

# General Laboratory Safety

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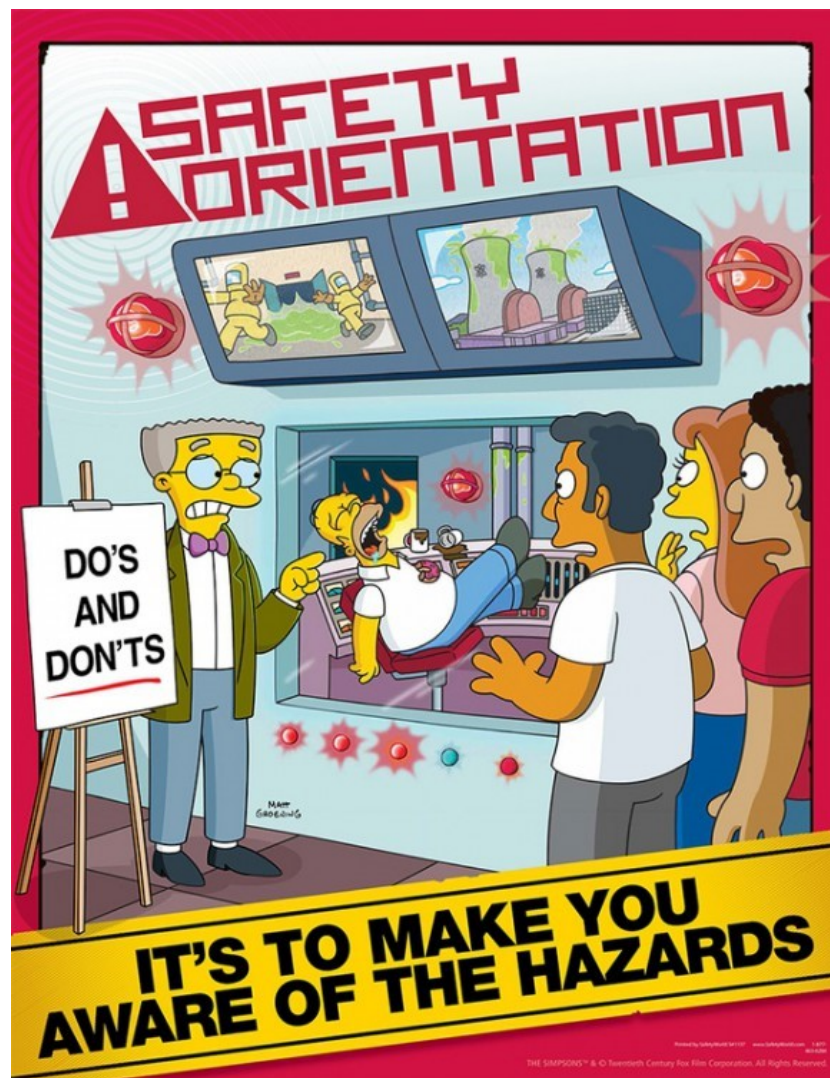
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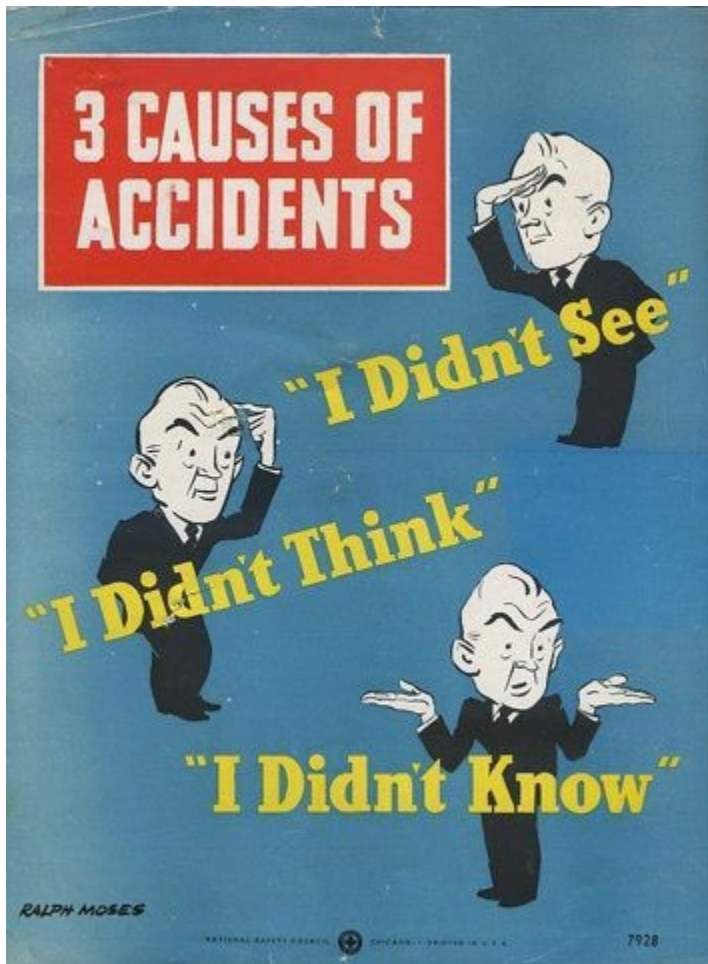
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# Our objective

- R**ecognize the hazards
- A**ssess risk of the hazards
- M**inimize risk of hazards
- P**repare for emergencies





## Common Excuses

Everybody has one

# But safety procedures are so silly...

## Japanese Railway



- “Shisa kanko” = Pointing-and-calling
  - Co-action helps keep attention
  - Mistakes reduce by 85%
  - accidents reduce by 30%
- No fatalities or injury since 1964

## Indian Railway



- Per year:
  - 75 Cr in capital loss
  - 320 Cr in compensation
  - 320 lives lost
  - 720 injuries



I am skilled / I am careful / I am God / I am a professor @ IISc!

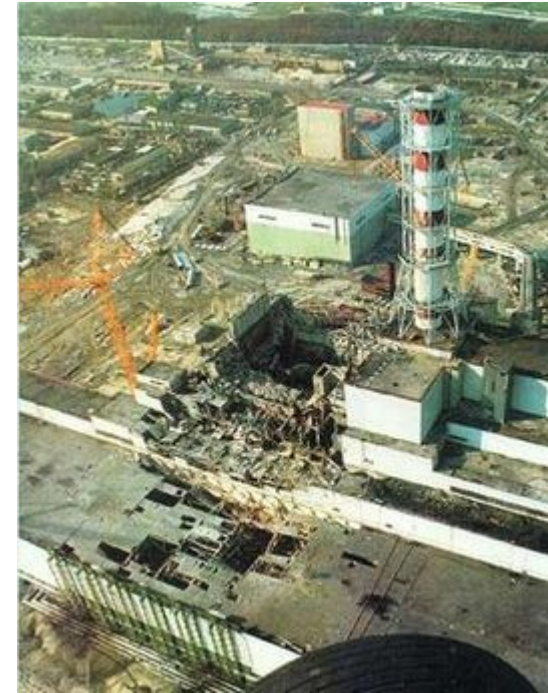


Three-mile island

What is common?

Human Error

Bhopal gas leak



Chernobyl

“To err is human, everyone errs, error is universal and constant”

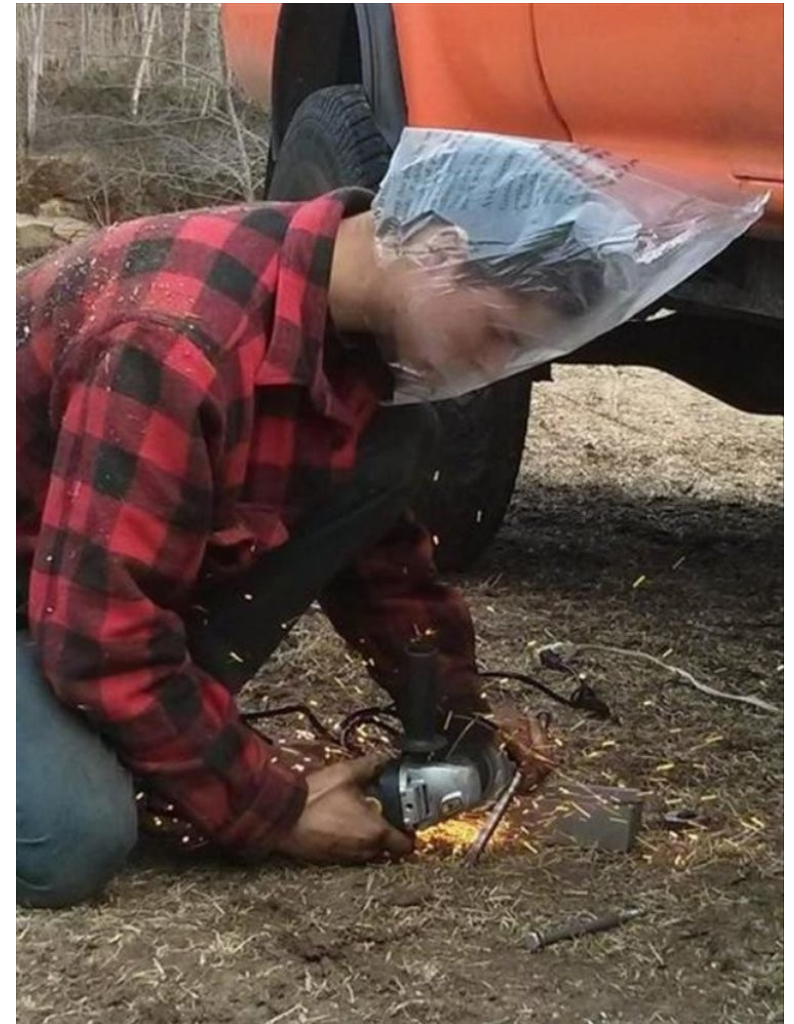
But I've been doing it this way for XX years



I do this everyday!

Hubris is bad for you.

When presented with data  
be prepared to change



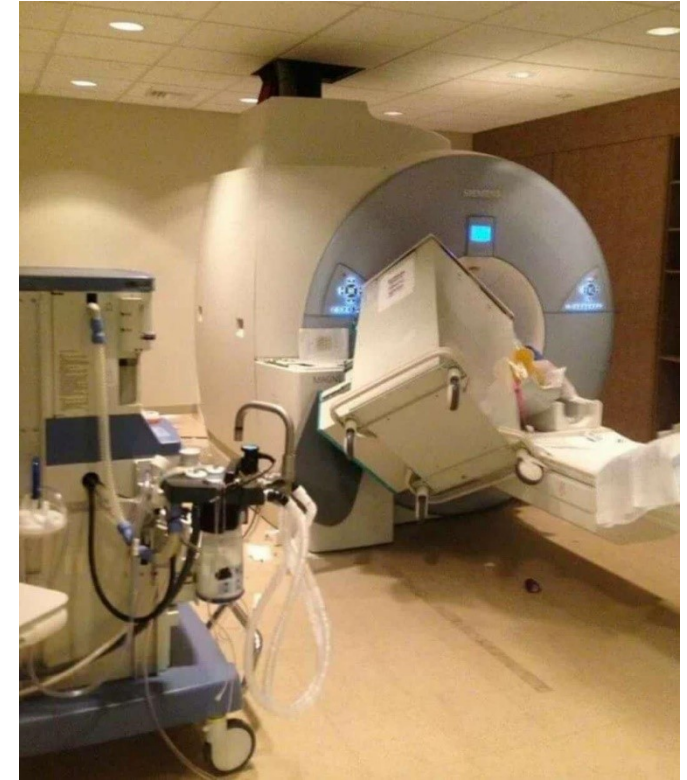
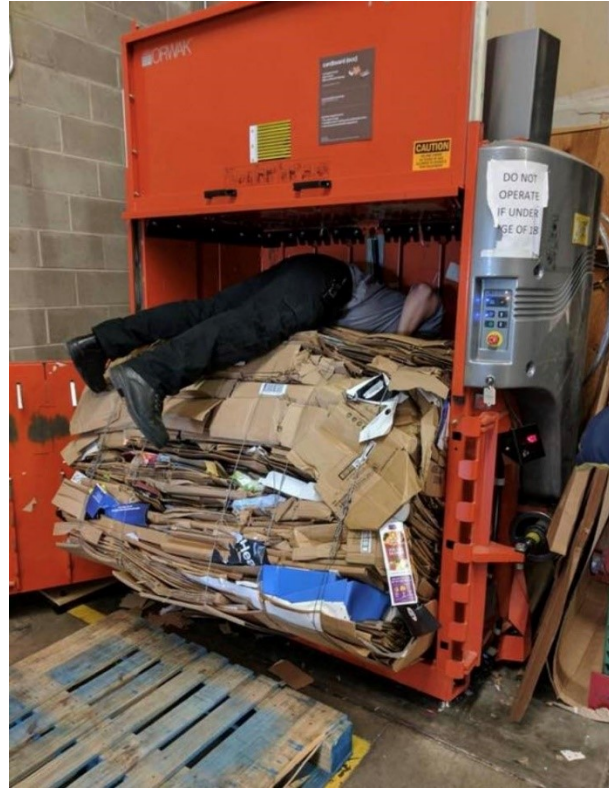
We have our OWN protocols

# It was only going to be a second

You caught me the ONE time I did this



It was not THAT risky



It was just bad luck!

Physics never takes a day off. Don't play lottery



# But it was not my fault

- HE asked me to do it
- I was poorly trained
- I am under a lot of pressure
- I wasn't thinking
- I need to graduate
- My adviser will kill me
- I have a deadline
- Nobody ever told me
- How could I have know?



Safety is **personal** responsibility. Be accountable.





