TO PROFESSIONALS: CHEMICAL SAFETY AND CHEMICAL SECURITY OVERVIEW

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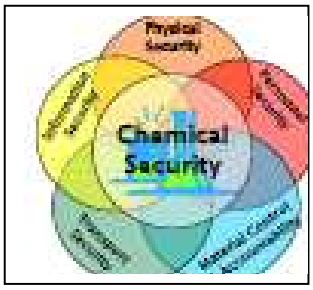
ABSTRACT

The importance of laboratory safety has been recognized for many years in industry. However, educational and research institutions have been slower to adopt such safety practices and programs. A science program has certain potential dangers. Yet, with careful planning, most dangers can be avoided in an activity-oriented science program. It is essential for all involved in the science instruction program to develop a positive approach to a safe and healthful environment in the laboratory. Safety and the enforcement of safety regulations and laws in the laboratory is the responsibility of both the stuff and the employees-each assuming his/her share. Safety and health should be an integral part of the planning, preparation, and implementation of any science program. Security, on the other hand, is a top priority for leading chemical producers' and the governmental authorized people. Responsible care companies should be expert in chemical security and work hard to safeguard the communities. Items discussed in this paper are thus: Why do we worry about chemical safety? fundamentals: personnel protection ; chemical storage: general handling and storage; emergency management; waste management: what are some strategies to reduce the amount and/or toxicity of chemical waste generated in the laboratory; risk government strategy; conclusion. *[AJCE 4(3), Special Issue, May 2014]*

INTRODUCTION



The importance of laboratory safety has been recognized for many years in industry. However, educational and research institutions have been slower to adopt such safety practices and programs.

Security, on the other hand, is a top priority for leading chemical producers. Responsible care companies should be expert in chemical security and work hard to safeguard the communities. Chemical professionals should collaborate with governments, national and international chemical organizations to raise awareness about chemical security and safety, and to reduce the risk of chemical threats.

The relationship between chemical safety and security

Safety is: The control of exposure to potentially hazardous substances to attain an acceptably low risk of exposure.

Security is: The preventive measures designed to reduce the risk of **intentional** removal (theft) and misuse of a chemical hazard – **intent** to cause harm.

Risk assessment is: The identification of **preventive** measures.

Chemical Safety is the protection against accidents while Chemical Security is the protection against deliberate harm. Many practices are the same for chemical safety and security, but there are a few areas of conflict. The following table (Table 1) shows some conflicts between chemical safety and chemical security:

Table 1: Some Types of Conflicts between Chemical Safety and Chemical Security:

Safety	Security
Label everything so people can recognize hazardous chemicals.	Labeling help identified targets for theft or attack.
Let community and especially emergency responders know what chemical dangers are.	Sharing locations of chemicals can publicize targets for theft or attack.
Share knowledge about chemical hazards so people know to be alert.	Sharing knowledge of chemical hazards could inspire harmful behavior.
People need to be able to leave quickly via many routes.	Exits & entrances should be controlled, so, chemicals (or equipments) are not be taken.

Why do we worry about chemical safety?

Chemicals that are used every day in labs and factories can be hazardous. Chemicals can be harmful to the health of the workers. They can be also a threat to the safety of the workers, the community and to the environment. In sequel, safety is the most right thing to do! Anticipation and considering the safety rules in the beginning, is easier, cheaper, safer, and it saves you time.

In the following table (Table 2) some common possible chemical health problem:

Table 2: Some Possible Chemical Health Problem

Chemical	Diseases	Chemicals	Diseases
Vinyl chloride	Liver cancer	Lead	Reprotoxin, birth defects
Asbestos	Mesothelioma	Thalidomide $C_{13}H_{10}N_2O_4$	Reprotoxin, Developmental

			Defects
Carbon tetrachloride	Hepatotoxin	Methanol	Blindiness
Mercury	Neurotoxin, CNS, narcosis	CO, CS_2	Hematopoietic hemoglobin, cynanosis

But disease depends on many factors:

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

FIRST: LABORATORY CHEMICAL SAFETY

The purpose of achieving the laboratory chemistry program is to establish uniform, safe and efficient practices in the laboratories and to assist in the safety instruction of new laboratory employees. There are general in nature and specific problems should be referred to the Chemical Abuse. It is the policy of the Lab safety is to do all that is reasonable to prevent injury to persons and the damage to property and to protect the employees, facility, patients, the environment, and the public from injury, fire or other damage.

