Chemical Safety in the Laboratory

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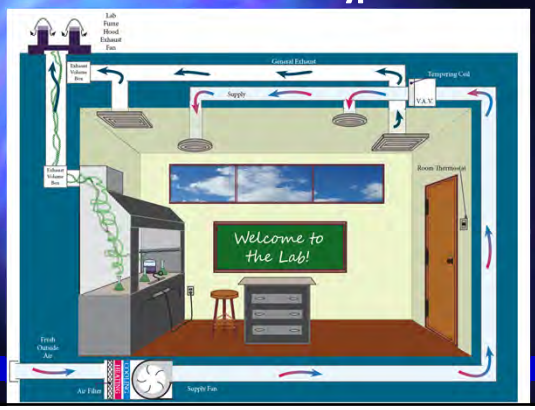
How HVAC Works In a Typical Lab



All You Need to Know to be Safe in the Laboratory are Found in the Following Three Hazard Control Areas.

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Work Practices and Administrative Controls Examples

- Standard operating procedures
- Training requirements
- Chemical Hygiene Plan
- Lab policies and procedures
- Inspections and audits
- Emergency procedures

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Hazard Control Measures

- Engineering Controls : The work environment is designed to eliminate hazards or reduce exposure to hazards.
- Work Practices and Administrative Controls : Policies or procedures used to reduce employee exposure
- Personal Protective Equipment : Worn by the worker to protect against exposure to chemicals.

Hazardous Work in Laboratories Standard

- MIOSHA Regulation, Jan 1, 1992
- Laboratory Use and Laboratory Scale
- Chemical Hygiene Plan
- Supersedes Right-To-Know and all other substance specific standards

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Chemical Hygiene Plan

- Hazards of chemicals
- Appropriate work practices and procedures.
- Controls to protect all workers.
- Basic standard operating procedures (SOPs).

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Personal Protective Equipment

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Laboratory Fire (9/27/98)

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Who is ultimately responsible for your Health and Safety?

YOU !

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Risk Management of Hazardous Chemicals

- Recognize Hazards
- Evaluate Hazards and Risks
- Control Hazards and Risks
- Anticipate Hazards and Risks

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UCLA Accident, March 2009

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Hazards -vs- Risks

- **Hazard:** physical and chemical properties of materials.
- **Risk:** probability that a substance will produce harm.

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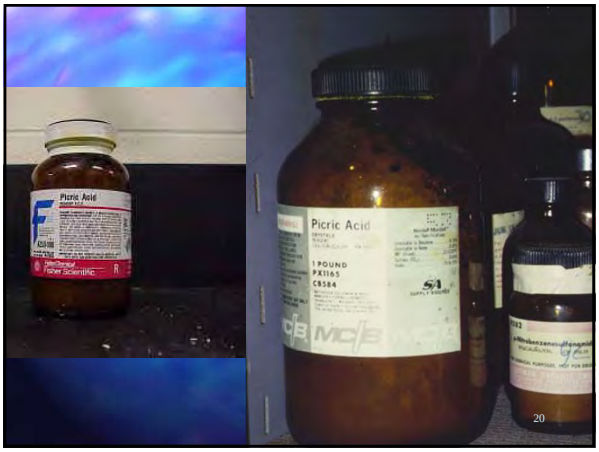

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Hazards in the Laboratory Environment

Radioactive Hazard

Biohazard

Chemical Hazard
- Health
- Physical

Safety Hazard
- Temperature
- Light
- Noise
- Electrical

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Routes of Exposure

- Inhalation
- Skin Contact
- Ingestion
- Injection

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Local Effect

Occurs at the point of contact with the skin, eyes, nose, throat and airway.

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Systemic Effect

Occurs when a chemical or physical agent gets into the blood and is distributed throughout the body to tissues.

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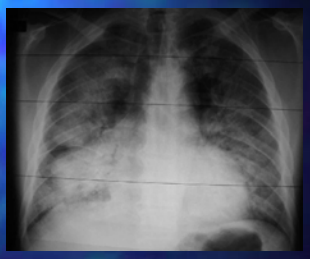
Latent Effect

Delayed effect that may occur one to seventy-two hours after exposure.



