Chemical Safety and Security Officer Training

Yemen
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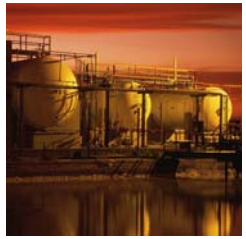
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Sandia National Laboratories

Chemical Safety and Security Overview

Why worry about chemical safety?

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



Possible chemical health problems

Chemicals

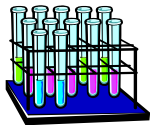
- Vinyl chloride
- Asbestos
- Carbon tetrachloride
- Mercury
- Lead
- Thalidomide
- Methanol
- CO, CS_2

Diseases

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

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/ehs.../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

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

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

10

Safety Video: Reactive Hazards

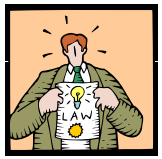
11

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

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, floods
- 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 safety?

- 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

Aum Shinrikyo: Tokyo, Japan

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.

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
  - 100g (0.25 lb) of potassium cyanide and 400 g (0.9 lb) 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 one-ton containers 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

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?

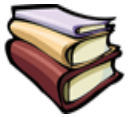
...Could it be improved?

...How?

Break

Fundamentals of Chemical Laboratory Safety

References



"Safety in Academic Laboratories, Vol.1 & 2," American Chemical Society, Washington DC, 2003, also available online: http://portal.acs.org/portal/acs/corg/content?_nfpb=true&_pageLabel=PP_SUPERARTICLE&node_id=2230&use_sec=false&sec_url_var=region1&_uuid=ef91c89e-8b83-43e6-bcd0-ff5b9ca0ca33

"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***

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

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?

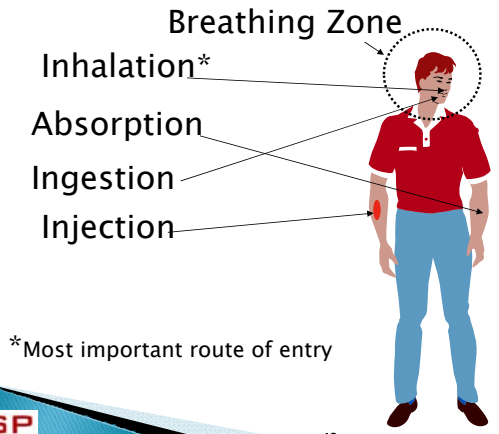
- **Engineering controls:**
  - enclosure / isolation
  - ventilation / hoods
- **Emergency Plan**
- **Personal Protective Equipment (PPE)**

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)

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

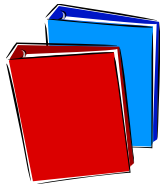
Highly Toxic Chemicals:
nerve gas, phosgene, riot control agents, chemical warfare agents

Evaluation & Control

- Administrative practices
  organizational policies
- Operational practices
  work practices
- Engineering controls
  ventilation, barriers

Administrative Practices

Lab Safety Policies



- Have a Safety Manual
  - Never work alone, especially after hours.
  - 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

Operational Practices

Safe Laboratory Procedures:

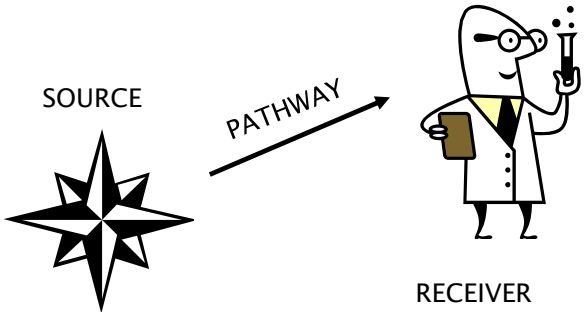
- Packages opened only in labs, not receiving
- Receiving staff trained to look for signs of breakage and/or leaking shipments
- Receiving area has spill kits
- Mailroom/receiving alert for suspicious shipments

Safe Laboratory Procedures

Use hoods properly:

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

Engineering Controls



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

Properly functioning & used correctly!

Laboratory hoods and ventilation are the basis of engineering controls.

Engineering Controls

Local exhaust ventilation includes:

- *snorkels*
- *vented enclosures*
-

Engineering Controls

Local exhaust includes:

- *special containment devices*
  - glove boxes
  - isolation chambers

Personal Protective Equipment

PPE includes:

eye protection,
gloves,
laboratory coats. etc.,
respirators,
appropriate foot protection

Emergency Planning & Response

- Have routine, unannounced evacuation drills.
- Designate a person for each area to ensure that inner rooms 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

Post each room with:

- emergency phone numbers
- after hour phone numbers
- person(s) to be contacted
- alternate person(s)
- unique procedures to be followed

Aspects of Chemical Security

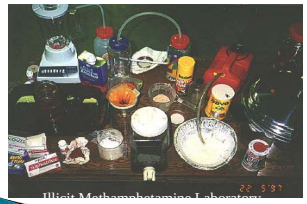
Dual-use Chemicals

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



- Clandestine meth labs in US, 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.**

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

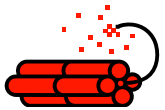
Many lab/industrial chemicals have dual uses

- 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



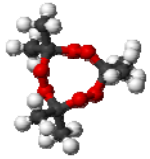
Theft / manufacture of explosives: Fertilizer Bomb

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"
  - 1997-New York subway suicide bomb plot
  - 2001-Richard Reid "shoe bomber"
  - 2005-London suicide bombs
  - 2009 – Arrest of N. Zazi, NY and Denver



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

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 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, >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 are on workshop CD.

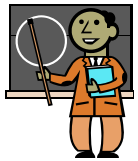
CWC: Reporting requirements

- 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, most relevant
  - *Amounts of chemicals* required for your National Authority to 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!

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.
  - Harmonizing 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
- UN 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 is encouraged, promoting universal adherence to existing international non-proliferation treaties.

Components of Chemical Security

Chemical Security Questions

- Is your facility secure?
- How easy would it be for someone to steal chemicals?
- Are the chemistry workrooms, stockrooms, classrooms and labs always locked and secure?
- Is someone always there when these rooms are open?
- Do you check your orders when chemicals arrive to be sure some chemicals are not missing?

Components of Chemical Security

- Physical security of site
- Personnel management
- Information security
- Management of chemical security activities
- Allocation of chemical security responsibilities
- Development of emergency plans
- Chemical security training

Goal: Ensure that you don't accidently help a criminal or a terrorist get dangerous chemicals

Chemical Security: Physical Site

LOCK UP!!

Controlled drugs

Chemical Surety Agents

Highly toxic chemicals

Facility Characterization

Characterize the facility in terms of:

- Site boundary
- Buildings (construction and HVAC systems)
- Room locations
- Access points
- Processes within the facility
- Existing Protection Systems
- Operating conditions (working hours, off–hours, potential emergencies)
- Safety considerations
- Types and numbers of employees
- Legal and regulatory issues

Facility Characterization

Facility characterization provides important data to:

- identify assets to be protected and their locations,
- survey the existing physical protection system components at the facility,
- document facility layout for security analysis.

