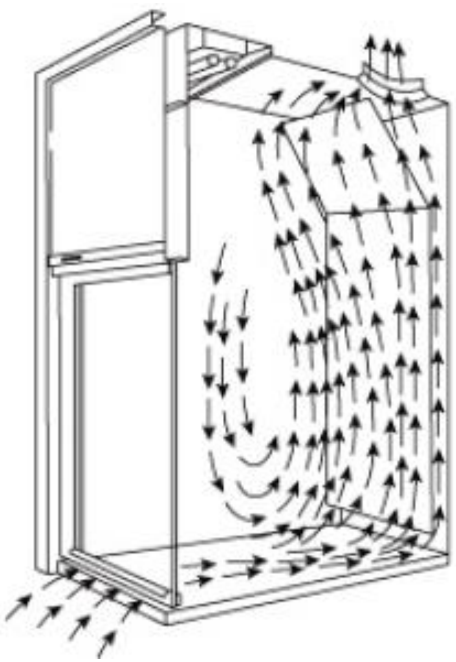
**Types of hoods:**

- An *enclosed hood* completely
- An *exterior hood* continuously draws contaminants into an exhaust from some distance away.
- A *receiving hood* is an exterior hood for collection.
- A *push-pull hood* uses push contaminants toward  exhaust system.

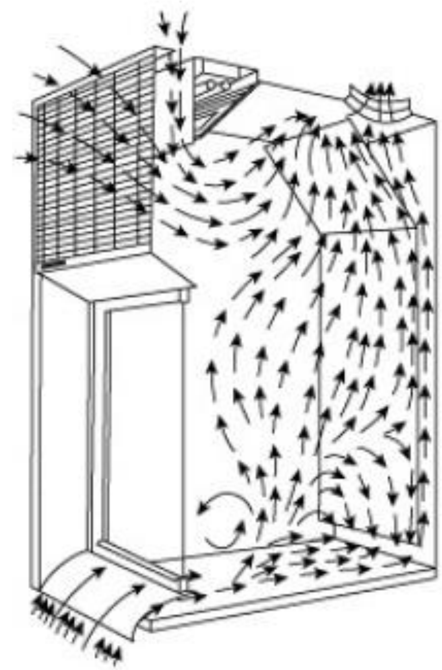
# Hoods

- The most common example of an enclosed hood is the laboratory hood

Another type of laboratory hood is the bypass hood,



**Standard utility laboratory hood**



**Standard bypass laboratory hood**

# Hoods

- The **advantage**s of enclosed hoods are
  - ✓ Completely eliminate exposure to workers
  - ✓ Require minimal airflow
  - ✓ Provide a containment device in the event of fire
  - ✓ Provide a shield by sliding door on the hood
- The **disadvantage**s of hoods are
  - ✓ Limit workspace
  - ✓ Can be used only for small, bench-scale or pilot plant equipment
- General operation a control velocity 80 to 120 feet per minute (fpm) is suggested.
- Other types of local ventilation methods include **“elephant trunks”** and **free-hanging canopies** and plenums.

# Dilution Ventilation

- used in an open area or room
- Unlike hood ventilation, worker exposure, dilution ventilation always exposes the worker but in amounts diluted by fresh air
- Requires more airflow than local ventilation
- Operating expenses can be substantial

**Restrictions** considered before implementing dilution ventilation:

- ✓ The contaminant must not be highly toxic
- ✓ The contaminant must be evolved at a uniform rate
- ✓ Workers must remain a suitable distance from the source to ensure proper dilution of the contaminant
- ✓ Scrubbing systems must not be required to treat the air before exhaust into the environment.

# On-Line Resources

- The National Institute for Occupational Safety and Health (NIOSH),

  *www.cdc.gov/niosh*.
- U.S. Code of Federal Regulations,

  *www.gpoaccess.gov*
- U.S. Department of Homeland Security (DHS)
  *www.dhs.gov*
- U.S. Occupational Safety and Health Administration (OSHA),

  *www.osha.gov*