In order to achieve these goals, the administration urges the active cooperation and commitment of all departments and employees. Ongoing dialogue and feedback are encouraged by labs' management, and they should support safety program in its promotion of employee. However, the attitude of the employee is the key to employees and environmental safety. If

he/she is interested and willing to follow the simple safety rules outlined in this manual, there will be little chance of injury or damage from material being handled in the laboratory.

I. Fundamentals:

Personnel Responsabilités Rules For Safe Practice

A. Laboratory Staff

- Lab staff is expected to obey safety rules.
- To report all unsafe conditions.
- Each person working with or around chemicals, having been properly trained and is responsible for remaining aware of the hazards associated with these chemicals and handling them in a safe manner.

- If there is any doubt as to the specific hazards/ material to the proper method of handling, the employee is expected to ask his supervisor for the appropriate information.
- Assess the risk by determining the likelihood and consequences to allow for strategic decisions on control measures.

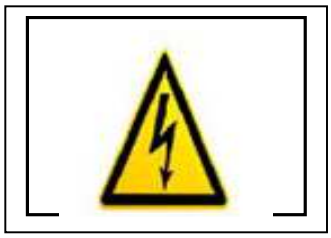
- Ideally we consider elimination or substitution **first**, to remove the hazard.
- A combination of measures might be used based on their effectiveness and our ability to use them and maintain them.
- Cost versus performance (risk reduction) is important.
- E.g. a) Describe the work activities: Snorkeling; b) Identify

the hazards: shark; c) Determine Risks: shark bites and/or drowning.

- The same for chemicals: a) Describe Work Activities: mixing reactive chemicals; b) Identify Hazards: reactive/ incompatible chemi Risks: explosions and/or fire.

B. For All:

- Do not eat, drink, or smoke or in the lab.
- Do not bring food into the laboratory.
- Mouth pipetting is forbidden.
- Wear a full-length, long-sleeved laboratory coat or chemical-resistant apron.



- Wear shoes that adequately cover the whole foot; low-heeled shoes with non-slip soles are preferable. Do not wear sandals, open-toed shoes, open-backed shoes, or high-heeled shoes in the laboratory.
- Appropriate gloves are recommended when handling any chemicals. Be sure that gloves are resistant to the particular material being handled.

- When it is not practical to wear gloves, extra care should be taken to avoid exposure.
- On leaving the lab remove your coat and wash your hands.
- Cover all cuts, abrasions, open sores and bruises with waterproof tape.

- Read all labels and warning signs.
- Be acquainted with local procedures in case of fire, or accidents;
- Clean up all spills and leakages immediately.
- Eye protection must be worn when handling materials that may splash.

Employees who wear contact lenses should be aware that fumes from concentrated acids and solvents can cause eye irritation and damage to lenses. Should eye irritation occur, remove lenses immediately and rinse eyes with clean water.

- ❖ Make Hair tied back, if shoulder length or longer.
- ❖ Keep the work area tidy and free of unnecessary equipment and materials.
- ❖ Shoes with open toe or open heel are prohibited in all areas.
- ❖ Low heeled, rubber soled shoes constructed of solid material are required.
- ❖ Do only the authorized work; no horseplay should take place in the laboratory.

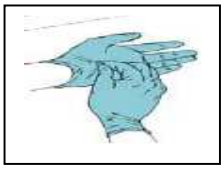
C. General Safety Rules:

- **Fire Regulations & Extinguishers should be trained and practiced & rechecked regularly.**
- Specify required training.
- Laboratory hoods/its ventilation are the basis of engineering controls.
- Label all chemical containers.
- Never someone work alone, especially after hours.
- Specify when eye protection & PPE is required.
- Specify operations that require hood use.
- Alarm system is well recognized and followed.
- Report all injuries, spills, and other releases of hazardous materials to the Safety Team.

D. Personal Protective Equipments (PPE):

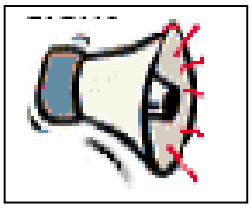
PPE <u>includes:</u>

- Eye protection (Goggles),
- Gloves,
- Laboratory coats… etc.,
- Respirators,
- Appropriate foot protection



<u>E. Lighting & Noise Levels</u>

Sufficient Lighting: is essential for each working area.



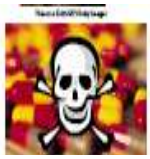
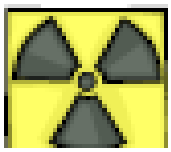
Elevated noise levels: *can be a problem:*

- Potential Hazards,
- Examples: bone-cutting saws,
- Mechanical water aspirators, pumps.
- Control Measures.
- Inspections, PPE, warning.
- Labels, training.