Threat Definition

Threat classes:

- Outsiders—no authorized access
- Insiders—authorized access
- Collusion—between Outsiders and Insiders

Target Identification

- Determine the possible targets for the following actions:
  - Sabotage
    - identify vital areas to protect
  - Theft of chemicals

  - Theft of information
    - identify location of materials to protect

Chemical Security: Personnel Management

- Guard against both *Insider and Outsider* threat
- Who checks people entering the building?
- Who has keys? How do they get authorized?
  - Building
  - Stockroom
  - Individual Labs
- When someone leaves, do you make sure they turn in keys?
  - Don't want people making duplicate keys

Chemical Security: Information Security

- How do you track chemical inventory?
  - Is the information secured so unauthorized people can't read it or alter it?
- Would you know if:
  - some toxic chemicals disappeared overnight?
  - some toxic chemicals didn't arrive?
  - someone was ordered chemicals in the name of your institution but diverted them?

Chemical Security: Assign Responsibilities

- Identify people responsible for various chemical security activities:
  - physical security, building modifications
  - chemical tracking and reporting
  - personnel and access management
  - information management
  - emergency planning
- Ensure they have the time and resources to do the job.
- Integrate with chemical safety responsibilities.

Chemical Security: Professional Behavior

- Chemical professionals
- use their scientific knowledge in a responsible manner.

- Chemical Educators
- need to train their students to use their scientific knowledge in a responsible manner.

Relationships between Chemical Security and Chemical Safety

Relationships Between Chemical Safety and Security

- Chemical safety:
  - Protection against *accidents*
- Chemical security:
  - Protection against *deliberate* harm

Many practices are the same for chemical safety and security, but there are a few areas of conflict.

Good Practices for Both Chemical Safety and Security

- **Minimize use of hazardous chemicals.**
  - Replace with less-hazardous chemicals, if possible.
  - Reduce scale of experiments.
- **Minimize supply of hazardous chemicals.**
- **Restrict access to hazardous chemicals.**
  - Know what you have.
  - Know how to store, handle and dispose of what you have.
  - Know who has access to materials, knowledge and expertise.
- **Plan what to do in an emergency.**

Conflicts Between Chemical Safety and Security: Information Sharing

Science generally means sharing information widely, but this may not always be advisable.

- **Safety**
  - label everything so people recognize hazardous chemicals,
  - let community and especially emergency responders know what chemical dangers exist,
  - share knowledge about chemical hazards so people know to be alert.
- **Security**
  - labels help identify targets for theft or attack,
  - sharing locations of chemicals can publicize targets for theft or attack,
  - sharing knowledge of chemical hazards could inspire harmful behavior (copy-cat criminals).

Conflicts Between Chemical Safety and Security: Facility Exits

Locking exit doors is secure, but not safe.

- For safety, people need to be able to leave the facility quickly and by many routes.
- For security, you want to control exits as well as entrances so chemicals (or equipment) are not taken.

Setting Priorities

- **Labs need to be safe, secure and productive.**
  - policies and practices need to be flexible enough to allow for the uncertainties of research.
  - policies and practices need to align with local laws, regulations, practices and culture. Can't just copy from somewhere else.
- **Use risk-based security and safety measures.**
  - can't afford to defend against every imaginable hazard.
  - identify threats, characterize facilities, identify alternatives, analyze costs vs. performance.
- **Be alert for suspicious activities or inquiries.**

All Chemical Facilities Need to be Secured

- **Small-scale research laboratories**
  - Many different chemicals used in small amounts.
- **Large-scale manufacturing plants**
  - Limited types of chemicals used in large amounts.
- **Security measures need to match facility and threat**
  - Can't afford to defend against all imaginable threat.

Lunch

Chemical Safety and Security Officer Training

Workshop Orientation

Workshop Materials

- **Binder:**
  - Presentations (in Arabic)
  - Compact Discs (CDs)
  - Resource section
    - Useful Websites
    - Information for labs and teaching resources
    - List of items on CDs
- **CDs:**
  - Presentations (in Arabic)
  - Resource section (same as Binder)
  - Additional resources
    - PDF of Chemical Security Reference and Toolkit
- **Chemical Security Reference Book and Toolkit:**
  - Book for institutional/academic CSS planning
  - Guidelines for chemical storage groups
  - Toolkit:
    - Instructor's guide
    - Case studies/lessons
    - Lab hazard signs

Workshop Activities

- **Group Exercises:**
  - MSDS & SOP-writing Process
  - Lab Hazard Assessment
  - Lab Improvements Plan
    - Prioritization
    - CSS Action Team
    - Improvement & Maintenance Schedule
  - Presentation of Findings and Plans
- **Laboratory Visits:**
  - Lab Inspection demonstration
  - Simple chemical spill cleanup demonstration
  - Practice Lab Inspection
  - Practice simple chemical spill cleanup
- **Open Discussions and Case Studies:**
  - Throughout workshop, Case Studies on Day 5.
- **Handouts:**
  - Throughout workshop, Presentations and Exercises.

