Chemical
SAFETY AND SECURITY TRAINING

Workshop

Indonesia

August 2009

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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

Welcome

- Workshop purpose
  - Improve Chemical Safety and Security
  - We learn status and needs in your country
- Overview of schedule
- Contents of binder/CD
- Other announcements
- Introductions

CSP

Chemical SAFETY AND SECURITY TRAINING

U.S. DEPARTMENT *of* STATE

The Chemical Security Engagement Program:

Improving Best Practices in Chemical Safety and Security

Nancy Jackson, PhD

Manager
International Chemical Threat Reduction Department
Sandia National Laboratories

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

Why? The Global Chemical Threat

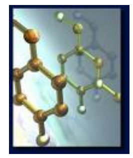
- Prevent disasters, protect the public & workers:
  - December, 1984: Bhopal, India

- Deter those that seek to:
  - Obtain and use chemical weapons;
  - Recruit scientific experts;
  - Use industrial chemicals as low-cost alternatives to conventional attacks.

Chemical Security Engagement Program (CSP)

Program Objectives:

- Raise awareness about chemical threat, dual-use nature of chemicals.
- Foster national and regional dialogue.
- Identify chemical safety & security gaps.
- Promote and strengthen scientific collaboration among chemical professionals.
- Provide assistance to improve chemical security and safety best practices.
- Reduce the chemical threat while promoting beneficial chemical R&D.



What can be done?

Addressing dual-use can provide dual-benefit:

- Improve occupational health and safety for workers and students.
- Foster dialogue and scientific collaboration among academia and industry worldwide toward peaceful aims.
- Promote safe, secure, sustainable S&T development.

How we do it:
Global Chemical Safety & Security Partners

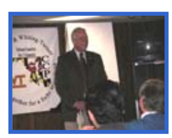
- Work with host countries to assess priorities and gaps in chemical security and safety
- Bring together experts to identify chemical security assistance needs
- Partner with :
  - Host governments
  - International, regional and national professional chemical societies (FACS, IUPAC, etc.)
  - Chemical professionals
  - International efforts to improve chemical safety and security

How CSP will work:

Raise Awareness – Dual use nature of chemicals:
Reducing the chemical threat by collaborating with partner governments and chemical professionals to raise awareness about chemical security and safety, consistent with national and international guidelines, norms and requirements.

Strengthen global scientific cooperation: Providing funding to institutions for projects that advance CSP objectives in chemical safety and security.

Chemical Security Projects in Industry: Working with chemists, chemical engineers and industry representatives in the areas of chemical security and safety, including assistance in risk assessment, safety and security consultations, and design and implementation.



Create training opportunities for scientists, laboratory managers, chemical industry and policy makers on risk/vulnerability assessment and chemical safety to improve chemical security for entities housing, importing or exporting toxic industrial chemicals.

Chemical Security Engagement Program (CSP)

Risks and Gaps Identified:

Universities:

- Lack of safe practices
- Dual use of chemicals
- Improper chemical management
- Improper storage of chemicals
- Lack of enforcement of safety rules/laws

Consequences:

- Injury or death
- Expenses incurred from incidents, spills, disposal
- Loss of trust with community

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

Chemical Security Engagement Program (CSP)

Risks and Gaps Identified:

Industry:

- Theft of unsecured chemicals
- Improper chemical management
- Improper disposal of chemicals
- Lack of enforcement of safety rules/laws

Consequences:

- Loss of $$$, lower profits, competitor gains
- Injury or death to workers and nearby residents
- Expenses incurred from incidents, spills, disposal
- Loss of trust with community

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

Chemical Security Engagement Program (CSP)

Course Goal:

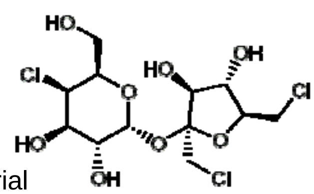
- Increase awareness of the importance of chemical safety and security
- Increase knowledge of methods for improving chemical safety and security
- Determine needs for future training/actions

Safety vs. Security:

- Chemical Safety: Protecting people from chemicals
- Chemical Security: Protecting chemicals from people (i.e., terrorists or thieves)

Where CSP will work

Countries with:



– Growing chemistry capabilities
– Growing chemical industry
– Regional security concerns
– Active producers/exporters of industrial chemicals

Regional Approach:

– South and Southeast Asia
– Middle East
– Expanding to other areas

Chemical Security Engagement Program (CSP)

Learn more:

- http://www.csp-state.net

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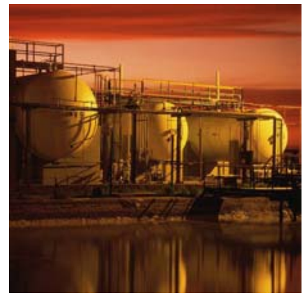
Chemical Safety and Security Overview

Pauline Ho, PhD

International Chemical Threat Reduction Department
Sandia National Laboratories

Why worry about chemical safety?

- Chemicals used everyday in labs and factories can be hazardous.



Bhopal: Pesticide plant chemical release

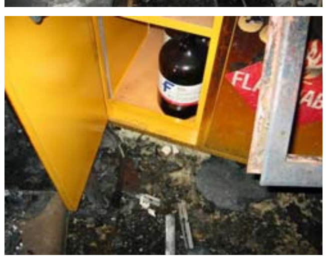
- **One of the greatest chemical disasters in history, December 1984**
- **Union Carbide plant making Sevin released ~40 tonnes of methyl isocyanate in the middle of the night**
- **Low local demand for pesticides meant the plant was only partially running**
- **Some hardware was broken or turned off, including safety equipment**
  - Safety measures and equipment far below US standards
- **Plant in heavily populated area**
- **At least 3800 immediate deaths, 500,000 people exposed**
  - 15,000-20,000 premature deaths since
- **Large area contaminated**
- **Many issues still not resolved**

* "The Bhopal disaster and its aftermath: a review", Edward Broughton, *Environmental Health: A Global Access Science Source* 2005, **4**:6, http://www.ehjournal.net/content/4/1/6, accessed 12/07

Taiwan: Silane fire

- Motech Industries solar cell plant in Tainan Industrial Park
  - 1 death
  - US $1.3 million damage
  - Silane / air explosion
    - Operator responded to gas-cabinet alarm
    - Explosion occurred when he opened gas-cabinet
    - Fire burned for 1 hour before being controlled
      - Caused other SiH_4 and NH_3 cylinders to empty
  - November 2005

University of California Santa Cruz: Fire



- Jan. 11, 2002, ~5:30 am, 4th floor of Sinsheimer Lab building, Dept. of Molecular, Cell and Developmental Biology
  - Firefighters responded to alert from heat-detection system in building
  - Controlled by noon
  - Up-to-date inventory of hazardous materials allowed firefighters to enter building and contain fire
  - Building did not have automatic sprinkler system
- Professors and students lost equipment, notes, materials, samples
- Other labs in building closed for weeks to months
  - Water and smoke damage
- Burned labs took 2 years to reopen
- Cause never determined

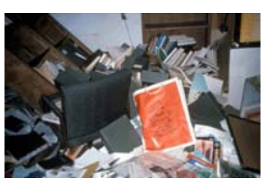
http://ehs.ucsc.edu/emergency/pubs/sinshfire2.htm

Dartmouth College: Dimethylmercury poisoning

- Karen Wetterhahn, professor and founding director of Dartmouth's Toxic Metals Research Program
  - expert in the mechanisms of metal toxicity
- In 1996, spilled a few drops of dimethylmercury on her gloved hand
  - Cleaned up spill immediately
  - Latex glove believed protective
- Six months later, became ill and died of acute mercury poisoning at age 48

Cal. State Univ. Northridge: Earthquake

- Magnitude 6.7, Jan. 17, 1994, 4:31 am
- 57 deaths, 11000 injuries
- Epicenter a few km from California State University Northridge campus



- Several fires in science buildings.
  - Allowed to burn because firemen worried about chemical hazards
- Professors and students lost equipment, notes, materials, samples

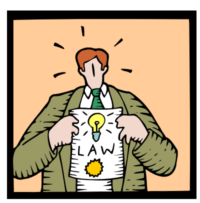
Images courtesy: P.W. Weigand, California State University Northridge Geology Department, Image source: Earth Science World Image Bank http://www.earthscienceworld.org/images

Why worry about chemical safety?