II. STORAGE

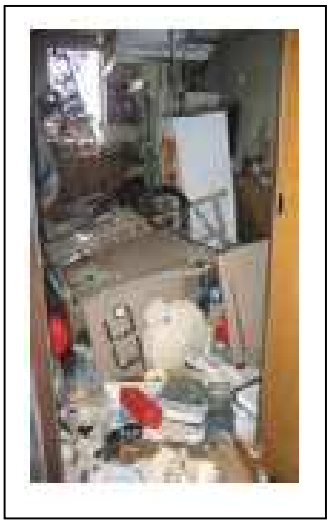
A) RECOGNITION

i. Chemicals/Lables

	***Flammable***		***Corrosive***
	***Poison***		***Radioactive***
	***Explosive***		***Compressed Gas***
	***Special Substances***		***Biohazards***

ii. Chemical Storage: Cryogenics

- Store cryogenics (liquid nitrogen & dry ice) separately from other chemicals & in well ventilated areas.
- Use proper PPE (including eye protection) when handling & moving cryogenics.
- Do not use cryogenics in closed areas.



Exploding liquid nitrogen cylinder ruins lab.

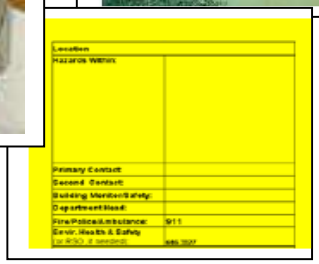
III. EMERGENCY MANAGEMENT

The staff, employee, and workers should consider the informal and formal guidelines, and the requirements. Terrorism and vandalism represent a significant risk to all facilities that use or store hazardous chemicals. It is important to recognize vulnerabilities of your facility and do **Common Safety Symbols and warnings** whatever is necessary to reduce or eliminate risk.

A. GENERAL ASPECTS

Emergency Planning and Response is Based on Four Principles:

1. Anticipation: **It means the emergency planning and the response.**
2. Recognition
3. Evaluation
4. Control



Examples for applying these principles:

- ❖ If people are expected to use extinguishers, they must be trained.
- ❖ Clearly post each room with emergency phone numbers.
- ❖ And after hours phone numbers/ person(s) to be contacted.
- ❖ Centrally locate safety showers and eyewashes. And teach employees to properly use the Safety Shower.
- ❖ Centrally locate spill clean-up kits.
- ❖ Clean up spill: only if you know the chemical hazards have appropriate equipment and are trained to do so!

IV. WASTE MANAGEMENT

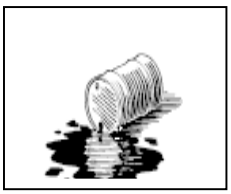
Wastes must be regulated & heavily minimized:

(Incinerateration: "is a waste treatment process")

General guidelines: a) <u>Nonhazardous</u> waste:

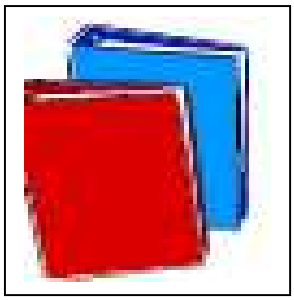
- ❖ Lab wastes are packaged in small containers.
- ❖ Used oil (uncontaminated) is not considered.

  hazardous waste Label Containers "USED OIL (not hazardous waste).
- ❖ Uncontaminated PPE (gloves, wipes).
- ❖ Triply rinsed glassware (bottles, droppers, pipettes).
- ❖ Secure and lock waste storage area.



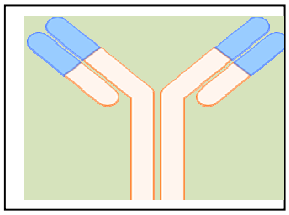
b) For Metal's Waste

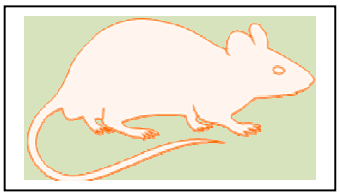
- ➢ Certain metals cause disposal problems
- ➢ When mixed with flammable liquids or other organic liquids.
- ➢ Pressure can build up in a waste vessel.
- ➢ Corrosion can occur in storage vessel.
- ➢ *Secondary containment is necessary*
- ➢ *Glass waste containers can break*