Chemical Security Engagement Program

Interactive Website

SAND No. 5293962 2011-3177 W
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
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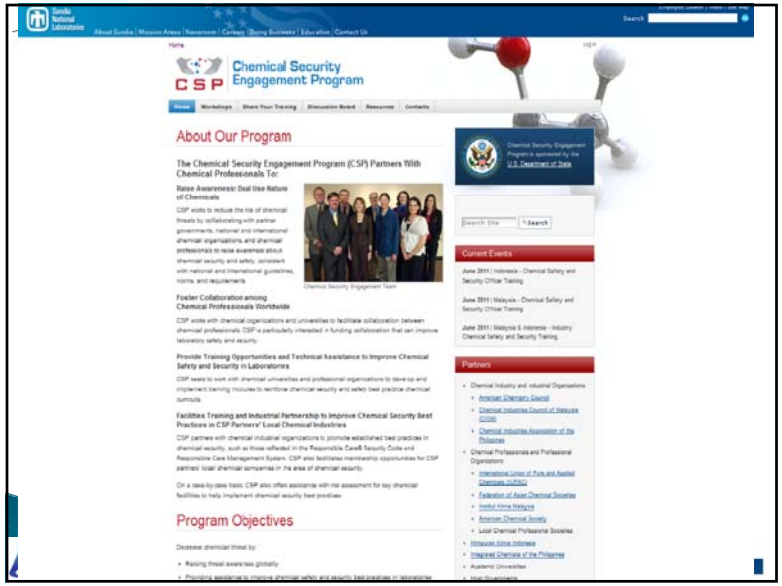
under contract DE-AC04-94AL85000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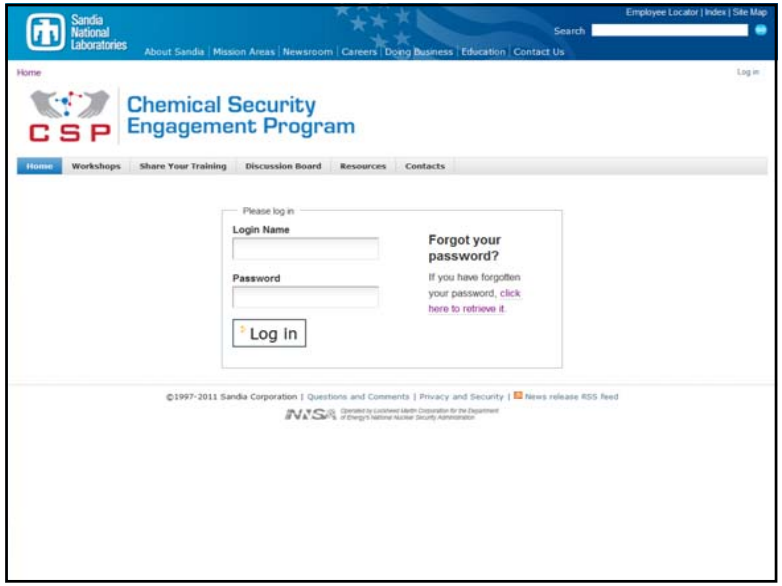
Program Objectives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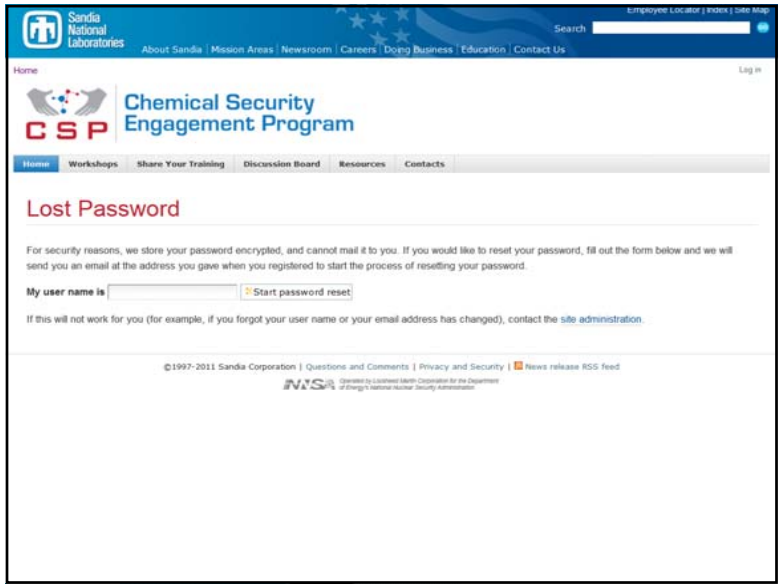
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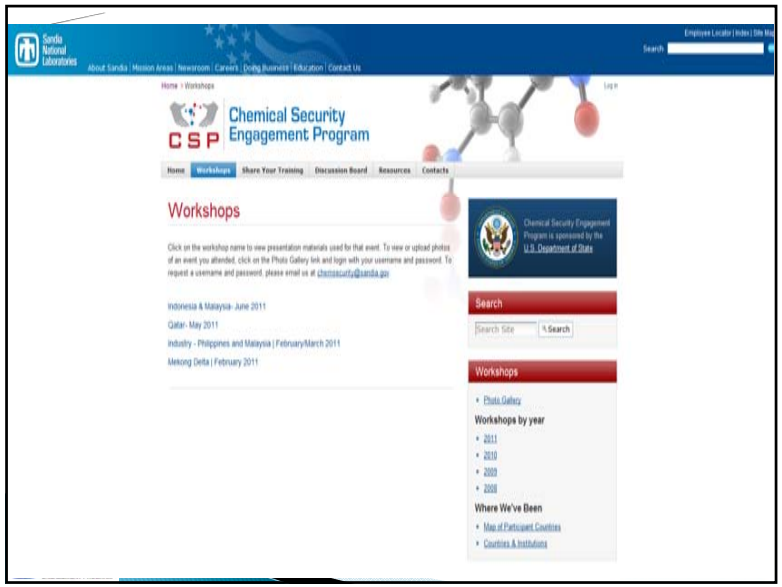
My user name is
Start password reset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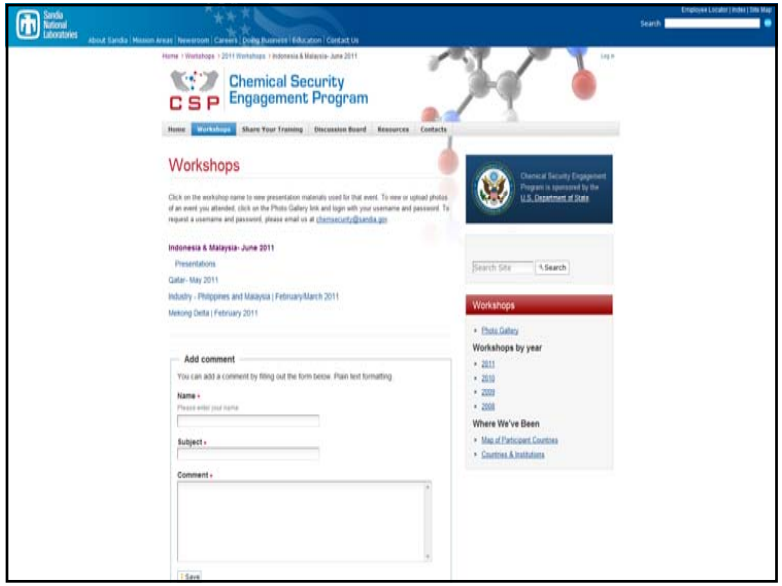
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Qatar- May 2011
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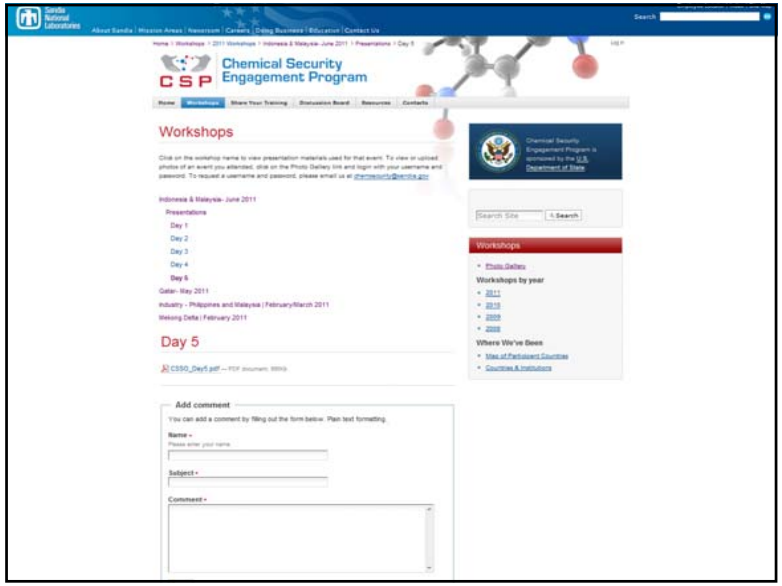
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Countries & Institutions


