Chemical

SAFETY AND SECURITY TRAINING

Chemical Safety and Security Training

Balitvet – Indonesian Institute for Veterinary Science

July 25-27, 2011

International Year of CHEMISTRY 2011

SAND No. 2010-7455 P, SAND No. 2009-8395P, SAND No. 2011-4604P
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

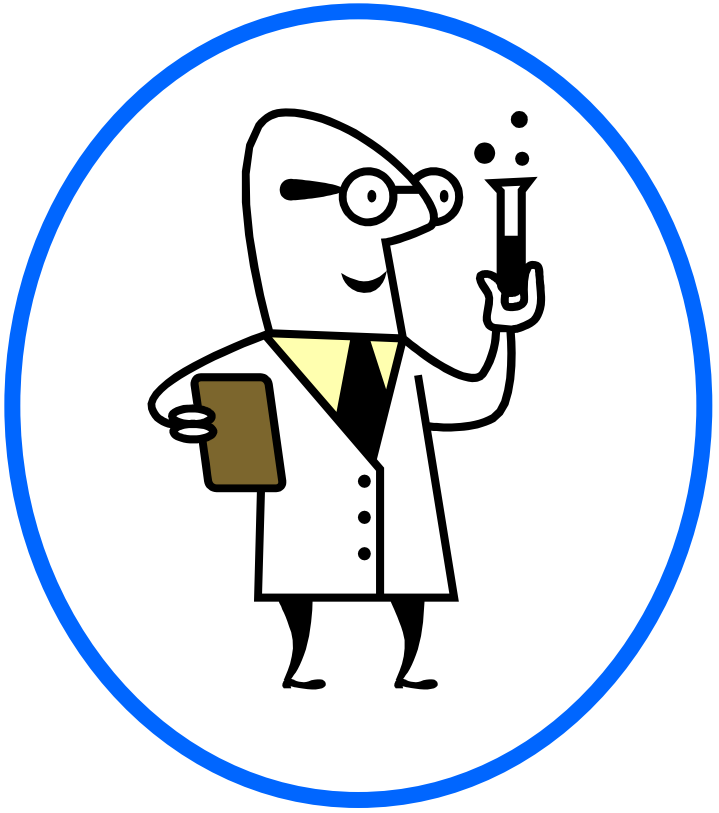
Sandia National Laboratories

Personal Protective Equipment (PPE) and Safety Equipment Performance Specifications

Worker Protection

SOURCE

PATHWAY



Personal Protective Equipment (PPE)

- **Should be a last resort, but may be necessary if:**
  - **engineering controls inadequate or being installed**
  - **administrative controls don't do the job**
  - **emergency response or spill cleanup**
  - **supplement other control techniques if can't achieve required level**
- **Depends upon human behavior**
  - **proper selection, fit and comfort issues**
- **Hazard is still present with PPE …**

US/OSHA PPE Regulations

- Eye and face protection
  - 29 CFR 1910.133
- Respiratory protection
  - 29 CFR 1910.134
- Head protection
  - 29 CFR 1910.135
- Foot protection
  - 29 CFR 1910.136
- Hand protection
  - 29 CFR 1910.138
- Hearing Protection
  - 29 CFR 1910.95

www.cdc.gov/nasd/menu/topic/ppe.html

www.osha.gov/SLTC/personalprotectiveequipment/index.html

www.osha.gov/Publications/osha3151.pdf

Training and Qualification

Employees should be trained to know:

- When PPE is necessary?
- What PPE is necessary?
- How to properly don, doff, adjust and wear PPE.
- Limitations of PPE.
- Proper care, storage, maintenance, useful life, and disposal of PPE.

www.free-training.com/osha/ppe/ppemenu.htm

Training and Qualification

Retraining is necessary when there is:

- **Change in the process.**
- **Change in type of PPE used.**
- **Inadequate employee knowledge or use of PPE.**
  - retrain to reinforce understanding or skill

Personal Protective Clothing (PPE)

- Evaluate task, select appropriate type and train to use it properly
  - lab coats, gowns, aprons
  - safety glasses (with side shields), goggles, face shields
  - gloves
- Remove PPE before leaving the lab

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Protective Equipment Works

"It's a hot day, why wear a lab coat?"

An experiment reacted unexpectedly and a flammable solvent from a hood splashed out and landed on the bottom of the lab coat

Eye and Face Protection

- **Thousands are blinded each year from work-related eye injuries.**
- **Nearly *three out of five* workers are injured while failing to wear eye and face protection.**

Eye & Face Protection

- **Safety glasses**
- **Goggles**
- **Face shield**

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Eye and Face Protection

Eye protection shields eyes by:

- **Primary protection:**
  - **Safety glasses with side shields protect from flying objects.**
  - **Goggles prevent objects from entering under or around the eyewear.**
- **Secondary protection:**
  - **Face shields**
    - **Combine with safety glasses or goggles**
    - **Do not protect from impact hazards**

Hazard Assessment

Hazard Type	Hazard Type	Common related tasks
Impact	Flying objects such as large chips, fragments, particles, sand, and dirt	Chipping, grinding, machining, masonry work, wood working, sawing, drilling, riveting, sanding,…
Heat	Anything emitting extreme heat	Furnace operations, pouring, casting, hot dipping, welding, …
Chemicals	Splash, fumes, vapors, and irritating mists	Acid and chemical handling, degreasing, plating, and working with blood or OPIMs
Dust	Harmful dust	Woodworking, buffing, and general dusty conditions
Optical Radiation	Radiant energy, glare, and intense light	Welding, torch-cutting, brazing, soldering, and laser work

Biohazards

Use caution anytime you are working with blood or other bodily fluids.

Contaminated blood or bodily fluids may result in transmission through the eyes.

Eye and Face Protection

Optical Hazards

- Welding helmets are secondary protection to shield from UV, heat, and impact.

- Exposure to laser beams requires suitable laser safety goggles with protection for the specific wavelength.

Eye and Face Protection Requirements

- **Eye and face protection should comply with the American National Standards Institute:**
  - **ANSI Z87.1-1989**

- **Ensure employees who wear prescription lenses or contact lenses:**
  - **Use safety eyewear that incorporates the prescription**
  - **Use eye protection that can be worn over prescription lenses**

Additional Considerations

- Provide adequate protection against the specific hazards.
- Safe design and construction for the work to be performed.
- Comfortable.
- Don’t interfere with the wearer’s movements.
- Durable!
- Capable of being disinfected.
- Easily cleaned.
- Distinctly marked to indicate they are approved eye protection.
- Worker satisfaction.
    - – Include workers in the selection process.

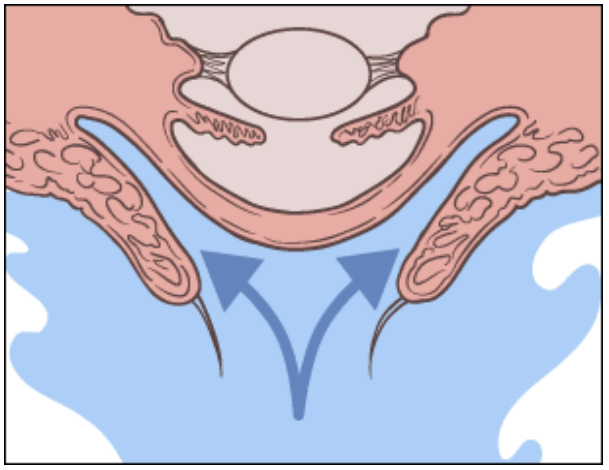
Eyewash and Showers

- **US regulations**
  - **29 CFR 1910.151(c)**
  - **ANSI Z358.1-2004**
- **Types**
  - **eyewash**
  - **shower**
  - **drench hose**
- **Concerns**
  - **drainage**
  - **freezing**
  - **contaminated water**

Eyewash and Showers

- **Know their locations**
- **Maintenance and testing program**
- **Concerns:**
  - **drainage**
  - **freezing**
  - **contaminated water**

Eyewash Standards



- Eye wash stations
  - Minimum 0.4 to 3.5 gal/min (1.4 – 13.2 l/min.)
  - Flush for 15 minutes
- Provide flow for both eyes
  - Hold eyes open
  - Tepid, pH match eye (preferred)
- Easily accessible locations
  - 33 to 45 in. (84-114 cm) from floor
  - 6 in. (15cm) from wall
- Test weekly
  - Portable: clean/refill (6 mo – 2 yrs)
- Various types

ANSI Z358.1
NC DOL Guide:
www.nclabor.com/osha/etta/indguide/ig28.pdf

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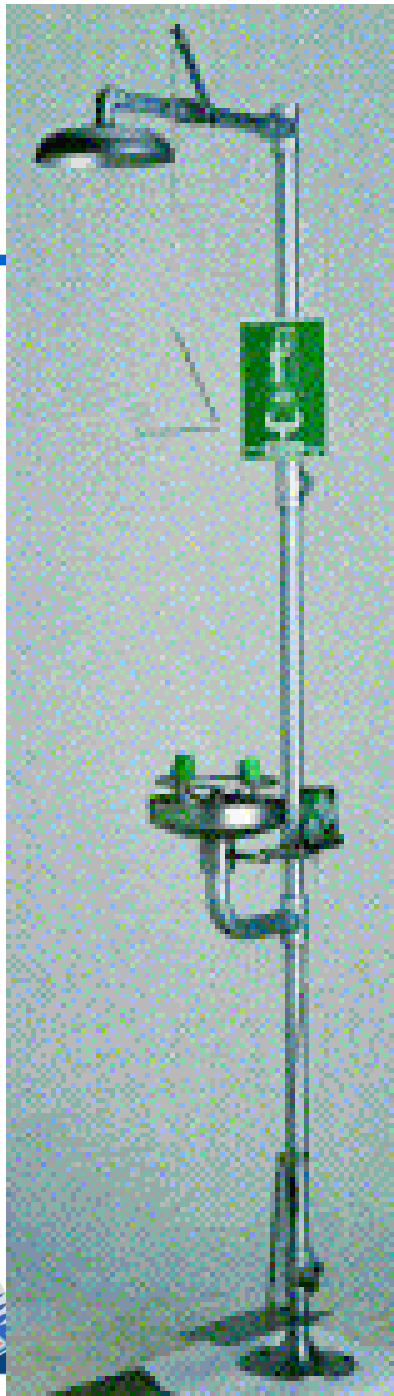
Safety Shower Standards

- **Within 55 ft. (17 m) or 10 seconds**
  - **Normal walking = 3.8 mph (6.1 km/hr)**
- **Test monthly**
- **Pull within reach (highly visible)**
  - **82 to 96 in. high (208 – 244 cm)**
  - **Deliver 20 in (51 cm) column**
  - **Height: 60” (152 cm) above floor**
- **20–30 gal/min (76-114 L/min)**
- **Tepid: 60 to 100 °F (16 – 38°C)**



Safety Shower Standards cont.

Consider:

- **Drains**
- **Blankets/modesty curtains**

Avoid or protect electrical outlets

- **ANSI Z358.1-2004**

Blocked Eyewash & Safety Shower

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Dirty Eyewash Station

Blocked Eye Wash Station

Hand Protection

- **Glove considerations**
  - **Type glove**
    - **Dexterity required**
    - **Chemical & physical**
      - **material**
      - **strength**
    - **Exposure time**
      - **breakthrough time**
    - **Size, comfort, reusable/disposable**
  - **Manufacturer selection charts**

Glove Selection

- **Considerations:**
  - **Chemicals (splashes vs immersion)**
  - **Thermal (extreme heat/cold)**
  - **Abrasion; cuts; snags; splinters; punctures**
  - **Grip: oily, wet, dry**
  - **Comfort, fit, size**
  - **Ergonomics**

Chemical Protective Gloves/ Clothing

- **Permeation (“silent killer”)**
  - **Substances pass through intact material on a molecular level.**
- **Penetration**
  - **Substances pass through seams, zippers, stitches, pinholes, or damaged material.**
- **Degradation**
  - **Substance damages material making it less resist or resulting in physical breakdown.**
- **Contamination**
  - **Substances transferred inside material (improper doffing or decontamination).**

Permeation Rate (PR)	Permeation Breakthrough (PB)	Permeation Degradation rate (DR)
E- Excellent; permeation rate of less than 0.9 mg/cm^2/min	>Greater than (time - minutes)	E - Excellent; fluid has very little degrading effect.
VG - Very Good; permeation rate of less than 9 mg/cm^2/min	< Less than (time - minutes)	G - Good; fluid has minor degrading effect.
G - Good; permeation rate of less than 90 mg/cm^2/min		F - Fair; fluid has moderate degrading effect.
F - Fair; permeation rate of less than 900 mg/cm^2/min		P - Poor; fluid has pronounced degrading effect.
P - Poor; permeation rate of less than 9000 mg/cm^2/min		NR - Fluid is not recommended with this material.
NR - Not recommended; permeation rate greater than 9000 mg/cm^2/min		† Not tested, but breakthrough time > 480 min DR expected to be Good to Excellent
		†† Not tested, but expected to be Good to Excellent based on similar tested materials

Gloves

- **It's important to have the right glove for the job and know how long it will last.**

- **Glove Chart Examples:**
  - **Consider several glove manufactures data before final selection.**
  - www.bestglove.com/site/chemrest/

The first square in each column for each glove type is color coded. This is an easy-to-read indication of how we rate this type of glove in relation to its applicability for each chemical listed. The color represents an overall rating for both degradation and permeation. The letter in each square is for Degradation alone…

- GREEN: The glove is very well suited for application with that chemical.
- YELLOW: The glove is suitable for that application under careful control of its use.
- RED: Avoid use of the glove with this chemical.

CHEMICAL	LAMINATE FILM — BARRIER			NITRILE — SOL-VEX			UNSUPPORTED NEOPRENE — 29-865			SUPPORTED POLYVINYL ALCOHOL — PVA			POLYVINYL CHLORIDE (Vinyl) — SNORKEL			NATURAL RUBBER — CANNERS AND HANDLERS*			NEOPRENE/ NATURAL RUBBER BLEND — CHEMI-PRO*		
	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate
1. Acetaldehyde	■	380	E	P	—	—	E	10	F	NR	—	—	NR	—	—	E	7	F	E	10	F
2. Acetic Acid	■	150	—	G	270	—	E	60	—	NR	—	—	F	180	—	E	110	—	E	260	—
3. Acetone	▲	>480	E	NR	—	—	E	10	F	P	—	—	NR	—	—	E	10	F	G	10	G
4. Acetonitrile	▲	>480	E	F	30	F	E	20	G	■	150	G	NR	—	—	E	4	VG	E	10	VG
5. Acrylic Acid	—	—	—	G	120	—	E	390	—	NR	—	—	NR	—	—	E	80	—	E	65	—
6. Acrylonitrile	E	>480	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7. Allyl Alcohol	▲	>480	E	F	140	F	E	140	VG	P	—	—	P	60	G	E	>10	VG	E	20	VG
8. Ammonia Gas	■	19	E	▲	>480	—	▲	>480	—	—	—	—	■	6	VG	—	—	—	■	27	VG
9. Ammonium Fluoride, 40%	—	—	—	E	>360	—	E	>480	—	NR	—	—	E	>360	—	E	>360	—	E	>360	—
10. Ammonium Hydroxide	E	30	—	E	>360	—	E	250	—	NR	—	—	E	240	—	E	90	—	E	240	—
11. Amyl Acetate	▲	>480	E	E	60	G	NR	—	—	G	>360	E	P	—	—	NR	—	—	P	—	—
12. Amyl Alcohol	—	—	—	E	30	E	E	290	VG	G	180	G	G	12	E	E	25	VG	E	45	VG
13. Aniline	▲	>480	E	NR	—	—	E	100	P	F	>360	E	F	180	VG	E	25	VG	E	50	G
14. Aqua Regia	—	—	—	F	>360	—	G	>480	—	NR	—	—	G	120	—	NR	—	—	G	180	—
15. Benzaldehyde	▲	>480	E	NR	—	—	NR	—	—	G	>360	E	NR	—	—	G	10	VG	G	25	F
16. Benzene, Benzol	▲	>480	E	P	—	—	NR	—	—	E	>360	E	NR	—	—	NR	—	—	NR	—	—
17. Benzotrichloride	—	—	—	E	>480	E	NR	—	—	—	—	—	—	—	—	NR	—	—	NR	—	—
18. Benzotrifluoride	—	—	—	E	170	G	F	—	—	E	—	—	G	<10	F	P	50	G	—	—	—
19. Bromine Water	—	—	—	E	>480	E	E	>480	E	—	—	—	—	—	—	—	—	—	—	—	—
20. 1-Bromopropane	▲	>480	E	■	23	F	■	<10	P	▲	>480	E	■	<10	F	■	<10	P	■	<10	P

Types of Gloves

Polyethylene/Ethylene-vinyl Alcohol {“Silver Shield®”}

- Resists permeation and breakthrough with chemicals.
- Uses: aromatics, esters, ketones, and chlorines.

Butyl

- Highest permeation resistance to gas or water vapors.
- Uses: ketones (MEK, acetone) and esters (amyl acetate, ethyl acetate).