# Contents

- A. Personal Protective Equipment (PPE)
- B. Safe working practices
- C. Chemical safety
- D. Hazardous waste
- E. Gas safety
  - 1. Compressed gases
  - 2. Cryogenics
- F. Fire safety
- G. Electrical safety
- H. Laser safety
- I. Radiation Safety
- J. Identify hazards





## A. Personal Protective Equipment (PPE)

Must be worn at ALL times in the laboratory



# PPE: Eye Protection Options

## Safety Glasses



- Protects from mechanical and impact hazards
- Must be worn in all other labs
- There are no labs in IISc that do not need these

## Chemical Splash Goggles



- Protects from liquid hazards
- Needed in any lab that *stores* chemicals
- Wear even if you are personally not working with chemicals

## Face Shields



- Protects from voluminous hazards
- For fuming or extremely dangerous chemicals: HF, liq. N<sub>2</sub>, etc.
- Need to be worn OVER splash goggles



# PPE: Eyewear Options

Wear eyewear even if they fog

Get anti-fogging eyewear

Wear eyewear even if you have specs

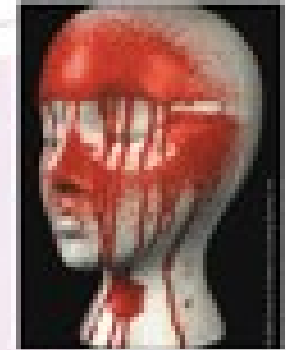
Get a habit of wearing eyewear ALL times

Before splash

After splash

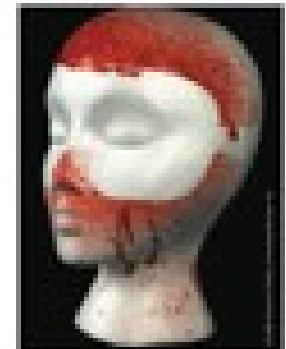
*Safety Glasses Without Side Shields (Impact Only)*

Eyes are not protected



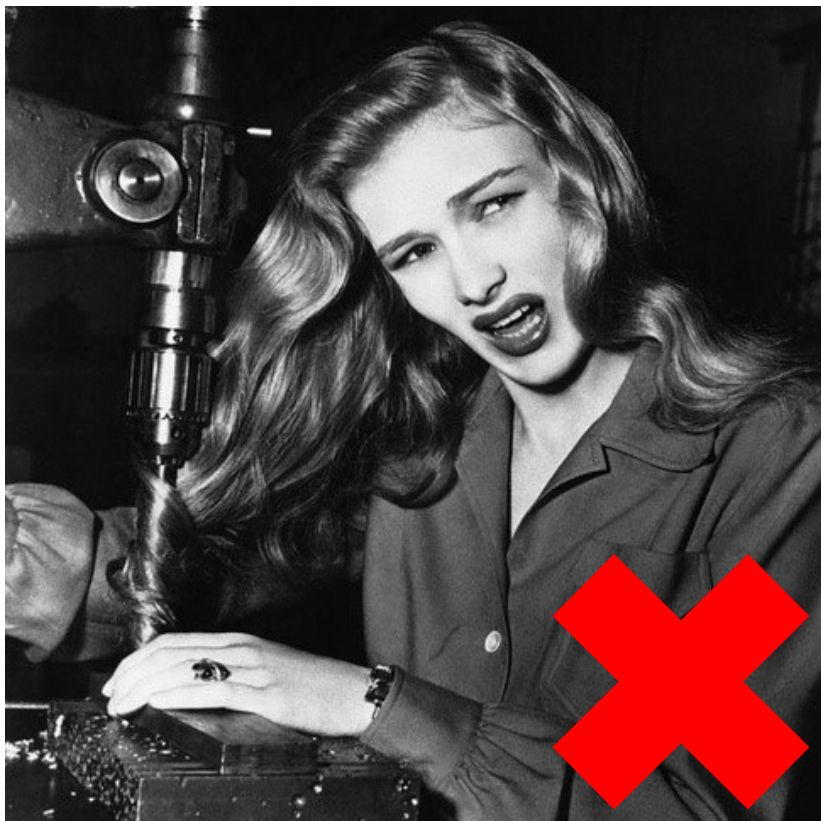
*Chemical Splash Safety Goggles (Impact and Splash Protection)*

Eyes are protected



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# PPE: Nothing Should Dangle



No dangling hair, necklaces,  
earrings, dupattas



Tie-up hair or use hairnets

Avoid or tie dupattas

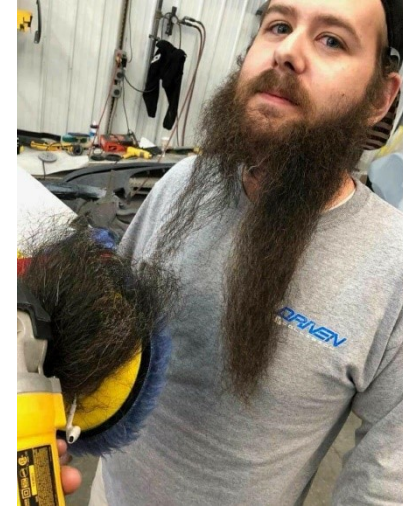


# PPE: Long Hair



Dangling hair caused Yale student Michele Dufault was killed in an accident in April 2011

Her hair got stuck in a drill. A hair tie may have saved her life





# PPE: Gloves

## Thin nitrile



- < 2 mil thick
- General purpose
- Solvents
- Biological samples

## Thick nitrile



- 2-4 mil thick
- Corrosive chemicals
- Acids & bases
- Toxins

## Heat-resistant silicone



- Ovens
- Furnaces
- Hot surfaces

## Cryogen gloves



- Liquid N<sub>2</sub>, He, etc.



Not allowed

Latex



Vinyl



Asbestos





# PPE: Gloves – Do and Don'ts

## Do

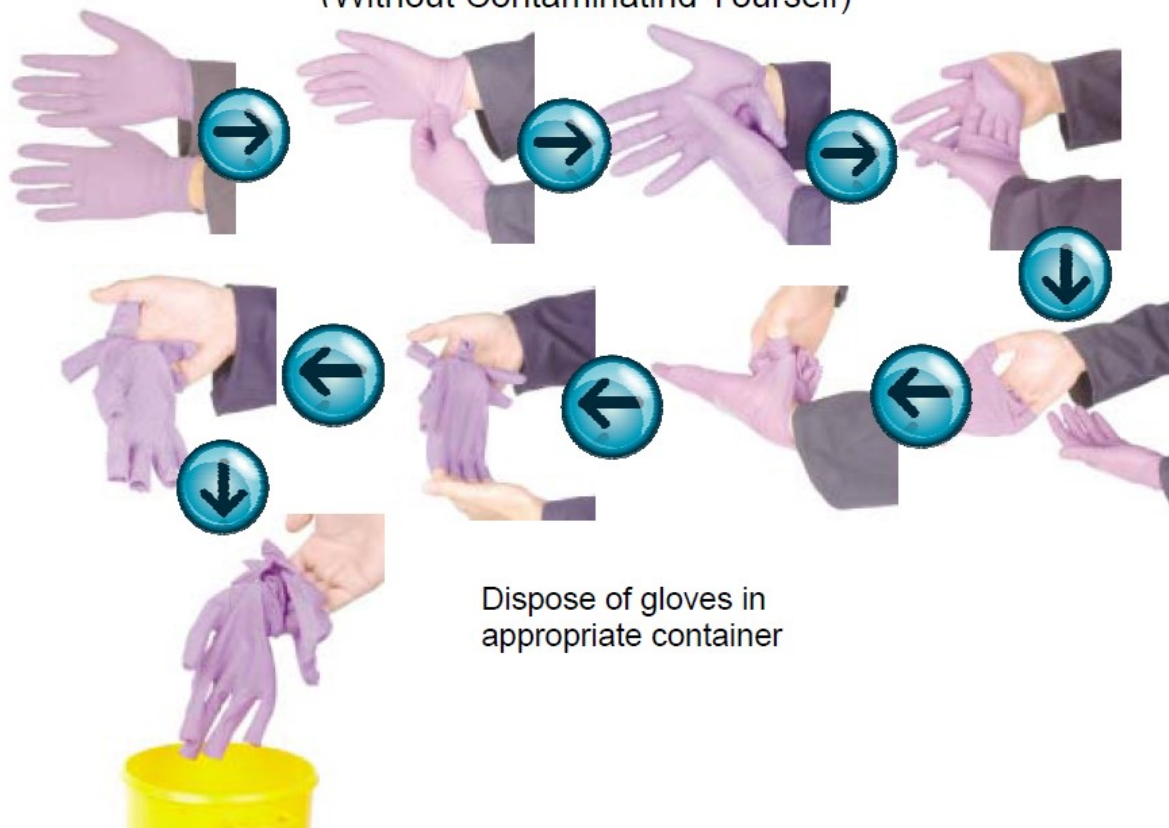
- Check gloves for holes or tears
- Replace a torn glove
- Dispose gloves in lab solid waste before leaving lab
- Wash hands after gloves

## Don't

- Re-use disposable gloves
  - Increased risk for contamination
- Continue using a torn glove

## How to Remove Gloves

(Without Contaminating Yourself)



Dispose of gloves in appropriate container





# PPE: Wash Your Hands!

Even if wearing gloves, always wash hands with soap after leaving the lab





# PPE: Footwear

- No flip-flops, sandals, crocs, or chappals.
- Only closed toe shoes
- Common violations
  - Several labs have a "take shoes off" policy.
  - Some labs use chappals inside lab.
  - “It is too hot to wear shoes.”
  - “I was not planning to do lab work today!”





# PPE: Summary



## Bare minimum



Safety Goggles or Glasses

Lab Coat or Long Sleeves

Gloves

Long Pants

Closed-toe Shoes

## Big hazards



Face shield

Long sleeved thick gloves

Apron

Chemical resistant shoes

From ehs.virginia.edu

From indiaMART.com



# PPE: Working with Cryogenics

Face Shield

Eye Protection

Hearing Protection



Lab Coat

Cryogen Apron

Cryogen or Leather Gloves

Long Pants

Closed Toe Shoes



Mandatory PPE for filling liquid N<sub>2</sub>, Ar, and He tanks



## B. Safe Working Practices

Common sense rules that must be followed

# SWP: No Food in Lab

## Don't eat/drink in lab

- No chai, coffee
- No mugs
- No lunchboxes
- No chewing



## Don't store food in lab fridge

- Not even when packed

Juice + lunch



Lab samples

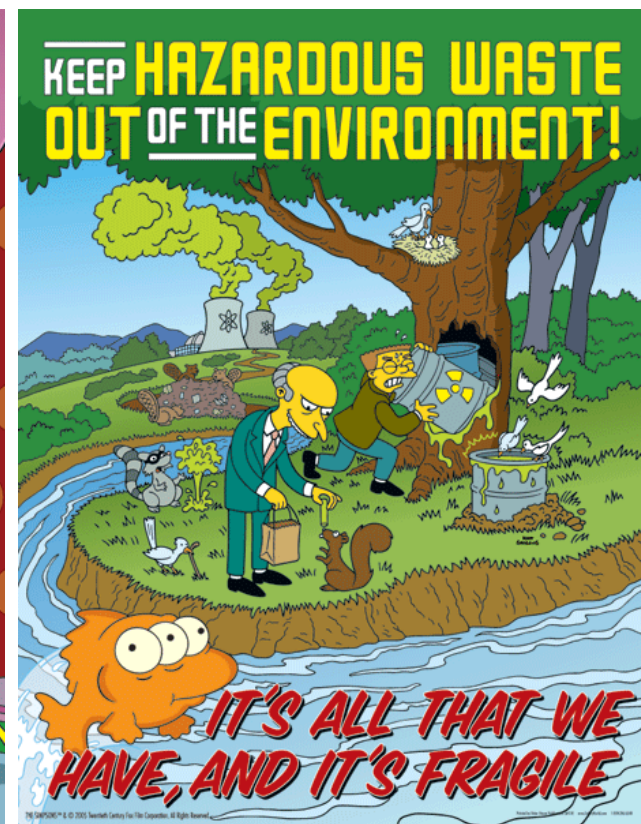
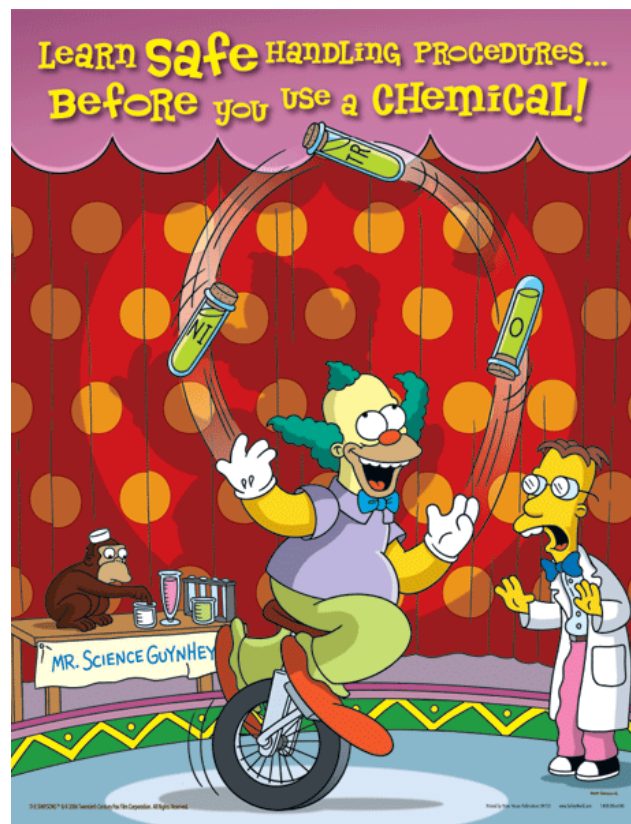


# SWP: Never Work Alone

- Follow Buddy System
  - Buddy == another person in lab
- Always have a buddy
  - Especially at night
  - Friend with a cell phone is not a “buddy”
- Look out for each other
  - If you see something unsafe, point it out
  - Be professional, don’t take it personally



Look out for another



## C. Chemical Safety (CS)

Most common type of hazard and the most preventable one



# CS: Hazard Labels



## Know Standard Hazard Symbols





# SWP: Material Safety Datasheet (MSDS)

**READ  
MSDS  
BEFORE USING**



Maintain hardcopy in lab



# Material Safety Data Sheet

## Hydrofluoric Acid, 48% MSDS

### Section 1: Chemical Product and Company Identification

**Product Name:** Hydrofluoric Acid, 48%

**Catalog Codes:** SLH2227

**CAS#:** 7664-39-3

**RTECS:** Not applicable.

**TSCA:** TSCA 8(b) inventory: Water; Hydrofluoric acid

**CI#:** Not available.

**Synonym:** Hydrogen Fluoride; Hydrofluoride

**Chemical Name:** Hydrofluoric acid

**Chemical Formula:** Not applicable.

**Contact Information:**

**Sciencelab.com, Inc.**

14025 Smith Rd.

Houston, Texas 77396

US Sales: **1-800-901-7247**

International Sales: **1-281-441-4400**

Order Online: [ScienceLab.com](http://ScienceLab.com)

**CHEMTREC (24HR Emergency Telephone), call:**  
1-800-424-9300

**International CHEMTREC, call:** 1-703-527-3887

**For non-emergency assistance, call:** 1-281-441-4400

### Section 2: Composition and Information on Ingredients

**Composition:**

Name	CAS #	% by Weight
Water	7732-18-5	52
Hydrogen fluoride	7664-39-3	48

**Toxicological Data on Ingredients:** Hydrofluoric acid: VAPOR (LC50): Acute: 1276 ppm 1 hours [Rat]. 342 ppm 1 hours [Mouse]. 1774 ppm 1 hours [Monkey]. 4327 ppm 0.5 hours [Guinea pig].