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Bahrain
Burkina Faso
Cambodia
Egypt
Ethiopia
Indonesia
Jordan
Laos
Lebanon
Malaysia
Morocco
Nigeria
Pakistan
Philippines
Thailand
Tunisia
United Arab Emirates
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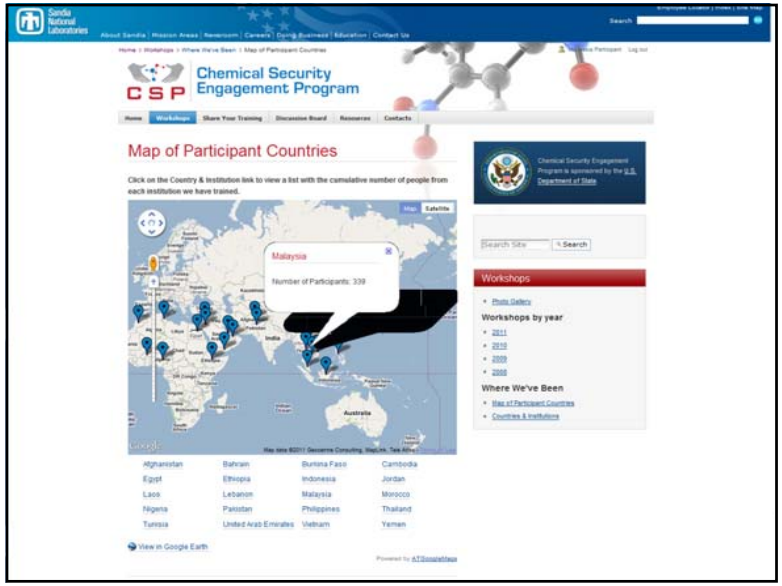
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Map of Participant Countries
Click on the Country & Institution link to view a list with the cumulative number of people from each institution we have trained.
Malaysia
Number of Participants: 339
Workshops
Photo Gallery
Workshops by year
2011
2010
2009
2008
Where We've Been
Map of Participant Countries
Countries & Institutions
Afghanistan
Bahrain
Burkina Faso
Cambodia
Egypt
Ethiopia
Indonesia
Jordan
Laos
Lebanon
Malaysia
Morocco
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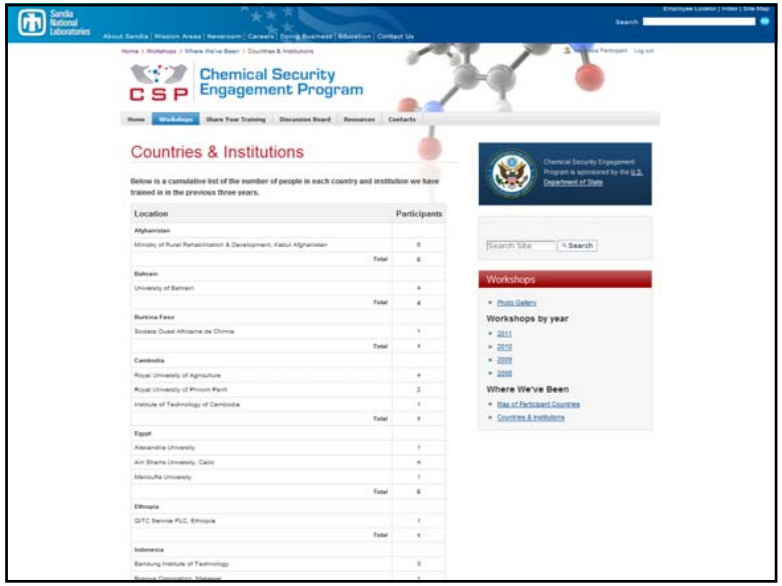
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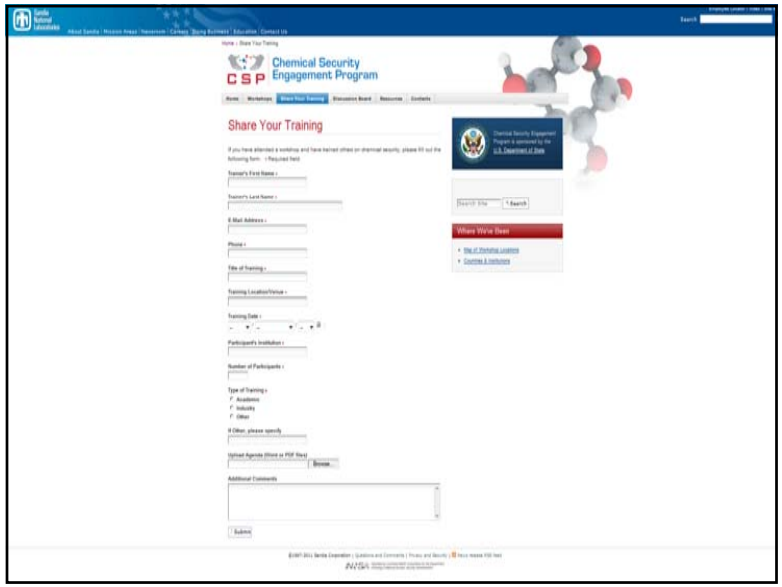
Countries & Institutions
Below is a cumulative list of the number of people in each country and institution we have trained in in the previous three years.
Location
Participants
Workshops
Photo Gallery
Workshops by year
2011
2010
2009
2008
Where We've Been
Map of Participant Countries
Countries & Institutions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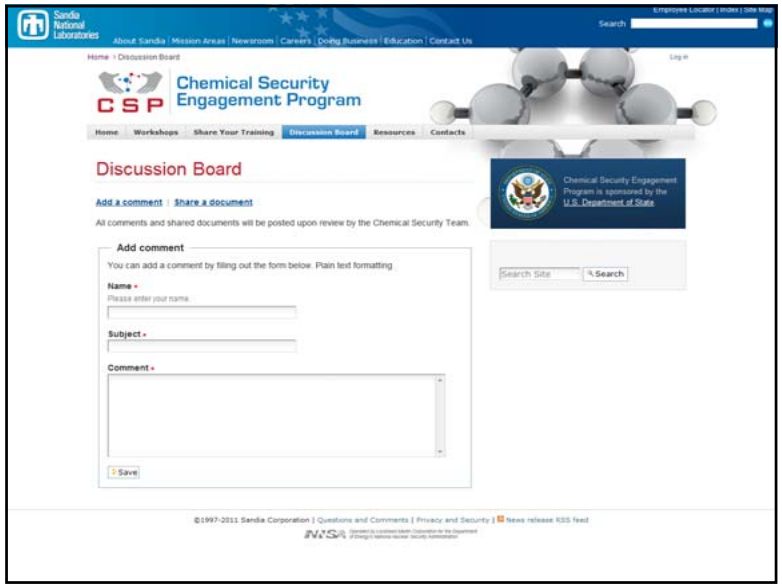
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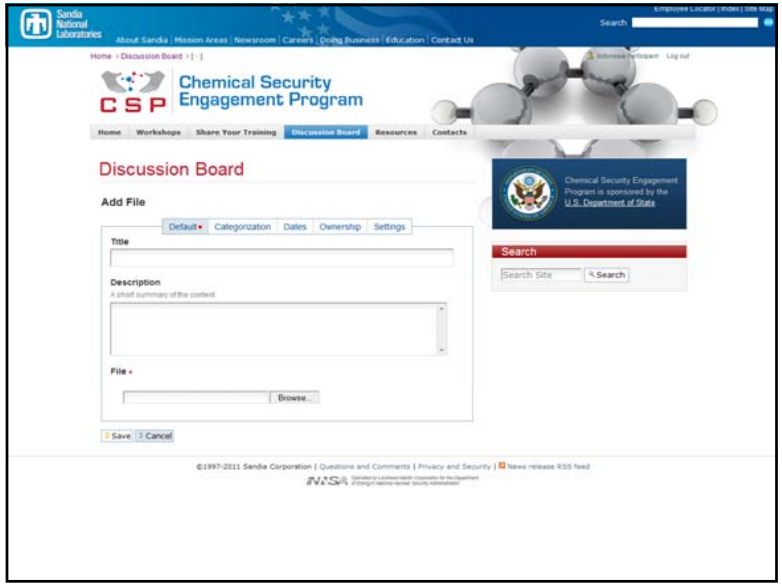
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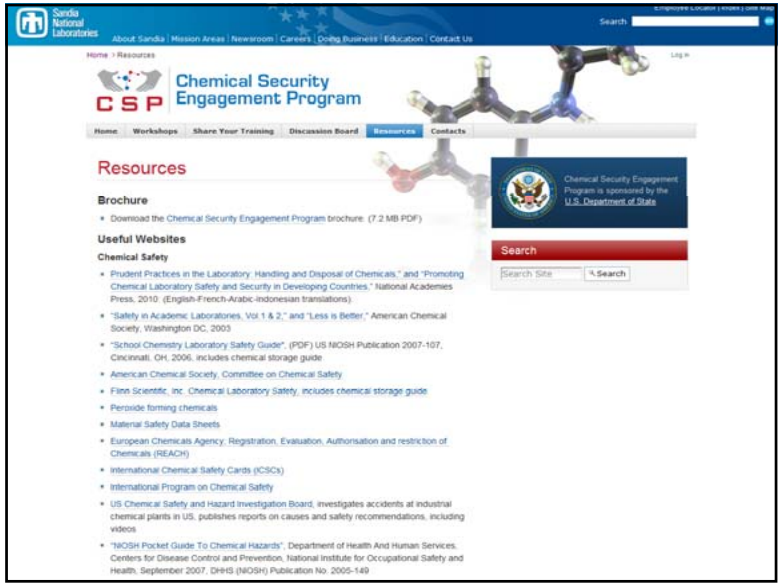
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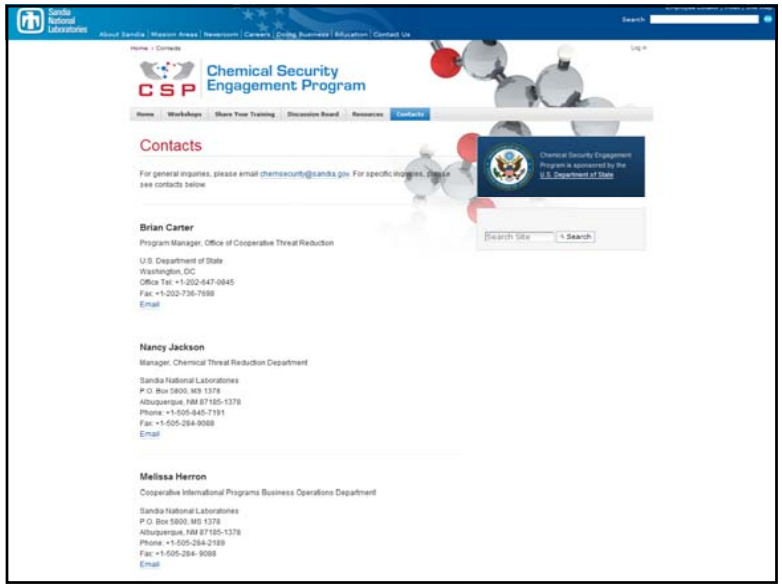