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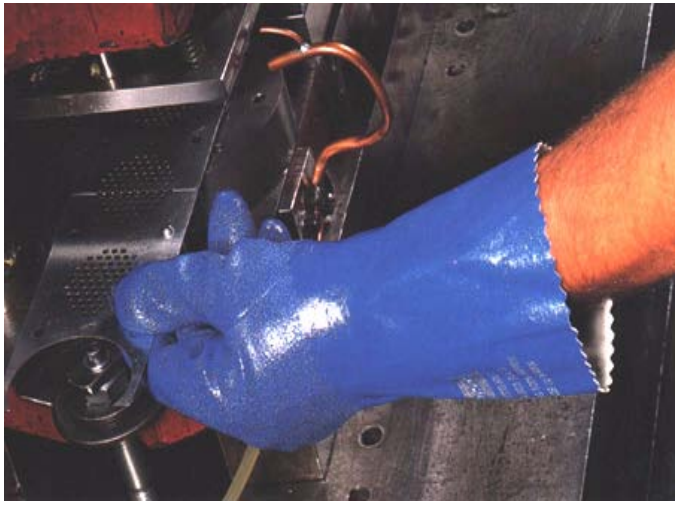
Types of Gloves

Viton®

- Highly resistant to permeation by chlorinated and aromatic solvents
- Can be used with water/water based solvents

Nitrile (acrylonitrile-butadiene rubber)

- Good replacement for latex
- Protects against acids, bases, oils, aliphatic hydrocarbon solvents and esters, grease, fats
- Resists cuts, snags, punctures and abrasions



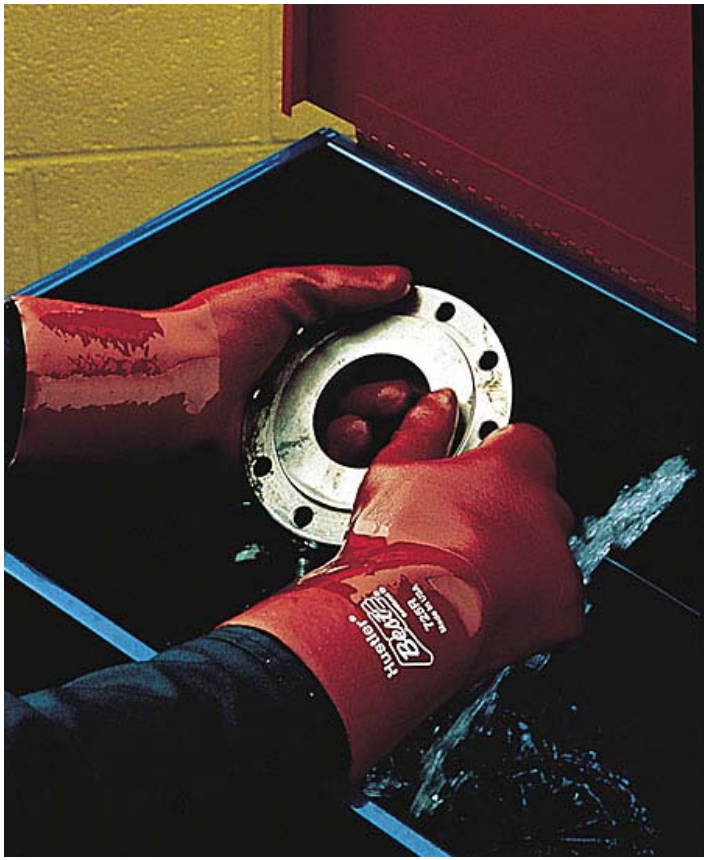
Types of Gloves

Neoprene

- Protects against acids, caustics, DMSO.
- Resists amines, alcohols, glycols.
- Limited use for aldehydes and ketones.

Poly vinyl chloride (PVC)

- Protects against acids, caustics.
- Resists alcohols, glycols.
- Not useful for aromatics, aldehydes and ketones.



What is latex allergy?

- **Natural rubber latex is from the rubber tree *Hevea brasiliensis.***
- **The major route of occupational exposure is absorption of latex protein through the skin.**
- **Allergens in or on gloves can be transferred to the person's tissue.**

Latex Allergies

- **Symptoms may occur within minutes of exposure or may take several hours depending on the individual.**
  - **Skin Redness**
  - **Hives**
  - **Itching**
  - **Respiratory Symptoms**
    - **Runny Nose**
    - **Itchy Eyes**
    - **Scratchy Throat**
    - **Asthma**

Latex Allergy

Latex Allergies

- **To prevent latex allergies consider:**
  - **Using non-latex gloves.**
  - **If you choose latex gloves, use the powder-free version.**
  - **When using gloves, do not use oil-based hand cream or lotions (these cause glove deterioration).**
  - **Recognize the symptoms of latex allergy.**
  - **Always wash hands after removing gloves.**

http://www.cdc.gov/niosh/topics/latex/

http://www.nursingworld.org/osh/latex.htm

Proper Steps for Removing Gloves

1

2

3

4

5

6

Respiratory Protection Program

- Written program
- Administered by Safety Office
- Medical clearance
  - Respiratory Protection Questionnaire
  - No beards
- Fit testing
- Respirator selection
  - Air monitoring
- Training (annual refresher)

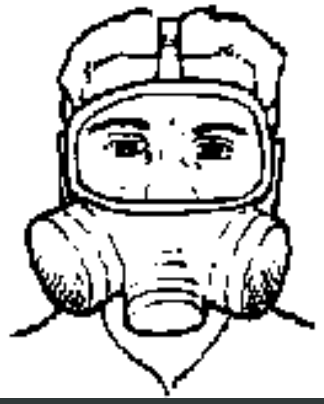
Respiratory Protection Standards

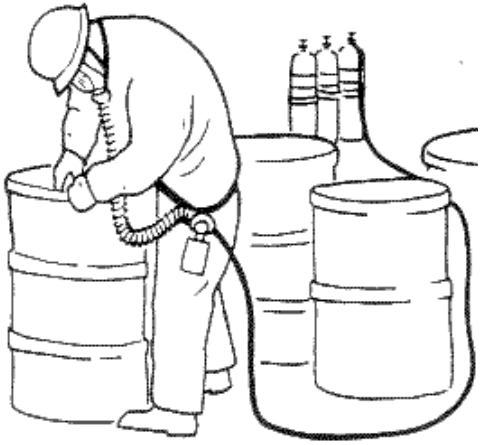
- **29 CFR 1910.134**
  - **OSHA Respiratory Protection Standard**
  - **New OSHA Assigned Protection Factors**
- **ANSI Z88.2–1992**
  - **ANSI Voluntary Consensus Standard**

Conduct an Exposure Assessment:
www.osha.gov/SLTC/etools/respiratory/haz_expose/haz_expose.html

Types of Respirators

- **Air purifying (APR)**
  - **Half Face**
  - **Full Face**
  - **PAPR**
- **Air supply**
  - **Air line**
  - **SCBA**



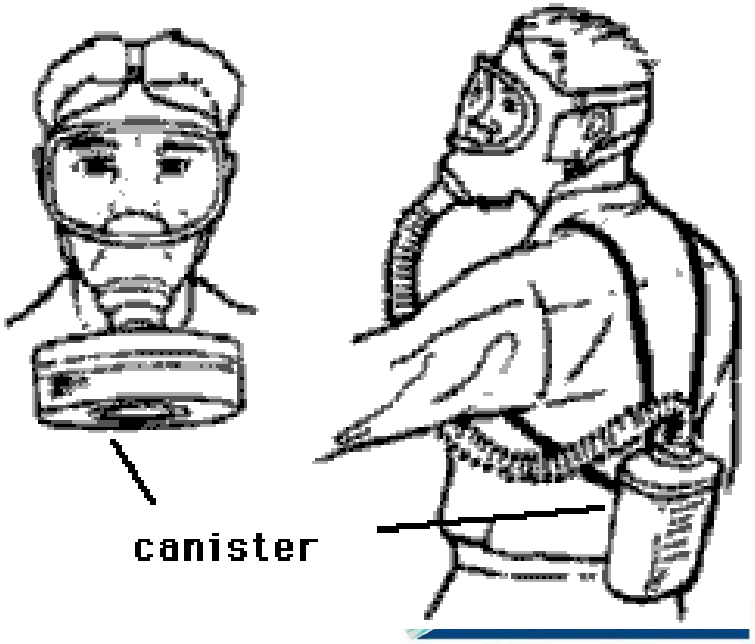


Air Purifying Respirators

- ***Must have at least 19.5% oxygen.***
  - **<u>Never</u> use in O_2 deficient atmospheres**
- ***Only filters the air.***
  - **Particulate filters**
    - **Removes aerosols**
  - **Chemical cartridges or canisters**
    - **Remove gases and vapors**
- ***Concentrations must not exceed limitations of filter/cartridge.***
- **PAPR (Powered Air Purifying Respirator)**
  - **Uses a blower to force air through an air purifying element**

APR Chemical Cartridge Selection

- Specific gases or vapors
- NIOSH or MSHA approval
- Adequate warning properties
- End of service life
- Mechanisms
  - adsorption
  - absorption
  - chemical reaction
- Breakthrough times
- *Proper maintenance and storage*



Cartridge Selection

Cartridge	Description
	Organic Vapor
	Organic Vapor and acid gases
	Ammonia, methylamine and P100 any particulates filter 99.97% minimum filter efficiency

End of Service Life Indicators (ESLI)

There are very few NIOSH-approved ESLI's:

- ammonia
- carbon monoxide
- ethylene oxide
- hydrogen chloride
- hydrogen fluoride
- hydrogen sulfide
- mercury
- sulfur dioxide
- toluene-2,4-diisocyanate
- vinyl chloride

Assigned Protection Factors (APF)

- **Level of workplace respiratory protection that a respirator or class of respirators is expected to provide.**
- **Each specific *type* of respirator has an Assigned Protection Factor (APF).**
- **Select respirator based on the exposure limit of a contaminant and the level in the workplace.**

Maximum Use Concentration (MUC)

= APF x Occupational Exposure Limit (e.g.OEL, TLV)

Assigned Protection Factors

Type of Respirator	Half Face Mask	Full Facepiece	Helmet/ Hood	Loose-Fitting Facepiece
Air-Purifying	10	50	-	-
PAPR	50	1,000	25/1,000	25
Supplied-Air or Airline				
– Demand	10	50	-	-
– Continuous flow	50	1,000	25/1000	25
– Pressure demand	50	1,000	-	-
SCBA				
– Demand	10	50	50	-
– Pressure Demand	-	10,000	10,000	-

Assigned Protection Factors

Workplace air sampling indicates the exposure to benzene is 30 ppm. OEL is 1 ppm. What respirator should you choose?

Maximum Use Concentration (MUC) = OEL x APF

Half Face Mask: MUC = 1 ppm x 10 = 10 ppm

PAPR (LFF): MUC = 1 ppm x 25 = 25 ppm

Full Face Respirator: MUC = 1 ppm x 50 = 50 ppm

Dust Masks *vs.* Hospital Masks

High Efficiency Particulate Air Filter (HEPA) Respirator

Fit Testing

- **Qualitative**
  - **Irritant smoke (stannic chloride)**
  - **Isoamyl acetate (banana oil)**
  - **Saccharin**
  - **Bitrex (bitter taste)**
  - *Employees should perform a user seal check each time they put on a tight-fitting respirator*
- **Quantitative**
  - **Portacount**

Qualitative Fit Test

Pass/Fail Fit Test

- **Assess the adequacy of respirator fit**
- **Relies on the individual's response to a test agent**

Qualitative Fit Test

Positive / Negative pressure fit test

Supplied Air

- Supplies breathing air to employee
- Examples:
  - SCBA
  - Airline
- Grade D Air
- Limitations

Breathing Air Quality and Use

- **Compressed breathing air must be at least Type 1 - Grade D [ANSI/CGA G-7.1-1989]:**
  - **Oxygen content = 19.5 - 23.5%**
  - **Hydrocarbon (condensed) = 5 mg/m^3 or less**
  - **CO ≤ 10 ppm or less**
  - **CO_2 of 1,000 ppm or less**
  - **Lack of noticeable odor**
- **Compressors equipped with in-line air-purifying sorbent beds and filters.**

Breathing Air Quality and Use

- **Non-oil lubricated compressors**
  - **CO levels in the breathing air ≤ 10 ppm**

- **Oil-lubricated compressors**
  - **High-temperature or CO alarm, or both**
  - **If only high-temperature alarm, the air supply must be monitored to prevent CO levels from exceeding 10 ppm**

Maintenance and Storage Procedures

- **Disposable filtering face-piece:**
  - **Dispose after use**
- **Half-mask:**
  - **Write expiration date (current date +estimate) making sure to keep entire label legible**
  - **Discard cartridges based on expiration date, end-of-service life indicator or calculated service life**
  - **Clean**
  - **Dry**
  - **Place in sealable bag (write your name on bag)**
  - **Contact Safety Office for repairs**

Maintenance and Storage Procedures

- **Exclusive use of an employee:**
  - **Clean and disinfect as often as necessary to be maintained in a sanitary condition.**
  - **Discard cartridges based on expiration date, end-of-service life indicator or calculated service life.**
- **Respirators issued to more than one employee or maintained for emergency use:**
  - **Clean and disinfect before worn by different individuals or after each use.**
- **Respirators used in fit testing and training:**
  - **Clean and disinfect after each use**
- **All respirators *must* be stored in clean, dry bags**

Hazards Requiring Body Protection

- *Hazardous chemicals.*
- **Potentially infectious materials.**
- **Intense heat.**
- **Splashes of hot metals and hot liquids.**

Body Protection for Emergency Response

Full suits:

- **Class A**
- **Class B**
- **Class C**
- **Class D**

Level A Protective Suits

Potential exposure to unknown:

- **Greatest level of skin, respiratory, and eye protection.**
- **Positive-pressure, full face-piece Self Contained Breathing Apparatus (SCBA) or positive pressure supplied air respirator with escape SCBA.**
- **Totally encapsulated (air-tight) chemical and vapor protective suit.**
- **Inner and outer chemical-resistant gloves, and boots.**

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Level B Protective Suits

- **Atmospheric vapors or gas levels** not **sufficient to warrant level A protection.**
- **Highest level of respiratory protection, with lesser level of skin protection.**
  - **Positive-pressure, full face-piece self contained breathing apparatus (SCBA) or positive pressure supplied air respirator with escape SCBA**
  - **Hooded chemical resistant clothing or coveralls (non-totally-encapsulating suit), inner and outer chemical-resistant gloves, and boots**

Level C Protective Suits

- **Concentration or contaminant known**
- **Full-face air purifying respirator permitted with a lesser skin protection**
- **Inner and outer chemical-resistant gloves, hard hat, escape mask, disposable chemical-resistant outer boots**
  - ***Difference in Level C and level B is respiratory protection***

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Level D Protective Suits

- **Minimum protection.**
- ***No*** **respiratory or skin protection.**
- **Used only if no known or suspected airborne contaminants present.**
- **May include gloves, coveralls, safety glasses, face shield, and chemical-resistant, steel-toe boots or shoes.**

Foot Protection

Should meet or exceed ANSI Standard.

Types:

- **Impact,penetration, compression, steel toe, etc.**
- **Non-skid, with slip resistant soles.**
- **Chemical resistant** (rubber, vinyl, plastic, with synthetic stitching to resist chemical penetration).
- **Anti-static**
- **Temperature resistant (high or low extremes).**
- **Electrical protection (non-conducting).**
- **Water resistant**
- **Combination shoes**

Personal Protective Equipment
Foot Protection

Steel toe-safety shoes are not necessary for laboratory work *unless* there is a serious risk from transporting or handling heavy objects.

However,

open toe shoes

should <u>NOT</u> be worn in labs.

Head Protection

Should meet or exceed Z89.1-2003

Types:

- **Bump caps - don't meet ANSI standard, provide minor protection**
- **Electrical protection 2200-22,000 v, depends on class)**
- **Mining protection**
- **Classic-- high impact general purpose protection.**
- **Impact 850-1000 pounds (386 - 454Kg)**
- **Penetration 3/8" (~1cm)**

Any Questions?

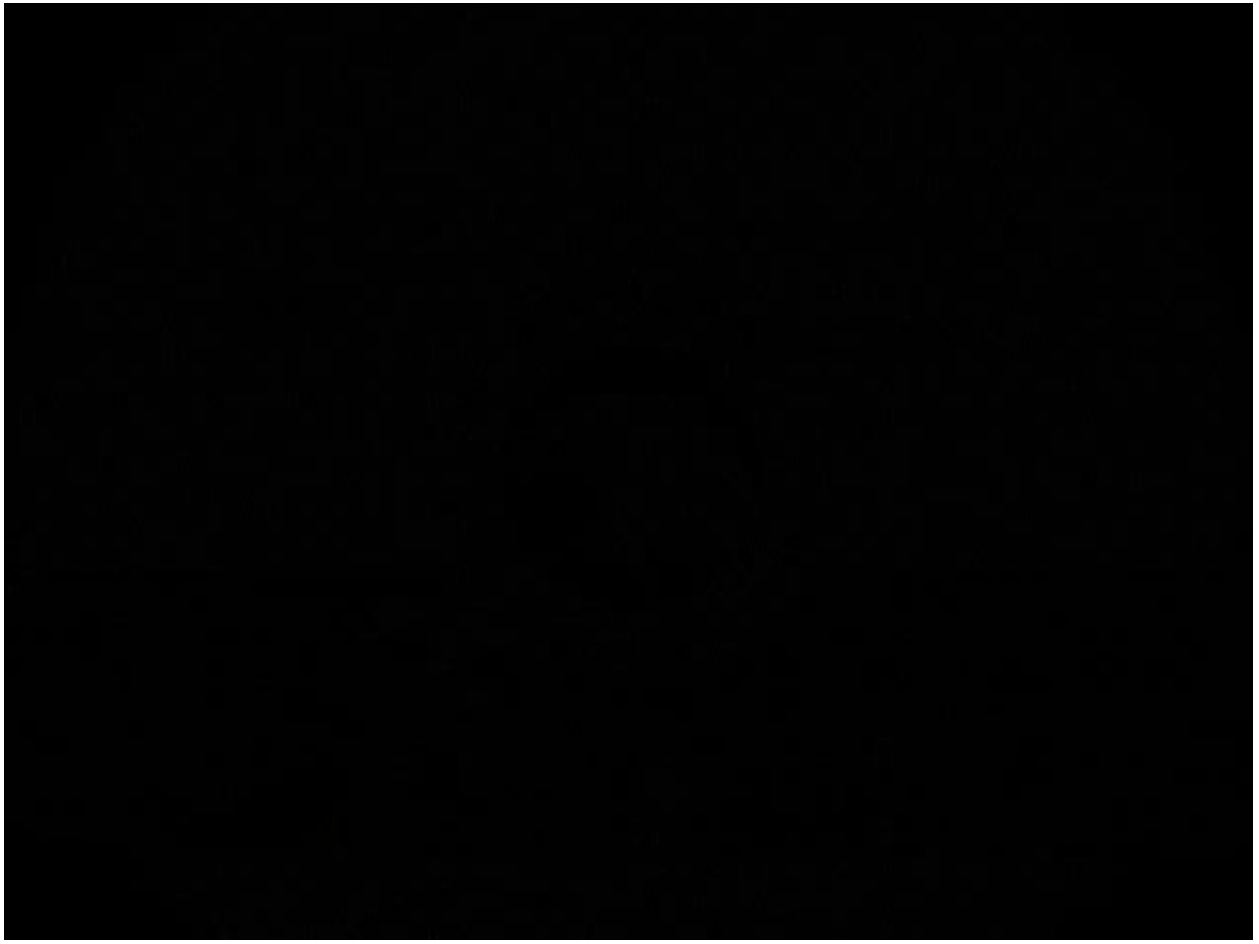
CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM
Chemical SAFETY AND SECURITY TRAINING