## Section 3: Hazards Identification

### Potential Acute Health Effects:

Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (irritant, corrosive), of ingestion. Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the spray mist may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Severe over-exposure can result in death. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

### Potential Chronic Health Effects:

Non-corrosive for skin. Non-irritant for skin. Non-sensitizer for skin. Non-permeator by skin. Non-irritating to the eyes. Non-hazardous in case of ingestion. Non-hazardous in case of inhalation. Non-irritant for lungs. Non-sensitizer for lungs. CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to lungs, mucous membranes, skin, eyes, bones,

## Section 4: First Aid Measures

### Eye Contact:

Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15-30 minutes. Cold water may be used. Keep the eyelids apart and away from the eyeballs during irrigation. Do not use oily drops or ointment or HF skin burn treatments on the eyes. Get medical attention immediately, preferably an eye specialist. If a physician is not immediately available, apply one or two drops of ophthalmic anesthetic (e.g. 0.5% Pontocaine Hydrochloride solution). Place ice pack on eyes until reaching emergency room.

### Skin Contact:

In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately. While waiting for medical attention, it has been shown that flushing the affected area with water for one minute and then massaging HF Antidote Gel into the wound until there is a cessation of pain is a most effective first aid treatment. HF Antidote Gel contains Calcium Gluconate which combines with HF for insoluble Calcium Fluoride, thus preventing the extraction of calcium from the body tissue and bones. Another alternative first aid treatment, after thorough washing of the burned area, is to immerse the burned area in a solution of 0.2% iced aqueous Hyamine 1622 or 0.13% iced aqueous Zephiran Chloride. If immersion is impractical, towels should be soaked with one of the above solutions and used as compresses for the burn area. Hyamine 1622 is a trade name for Tetracaine Benzethonium Chloride. Zephiran is a trade name for Benzalkonium Chloride. Again, seek medical attention as soon as possible for all burns regardless of how minor they may appear initially.

## Section 5: Fire and Explosion Data

**Flammability of the Product:** Non-flammable.

**Auto-Ignition Temperature:** Not applicable.

**Flash Point:** Not applicable.

## Section 6: Accidental Release Measures

### Small Spill:

Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container. If necessary: Neutralize the residue with a dilute solution of sodium carbonate.

### Large Spill:

Corrosive liquid. Poisonous liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material.

## Section 7: Handling and Storage

### Precautions:

Do not ingest. Do not breathe gas/fumes/ vapor/spray. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as organic materials, metals, alkalis, moisture. May corrode metallic surfaces and glass. Store in a polyethylene container.

**Storage:** Keep container tightly closed. Keep container in a cool, well-ventilated area.

## Section 8: Exposure Controls/Personal Protection

### Engineering Controls:

Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

### Personal Protection:

Face shield. Synthetic (impervious) apron or full suit. A full impervious suit is recommended if exposure is possible to a large portion of the body. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves (impervious - neoprene, nitrile). Impervious Boots.

## Section 9: Physical and Chemical Properties

**Physical state and appearance:** Liquid.

**Odor:** Acrid (Strong.)

**Taste:** Not available.

**Molecular Weight:** Not applicable.

**Color:** Colorless. Clear

## Section 10: Stability and Reactivity Data

**Stability:** The product is stable.

**Instability Temperature:** Not available.

**Conditions of Instability:** Incompatible materials

**Incompatibility with various substances:**

Highly reactive with metals. Reactive with organic materials, alkalis.

**Corrosivity:**

Extremely corrosive in presence of glass, of aluminum, of stainless steel(304), of stainless steel(316). Slightly corrosive in presence of copper.

**Special Remarks on Reactivity:**

Incompatible with glass, ceramics, concrete, alkali materials, and will generate hydrogen gas on contact with metals, leather, rubber, common metals, carbonates, sulfides, cyanides, oxides of silicon, fluorine. Reacts violently with: Acetic anhydride, 2-amino ethanol, Ammonium hydroxide, Arsenic trioxide, Bismuthic acid (produces oxygen), Calcium oxide, Chlorosulfonic acid, Dialuminum octavanadium tridecasilicide, Ethylene diamine, Ethyleneimine, Fluorine, Mercuric oxide, Mercury (II) oxide plus organic materials(above zero degree C), Nitric acid plus lactic acid (mixtures are unstable), Nitric acid plus propylene glycol, Olen-Phenylazopiperidine, Phosphoric anhydride (Phosphorus pentoxide unites with hydrogen fluoride vigorously, even at 19.5 degrees C, HSDB 1990), Potassium permanganate, Potassium tetrafluorosilicate(2-) (evolves silicon tetrafluoride gas), Propriolactone (beta-), Propylene glycol and silver nitrate (gas evolution and formation of silver fulminate), Propylene oxide, Sodium, Sodium hydroxide, Sodium tetrafluorosilicate, Sulfuric acid, Vinyl acetate.

## Section 11: Toxicological Information

**Routes of Entry:** Absorbed through skin. Dermal contact. Eye contact. Inhalation. Ingestion.

**Toxicity to Animals:** Acute toxicity of the vapor (LC50): 342 1 hours [Mouse].

**Chronic Effects on Humans:** May cause damage to the following organs: lungs, mucous membranes, skin, eyes, bones, teeth.

**Other Toxic Effects on Humans:**

Extremely hazardous in case of inhalation (lung corrosive). Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (corrosive), of ingestion, .

**Special Remarks on Toxicity to Animals:** Not available.

## Section 12: Ecological Information

**Ecotoxicity:** Not available.

**BOD5 and COD:** Not available.

**Products of Biodegradation:**

Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

**Toxicity of the Products of Biodegradation:** The products of degradation are less toxic than the product itself.

**Special Remarks on the Products of Biodegradation:** Not available.

## Section 13: Disposal Considerations

**Waste Disposal:**

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

## Section 14: Transport Information

## Section 15: Other Regulatory Information

### Federal and State Regulations:

Connecticut hazardous material survey.: Listed as Hydrofluoric acid or Hydrogen fluoride Illinois toxic substances disclosure to employee act: Listed as Hydrofluoric acid or Hydrogen fluoride Illinois chemical safety act: Listed as Hydrofluoric or Hydrogen fluoride New York release reporting list: Listed as Hydrofluoric acid Rhode Island RTK hazardous substances: Listed as Hydrofluoric acid or Hydrogen fluoride Pennsylvania RTK: Listed as Hydrofluoric acid Minnesota: Hydrogen fluoride Massachusetts RTK: Listed as Hydrogen fluoride Massachusetts spill list: Listed as Hydrofluoric acid or Hydrogen fluoride New Jersey: Listed as Hydrofluoric acid or Hydrogen fluoride New Jersey spill list: Listed as Hydrofluoric acid or Hydrogen fluoride Louisiana RTK reporting list: Listed as Hydrogen fluoride Louisiana spill reporting: Listed as Hydrogen fluoride California Director's List of Hazardous substances: Listed as Hydrofluoric acid or Hydrogen Fluoride TSCA 8(b) inventory:

## Section 16: Other Information

**References:** Not available.

**Other Special Considerations:** Not available.

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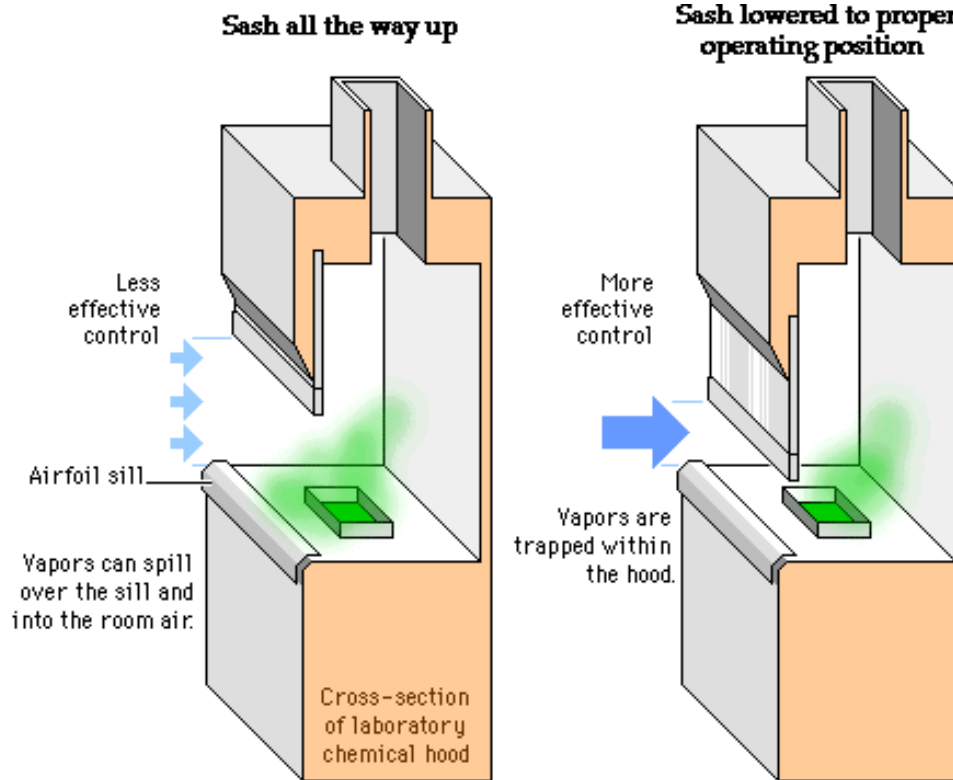
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# CS: Chemicals Handling



All chemical processing in fume hoods

Keep the sash as low as possible

# CS: Fume Hoods



From Dow Corning Safety Presentation

Don't put face or head inside



From Univ. of Waterloo

Hood is not for storage



# CS: Transporting Chemicals

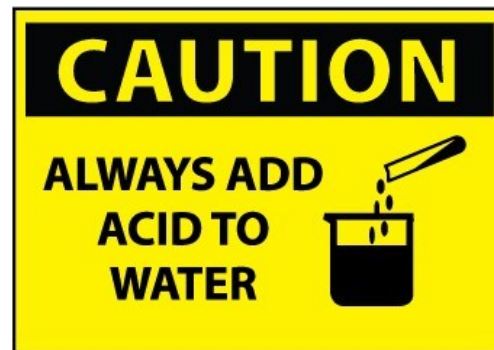
- Don't carry chemicals with hands.
  - Hazard to you and others
- Use bottle carriers, carts with trays, buckets, etc
- Avoid glass bottles



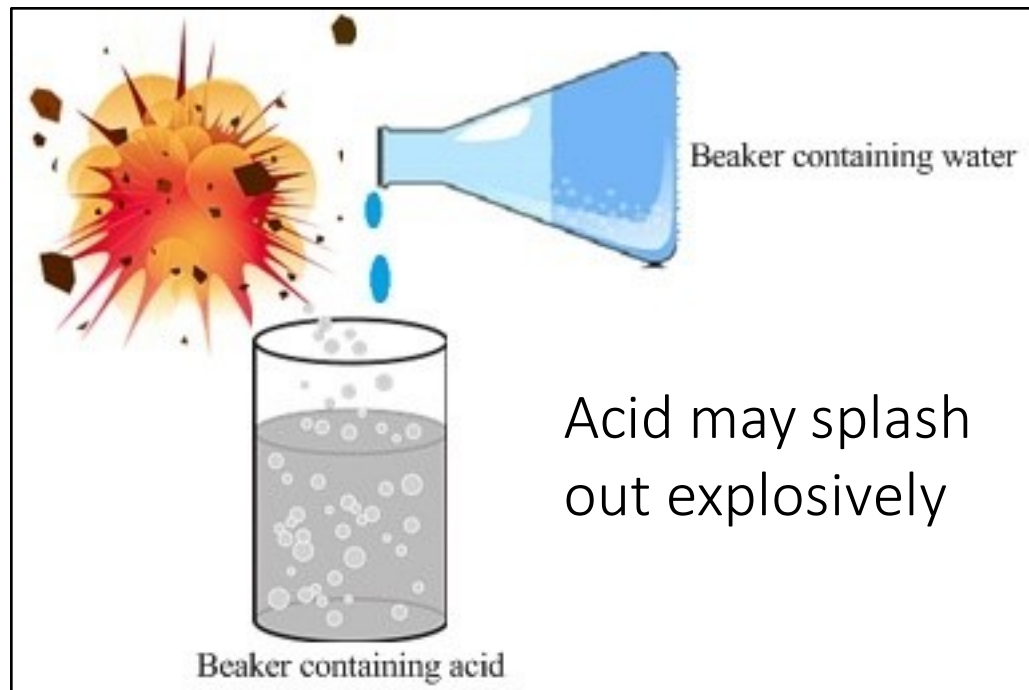


# CS: Always Add Acid to Water

- Dilution of concentrated acid releases a lot of heat
- Adding water to conc. acid releases this heat violently
  - Acid can splash out of the container and onto your face
- Always add conc. acid to water