Chemical Security Engagement Program
Contacts
Brian Carter
Program Manager, Office of Cooperative Threat Reduction
Nancy Jackson
Manager, Chemical Threat Reduction Department
Melissa Herron
Cooperative International Programs Business Operations Department


Chemical
Safety and Security Program
Organization and
Responsibilities
CSP
Chemical

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

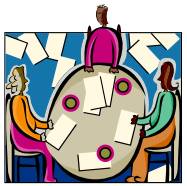
Crisis Management: Prevention & Response

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

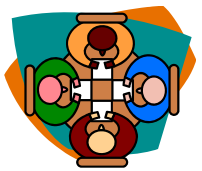
Crisis Management: Criminal & Terrorism Concerns

- **Theft**
  - Chemicals, materials
  - Equipment
- **Bombing**
- **Toxic release**
- **Physical security**
  - Fences
  - Cameras
  - Guards
- **Internal security**
  - Personnel background checks
  - Property/information safeguards
  - Employees, contractors, students

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
- 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

Chemical Safety and Security Officer

The CSSO has the responsibility…

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

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 management
- 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 every 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

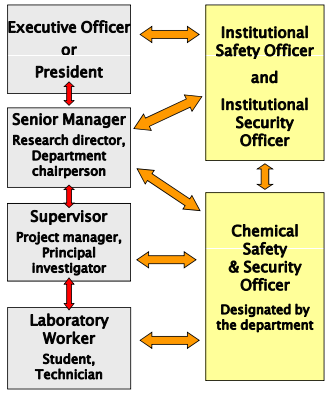
- By senior management
- Typically brief
- Clear goals
- Commitment
- Defines employee role
- Identifies resources and staff
- Signed by person in authority

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 accountability to 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

CSSO Duties Include:

- Surveys
- Job Hazard Analysis
- Inspections
- Training
- Medical Monitoring
- Investigations

CSSO Duties

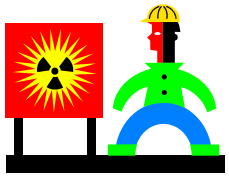
- Oversee procurement, use, storage & disposal of hazardous materials
- Set criteria for exposure levels
- Write and revise CSS Plan
- Train, document and ensure training is performed
- Perform risk assessment and monitoring
- Conduct audits and inspections
- Investigate and report on accidents, incidents
- Interact with staff to correct deficiencies
- *Follow 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

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/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

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 *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

Break

Chemical Safety and Security Plan

First step: Collect information

- Writing a good CSS plan requires a lot of information
- Assessment questionnaires can be used to collect such information
- Distribute to:
  - PIs
  - Management
  - Facilities
  - Security
  - Medical

Assessment Questionnaire

- Who is responsible for CSS compliance?
  - Criteria for exposure control
  - Developing exposure control measures
  - Exposure monitoring
  - Identification of hazardous materials
  - Limited access policy
  - Ventilation maintenance
  - Safety equipment
  - Personal protective equipment
  - Training
  - Hazardous waste management
  - Medical surveillance
  - Emergency response

Assessment Questionnaire, cont'd.