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ACUTE EXPOSURE AND EFFECT

Single Exposure

Usually High Concentrations

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WARNING SIGNS

- Dizziness
- Disorientation
- Rapid Breathing
- Blurred vision
- Heavy Sweating
- Difficulty Breathing
- Chest Pains
- Headache
- Loss of Coordination
- Ringing in Ears
- Skin Irritation
- Nausea

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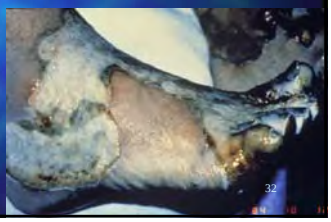
Acute Corrosive Exposures



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CHRONIC EXPOSURE AND EFFECT

Repeated Exposures

Usually Low Concentrations

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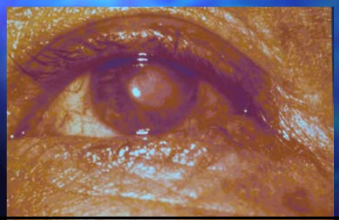
Acute Eye Injuries



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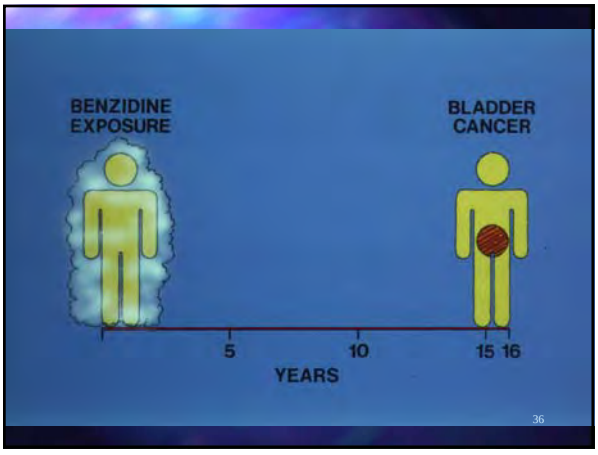

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Properties and Hazardous

- **Physical & Chemical Hazards involve the release of energy in a violent fashion: fires, explosions, violent reactions**
- **Health Hazards interact directly with the body to cause harm.**

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Health Hazards (Pre GHS)

- **Carcinogens**
- **Toxic**
- **Highly Toxic**
- **Irritants**
- **Corrosives**
- **Sensitizers**
- **Reproductive Toxin**

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Health Hazards (GHS)

- **Acute Toxicity**
- **Skin Corrosion**
- **Skin Irritation**
- **Serious Eye Damage**
- **Eye Irritation**
- **Respiratory Sensitizer**
- **Skin Sensitizer**
- **Germ Cell Mutagenicity**
- **Carcinogenicity**
- **Reproductive Toxicity**
- **Specific Target Organ Toxicity (STOT**
- **Aspiration Hazard**

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Carcinogens

- Chemicals that cause cancer either by genetic damage or effecting cellular regulation.
- List is found in the Hygiene Plan
- Common lab carcinogens:

Benzene	Formaldehyde
Chloroform	Carbon Tetrachloride
Methylene Chloride	

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Working With Carcinogens

- **Using engineering controls, such as fume hoods or glove boxes.**
- **Using PPE such as eye protection, lab coat and gloves.**
- **Developing an SOP.**
- **Keeping quantities to a minimum.**
- **Labeling bottle and storage area with the words *carcinogen* or *cancer hazard*.**

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Toxic Effects

- This information will be found on the MSDS.
- Examples are:
  - Burns to the skin
  - Difficulty breathing
  - Disorientation

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Corrosives: (Acids & Bases)

- Cause *irreversible* alteration in living tissue at the site of contact.
- Examples:
  - Sulfuric acid
  - Acetic acid
  - Ammonium hydroxide
  - Sodium hydroxide
  - Hydrofluoric acid
- Irritants - cause a *reversible* inflammatory effect at site of contact.