Else





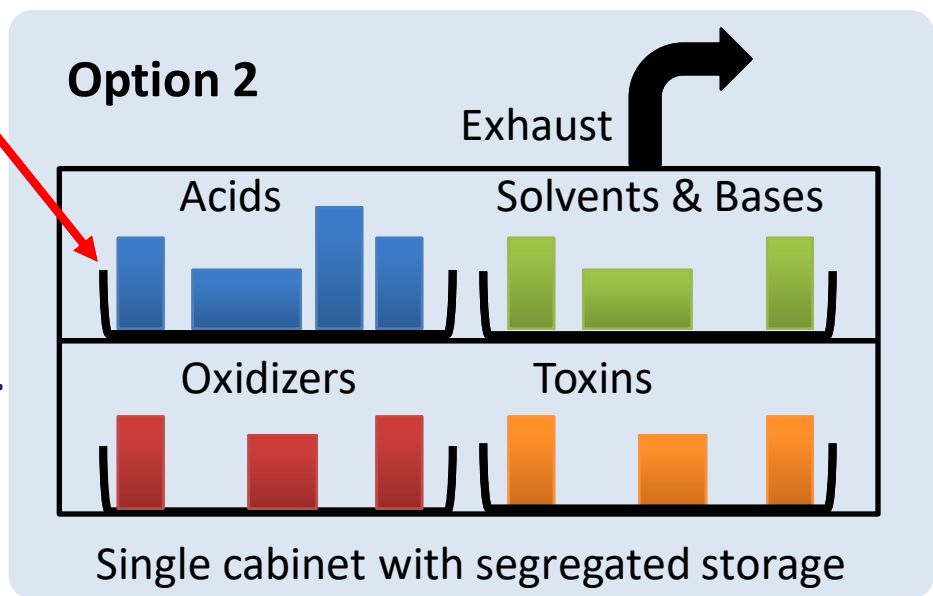
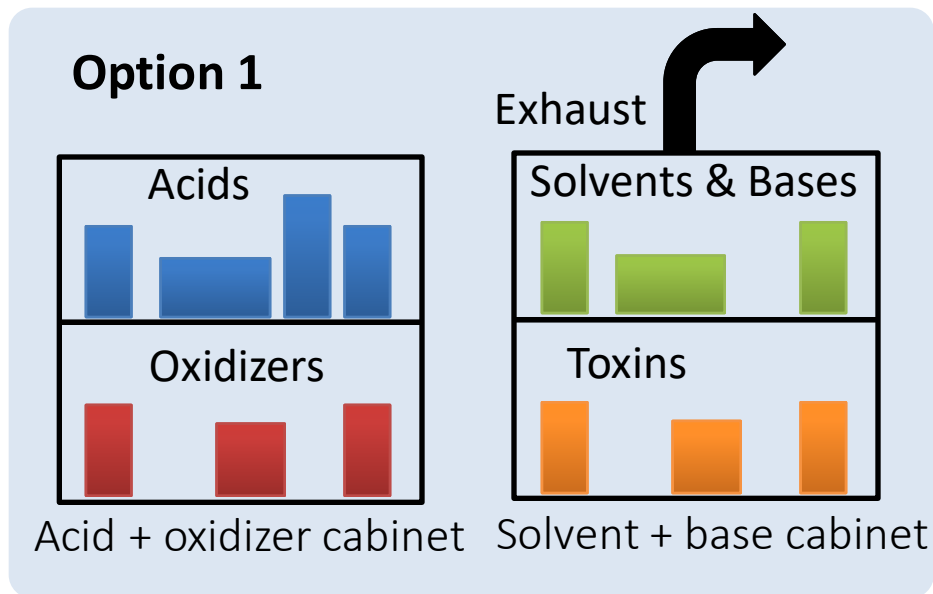
# CS: Storage

- Separate storage for acids; oxidizers; and bases & solvents
  - Acid + solvents are explosive
  - Acid + base is exothermic
  - Oxidizers help combustion
- At the very least use secondary containment



Secondary containment

- Chemicals stored in rated cupboards.
  - Not wooden shelves
  - Large solvent cupboards are exhausted



# HW: Spill Response

## Neutralizing kits



- 10-50 ml of spill
- Experienced student or staff
- Area must be barricaded and labelled

## Large spill kits



- For large spills, 0.1 to 50 litres
- Only by trained staff
- Affected lab to be evacuated

## Emergency evacuation



- For significant toxic, explosive or fire hazards
- Evacuate building
- Trip fire alarm



## D. Hazardous Waste (HW)

Don't cook unknown soups

There is no common method of disposal



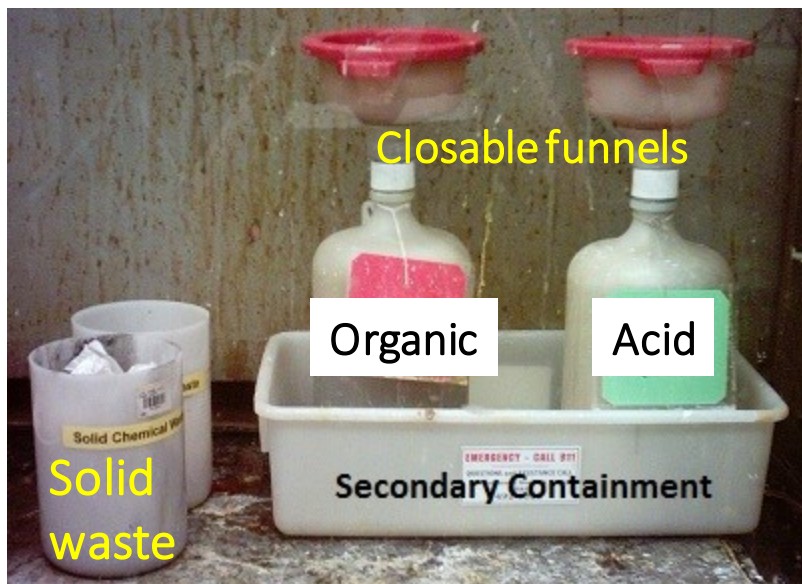
# HW: Segregation

- Don't throw chemicals in sewage (pH<4 or pH>10)
- Accumulate segregated waste in plastic containers
- Waste collected every month. For free
  - [http://ipc.iisc.ac.in/chem\\_waste\\_pickup.php](http://ipc.iisc.ac.in/chem_waste_pickup.php)
  - Unknown waste is NOT accepted
  - Most segregated and labelled waste is accepted



From ehs.uci.edu

No chemicals down sewage



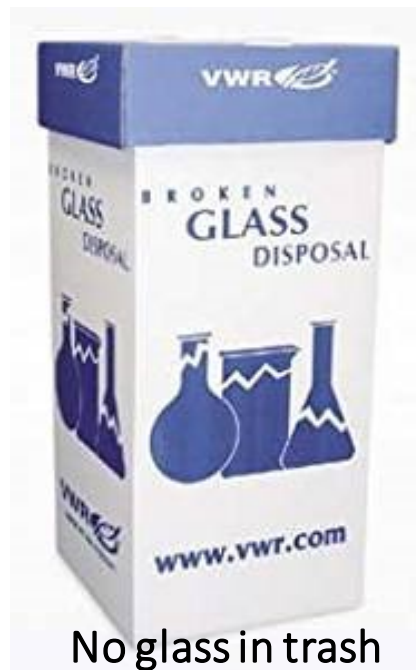
Closable funnels

Organic

Acid

Secondary Containment

From CU Boulder



No glass in trash



No sharps in trash





# Chemical Waste Compatibility

Chemical Hazard Always refer to the SDS	Flammable 	Acid 	Base 	Oxidizer 	Toxic 
Flammable 					
Acid 					
Base 					
Oxidizer 					
Toxic 					

# Chemical Waste Disposal Guideline

## Innocuous aqueous waste

- **Acid** (pH<4)
- **Alkali** (pH> 10)
- Harmless soluble inorganic salt
- Alcohol containing salt
- Hypochlorite solution
- Fine (tlc grade) silica and alumina

These chemicals should be washed down with excess water.

## Organic Solvent

- **Chlorinated**

Example: DCM, Chloroform, Chlorobenzene etc.

- **Non-Chlorinated**

Example: THF, ethyl acetate, hexane, toluene, methanol, etc.



## Red List

- Compounds with transitional metals
- Biocides
- Cyanides
- Mineral oils and hydrocarbons
- Poisonous organosilicon compounds
- Metal phosphides
- Phosphorus element
- Fluorides and nitrites.

## Solid Waste

- Lightly contaminated
- Example: Gloves, empty vials/centrifuge .

## Broken Glassware

Broken glassware are usually collected in plastic-lined cardboard boxes for landfilling. Due to contamination, they are usually not suitable for recycling.



# HW: BioWaste

## Solid bio-waste

- Napkins, blood-stained wipes, etc.
- Same as sanitary waste

## Sharps

- Syringes, needles, etc.
- Sharp boxed labelled bio-waste

## Wet waste

- Blood or tissue/bacteria cultures
- Diluted with 0.5% sodium hypochlorite solution & disposed down the drain

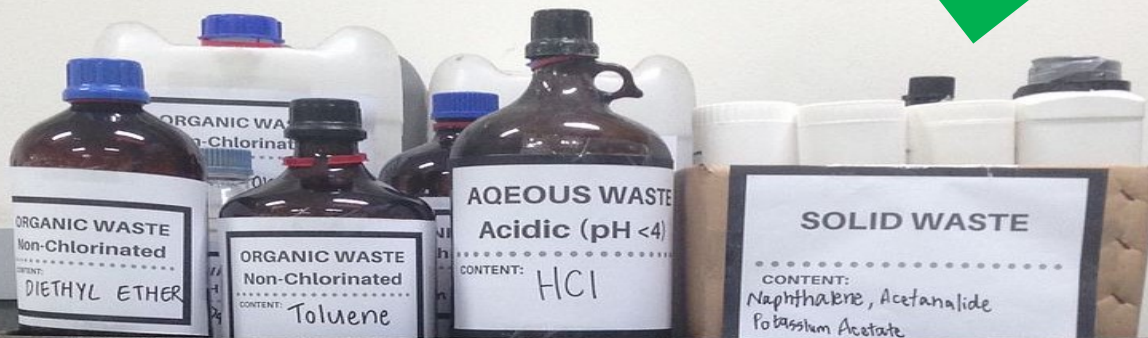
## Carcasses

- Dead rats, animals, etc.
- Store in dedicated freezers
- Dispose separately

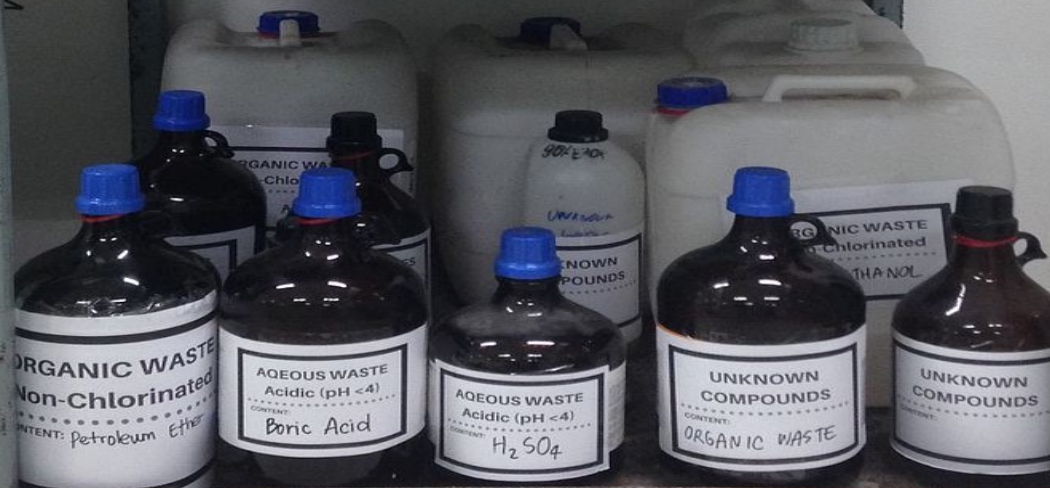


Poor  
upkeep

**CAUTION !**  
**CHEMICAL WASTE**  
**AREA**



**LABEL YOUR CHEMICAL WASTE**





**Restrain Cylinders**

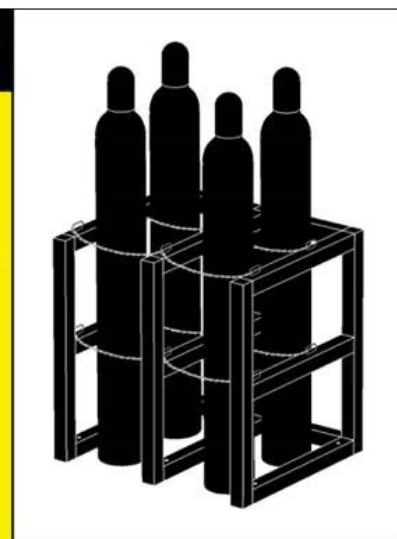
\*Restrain no more than two cylinders in any restraint configuration

**Secure up to two cylinders with  
TWO chains at 1/3 and 2/3 height**

Contact SOM Health and Safety Programs @ 723-0110

**CAUTION**

**GAS  
CYLINDER  
STORAGE  
AREA**



## E. Gas Safety (GS)

Chemical hazard combined with high-pressure hazards

# GS: Hazards

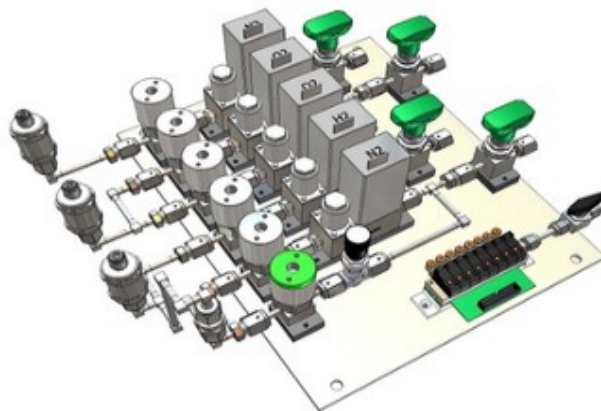
Hazard	Gasses
Compressed inert gas	$N_2$ , Ar, He, $CO_2$
Flammable gasses	$H_2$ , $CH_4$ , $C_2H_6$ , $C_2H_2$ , LPG
Oxidizers	$O_2$ , $N_2O$
Toxic	$CO$ , $H_2S$ , $BCl_3$ , $B_2H_6$ , $Si_2Cl_2$ , $GeH_4$ , $NH_3$
Pyrophoric (instantly catches fire in air)	$SiH_4$ , $PH_3$ ,

