Chemical Laboratory Safety and Security

Executive Summary

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

Institutions must be aware of the potential for the accidental misuse of chemicals, as well as their intentional misuse.

WHY ARE CHEMICAL SAFETY AND SECURITY IMPORTANT FOR YOUR INSTITUTION?

Over the past century, chemistry has increased our understanding of the physical and biological world as well as our ability to manipulate it. The work carried out in chemistry laboratories around the globe continues to enable important advances in science and engineering. The chemical laboratory has become the center for acquiring knowledge and developing new materials for future use, as well as for monitoring and controlling those chemicals currently used routinely in thousands of commercial processes.

Most of the chemicals produced and used today are beneficial, but some also have the potential to damage human health, the environment, and public toward chemical enterprises. As the leader of your institution, you must be aware of the potential for the accidental misuse of chemicals, as well as their intentional misuse. Laboratories face a number of threats, including the theft of sensitive information, high-value equipment, or dual-use chemicals that may be employed for weapons or illicit drug production. Chemical safety and security can mitigate these risks.

A new culture of safety and security consciousness, accountability, organization, and education has developed around the world in the laboratories of the chemical industry, government, and academe. Chemical laboratories have developed special procedures and equipment for handling and managing chemicals safely and securely. The development of a "culture of safety and security" results in laboratories that are safe and healthy environments in which to teach, learn, and work.

WHAT ARE THE TYPES OF HAZARDS AND RISKS?

Laboratories face a variety of risks, from both inside and outside the facility. Some risks may affect mainly the laboratory itself, but others could affect the larger institution and even the public if handled improperly.

Large-Scale Emergencies and Sensitive Situations

Many types of large-scale events can affect an institution and severely disrupt laboratory operations. Some of the most common large-scale emergencies and sensitive situations include: fire, flooding, and earthquakes; power outages; hazardous material spill or release; political or controversial researchers or research; loss of laboratory materials or equipment; loss of data or computer systems; and loss of high-value or difficult-to-replace equipment.

Security Breach

Intentional or unintentional security breaches in the laboratory, either by personnel or by outside agents, pose a serious risk for institutions. Possible breaches include: theft or diversion of high-value equipment or dual-use chemicals or materials that may be utilized for illegal activities; accidental or intentional release of or exposure to hazardous materials; and unauthorized laboratory experimentation.

Toxic Chemical Exposure

One of the least predictable, most dangerous risks in a laboratory is the toxicity of various chemicals. No substance is entirely safe, and all chemicals result in some toxic effects if living systems are exposed to a large enough amount of the substance. For example, some chemicals can cause a harmful effect after a single exposure, such as corrosive nitric acid. Others cause an effect after repeated or long-duration exposure, such as carcinogenic chloromethyl methyl ether.

Flammable, Explosive, and Reactive Chemicals

Flammable chemicals are those that readily catch fire and burn in air, such as gasoline. Reactive chemicals are substances that react violently in combination with another substance, such as water-reactive alkali metals or incompatible strong acids and bases. Explosive chemicals include a variety of substances that can explode under certain conditions, such as oxidizing agents and certain powders and dusts.

Biohazards

Biohazards are a concern in laboratories that handle microorganisms or materials contaminated with them. These hazards are usually present in clinical and infectious disease research laboratories but may also be present in other laboratories. Risk assessment for biohazardous materials requires the consideration of a number of factors, including the organism being manipulated, any alterations made to the organism, and the activities that will be performed with the organism.

Hazardous Waste

Virtually every laboratory experiment generates some waste. Waste is material that is discarded or intended to be discarded, or is no longer useful for its intended purpose. It includes abandoned chemicals and spilled chemicals. Wastes include items such as used disposable laboratory supplies, filter media, aqueous solutions, and hazardous chemicals. Waste is considered hazardous if has one or more of the following properties: ignitable, corrosive, reactive, or toxic.

Physical Dangers

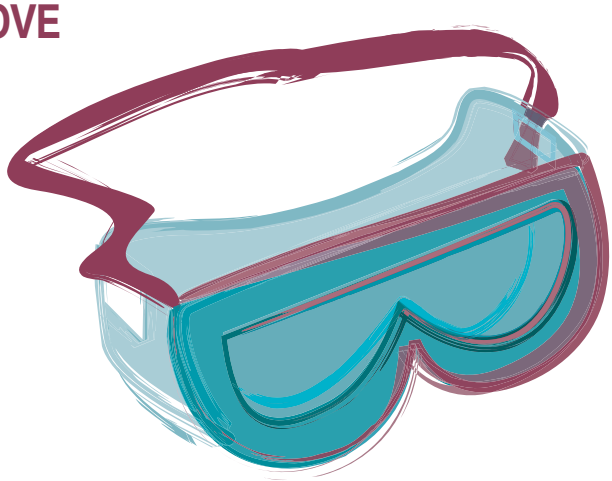
Some laboratory operations pose physical hazards to personnel because of the substances or equipment used, such as compressed gases, nonflammable cryogens, high-pressure reactions, vacuum work, radio-frequency and microwave hazards, and electrical hazards. Personnel also face general workplace hazards that result from conditions or activities in the laboratory, such as cuts, slips, trips, falls, and repetitive motion injuries.