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Sensitizers

- Chemical that causes an allergic reaction in normal tissue after repeated exposure to the chemical.
- Examples:
  - Formaldehyde
  - Isocyanates
- Reactions:
  - Contact Dermatitis
  - Anaphylactic Shock

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Reproductive Toxins

- Affect the reproductive capabilities of males or females, including chromosomal damage or effects on the fetus.
- **Mutagen** - anything that can cause a change in the genetic material of a living cell.
- **Teratogen** - an agent or substance that may cause physical defects in the developing embryo or fetus when a pregnant female is exposed to the substance.

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Reproductive Toxins

- Arsenic
- Benzene
- Cadmium
- Carbon disulfide
- Lead compounds
- Mercury compounds
- Toluene
- Vinyl chloride

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Particularly Hazardous Substances

- Select carcinogens, reproductive toxicants and highly toxic chemicals
- Special Considerations:
  - Establish and label designated work areas.
  - Notify ALL lab staff of the work area.
  - Label, decontaminate or dispose of contaminated items.

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Chemical / Physical Properties

- **Allow researchers to predict the hazards from chemicals during the experiment.**
- **Allow researchers to ensure the appropriate control measures are in place.**

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Chemical Hazards

- Flammable Liquid
- Combustible Liquid
- Oxidizer
- Organic Peroxide
- Explosive
- Compressed Gas
- Reactive Chemical
- Pyrophoric

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Flammable Liquids / Organic Liquids

- Ketones
- Alcohols
- Ethers
- Aldehydes
- Alkanes
- Alkenes
- Alkynes
- Aromatics
- Esters
- Amides
- Carboxylic Acids
- Amines
- Thiols

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Flash Point

- Lowest temperature at which a liquid gives off enough vapor to form an ignitable mixture under controlled conditions.

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Flammable & Combustible Liquids (OSHA & NFPA)

- Flammable: Flash Point <100°F (37.8°C)
  - Xylene
  - Ethyl alcohol
- Combustible: Flash Point 100°F and < 200°F (93.3°C)
  - Acetic acid, glacial
  - Benzaldehyde
- Non-combustible: Flash Point >200°F
  - Benzyl alcohol
  - Ethylene glycol

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Ignitable / Flammable & Combustible Liquids (EPA & DOT)

- Flammable: Flash Point <140°F (60°C)
  - Xylene
  - Ethyl alcohol
- Combustible: Flash Point 140°F and < 200°F (93.3°C)
  - Cyclohexanol
  - Benzaldehyde
- Non-combustible: Flash Point >200°F
  - Benzyl alcohol
  - Ethylene glycol

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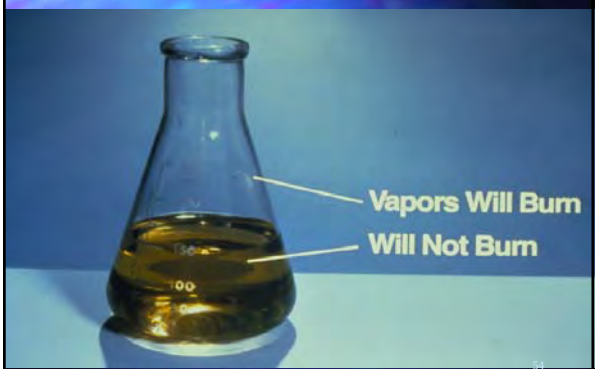

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Oxidizers

Promotes combustion in other materials
Oxidizers are incompatible with organics.
Examples of Oxidizers

- Nitrates
- Permanganates
- Nitric Acid
- Perchlorates

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Specific Oxidizers

- Nitric Acid
- Sulfuric Acid
- Hydrogen Peroxide

Nitric Acid/Alcohol Explosion

Organic Peroxides

- An organic compound that contains the bivalent -O-O- structure.
- Shock, heat and friction sensitive when dry.
- Used as catalysts in epoxy resins.
- Examples:
  - Methyl ethyl ketone peroxide
  - Benzoyl peroxide

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Acid/Flammable Liquid Explosion