- Health and safety of scientists
- Community relationships
  - Loss of trust can interfere with how you operate your lab facility
- Environment
  - People want clean air, safe food and water
- Reduce chance of accidental chemical release
  - Normal operations
  - Abnormal conditions such as earthquakes
- Avoid loss and damage to labs and equipment
- Be safe while doing good science

Government regulations: Chemical safety

- Will be different from country to country
- US examples:
  - OSHA (Occupational Safety and Health Act)
  - RCRA (Resource Conservation and Recovery Act)
  - TSCA (Toxic Substances Control Act)
  - CAA (Clean Air Act)
  - NEPA (National Environmental Policy Act)
  - Various State-specific regulations
- European Union: REACH
- Your country ?



Why worry about chemical security?

- Long history of people deliberately using chemicals to harm others.
- Information on how to acquire and deliver them is easy to get.

Aum Shinrikyo: Matsumoto and Tokyo, Japan

Photo of wanted poster from Wikipedia commons

- Sarin attack on Judges in Matsumoto, June 1994
  - Sarin sprayed from truck at night
  - 7 deaths, 144 injuries
- Sarin attack on Tokyo subway, March 1995
  - 11 bags with 600 g each on 3 main subway lines
  - 12 deaths, 3938 injuries
- Hydrogen cyanide attacks on Tokyo subway, May 1995
  - Bags of NaCN and sulfuric acid
  - No deaths, 4 injuries
- Recruited young scientists from top Japanese universities
- Produced sarin, tabun, soman, VX
- Purchased tons of chemicals through cult-owned companies
- Motives: proof of religious prophecy, kill opponents, interfere with legal proceedings and police investigations

Chicago, Illinois, USA

- March 2002, an anarchist (called himself "Dr. Chaos") was found at 2 am in a Univ. Illinois, Chicago, building carrying sodium cyanide
- Had chemicals in a storage room at the Chicago subway
  - included containers marked mercuric sulfate, sodium cyanide, potassium cyanide, and potassium chlorate
  - 0.25 pound of potassium cyanide and 0.9 pound of sodium cyanide
  - stolen from an abandoned warehouse, owned by a Chicago-based chemical company
    - 15 drums and 300 jars of various other laboratory chemicals were discovered there

- Sentenced to prison for "possessing a chemical weapon", as well as other charges (Interfering with power, air-traffic control systems, computer systems, broadcast systems and setting fires).

http://cns.miis.edu/db/wmdt/incidents/1190.htm, accessed 12/07

Iraq

- Many incidents in which chlorine gas cylinders are blown up with explosives
  - Chlorine probably stolen/diverted from water purification plants or oil industry
  - Many civilians and non-combatants injured
- Chlorine first used in WWI as a chemical weapon

On March 23, 2007, police in Ramadi's Jazeera district seized a truck filled with "five 1000-gallon barrels filled with chlorine and more than two tons of explosives"

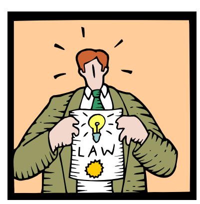
From http://www.longwarjournal.org/archives/2007/03/al_qaedas_chlorine_w.php downloaded Jan 2008.

Why worry about chemical security?

- Health and safety of people and environment
- Community relationships
- Reduce chance of accidental chemical release
- Avoid loss and damage to labs and equipment
- Prevent criminals and terrorists from getting dangerous chemicals
  - Wide variety of chemicals have been used
  - Wide variety of motivations for actions
- A deliberate attack on a chemical facility could release a large amount of hazardous chemicals
  - Injure or kill people in nearby areas
  - Eliminate jobs and economic assets

Government regulations: Chemical security

- Will be different from country to country
- Legislation needed to fulfill requirements under the Chemical Weapons Convention
  - Each country passes appropriate laws
  - Each country must declare and track certain chemicals
- UN Resolution 1540
- Other export control legislation



Laboratory Chemical Safety: Concepts of Anticipation, Recognition, Evaluation and Control

