Chemical

SAFETY AND SECURITY TRAINING

Awareness- Chemical Safety and Security Workshop

Department of Chemistry, Colleges of Sciences, University of Sharjah , UAE

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
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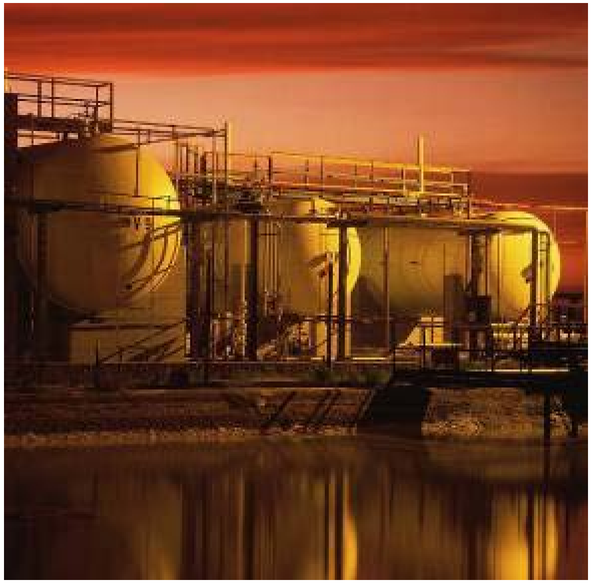
Sandia National Laboratories

Chemical Safety and Security Overview

Why worry about chemical safety?

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



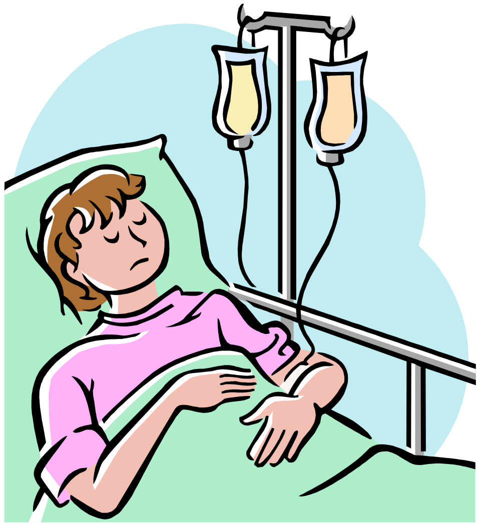
Studies indicate lab chemists *may* have:

- Shorter life spans, more disease

  Hoar, S. K. et al, *J. Occup. Med,*. 23, 485 (1981)

- Higher cancer incidence

  Dement J.M. & Cromer J.R., *Appl. Ocup. Environ. Hyg.*, 7,120 (1992)



Possible chemical health problems

Chemicals

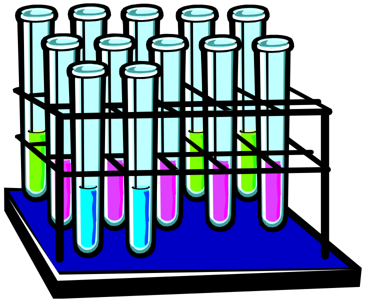
- Vinyl chloride
- Asbestos
- Carbon tetrachloride
- Mercury
- Lead
- Thalidomide
- Methanol
- CO, CS_2

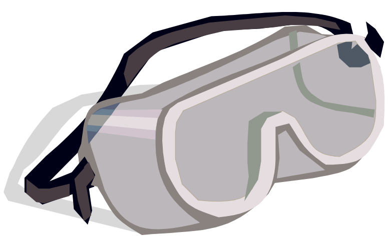
Diseases

- Liver cancer
- Mesothelioma
- Hepatotoxin (jaundice)
- Neurotoxin, CNS, narcosis
- Reprotoxin, birth defects
- Reprotoxin, developmental defects
- Blindness, death
- Hematopoietic, hemoglobin, cynanosis

But disease depends on many factors…

- Genetics
- Specific chemical
- Protection controls used
- Dose
- Concentration
- Duration
- Life style
- Environment





University of California Santa Cruz: Fire

- **January 11, 2002: about 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.

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

University of California Santa Cruz: Fire, cont’d.

- 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.

Environmental hazards
California State Univ. Northridge: Earthquake

- Magnitude 6.7
- January 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

University lab chemical accidents

Incident – Chemical

- Fire and one death – t-butyl lithium + pentane
- Dartmouth, wrong gloves – methyl mercury
- Wroclaw Poland, explosion – dry perchlorates
- Australia, skin absorption – hydrofluoric acid
- Okazaki Japan, explosion – peroxide by-products in synthesis
- OSU, US cylinder explosion – liquid nitrogen cylinder
- Material science engineering lab explosion – nitric acid + ethanol explosion

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**

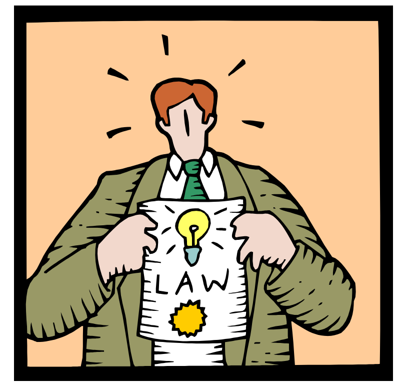
* “The Bhopal disaster and its aftermath: a review”, Edward Broughton, *Environmental Health: A Global Access Science Source* 2005, **4**:6, http://www.ehjournal.net/content/4/1/6, accessed 12/07

Safety Video: Reactive Hazards

Major industrial chemical disasters

Accident/location	Chemical product & exposure
~1912 Toyama Japan	itai-itai disease/cadmium
1921 Oppau Germany	ammonium nitrate
1930 Gauley Bridge WV USA	silica
1968 Yusho Japan	rice oil/PCB,PDDF
1974 Flixborough UK	cyclohexane
1976 Seveso Italy	herbicide production/TCDD
1984 Bhopal India	methyl isocyanate
1986 Chernobyl Ukraine	ionizing radiation
2005 Texas City USA	hydrocarbon production
2005 Jilin China	benzene/aniline

Chemical accidents are now under stricter control and scrutiny



- Better individual country regulations
- Better international regulations
  - IATA
  - GHS
  - REACH
- Environmental problems after natural disasters
  - Earthquakes, cyclones, hurricanes, flood

- Increased public awareness
- Increased media coverage
- Less public tolerance

Why worry about chemical safety?

- Health of the workers
- Safety of the workers
- Safety of the community
- Safety of the environment

…It's the right thing to do!

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

- **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

Photo of wanted poster from Wikipedia commons

Aum Shinrikyo: Tokyo, Japan

[redacted]

Aum Shinrikyo:
Matsumoto and Tokyo, Japan, cont'd.

- 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.

Chemical Security

US Homeland Security Secretary Michael Chertoff told the American Chemistry Council, March 21, 2006:

> "Now, the chemical sector certainly stands as one of the principal areas of infrastructure about which we have to be concerned. If you look back at the whole history of the way al Qaeda has conducted its operations, where possible, they have always tried to leverage our own technology against ourselves. They've turned jets, commercial jets, into weapons. They've tried to use our own chemicals and our own products as means of exploding devices against us. And obviously, one of the areas we have to be concerned about are parts of our infrastructure which house chemicals which could, if properly ignited, create a huge amount of havoc in a populated area – whether it be because of a large explosion or whether it's because of toxic inhalation..."

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

Safety and Security Issues are similar

Variables

- Many different chemicals with:
  - different properties
  - different hazard
  - different applications
- Many different ways to misuse chemicals
  - chemical weapons
  - poisons

Protect

- Workers
- Facility
- Community
- Environment

Government regulations: Chemical security

- **Differ 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**

Important Questions:

How does your country regulate and control chemical safety and security?

…Is it effective?

…Could it be improved?

…How?

Historical Perspective of Chemical Safety and Security

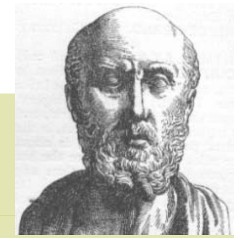
Chemical Safety History

Persons, Events and U.S. Regulation

http://www.osha.gov/ http://www.epa.gov/ http://www.csb.gov/

Chemical Safety History: Persons

Early Observers



Hippocrates

400 BC — HIPPOCRATES

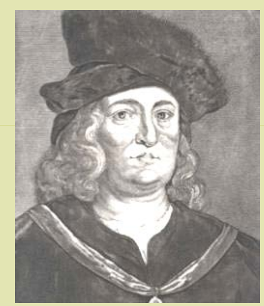
- FATHER OF MEDICINE
- FIRST TO WRITE OF OCCUPATIONAL DISEASE
  - LEAD POISONING IN SLAVES

Pliny the Elder

23-79 AD — PLINY THE ELDER

- USE OF ANIMAL BLADDERS AS MASKS
  - FOR METALWORKERS

Agricola



Paracelsus

1494 — GEORGIUS AGRICOLA

- ADVOCATED VENTILATION & MASKS
  - FOR MINERS & SMELTER WORKERS

1529-37 — PARACELSIUS

- FATHER OF TOXICOLOGY
  - FIRST BOOK ON OCCUPATIONAL DISEASE (1533: miners' disease)
  - "DOSE MAKES THE POISON" (paraphrased from "All things are poison and nothing is without poison, only the dose permits something not to be poisonous")

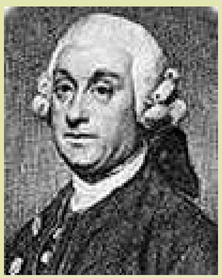
Chemical Safety History: Persons

Ramazzini

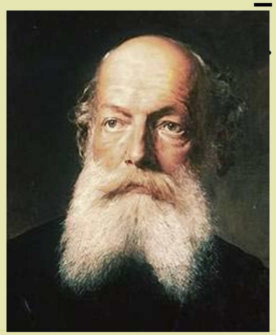
Later Observers

1713 **BERNADINO RAMAZZINI**
- FATHER OF OCCUPATIONAL MEDICINE
  - DESCRIBED PATHOLOGY OF SILICOSIS

1775 **PERCIVAL POTT**
- PHYSICIAN
  - SHOWED FIRST OCCUPATIONAL LINK TO CANCER
  - AS ENVIRONMENTAL CARCINOGEN
    - Chimney sweeps & scrotal cancer



Pott



Kekulé

Hamilton

1890 **AUGUST KEKULE**
- THEORETICAL CHEMIST (benzene structure)
  - "IF YOU WANT TO BECOME A CHEMIST… *YOU HAVE TO RUIN YOUR HEALTH*. WHO DOES NOT RUIN HIS HEALTH BY HIS STUDIES, NOWADAYS WILL NOT GET ANYWHERE IN CHEMISTRY."