Compressed gasses

Hazardous gasses

additional

## Gas detectors

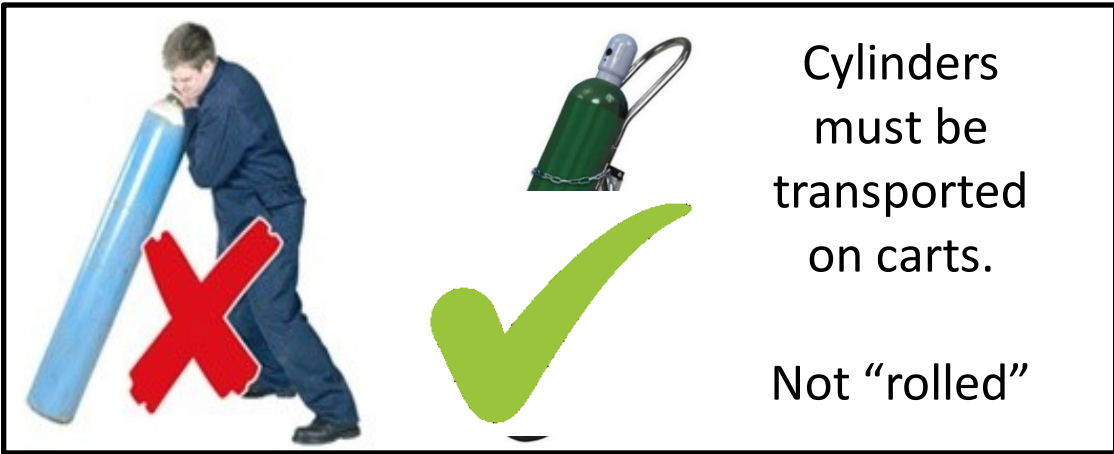


Orbital welded fittings



Gas cabinets

# GS: Cylinder Handling



Cylinders must be transported on carts.  
Not "rolled"

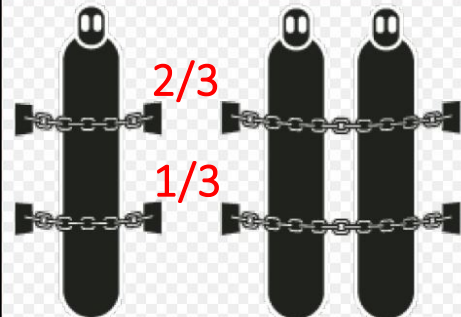
All cylinders must have tags



At least mention gas name & use-status



## Restrain Cylinders



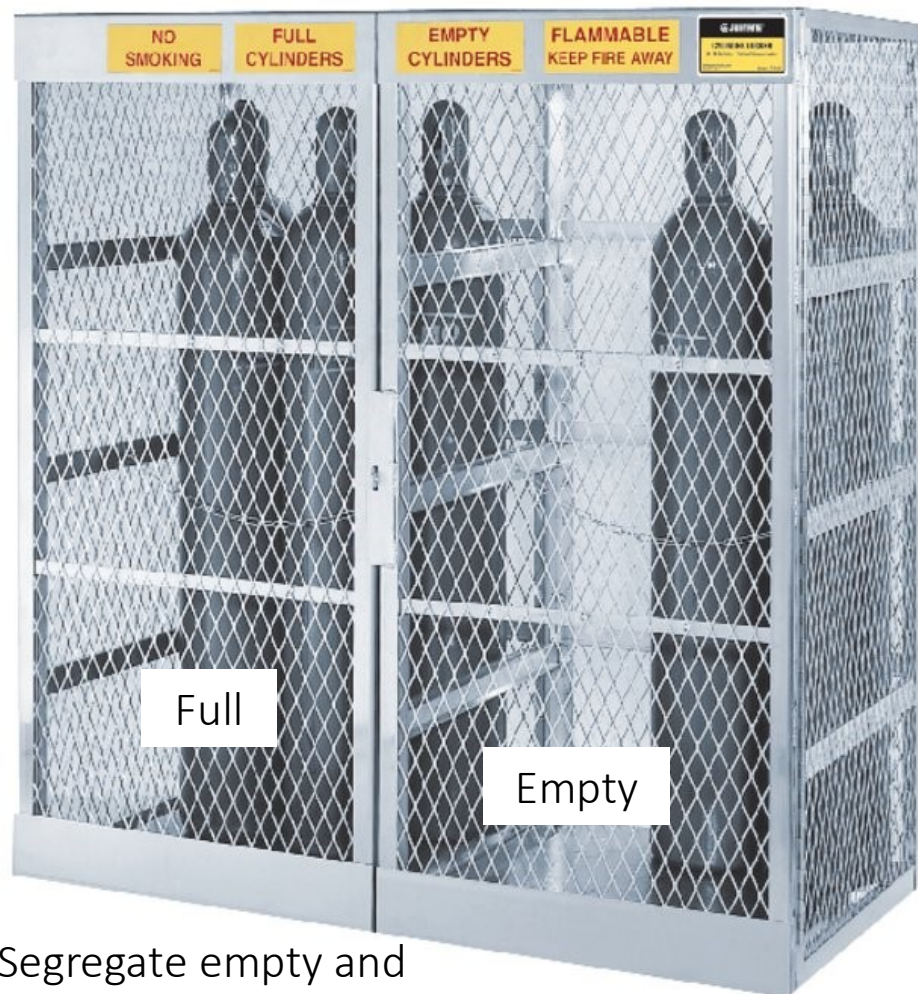
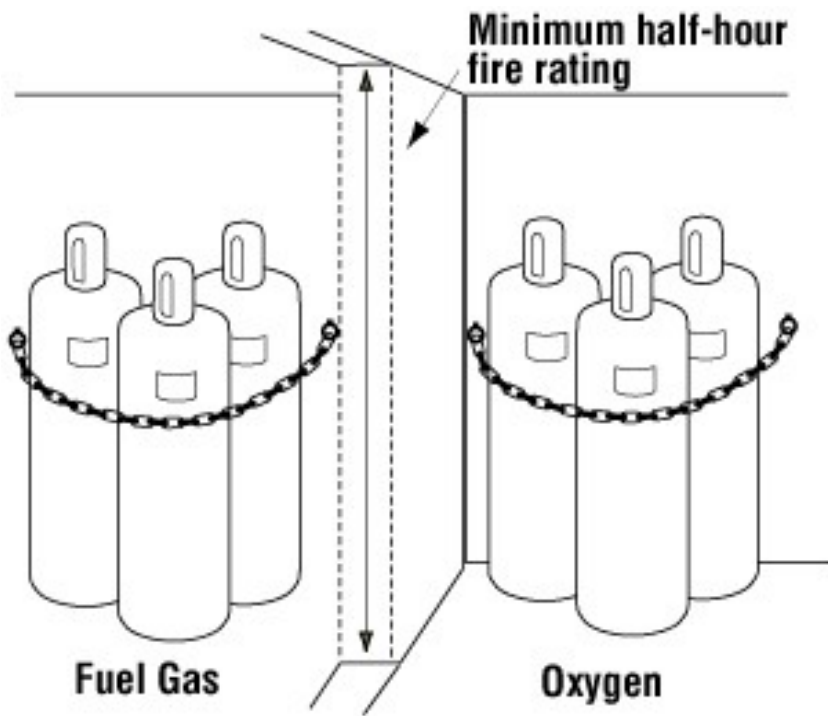
\*Restrain no more than two cylinders in any restraint configuration

Secure up to two cylinders with TWO chains at 1/3 and 2/3 height

In-use cylinders must be chained



# SWP: Cylinder Storage



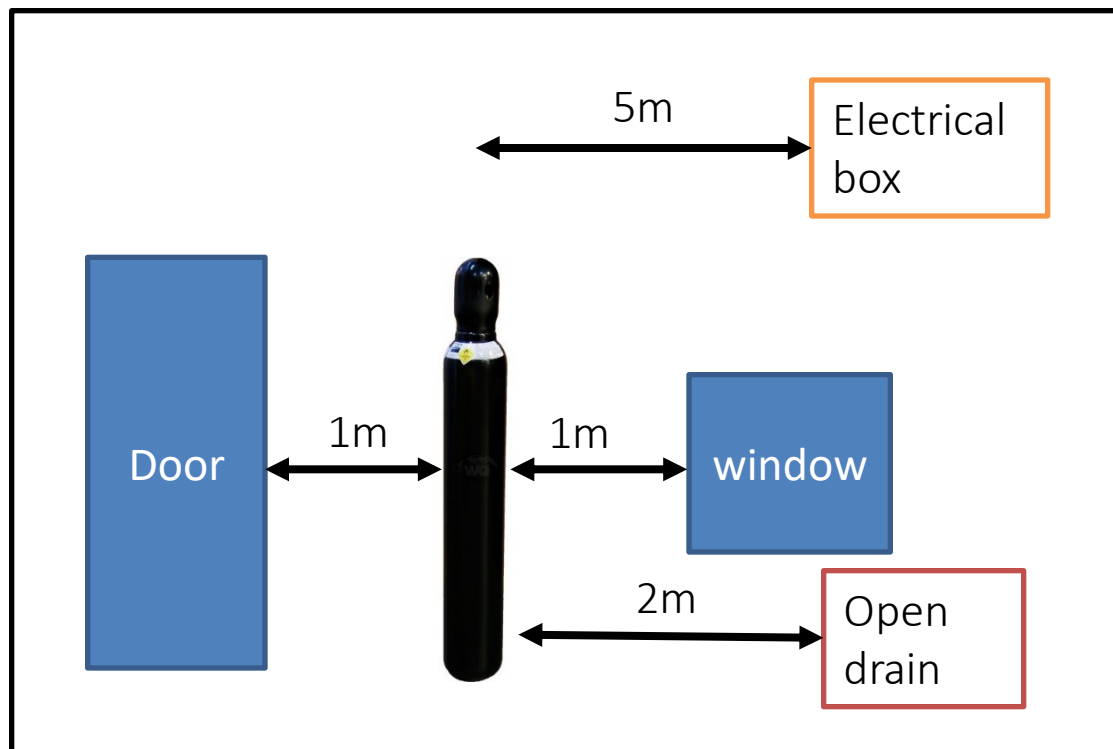
Segregate empty and filled cylinders

# SWP: Cylinder at Point-of-Use



Regulator and valve guard

All cylinders must be used with correct regulator and valve guard

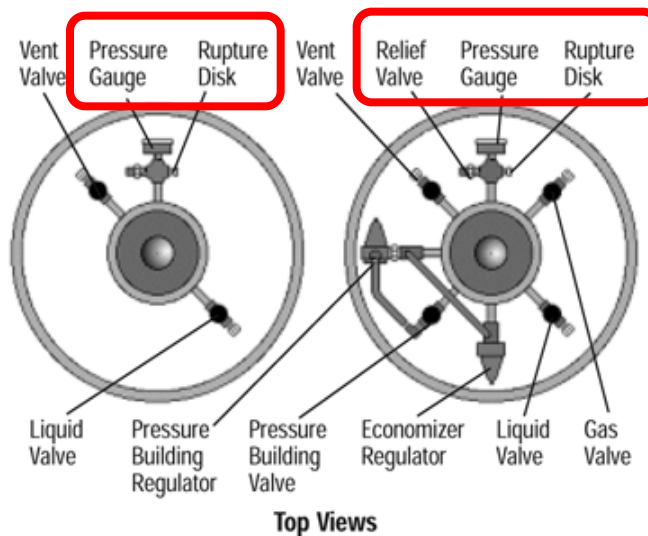
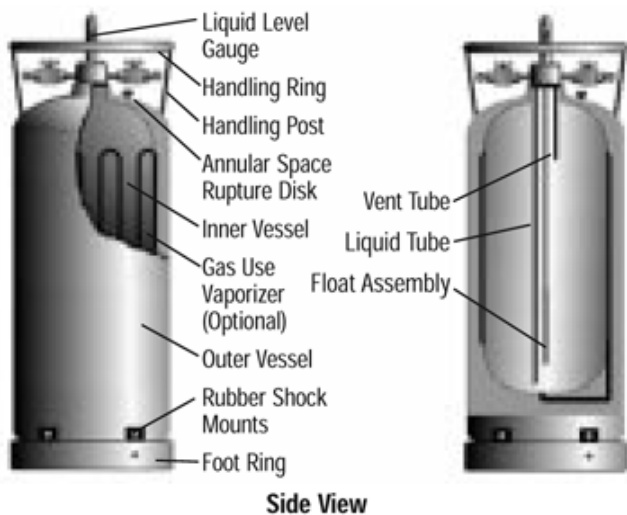


Cylinder must be placed in lab with enough exclusion zone around it.



# GS: Cryogenics

<b>Liquid Oxygen</b>	-297.3 °F (-183 °C)
<b>Liquid Nitrogen</b>	-320.4 °F (-195.8 °C)
<b>Liquid Argon</b>	-302.6 °F (-185.9 °C)
<b>Sublimation Point</b>	
<b>Liquid CO<sub>2</sub></b>	-109.3 °F (-78.5 °C)



Compressed cylinders



# A Tale of Liquid Nitrogen Tank that Exploded

## Safety Report:

The cylinder had been standing at one end of a ~20' x 40' laboratory on the second floor of the chemistry building. It was on a tile covered 4-6" thick concrete floor, directly over a reinforced concrete beam. The explosion blew all of the tile off of the floor for a 5' radius around the tank turning the tile into quarter sized pieces of shrapnel that embedded themselves in the walls and doors of the lab. The blast cracked the floor but due to the presence of the supporting beam, which shattered, the floor held. Since the floor held the force of the explosion was directed upward and propelled the cylinder, sans bottom, through the concrete ceiling of the lab into the mechanical room above. It struck two 3 inch water mains and drove them and the electrical wiring above them into the concrete roof of the building, cracking it. The cylinder came to rest on the third floor leaving a neat 20" diameter hole in its wake. The entrance door and wall of the lab were blown out into the hallway, all of the remaining walls of the lab were blown 4-8" off of their foundations. All of the windows, save one that was open, were blown out into the courtyard.