Douglas B. Walters, Ph.D., CSP, CCHO

Environmental & Chemical Safety Educational Institute

Fundamentals of

Laboratory Chemical Safety

References

"Safety in Academic Laboratories, Vol.1 & 2," American Chemical Society, Washington DC, 2003, handouts and available online: http://membership.acs.org/c/ccs/publications.htm

"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

"Hazardous Chemicals: Control and Regulation in the European Market," H.F.Bender and P. Eisenbarth, Wiley-VCH, Weinheim Germany, 2007

Purpose of Laboratory Chemical Safety

- Protect the worker
- Safeguard the environment
- Comply with regulations
- Support the conduct of the studies

Laboratory Chemical Safety

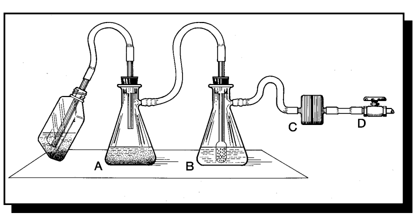
Safety---freedom from danger, injury, or property damage

Hazard---the potential to harm

Risk---the probability that harm will result

Laboratory Chemical Safety

Are all agents dangerous?



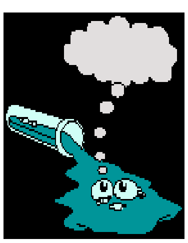
or

Is it their *improper* use that makes them dangerous?

Degree of hazard depends on

- Chemical / physical properties
- Route of entry
- Dosage or airborne concentration
- Exposure duration or frequency
- Environmental conditions
- Controls

Chemical Laboratory Hazards



- Chemical hazards
  - dusts, fumes, mists, vapors, gases
- Physical hazards
  - fire, electrical, radiation, pressure vibration, temperatures, noise,
- Ergonomic hazards
  - repetitive motion (pipetting), lifting, work areas (computers, instruments)
- Biological hazards
  - pathogens, blood or body fluids

Chemical Laboratory Safety

Based on Industrial Hygiene Principles

- Anticipation
- Recognition
- Evaluation
- Control

chemical hazards
physical hazards
ergonomic hazards
biological hazards

Anticipate

- Potential problems and concerns

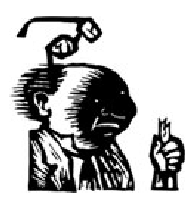
- Design a safe experiment first—
  - Don't just design an experiment!

Anticipation

- **Plan Experiment in Advance**
  - Outline proposed experiment
    - What chemicals? How much?
    - What equipment?
  - Acquire safety information
    - MSDS (Material Safety Data Sheet)
    - REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals)
    - ICSCs (International Chemical Safety Cards)
    - Reference textbooks
  - Consult with Safety Office?

Hazard Recognition & Evaluation

- **What are the anticipated risks?**
  - Are the equipment & facilities adequate?
    - Is special equipment needed?
  - Are staff properly and sufficiently trained?
    - Who will do the experiment?
    - What kind of training do they need?
  - Can the experiment go wrong?
    - What would go wrong?
    - Is there a plan for this?



Hazard Evaluation

- What are the potential or actual agents/exposures?
- When and where does the exposure occur?
- Which workers are exposed and how does the exposure occur?
- What is the evidence of exposure?
- What control measures are present, available, and effective?

Control

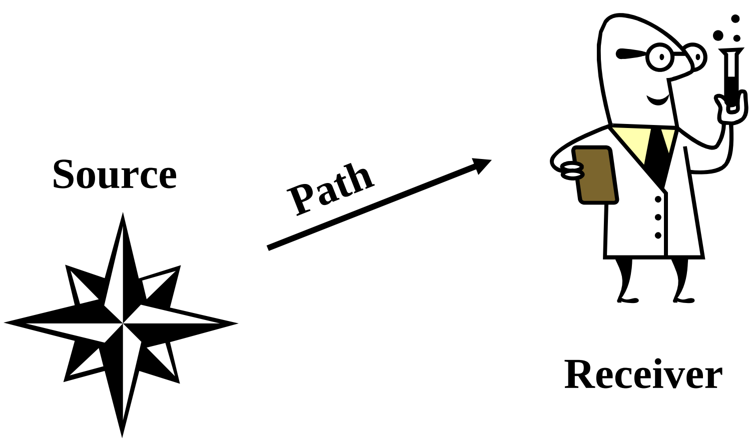
- How are the risks controlled?