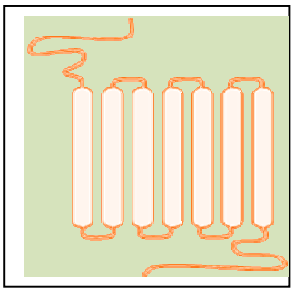


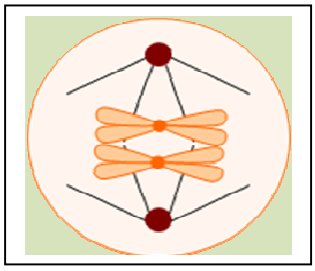
<u>c) Medical wastes & Biological Wastes:</u>

- ➢ Blood and tissue.
- ➢ Sharps –needles, scalpels.
- ➢ Contaminated glassware, PPE.
- ➢ Autoclave or sterilize wastes.
- ➢ Each employee should attempt to minimize wastes generated.
- ➢ Do not spill liquids.









- ➢ **<u>Waste Mercury (Hg) Needs Special Treatment:</u>**
- ➢ Collect pure liquid mercury in a sealable container
- ➢ Label as "MERCURY for Reclamation".
- ➢ Place broken thermometers and mercury debris in a sturdy sealable plastic bag, plastic or glass jar.

- Label the container "Hazardous Waste - Hg SPILL“.
- Never use a regular vacuum to clean up.
- Mercury spill -contaminates vacuum, heat evaporates Hg.
- Never use a broom to clean up mercury –
- Spreads smaller beads-contaminates the broom.

DARMOUTH COLLEDGE: Dimethyl-Mercury Poisoning

<u>One of the most tragedy accidents:</u>

Karen Wetterhahn, professor and founding director of Dartmouth's Toxic Metals Research Program & expert in the mechanisms of metal toxicity. In 1996, she spilled a few drops of dimethylmercury on her gloved hand. She cleaned up spill Hg immediately, believing that the Latex glove is protective.

Six months later, she became ill, and died of acute Hg poisoning at age 48 years. The investigation by **Occupational Safety and Health Administration (OSHA)** revealed that there was another case from Dartmouth/a researcher died from dimethylmercury poisoning in this century. **OSHA** has proposed fining Dartmouth $13,500 for: allegedly not providing enough training to employees, limitations of protective gloves were not considered, and there was inappropriate and for having deficiencies in the laboratory's chemical hygiene plan.

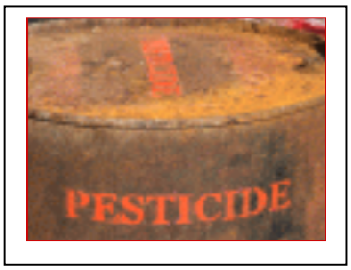
<u>Environmental Hazards:</u>

California State University, Northridge: Earthquake:

On January 17, 1994 – 4:31 am, an earthquake of Magnitude 6.7 surprised Epicenter, located a few km from California State University, Northridge campus. 57 death, and 11000 injuries were the victims of the earthquake. Several fires in science buildings allowed to burn because firemen worried about chemical hazards. It was a big problem as **Professors and students lost equipment, notes, materials, samples.**

Another Big World Chemical Disaster was Bhopal: Pesticide Plant Chemical Release

On 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 12 safety equipment – Safety measures and equipment were far below normal standards.

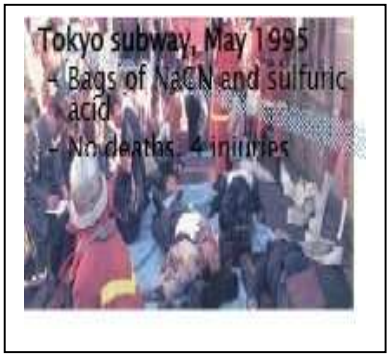


The problem was being the **Plant** was in heavily populated area. For more information about The Bhopal disaster and its consequences: a review, Environ. Health: A Global Access.

DELIBRATE HARM

Tokyo, Japan: Hydrogen cyanide attack

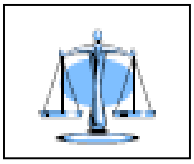
On purpose, a **Sarin** attack on Judges in Matsumoto, June 1994 was operated. The **Sarin** sprayed **Hydrogen Cyanide** from a truck at night: 7 deaths, 144 injuries.



SECOND: SECURITY

Security is a top priority for leading chemical producers. Responsible care companies should be expert in chemical security and work hard to safeguard the communities. Chemical professionals should collaborate with governments, national and international chemical organizations to raise awareness about chemical.