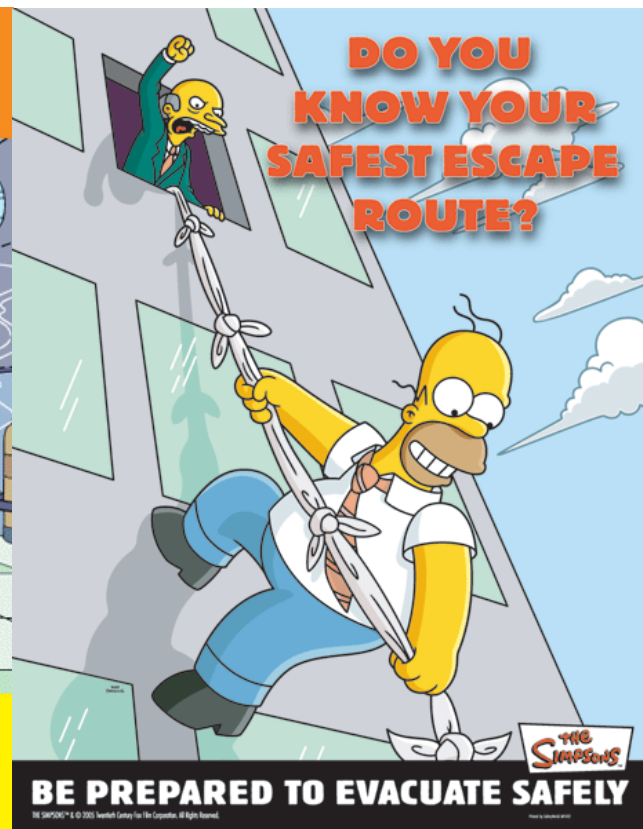
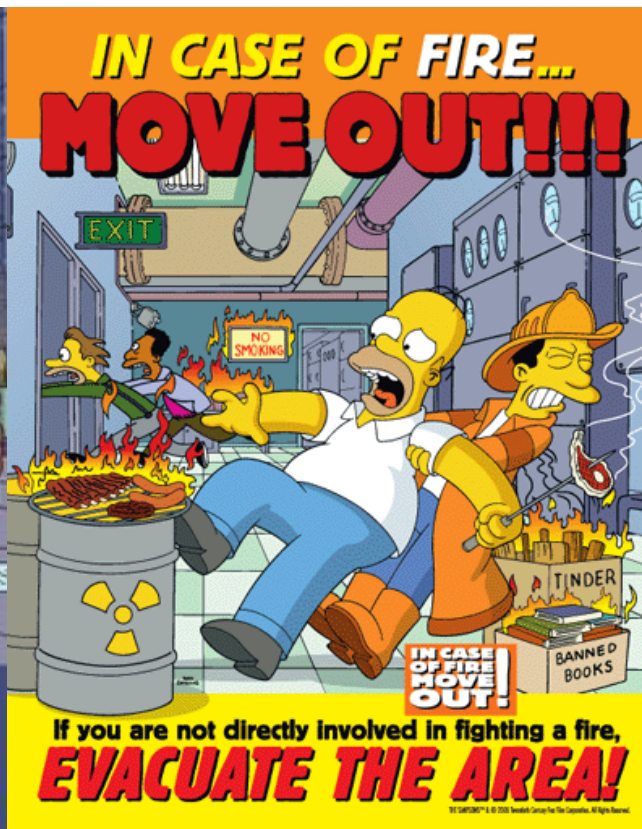
-- University of Texas at Austin



IPC Lab 2018

28-Jan-2019

General Lab Safety



## F: Fire Safety (FS)

Fire: the combustion reaction from interaction of HEAT + FUEL + OXYGEN

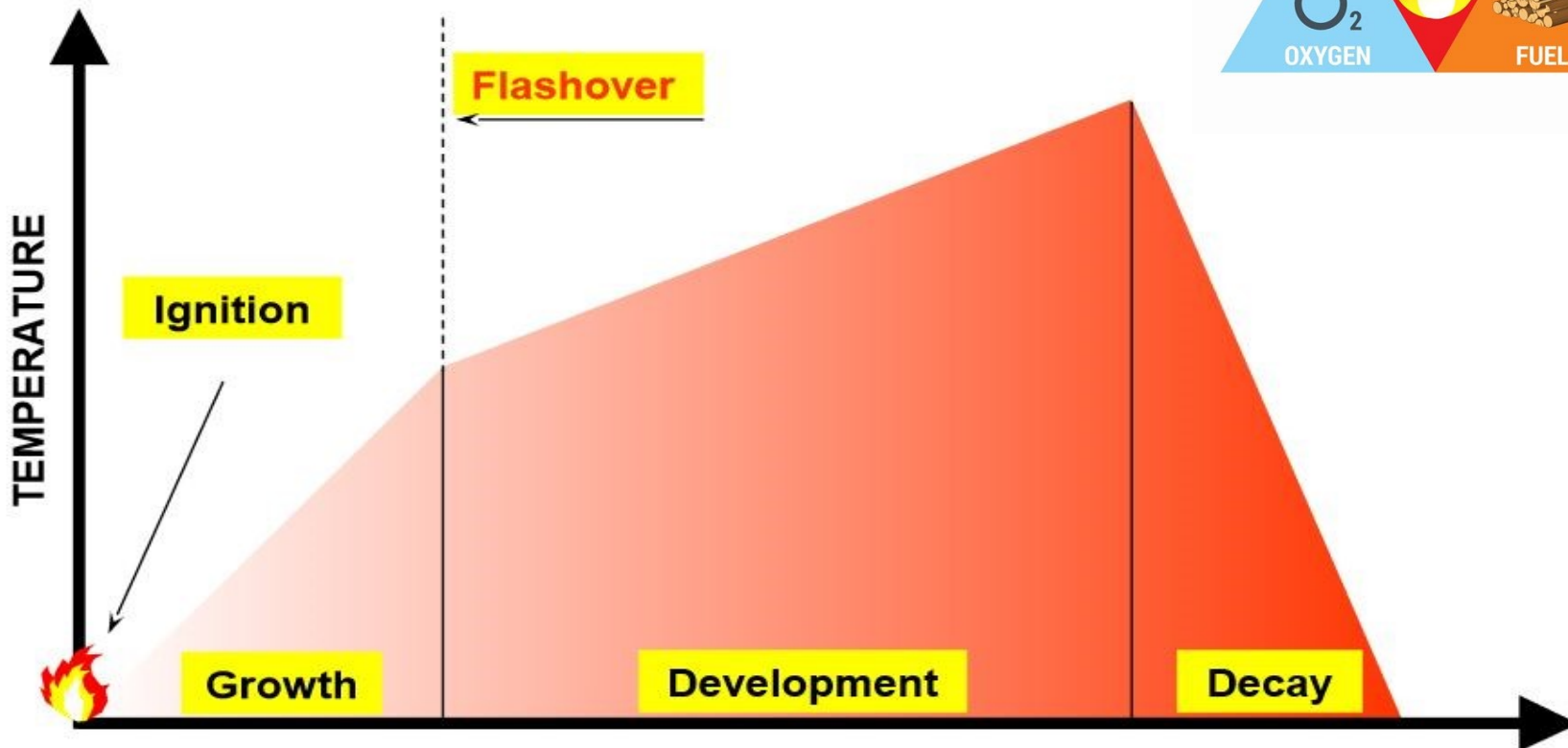
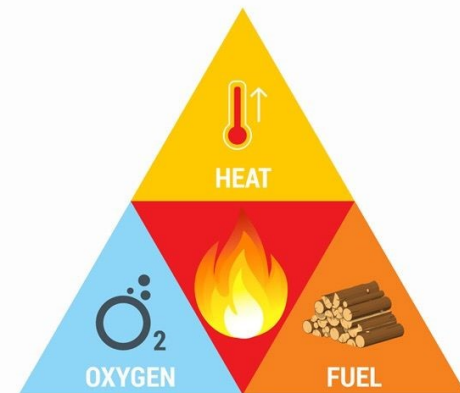
Remove any one and fire cannot spread

Do you know what to do in a emergency?



# FS: Stages of Fire

## Timeline of a Fire



Fires are very difficult to control once it crosses the flashover stage. Therefore, calling fire brigade ASAP makes all the difference

# FS: First Extinguishers



To operate an extinguisher:

**P**ull

**A**im

**S**queeze

**S**weep



Know your extinguisher

Use the correct extinguisher

*(Check your own extinguisher's label for detailed instructions.)*

- All labs must have them in clearly marked places
  - One for each class of hazards (see next slide)
- They expire. Make sure to refill/service them
  - Typically need service every 3 years.

Learn how to use them. Very cheap to organize practical training on test fires



Type Extinguisher	Fire		CLASS A	CLASS B	CLASS C	CLASS D	Electrical	CLASS F	Comments
	Combustible materials (e.g. paper & wood)	Flammable liquids (e.g. paint & petrol)	Flammable gases (e.g. butane and methane)	Flammable metals (e.g. lithium & potassium)	Electrical equipment (e.g. computers & generators)	Deep fat fryers (e.g. chip pans)			
Water	✓	✗	✗	✗	✗	✗	✗	✗	Do not use on liquid or electric fires
Foam	✓	✓	✗	✗	✗	✗	✗	✗	Not suited to domestic use
Dry Powder	✓	✓	✓	✓	✓	✓	✗	✗	Can be used safely up to 1000 volts
CO2	✗	✓	✗	✗	✗	✓	✗	✗	Safe on both high and low voltage
Wet Chemical	✓	✗	✗	✗	✗	✗	✓	✗	Use on extremely high temperatures



# FS: Fire Response

## Fire action



Raise the alarm



Leave the building by the nearest exit



Report to assembly point



Do not return to the building until authorised to do so



Do not use lifts



Trigger fire alarm



**Shout**  
**“FIRE FIRE FIRE FIRE”**

## Fire action



**Raise the alarm**



**Leave the building by the nearest exit**



**Report to assembly point**



**Do not return to the building until authorised to do so**



**Do not use lifts**



Prepare and display an emergency exit plan

Always know the nearest exit



There should be clear signage for all fire exits



# FS: Fire Response

## Fire action



Raise the alarm



Leave the building by the nearest exit



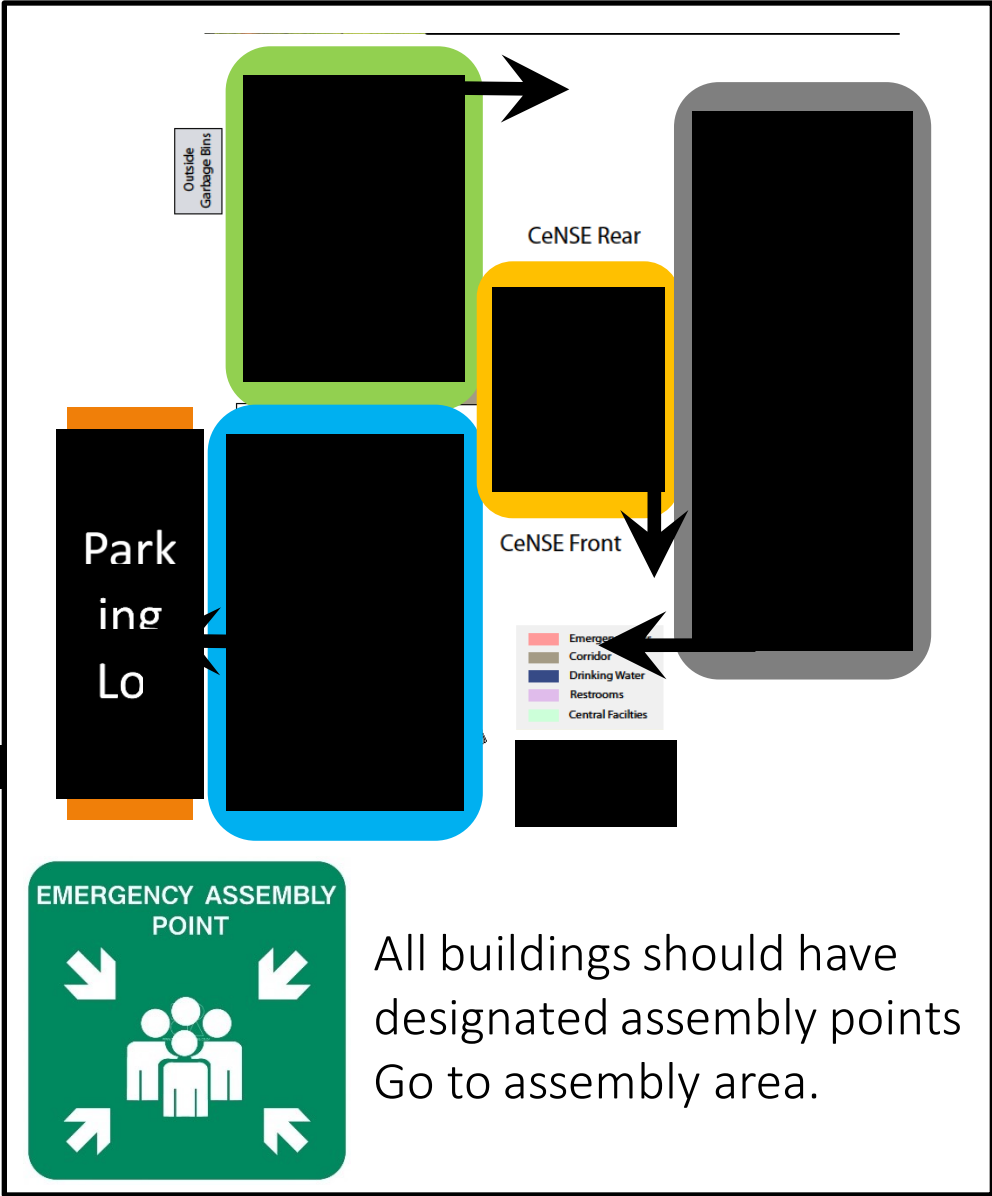
Report to assembly point



Do not return to the building until authorised to do so



Do not use lifts



All buildings should have designated assembly points  
Go to assembly area.