Break

REHAT

Laboratory Emergency Planning, Response, and Management

Video – Explosion and Fire at T2 Lab



Emergency Planning and Response is based on principles of:

- **Anticipation**
- **Recognition**
- **Evaluation**
- **Control**

Preparing For Emergencies

- Emergencies
  - potentially life threatening
  - occur suddenly without warning
- Quick response will:
  - make difference between life and death
  - minimize damage
  - prevent panic, timely control
- Emergency responders
  - organize, stabilize, administer
- Adequate preparation requires
  - planning, practice, evaluation, adjustment

Emergency Management

- Mitigate
  - eliminate / reduce occurrence or effects of an emergency
- Preparedness
  - plan how to respond; resources
- Response
  - assist victims, reduce damage
- Recovery
  - return to normal and assess

Planning & Preparation

Anticipate types of emergencies:

- **Step-by-step procedures**
- **Assess resources available**
- **Coordinate with all responding agencies**
- **Chain of command**
- **Roles & assignments**
  - **Clearly spelled out and understood**
- **Accident prevention strategies**
- **First aid – inspect, date, replacements**
- **Site maps – update**
- **Train & practice**
- **Evaluate & improve**

Emergency Response Plan

Include all situations and conditions:

- **Weather emergencies:**
  - Flood
  - Tidal waves
  - Cyclones
  - Heavy rains
  - High winds
- **Fire**
- **Earthquakes**
- **Security breaches**
- **Distraught employees**
- **Medical Emergencies**
- **Student unrest**
- **Political unrest**
- **Explosion**
- **Evacuation**
- **Terrorism**

Prepare for and expect the unexpected

Emergency Action Plan

- **Have a written plan and distribute it to all employees, especially new employees:**
  - **Emergency escape/evacuation procedures & routes**
  - **Critical process emergency shutdown procedures**
  - **Procedures to account for evacuated employees**
  - **Rescue or medical duties if employees required to perform them**
  - **Procedure for reporting emergencies**
  - **Contact information for Q&A**
- **Alarm systems**
- **Training**

Emergency Response Plan

- Comprehensive employee training
  - General employee training
  - Specialized & emergency responders
  - Annual refresher training or drills
  - Untrained personnel should not participate
- Spill & emergency response plans
- Contingency plans
- Medical response/first aid
- Personal Protective Equipment
- Safety Data Sheet's
- Site maps
- Clean up procedures
- Decontamination techniques

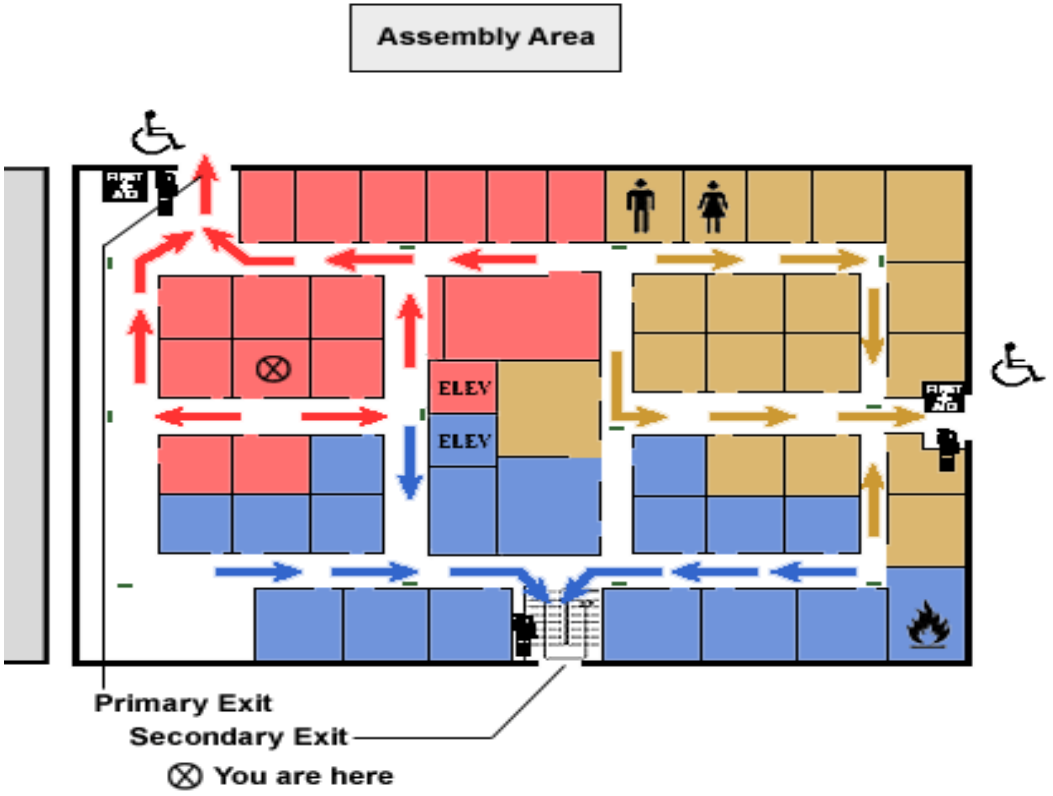
Include:
Fire Prevention Plan

- **Written plan**
  - **List major fire hazards**
  - **Proper handling and storage procedures**
  - **Potential ignition sources & controls**
  - **Type of fire prevention systems**
  - **Contact information for those responsible for system maintenance**
  - **Contact information for Q&A**
- **Housekeeping requirements**
- **Training**
- **Maintenance requirements**

Emergency Planning & Response

Have an evacuation plan for all buildings and areas and

POST IT



Emergency Planning & Response

Don’t use hallways for storage

Dangerous!!

Blocks passage and emergency exit path

82

Emergency Planning & Response

Label and keep all exits clearly.

Keep unlocked or equipped with panic bars.

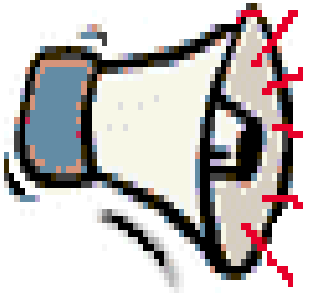
Emergency Planning & Response

- Have routine, unannounced evacuation drills.
- Test and maintain alarms.
- Designate person for each area to ensure bathrooms, etc. are evacuated.

- Locate outside staging areas sufficient distance from building.
- Designate person to meet/direct emergency vehicles.

Emergency Planning & Response

Alarm systems need to be properly located, maintained, and serviced regularly.



Emergency Planning & Response

Backup power

Does switch-over automatically?

How long will it run?

How much fuel do you have?

What areas will it support?

How often is it tested and maintained?

Emergency Planning & Response

Post each room with:

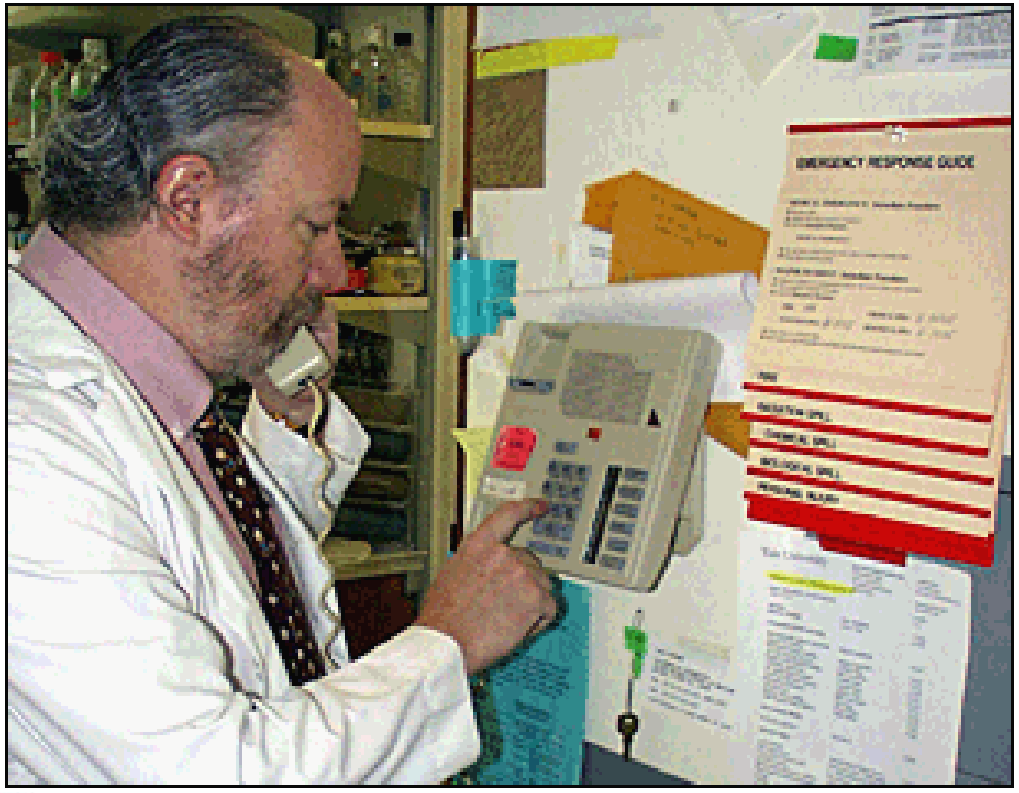
- **Emergency phone numbers**
- **After hours phone numbers**
- **Person(s) to be contacted**
- **Alternate person(s)**
- **Unique procedures to be followed**

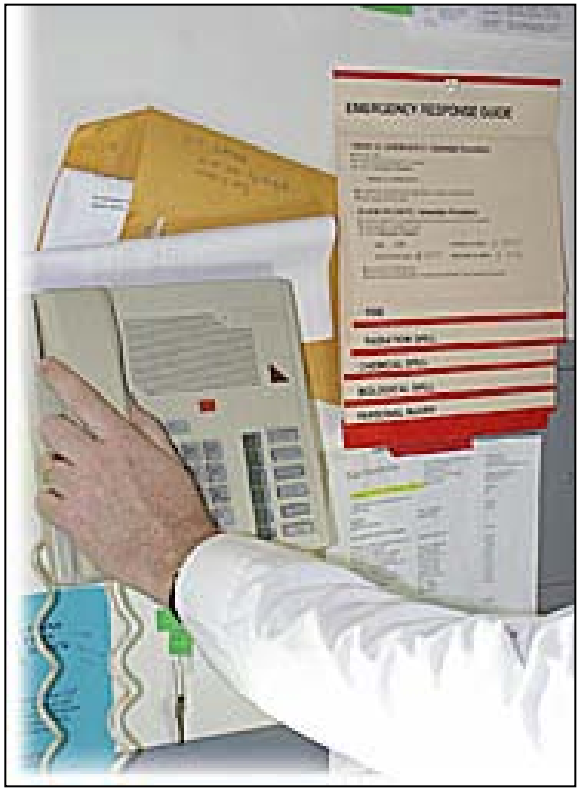
Location	
Hazards Within:	
Primary Contact:	
Second Contact:	
Building Monitor/Safety:	
Department Head:	
Fire/Police/Ambulance:	911
Envir. Health & Safety (or RSO, if needed):	646-3327

Emergency Phone Numbers

Clearly post emergency numbers

Do people know what to do?





Emergency Planning & Response

Hoods should have low flow alarms.

Chemical specific toxicity alarms may be needed in certain areas.

Emergency Planning & Response

Centrally locate safety showers and eyewashes.

Schedule routine, periodic maintenance of all safety equipment.

Teach employees to properly use the Safety Shower

Time can make a difference…

Chemical Spills

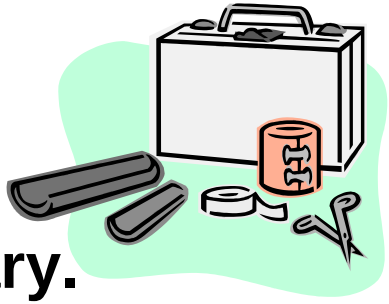
Centrally locate spill clean-up kits

Clean up spill only if you know the chemical hazards, have appropriate equipment and are trained to do so!

- Alert colleagues and secure area
- Assess ability to clean-up spill
- Find spill kit
- Use appropriate PPE and sorbent material
- Protect sinks and floor drains
- Clean-up spill, collect/label waste for disposal
- Report all spills

Chemical Laboratory First Aid

- First aid kits for minor injuries should be centrally located and available in or nearby each laboratory.
- Use for minor accidents/incidents.
- Determine if medical attention is necessary.
- Immediately notify proper authorities, if necessary or in doubt.
- Determine if chemical exposure occurred.
- If necessary, take immediate preventative action to make lab safe, e.g., shut down reactions, electricity, etc.

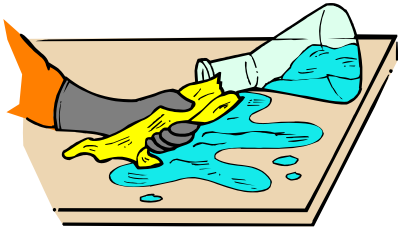


Chemical Laboratory First Aid

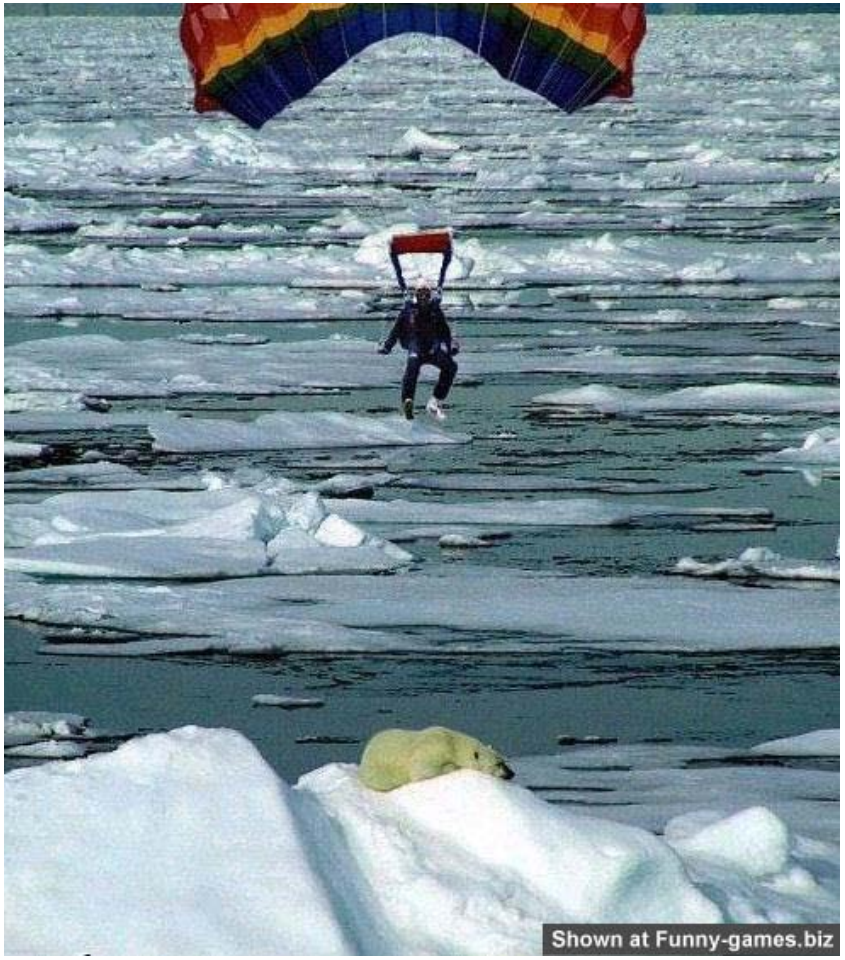
- **Chemical Burns:**
  - Speed is essential.
  - Consult chemical labels & MSDS for special instructions.
  - Flush burn area immediately with water for 15 minutes.
  - Taking care not to spread the chemical, remove any clothing,especially shoes and socks, that may be contaminated.
  - Do NOT use salves, ointments, cream, sprays, or any other covering except for chemical-specific remedies such as for HF or phenol.
  - Do NOT attempt to rupture blisters over the burn.
- **If chemicals splashed into the eyes:**
  - Flush the affected area with water for a minimum of 15 minutes.
  - Remove contact lenses, if present, as rapidly as possible, since they prevent water from reaching the cornea.
  - Eyelids may have to be forced open so eyes can be totally flushed.
  - If large particles are in the eye, an eye wash should not be used.
  - Do NOT use salves, ointments, cream, sprays, or any other covering except for chemical-specific remedies such as for HF or phenol.

Centrally locate, inspect and maintain:

- First aid kits
- Special chemical antidotes, if necessary
- Respirators
- Specially train emergency personnel, if necessary
- Post inspection dates on equipment, including hoods



Always Expect the Unexpected



Occupational Exposure Limits (OELs)

Requirements, Recommendations, and Guidelines

Goals of OELs

- Control health effects of exposures to “agents” (chemical, biological, physical).
- Designed to protect workers against adverse health effects day-after-day.
- Applies only to the traditional workplace.