TEN STEPS TO ESTABLISH A SAFETY AND SECURITY MANAGEMENT SYSTEM

One of the most important pieces of a successful chemical safety and security management system is the commitment of institutional leaders. Leadership must take the first steps in creating a plan and assigning people to put the plan in place

1. *Create an Institutional Safety and Security Oversight Committee and Appoint a Chemical Safety and Security Officer (CSSO).* A safety and security oversight committee should have representatives from all affected sections and at all levels. A CSSO oversees the safety and security management program. Give the CSSO dedicated time, resources, and the necessary authority to carry out his or her responsibilities.
2. *Develop a safety and security policy statement.* Setting a formal policy is meant to define, document, and endorse a chemical safety and security management system. A formal policy statement establishes expectations and communicates the institution's intent to all laboratory personnel.
3. *Implement administrative controls.* Administrative controls define an institution's rules and procedures for safe and secure practices and establish the responsibilities of individuals involved. These controls should include general safety rules, laboratory housekeeping procedures, manuals for use of materials and equipment, and other documents to communicate rules and expectations to all laboratory personnel.
4. *Identify and address particularly hazardous situations.* Conducting a risk-based evaluation will determine the impact and adequacy of existing control measures, prioritize needs, and incorporate corrective actions based on level of importance and available resources. This information will provide the foundation for a robust safety management system, as well as help prioritize efforts to improve safety and security.
5. *Evaluate facilities and address weaknesses.* Safety and security must be considered when designing and maintaining a laboratory and its workspaces. Laboratories should be designed to facilitate experimental work as well as reduce accidents.
6. *Establish procedures for chemical management.* Chemical management is a critical component of a laboratory safety program and includes defined procedures for buying and handling chemicals, including adequate ventilation, appropriate use of personal protective equipment, and institutional rules and procedures, especially for spills and emergencies, storing chemicals, inventory tracking of chemicals, transporting and shipping chemicals, and disposing of chemical waste.
7. *Employ engineering controls and personal protective equipment.* Engineering measures, such as a laboratory hood or local exhaust ventilation are the primary methods for controlling hazards in the chemical laboratory. Personal protective equipment, such as chemical splash goggles and face shields, should supplement engineering controls.
8. *Plan for emergencies.* The steps in developing an emergency plan include: assessing what types of incidents are most likely to occur; identifying the decision makers and stakeholders, as well as laboratory priorities; creating a plan for the types of emergencies identified in the first step; and training staff in the procedures outlined in the plan.
9. *Identify and address barriers to following safety and security best practices.* Good safety and security practices involve having people consistently follow policies and procedures. However, it is often challenging to change behaviors and foster a culture of best practices. The institution must identify barriers and establish incentives for all laboratory personnel to comply with safety and security measures.
10. *Train, communicate, and mentor.* The best way to create a culture of safety in the workplace is to set a good example every day by following and enforcing safety and security rules and procedures. It is vitally important to establish a system for training and mentoring all people working in the laboratory. Every institution should also establish effective channels for communicating about chemical safety with personnel at all levels of the institution.

WHAT CAN YOU DO TO IMPROVE CHEMICAL SAFETY AND SECURITY?



Promote a Culture of Chemical Safety and Security

- As the leader of your institution, you should ensure that work conducted in laboratories is carried out safely and responsibly. Your institution must establish general guidelines for what constitutes safe and secure practices in laboratory work, including setting standards, keeping records of any necessary training of laboratory personnel, and developing and implementing laboratory policies and standards for emergency response procedures and training.

- Nurturing basic habits of prudent behavior is a crucial component of chemical education at every level and remains critical throughout a chemist's career. By promoting safety and security best practices, you will have an impact not just on students, but on everyone who will share their future work environments.

- Each institution should develop its own safety and security management system according to its own needs and based on the guidelines provided in this brochure. A successful safety and security program requires a daily commitment from everyone in the institution. People at all levels must understand the importance of eliminating risks in the laboratory and work together toward this end. Institutional leaders have the greatest power and authority and, therefore, the greatest responsibility for cultivating a culture of safety and security.

Assign Responsibility and Accountability for Laboratory Safety and Security

Institutions need well-developed administrative structures and personnel with responsibility for maintaining a safe and secure laboratory environment, which may include the following:

- Environmental Health and Safety Office: This is an office staffed with experts in chemical safety, engineering, occupational medicine, fire safety, toxicology, or other fields. The office helps design safety and security programs that provide technical guidance and training support, are practical to carry out, and comply with the law and basic standards of safety and security.

- Chemical Safety and Security Officer (CSSO): The CSSO establishes a unified effort for safety and security management and provides guidance to people at all levels of the institution. The CSSO should be equipped with the knowledge, responsibility, and authority to develop and enforce an effective safety and security management system.

