

Chemical Safety in the Laboratory

Bob Ceru
MSU Chemical Safety Officer
Environmental Health and Safety

355-5146
bobceru@ehs.msu.edu
www.ehs.msu.edu

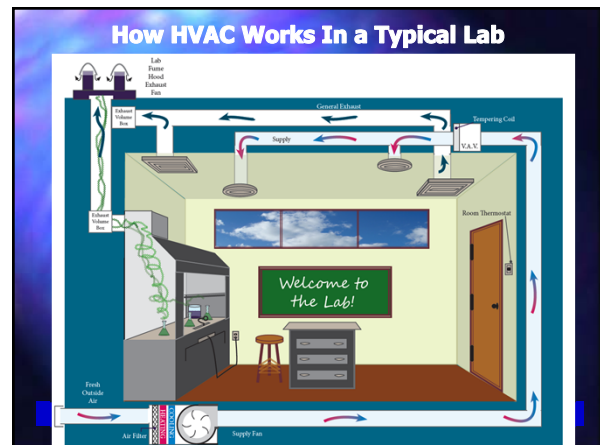
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All You Need to Know
to be Safe in the
Laboratory are Found
in the Following
Three Hazard Control
Areas.

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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.



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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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)

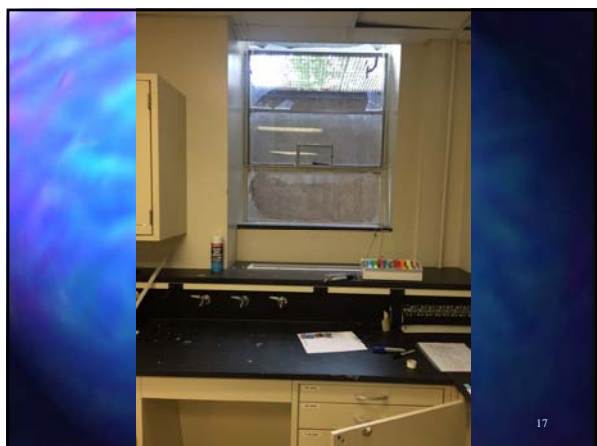


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UCLA Accident, March 2009



Who is ultimately responsible for your Health and Safety?

YOU !

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Safe Research

- Anticipate and Identify the Hazard(s)
- Select the Appropriate Hazard Control and Safety Measures
- Control Hazards and Risks

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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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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 (Immediate)

Single Exposure

Usually High Concentrations

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Acute Eye Injuries



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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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CHRONIC EXPOSURE AND EFFECT

Repeated Exposures

Usually Low Concentrations

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BENZIDINE EXPOSURE



BLADDER CANCER



5 10 15 16
YEARS

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Hazards in the Work Environment

Radioactive Hazards



Biohazards



Physical Hazards

- Temperature



Light



Noise



Electrical



Chemical Hazard

- Health



- Physical



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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Physical Hazards

- 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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Physical Hazards

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



Flammables

Most commonly used hazardous chemicals on campus

Flash point of not more than 93°C

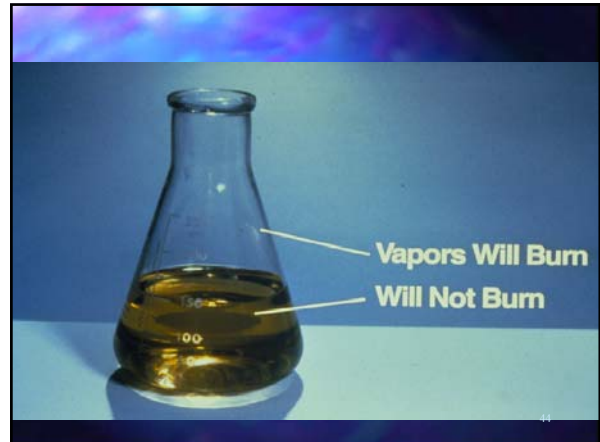
One of four hazard categories on the basis of the flash point and boiling point

Examples: alcohols, ketones, xylenes and carboxylic acids

Most organic chemicals are also flammable or combustible



Category	Criteria
1	Flash point < 23°C and initial boiling point ≤ 35°C (95°F)
2	Flash point < 23°C and initial boiling point > 35°C (95°F)
3	Flash point ≥ 23°C and ≤ 60°C (140°F)
4	Flash point ≥ 60°C (140°F) and ≤ 93°C (200°F)



Corrosives (Acids & Bases)

- Corrosives- Irreversible tissue and/or metal damage

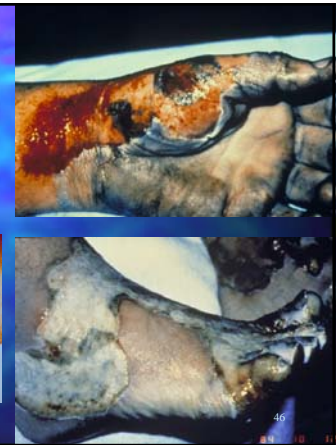
low or high pH (<2.0 or >12.5)

- can cause damage to equipment, storage cabinets and structural elements

- contact with skin or eyes causes acute, irreversible and visible damage at the site of contact



Acute Corrosive Exposures



Oxidizers

- Compound itself is not necessarily combustible. Yields oxygen, causing or contributing to combustion of other material

- Oxidizers are incompatible with organics

- Examples:
 - Nitric acid
 - Hydrogen peroxide
 - Oxygen
 - Nitrous oxide
 - Perchloric acid
 - Nitrates



Nitric Acid/Alcohol Explosion



Acid/Flammable Liquid Explosion



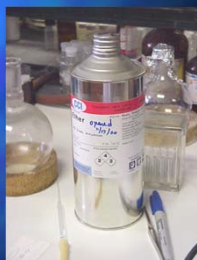
Specific Oxidizers

- Nitric Acid
- Sulfuric Acid
- Hydrogen Peroxide



Peroxide formers

- Very unstable, can explode with impact, heat or friction
 - Common peroxide formers in MSU Labs: Ethyl Ether, Dioxane, Tetrahydrofuran (THF)
- All peroxide formers must be tested regularly!