Healthy Worker Syndrome

OELs are set for:

Healthy, young, male workers

Able to report for work every day

Work 5 days of 8 continuous hours work per week

Based on data that varies widely in accuracy and age

Presumed to be an adequate margin of safety

Exposure is Affected by:

- Genetics
- Age
- Personal habits
  - Smoking
  - Alcohol
  - Drugs
- Medication
- Previous Exposure
- Environmental Exposure

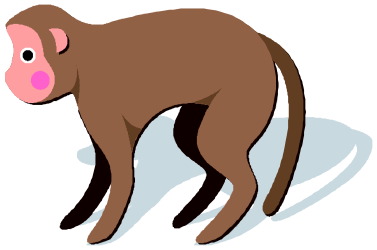
Basis for Setting OELs

Paracelsus (~1500) said – "all substances are poisons… only the dose differentiates a poison from a remedy"

- **Human use and experience**
  - Epidemiological data
  - Medical case histories
  - Human exposure data on adverse effects
- **Long term animal toxicity studies**
  - Best for chronic toxicity and carcinogenicity
- **Short term animal toxicity studies**
  - Dermal data on skin penetration
  - Basis for STEL or Ceiling Limit

Basis for Setting OELs

Special animal studies:



- **Genetic toxicity**
- **Developmental/reproductive toxicity**
  - **Unique hazard (e.g., thalidomide)?**
  - **Male or female reproductive performance?**
- **Metabolism/pharmacokinetics**
  - **Absorption, distribution, fate and elimination**
- **Physical/chemical properties**

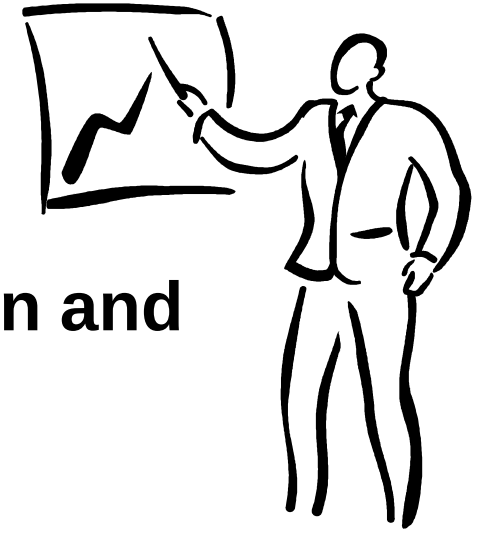
Animal Toxicology Information

- Route of exposure
- Route of administration
- Species tested
- Chemical/physical/biological factors
- Test material
- Dose, route, frequency, concentration, duration
- Genetic factors
- Immunologic and dietary factors
- Gender, age and emotional status

Extrapolation of Animal and Other Data

- **Application of known data and/or experience to areas not known.**

- **Based on assumptions**:
  - **Continuity**
  - **Parallelism between what is known and unknown.**



Exposed Dose vs. Absorbed Dose

- **Exposed Dose:**

  Amount of substance which a given organism is exposed, expressed as:

  – parts per million (ppm) for gases & vapors
  – milligram per cubic meter (mg/m^3) for solids
  – Fibers per cubic centimeter (fibers/cc) for fibers

- **Absorbed Dose:**

  Amount of substance deposited in or absorbed by an organism, expressed as:

  – mg/kg

Occupational Exposure Limits (OEL)

OELs are country specific and variously know as:

- **PEL – Permissible Exposure Limits –** OSHA, USA, required legal limits.
- **REL – Recommended Exposure** Limits **–** NIOSH, USA, recommendations.
- **TLV® – Threshold Limit Values® –** ACGIH, USA, recommendations
  - **(OSHA adopted 1968 TLV list – PELs)**
- **WEEL – Workplace Environmental Exposure Limits –** AIHA, USA, recommendations.
- **MAK – Maximium Workplace Concentrations –** German, required legal limits.
- **BEI® – Biological Exposure Indices –** ACGIH, USA, recommendations.

Permissible Exposure Limit (PEL)

- **Legal US exposure limit** to control health effects from exposures to “agents.”
- Protect workers day-after-day without adverse health effects.
- Applies only to workplaces covered by US OSHA.

Action Levels and Policies

- **Action Level (usually ½ PEL)**

- **Other US OSHA Policies**

  Carcinogens

  - **Zero tolerance**
  - **No known safe exposure level**

TLV® Definitions

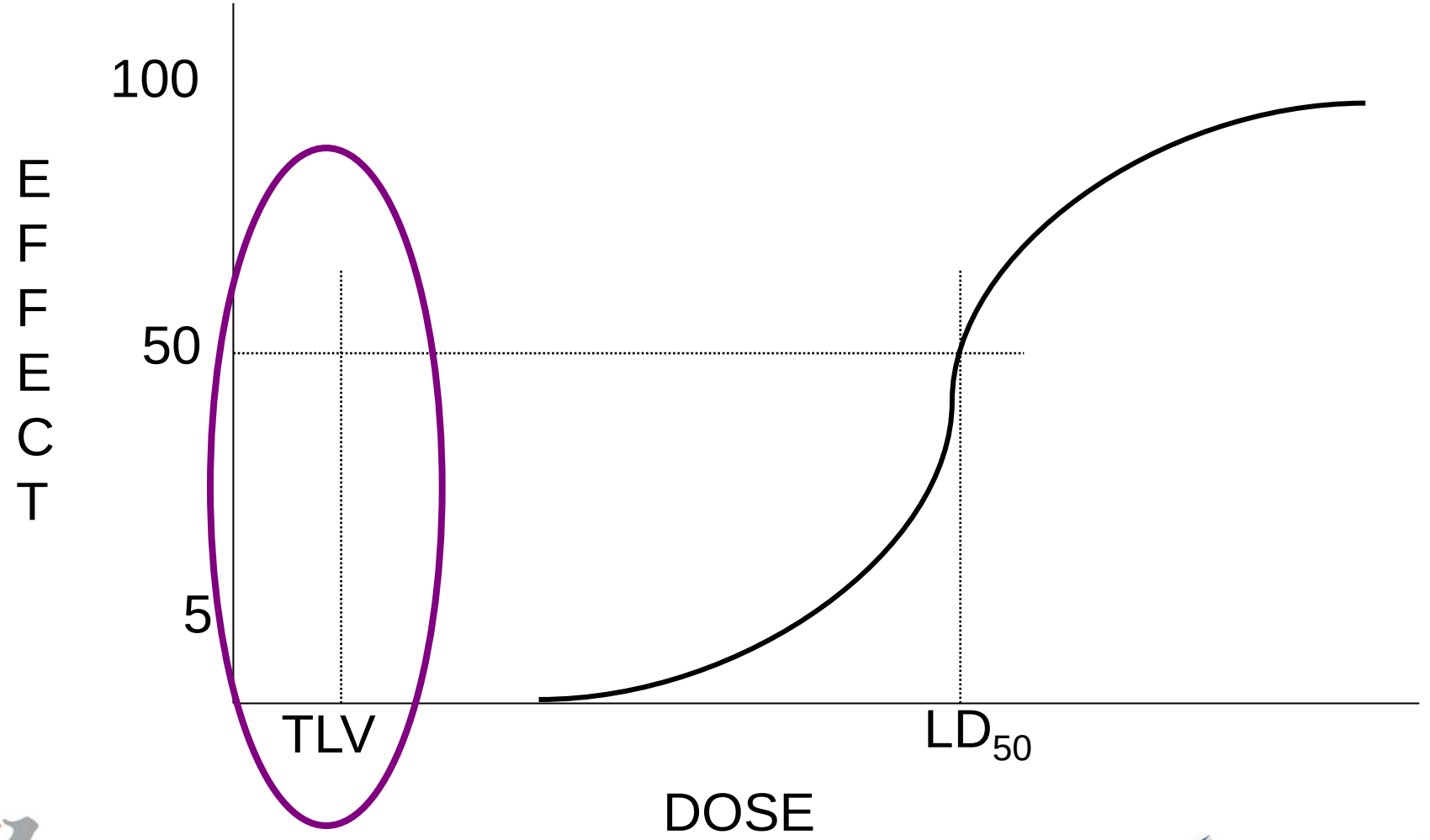
Threshold limit values refer to:

… airborne concentrations of substances and represents conditions under which it is **believed that nearly all workers may be repeatedly exposed day after day without adverse health effects.**

… a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit.

… may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness.

Threshold Limit Values (TLV)



Categories of TLV's

AIR CONTAMINANTS

- **Time-weighted average (TWA)**
- **Short-term exposure limit (STEL)**
- **Ceiling value (C)**

- **TLV Range:**

  HIGHEST

  – Carbon dioxide - 5000 ppm

  LOWEST

  – Osmium tetroxide - 0.0002 ppm

TLV Limitations

- **Not** a relative index of toxicity.
- **Not** intended to apply to general public.
- **Not** for exposures >8 hr/day; 40 hr/wk.
- **Not** used as proof of hazard.
- **Not for other countries with different working conditions.**

Biological Exposure Indices (BEIs®)

- **BEIs are indications of a person's "uptake" of a substance.**
  - **Chemical, metabolite, characteristic or reversible biochemical change**
    - Urine, blood, exhaled air
  - **Represent levels observed in healthy workers exposed at the TLV.**
    - Not always the case…e.g. lead, based on health effect.
  - **Indirectly reflects dose**
  - **Not a measure of adverse effects or diagnosis of illness**
  - **Not a distinction between hazard and non-hazard.**

Biological Exposure Indices (BEIs)

- **BEIs can assist CHHO Professionals:**
  - » Used as a guideline
  - » Apply to 8 hr day, 5 day week
    - – Adjustment to irregular work schedules is not recommended
  - » Detect and determine absorption by skin or GI
  - » Assess body burden
  - » Reconstruct past exposure in absence of exposure data
  - » Test efficacy of PPE and engineering controls
  - » Monitor work practices
- **BEI does <u>not</u> indicate need for biological monitoring.**

Working with BEIs

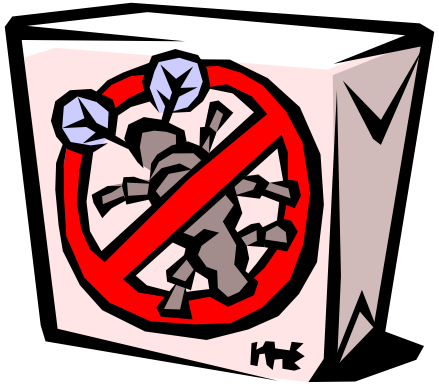
- **Sample collection time is very important.**
- **Sample acceptability:**
  - » Reject highly diluted or concentrated urine samples.
- **Sample collection requires proper quality assurance.**
  - » Include blind challenges to assess lab capability.
  - » B – background (may be present in unexposed)
  - » Nq – non-quantitative
  - » NS – nonspecific (observed with other chemicals)
  - » Sq – semi-quantitative (interpretation may be ambiguous)

BEIs vs. TLVs

- **BEIs – Index of uptake**
  - » Uptake may vary between workers.
  - » Measurement on a person
- **TLVs – indicate potential for inhalation exposure**
  - » Measurement on an environment
- **Inconsistencies between BEIs and TLVs due to:**
  - » Physiological makeup and health status
  - » Occupational exposure factors
  - » Non-occupational exposure factors
  - » Sampling location
  - » Particle size distribution
  - » Effectiveness of PPE or controls

Classification Schemes

ACGIH CARCINOGEN



- **A1 Confirmed human carcinogen**
  - » Human data
- **A2 Suspected human carcinogen**
  - » Animal data due to conflicting or insufficient human data
- **A3 Animal carcinogen**
  - » Not relevant for extrapolation to humans

Classification Schemes

ACGIH CARCINOGEN

- **A4 Not classified as a human carcinogen**
  - » Inadequate data
- **A5 Not suspected as a human carcinogen**
  - » Good negative human
  - » Considers animal data

NOTE: If no data exists, compound remains unclassified

Time Weighted Average (TWA)

- **Average exposure for an individual over a working period of time, determined by taking one or more samples during the working period:**

$$\text{TLV-TWA*} = \frac{C_1T_1 + C_2T_2 + \ldots + C_NT_N}{T_1 + T_2 + \ldots + T_N}$$

Where:

C = airborne concentration

T = time

*** A TLV expressed as a TWA**

8-Hr Time Weighted Average

- **Average exposure for an individual over an 8-hr working period of time, determined by taking one or more samples during the 8-hr working period:**

$$\text{TLV-TWA}_8 = \frac{C_1T_1 + C_2T_2 + \ldots + C_NT_N}{8 \text{ hrs}}$$

Example 1

A degreaser operator is monitored for exposure to Stoddard solvent. The monitoring data is:

TIME PERIOD (NUMBER)	*CONCENTRATION (PPM)*	*TIME (HOUR)*
1	80	2
2	110	4
3	55	2

Solution

$$\text{TLV-TWA}_8 = \frac{C_1T_1 + C_2T_2 + \ldots + C_NT_N}{8 \text{ hrs}}$$

$$\text{TLV-TWA}_8 = \frac{(80 \times 2) + (110 \times 4) + (55 \times 2)}{8 \text{ hrs}}$$

EIGHT HOUR TLV-TWA = 89 ppm

Over exposed?
(TLV = 100 ppm)

Example 2

Consider the same example with no exposure for the last two hours:

TIME PERIOD (NUMBER)	CONCENTRATION (PPM)	TIME (HOUR)
1	80	2
2	110	4
3	0	2

Solution

$$\text{TLV-TWA}_8 = \frac{C_1T_1 + C_2T_2 + \ldots + C_NT_N}{8 \text{ hrs}}$$

$$\text{TLV-TWA}_8 = \frac{(80 \times 2) + (110 \times 4) + (0 \times 2)}{8 \text{ hrs}}$$

EIGHT HOUR TLV-TWA = 75 ppm

Unit Concentration

$$\text{TLV (ppm)} = \frac{\text{TLV (mg/m}^3\text{)} \quad 24.45}{\text{(molecular weight)}}$$

$$\text{TLV (mg/m}^3\text{)} = \frac{\text{TLV (ppm) (MW)}}{24.45}$$

TLV - Short Term Exposure Limit (STEL)

- A 15-minute TWA exposure.
- No more than 4 times per day, with at least 60 minutes between.
- Should not be exceeded anytime during workday, even if 8-hour TWA is within TLV-TWA.

Excursion Limit (without STEL)

- **Excursions in worker exposure levels may exceed 3 times the TLV-TWA for no more than a total of 30 minutes during a workday.**

- **Under no circumstances should they exceed 5 times the TLV-TWA, provided the TLV-TWA is not exceeded.**
  - **Applicable to TLV-TWAs that do not have STELs**

Other TLV Notations …

- “Skin” potential exposure by the cutaneous route, including mucous membranes and the eyes.

- “SEN” potential to produce sensitization.

Unusual Work Schedules

Application of TLVs to unusual work shifts:

Different from 8-hour day, 40-hour week

Requires judgment.

OSHA model Modified PEL

$$PEL_{modified} = PEL \frac{8 \text{ (hours)}}{T \text{ (hours)}}$$

T > 8 Hours

Example

- 1,1,2-trichloroethane has a biologic half-life of 16 hours in people. What modified TLV or PEL is appropriate for persons who want to work 3 days at 12 hours per day for the work week?

- The ACGIH TLV & OSHA PEL for 1,1, 2-trichloroethane is 10 ppm.

$$PEL_{modified} = 10 \frac{8 \text{ (hours)}}{12 \text{ (hours)}} = 6.66 \text{ ppm}$$

Mixtures

If the biological effects of mixture components are additive:

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \ldots + \frac{C_N}{T_N} = K$$

Where:

C_N = Measured TWA concentration

T_N = TLV for a substances

If k is **<** 1, combined exposure is less than TLV

If k is **>** 1, combined exposure exceeds the TLV

Acknowledgements

University of North Carolina
Education and Research Center
Chapel Hill NC USA

Nelson Couch, PHD, CIH, CSP, Durham NC USA

Mary Carol Lewis,
NC Employment Security Commission, Raleigh NC USA

Lunch

MAKAN SIANG

Chemical Safety & Security

Other Hazards in the Chemical and Biological Lab

Other Hazards: Physical Hazards

Conditions besides chemical or biological hazards that can cause harm:

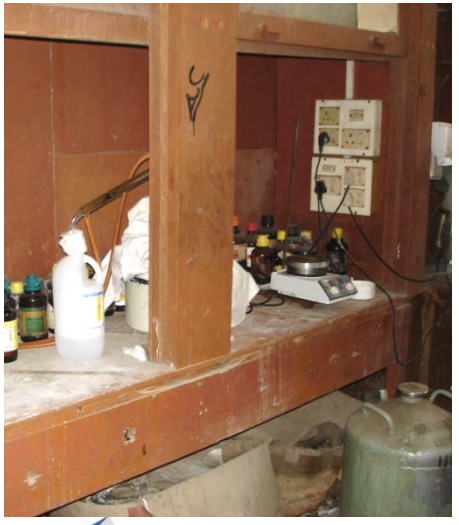
- Fire
- Asbestos
- Centrifuges
- Heat/cold
- Cryogenics
- Ergonomics
- Slips/trips/falls
- Noise
- Mechanical
- Electrical
- Ionizing radiation
- Non-ionizing radiation
- Housekeeping issues
- Spills

Other Hazards: Asbestos-Containing Materials

- Gloves
- Lab hoods
- Insulation
- Lab benches

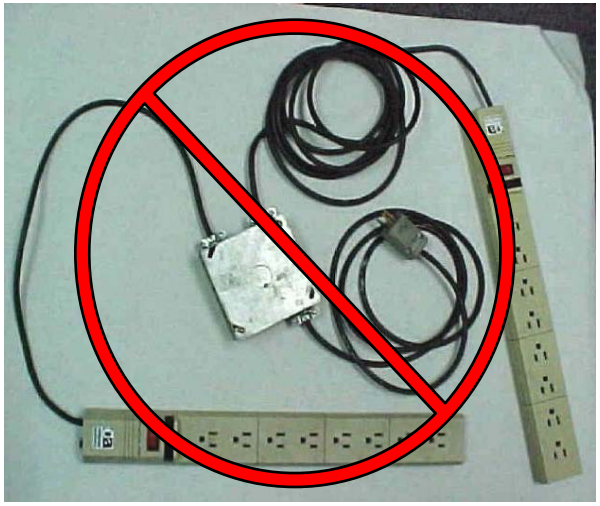
Other Hazards: Electrical Hazards

- **Can be a significant problem**
  - **frayed cords, no UL-listing, overloaded circuits**
  - **static electricity**
- **Hazards**
  - **fires, electrical shock, power outages**
- **Control**
  - **inspect, act immediately, education**
  - **check that all outlets are grounded and that polarity is correct**



Other Hazards: Electrical Hazards

- **Multi-outlet strips must be approved and <u>not</u> used for high-amp equipment.**
- **Keep outlets clear of flammables.**
- **Do NOT chain outlet strips.**



Other Hazards: Mechanical Hazards

Mechanical hazards like open drive belts with pinch points must have shields and guards.