- List individuals (managers, PIs, professionals, technicians) with Safety & Security responsibilities; indicate SO, CSSO, BSO, RSO, etc.
- Who maintains CSS records?
- Is there a Safety/Security Committee?
  - Responsibilities
  - Who are the members?
  - How often do they meet?
- Is there a CSS Manual, Plan?
- Are there CSS policies?
- Is there an Emergency Response Plan?
- Are routine CSS inspections conducted?
  - By whom
  - Details

Chemical Safety and Security Plan

- Includes CSS Policy Statements from senior management.
- Describes the entire Program.
- Describes the organization of the Program.
- Explains everyone's responsibilities.
- Describes in general terms policy and who, what, where and why a safety or security task or job is performed.
- Includes references, if necessary.

Parts of a Chemical Safety and Security Plan

- Policy statement from Senior Management
- Safety & Security Organization
  - Management
  - Responsibilities
    - Management
    - Administration
    - CSSO staff
    - Facilities Management
    - Principal Investigators
    - Staff
    - Contractors

- General Policies:
  - General housekeeping
  - Eating, smoking areas
  - Signs & labels
  - Emergency procedures
  - Chemical storage
  - Personal protective equipment
  - Respirator protective program

Parts of a Chemical Safety and Security Plan, cont'd.

- Engineering Controls
  - Ventilation
  - Laboratory hoods
- Waste Management
- Training
- Record keeping
- Fire Protection & Protection
- Location of emergency equipment
- Evacuation plans
- Personal and environmental monitoring
- Inspections
- Medical surveillance
- Administration
  - Purchasing chemicals
  - Purchasing safety equipment

Standard Operating Procedures (SOPs)

- An SOP explains *concisely and precisely* how, where and who performs a task.
- It does *not* explain why the task is done.
- The Safety and Security Plan explains policy and why a task is performed

Standard Operating Procedures (SOPs), cont'd.

- SOPs are:
  - Dated
    - When issued
    - When reviewed
    - When revised
  - Have: subject, title and identification code
  - Officially reviewed by management
  - Signed by all responsible parties
  - May include forms
  - Written in a consistent and official format with numbered pages

Standard Operating Procedures (SOPs)

Consider written SOPs on:

- Security clearance and visitor access
- Employee training
- Medical surveillance
- Respiratory protection and fit
- Eye protection
- Ventilation system maintenance
- Storage, receipt, transport and shipping of hazardous materials
- Accident and emergency response including natural disasters
- Spill cleanup
- Waste management
- Hazardous material handling
- Special operations, radiation, biosafety, lasers, infectious agents

Plan and SOPs Revision Guidelines

CSS Plan	As needed, every 5 years
(M)SDS	As received
Laboratory Hoods	As needed
Training records	Yearly, and as needed
Medical Surveillance records	As needed, and every 12–18 months
Exposure monitoring	As needed
Waste records	As needed

Record Retention Recommendations

- Personal records kept by Human Resources for the duration employment + 30 years.
- Medical records are *confidential* and should be kept by the examining physician for duration of employment + 30 years.
- Most other records (e.g., routine monitoring, should be kept for 5 years after date of performance).

Chemical Safety & Security

Standard Operating Procedures: SOP Exercise

SOP Exercise: Electrophoresis

- To develop an SOP:
  - focus on safety portion of SOP, ask/answer:
    mitigation = PPE, engineered controls, operational controls, etc.
    - what are **reagents** & hazards, and mitigation?
    - what are **products** & hazards, and mitigation?
    - what are **equipment** hazards, and mitigation?
    - what **waste** is generated? Hazards, and mitigation?
    - how to store chemicals?
    - waste reduction?
    - how to dispose of waste?

SOP Exercise: Electrophoresis

- Refer to the incomplete SOP distributed:

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

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

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

adapted from image by Patrick Besong.
http://www.personal.psu.edu/pzb4/blogs/besong/2009/04/

SOP Exercise: Electrophoresis

- Refer to the incomplete SOP distributed:
  - contains 3 columns:
    - procedure step
    - hazards ← fill in shaded areas
    - mitigations/controls ← fill in shaded areas

#	Step in Process	Hazards in this step	CONTROLS REQUIRED
0	Prepare Tris-Acetate-EDTA (TAE) Buffer:		
	1. **Stock Solution of TAE Buffer**: a) Make (50x) stock solution of TAE by: b) weigh out 242 g Tris base (FW = 121.14) c) dissolve in ~750 mL DI water d) add 57.1 ml glacial acid acid e) add 100 mL of 0.5 M EDTA (pH 8.0) f) adjust to final volume of 1 L. *Stock solution can be stored at room temperature. The pH is not adjusted and should be ~8.5. 2. **Working Solution of TAE Buffer**: Working solution of 1x TAE buffer is made by diluting the stock solution by 50x in DI water. * Final solute concentrations are 40 mM Tris and 1 mM EDTA. Working buffer is ready to use in agarose gel electrophoresis.	**Glacial Acetic Acid:** • • ??(hazards)?? • **EDTA & Tris base**: • May be harmful if swallowed/inhaled. • Causes serious eye irritation. • EDTA harmful to aquatic life.	• Wear PPE to minimize exposure (acetic acid: ??(PPE)??; EDTA: irritant). • • • . • Do not allow down drains. • acetic acid spills.. ??(cleanup)??. • EDTA Tris base: avoid oxidizing agents.