Peroxide Forming Solvents

- Materials which undergo auto-oxidation with air to form organic peroxides
- Can explode with impact, heat or friction.
- Examples:
  - Dioxane
  - Tetrahydrofuran
  - Ether
  - Isopropyl Ether

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Peroxide Formation Prevention

- Date when opened
- Reduce amount in labs
- Check for peroxide formation after the expiration date:
  - 3 months: Isopropyl ether
  - 12 months: Ether, Dioxane, THF

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Gas Cylinders

- **Secure cylinders and cap when moving.**
- **High pressure hazard if rupture occurs.**

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Explosives

- **Chemical that causes an almost instantaneous release of pressure, gas and heat when agitated.**
- **Polynitrated organics are typically explosives.**
- **Picric acid (Trinitrophenol)**
- **Perchlorate salts of organic, inorganic complexes.**

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Examples of Gases

Gas	Property
Nitrogen	Asphyxiant
Argon	Asphyxiant
Helium	Asphyxiant
Hydrogen	Flammable
Chlorine	Toxic
Carbon monoxide	Toxic/Flammable
Phosgene	Toxic

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Compressed Gases

Mechanical and chemical hazards

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Reactive and Pyrophoric

- **Reactives include:**
  - **Self-polymerizing materials**
  - **Water and air reactive chemicals**
- **Water reactive chemicals release heat or flammable gas.**
- **Examples of reactives: Sodium metal, Lithium aluminum hydride**
- **Pyrophoric materials ignite spontaneously air at or below 130°F. For example: White Phosphorous.**

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Chemical Reactions

- Interaction between two or more materials that release or absorb energy

- Reactions produce new chemical substances which ma be toxic, corrosive or flammable.

Eye and Face Protection in MSU Laboratories

Appropriate eye and face protective equipment must be worn at all times in those labs where eye hazards exist. Guidelines for selecting appropriate eye and face protection

Safety Glasses	Chemical Splash Goggles	Face Shield + Chemical Splash Goggles
		
Required when: An impact hazard exists or when working with low hazard chemicals* or when a low probability of splash exists.	**Required when:** Working with smaller amounts of corrosive or injurious chemicals* and a reasonable probability of splash exists.	**Required when:** Working with larger quantities of corrosive chemicals* and / or a high probability of eye and face injury exists.
Examples: • Pipetting • Handling closed bottle of injurious chemical • Mixing solutions • Opening centrifuge tubes	**Examples:** • Pouring acid out of a 1 pint bottle • Pouring methylene chloride from a 1 liter bottle • Working with liquids under pressure	**Examples:** • Working with an acid bath • Pouring 4 liters of acid into a container • Handling highly reactive chemicals that may spatter

Piranha Solutions

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Occupational Eye Injuries in the U.S.:

- ***1000*** occupational eye injuries every day in the US.
- **50%** of the injuries are caused by someone else.
- **93%** of the injuries could have been prevented if the proper eye protection was worn.

Eye and Face Protection

- Eye and face protection equipment must be made available to all employees and visitors where chemicals are used and stored.
- Appropriate eye and face protection equipment must be worn at all times in those labs (including teaching labs) where eye hazards exist.
- Eye and face protection equipment must be ANSI Z87.1 approved.

Types of Eye and Face Protection Equipment

- Safety glasses

- Chemical splash goggles

- Face shield and chemical splash goggles

+

Selecting appropriate eye and face protection

- **Safety glasses required when:**
  - An impact hazard exists
  - When working with low hazard chemicals
  - When a low probability of splash exists.
- **Examples:**
  - Pipetting
  - Handling closed bottle of injurious chemical
  - Mixing solutions
  - Opening centrifuge tubes

Safety Glasses

Selecting appropriate eye and face protection

- **Chemical splash goggles offer the best eye protection from chemical splashes. Impact goggles cannot be used as chemical splash goggles when a reasonable of splash exists**

Chemical Splash Goggles

Impact goggles

Selecting appropriate eye and face protection

- **Ordinary prescription glasses do not provide adequate protection against eye injury.**
- **Safety glasses should be worn over prescription glasses.**