Oil pumps need drip pans to contain oil.

Other Hazards: Vacuum Work

- **Uses**
  - aspiration
  - inert environments
  - dessication
- **Hazards**
  - breakage and leaks:
    - injury due to glass breakage
    - hazard of chemical/biological contained in vacuum
    - fire following breakage
    - contaminated pump oil
- **Control Measures**
  - SOPs, inspection, training
  - engineering controls

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Other Hazards: High Pressure Reactions

- **Proceedures that involve:**
  - **pressures above 1 atm (760 Torr, ~1bar, ~100,000 Pa).**
  - **use of supercritical fluids (i.e. CO_2)**
- **Hazards**
  - **explosions**
  - **exposure of contents**
  - **equipment failure**
- **Control Measures**
  - **SOPs, training, inspection**
  - **engineering controls**
  - **dry runs**

Other Hazards: Explosive Reactions/Processes

Other Hazards: Centrifuge Equipment

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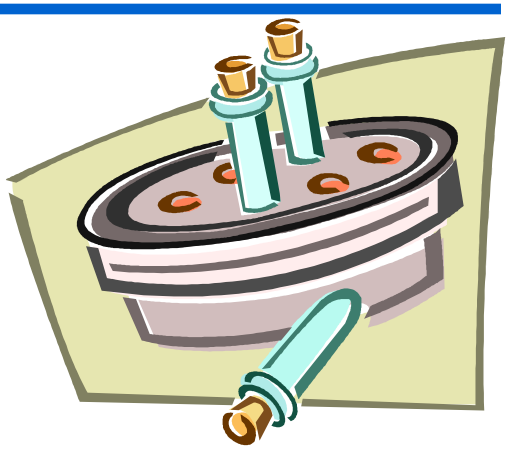
Chemical SAFETY AND SECURITY TRAINING

Other Hazards: Centrifuge Equipment

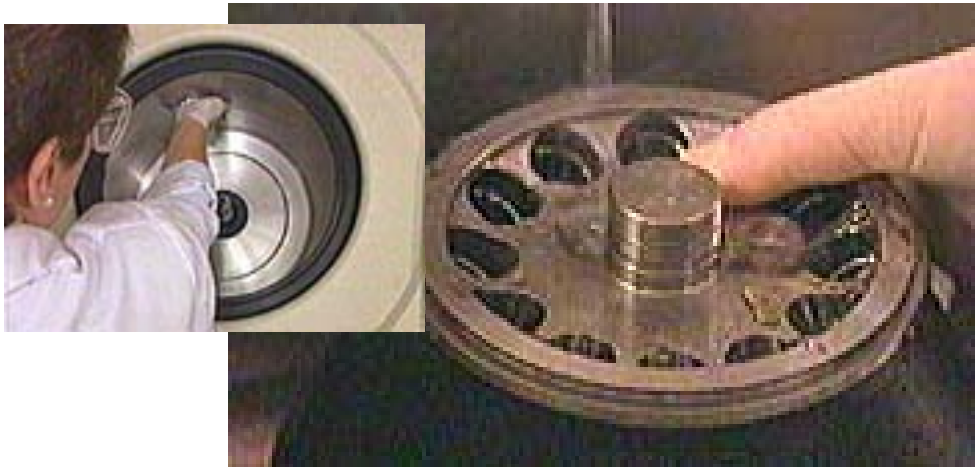


- **Hazards**
  - **aerosol generation**
  - **imbalance**
- **Control of hazards**
  - **only authorized users can use**
  - **users must be trained**
  - **follow SOPs**
  - **assign responsibility to lab tech**
  - **include in periodic lab inspections**

Other Hazards: Centrifuge Equipment

Don’t overload . . .

Check rotor for cracks



Keep rotor and centrifuge clean . . .

Set it upright & level . . .

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Other Hazards: Cyrogen Storage

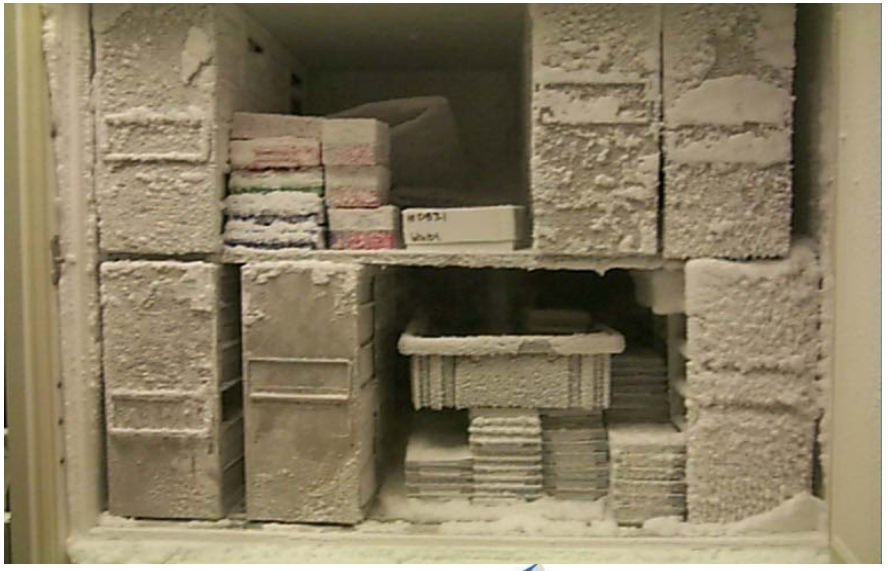
Exploding liquid nitrogen cylinder ruins lab.

Other Hazards: Cryogens

- **Cryo-freezing tissue:**
  - snap-freeze tissue by quenching in liquid N2
  - muscle must be frozen with isopentane to prevent ice crystal artefacts
  - package and store samples properly (air tight at -70 degC)
- **Cryogenic Storage:**
  - store cryogenics separately from other chemicals
  - store cryogenics (liquid N2) & dry ice in well ventilated areas
    - do not use cryogenics in closed areas
  - use proper PPE (including eye protection) when handling & moving cryogenics

Other Hazards: Chemicals in Freezers

- **Ultra low temperatures**
  - **-20°C, -80°C**
  - **upright vs. walk-in**
- **Emergency power**
- **Labels**



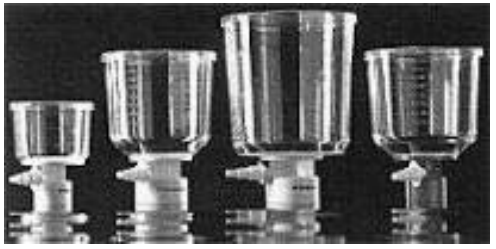
- **Precautions**
  - *no dry ice in freezers!*
  - **improper storage**
- **PPE**

Other Hazards: Autoclaves & Microwave Ovens

Other Hazards: Autoclaves & Microwave Ovens

Autoclave & microwave emissions:

- substances in autoclaves produce emissions
- emissions release once autoclave opened
- some emissions are foul or hazardous
- unstable plastics can decompose in autoclaves
  - polystyrene (should not put in autoclave) emits styrene and ethyl benzene gases
  - acetal polyoxymethylene (Delrin) emits formaldehyde
    - limit to 20 min at 121 °C



- general suggestions:
  - never autoclave toxic, volatile, or flammable chemicals
    - hazardous exposures, explosion
  - allow autoclave to cool before opening
  - employ recycling/waste reduction
  - provide ventilation
  - frequently clean autoclave

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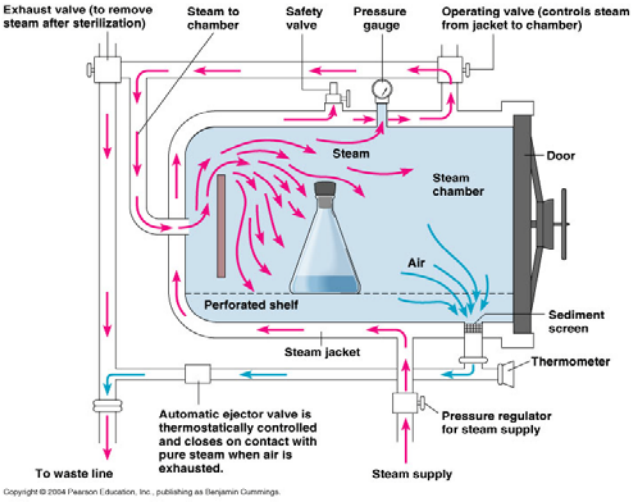
Chemical SAFETY AND SECURITY TRAINING

Other Hazards: Autoclaves & Microwave Ovens

Autoclave/microwave emissions:

- foul smelling emission examples
  - bile salts, sulfur, meat peptones, nitrogen compounds
- corrosives damage equipment
  - NaOH solutions to inactivate prions
    - neutralize to pH<8 prior to autoclaving
- hazardous emission examples
  - chlorine gas from sodium hypochlorite
    - neutralize with sodium thiosulfate
  - radioactive materials:
    - C-14, H-3 okay, NOT I-125
      - treating I-125 with chlorine solutions releases iodine
  - don't autoclave:
    - formaldehyde, gluteraldehyde from treated agar
    - phenol from DNA extraction
    - lead foil, mercury, ethidium bromide gels



Other Hazards: Autoclaves

Autoclave best practices:

- time to sterilize differs, depending on load density and cycle chosen
  - perform tests to determine cycles for various situations
- clean drain strainer before loading
- load approved material only, within limits
- loosen caps of containers with liquids (for expansion)
- use solid-bottom tray (hold bottles & catch spills)
- do not place glassware directly on autoclave floor
- assure door is fully closed and latched
- assure proper cycle is selected
- use heat-protecting gloves to open autoclave

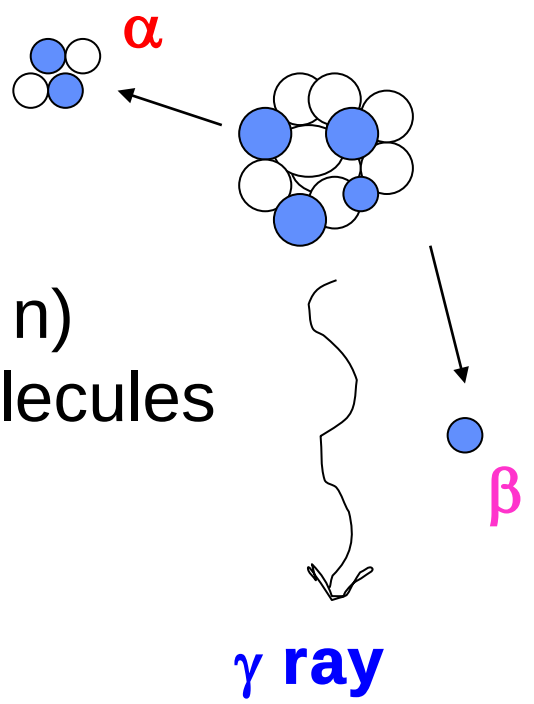
Other Hazards: Autoclaves

Autoclave best practices (continued):

- **wait before removing items**
  - **5 minutes for dry glassware**
  - **10 minutes for glassware with liquids**
- **wear a rubber apron, rubber sleeve protectors, heat resistant mitts and a face shield to remove items**
  - **wait 15 minutes before touching without thermal gloves**
  - **if liquids are bubbling, let cool a full hour**
- **clean autoclave and work areas *after every use* and disinfect the work area**
- **keep log of autoclave use**
  - **date, time, operator name, type/amount of waste**
  - **run parameters: temperature, time, pressure**
- **test periodically (spore test)**
  - **every 40 hours of use, or**
  - **monthly (for autoclaves to inactivate pathogens & tissue)**
  - **every 6 months (for milder uses)**

Other Hazards: Radiation: Ionizing vs. Non-ionizing

- **Ionizing Radiation**
  - particulate or electromagnetic
  - charged (α, β) or uncharged (γ, X, n)
  - causes **ionization** of atoms or molecules



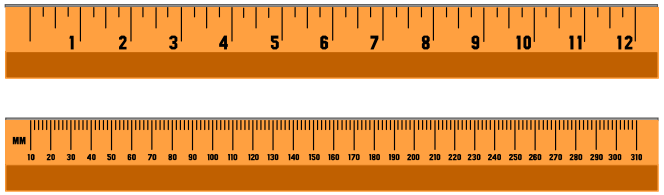
- **Non-Ionizing Radiation**
  - electromagnetic (UV, IR, MW, RF)
  - can not ionize atoms or molecules

Other Hazards: Ionizing Radiation Protection

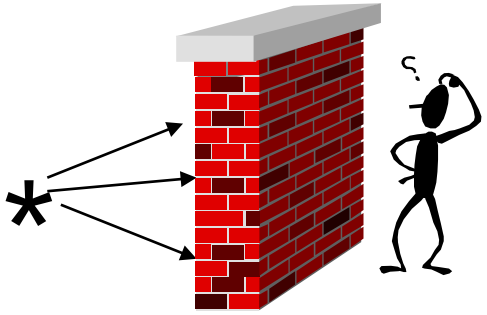
- **Time:** limit time near source

- **Distance:** stay away

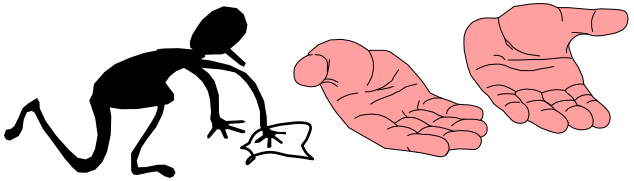
$$I_2 = I_1\left(\frac{d_1}{d_2}\right)^2$$



- **Shielding:** absorb energy



- **Contamination control:**
  - **containment, cleanup**
  - **housekeeping**



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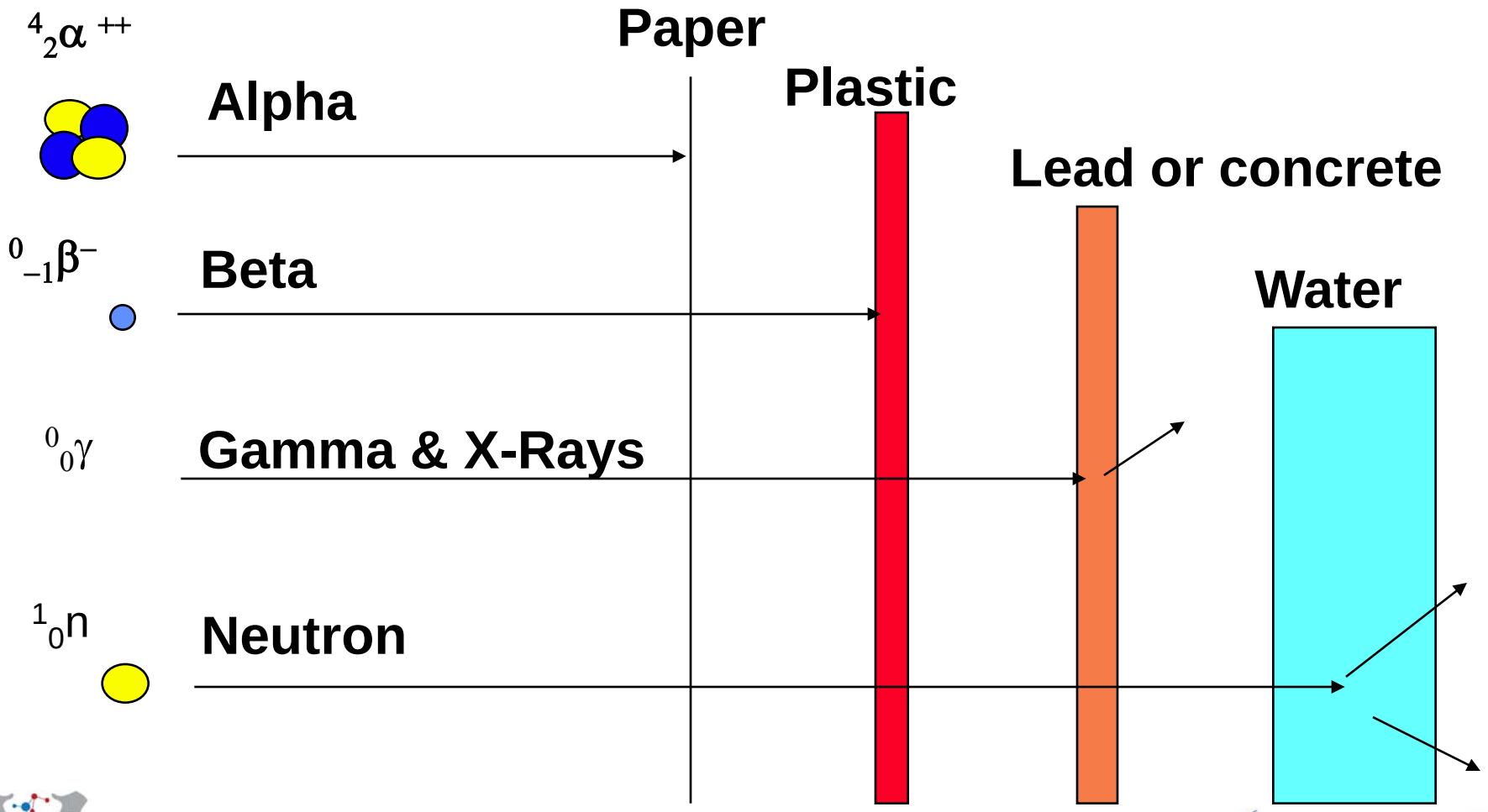
Other Hazards: Ionizing Radiation Shielding



Ionizing Radiation: Electron Microscopes

- Types
  - SEM, TEM
- Hazards
  - X-rays
- Control of hazard
  - periodic maintenance
  - conduct radiation survey
  - include in personnel radiation safety program

Other Hazards: Non-Ionizing Radiation

- UV, Visible, IR, Lasers
- Hazards
  - skin erythema
  - eye injuries
- Control Measures
  - training,
  - PPE,
  - warning signs and labels,
  - interlocks

Other Hazards: Magnetic Fields

- **Uses – NMR, MRI**
- **Hazards**
  - **magnetic field**
  - **high voltage**
  - **cryogenic liquids**
    - e.g., nitrogen, helium
  - **other hazardous materials in lab**
- **Control Measures**
  - **control access to area**
  - **training**
  - **warning signs**

Other Hazards: Repetitive Motion Disorders

- **Why be concerned with Ergonomics?**

About 15 to 20% of workers in jobs requiring highly repetitive motion of shoulders, arms, wrists or hands develop repetitive motion disorders.