- Laboratory Managers, Supervisors, and Instructors: Direct responsibility for management of the laboratory safety program typically rests with the laboratory manager. In coursework, laboratory instructors carry direct responsibility for actions taken by students. Instructors must promote a culture of safety and security and teach the skills that students and other personnel need if they are to handle chemicals safely.

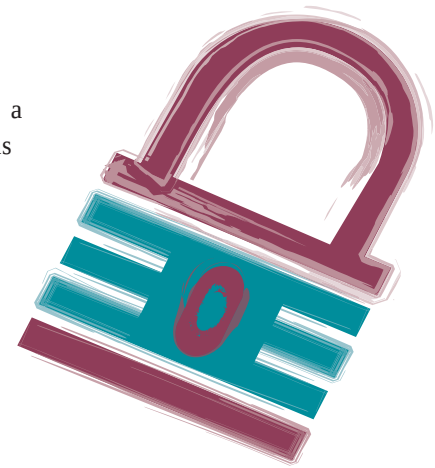
- Laboratory Students and Staff: Students and other laboratory personnel are directly responsible for working safely and safeguarding the chemicals they use. Anyone working in a laboratory should preplan all experiments and follow all of the safety and security protocols for the protection of themselves and others.

Understand Barriers to Following Safety and Security Procedures

There may be occasions when personnel do not follow laboratory safety and security procedures, either intentionally or unintentionally. Institutions must be aware of and address these barriers when designing safety and security policies and procedures. Possible barriers include:

- rapid turnover of students and staff who must be trained in safety and security procedures;
- variable levels of laboratory experience among students, staff, and even supervisors;
- a shortage of instructors or others who can train new students and staff;
- the time burden of adequate training and record keeping;
- the cost or limited availability of safety and security equipment;
- environmental conditions, such as climate, that make compliance difficult;
- cultural beliefs that minimize the importance of individual health and safety; and
- a lack of companies to discard dangerous wastes from laboratories.

Enforce Laboratory Safety and Security



Laboratory safety and security require mandatory rules and programs, a commitment to them, and consequences when those rules and expectations are not met. A program of periodic laboratory inspections will help keep laboratory facilities, equipment, and personnel safe and secure. The institution's management should help design the inspection program and decide on the types of inspections, their frequency, and the personnel who will conduct them. A comprehensive inspection program may include the following types of inspections:

- program audits conducted by a team;
- peer inspections by laboratory coworkers from different departments;
- environmental health and safety inspections conducted on a regular basis;
- self-audits of practices and equipment; and
- inspections by external entities, such as emergency responders.

WHERE CAN YOU GET HELP?

There are many organizations to contact for information, training, and funding. Some suggestions include the following:

- The U.S. Chemical Security Engagement Program
  www.csp-state.net/dev/index.aspx
- International Union of Pure and Applied Chemistry—Safety Training Program
  www.iupac.org/standing/coci/safety-program.html
- Organization for the Prohibition of Chemical Weapons
  www.opcw.org/
- American Chemical Society—Division of Chemical Health and Safety
  membership.acs.org/c/chas/default.htm
- The International Program on Chemical Safety INCHEM program
  www.inchem.org/ or **www.who.int/ipcs/en/**

Manila, PHILIPPINES: A broken wooden cabinet storing containers of about 30 assorted laboratory chemicals rests on the floor of the abandoned science room of San Isidro High School in Makati, suburban Manila, 27 November 2006. A mixture of chemicals released toxic fumes sending 10 teachers and staff to the hospital after bouts of vomiting and skin rashes. Classes were suspended as firemen cleaned up the area and nearby residents were evacuated. LOUIE DOMINGO/AFP/Getty Images

This brochure is based on the book,
Chemical Laboratory Safety and Security: A Guide to Prudent Chemical Management,
which is available for free on the Internet at www.nas.edu/bcst.

AUTHORING COMMITTEE CREDITS

Committee on Promoting Safe and Secure Chemical Management in Developing Countries

From Pakistan: M. IQBAL CHOUDHARY, University of Karachi
From the Philippines: PATRICK J. Y. LIM, University of San Carlos, Cebu City
From the United States: NED D. HEINDEL (*Chair*) Lehigh University, Bethlehem, PA; CHARLES BARTON, Independent Consultant, San Ramone, CA; JANET S. BAUM, Independent Consultant, University City, MO; APURBA BHATTACHARYA, Texas A&M University, Kingsville; CHARLES P. CASEY, University of Wisconsin, Madison*; MARK C. CESA, INEOS USA, LLC, Naperville, IL; ROBERT H. HILL, Battelle Memorial Institute, Atlanta, GA; ROBIN M. IZZO, Princeton University, NJ; RUSSELL W. PHIFER, WC Environmental, LLC, West Chester, PA; MILDRED Z. SOLOMON, Harvard Medical School, Boston, MA; JAMES M. SOLYST, ENVIRON, Arlington, VA; USHA WRIGHT, O'Brien & Gere, Syracuse, NY.

*Member, U.S. National Academy of Sciences

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