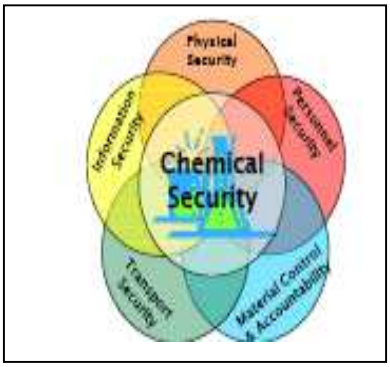
Government Regulations: Rules and Laws are different from country to country. E.g. a) the legislation needed to fulfill requirements under the chemical; b) Weapons Convention–Each country passes appropriate laws; c) Each country must declare and track certain chemicals.



Chemical Security Assessment

Characterize chemicals and threats:

a) Evaluate chemical compounds at a facility (Asset Assessment); b) Evaluate adversaries who attempt to steal those chemicals or equipment (Threat Assessment).



2. Characterize the facility

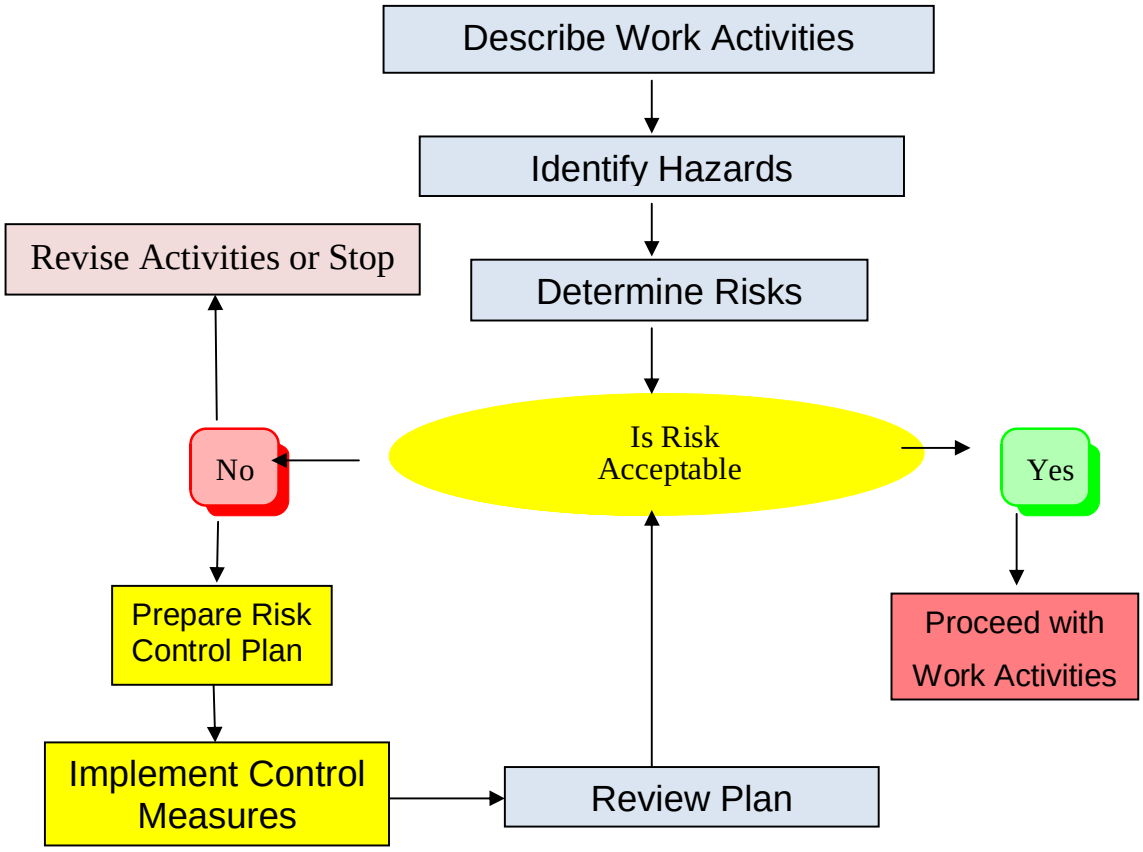
a) Evaluate the likelihood the facility will be targeted;

b) Evaluate the likelihood of a "**Risk**" or an **Event** that has consequences.

3. Characterize the risk:

On facing an accident or a disaster, we should determine what is acceptable and what is unacceptable risks; develop risk statement; assess the risk by determining likelihood and consequence to allow for strategic decisions on control measures; ideally we consider elimination or substitution first, to remove the hazard. A combination of measures might be used based on their effectiveness and our ability to use them and maintain them. *Cost versus performance (risk reduction).*

RISK GOVERNMENT STRATEGY



CONCLUSIONS

Generally, it is a chain of commands to handle specific safety/secure responsibilities within the facility. Chem. Security, in conjunction with Labs Safety Team individual science teachers, holds responsibility for developing and maintaining a safe working environment for lab workers. Finally, security, the staff & employees are one team, responsible for Secure/Safe Lab.