Disorder	Affected Site
Carpal Tunnel Syndrome	Wrist
Tendonitis	Elbow, wrist, hand
Tenosynovitis	Elbow, wrist, hand
Epicondylitis	Tennis elbow
Reynaud's phenomenon	"White finger"
Ulnar neuropathy	Fingers

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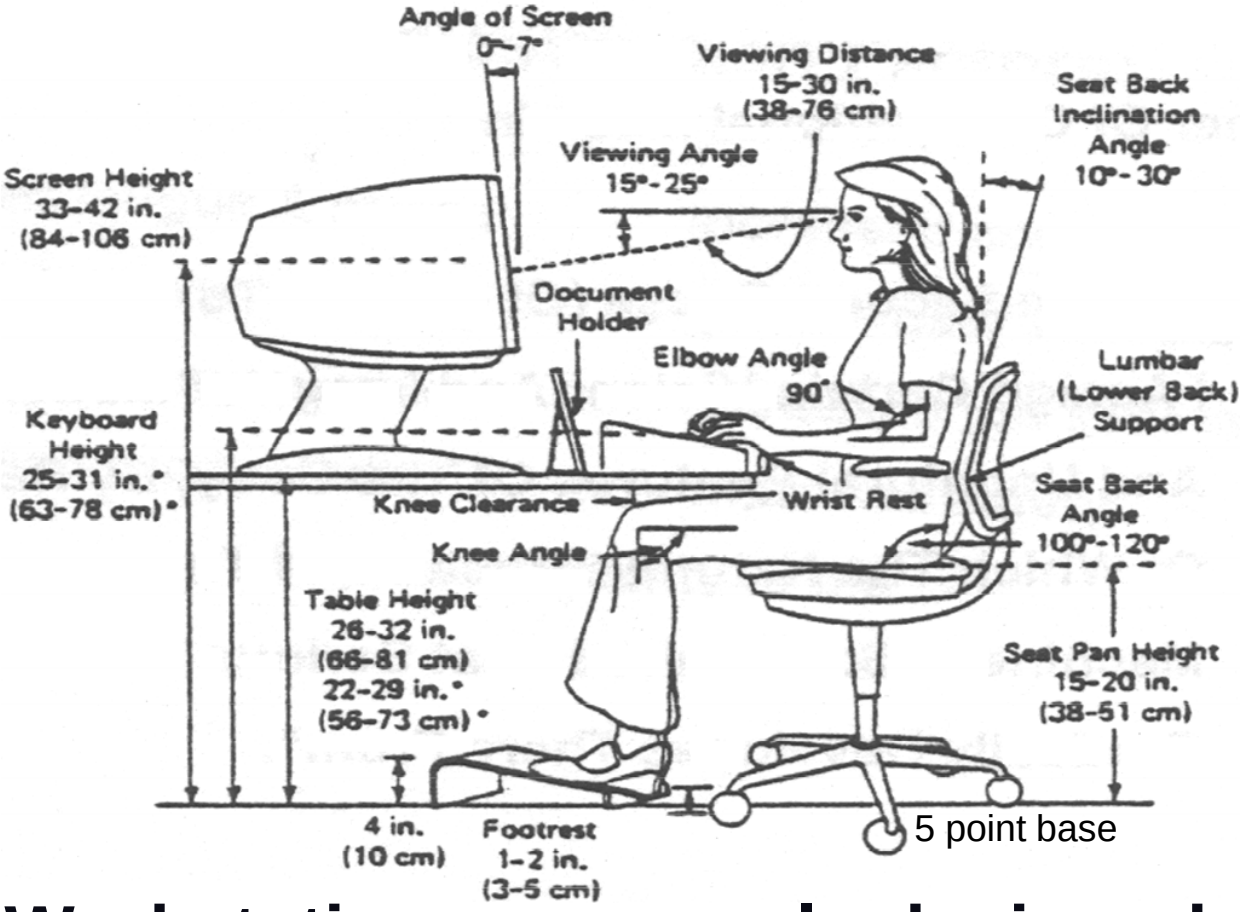
Other Hazards: Ergonomics



Workstations are poorly designed

Other Hazards: Robotics

Aerosol Generation

Enclosure/isolation

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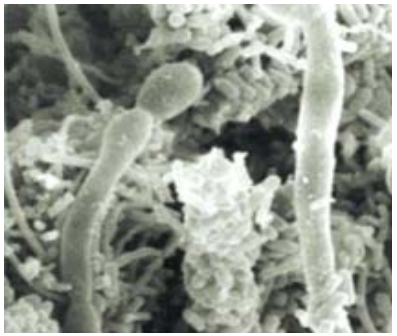
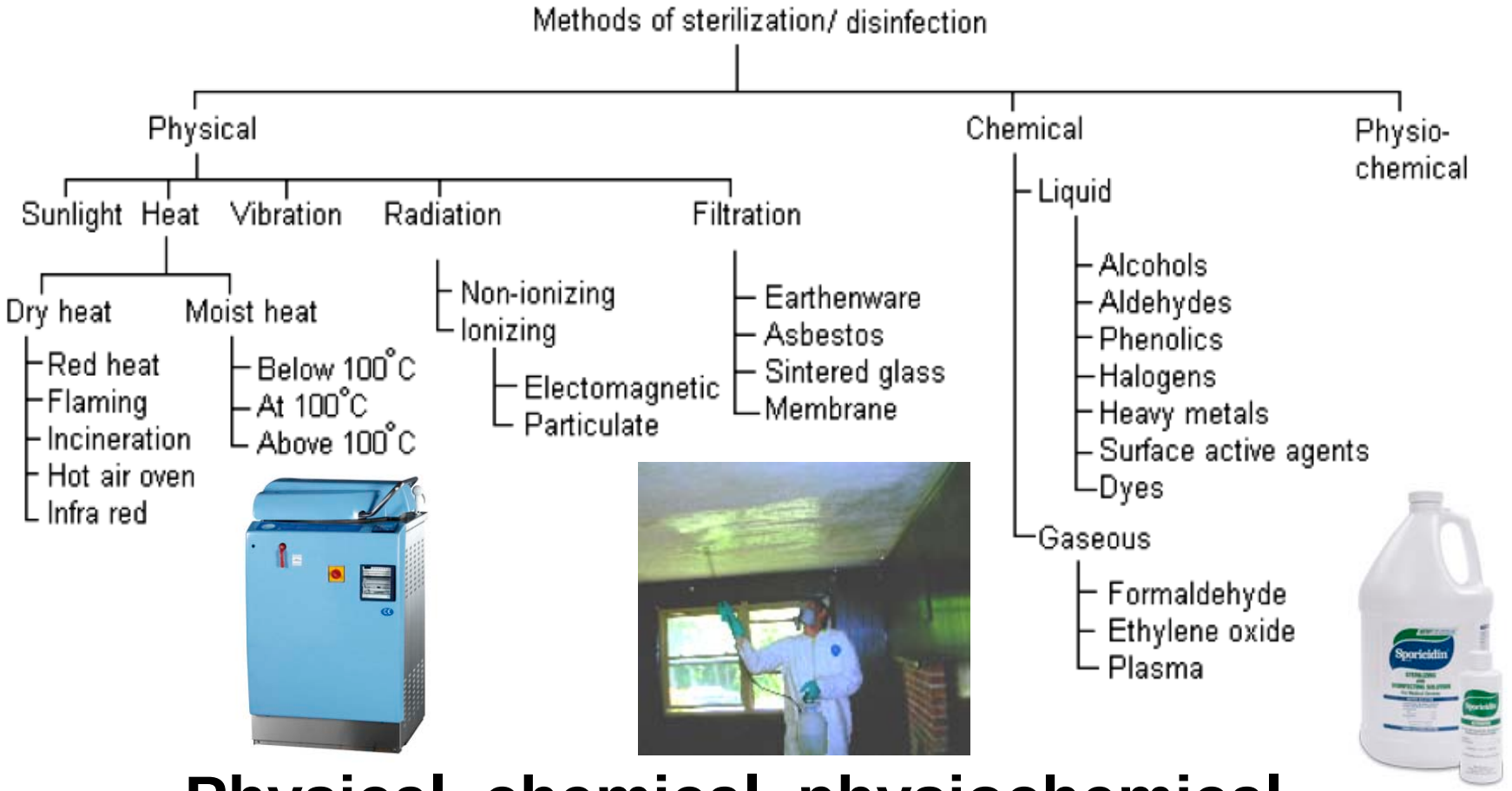
Other Hazards: Decontamination Definitions

- **Sterilization:**
  - **a process that destroys or *eliminates all* forms of microbial life by physical or chemical methods**



- **Disinfection:**
  - **a process to *eliminate pathogenic* microorganisms *except bacterial spores* on surfaces, by physical or chemical methods**
- **Decontamination:**
  - ***reduction* of microorganisms to an acceptable level so objects are safe to use or discard**
  - **can achieve by disinfection or sterilization**

Other Hazards: Decontamination Methods



- **Physical, chemical, physiochemical**

Other Hazards: Chemical Disinfection

- Chemical Disinfectants
  - alternative to steam sterilization
  - high temperatures and moisture may damage instruments.
- Chemical disinfectant categories:
  - acids/alkalis
  - alcohols
  - chlorides
  - formaldehyde
  - peroxides
  - glutaraldehyde
  - iodine
  - mercurical
  - phenolics, and
  - quaternary ammonium compounds

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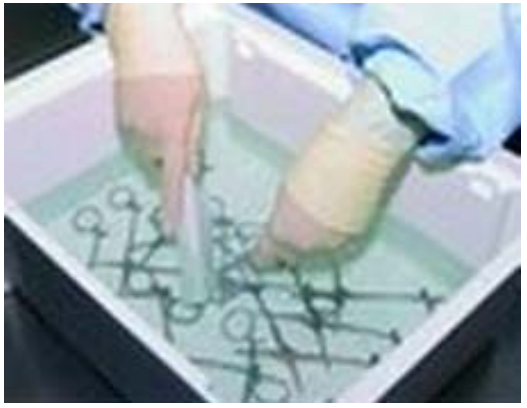
Chemical SAFETY AND SECURITY TRAINING

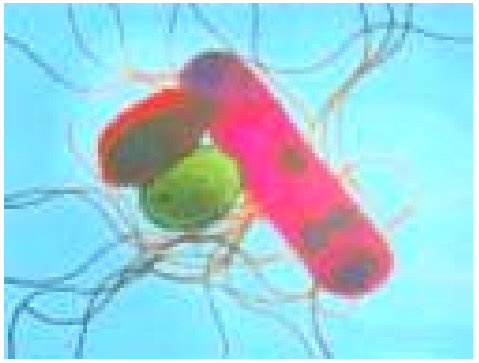
Other Hazards: Chemical Disinfection

- **A successful disinfectant must have:**
  - **good and complete *distribution***
  - **good and total *penetration***
  - **sufficient *contact time* at specified *concentration***
- **Resistance to chemical disinfectants can be altered by:**
  - ***distribution & penetration:***
    - ***contact time***
    - ***concentration***
    - **presence of *grime* (organic matter and dirt)**
    - ***humidity***
    - ***temperature***
  - **also:**
    - **types and numbers of microorganisms**
    - **condition and nature of the surfaces**
    - **human error**



Other Hazards: Chemical Decon - Considerations

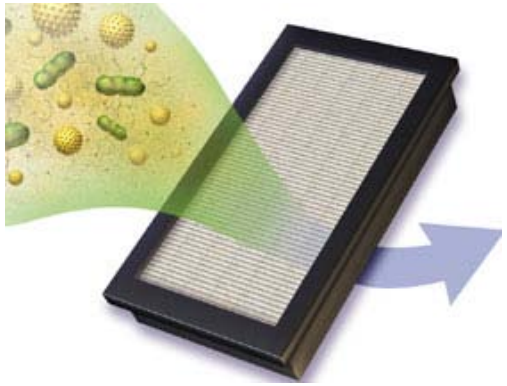
- **Considerations:**
  - **what organism is to be neutralized?**
  - **what level of decontamination is desired?**
  - **what maximum concentration of organism is expected?**
  - **how is the microorganism suspended?**
    - **simple or complex,**
    - **on solid or porous surfaces,**
    - **airborne**



  - **permissible exposure level (PEL) or threshold limit value (TLV) of the decon agent (US-OSHA)**
  - **odor threshold relative to the OSHA PEL or TLV**
    - **a strong odor can provide a self-alerting factor**

Other Hazards: Chemical Decon - Considerations

- Considerations (continued)…:
  - minimum cycle time (less time = less leaks, less exposure)
  - decon agent hazards (carcinogenic, toxic, etc)
  - cleanup: how quickly until the environment is safe, if an accident or leakage occurs?
  - is the agent officially recommended & approved?
  - does the decon agent leave a residue?
  - agent ability to penetrate water, oil, etc.
  - decon agent ability to penetrate HEPAs
  - typical concentrations in use
  - is the agent stable?



Other Hazards: Chemical Decon - Main Factors

Summary of Decontaminant Considerations

	CD	VPHP	Formaldehyde
1. OSHA 8 hr TWA (time weighted average)	0.1 ppm	1.0 ppm	0.75 ppm
2. Odor Detection	Yes	No	Yes
3. Cycle Time (Risk of Exposure)	3-4 hours	4-7 hours	9-15 hours
4. Carcinogen	NO	NO[1]	YES
5. Typical Concentrations	1800 ppm	1000 ppm	8000-10000 ppm
6. Penetration & Distribution	Yes (gas)	No (Vapor)	Yes (gas)
7. Penetrate Water Penetrate Oil Penetrate Grease	Yes No No	No No No	Yes No No
8. Emergency Aeration Time	5-30 min	1-6 hours	1 hour + cleanup
9. Residues	None	None	Yes
10. NSF approvals	Yes	No	Yes
11. U.S. EPA approvals	Yes	Yes	No

[1] IARC, NTP, and OSHA do not list hydrogen peroxide as a carcinogen. ACGIH lists hydrogen peroxide as an A3 animal carcinogen.

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Use risk-based selection:

risk = *probability* of occurrence and *consequence*

cost? availability? difficulty?

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Chemical SAFETY AND SECURITY TRAINING

Other Hazards: Chemical Decon - VPHP

Bioquell VPHP Cycle Parameters (Lin, 2010a)

Width (ft)	Manufacturer	"Set" Volume (ml)	Gassing Time	Aeration Time
6	Esco	155	80 minutes	4 hours 10 minutes

Steris Cycle Parameters (Lin, 2010b)

Process	Time (minutes)	Airflow (SCFM)	Injection Rate (g/m)
Dehumidification	15	20	–
Conditioning	4	17	6.0
Decontamination	45	17	3.5
Aeration	180	20	–

Steris Cycle Parameters (Jones, 1993a)

Process	Time (minutes)	Airflow (SCFM)	Injection Rate (g/m)
Dehumidification	60	12	–
Conditioning	1	12	6.7
Decontamination	30	12	3
Aeration	210	12	–

Bioquel VPHP Cycle Parameters (Driskill, 2007)

Width (ft)	Manufacturer	"Set" Volume (ml)	Gassing Time	Aeration Time
4	Nuaire	155	80 minutes	70-130 minutes
6	Baker	155	80 minutes	70-130 minutes

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VPHP Cycle times, including setup, decontamination, aeration and breakdown.

Reference	Total Cycle Time (hours)
Lin, 2010a	3 ducted, 6 non-ducted
Lin, 2010b	5
Jones, 1993	6
Driskill, 2007	4-5
Hillman, 2004	5 ducted cabinet, 9 non ducted

- **VPHP cycle times for BSCs vary:**
- **with process, cabinet size and ducting:**
  - **dehumidification**
    - **15-60 minutes**
  - **conditioning**
    - **1-4 minutes**
  - **decontamination**
    - **30-80 minutes**
  - **aeration**
    - **70-210 minutes**
  - **total times:**
    - **3-9 hours**

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Chemical SAFETY AND SECURITY TRAINING

Other Hazards: Chemical Disinfectants

- **Quaternary Ammonium Compounds (QACs/Quats):**

zwitterionic, concentrate at and disrupt membranes

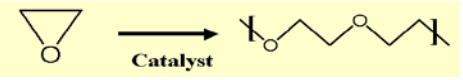
Advantages

+ good disinfectant action - Gram (+) microbes
+ soluble in water and alcohol
+ generally nontoxic and non-allergenic
+ easily prepared and used
+ EPA registered as a disinfectant
+ possess detergent and surfactant properties
+ almost odorless (pleasant aromatic smell)
+ materials compatible
+ useful for sanitizing applications
+ inexpensive

Disadvantages

- decreased activity against Gram (-) microbes
- no sporicidal activity
- poor activity against pseudomonads
- not effective against all nosocomial infections
- substantial interference by organic matter
- reports of contact dermatitis
- lack tuberculocidal properties
- poor activity against hydrophilic viruses
- development of resistant bacterial strains
- incompatible with soaps
- inactivated by stoppers, gauze, cotton, etc.