1910-50 **ALICE HAMILTON**
- US MOTHER OF OCCUPATIONAL MEDICINE
  - DESCRIBED LEAD POISONING, AND
  - PHOSSY JAW
    - » in match workers, from white/yellow phosphorus

Chemical Safety History: Events & US Regulation

child mill worker

1833-1901 — **British Factories Acts (BFA)**

- BASIS OF EARLY US REGULATIONS
  - CHILD AND WOMEN LABOR LAWS
  - VENTILATION REQUIRED: "to render harmless any gases, dusts… that may be damaging to health…."
  - APPOINTMENT OF INSPECTORS

mine rescue

1907 — **US Bureau of Mines created**

- 3,200 KILLED IN U.S. MINING ACCIDENTS (1907)

1908 — **Federal Employer's Liability Act (FELA)**

- IN RESPONSE TO HIGH NUMBER OF RAILROAD WORKER DEATHS IN LATE 1800s
- BOTH FCA and BFA LEGISLATED COMPENSATION TO INDUSTRIAL ACCIDENT VICTIMS

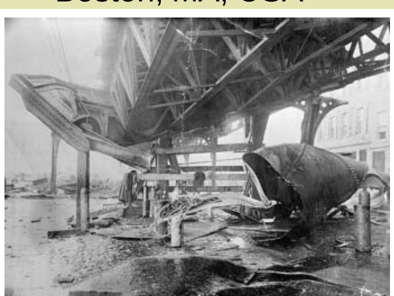
fatal rail accident

Chemical Safety History: Events & US Regulation

Triangle Fire protest

1911	**Triangle Shirtwaist Fire** New York City; USA	◦ 146 GARMENT WORKER DEATHS − RAISED AWARENESS OF SWEATSHOPS AND CHILD LABOR CONDITIONS − LED TO WORKERS' COMPENSATION LAWS
1912	**Sinking of the Titanic**	• LED TO ADOPTION OF **S-O-S** AS INTERNATIONAL DISTRESS CALL
1919	**Molasses Disaster** Boston, MA; USA	• KILLED >20; INURED >150 PERSONS − EXPLOSION FROM PRESSURE BUILD-UP IN STORAGE TANK


Titanic sinking


Molasses damage

Chemical Safety History: Events & US Regulation

Hawk's Nest Tunnel

1936 — **Gauley Bridge**
Fayette County, WV; USA

- ~800 WORKERS DIED FROM ACUTE SILICOSIS
  - FROM BUILDING THE 4 MILE HAWKS NEST TUNNEL
  - LESSONS ***NOT*** LEARNED:
    - NO PRECAUTIONS WERE TAKEN ALTHOUGH HEALTH EFFECTS OF SILICA WERE KNOWN

1936 — **Walsh-Healy Act**

- FOR US FEDERAL CONTRACTS OVER $10,000
  - "NO PART OF SUCH CONTRACT WILL BE PERFORMD… IN ANY PLANTS, FACTYORIES, BUILDINGS, OR SURROUNDINGS OR *UNDER WORKING CONDITIONS WHICH ARE HAZARDOUS, UNSANITARY, OR DANGEROUS TO THE HEALTH AND SAFETY OF EMPLOYESS* ENGAGED IN THE PERORMANCE OF SAID CONTRACT."
  - START OF U.S. OCCUPATIONAL SAFETY & HEALTH ACT (OSHA)

WHA Poster

Chemical Safety History: Events & US Regulation

Elixir Sulfanilamide

1937 — **Elixir Sulfanilamide**

- STREPTOCOCCAL DRUG CAUSED >100 DEATHS IN 15 STATES
  - LIQUID FORM OF SULFANILAMIDE WITH DIETHYLENE GLYCOL SOLVENT
  - HASTENED ENACTMENT OF THE FOOD, DRUG, AND COSMETIC ACT
    - » SAVED U.S. FROM THE THALIDOMIDE DISASTER 25 YEARS LATER

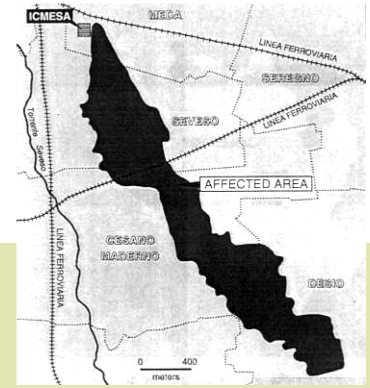
1942 — **Cocoanut Grove Fire**
Boston, MA; USA

- ◦ KILLED 492 PERSONS IN A NIGHTCLUB
  - POOR EGRESS (ONE REVOLVING DOOR ENTRY, INWARD-SWINGING DOORS, LOCKED DOORS)
  - HIGHLY FLAMMABLE MATERIALS
- ◦ REFORM OF FIRE CODES AND SAFETY STANDARDS IN U.S.
- ◦ LESSONS ***NOT*** LEARNED:
  - 1903 IROQUOIS THEATER FIRE IN CHICAGO
  - KILLED >600 PERSONS

Cocoanut Grove Fire

Chemical Safety History: Events & US Regulation

Seveso area contamination



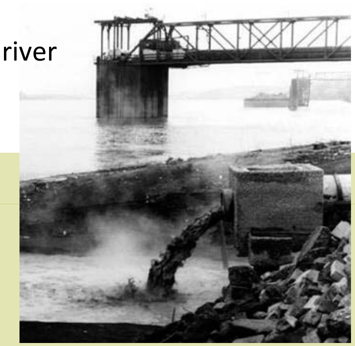
1970	**Occupational Safety and Health Act (OSHA)**	• MAIN GOAL: “SEND EVERY WORKER HOME, WHOLE & HEALTHY EVERY DAY”
1976	**TCDD (dioxin) exposure** Seveso, Italy	◦ RECOGNITION OF DIOXIN COMPOUND PROPERTIES − PERSISTENCE AND ACCUMULATION IN FATTY TISSUE
1976	**Toxic Substances Control Act (TSCA, EPA)**	• ADDRESSES THE PRODUCTION, IMPORT, USE AND DISPOSAL OF SPECIFIC CHEMICALS INCLUDING PCBs, ASBESTOS, RADON AND LEAD-BASED PAINT.
1976	**Resources Conservation and Control Act (RCRA, EPA)**	• THREE MAIN PROGRAMS: − UNDERGROUND STORAGE TANKS − SOLID WASTE − HAZARDOUS WASTE

TSCA Lead-Safe label

Hazardous Waste Resource Locator

Chemical Safety History: Events & US Regulation

Industrial discharge to river



CH&S
CONNECTING CHEMISTRY AND SAFETY

ACS-CH&S

Year	Event	Notes
1977	**Clean Water Act (CWA, EPA)**	
1977	**American Chemical Society (ACS) founds Division of Chemical Health and Safety**	
1978	**Love Canal toxic dumping** Niagara Falls, NY; USA	• 950 FAMILIES EVACUATED • LED TO CERCLA
1978	**Ward Transformer dumping** North Carolina; USA	◦ IMPROPER DUMPING OF PCBs ◦ PERSISTENT CONTAMINATION
1979	**Valley of the Drums** near Louisville, KY; USA	• EMERGENCY CLEANUP STARTED • 23-ACRE TOXIC WASTE SITE • CAUGHT FIRE AND BURNED FOR > A WEEK IN 1966 • LED TO CERCLA • CLEANUP FOR >7 YEARS

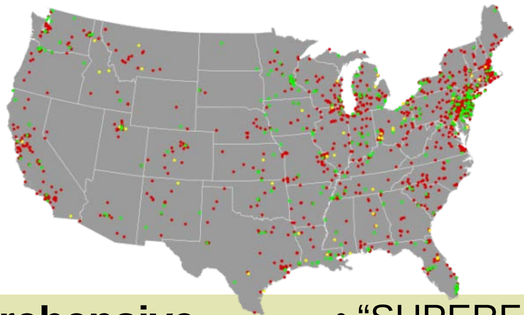
Love Canal waste

Valley of Drums

Ward Transformer Site

Chemical Safety History: Events & US Regulation

Superfund Sites (March 2010)



Tylenol removal

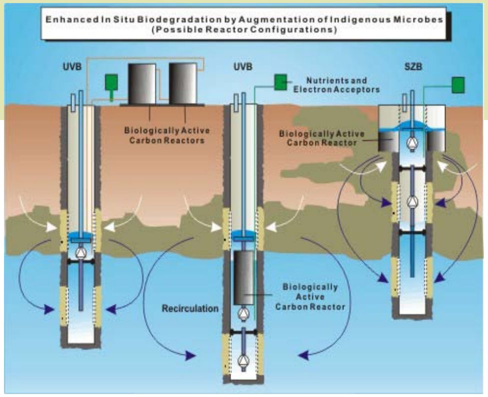
1980	**Comprehensive Environmental Response, Compensation & Liability Act (CERCLA, EPA)**	• "SUPERFUND" TO CLEAN UP SITES CONTAMINATED WITH HAZARDOUS SUBSTANCES • CREATED THE AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY (ATSDR)
1982	**Tylenol tampering –** Chicago, IL; USA	• CRIMINAL ACT OF LACING TYLENOL WITH CYANIDE – 7 PERSONS KILLED – RESULTED IN TAMPER-PROOF PACKAGING
1983	**Dioxin contamination** Times Beach, MO; USA	• LARGEST CIVILIAN EXPOSURE TO DIOXINS IN U.S. – TOXIC WASTE MIXED WITH OIL – USED TO COAT RURAL TOWN ROADS – SOIL & WATER CONTAMINATED WITH DIOXIN & PCBs – TOWN FLOODED IN1982, SPREADING CONTAMINATION – ILLNESSES, MISCARRIAGES & ANIMAL DEATHS • TOWN FULLY EVACUATED 1982-85 – FULLY DEMOLISHED BY 1992

Times Beach dioxin

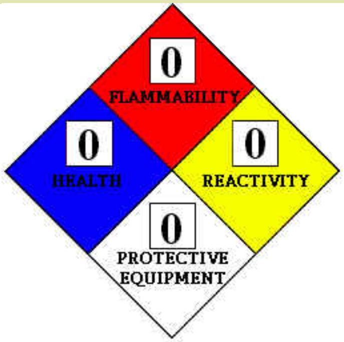
Chemical Safety History: Events & US Regulation

Bhopal 25-yr vigil

Year	Event	Details
1984	**Bhopal accident** **Bhopal, India**	
1985	**Hazard Communication Standard**	• EMPLOYERS TO NOTIFY, TRAIN AND INFORM WORKERS ABOUT POTENTIALLY HAZARDOUS CHEMICALS AND PROVIDE MSDS
1986	**Superfund Amendments and Reauthorization Act (SARA, EPA)**	• STRESSED PERMANENT REMEDIES AND NEW TREATMENT TECHNOLOGIES • REVISED HAZARD RANKING SYSTEM (HRS) TO ACCURATELY ASSESS RISKS TO HUMAN HEALTH AND THE ENVIRONMENT FROM UNCONTROLLED HAZARDOUS WASTE SITES



Bioremediation system



MSDS/NFPA Hazard Ratings

Chemical Safety History: Events & US Regulation

PEPCON explosion #2

1988	**PEPCON disaster –** Henderson, NV; USA	• WELDING TORCH TO FIBERGLASS TO HDPE STORAGE DRUMS • AMMONIUM PERCHLORATE EXPLOSIONS – 7 EXPLOSIONS & NATURAL GAS LINE BENEATH FACILITY – 2 DEATHS, 372 INJURED – BLAST DAMAGE >10 MILES FROM EXPLOSIONS – DISASTER PLANS ACTIVATED
1990	**Occupational Exposure to Hazardous Chemicals in Laboratories** (Lab Standard, OSHA)	• REQUIRES CHEMICAL HYGIENE PLANS – “WRITTEN PROGRAM STATING THE POLICIES, PROCEDURES, AND RESPONSIBILITIES THAT SERVE TO PROTECT EMPLOYESS FROM THE HEALTH HAZARDS ASSOCIATED WITH THE HAZARDOUS CHEMICALS USED IN THAT PARTICULAR WORKPLACE“

OSHA Lab Standard

Chemical Safety History: Events & US Regulation

CSB Inspectors

1990 **Clean Air Act Amendments**

- ESTABLISHED CHEMICAL SAFETY BOARD
  - "TO INVESTIGATE ACCIDENTS TO DETERMINE THE CONDITIONS AND CIRCUMSTANCES WHICH LED UP TO THE EVENT AND TO IDENTIFY THE CAUSE OR CAUSES SO THAT SIMILAR EVENTS MIGHT BE PREVENTED"

1991 **Imperial Foods fire**
Hamlet, NC; USA

- 25 workers killed
  - doors locked, no egress
  - owner jail sentence of 20 years

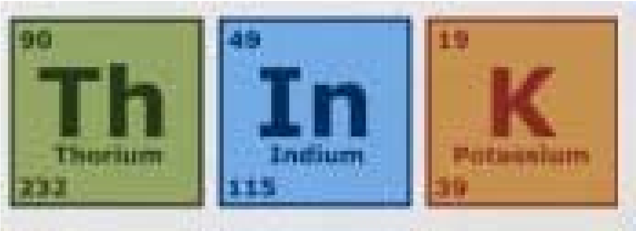
Imperial Foods door

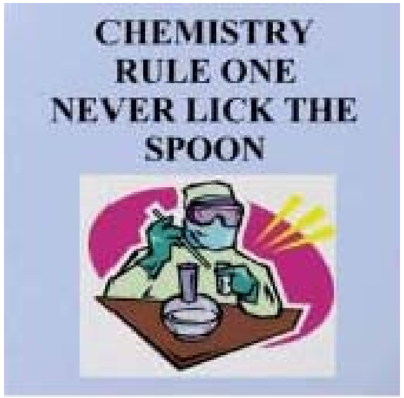
2003 **House Appropriations Subcommittee on workforce protections**

- TESTIMONY:
  "FROM 1972 TO 2001, THERE HAVE BEEN AT LEAST 200,000 ON-THE-JOB DEATHS, 151 REFERRALS FOR CRIMINAL INVESTIGATION, AND 8 CASES RESULTING IN JAIL TIME."