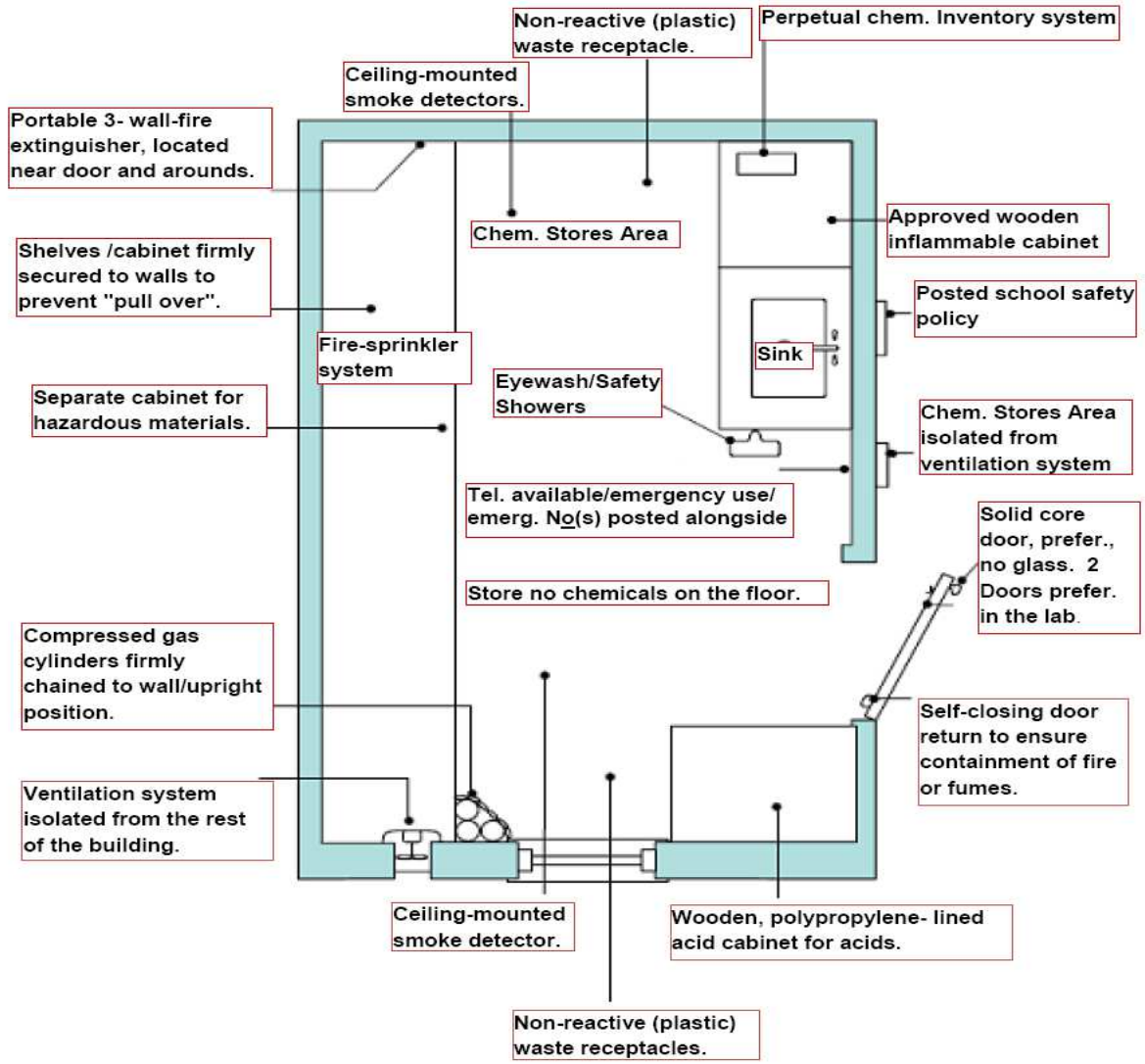
And finally, together we can design, build, and operate safe/secure laboratories!

Appendices

1. Figure is a model for the Lab.
2. Questionnaire to help in the Inventory, Chemical Safety, Chemical Security Issues and the Assessment Questionnaire Laboratory Safety and Security.