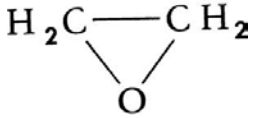
- **Ethylene Oxide gas (alkylating agent):**



colorless liquid at room T, sweet odor, polymerizes w/ water (polyethylene oxide/glycol)

Advantages

+ not deleterious to heat-labile materials
+ egress of gaseous residues
+ simple equipment can be used
+ terminal sterilization of packaged items
+ penetrability
+ not readily inactivated by organic matter



Disadvantages

- special handling (flammable, toxic)
- more costly than heat
- decreased effectiveness when improperly processed
- flammable, carcinogenic, mutagenic, irritating, and anaesthetic gas
- long sterilization & decontamination time
- potential health hazard, must monitor fumes

Other Hazards: Chemical Disinfectants

- **Phenolics:**

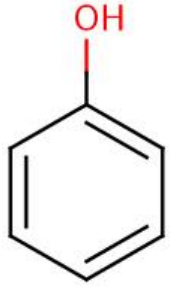
disruption of membranes, precipitation of proteins and inactivation of enzymes

Advantages

+ wide spectrum of antimicrobial activity
+ many formulations available
+ good sanitizer/germicide for housekeeping
+ phenol coefficient readily attainable
+ readily miscible with additives (e.g. soap)
+ good cleansing action
+ EPA registered as a disinfectant

Disadvantages

- relatively poor sporicide
- skin and mucous membrane irritant
- inactivated by organic matter
- relatively expensive
- possesses unpleasant odor
- toxic
- materials incompatible (stains and ordors)



- **Iodophores (halogens):**

cause damage by oxidation of essential sulfydryl groups of enzymes

Advantages

+ powerful germicidal properties of iodine
+ relatively free of toxicity and irritancy
+ safe and convenient to use
+ stable in storage
+ EPA registered as a disinfectant
+ readily miscible with water
+ almost colorless and nonstaining
+ powerful detergent action
+ generally non-corrosive

Disadvantages

- corrosiveness of some surfaces
- relatively expensive
- unstable above 54°C
- not considered instrument-safe

Other Hazards: Chemical Disinfectants

- **Chlorine compounds (halogen):**

reacts with water to form hypochlorous acid, which is microbicidal

HOCl

Advantages

+ wide spectrum of rapid biocidal properties
+ facility of handling and use
+ insignificant residues
+ acceptable odor
+ deodorizing/sanitizing properties
+ low levels of toxicity and irritancy
+ non-staining and colorless
+ low cost

Disadvantages

- sporicidal properties questionable
- possible bronchial irritation from inhalation
- corrosion of metals
- bleaching effect on fabrics
- not registered as disinfectant by EPA
- skin irritation on prolonged contact
- general caustic effects
- product deterioration on standing
- non-wetting action
- possible CO-carcinogenic properties

- **Glutaraldehyde:**

alkylation of amino-, carboxyl- and hydroxyl groups; damages nucleic acids

Advantages

+ broad spectrum of antimicrobial properties
+ good activity in presence of organic matter
+ low volatility (vapor pressure like water)
+ EPA registered as disinfectant
+ relatively rapid disinfecting action - 10 minutes
+ comparability with metal, rubber, and plastic materials
+ nonflammable
+ EPA registered as a sporicide

Disadvantages

- activation required
- slightly to moderately toxic
- not recommended for carbon steel surfaces
- can cause allergic contact dermatitis
- rinsing required to remove residual disinfectant
- tissue irritation (especially to eyes and mucous membranes)
- definite shelf-life

Other Hazards: Chemical Disinfectants

- **Formaldehyde**

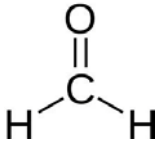
alkylation of amino-, carboxyl- and hydroxyl groups; damages nucleic acids

Advantages

+ wide spectrum of biocidal properties
+ can be rapidly neutralized
+ relatively inexpensive
+ stable when properly stored
+ excellent vapor phase disinfectant paraformaldehyde
+ active in the presence of organic matter
+ readily available
+ registered as a disinfectant by EPA

Disadvantages

- extremely pungent and suffocating odor
- can cause allergic dermatitis
- skin and mucous membrane irritant

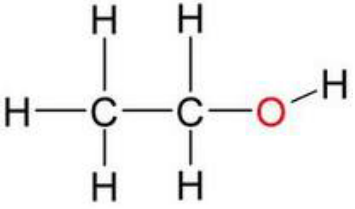


- **Alcohols**

dehydrate cells, disrupt membranes and coagulate proteins

Advantages

+ highly effective bactericides
+ effective virucidal agents
+ pleasant odor
+ non-staining
+ easily obtainable and used
+ non-irritating
+ stable when stored properly
+ effective tuberculocidal agents
+ time to kill - in seconds
+ evaporation without residue formation
+ cleansing activity
+ generally nontoxic
+ inexpensive
+ non-allergenic



Disadvantages

- nonsporicidal
- skin and mucous membrane irritation
- volatile flammable
- inventory and procurement problems
- activity against hydrophilic viruses questionable
- organic matter interference
- some incompatibility with rubber and plastic materials
- not registered as a disinfectant by EPA

Other Hazards: Chemical Disinfectants

Disinfectant Chart: MU Biosafety Manual; University of Missouri-Columbia USA

Disinfectant Class	-cidal Activity Indicated				
	Bacteri-	Tuberculo-	Pseudomona-	Spori-	Viru-
Quaternary Ammon. Cpds.	Good	None	Fair	None	Moderate
Phenolic Compounds	Good	Good	Good	Poor	Moderate
Iodine	Good	Good	Good	Moderate	Good
Chlorine Compounds	Good	Good	Good	Moderate	Good
Glutaraldehyde	Good	Good	Good	Good	Good
Formaldehyde	Good	Good	Good	Good	Good
Alcohols	Good	Good	Good	Good	Moderate
Acids/alkalies	Good	Good	Good	Good	Good
Mercurials	Fair	None	Fair	None	Fair

- **resistance varies with organism**

Spectrum of activity

	Vegetative cells	Mycobacteria	Spores	Fungi	Viruses	Examples
High level	+	+	+	+	+	Ethylene Oxide, Gluteraldehyde, Formaldehyde
Intermediate level	+	+	-	+	+	Phenolics, halogens
Low level	+	-	-	+	+/-	Alcohols, quaternary ammonium compounds

Sterilization & Disinfection; Sridhar Rao, Dept. of Microbiology, JJMMC, Davangere India

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Other Hazards: Slips, Trips, Falls

- Most common injuries in labs
- Causes
  - chemical spills and leaks
  - improper work practices
- Control measures
  - SOPs,
  - proper equipment,
  - effective communication,
  - engineering controls
  - secondary containment

Other Hazards: Sharps, Needles, Blades

- **Hazards:**
  - needle sticks
  - cuts
  - contamination
- **Control Measures**
  - SOPs
  - training
  - work practices
  - engineering controls

Other Hazards: Mercury Exposure

- **Mercury metal exposure can cause severe health problems:**
  - **tremors**
  - **changes in vision or hearing**
  - **insomnia**
  - **weakness**
  - **memory difficulty**
  - **headaches**
  - **irritability**
  - **nervousness or shyness**
  - **acrodynia (painful extremities) - *a condition caused by chronic exposure to mercury***

Other Hazards: Mercury Exposure

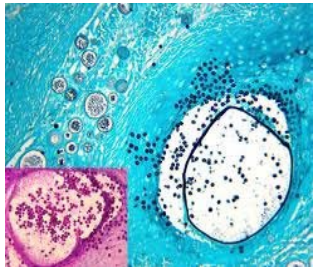
- **Routes of exposure**
  - **inhalation**
    - **main hazard**
    - **hazardous vapors**
  - **skin absorption**

- **Personal protective equipment**
  - **nitrile gloves**
  - **safety glasses**
  - **closed-toed shoes**
  - **lab coat**

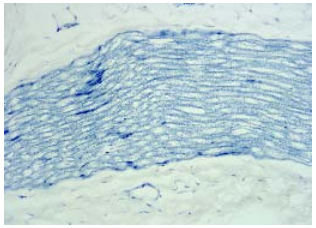
- **Substitution is best solution**

Other Hazards: Histological Staining

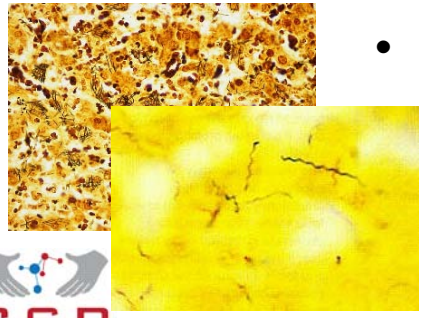
- **Example staining methods:**
  - **Gomori's hexamine silver (methenamine silver) for basement membranes**



    - **alcohol (flammable), periodic acid (pH, corrosive), hexamine (potential carcinogen, permeator, irritant), silver nitrate (toxic, irritant), glacial acetic acid (pH, flammable)**
  - **Solochrome cyanine for myelin**



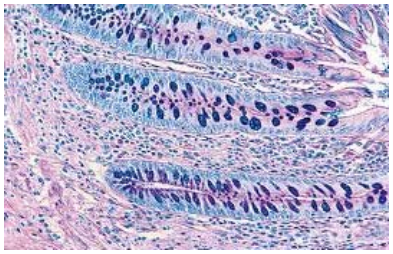
    - **alcohol (flammable), solochrome cyanine (harmful, irritant), picric acid (toxic, permeator, explosive), ponceau S (irritant), glacial acetic acid (pH, flammable), sulphuric acid (pH)**
  - **Warthin & Starry for Tyzzer's disease and spirochaetes**



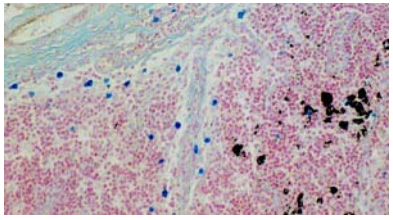
    - **silver nitrate (toxic, irritant), hydroquinone/quinol (harmful, toxic to aquatics, suspected carcinogen, sensitizer), glacial acetic acid (pH, flammable), nitric acid (pH)**

Other Hazards: Sample Staining

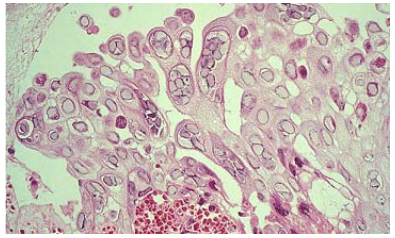
- **Example staining methods (continued):**
  - **Alcian blue/PAS for acid and neutral mucopolysaccharides**



    - **alcohol (flammable), alcian blue (toxic, irritant), glacial acetic acid (pH, flammable), periodic acid (pH, corrosive), Mayers haematoxylin (oral toxin)**
  - **Alcian blue/safranin for mast cell differentiation**



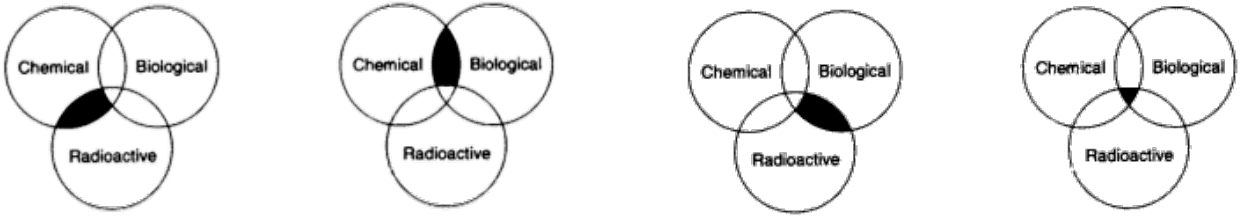
    - **alcohol (flammable), alcian blue (toxic, irritant), butyl alcohol (flammable), glacial acetic acid (pH, flammable), HCl (pH), NaOH (pH)**
  - **Phloxine tartrazine for viral inclusions**



    - **alcohol (flammable), mayers haemotxylin (oral toxin), cellosolve (2-ethoxyethanol) (toxic, irritant), tartrazine (irritant, sensitizer)**

Other Hazards: Mixed Hazardous Waste

- *Elimination is <u>best</u>* – examples:
  - replace toluene-based liquid scintillation fluid with non-flammable fluid (eliminate chemical hazard)
  - use radionuclides with short half lives that are allowed to decay in storage prior to disposal (eliminate radiation hazard)



- Practice *waste minimization* through:
  - source *separation* of biological waste from other wastes
    - do not use/mix containers, gloves, etc that contain PVC or other halogenated plastics for other hazards to be incinerated/burned/buried
    - train workers to identify and separate biological waste from other wastes
  - neutralization, oxidation, reduction, and various other chemical conversions or physical separations to reduce chemical hazards
  - use a compatible chemical disinfectant to neutralize biological hazards

Other Hazards: Unsafe Housekeeping

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM
Chemical SAFETY AND SECURITY TRAINING

Other Hazards: Housekeeping & Hoods

Don’t block hood air flow.

Place large equipment on 5 cm blocks to allow air flow around and under equipment.

Do not use hoods for storage!

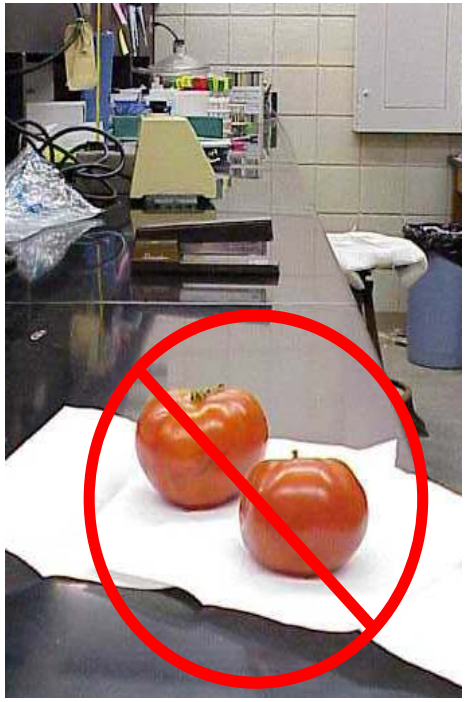
Safety shields can block airflow and reduce hood effectiveness.

Other Hazards: Lab Practices

Don’t block hallways and exits!

Other Hazards: Lab Practices

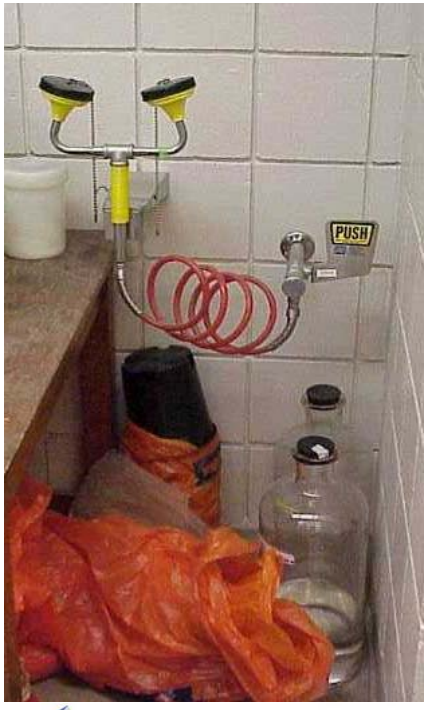
Food is never allowed in laboratories.



Open-toed shoes should not be allowed in laboratories.

Employees should not wear gloves, lab coats or other PPE outside the lab.

Always check that emergency equipment is not blocked.



Other Hazards: Lab Practices

- **Working alone**
  - ***avoid!***
  - **Murphy's Law will get you! (anything that *can* go wrong, *will* go wrong!)**
  - **use the "Buddy System"**
- **Unattended operations/reactions**
  - **caution! *prime sources of fires, spills and explosions***
  - **check periodically!**
  - **fail-safe provisions**
  - **leave the lights on to indicate the presence of an unattended activity**
  - *post appropriate signs and emergency phone #'s*
  - **notify those potentially impacted by malfunction**

Other/All Hazards: Control of Hazards

- **Think!**
- **Develop SOPs, safety manual, policies**
  - **reviewed and approved by management**
- **Research protocol review**
- **Install engineering controls**
- **Provide PPE**
- **Provide training**
- **Conduct inspections, routine & unannounced with lab supervisor**
- **Document and *follow-up***
- **Take action**

Chemical Safety & Security

Standard Operating Procedures: SOP Exercise

SOP Exercise: Electrophoresis

- Develop an SOP for electrophoresis
  - focus on safety portion of SOP – to document safety steps of the procedure, ask/answer:

    mitigation = PPE, engineered controls, operational controls, etc.
    - what are reagents & hazards, and mitigation?
    - what are products & hazards, and mitigation?
    - what are equipment hazards, and mitigation?
    - what waste is generated & hazards, and mitigation?
    - how store chemicals & hazards, and mitigation?
    - waste reduction & hazards, and mitigation?
    - how dispose of waste & hazards, and mitigation?

SOP Exercise: Electrophoresis

- **Refer to the incomplete SOP distributed:**

Rev/Date: Rev01, 25/01/11	**Institute/Dept:** INH/DNA Lab	**completed by:** you	**1** of **4**
Title: DNA Separation via Electrophoresis	**Location**: SMF/ L-001	**approved by:** E. Hoefer	

Briefly explain the procedure for this task: When an electric charge is applied to an agarose gel, DNA migrates through the gel matrix at a rate inversely proportional to the log10 of the number of bases. Super-helical, nicked circular, and linear DNA migrate at different rates relative to each other, and the relative mobility varies depending on many factors. DNA is visualized by the addition of a dye that intercalates between the stacked base pairs of the DNA molecule. Upon exposure to light of a specific wavelength, DNA-dye complexes emit fluorescent or luminescent light. Traditionally ethidium bromide dye has been used.