Conclusions

- Chemical safety regulation in US <u>is young</u>…
  - Early 20th century:
    - earliest few safety measures
    - only industry-specific
  - 1936 Walsh-Healy
    - broader safety measures
    - federal employees only, large contracts
  - 1970s-80s; OSHA, RCRA, CWA, CERCLA, SARA, MSDS,
    - all workers
    - environmental protection
  - 1990; OSHA Lab Standard
    - first safety regulation specific to labs
- There is room for improvement!
  - opportunities for emerging programs





Fundamentals of

Chemical Laboratory Safety

References

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

"Prudent Practices in the Laboratory: Handling and Disposal of Chemicals," National Academy Press, 1995, also available online: http://www.nap.edu/catalog.php?record_id=4911

Definitions

Chemical Laboratory Safety

– *The control of exposure to potentially hazardous substances to attain an acceptably low risk of exposure*

Chemical Laboratory Safety

Hazard – ***the potential to harm***

We want to avoid this.

Risk – ***the probability that harm will result***

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 the principle of

Industrial Hygiene

– *The anticipation, recognition, evaluation and control of health hazards in the work environment to protect workers health and well-being and to safeguard the community and the environment*

Chemical Laboratory Safety

↓

Industrial Hygiene Principles

Anticipation	Chemical hazards
Recognition	Physical hazards
Evaluation	Ergonomic hazards
Control	Biological hazards

Anticipation

Safety First !

To consider safety in the beginning is:

Easier,

Cheaper,

Safer,

... and it saves you time !

Anticipation

Advance Experiment Planning:

Outline proposed experiment

Acquire safety information
(M)SDS, REACH

Consult with CSSO?

Anticipation

Risk Analysis

- Which chemicals?
- How much?
- Special equipment needed?
- Who does the work?
- Staff properly trained?
- Can the experiment go wrong?
- Do you have an emergency plan?

Recognition

Types of lab hazards:

chemical toxicity

fire / explosion

physical hazards

biohazards

radiation

special substances

Recognition & Evaluation

What are the anticipated risks?

- Are the equipment & facilities adequate?
- Are staff properly and sufficiently trained?
- Risks if experiment goes wrong?
- Is there a plan for this?

Control

How are the risks controlled?

- **Engineering controls:**
  - enclosure / isolation
  - ventilation / hoods

- **Emergency Plan**

- **Personal Protective Equipment (PPE)**

Chemistry Laboratory Hazards

Chemical Toxicity

Acute (short term, poisons, asthmagens)

cyanide

strychnine

Chronic (long term, carcinogens, reproductive)

vinyl chloride (liver cancer)

asbestos (mesothelioma, lung cancer)

thalidomide (developmental birth defects)

Chemical Toxicity

“Dose makes the poison. All substances have the potential to harm.”

– Paracelsus ~1500 AD

300 mg aspirin = safe*

3000 mg = toxic

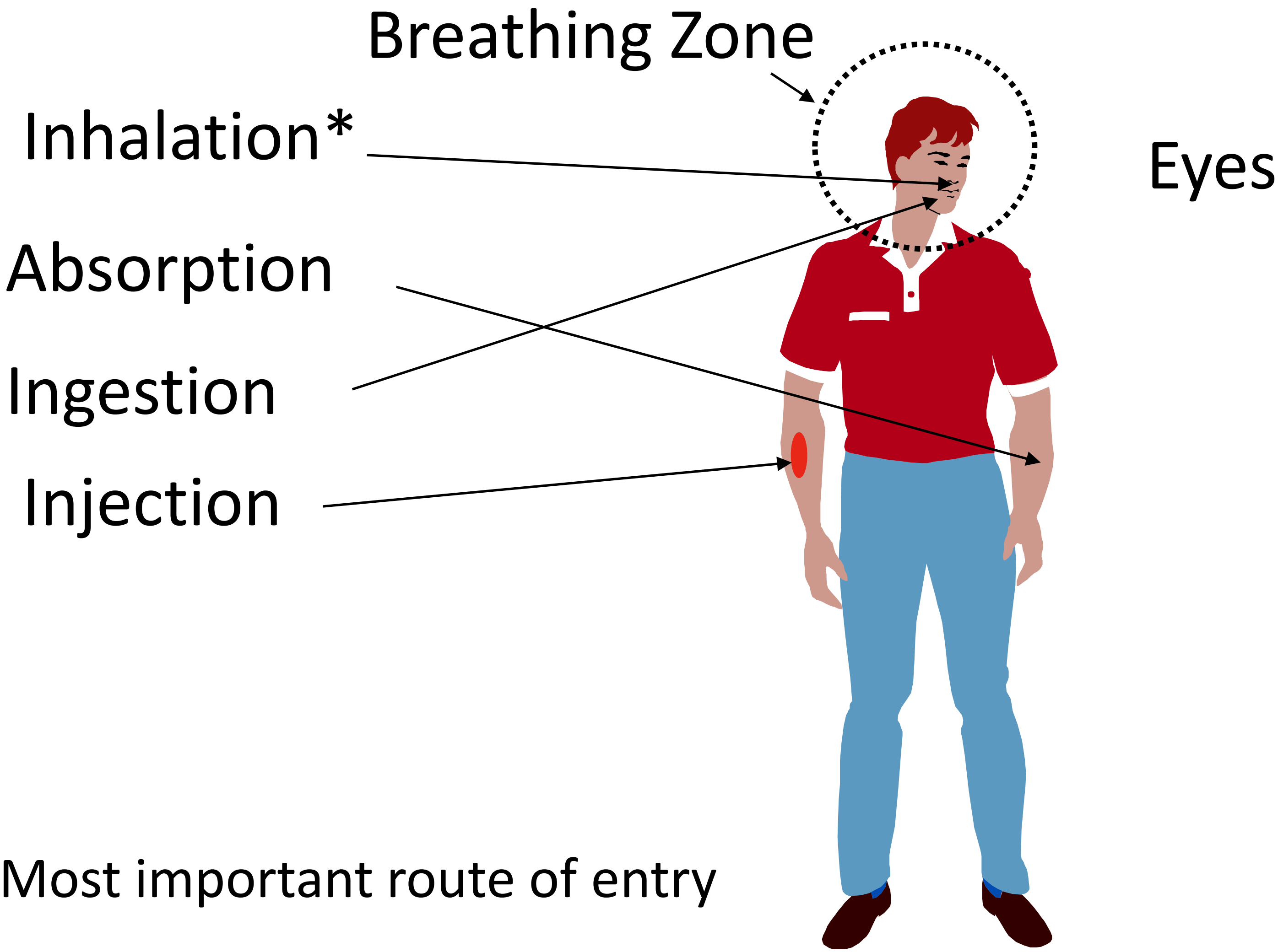
***normal, healthy, adult**

Chemical Toxicity

Toxicity depends on:

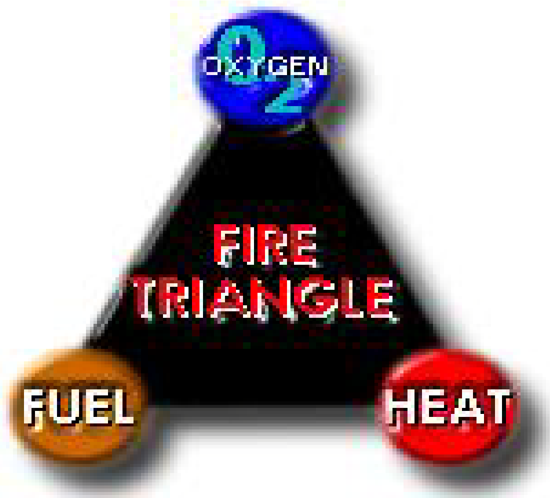
- Concentration (dose)
- Frequency
- Duration
- Route of exposure

Routes of Exposure



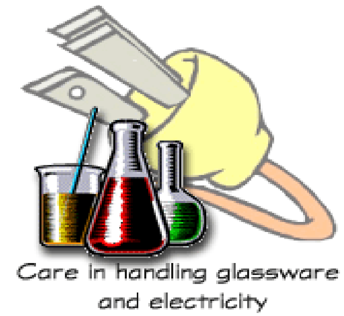
*Most important route of entry

Fire and Explosion Hazards



Physical and Ergonomic Hazards

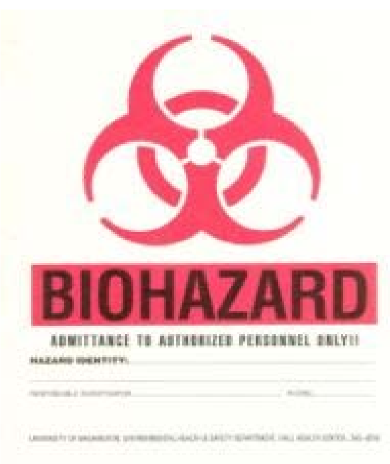
- Moving unguarded parts, pinches vacuum pump belts
- Broken glassware and sharps, cuts
- Pressure apparatus
- Vacuum containers
- Dewar flasks
- High voltage equipment
- Computer workstations
- Slips, trips & falls



Biohazards

- Blood borne pathogens

  AIDS, HIV, hepatitis, clinical chemistry labs



- Recombinant DNA

  Genetic engineering, cloning

- Work with animals

  Zoonoses,

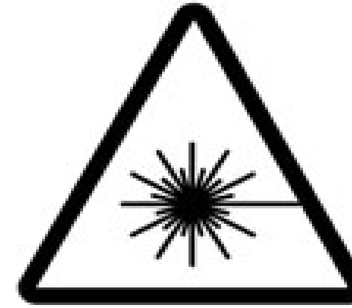
  diseases from animals

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

Highly Toxic Chemicals:

nerve gas, phosgene, riot control agents, chemical warfare agents

Evaluation & Control

– Administrative practices
  organizational policies

– Operational practices
  work practices

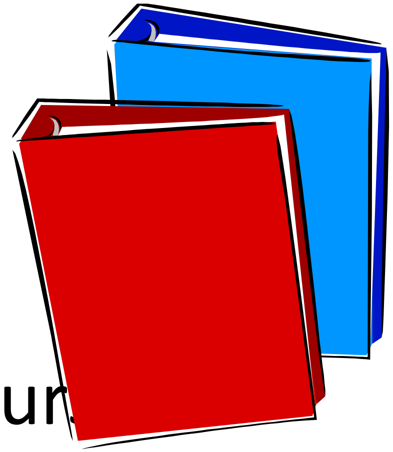
– Engineering controls
  ventilation, barriers

Administrative Practices

organizational *safety policies*

that apply to everyone

Lab Safety Policies



- Have a Safety Manual

- Never work alone, especially after hour
- Specify when eye protection & PPE is required.
- Specify operations that require hood use.
- Specify required training.
- No mouth pipetting.
- No long hair or dangling attire.

Lab Safety Policies

- No eating, drinking, smoking in laboratories
- Label all chemical containers
- Label refrigerators, No Food
- Label explosion safe refrigerators
- Require periodic fire drills

Lab Safety Policies

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

Operational Practices

Safe Laboratory Procedures:

- Packages opened only in labs, not receiving
- Receiving staff trained to look for signs of breakage and/or leaking shipments
- Receiving area has spill kits
- Mailroom/receiving alert for suspicious shipme

Safe Laboratory Procedures

- Schedule routine maintenance, calibration and inspection of all hoods and safety equipmen

- Schedule and participate in routine fire drills

- Train personnel in emergency response.

- Wear PPE <u>properly</u>, don’t just have it.