- Administrative controls
- Engineering controls
  - enclosure / isolation
  - ventilation / hoods
- Personal Protective Equipment (PPE)
- Emergency Plan

Control Objectives

- ❑ Maximize Containment
- ❑ Minimize Contamination
- ❑ *Redundancy is the Key*

Exposure Control



Recognition

- Types of lab hazards
  - Chemical toxicity
  - Fire / explosion
  - Physical hazards
  - Biohazards
  - Radiation
  - Special substances

Types of Hazards in Chemical Laboratories

Douglas B. Walters, Ph.D., CSP, CCHO

Environmental & Chemical Safety Educational Institute

Chemical Toxicity

Acute (short term, poisons, asthmagens)
cyanide
strychnine

Chronic (long term, carcinogens, reproductive)

vinyl chloride (liver cancer)
asbestos (mesotheloma, lung cancer)
thalidomide (developmental birth defects)

Chemical Toxicity

- **Toxicity depends on**
  - concentration (dose)
  - frequency
  - duration
  - route of exposure

"**Dose makes the poison.** All substances have the potential to harm."
Paracelsus ~1500 AD

300 mg aspirin = safe

3000 mg aspirin = toxic

Particularly Hazardous Substances

- ❑Chemical Carcinogens
- ❑Reproductive & Developmental Toxins
- ❑Highly Toxic Chemicals

Routes of Exposure

Breathing Zone

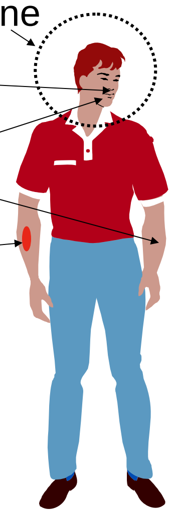
Inhalation*

Absorption

Ingestion

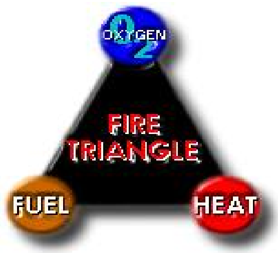
Injection

Eyes



*Most important route of entry

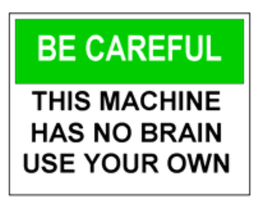
Fire and Explosion Hazards



- **Flammable solvents**
- **Pyrophorics**
- **Spontaneous combustion**

Physical and Ergonomic Hazards

- **Moving unguarded parts, pinches**
  - **vacuum pump belts**
- **Broken glassware and sharps, cuts**
- **Pressure apparatus**
- **Vacuum containers**
- **Dewar flasks**
- **Cryogenics**
- **High voltage equipment**
- **Computer workstations**
- **Slips, trips & falls**

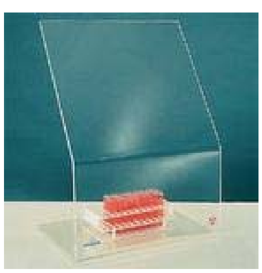


BioHazards

- Blood borne pathogens
  - AIDS, HIV, Hepatitis, clinical chemistry labs
- Recombinant DNA
  - Genetic engineering, cloning

- Work with animals
  - Zoonosis, diseases from animals

Radiation Hazards



- Ionizing Radiation
  - alpha α, beta β, gamma γ, X-rays, neutrons
- Radioactive isotopes
  - tritium (H-3), carbon (C-14), sulfur (S-35), phosphorus (P-32/33), iodine (I-135)

Radiation Hazards

❑ ***Non-Ionizing Radiation***

Ultraviolet (UV spectrometers)

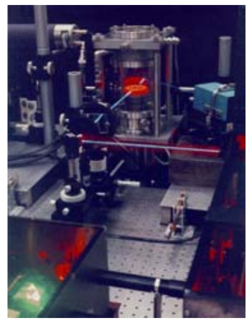
Magnetic (NMR, MRI)

Microwave

(Heart pacemaker hazard)