SOP Exercise: Electrophoresis

- Electrophoresis:
  - consider experimental setup (continued):
    - chemicals in this SOP:
      - agarose
      - Tris-Acetate-EDTA (TAE) = EDTA + **Acetic Acid** + Tris Base
      - **ethidium bromide**
    - other chemicals often used with electrophoresis:
      - polyacrylamide (acrylamide: CH2 = CHCONH2)
      - TEMED (*N*,*N*,*N*′,*N*′-tetramethylethylenediamine)
      - ammonium persulfate
      - CHAPS (3-[(3-cholamidopropyl)-dimethylammonio]-1-propane sulfonate)
      - Bromophenol blue (C19H9BR4NaO5S)
      - Dithiothreitol (DTT, C4H10O2S2)
      - EDTA (Ethylenediaminetetraacetic acid)
      - Tris (NH2C(CH2OH)3)
      - phenol
      - chloroform

SOP Exercise: Electrophoresis

- Use MSDS information:
  - MSDS sections:


SIGMA-ALDRICH

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

SOP Exercise: Electrophoresis

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

Chemical Safety & Security

Standard Operating Procedures: SOP Exercise

SOP Exercise: Electrophoresis

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

SOP Exercise: Electrophoresis

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

SOP Exercise: Electrophoresis

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

SOP Exercise: Electrophoresis

- **Hazard Controls:**
- **thermal hazard**:
  - caution using microwaves to liquefy gels
    - don't use sealed containers,
    - beware of superheated liquids that may froth up,
    - let gels cool to 50-60°C before adding stain or pouring into trays,
    - wear insulated gloves,
    - point flask opening away from you.
    - **Process for agarose gel in microwave**:
      - loosen cap of bottle when heating solution,
      - heat for 30sec or less at a time,
      - heat agarose solution in intervals with occasional swirling
        - help agarose melt quickly without forming a superheated solution
      - fill solution only 1/3 of bottle volume,
      - standard PPE includes lab coat, gloves and safety glasses.

SOP Exercise: Electrophoresis

- Hazard Controls:
  - Chemical Hazards:
    - handle all hazardous chemicals or gel prep mixtures with hazardous components in the fume hood.
      - e.g., acrylamide monomer, ethidium bromide, phenol, ammonium persulfate, and formaldehyde
    - store all organic/flammable solvents in flammable storage cabinets.
    - purchase pre-made gels or solutions instead of making them.
      - pre-mixed acrylamide
      - ethidium bromide solutions.

SOP Exercise: Electrophoresis

- Electrical Hazard Controls:
- power supplies:
  - ensure all switches and indicators are in proper working condition and that power cords and leads are undamaged,
  - label equipment with warning "Danger Electrical Hazard",
  - connect to ground fault circuit interrupters (GFCIs),
  - use 3-prong plugs,
  - use power supplies with safety features:
    - detect no-load, overload, sudden load change, short circuit, arc or ground leak, etc.
  - elevate electrophoresis power supply and locate away from electrophoresis tank.

SOP Exercise: Electrophoresis

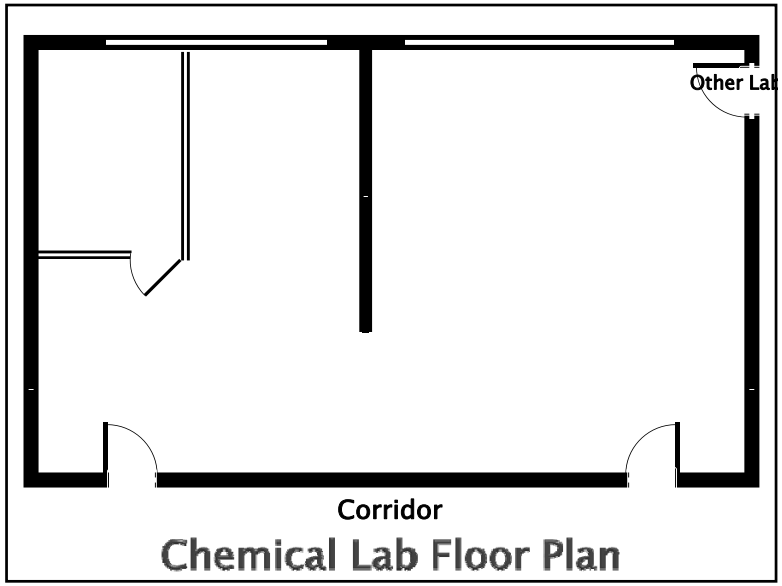
- Electrical Hazard Controls (continued):
- **Connecting leads:**
  - turn off main power supply before connecting or disconnecting electrical leads,
  - connect one lead at a time using one hand only, with dry gloved hands,
  - be sure that leads/banana plugs are fully seated.
- **Using equipment:**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

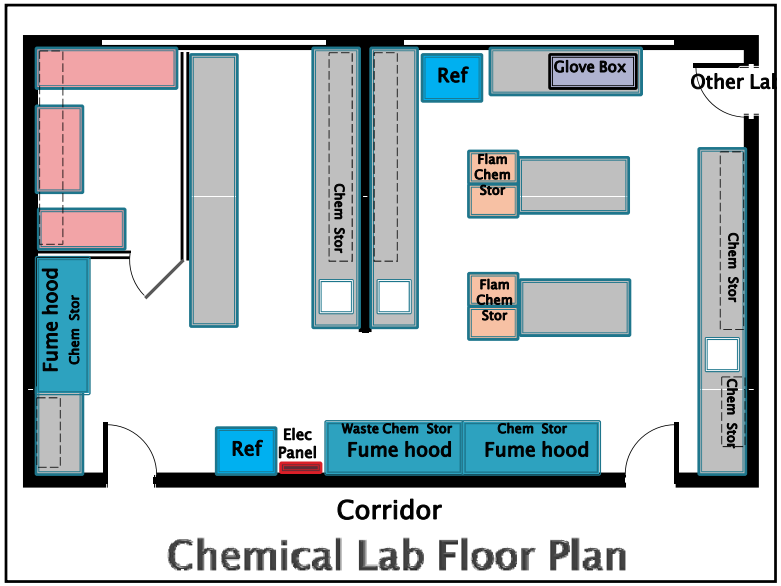
SOP Exercise: Electrophoresis

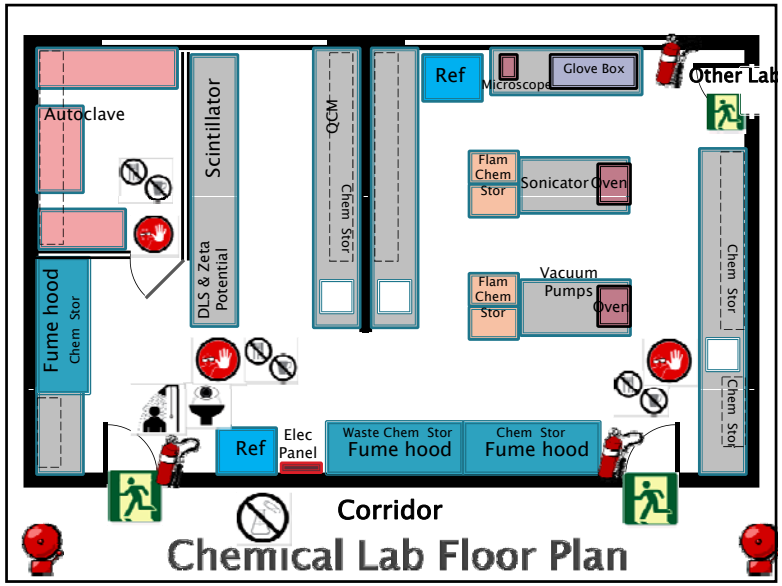
- Emergency event:
  - inform supervisor, coworkers and first aid officer.
  - for major emergencies dial xxx.
  - nearest first aid kit in room xxx.
  - nearest safety shower in room xxx.
  - nearest fire extinguishers:
    - CO_2 fire extinguisher in rooms xxx and yyy;
    - dry chemical extinguisher beside store room.
  - evacuate per evacuation plan with Assembly Area in front of Building xxx.