Safe Laboratory Procedures

Use hoods properly:

- Work 6" (15 cm) in from sash
- In center of hood
- Work with hood sash at ~18" (45 cm) high
- Close sash when not in use
- Don't use for storage

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

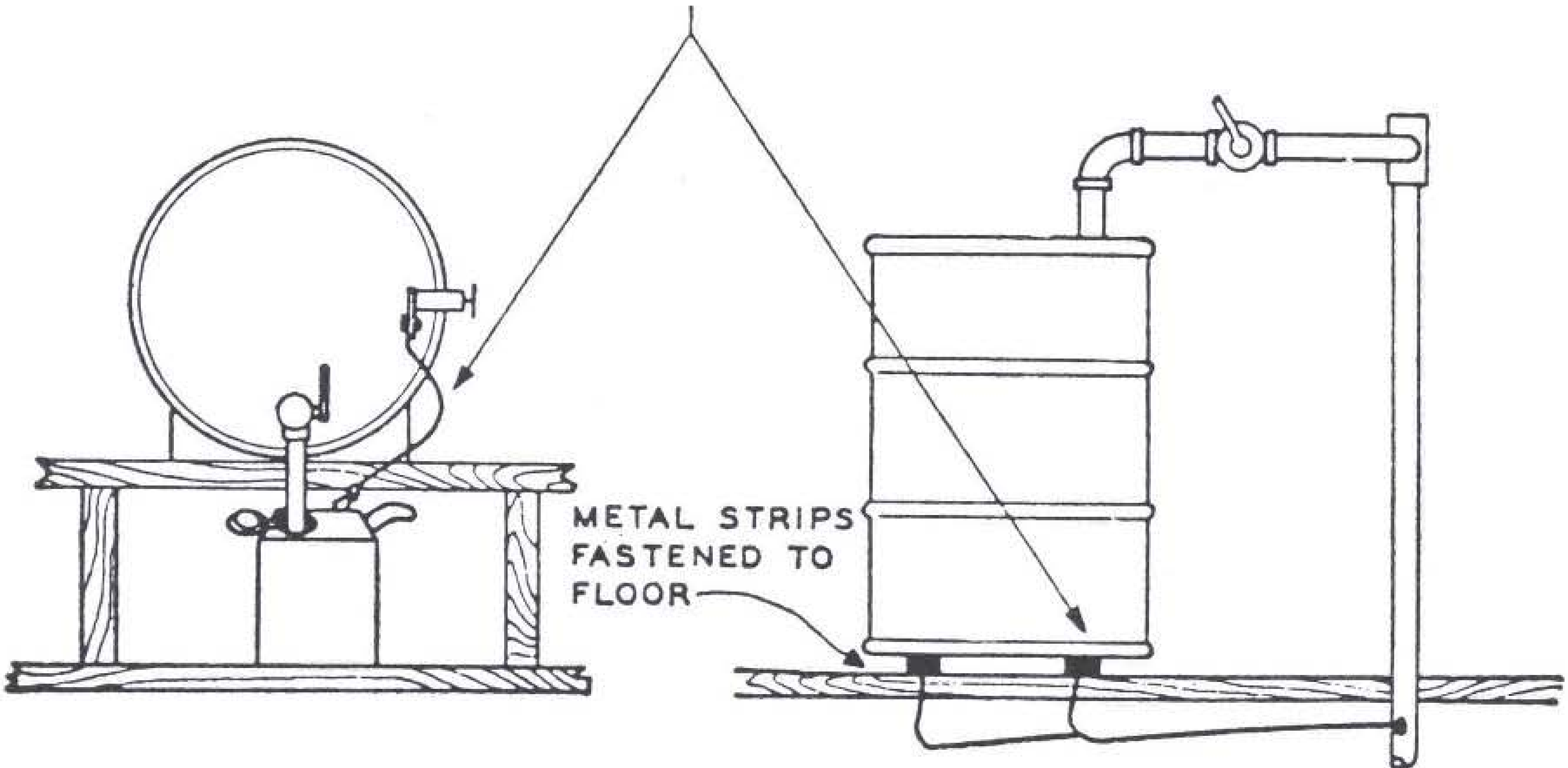
Transfer Chemicals Properly

- **Some flammable liquids accumulate a static electric charge, which can release a spark that ignites the liquid**
- **Always bond metal dispensing and receiving containers together *before* pouring**

benzene toluene gasoline xylene

Control of Static

Bond wire necessary except where containers are inherently bonded together, or arrangement is such that fill stem is always in metallic contact with receiving container during transfer.



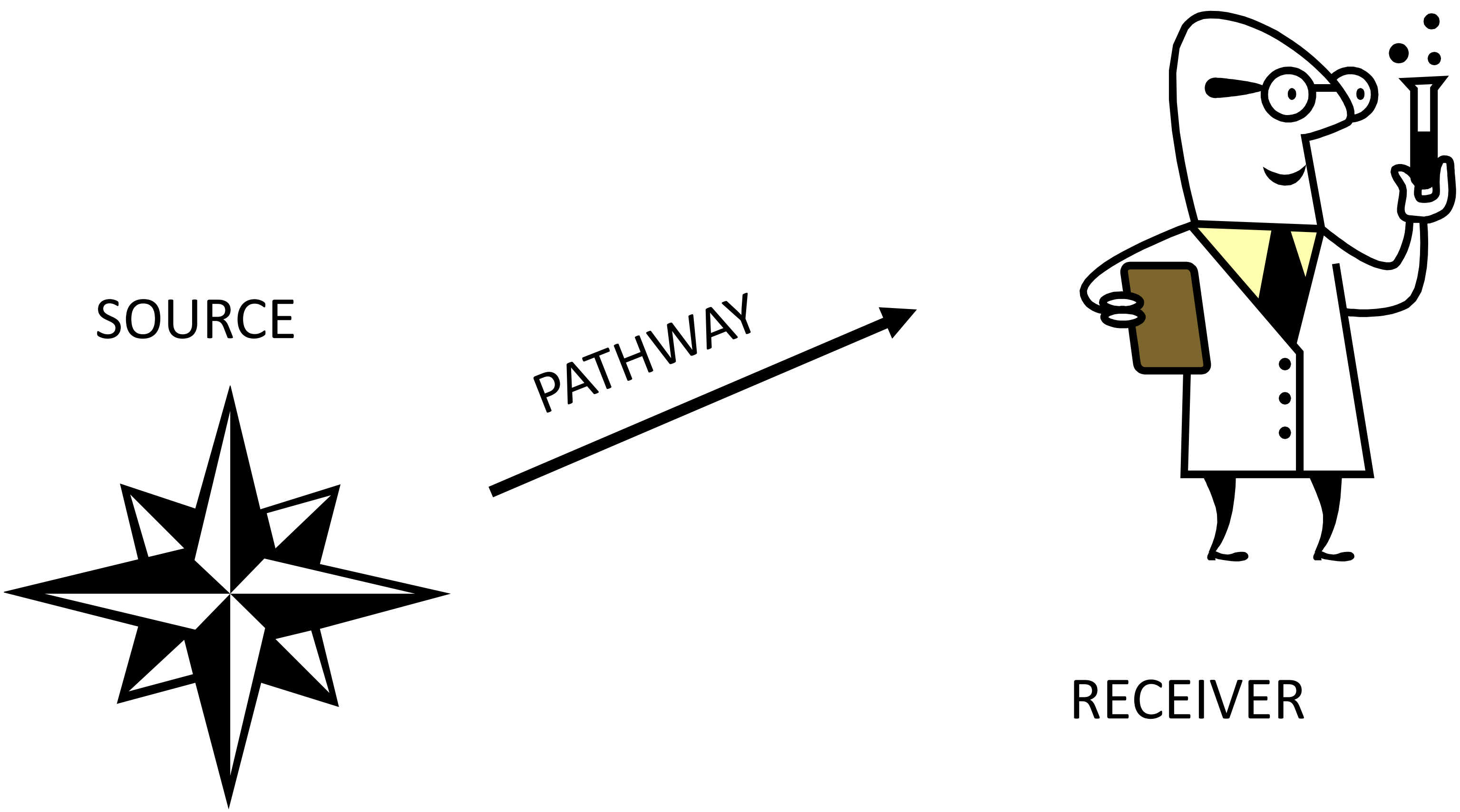
Safe Laboratory Procedures

Housekeeping:

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

Dangerous Housekeeping

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

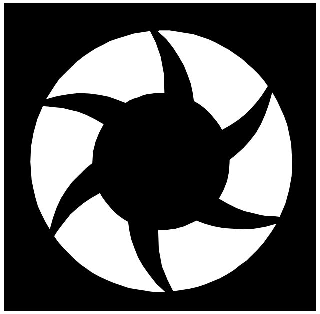
non-hazardous substance for hazardous

(e.g. - toluene for benzene)

Engineering Controls

3. Isolate or enclose the process or worker Use a barrier

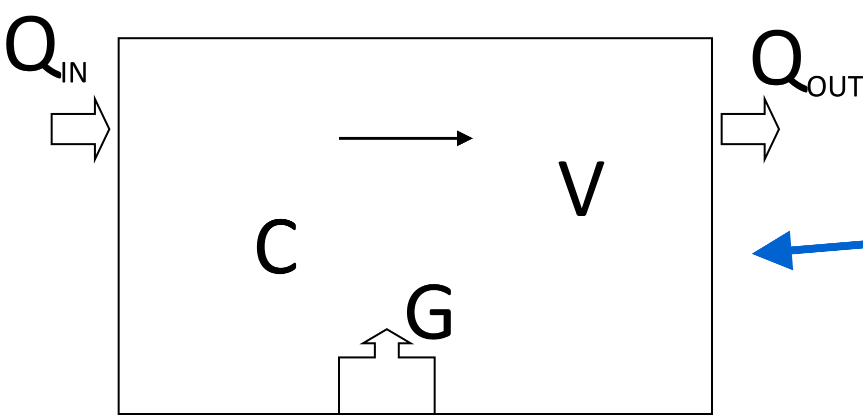
4. Ventilation



Dilution (general ventilation) - Not good

Local exhaust ventilation (LEV) - Preferred

Engineering Controls



Dilution (general) ventilation

not good

Local exhaust ventilation

preferred

Q = flux, C = contaminant conc.

V = velocity, G = generation rate

Engineering Controls

Properly functioning & used correctly!

Laboratory hoods and ventilation are the basis of engineering controls.

Laboratory Hoods

Must be used and maintained properly.

Engineering Controls

Local exhaust ventilation includes:

snorkels

Engineering Controls

Local exhaust ventilation includes: *vented enclosures*

Engineering Controls

Local exhaust includes:

special containment devices

(e.g. - glove boxes)

Engineering Controls

Local exhaust includes:

special containment devices

(e.g. - isolation chambers)

Engineering Controls

Local exhaust includes:

biological safety cabinets

Engineering Controls

- Special barrier facilities

  clean rooms, carcinogen rooms, weighing rooms

- Safety shields

  radiation shields, hood sashes, splash guards

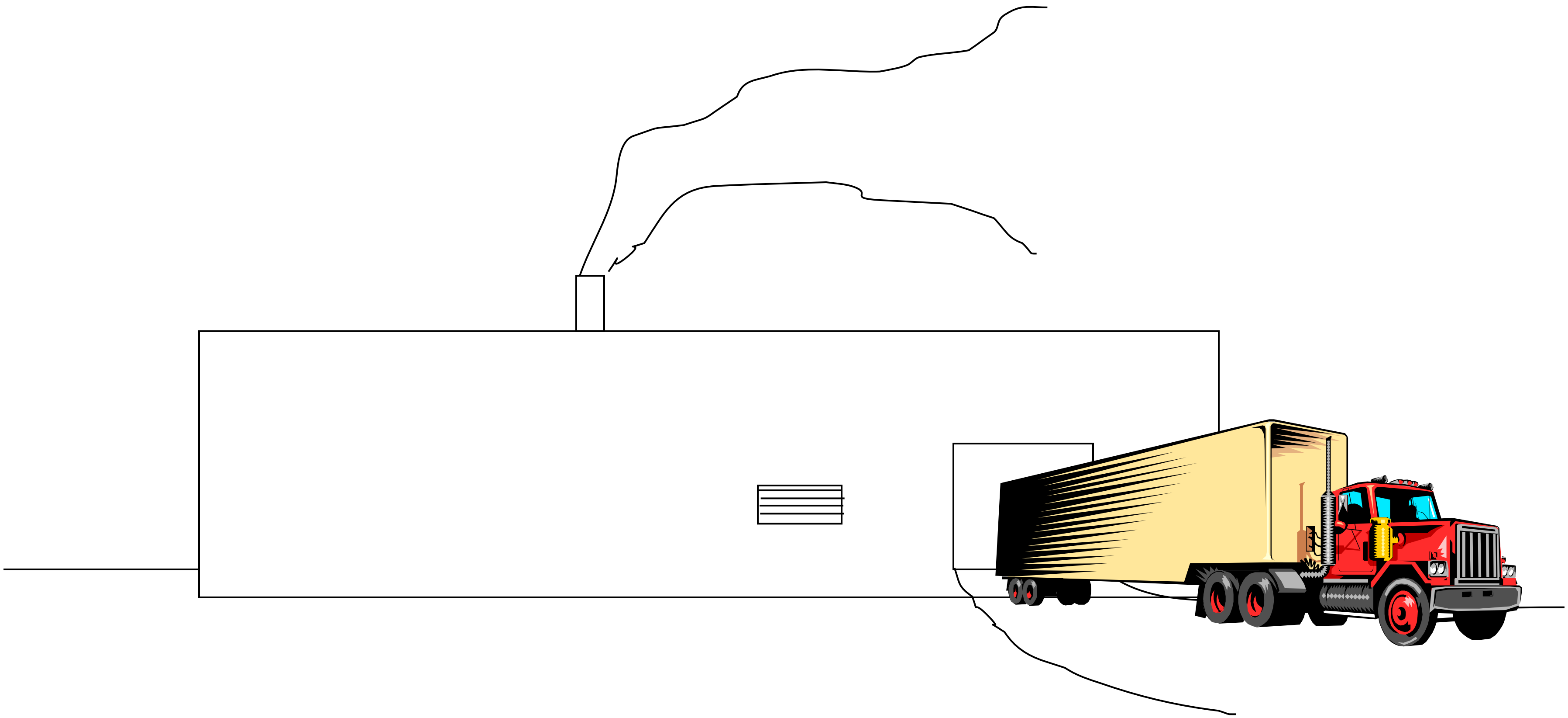
Engineering Controls

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

Avoid re-entrainment

Disperse emissions straight upward and downwind!

Avoid Recirculation!



Personal Protective Equipment

PPE includes:

eye protection,

gloves,

laboratory coats. etc.,

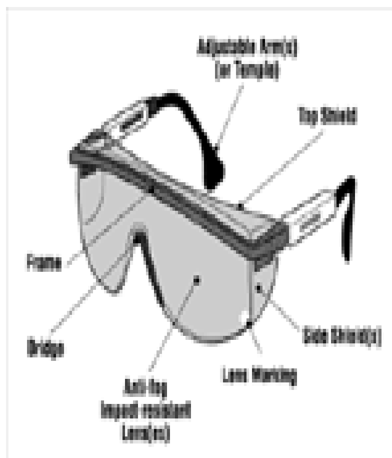
respirators,

appropriate foot protection

Personal Protective Equipment

Eye protection -

specific to the hazard



Personal Protective Equipment

Gloves -

must be chemical specific

Personal Protective Equipment

- Laboratory coats
- Aprons
- Other protective clothing

Personal Protective Equipment
Respiratory Protection

Requires:

training &

fit-testing

Can provide a

false sense of security.

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.

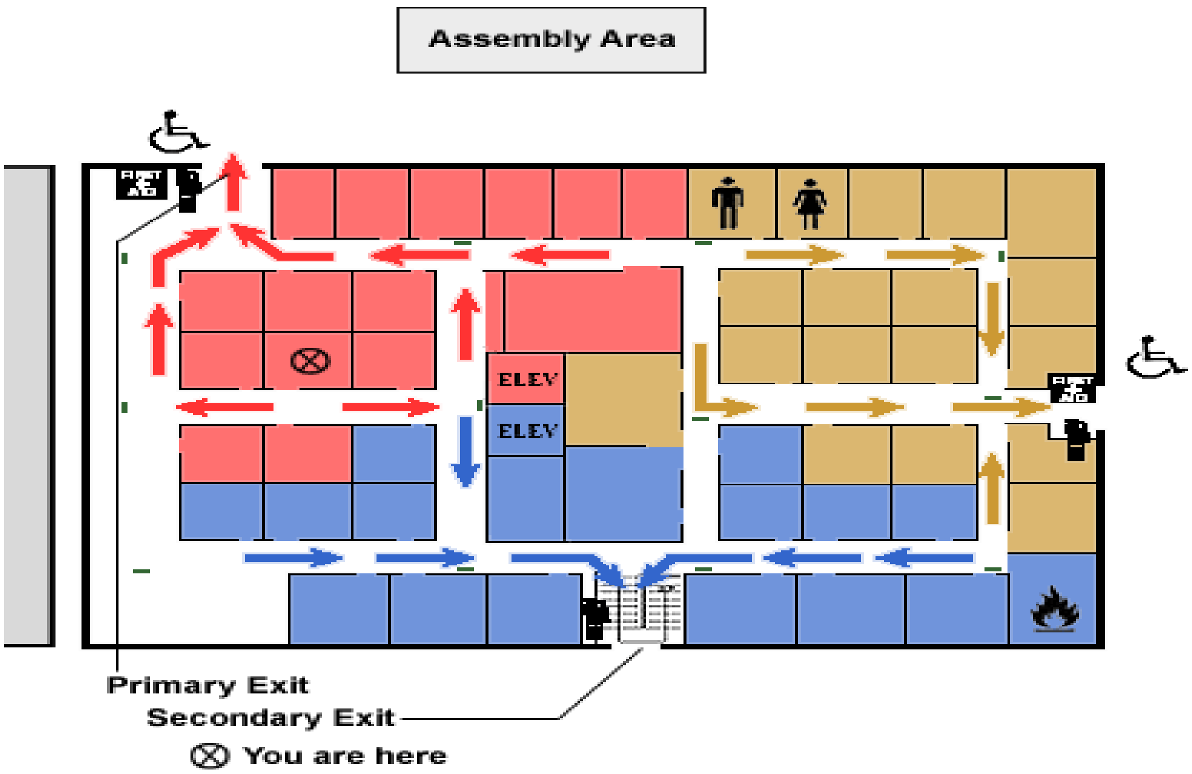
However,

open toe shoes

should NOT be worn in labs.

Emergency Planning & Response

Have an evacuation plan and POST IT!



Emergency Planning & Response

Never use hallways for storage

Dangerous!!

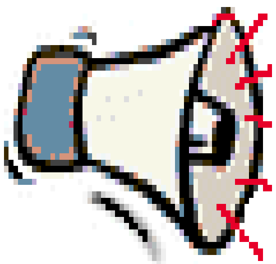
Blocks passage and emergency exits

Emergency Planning & Response

- Have routine, unannounced evacuation drills.
- Designate a person for each area to ensure bathrooms, etc. are evacuated.
- Locate outside staging areas at sufficient distance from the building.
- Test and maintain alarms.
- Post a person to meet/direct emergency vehicles.

Emergency Planning & Response

Alarm systems need to be properly located, maintained,



and serviced regularly

and

be suitable for all disabled workers.

Emergency Planning & Response

All hoods should have low flow alarms.

Chemical specific toxicity alarms may be needed in certain areas.

Emergency Planning & Response

Centrally locate and *maintain* fire extinguishers and alarms.

Emergency Planning & Response

If employees are expected to use extinguishers, they must be trained!

Emergency Planning & Response

Post each room with:

Emergency phone numbers

After hour phone numbers

Person(s) to be contacted

Alternate person(s)

Unique procedures to be followed

Emergency Planning & Response

Label and keep all exits clear,

unlocked or equipped with panic bars.

Chemical Exposures to Eyes or Skin

Centrally locate equipment

- Remove contaminated clothing
- Thoroughly flush with water
- Follow chemical specific procedures (i.e.. HF)
- Seek medical assistance

Chemical Spills

Centrally locate spill kits for quick access

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

Emergency Planning & Response

Backup power:

Does power 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

Centrally locate, inspect and maintain:

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

Any Questions?

BREAK

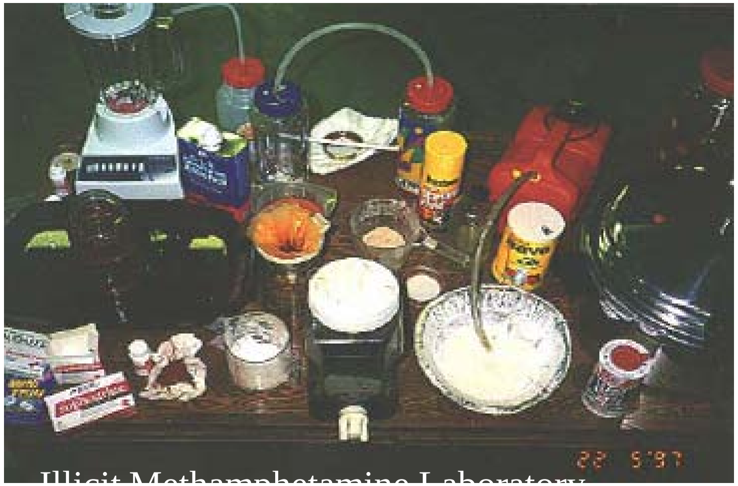
Chemical dual-use awareness

Dual use chemicals: Chemicals used in industry or everyday life that can also be used in bad ways.



Dual-use chemical example: Pseudoephedrine

- Pseudoephedrine is a common ingredient in cold medicines
- Precursor to crystal methamphetamine
- Recipes for conversion available on web



Illicit Methamphetamine Laboratory

- **Clandestine meth labs in US during 2002**
  - **Caused 194 fires, 117 explosions, and 22 deaths**
  - **Cost $23.8 million for cleanup**
  - **Dumped chemicals led to**
    - **deaths of livestock**
    - **contaminated streams**
    - **large areas of dead trees and vegetation**

US DEA, http://www.deadiversion.usdoj.gov/pubs/brochures/pseudo/pseudo_trifold.htm, viewed Dec 2007

Dual-use chemical example: Cyanide

Therence Koh/AFP/Getty Images

- Widely used in mining and metal plating industries, but is also a well known poison.
- Product tampering*
  - Tylenol capsules
    - laced with KCN
    - 7 deaths, fall 1982, Chicago, Illinois, USA
    - Led to tamper-proof product packaging
- Popular with criminals and terrorists because it is relatively easy to obtain
- HCN is CW agent AC

* "Tylenol Crisis of 1982." *Wikipedia, The Free Encyclopedia*. 22 Nov 2007, 06:04 UTC. Wikimedia Foundation, Inc. 28 Nov 2007 <http://en.wikipedia.org/w/index.php?title=Tylenol_Crisis_of_1982&oldid=173056508>.