Lasers

(eye protection required)



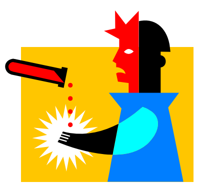
Special Chemical Substances

❑ **Controlled Substances**

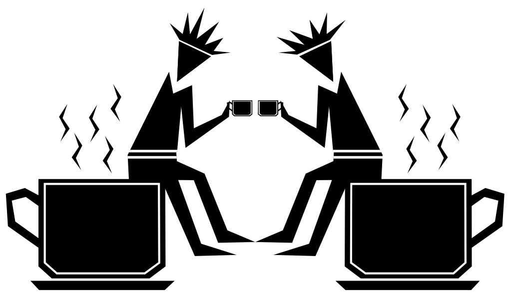
regulated drugs, psychotropic (hallucinogenic) substances, heroin

❑ **Chemical Surety (Warfare) Agents**

nerve gas, phosgene, riot control agents



Break



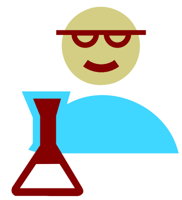
Chemical Lab Safety: Administrative, Operational, and Engineering Controls

Douglas B. Walters, Ph.D., CSP, CCHO

Environmental & Chemical Safety Educational Institute

Evaluation & Control

- ❑ **Administrative practices**
  organizational policies
- ❑ **Operational practices**
  work practices
- ❑ **Engineering controls**
  Hardware (ventilation, barriers)



Administrative Practices: Lab Safety Policies

- ❖ **Have organizational safety practices**
  - **Apply to everybody**
  - **Don't work alone after hours**
  - **Specify when eye protection & PPE is required**
  - **Specify operations that require hood use**
  - **No eating in labs**
  - **No mouth pipetting**
  - **No loose long hair or dangling attire**
  - **Label all chemical containers**
- ❖ **Have a Safety Manual**

Administrative Practices: Lab Safety Policies

- Schedule routine, periodic maintenance and inspection of fume hoods
- Schedule routine, periodic maintenance of safety showers and eye wash stations
- Schedule routine, periodic maintenance of fire suppression/fighting equipment
- Post restricted areas with proper signs
  - radiation, biosafety, carcinogen, high voltage, lasers, authorized personnel only, etc.





Operational Practices: Safe Laboratory Procedures

- Use hoods properly
  - 6” (15 cm) in from sash
  - in center of hood
  - work with hood sash at 12 - 18” (30 - 45 cm)
  - close sash when not in use
  - don’t use for storage

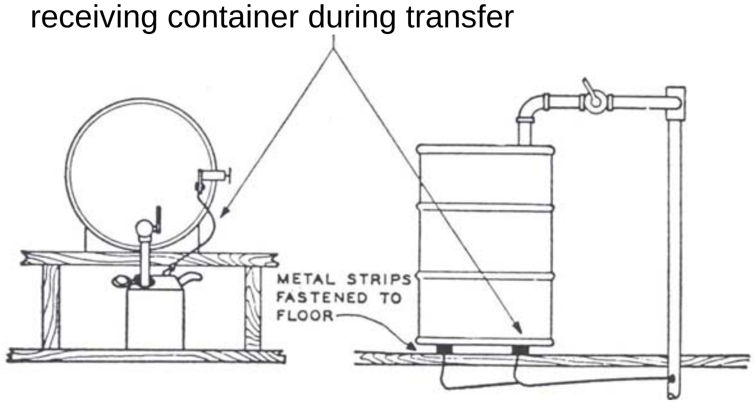
Operational Practices: Safe Laboratory Procedures

❖ **Safely transport chemicals**

- **use container in a container concept**
- **label all containers**
- **inform driver of hazards**
- **provide contact names, phone numbers**
- **provide MSDS**

Operational Practices: Control of Static

Wire needed unless containers are already bonded together, or fill stem is always in metallic contact with receiving container during transfer



Operational Practices: Safe Laboratory Procedures

❖ **Housekeeping**

- label all containers
- clean-up spills
- eliminate trip hazards
- proper storage