1. Is your laboratory a safe/secure place to work?

The following Figure is a model for the Lab:



The following form has been devised as a Questionnaire to help in the Inventory, Chemical Safety, Chemical Security Issues and the Assessment Questionnaire Laboratory Safety and Security. This questionnaire is intended to orient the assessor to the nature of hazardous chemical use and control in laboratories at the facility.

1. Who at the facility is responsible for development, implementation, and administration of programs for compliance with applicable governmental and company requirements for each of the following lab chemical safety and security issues:

1.1. Setting criteria to determine and implement control measures for exposure reduction in laboratories?

_____

1.2. Developing experimental protocols and proposing control measures to reduce potential employee exposures?

_____

1.3 Employee exposure determination/monitoring?

_____

1.3. Identification of select carcinogens, reproductive toxins, and acutely toxic chemicals, and maintenance of a chemical inventory?

_____

1.5 Limited access policy, including procedures, training and awareness?

_____

1.6. Ventilation system maintenance?

_____

1.7. Laboratory containment and safety equipment?

_____

1.8. Personal protective equipment?

_____

1.9. Training?

_____

1.10. Hazardous waste?

_____

1.11. Medical surveillance?

_____

1.12. Emergency response?

_____

2. List the names of laboratory heads/mangers and principal investigators, and the names of lab technicians who have safety and security responsibilities. Also indicate who at the facility is designated the Chemical Safety & Security Officer.

_____

	Yes	**No**	**N/A**
3. Are there job descriptions specifying responsibilities, authorities, accountabilities, and measures of performance for each person identified in 1 and 2 above?	____	____	____
4. Are the people identified in 1 and/or 2 above responsible for keeping up-to-date with regulations/guidelines in their respective areas?	____	____	____
5. Does the facility have a lab safety & security committee?		____	____ ____

5.1 List the members' names and credentials below:

Member Credentials

_____ _____

5.2 How often does the committee meet?_____

5.3 What does the committee usually discuss?_____

6. Briefly describe the major function(s) of the laboratories at the facility and characterize operations, protocols, assays, etc. by function. _____

7. List the types of containment and safety equipment used at the facility (e.g., chemical laboratory hoods, biological safety cabinets, safety showers, eye wash stations, etc.).

_____

	Yes	No	N/A
8. Are there any areas designated especially for work with particularly hazardous substances?	____	____	____

Locations and operations: _____

	Yes	No	N/A
9. Does the facility have a lab safety & security manual and/or Chemical Safety & Security plan?		____	____ ____

9.1 Who writes and updates this document?

_____

9.2 How often are updates provided?

_____

10. Does the facility have any of its own specific policies, procedures, standards or guidelines pertaining to:

		Yes	No	N/A
10.1	Evaluating chemical hazards?	____	____	____
10.2	Employee exposure duration?	____	____	____
10.3	Labeling hazardous chemicals?		____	____ ____
10.4	Receipt, distribution, storage and inventory of hazardous chemicals?		____	____ ____
10.5	Maintenance of (M)SDSs?	____	____	____
10.6	General rules for handling hazardous chemicals in the lab?			____ ____ ____
10.7	Housekeeping?		____	____ ____
10.8	Transportation of hazardous chemicals and wastes?		____	____ ____
10.9	Limited access policy?	____	____	___
10.10	Installation, certification, testing and maintenance of ventilation systems and laboratory containment and safety equipment?	____	____	____

10.11	Decontamination of equipment, wastes and/or emergency response?	____	____	____
10.12	Personal protective equipment?	____	____	____
10.13	Hazcom training for non-laboratory personnel?	____	____	____
10.14	Lab safety and security training for laboratory personnel?	____	____	____
10.15	Training for hazardous chemical emergencies?	____	____	____
10.16	Emergency response?	____	____	____
10.17	Medical surveillance?	____	____	____
10.18	Injury, illness and accident recordkeeping?	____	____	____
10.19	Internal lab safety and security inspections?	____	____	____

		Yes	**No**	**N/A**
10.20	Other?	____	____	____

_____

For each of the topics above, indicate whether SOPs or other written documents have been prepared.

11.	Does the facility have an emergency response plan?	____	____	____
11.1	Does the plan address accidental releases of hazardous chemicals to the environment?	____	____	____
11.2.	Does the plan address community response?	____	____	____
11.3	Does the plan address achieving awareness with local authorities?	____	____	____
11.4	Does the plan address programs for achieving community awareness?	____	____	____

		Yes	**No**	**N/A**
12.	Does the facility conduct routine inspections audits/reviews of its operations to ensure compliance with applicable rules and regulations, and policies and procedures?	____	____	____
12.1	Who conducts these reviews?			