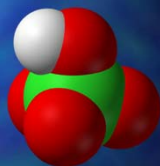
Organic Peroxides & Explosives

- Organic Peroxides
Contains a "peroxy" group. (-O-O-)
Shock, heat and friction sensitive when dry.
- Examples: Methyl ethyl ketone peroxide, Benzoyl peroxide
- Explosives
Instantaneous release of pressure, gas and heat when agitated.
- Examples: Polynitrated organics, picric acid, perchlorate salts of organic and inorganic complexes



Perchloric Acid

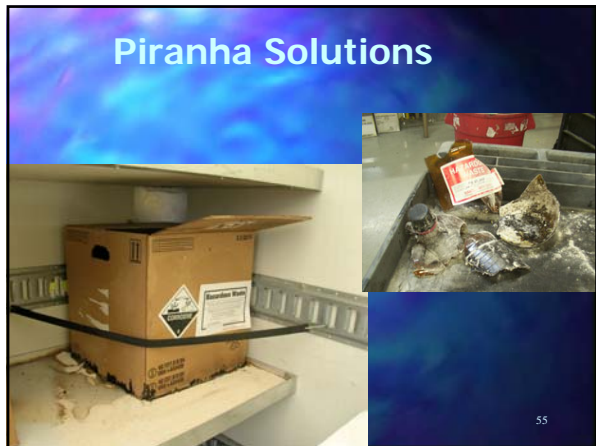
- Highly corrosive, strong oxidizer
- Anhydrous form and certain salts are highly explosive
- DO NOT USE perchloric acid in hot processes, use substitute process
- Store in a well-ventilated area separate from all other materials
- Must receive prior approval before use



Reactive and Pyrophoric

- Water reactive chemicals: some can release toxic or flammable gas in water
 - Store away from moisture and water
 - Handle inside fume hoodExamples: Sodium metal, Lithium aluminum hydride
- Pyrophoric materials ignite spontaneously air at or below 45°C (113°F)
 - Store under a dry, inert atmosphere in sealed containers
 - Handle in a fume hood over a spill trayExample: White Phosphorous





Compressed Gas Cylinders

- Physical hazards
 - Flammables
 - Oxidizing
 - Decompression
- Health Hazards
 - Cryogenics
 - Corrosives
 - Toxic

Health Hazards

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

Exposure Limits

- Examples of PELs :
- Permissible Exposure Limit (PEL)
 - Regulatory limits on concentration of a substance in air
 - Based on an 8-hour time weighted average (TWA)

Chemical	PEL (ppm)
Acetone	750
Ethyl ether	400
Methanol (skin)	200
Formaldehyde	0.75

If PEL is less than 50 ppm, work in a hood

Dose Response Curve

The effects of exposure to hazardous chemicals vary with the amount of exposure or "dose".

Goal: Keep exposure at level where no adverse effects occur

LD₅₀

LD₅₀: amount to kill 50% of test animals in one dose
 Low LD₅₀ = High toxicity
 LD₅₀ says nothing about levels at which other acute toxic, but non-lethal effects might occur

If LD₅₀ < 50 mg/kg:

- Engineering controls: Work inside a hood
- PPE
- Training
 - Label, dispose or decontaminate all equipment
 - Handle with care

Carcinogens

Chemical substances which induce cancer or increase its incidence.

Carcinogens are assigned to one of three hazard categories:

- 1A - Known Human Carcinogen
- 1B - Presumed Human Carcinogen
- 2 - Suspected Carcinogen.

A list of carcinogens can be found in the CHP.

Do not cause harm upon initial exposure, but repeated exposures over many years.

Common lab carcinogens and their uses are:

- Chloroform - laboratory solvent
- Formaldehyde - tissue preservation
- Carbon tetrachloride - laboratory solvent



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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Mutagens & Teratogens

Mutagen:

Agent giving rise to an increased occurrence of mutations in populations of cells and/or organisms.

One of two hazard categories, 'known or presumed' and 'suspected'.

Examples:

- Ethidium bromide
- Formaldehyde, nicotine

Reproductive Toxicity:

Adverse effects on sexual function and fertility in adult males and females

- developmental toxicity in offspring.

One of two hazard categories, 'known or presumed' and 'suspected'.

Examples:

- Ethyl alcohol
- Mercury compounds



Sensitizers

Cause an allergic reaction after repeated exposure

Respiratory sensitizer: induces hypersensitivity of the airways

Skin sensitizer: induces an allergic response following skin contact

Abnormally severe allergic responses upon repeated exposure to the chemical.

Examples of sensitizers:

- Formaldehyde/Formalin
- Latex



Irritants

- Reversible, but still painful, inflammation of skin, eyes, nose or respiratory tract.

Examples:

- Diluted acids
- Halogens
- Alkaline dusts and mists
- Ozone
- Hydrogen chloride
- Arsenic trichloride
- Diethyl/dimethyl sulfate



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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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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Compressed Gases

Mechanical and chemical hazards



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Gas Cylinders

Secure cylinders and cap when moving.

High pressure hazard if rupture occurs.



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 may be toxic, corrosive or flammable.






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.

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.

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

- 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

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

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

- **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



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



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

Glove Selection and Use

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





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.

Gloves Available and in Good Condition



Lab Coats Available and Worn



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.



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.



Eyewash Stations



Emergency Showers



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.