# FS: Fire Response

## Fire action



Raise the alarm



Leave the building by the nearest exit



Report to assembly point



Do not return to the building until authorised to do so



Do not use lifts



Only listen to a designated emergency response team

Don't go for coffee. Stay in assembly area  
We may need a headcount





# FS: Fire Safety Planning

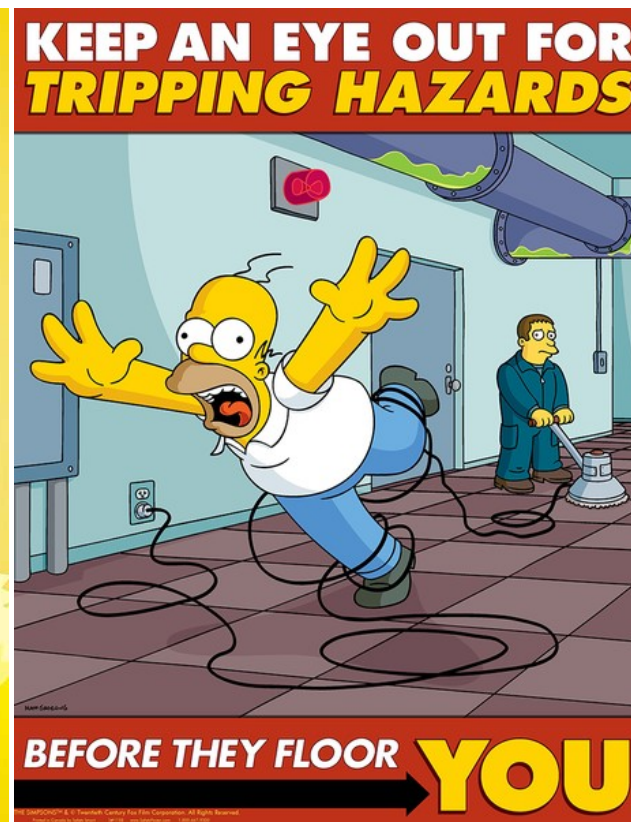
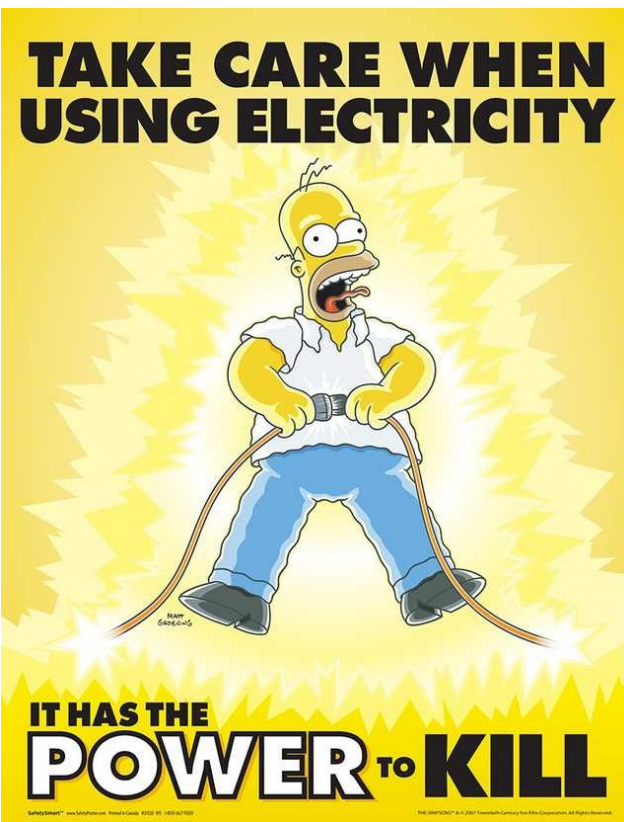
- Install fire alarms
- Have a Emergency Response Team (ERT)
  - Respond to fire/emergency
  - Ensure evacuation
  - Man assembly areas
  - Take attendance
  - Call fire-station, security cell, ambulance, etc.
- Identify fire exits
- Define assembly points
- ALL incidents (big or small) must have a incident report.
  - For evaluation and posterity



CeNSE Incident Report

1	Location	SF-13
2	Type of incident reported	Smell coming out the wet bench
3	Incident in brief	Acidic smell was coming out from wet bench on inspection found glass bottle with yellow solution fallen and leaking, bottle was unlabelled. Another bottle with PMMA solution also found to be leaking
4	The incident attended by	FM team
5	Date and time of the incident	21 <sup>th</sup> Sep , 2017 at around 12:00Hrs

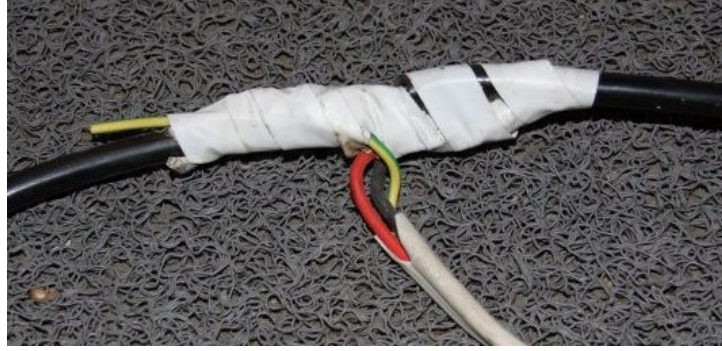
Organize regular mock drills.



## G. Electrical Safety (ES)

Grounding, insulation, phase matching, and electrical distribution system

# ES: Electrical Hazards & Steps for prevention



1. Replace any worn-out or stripped wires



2. Only use 3-pin plugs



3. Earth all equipment



4. Power strips

- Avoid them
- Use power strips with fuse
- Calculate the load



# ES: Electrical Hazards & Steps for prevention



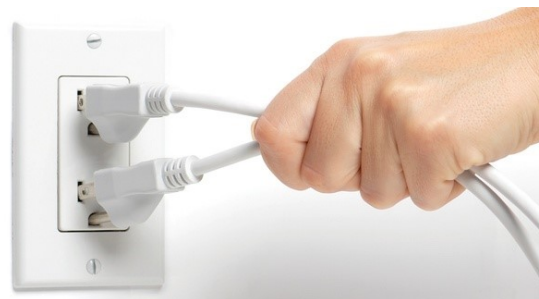
5. No trip hazard



6. No water in vicinity



7. No wet hands



8. Don't pull cord



9. Don't poke power sockets

- No jugaad please



10. Switch off



## H. Laser Safety (LS)

Exposure to laser light can cause significant damage to the skin and eyes  
– typically in the form of burns and direct damage to the retina.

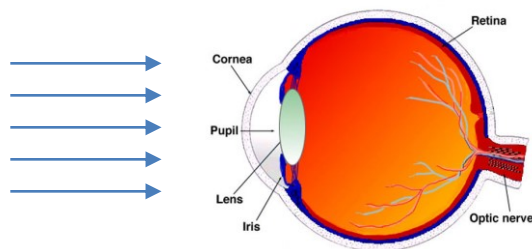


# LS: Hazard from Laser

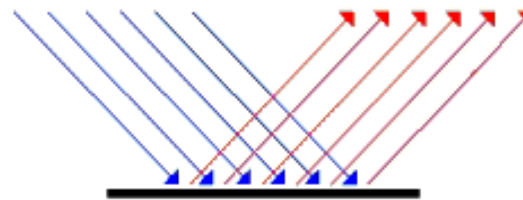
- Exposure to laser light can cause significant damage to the skin and eyes – typically in the form of burns and direct damage to the retina.



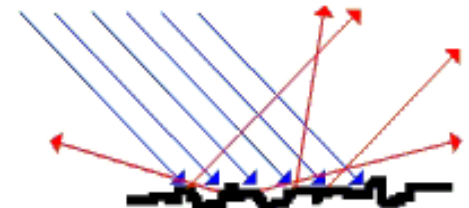
- Injury can be from direct, specular (reflected) or diffuse radiation



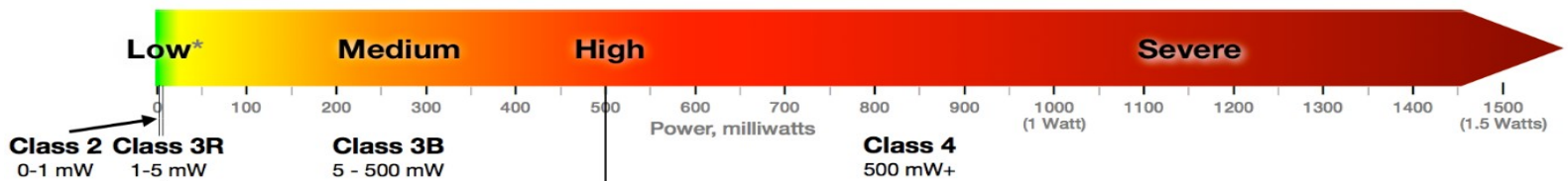
Direct



Specular Reflection  
(smooth surfaces)

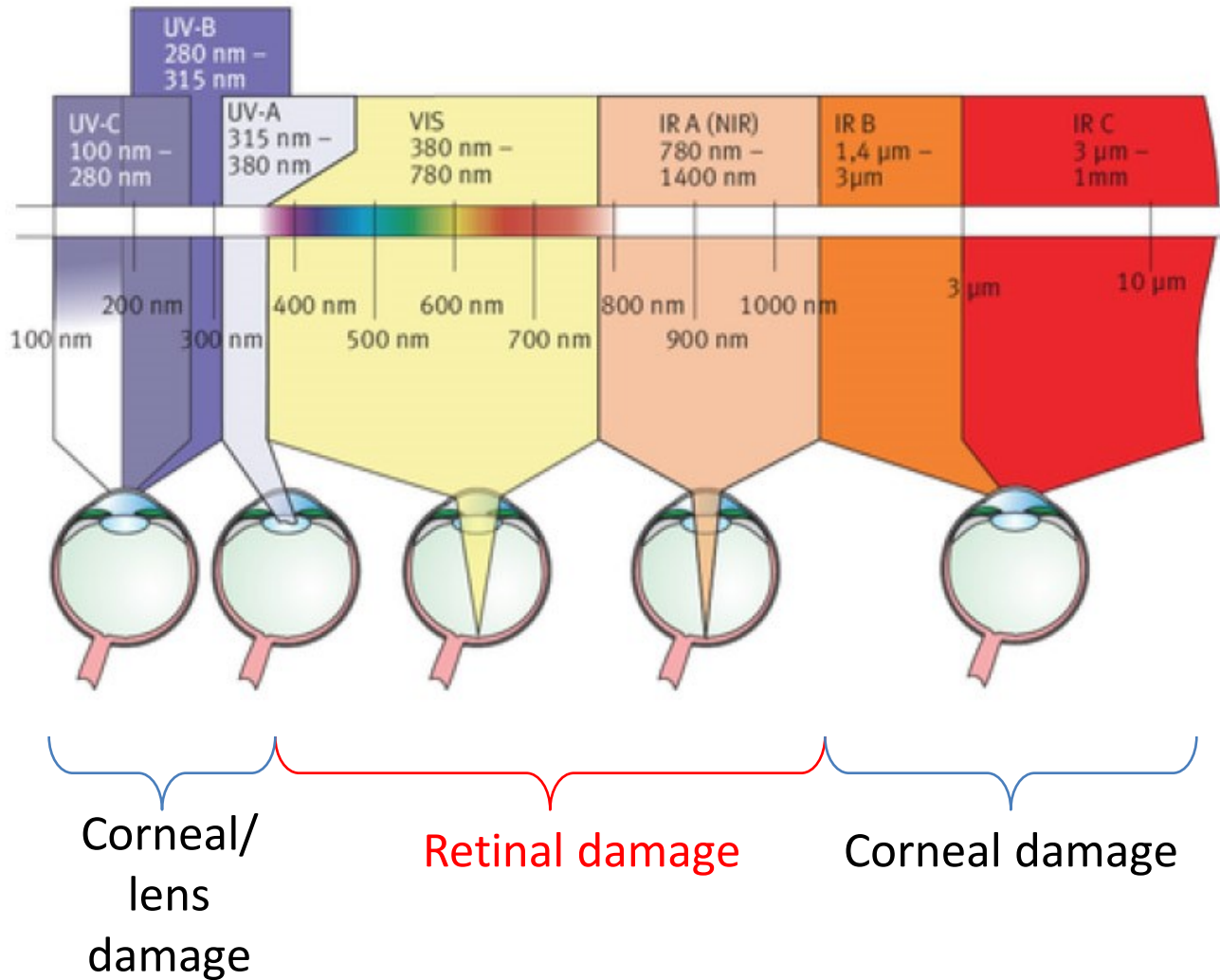


Diffuse Reflection  
(rough surfaces)



Class	Procedure	Training	Eye Exam	Energy	Hazard
1	Not Required	Not Required	Not Required		Non-hazardous to eye
1M	Not Required*	Not Required*	Not Required		Hazardous with collecting optics
2	Not Required	Not Required	Not Required	< 1mW	Hazardous only when person overcomes aversion response
2M	Not Required*	Not Required*	Not Required		Hazardous with collecting optics and/ Class 2 hazard
3R	Not Required	Not Required	Not Required	1 - 5mW	Hazardous when person overcomes aversion response or uses optics
3B	Required	Required	Suggested	5 - 500mW	Direct beam eye hazard. No serious injury from diffuse reflection to eye or to skin
4	Required	Required	Suggested	> 500mW	Hazard to eye & skin from direct, specular or diffuse reflection. Fire hazard

# LS: Effect of wavelengths of laser



Retina damage is often permanent and irreparable.

Cornea and lens damage can heal, although the injury is incredibly painful.



# Selecting laser safety glasses – ANSI Z136 standard

- Choice of laser safety eyewear must be evaluated on case-by-case basis.
- Decide on factors such as the beam path, laser parameters, and lab environment.
  - Discuss your needs with your supervisor/manager
- Common safety standard is ANSI Z136

Uses OD to represent the opacity of the glasses

$$OD = \log_{10} \frac{1}{T} \quad \text{or} \quad T = 10^{-OD}$$

OD = Optical Density  
 T = Transmittance (decimal)

Valid for a given wavelength range



OD	Transmittance
0.0	100%
1.0	10%
2.0	1%
3.0	0.1%
4.0	0.01%
5.0	0.001%
6.0	0.0001%
7.0	0.00001%
8.0	0.000001%
9.0	0.0000001%



# Selecting laser safety glasses – EN207 Standard

- More comprehensive than ANSI standard.
- Provides an LB-Rating which has 3 components:
  - Wavelength range,
  - Laser mode designation, and
  - Scale number (LBn)
- The scale number (LBn) is used with wavelength range and laser mode to determine minimum required level of protection
  - See table

Laser Mode	Engraved Symbol	Pulse Duration
Continuous Wave (CW)	D	>0.25 s
Pulsed Mode	I	>1 $\mu$ s - 0.25 s
Giant Pulsed Mode	R	1 ns - 1 $\mu$ s
Mode Locked	M	< 1ns

Wavelength	Laser Mode	Maximum Power Density (P) or Maximum Energy Density (E)	Minimum Scale Number (LBn)
180 - 315 nm	D	$1 \times 10^{n-3}$ W/m <sup>2</sup> ( $1 \times 10^{n-7}$ W/cm <sup>2</sup> )	$\log_{10}(P)+3$
	I and R	$3 \times 10^{n+1}$ J/m <sup>2</sup> ( $3 \times 10^{n-3}$ J/cm <sup>2</sup> )	$\log_{10}(E/3)-1$
	M	$3 \times 10^{n+10}$ W/m <sup>2</sup> ( $3 \times 10^{n+6}$ W/cm <sup>2</sup> )	$\log_{10}(P)-10$
>315 - 1400 nm	D	$1 \times 10^{n+1}$ W/m <sup>2</sup> ( $1 \times 10^{n-3}$ W/cm <sup>2</sup> )	$\log_{10}(P)-1$
	I and R	$5 \times 10^{n-3}$ J/m <sup>2</sup> ( $5 \times 10^{n-7}$ J/cm <sup>2</sup> )	$\log_{10}(E/5)+3$
	M	$1.5 \times 10^{n-4}$ J/m <sup>2</sup> ( $1.5 \times 10^{n-8}$ J/cm <sup>2</sup> )	$\log_{10}(E/1.5)+4$
>1400 - 1000000 nm	D	$1 \times 10^{n+3}$ W/m <sup>2</sup> ( $1 \times 10^{n-1}$ W/cm <sup>2</sup> )	$\log_{10}(P)-3$
	I and R	$1 \times 10^{n+2}$ J/m <sup>2</sup> ( $1 \times 10^{n-2}$ J/cm <sup>2</sup> )	$\log_{10}(E)-2$
	M	$1 \times 10^{n+11}$ W/m <sup>2</sup> ( $1 \times 10^{n+7}$ W/cm <sup>2</sup> )	$\log_{10}(P)-11$

Valid for a given wavelength range

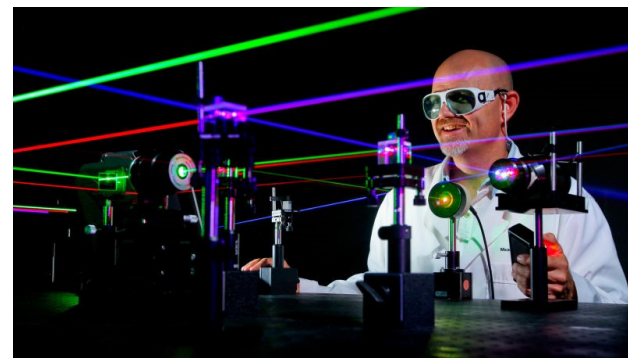






# LS: Safe practices

- Carry out experiments on an optical table such that all laser beams travel horizontally.
- Do not place laser beams at eye level.
- Turn off the laser before manipulating beam path
- If possible, reduce the output power of a laser during alignment procedures.
- All beams should be terminated at the table
- Laboratory doors should be closed whenever a laser is in use.
- Be aware that lenses and other optical devices may reflect a portion of the incident beam from the front or rear surface.
- No jewellery, watches, etc



General Lab Safety



## I: Radiation Safety (RS)

X-rays, Magnetic fields, Radioactivity, etc.