Dual-use chemical example: Pesticides

- **Widely used in homes and agriculture, but also used to poison people.**

FIGURE. Package of Chinese rodenticide implicated in the poisoning of a female infant aged 15 months — New York City, 2002

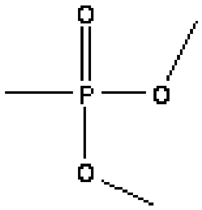
Photo/New York City Poison Control Center

- Dushuqiang (Strong Rat Poison)
  - Outlawed in China in the mid-1980s, but was still available
  - Nanjing, China, Sept. 2002
    - 38 people killed by poison in snack-shop food, >300 sick
    - Jealously by rival shop owner
  - Hunan, China, Sept. 2003
    - 241 people poisoned by cakes served by school cafeteria
    - Motive and perpetrator unknown
  - Tongchuan City, Shaanxi, China, April 2004
    - 74 people poisoned by scallion pancakes
    - Motive and perpetrator unknown
  - 5 other incidents reported between 1991 and 2004

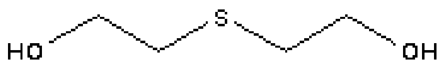
Ann. Emerg. Med., Vol. 45, pg. 609, June 2005

Many lab/industrial chemicals have dual uses

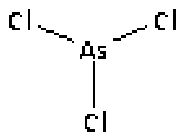
- Dimethyl methyl phosphonate (DMMP)
  - Flame retardant for:
    - building materials, furnishings, transportation equipment, electrical industry, upholstery
  - Nerve agent precursor



- Thiodiglycol
  - Dye carrier, ink solvent, lubricant, cosmetics, anti-arthritic drugs, plastics, stabilizers, antioxidants, photographic, copying, antistatic agent, epoxides, coatings, metal plating
  - Mustard gas precursor



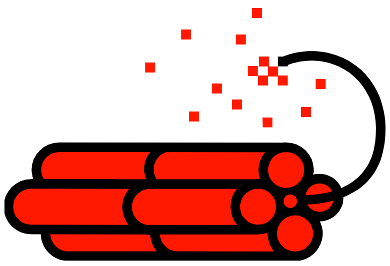
- Arsenic Trichloride
  - Catalyst in CFC manufacture, semiconductor precursor, intermediate for pharmaceuticals, insecticides
  - Lewisite precursor

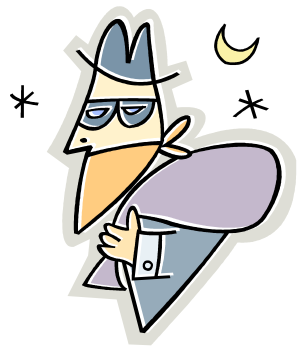


From: Chemical Weapons Convention: Implementation Assistance Programme Manual (on CD)

Dual-use Chemicals: Explosives

- Theft of conventional explosives
  - Chemical suppliers
  - Users such as mines or construction sites
- Diversion of industrial or laboratory chemicals
  - Chemical suppliers
  - Chemical factories
  - Academic teaching or research laboratories
  - Disposal sites





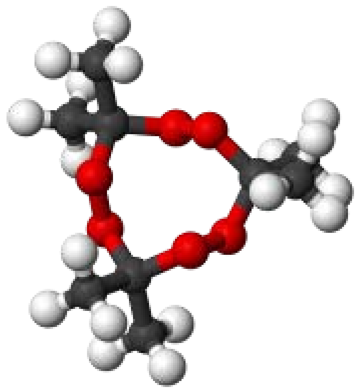
Theft / manufacture of explosives: Fertilizer Bomb

Photo: US DOD

- Ammonium nitrate fertilizer and fuel oil (diesel, kerosene)
- Used to bomb Alfred P. Murrah building in Oklahoma City, OK, USA
  - with nitromethane and commercial explosives
  - 168 dead, including children
  - April 1995
- Favored by IRA, FARC, ETA, etc.

Theft / manufacture of explosives: TATP

- Triacetone triperoxide (TATP)
- Invisible to detectors looking for N-based explosives
- Made using acetone, hydrogen peroxide, strong acid (HCl, sulfuric)
- Favored by terrorists "Mother of Satan"
  - Sept 2009 arrest of N. Zazi, NY and Denver
  - July 2005 London suicide bombs
  - 2001 Richard Reid "shoe bomber"
  - 1997 New York subway suicide bomb plot



CAS 17088-37-8

Wikipedia downloaded Oct 2009
http://en.wikipedia.org/wiki/Acetone_peroxide

Diversion of industrial / laboratory chemicals: Sodium azide

- Widely available from older automobile airbags
  - 1980s to 1990s
- Poisonous
- Reacts explosively with metals
  - Biological laboratory drains have exploded from discarded waste solutions containing NaN_3 as a preservative.
- Has been found in possession of terrorists

Diversion of industrial / laboratory chemicals: Bali bombing

- Amrozi purchased chemicals used to make bombs
- One ton of potassium chlorate* purchased in three transactions from the Toko Tidar Kimia fertilizer and industrial chemicals store in Jalan Tidar, Surabaya, owned by Sylvester Tendean.
  - Claimed he was a chemical salesman.
  - Obtained a false receipt saying he purchased sodium benzoate.
  - Tendean lacked proper permit to sell this chemical, didn't know the chemical would be used to make a bomb.
- Details of Aluminum powder purchases not known

* Some press reports state potassium choride, but this is clearly an error

http://www.smh.com.au/articles/2003/06/09/1055010930128.html

http://www.thejakartapost.com/news/2002/12/18/amrozi-owns-possessing-chemicals.html

Diversion of industrial / laboratory chemicals: Quote from the "Terrorists Handbook"

2.1 ACQUIRING CHEMICALS

The first section deals with getting chemicals legally. This section deals with "procuring" them. The best place to steal chemicals is a college. Many state schools have all of their chemicals out on the shelves in the labs, and more in their chemical stockrooms. Evening is the best time to enter lab buildings, as there are the least number of people in the buildings, and most of the labs will still be unlocked. One simply takes a bookbag, wears a dress shirt and jeans, and tries to resemble a college freshman. If anyone asks what such a person is doing, the thief can simply say that he is looking for the polymer chemistry lab, or some other chemistry-related department other than the one they are in.

9.0 CHECKLIST FOR RAIDS ON LABS

http://www.totse.com/en/bad_ideas/irresponsible_activities/168593.html, downloaded Nov. 2007

Group Discussion

- What chemicals are of most concern for diversion?
  - Common laboratory/industrial chemicals that would be targeted by someone for illegal reasons such as making explosives, illegal drugs, or chemical weapons.

International Chemical Controls

International chemical control groups

ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS

Chemical weapons convention

The Australia Group

Export controls

UN Security Council Resolution 1540

Organization for the prohibition of chemical weapons (OPCW)

- International group headquartered in The Hague, Netherlands
  - https://www.opcw.org/index.html
- Chemical weapons convention (CWC)
  - International treaty which bans the development, production, stockpiling, transfer and use of chemical weapons
- Promotes international cooperation in peaceful uses of chemistry
- Protecting each other

Chemical Weapons Convention (CWC)

- International treaty which bans the development, production, stockpiling, transfer and use of chemical weapons
  - Entered into force in April 1997 with 87 State Parties participating
  - Today: 183 nations have joined, 5 others have signed, only 7 have not taken any action.
    - Each nation enacts appropriate laws
    - Each nation agrees to assist other Member States

CWC: Destroy existing stockpiles and facilities

- Twelve States parties have declared CW production facilities.
  - Bosnia and Herzegovina
  - China
  - France
  - India
  - Islamic Republic of Iran
  - Japan
  - Libyan Arab Jamahiriya
  - Russian Federation
  - Serbia
  - United Kingdom of Great Britain and Northern Ireland
  - United States of America
  - another State Party

- As of August 2007, 42 of 65 declared CW production facilities have been certified as destroyed, 19 converted to peaceful purposes.
- As of August 2007, 23,912 metric tonnes of CW agent has been destroyed out of 71,330 metric tonnes declared.
- On 11 July 2007, the OPCW confirmed the destruction of the entire chemical weapons stockpile in Albania.
- Includes old and abandoned CW munitions

CWC: Prevent spread or production of new chemical weapons

- States declare and agree to inspections of many other chemical facilities, depending on chemical type and amount produced
- Over 3,000 inspections have taken place at 200 chemical weapon-related and over 850 industrial sites on the territory of 79 States Parties since April 1997
- Worldwide, over 5,000 industrial facilities are liable to inspection

CWC: Chemicals on schedules subject to verification measures

- Schedule 1:
  - Known CW agents
  - Highly toxic, closely related chemicals, or CWA precursors
  - Has little or no peaceful application
- Schedule 2:
  - Toxic enough to be used as a CWA
  - Precursor to or important for making a Schedule 1 chemical
  - Not made in large commercial quantities for peaceful purposes
- Schedule 3:
  - Has been used as a CWA
  - Precursor to, or important for making a Schedule 1 or 2 chemical
  - Is made in large commercial quantities for peaceful purposes
- Unscheduled Discrete Organic Chemicals (UDOC)
- Lists of scheduled chemicals follow: also in documents on CD

CWC: Reporting requirements

- Use/transfer of these chemicals is allowed for research, medical, or pharmaceutical purposes.
- Reporting requirements depend on facility type, chemical types and amounts.
  - "Other Facility" type, as defined in CWC documents, most relevant here
  - Amounts of chemicals that would require that your National Authority approve the work and report your institution annually to the OPCW
    - Schedule 1: 100 g aggregate
    - Schedule 2: 1 kg for 2A*, 100 kg for other 2A, 1 Tonne of 2B
    - Schedule 3: 30 Tonnes
    - UDOC: 30 or 200 Tonnes (lower number if contains P, S, or F)

Caution:
Your country might require reporting of lower amounts!

Schedule 1 Chemicals

A. Toxic chemicals

- (1) O-Alkyl (<C10, incl. cycloalkyl) alkyl (Me, Et, n-Pr or i-Pr)-phosphonofluoridates, e.g.
  - Sarin: O-Isopropyl methylphosphonofluoridate
  - Soman: O-Pinacolyl ethylphosphonofluoridate
- (2) O-Alkyl (<C10, incl. cycloalkyl) N,N-dialkyl (Me, Et, n-Pr or i-Pr) phosphoramidocyanidates, e.g. Tabun: O-Ethyl N,N-dimethyl phosphoramidocyanidate
- (3) O-Alkyl (H or <C10, incl. cycloalkyl) S-2-dialkyl (Me, Et, n-Pr or i-Pr)-aminoethyl alkyl (Me, Et, n-Pr or i-Pr) phosphonothiolates and corresponding alkylated or protonated salts, e.g. VX: O-Ethyl S-2-diisopropylaminoethyl methyl phosphonothiolate
- (4) Sulfur mustards:
  - 2-Chloroethylchloromethylsulfide
  - Mustard gas: Bis(2-chloroethyl)sulfide
  - Bis(2-chloroethylthio)methane
  - Sesquimustard: 1,2-Bis(2-chloroethylthio)ethane
  - 1,3-Bis(2-chloroethylthio)-n-propane
  - 1,4-Bis(2-chloroethylthio)-n-butane
  - 1,5-Bis(2-chloroethylthio)-n-pentane
  - Bis(2-chloroethylthiomethyl)ether
  - O-Mustard: Bis(2-chloroethylthioethyl)ether
- (5) Lewisites:
  - Lewisite 1: 2-Chlorovinyldichloroarsine
  - Lewisite 2: Bis(2-chlorovinyl)chloroarsine
  - Lewisite 3: Tris(2-chlorovinyl)arsine
- (6) Nitrogen mustards:
  - HN1: Bis(2-chloroethyl)ethylamine
  - HN2: Bis(2-chloroethyl)methylamine
  - HN3: Tris(2-chloroethyl)amine
- (7) Saxitoxin
- (8) Ricin

B. Precursors

- (9) Alkyl (Me, Et, n-Pr or i-Pr) phosphonyldifluorides, e.g. DF: Methylphosphonyldifluoride
- (10) O-Alkyl (H or <C10, incl. cycloalkyl) O-2-dialkyl (Me, Et, n-Pr or i-Pr)-aminoethyl alkyl (Me, Et, n-Pr or i-Pr) phosphonites and corresponding alkylated or protonated salts e.g. QL: O-Ethyl O-2-diisopropylaminoethyl methylphosphonite
- (11) Chlorosarin: O-Isopropyl methylphosphonochloridate
- (12) Chlorosoman: O-Pinacolyl methylphosphonochloridate

Schedule 2 Chemicals

A. Toxic chemicals

- (1) Amiton: O,O-Diethyl S-[2-(diethylamino)ethyl] phosphorothiolate and corresponding alkylated or protonated salts
- (2) PFIB: 1,1,3,3,3-Pentafluoro-2-(trifluoromethyl)-1-propene
- (3) BZ: 3-Quinuclidinyl benzilate

B. Precursors

- (4) Chemicals, except for those listed in Schedule 1, containing a phosphorus atom to which is bonded one methyl, ethyl or propyl (normal or iso) group but not further carbon atoms, e.g.
  - ethylphosphonyl dichloride
  - dimethyl methylphosphonate
  - Exemption: Fonofos: O-Ethyl S-phenyl ethylphosphonothiolothionate
- (5) N,N-Dialkyl (Me, Et, n-Pr or i-Pr) phosphoramidic dihalides
- (6) Dialkyl (Me, Et, n-Pr or i-Pr) N,N-dialkyl (Me, Et, n-Pr or i-Pr)-phosphoramidates
- (7) Arsenic trichloride
- (8) 2,2-Diphenyl-2-hydroxyacetic acid
- (9) Quinuclidin-3-ol
- (10) N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethyl-2-chlorides and corresponding protonated salts
- (11) N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethane-2-ols and corresponding protonated salts
  - Exemptions: N,N-Dimethylaminoethanol and corresponding protonated salts
  - N,N-Diethylaminoethanol and corresponding protonated salts
- (12) N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethane-2-thiols and corresponding protonated salts
- (13) Thiodiglycol: Bis(2-hydroxyethyl)sulfide
- (14) Pinacolyl alcohol: 3,3-Dimethylbutan-2-ol

Schedule 3 Chemicals

A. Toxic chemicals

- (1) Phosgene: Carbonyl dichloride
- (2) Cyanogen chloride
- (3) Hydrogen cyanide
- (4) Chloropicrin: Trichloronitromethane

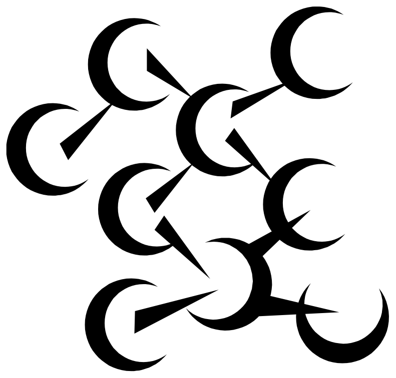
B. Precursors

- (5) Phosphorus oxychloride
- (6) Phosphorus trichloride
- (7) Phosphorus pentachloride
- (8) Trimethyl phosphite
- (9) Triethyl phosphite
- (10) Dimethyl phosphite
- (11) Diethyl phosphite
- (12) Sulfur monochloride
- (13) Sulfur dichloride
- (14) Thionyl chloride
- (15) Ethyldiethanolamine
- (16) Methyldiethanolamine
- (17) Triethanolamine

Unscheduled discrete organic chemicals (UDOC)

- Also subject to CWC reporting, but only for large amounts.