- consider the experimental setup:
  - equipment
    - typical electrophoresis units operate at ~100 volts
      - power supply
      - connecting leads
      - combs, loading strips, gel trays, buffer chamber, buffer recirculating ports, casting stand, lid
    - UV light illuminator, peristaltic pump
  - samples
    - DNA

SOP Exercise: Electrophoresis

- **Electrophoresis:**
  - **consider experimental setup (continued):**
    - **chemicals in this SOP:**
      - **agarose**
      - **Tris-Borate-EDTA (TBE) –or– Tris-Acetate-EDTA (TAE)**
      - **ethidium bromide**
    - **other chemicals used with electrophoresis:**
      - **polyacrylamide (acrylamide: $CH_2 = CHCONH_2$)**
      - **TEMED (*N*,*N*,*N*′,*N*′-tetramethylethylenediamine)**
      - **ammonium persulfate**
      - **CHAPS (3-[(3-cholamidopropyl)-dimethylammonio]–1-propane sulfonate)**
      - **Bromophenol blue ($C_{19}H_9BR_4NaO_5S$)**
      - **Dithiothreitol (DTT, $C_4H_{10}O_2S_2$)**
      - **EDTA (Ethylenediaminetetraacetic acid)**
      - **Tris ($NH_2C(CH_2OH)_3$)**
      - **phenol**
      - **chloroform**

SOP Exercise: Electrophoresis

- **Use the MSDS information distributed:**
  - **MSDS sections:**
    - **Section 2. HAZARDS IDENTIFICATION.**
      - **OSHA Hazards, Hazard statement(s), Precautionary statement(s), HMIS Classification, NFPA Rating, Potential Health Effects**
    - **Section 4. FIRST AID MEASURES**
      - **General advice, if inhaled, in case of skin contact, in case of eye contact, if swallowed**
    - **Section 5. FIRE-FIGHTING MEASURES**
      - **Suitable extinguishing media,**
    - **Section 7. HANDLING AND STORAGE**
      - **Precautions for safe handling, Conditions for safe storage**
    - **Section 8. EXPOSURE CONTROLS/PERSONAL PROTECTION**
      - **OELs, PPE**
    - **Section 10. STABILITY AND REACTIVITY**
      - **Chemical stability, Conditions to avoid, Materials to avoid, Hazardous decomposition products**
    - **Section 12. ECOLOGICAL INFORMATION**
      - **Toxicity**

SOP Exercise: Electrophoresis

- **Complete the SOP:**
  - **write in general safety/PPE at heading,**
  - **write in the hazards of each step,**
  - **write in proper waste handling,**
  - **write mitigation of hazards where the exist:**
    - **PPE, engineered controls, procedural controls, substitution/elimination**
  - **write in suggestions to reduce waste,**
  - **write in suggestions to improve SOP steps (for safety)**

Chemical Safety & Security

Standard Operating Procedures: SOP Exercise

SOP Exercise: Electrophoresis

- **Hazards in this SOP:**
  - **preparation of agarose gel solution**
    - **formation of super heated solution during heating with microwave.**
  - **setting up/running electrophoresis system**
    - **electrical shock.**
  - **staining of gels**
    - **ethidium bromide is a known carcinogen**
  - **waste/disposal**
    - **dispose of chemicals and gels with ethidium bromide as hazardous waste**

SOP Exercise: Electrophoresis

- **Hazards in other electrophoresis SOPs:**
  - **preparation of polyacrylamide gel**
    - **flammable solvents used (isobutanol) in curing gel.**
    - **chemical exposure to acrylamide, SDS, TEMED and ammonium persulfate**
      - **acrylamide affects central and peripheral nervous system and reproductive system when swallowed, inhaled or absorbed through skin**
      - **TEMED, SDS and ammonium persulfate causes irritation to respiratory system, eyes and skin upon inhalation and contact**
  - **setting up/running electrophoresis system**
    - **electrical shock**
    - **SDS electrophoresis buffer may cause irritation to eyes and skin upon contact**

SOP Exercise: Electrophoresis

- **Hazard Controls:**
- **Substitution:**
  - ethidium bromide (known mutagen) – use:
    - SYBR® Safe DNA gel stain (Invitrogen product)
      - SYBR® Green I is for dsDNA, and SYBR® Green II is for RNA and ssDNA
- **PPE:**
  - lab coat with full sleeves, splash goggles, nitrile gloves (latex is not effective), pants, and closed-toe shoes
  - skin and eye protection for UV radiation work
- **Waste/disposal:**
  - some gels may be considered non-hazardous and may be treated as such. For example, ethidium bromide <0.4 wt% in non-polyacrylamide gel, is considered non-hazardous waste and can be placed into a closed bag, then into trash

SOP Exercise: Electrophoresis

- **Hazard Controls:**
- **Thermal hazard:**
  - Exercise caution when using microwave to liquefy gels – don't use sealed containers, beware of superheated liquids that may froth up unexpectedly. Let hot gel preps cool to 50-60°C before adding stain or pouring into trays. Wear insulated gloves and point the flask opening away from you.
  - Loosen cap of bottle when heating solution. Do not heat for more than 30sec at a time. Heating up agarose solution in intervals using microwave with occasional swirling to mix the solution will help ensure agarose is melted more quickly without the formation super heated solution.
  - Fill solution only 1/3 of bottle volume
  - Standard PPE includes lab coat, gloves and safety glasses.

SOP Exercise: Electrophoresis

- **Hazard Controls:**
  - **Chemical Hazards:**
    - **Measure, mix and handle all hazardous powdered chemicals or gel prep mixtures with hazardous components (e.g., acrylamide monomer, ethidium bromide, phenol, ammonium persulfate, and formaldehyde) in the fume hood.**
    - **All organic/flammable solvents to be kept in the flammable storage cabinets.**
    - **Use respiratory half mask when handling TEMED or SDS powder.**
    - **Purchase pre-made gels or pre-mixed acrylamide and ethidium bromide solutions instead of making your own.**

SOP Exercise: Electrophoresis

- **Electrical Hazard Controls:**
- **Power supplies:**
  - **inspect to ensure all switches and indicators are in proper working condition and that power cords and leads are undamaged and properly insulated.**
  - **label equipment with warning: “Danger Electrical Hazard.”**
  - **connect to ground fault circuit interrupters (GFCIs)**
  - **use 3-prong plugs.**
  - **use power supplies with safety features that detect no-load, overload, sudden load change, short circuit, arc or ground leak, etc.**
  - **place electrophoresis power supply on a elevated position and separated from electrophoresis tank.**

SOP Exercise: Electrophoresis

- **Electrical Hazard Controls (continued):**
- **Connecting leads:**
  - **turn off main power supply before connecting or disconnecting electrical leads.**
  - **with dry gloved hands, connect one lead at a time using one hand only.**
  - **be sure that leads/banana plugs are fully seated.**
- **Using equipment:**
  - **don't run equipment unattended.**
  - **keep equipment clear of unintentional grounding points and conductors (e.g., sinks or other water sources, metal plates, jewelry, aluminum foil, pipes or other electrical/metal equipment).**
  - **gel chamber must have a lid or cover with safety interlocks to prevent accidental contact with energized electrodes or buffer solutions.**
  - **gel chamber exterior must be dry with no spills. Check for leaks.**
  - **ensure SDS electrophoresis buffer is not beyond the max fill line.**

SOP Exercise: Electrophoresis

- **Emergency event:**
  - **inform supervisor, coworkers and first aid officer.**
  - **for major emergencies dial xxx.**
  - **nearest first aid kit in room xxx.**
  - **nearest safety shower in room xxx.**
  - **nearest fire extinguishers:**
    - **CO2 fire extinguisher in rooms xxx and yyy;**
    - **dry chemical extinguisher beside store room.**
  - **evacuate per evacuation plan and gather in front of xxx Building.**

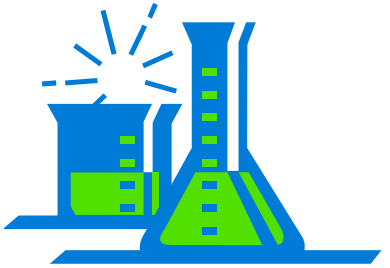
Break

REHAT

Chemical Waste Management and Disposal

Waste Management

- Nonhazardous waste
- General guidelines- Storage - Packaging
- Special categories
  - Metal waste
  - Radioactive and mixed waste
  - Biological waste
  - Unknown and orphan waste
- Treat on-site



Waste management: nonhazardous waste

- Used oil (uncontaminated) is not considered hazardous waste. Label Containers "USED OIL", not "hazardous waste."

- Uncontaminated PPE (gloves, wipes)
- Triply rinsed glassware (bottles, droppers, pipettes)
- Salts (KCl, NaCl, Na_2CO_3)

- Sugars - Amino acids
- Inert materials (uncontaminated resins and gels)

Waste management: General guidelines

- Secure and lock waste storage area
- Post signs to warn others
- Keep area well ventilated
- Provide fire extinguishers and alarms, spill kits
- Provide suitable PPE
- Provide eye wash, safety showers
- Do not work alone

Waste management: General guidelines

- Insure against leakage; dyke area if possible
- Label all chemicals, containers, vials
- Separate incompatible chemicals
- Keep gas cylinders separate
- Keep radioactive material separate
- Know how long waste can be stored
- Provide for timely pick-up

Waste - Storage guidance

- **Container should not react with the waste being stored (e.g. no hydrofluoric acid in glass).**
- **Similar wastes may be mixed if they are compatible**
- **Whenever possible, *wastes from incompatible hazard classes should not be mixed* (e.g. organic solvents with oxidizers).**
- **Containers must be kept closed except during actual transfers. Do not leave a funnel in a hazardous waste container.**
- **Chemical containers that have been triple-rinsed and air-dried in a ventilated area can be placed in the trash or recycled.**

Waste – General guidance

Certain metals cause disposal problems when mixed with flammable liquids or other organic liquids

Pressure can build up in a waste vessel

Corrosion can occur in storage vessel

Secondary containment is necessary

Glass waste containers can break

Dangerous waste management

Video – Fire at Apex Waste Facility

Best practice – Orphan control

Before moving to new job meet with new lab occupant

- **This can be a new employee or new student**
- **Label all chemicals and samples carefully**
- **Make notations in common lab book**

Dispose of all unneeded or excess chemicals

- **Put into chemical exchange program**
- **Dispose of as hazardous waste**

Do not leave any chemicals behind except by agreement

Waste management

- **Recycle, reuse, redistill, if possible**
- **Dispose by incineration, if possible**
- **Incineration is NOT the same as open burning**

Emissions from incineration vs. open burning

	Open Burn (µg/kg)	Municipal Waste Incinerator (µg/kg)
PCDDs	38	0.002
PCDFs	6	0.002
Chlorobenzenes	424150	1.2
PAHs	66035	17
VOCs	4277500	1.2

Source: EPA/600/SR-97/134 March 1998

Laboratory wastes are packaged in small containers

Lab packs consists of small containers of compatible waste, packed in absorbent materials.

Lab packs segregated at hazardous waste facility

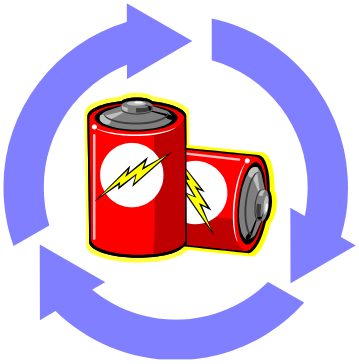
Waste management: Waste disposal service

- Is disposal service licensed?
- How will waste be transported?
- How will waste be packaged?
- Where will material be disposed?
- How will it be disposed?
- Maintain written records

Battery recycling and disposal

Hazardous waste

- Lead acid (Pb) - recycle (90% car batteries)
- Sealed lead (Pb) - recycle
- Mercury-oxide (HgO) button, silver-oxide (AgO) button - recycled by jewelers
- Nickel Cadmium (NiCd) recycle



Nonhazardous waste

- Nickel Metal Hydride (Ni-MH) recycle
- Carbon – zinc
- Alkaline
- Zinc-air button

Mercury metal disposal

- Collect pure liquid mercury in a sealable container. Label as "MERCURY FOR RECLAMATION"
- Place broken thermometers and mercury debris in a sturdy sealable plastic bag, plastic or glass jar. Label the container "Hazardous Waste - MERCURY SPILL DEBRIS".
- Never use a regular vacuum to clean up a mercury spill - contaminates vacuum, heat evaporates the mercury
- Never use a broom to clean up mercury – spreads smaller beads - contaminates the broom.

Mixed Waste (chemical radioactive)

These wastes must be minimized - heavily regulated

- **Universities, hospitals**
  - **Low level radioactive with chemical**
    - **Scintillation cocktails**
    - **Gel electrophoresis waste**
- **Nuclear energy research**
  - **Low and high level radioactive with chemical**
  - **Lead contaminated with radioactivity**

Mixed Waste (chemical-biological)

- Medical wastes
  - Blood and tissue
  - Sharps – needles, scalpels
  - Contaminated glassware, ppe
- Autoclave or sterilize
  - Bleach incompatible with autoclave
  - Do not autoclave flammable liquids
- Incinerate

Mixed Waste (radioactive-biological)

Medical wastes

- Often disinfect high biohazard to minimize handling risk
- Let short-lived isotopes decay and then use sanitary sewer
- Refrigerated storage for putrescible waste (carcasses-tissue)
- Autoclave or disinfect labware and treat as low level radioactive
- On-site incineration of low level rad waste if allowed (sharps as well)

Unknown “orphan” waste

Avoid if at all possible -- requires analysis before disposal!

Pre-screen

- Crystals present ? (potential peroxide formation)
- Radioactive (Geiger counter)
- Bio waste? (interview history)

Screen

- Prepare for the worst – wear gloves-goggles-hood

- Air reactivity
- Water reactivity
- Flammability
- Corrosivity

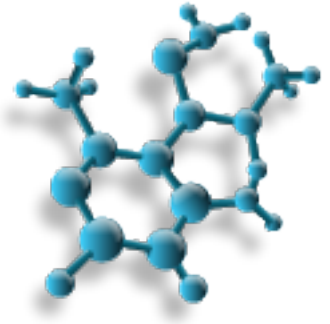
Unknown waste characterization*

Physical description - Water reactivity - Water solubility

pH and neutralization information

Presence of:

- ✓ **Oxidizer**
- ✓ **Sulfides or cyanides**
- ✓ **Halogens**
- ✓ **Radioactive materials**
- ✓ **Biohazards**
- ✓ **Toxics**

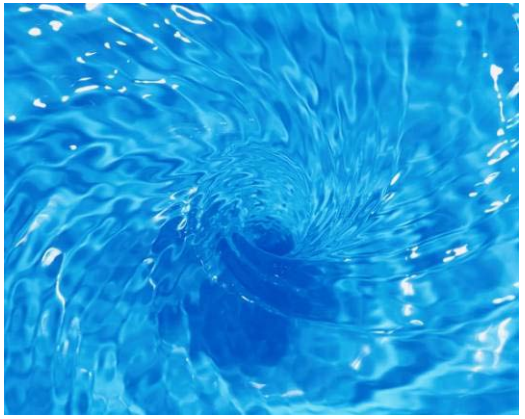


***Prudent Practices in the Laboratory: Handling and Disposal of Chemicals," National Academy Press, 1995 Section 7.B.1**

Waste management: Down the drain?

If legally allowed:

- **Deactivate & neutralize some liquid wastes yourself**
  - **e.g., acids & bases**
  - **Don't corrode drain pipes**
- **Dilute with lots of water while pouring down the drain**
- **Be sure that you do not form more hazardous substances**
  - **Check reference books, scientific literature, internet**



Treating on site – volume reduction

Evaporation – if not excessive

- **Roto evaporation for recovery**
- **Do not evaporate corrosives or radioactives**
- **Only in laboratory hood**
- **Beware toxics and flammables**

Adsorption

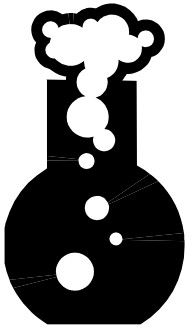
- **Activated carbon**
- **Ion exchange resin**
- **Activated alumina**

Precipitation - Extraction

Handbook of Laboratory Waste Disposal, Martin Pitt and Eva Pitt, 1986. ISBN 0-85312-634-8

Treating on site – chemical conversion

Requires chemical expertise - may not be allowed by regulations - specific to each chemical



Dilution to reduce hazard

- H_2O_2, $HClO_4$, HNO_3
- Never add water to concentrated acid
- Neutralization acid base -gentle

Hydrolysis (acid and base)

- Active halogen compounds with NaOH
- Carboxamides with HCl

Oxidation-reduction

Handbook of Laboratory Waste Disposal, Martin Pitt and Eva Pitt, 1986. ISBN 0-85312-634-8

Chemical Waste Example: Tollens Reagent

$Ag(NH_3)_2NO_3$ (aq)

- The reagent should be freshly prepared and stored refrigerated in a dark glass container. It has a shelf-life of ~24 hours when stored in this way.
- After the test has been performed, the resulting mixture should be acidified with dilute acid before disposal. These precautions are to prevent the formation of the highly explosive silver nitride.

Chemical Waste Example: Sodium Cyanide

- **Wear PPE, work in hood**
- **Add sodium cyanide to a solution of 1% sodium hydroxide (~50mL/g of cyanide).**
- **Household bleach (~70mL/g of cyanide) is slowly added to the basic cyanide solution while stirring.**
- **When addition of the bleach is complete, test for the presence of cyanide using the Prussian blue test:**
  - **To 1mL of the solution ot be tested, add 2 drops of a freshly prepared 5% aqueous ferrous sulfate solution.**
  - **Boil this mixture for at least 60 seconds, cool to room temperature, then add 2 drops of 1% ferric chloride solution.**
  - **Take the resulting mixture, make it acid (to litmus paper) using 6M hydrochloric acid.**
  - **If cyanide is present, a deep blue precipitate will be formed.**
- **If test is positive, add more bleach, then retest.**

From “Hazardous Laboratory Chemicals Disposal Guide”, Armour, 2003.

Waste management: Treatment in Lab

- **References:**
  - **"Procedures for the Laboratory-Scale Treatment of Surplus and Waste Chemicals, Section 7.D in Prudent Practices in the Laboratory: Handling and Disposal of Chemicals," National Academy Press, 1995, available online: http://www.nap.edu/catalog.php?record_id=4911**
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