_____

13. Does the facility maintain files for documents relating to:

		Yes	**No**	**N/A**
13.1	Activities of the lab safety and security committee?	____	____	____
13.2	Standard operating procedures (indicate topics) and experimental protocols?	____	____	____

13.3 Receipt, distribution, storage and inventory of hazardous chemicals? ____ ____ ____

13.4 Transportation of hazardous chemicals and wastes? ____ ____ ____

13.5 Installation, certification, testing and maintenance of ventilation systems and laboratory containment and safety equipment? ____ ____ ____

		Yes	**No**	**N/A**
13.6	Use and maintenance of personal protective equipment?	____	____	____
13.7	Hazcom training for non-laboratory personnel?	____	____	____
13.8	Lab safety and security training for laboratory personnel?	____	____	____
13.9	Emergency plans?	____	____	____
13.10	Pre-employment physicals and screening?	____	____	____
13.11	Employee exposure mentoring?	____	____	____
13.12	Injury, illness, and accident reports?	____	____	____
13.13	Internal safety/security inspections?	____	____	____
13.14	Insurer reviews?	____	____	____
13.15	OSHA inspections?	____	____	____

14. Is the facility currently under a consent order, compliance schedule, etc., to comply with regulatory program requirements? ____ ____ ____

14.1 If yes, who is responsible for ensuring compliance with this order or schedule?

15. Is training provided to facility personnel in the following categories? ____ ____

		Yes	**No**	**N/A**
15.1	Facility lab health and safety rules including methods to detect presence or release of hazardous chemicals?	____	____	____
15.2	Hazard communication content of CSSP, including physical and health hazards of chemicals in the work area?	____	____	____
15.3	Proper use of laboratory containment and safety equipment?	____	____	____
15.4	Proper use of personal protective equipment?	____	____	____
15.5	Emergencies?	____	____	____

16. Who receives training in these topics?

Name(s) of interviewee(s): _____

Chemical Safety and Security Officer Training

Useful Websites

Chemical Security Engagement Program: https://chemsecurity.sandia.gov/

Chemical Safety

"Prudent Practices in the Laboratory: Handling and Disposal of Chemicals," and "Promoting Chemical Laboratory Safety and Security in Developing Countries," National Academies Press, 2010: [***English-French-Arabic-Indonesian translations***]:
http://dels.nas.edu/global/bcst/Chemical-Management
"Safety in Academic Laboratories, Vol.1 & 2," and "Less is Better," American Chemical Society, Washington DC, 2003.

Chemical Security

Organization for the prohibition of chemical weapons (OPCW): https://www.opcw.org/
CWC Implementation Assistance Program: http://iap.cwc.gov/
Australia Group: http://www.australiagroup.net/en/index.html
UN Security Council Resolution 1540: http://www.un.org/sc/1540/
"Raising Awareness: Multiple Uses of Chemicals and the Chemical Weapons Convention", IUPAC Project 2005-029-1-050: http://multiple.kcvs.ca/
"Terrorism and the Chemical Infrastructure: Protecting People and Reducing Vulnerabilities", National Academy Press, 2006, available online:
http://www.nap.edu/catalog.php?record_id=11597
"Toxic Chemical Agent Safety Standards", US Department of the Army Pamphlet 385–61, 2002, available online at:
http://www.army.mil/usapa/epubs/385_Series_Collection_1.html

Pesticides

"Programmes: International Code of Conduct on the Distribution and Use of Pesticides", Food and Agriculture Organization of the United Nations.

http://www.fao.org/DOCREP/005/Y4544E/y4544e00.htm

"The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification, 2004", updated June 2006:

http://www.who.int/ipcs/publications/pesticides_hazard_rev_3.pdf

"Organochlorine waste management", Roger Papp, Pure & Appl. Chem., Vol. 68, No. 9, pp. 1801 -1 808, 1996:

http://old.iupac.org/publications/pac/1996/pdf/6809x1801.pdf

Chemical Waste

"Training Resource Pack for hazardous waste management in developing economies", Prepared by David Wilson, Fritz Balkau and Maggie Thurgood for International Solid Waste Association, United Nations Environment Programme, Division of Technology, Industry and Economics. UNITED NATIONS PUBLICATION ,ISBN: 92-807-2235-2, 2002.

http://www.unep.fr/shared/publications/cdrom/3128/menu.htm

"Chemical waste management resources for laboratories", Natural Sciences Research Institute, University of Philippines, Diliman, Quezon City. Includes chemical safety guidelines and on-site treatment.

http://www.nsri.upd.edu.ph/CWM/