- "Discrete Organic Chemical" means any chemical belonging to the class of chemical compounds consisting of all compounds of carbon except for its oxides, sulfides and metal carbonates, identifiable by chemical name, by structural formula, if known, and by Chemical Abstracts Service registry number, if assigned.



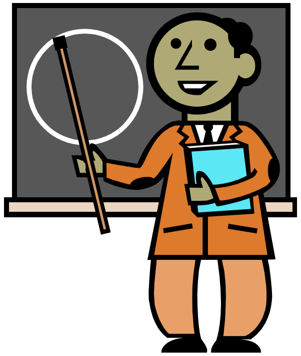
From CWC text – on CD

OPCW: Promotes international cooperation in peaceful use of chemistry

- Associates program
- Analytical skills development course
- Conference support program
- Research projects program
- Internship Support Program
- Laboratory Assistance Program
- Equipment Exchange Program

OPCW: Protecting each other

- Each member state can request assistance from other member states in the event of a threat or attack, including chemical terrorism
- This can take the form of expertise, training, materials, and/or equipment



Australia Group

- An informal arrangement to minimize the risk of assisting chemical and biological weapon (CBW) proliferation.
  - Harmonising participating countries' national export licensing measures
  - Started in 1985 when Iraq CW program was found to have diverted chemicals and equipment from legitimate trade
- 40 nations plus European Commission participate

Australia Group: Export Controls

- Controls exports of:
  - 63+ Chemical weapon agent precursor chemicals
  - Dual-use chemical manufacturing facilities and equipment and related technology
  - Dual-use biological equipment and related technology
  - Biological agents
  - Plant pathogens
  - Animal pathogens
- Includes no-undercut policy
  - Countries won't approve an export that another member country denied

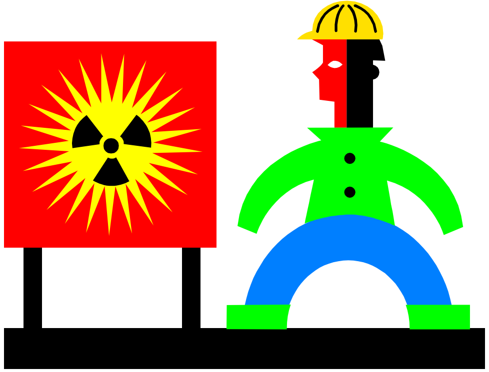
UN Security Council Resolution 1540

- Unanimously passed on 28 April 2004
- Member States:
  - must refrain from supporting non-State actors in developing, acquiring, manufacturing, possessing, transporting, transferring or using nuclear, chemical or biological weapons and their delivery systems.
  - must establish domestic controls to prevent the proliferation of nuclear, chemical and biological weapons, and their means of delivery, including by establishing appropriate controls over related materials.
- Enhanced international cooperation on such efforts is encouraged, in accord with and promoting universal adherence to existing international non-proliferation treaties.

Organization of a Chemical Safety and Security Program

Hazard Survey

- Baseline
- Periodic (inspections)
- Identify potential job hazards, material hazards, and process hazards



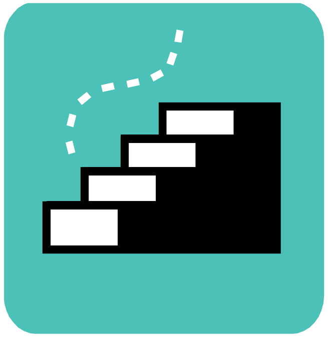
Hazard Survey Process

- Prepare survey form
- Walk-through
- Take measurements
  - Sample if necessary, monitor exposure (e.g., formaldehyde, radiation)
- Data analysis
- Write and deliver report

Job Hazard Analysis (JHA)

Hazards associated with a particular task become apparent from a brief survey:

- Compile steps needed to complete job.



- Analyze each step in detail.
  - Could exposure occur?
  - Could an accident occur?
  - Could a change in practice / process could create hazard?

- Develop recommendations on precautions to eliminate/minimize hazard.

Periodic Lab Inspections

- Done by CSSO
- Coordinate with lab supervisor/Chief/PI/occupants/safety representative
- Team may include:
  - Peers
  - Facilities representative
- Frequency determined by hazards present and local practices
  - 2 - 4 times/yr
- Look for:
  - Good and bad practices
  - new hazards
  - new security issues

Sample Laboratory Survey/Inspection Checklist

- Date of Inspection:_______
- Conducted by:_______
- Location (room and building):_______
- Principal Investigator/supervisor:_______

- Laboratory Work Practices
  - Smoking observed?
  - Food observed/stored. In refrigerators?
  - Mechanical pipetting devices present/used?
  - Hazardous chemicals present/used in designated areas?
  - Lab surfaces cleaned/decontaminated after use?
  - PPE available/properly used, stored, maintained?

Survey/Inspection Checklist, cont'd.

- Hazard Communication
  - Warning signs, required PPE *posted*.
  - (M)SDS available.
  - Signs for storage areas, refrigerators, waste, designated work areas' specific hazards.
  - Label all containers.
  - Access controlled.
- Personal Protective Equipment
  - Available for each specific hazard.
  - Eye protection available, when & where required & *posted.*
  - Other PPE available as necessary.
  - Visitor PPE available.
  - Visitor requirements for PPE *posted*.

Survey/Inspection Checklist, cont'd.

- Chemical Storage
  - Area secured
  - Chemicals with special security needs present?
  - Chemicals inventoried
  - Incompatible chemicals segregated.
  - Volatile, flammable material keep away from heat.
  - Corrosives, flammables keep below eye level.
  - Limited quantities of flammables, or other hazardous chemicals, stored in lab.
  - Unnecessary, outdated chemicals discarded.
  - Safety carriers available for bottle transport.

Survey/Inspection Checklist, cont'd.

- Compressed Gas Cylinders
  - Properly chained or secured
  - Caps in place, if available
  - Stored away from heat
  - Cylinders properly marked with contents
  - Empty and full separated
  - Flammables separated from non-flammables
  - Lines labeled and in good condition
  - Proper valves used
  - Toxic gases stored securely

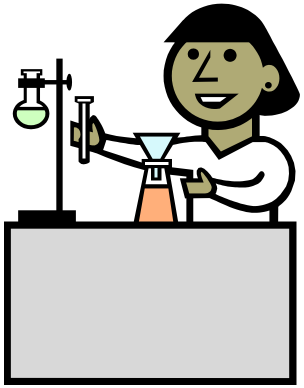
Survey/Inspection Checklist, cont'd.

- Safety Equipment
  - Eyewashes & safety showers present, unobstructed, in good working order, routinely tested and maintained.
  - Fire alarms & telephones appropriately placed and labeled.
  - Adequate number and type of unobstructed, routinely inspected fire extinguishers.
  - Spill kits available, maintained, labeled.
  - Adequate number of fire alarm/ detection devices.
  - Flammable storage cabinets available.
- General Facility
  - Benches are water/chemical heat resistant.
  - Sturdy furniture.
  - Sinks for hand washing.
  - Exits marked
  - Access controls

Survey/Inspection Checklist, cont'd.

- Ventilation
  - Hoods available and in good working order.
  - All hoods marked with proper operating height and restrictions for use.
  - Hoods not cluttered with chemical and equipment storage.

- Housekeeping
  - Lab areas uncluttered.
  - Aisles & exits unobstructed.
  - Work surfaces free from contamination.
  - Spills cleaned up.
  - Electrical cords in good condition, equipment grounded.
  - Heavy objects on lower shelves.
  - Glassware free from defects.



Training Program

- Determine if training is needed, e.g., JHA
- Identify needs
- Identify Goals & Objectives
- Develop training activities
- Identify resources
- Conduct training
- Evaluate effectiveness
- Improve program

Employee Training Topics

- New employee orientation
- Specialized laboratory equipment and procedures
- Recognize Occupational Exposure Limits (OEL) for hazardous chemicals; (M)SDS
- PPE use, storage and maintenance (especially respirators)
- Fire safety and fire extinguisher use
- Emergency plans, evacuation procedures & routes
- Ionizing radiation
- Non-ionizing radiation, lasers, microwaves
- Special exposure, e.g., formaldehyde
- Biosafety, Bloodborne pathogens
- Facility security requirements
- Animal Care facilities - use and techniques

Training Documentation: Sample

- Employee name: ___________________________
- Department: _________________________
- Date: ______

- Training Subject: ______________________________
- Training Date: ___________
- Re-instruction date: _________

- Employee Signature: ______________________________
- Date Signed: __________
- Supervisor's signature: _____________________________
- Date: __________

Medical Surveillance Program

- Baseline screening
  - Medical history
  - Past illnesses, exposures and diseases
  - Comprehensive physical exam
  - Assessment of limitations
    - Respirator use and other PPE
- Treatment
  - Emergency
  - Non-emergency (e.g., first aid)
- Periodic Medical exam
- Termination exam
- *Confidential* record keeping
  - Physician, employee

Biological Monitoring Program

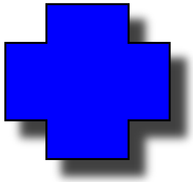
- Identify employees with potential exposure to specific hazardous chemicals, biological agents, working conditions.
  - Specific signs and symptoms of chemical exposure.
  - Use of respirators.
    - Cardiovascular, hearing (perforated tympanic membrane), neurological (e.g., epilepsy), psychological disorders
  - Working in noisy areas.
  - Working in Biosafety risk areas.
    - Bloodborne pathogens
      - e.g., Human blood and body fluids, hepatitis B (HBV), HIV, AIDS
    - Infectious agents
      - e.g., Zoonosis, animal care, recombinant DNA

- Determine extent of personal and environmental exposure.
- Take actions to eliminate/minimize exposure.
- *Confidential* record keeping .

Medical Surveillance *vs.* Biological Monitoring

Medical Surveillance

- General program
- Establishes baseline
- Evaluates employees before potential exposure
- Documents past exposure and existing conditions
- Simpler, cheaper, less invasive medical testing
- May be used in conjunction with biological monitoring



Biological Monitoring

- Chemical specific signs and symptoms
- Known exposure levels
- Documented exposure
- Documented amounts of personal exposure
- Documented environmental exposure
- Most specific, most expensive, more invasive

Guidelines for Incident Investigation

- Description/report of incident
- Review of organizational policy
- Start of investigation
- Cause of incident
  - Emphasis is prevention, *NOT* blame
  - Timely report with recommendations to all responsible parties including senior management
- Timely response to recommendations
  - Correction
  - Follow-up
  - Action taken
  - Training

Incident Investigation Form: Sample

- Date of accident/incident_______
- Time reported_______
- Location________
- Type of incident: fire, explosion, spill, employee exposure, theft, intruder, near-miss ________
- Date of investigation_________
- Investigation team members__________________

Nature of Incident

- Incident description, include people, task, chemicals, etc. involved
- Nature of injuries, exposures, illnesses, damages, losses
- Determination of potential causes
- PPE worn at the time
- Hazard control or access control measures in use

Incident Investigation Form, cont'd.