# RS: X-ray Protection Practices

## As Low As Reasonably Achievable (ALARA)

### Time

- Reduce time spent with X-rays on
- Track per day exposure

### Distance

- Keep as far as possible
- Don't loiter

### Shielding

- Reduce radiation to < milli Roentgens per hr.



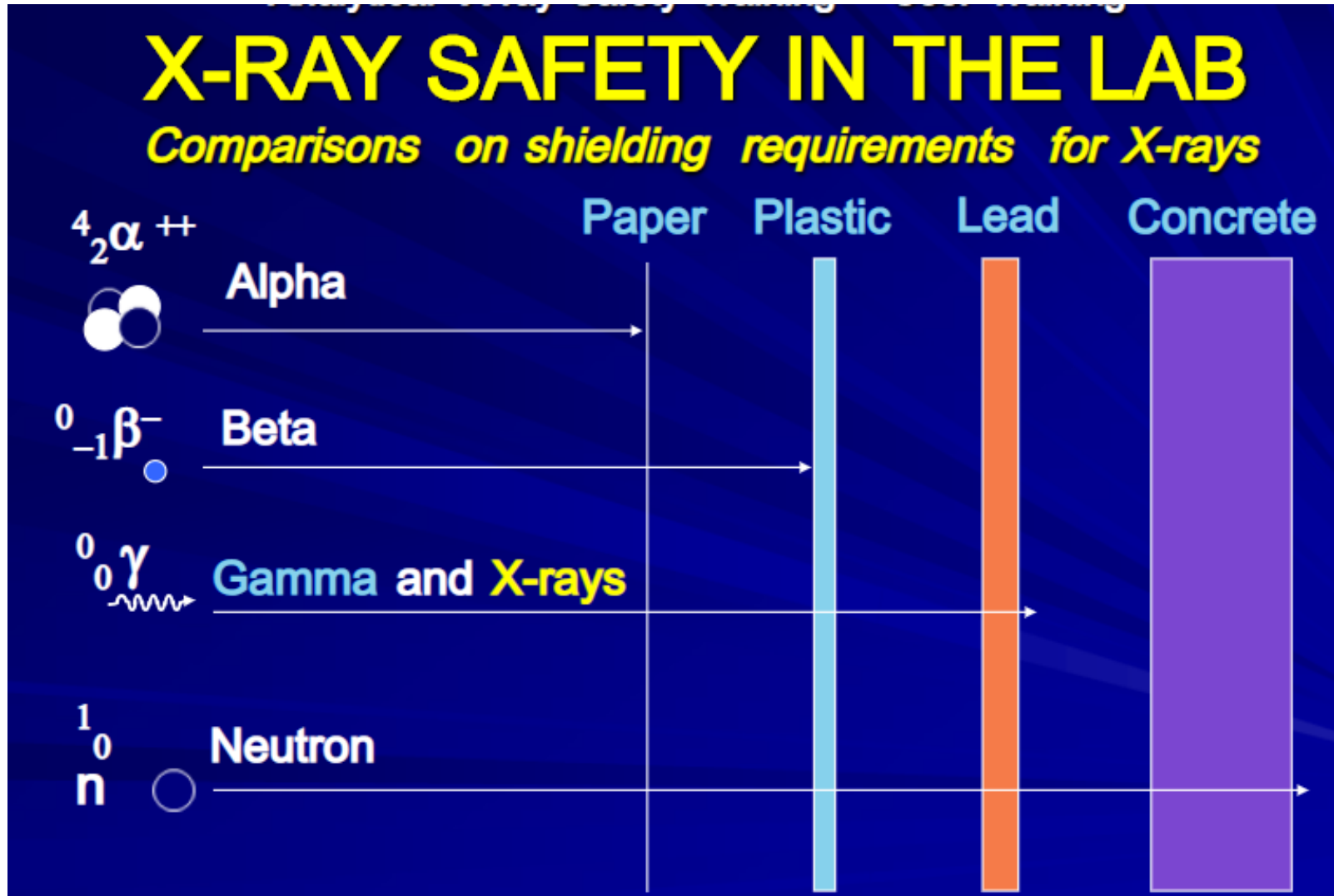
Exposed X-ray sources and self-designed equipment may need to be registered with AERB on eLORA



Depending on the instrument, may need thermoluminescent dosimeter (TLD), a type of radiation dosimeter



# RS: Shielding





# RS: Radioactive Materials

From Princeton.edu



- Use absorbent paper on all surfaces
- Use appropriate shielding
- Use dedicated equipment
- Clearly label everything

- Store material under lock and key
- Keep a track of usage
- Supervise visitors
- Segregate waste



# RS: Limit of exposure for Ionizing Radiation

## Occupational Worker

- an effective dose of 20 mSv/yr running averaged over five years
- an effective dose of 30 mSv in any year;
- an equivalent dose to the lens of the eye of 150 mSv in a year;
- an equivalent dose to the extremities (hands and feet) of 500 mSv in a year
- an equivalent dose to the skin of 500 mSv in a year;

## Apprenticeship & Trainee

- an effective dose of 6 mSv in a year;
- an equivalent dose to the lens of the eye of 50 mSv in a year;
- an equivalent dose to the extremities (hands and feet) of 150 mSv in a year and
- an equivalent dose to the skin of 150 mSv in a year

## Public

- an effective dose of 1 mSv in a year;
- an equivalent dose to the lens of the eye of 15 mSv in a year; and
- an equivalent dose to the skin of 50 mSv in a year.

During pregnancy: equivalent dose limit to embryo/fetus shall be 1 mSv



# RS: High magnetic-fields

- People who have pace makers should consult before entering lab
- Strong magnetic fields extend beyond strong magnets.
  - Lines indicating 10-G and 100-G levels must be drawn on the floor of the lab.
- Behind the 100 G line:
  - Credit and ATM cards
  - Steel, iron or other magnetic objects
  - screwdrivers, wrenches and other hand tools lying around the lab
  - All compressed gas cylinders must be kept behind the 100G line

[www.reddit.com/r/osha](http://www.reddit.com/r/osha)





## J: Identify Hazards

Think about safety. It is part of your job.



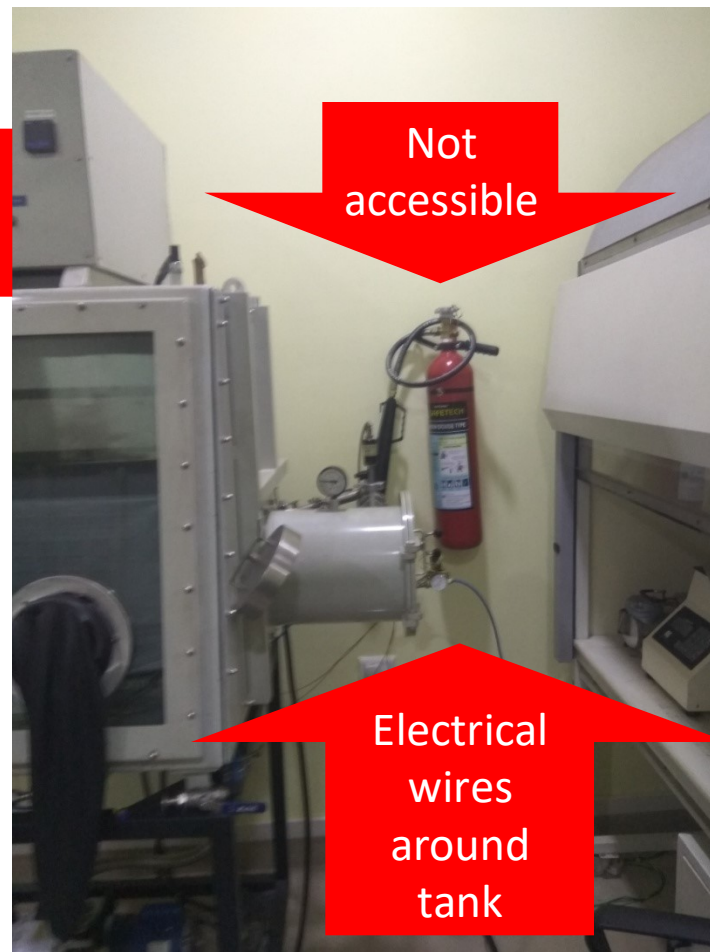


# Find the hazards





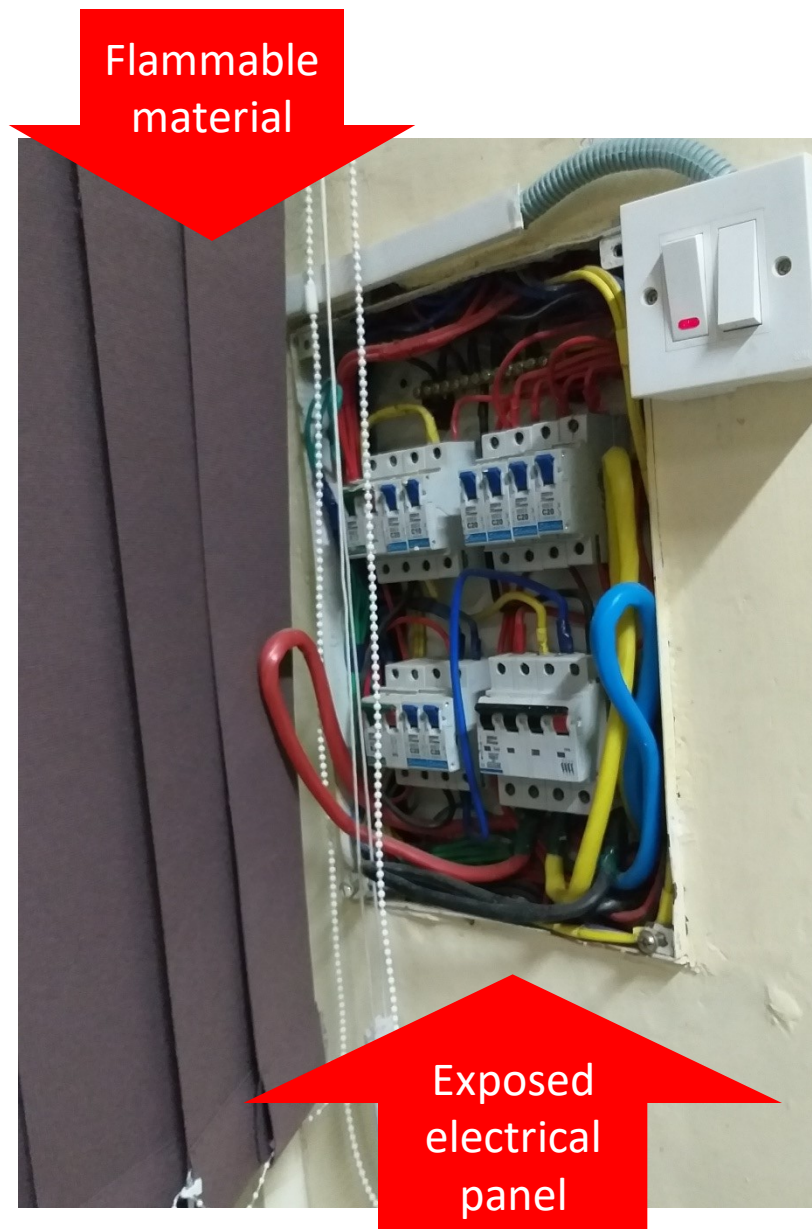
# Find the hazards



# Find the hazards



Electrical  
boxes near  
tank



Flammable  
material

Exposed  
electrical  
panel



# LABORATORY RISK ASSESSMENT





# Housekeeping

- Safety orientation is mandatory
  - Make sure to mark attendance
- Please work with OLSEH for safety drills and fire alarms.
  - These are mandatory.
- Homework....
  - Read safety manual
  - If needed, attend specialized orientation for lasers and NNfC
  - Be prepare for safety audits.
- If you see unsafe conditions, speak up.
  - Email Dr. Sushobhan Avasthi, CeNSE safety warden ([savasthi@iisc.ac.in](mailto:savasthi@iisc.ac.in))
  - Escalate to [safety.cense@iisc.ac.in](mailto:safety.cense@iisc.ac.in)
  - Talk to OLSEH ([www.olseh.iisc.ac.in](http://www.olseh.iisc.ac.in))
  - Contact Prof. Satish Patil or institute safety committee



Thank You  
[www.olseh.iisc.ac.in](http://www.olseh.iisc.ac.in)