Engineering Controls: Laboratory Containment Principles

Concept

Source → **Path** → **Receiver**

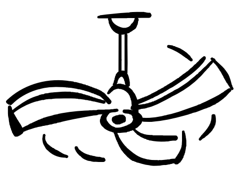
Control Used

Engineering Control → **Operational Practices** → **PPE**

Engineering Controls

1. Change the process
   eliminate the hazard
2. Substitution
   use non-hazardous substance instead of hazardous, such as toluene for benzene
3. Isolate or enclose the process or worker
   use a barrier
4. Ventilation
   dilution (general ventilation) - not good
   local exhaust ventilation (LEV) - Preferred

Engineering Controls



Dilution / general ventilation

not good

Local exhaust ventilation

Preferred

Engineering Controls

Laboratory hoods and ventilation are the basis of engineering controls.
But they must be properly: functioning, maintained and used!

Engineering Controls: Local exhaust

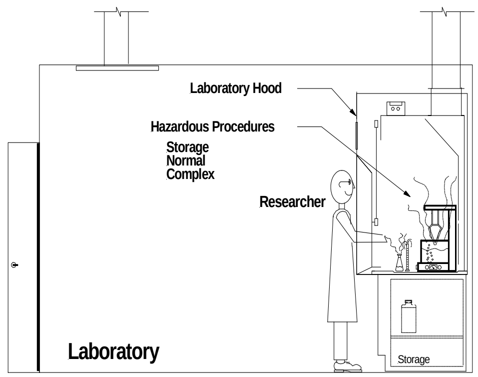
Local exhaust ventilation options include:

Snorkels

Vented enclosures

Proper Hood Use

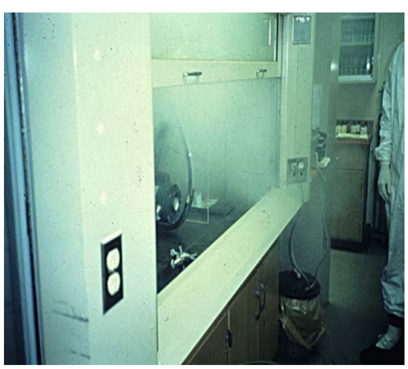
- Locate hood away from potential cross drafts
  - Diffusers, doors, windows, traffic
- Check hood is working properly before starting
- Check for containment
- Avoid clutter
- Do not use for storage
- Sash height at 12 - 18” (30 - 45 cm)
- Work 6” (15cm) in from sash and in center

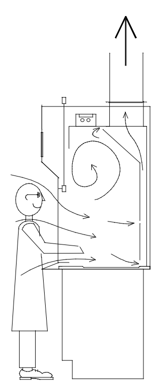


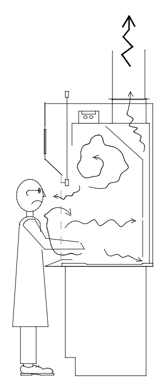
Chemical
SAFETY AND SECURITY TRAINING

Hood Containment

- Smoke candles and tubes can evaluate hoods







Chemical
SAFETY AND SECURITY TRAINING

Engineering Controls: Exhaust vents

Hood exhaust should not be blocked or deflected downward, but should exhaust straight up

Chemical SAFETY AND SECURITY TRAINING

Engineering Controls: Exhaust vents

Avoid exhaust re-entrainment

Disperse emissions straight upward and downwind!

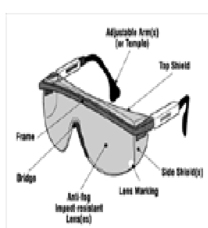
Chemical SAFETY AND SECURITY TRAINING

Engineering Controls: Personal Protective Equipment (PPE)

PPE includes:
eye protection,
gloves,
laboratory coats. etc.,
respirators,
appropriate foot protection

Engineering Controls: Personal Protective Equipment

Eye protection specific to the hazard



Engineering Controls: Personal Protective Equipment

Gloves

must be chemical specific

Engineering Controls: Foot Protection

Safety shoes with steel toes are not necessary for laboratory work unless there is a serious risk from transporting or handling heavy objects.

however,
open toe shoes
should NOT be worn in labs

Breakout Discussion

- Current Status of Chemical Safety and Security
- 45 minutes
- Summarize on Worksheet

Lunch