- Organizational polices, procedures, etc. that apply
- Was training proper and up-to-date?
- How could incident been prevented?
- Has similar incident occurred in past, when, where, circumstances?

Team recommendations to prevent reoccurrence of such incidents:

____

____

____

Chemical
Safety and Security Program

Organization and Responsibilities

Chemical Safety and Security Program Purpose

- Help establish a safe and secure workplace.
- Help safeguard the environment.
- Prevent/reduce release of hazardous chemicals and operations.
- Prevent/reduce exposure to staff.
- Reduce stress.
- Enhance community relations.
- Comply with regulations.
- Crisis management

Crisis Management: Prevention & Response

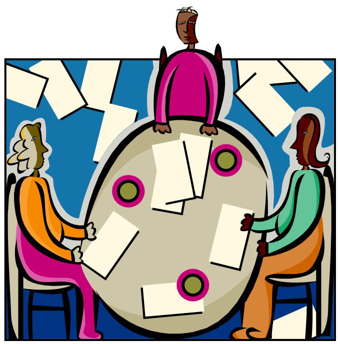
- **Facility crisis**
  - **Fire**
  - **Explosion**
  - **Chemical release**
- **Natural disaster**
  - **Earthquakes**
  - **Hurricane/typhoon**
  - **Tsunami**
- **Disgruntled personnel**
  - **Employees**
  - **Ex-workers**
  - **Students**
- **Demonstrations, protests**
- **Evacuation / reoccupancy**
- **Terrorism**

Crisis Management:
Criminal & Terrorism Concerns

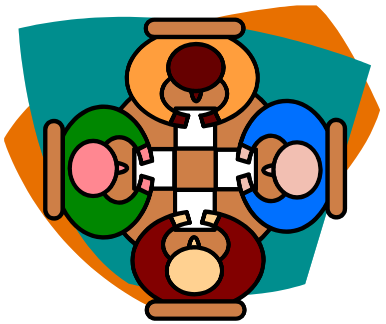
- **External security**
  - **Fences**
  - **Cameras**
  - **Guards**
- **Internal security**
  - **Personnel background checks**
  - **Employees, contractors, students**

- Theft
  - Chemicals, materials
  - Equipment
- Bombing
- Toxic release

Chemical Safety and Security Applies to Everyone



Administration
Human Resources
Purchasing
Facilities
Construction
Police/Security
Department Administration
Research Administration
Employees
Students
Contractors
All visitors



Faculty/Principal Investigator

has the responsibility

to *teach, model* and *encourage* good Chemical Safety and Security practices

Principal Investigator
CSS Responsibilities

- Develop procedures with CSSO for unique hazards and chemicals (e.g. carcinogens)
- Develop proper control practices with CSSO
- Participate in developing CSS Plan, CSS Committee, accident investigations
- Ensure CSS documents and records are maintained
- Maintain local chemical inventory for their lab
- Ensure (M)SDS are available in the laboratory
- Facilitate compliance with policies, guidelines and regulations

CSS Responsibilities
Principal Investigator, cont'd.

- Ensure students/workers know and follow policies and practices
- Ensure equipment and controls are properly maintained
- Ensure all students/workers received proper training and refreshers
- Ensure new students/workers receive proper training before starting work
- Inform CSSO of any accidents and incidents
- Follow-up on accidents and incidents

Employees and students

have a responsibility

to *actively* support and participate in the CSS Program.

Employee/Student CSS Responsibilities

- Follow policies/rules
- Wear Personal Protective Equipment (PPE)
- Report accidents, incidents/near misses, problems
- Learn about hazards of specific chemicals
- Suggest changes and improvements
- Work safely
- Do not put others at risk
- Encourage good safety and security
- Behave responsibly

Employee/Student CSS Responsibilities

- Understand and act in accordance with policies and practices
- Wear and maintain proper PPE
- Use engineering controls properly
- Follow good chemical safety practices
- Participate in required training
- Read & understand CSS related documents
- Report accidents, incidents
- Suggest improvements and changes to the CSS Program
- Participate in the CSS Program

Chemical Safety and Security Officer

has the responsibility

to provide expertise and information
so that
a safe and healthy workplace
is present

CSSO
Training, Experience, Skills

- **Chemistry**
  - Nomenclature
  - Physical properties
  - Reactivities
  - Chemical compatibilities
- **Health and Safety (industrial hygiene)**
- **Security**
  - Facility
  - Chemicals
  - Equipment
  - Personnel
- **Psychology**
  - Dealing with people
- **Physics**
  - Ventilation
  - Radiation (ionizing/non-ionizing)
  - Electrical
- **Biology**
  - Biosafety
  - Recombinant DNA
  - Blood borne pathogens
- **Administration**
- **Writing**
- **Speaking/presentations/training**

CSSO Responsibilities

- Report directly to higher management
- Provide leadership in safety and security
- Draft a budget
- Ensure Plans and Manuals are written and updated
- Advise administration, staff, employees, students
- Conduct inspections and audits
- Investigate accidents and incidents
- Respond to problems and concerns
- Participate in Chemical Safety and Security Committee(s)
- Ensure documentation, records and metrics are maintained
- Develop CSS Training plans
- Know legal regulations and ensure compliance

The Function of the CSSO is to Act as a Co-Worker, *NOT* as a Policeman

Chemical Safety and Security Committee

has the responsibility

to oversee and monitor the CSS Program for management so that

a safe and healthy workplace

is maintained

Chemical Safety and Security Committee Responsibilities

- Reports directly to senior managemen
- Endorses policies
- Meets regularly (2 – 4 times/yr) with agendas
- Reviews accidents and incidents, may investigate, write reports with recommendations
- Establishes appropriate subcommittees on specific topics

Chemical Safety and Security Committee Composition

- Chaired by committed staff
- CSSO is ex-officio member
- Includes representatives from:
  - Facilities Management
  - Security
  - Administration
  - Faculty/Staff
  - Teaching Assistants/Graduate Students
  - Shops/Unions
- Representatives should rotate after a few years

Management
CSS Responsibilities

Commitment:

- Establish a formal CSS Program
- Announce formation of a CSS Program
- Create a written policy statement
- Designate a Chemical Safety and Security Officer
- Endorse a written CSS Plan (Manual)
- Participate and intervene as needed

Support:

- Financial support (budget)
- Staffing
- Response/resolution of problems by
  - Establishing a CSS Committee
- Stipulates CSS is part of everyone's job
  - CSS applies to everyone
  - Specifies CSS orientation for new employees
- Supports CSS staff

Management
CSS Responsibilities

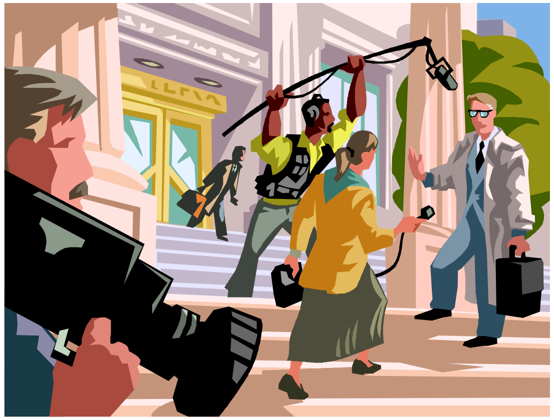
POLICY STATEMENT

Documents and describes
the commitment and support
from the highest management level
for the Chemical Safety and Security Program

Policy Statement
Purpose

Establish and provide for maintenance of an effective Chemical Safety and Security Program to protect:

- **Employees**
- **Facility**
- **Neighbors**
- **Environment**
- **Comply with regulations**



Policy Statements

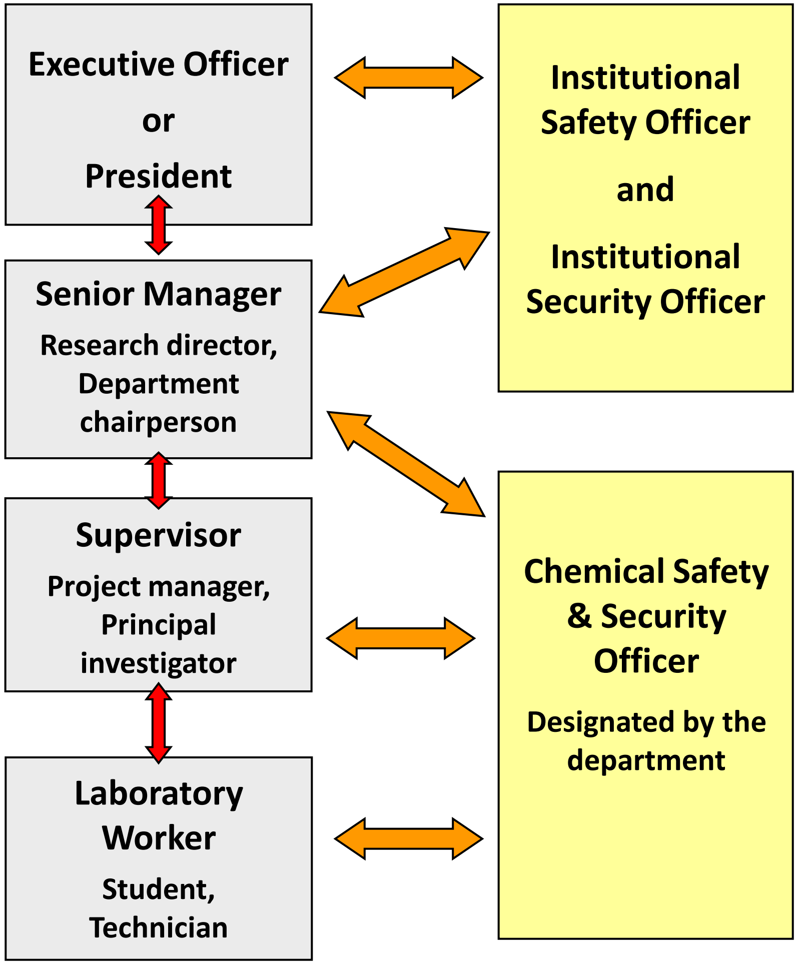
- By senior management
- Typically brief
- Clear goals
- Commitment
- Defines employee role
- Identifies resources and staff
- Signed by person in authority

Director/President CSS Responsibilities

- Establish an effective CSS Program
- Provide for a budget
- Endorse written Policies, Plans and Manuals
- Appoint CSS Officers
- Ensure CSSO has responsibility, authority and accountabili perform assigned duties
- Establish a CSS Committee
- Maintain support and endorsement
- Timely response to Safety Committee recommendations
- Follow and set example, e.g., wears PPE

Chemical Safety and Security Program
Ideal Roles

- Culture of Chemical Safety and Security should exist at all levels of the organization.
- Top management sets policy, provides resources.
- Workers, students, researchers must understand and implement.
- Many organizational interactions are important for chemical safety and security
  - After Fig 1-1 in Prudent Practices in the Laboratory, NRC 1995



CSS
Program Evaluation

- Management leadership
- Employee involvement
- Administrative controls
- Security controls
  - Access to buildings, materials
- Engineering controls
- Accident/incident investigation
- Training
- Use of Personal Protective Equipment (PPE)
- Emergency Response Program
- Medical Surveillance Program
- Work site analysis
  - Inspections, surveys, hazard analysis

Chemical Safety and Security Officer Duties

Surveys

Job Hazard Analysis

Inspections

Training

Medical Monitoring

Investigations

CSSO
Duties

- Oversee procurement, use, storage & disposal of hazardous materials
- Set criteria for exposure levels
- Write and revise CSS Plan
- Trains, documents and ensures training is performed
- Performs risk assessment and monitoring
- Conducts audits and inspections
- Investigates and reports on accidents, incidents
- Interacts with staff to correct deficiencies
- *Follows up* to ensure correction and resolution of issues

CSSO
Duties

- Consult/advise project management on CSS concerns
- Coordinate with Principal Investigators
- Coordinate and facilitate medical surveillance
- Coordinate record keeping
- Coordinate with BSO, RSO, facilities, administration, security

Closing and Adjourn

LUNCH