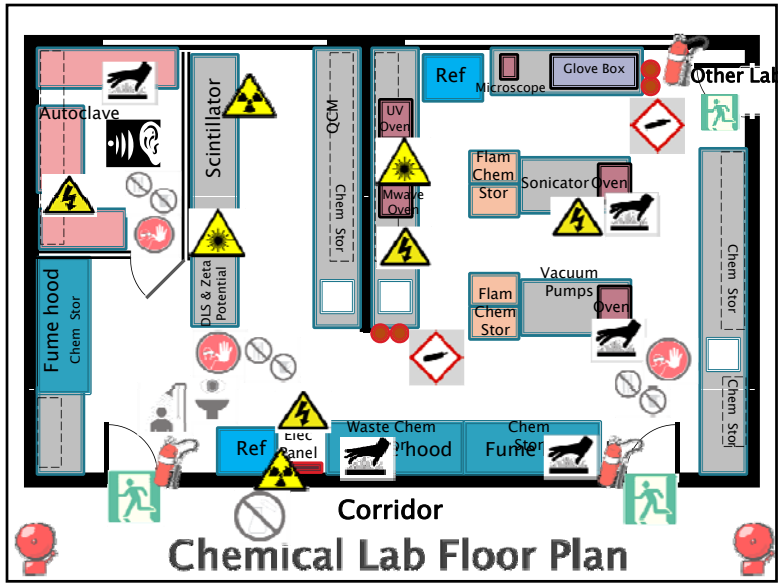
Lab Assessment Exercise

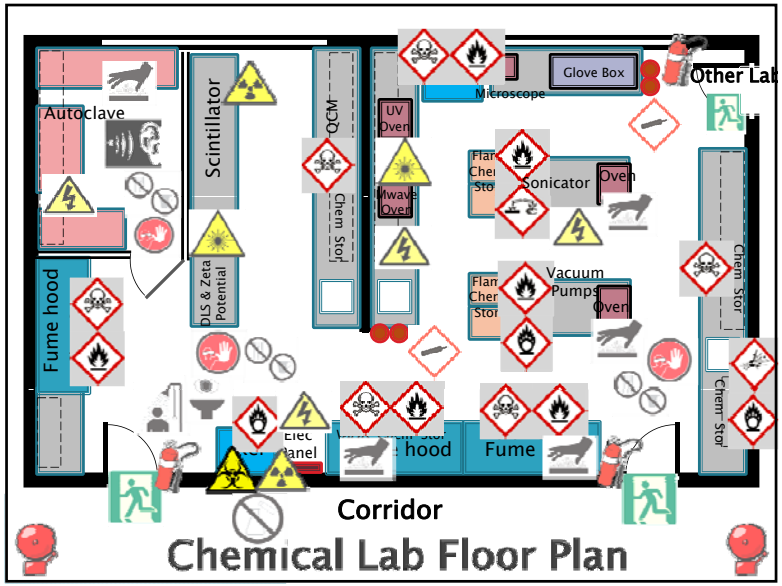
Introduction

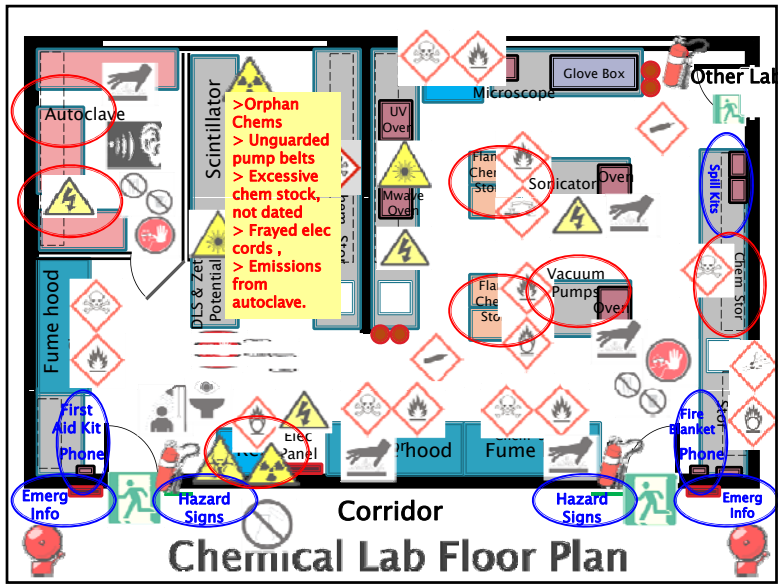












CSS Action Plan

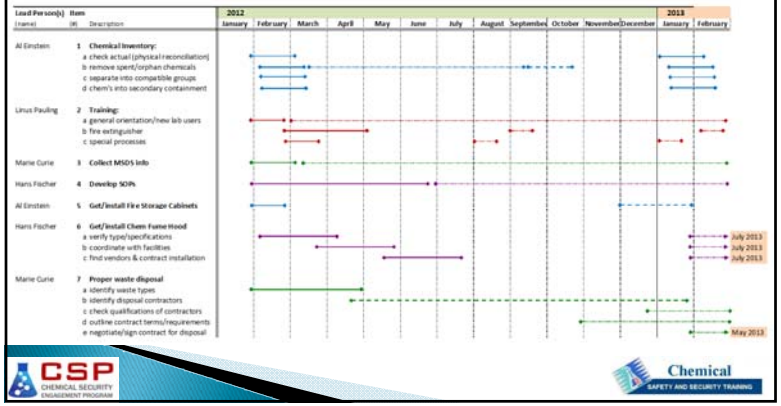
- Prioritization:
  - **Easiest** → **Medium** → **Difficult**
  - inventory
    - check actual
    - remove spent chems
    - separate groups
    - secondary containment
  - training
  - collect MSDS info
  - fire storage cabinets
    - develop SOPs
  - new fume hood
    - proper waste disposal
- CSS leadership team:
  - You, fellow labmate? fellow professor? EHS specialist? department director? others?
- Timeline & commitment:
  - initiate actions, complete actions, ongoing actions, persons responsible

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

CSS Action Plan

- Timeline & commitment:
  - initiate & complete actions, ongoing actions, persons responsible



Questions? Open Discussion

198