Safety Glasses

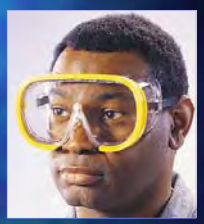
Selecting appropriate eye and face protection

- **Face shield and splash goggles required when:**
  - Larger quantities of corrosive chemicals
  - A high probability of eye and face injury exists.
- **Examples:**
  - Working with an acid bath
  - Pouring 4 liters of acid into a container
  - Handling highly reactive chemicals that may spatter

Face shield and Splash Goggles

Selecting appropriate eye and face protection

- **Chemical splash goggles required when:**
  - Working with small amounts of corrosive or injurious chemicals
  - Reasonable probability of splash exists
- **Examples:**
  - Pouring acid out of a 1 pint bottle
  - Pouring methylene chloride from a 1 liter bottle
  - Working with liquids under pressure



Chemical Splash Goggles

Exemptions

- **Safety glasses should be worn in all MSU laboratories at all time. However, it is not required if you:**
  - **walk in a lab where chemicals are not being handled/used.**
  - **are in a computer lab where no chemicals are present.**
  - **work in a separate office area within a lab**

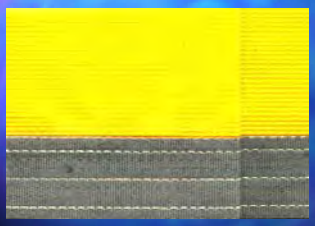
Separate office area: Room adjacent, but separated by floor to ceiling walls

Glove Use

- Consult the manufacturer's chemical resistance guide.
  - Consider degradation, permeation and breakthrough.
- All gloves are permeable.
  - Permeation depends on length of exposure, glove material and thickness.

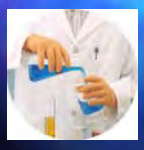
Safety glasses and goggles must not only be available but worn when hazards exist.

Penetration



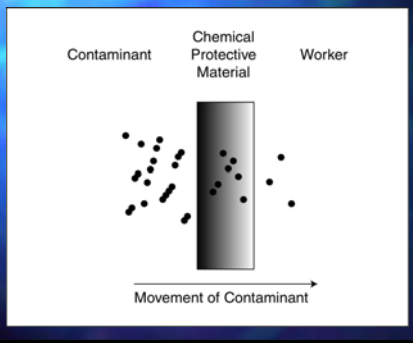
Glove Selection and Use

- Refer to the Manufacturer's web site for glove selection criteria and information



Degradation

Permeation



Glove Handling

- Care of reusable gloves.
  - Rinse reusable gloves then allow to air dry.
  - Replace reusable gloves when they become discolored or show signs of damage.
- Use of disposable gloves.
  - NEVER reuse disposable gloves.
  - Provide barrier protection when working with smaller amounts of chemicals.
- Consult the MSDS for more information regarding glove selection.

Gloves Available and in Good Condition

Lab Coats Available and Worn

Glove Use…con't

- There is no such thing as the "ideal" chemically resistant glove.
  - Gloves may have limitations in dexterity, ability to grip and resistance to puncture and tearing.
- Sometimes 2 glove materials can be worn together.
  - Wearing disposable gloves under reusable gloves offers a greater range of protection.

Emergencies

Call 911 for Police, Medical or Fire

Chemical Spills

- For spills less than 1 liter of a low toxicity and low flammable hazard, non-emergency situation, use a spill kit.
- For spills greater than 1 liter in volume contact the ORCBS for assistance.

Eyewash Stations

Emergency Equipment

- Spill Kits
- Emergency Showers
- Emergency Eyewash Fountain
- Fire Blankets
- Emergency Lighting
- Fire Extinguishers
- First Aid Kit

Emergency Showers

Emergency Eye/Body Washes

- Know locations of emergency eye/body washes within the work area.
- Check them regularly.
- Required for labs where injurious or corrosive chemicals are present.

Hazard Control Measures

- Engineering Controls : The work environment is designed to eliminate hazards or reduce exposure to hazards.
- Work Practices and Administrative Controls : Policies or procedures used to reduce employee exposure
- Personal Protective Equipment : Worn by the worker to protect against exposure to chemicals.