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DEPARTMENT OF LICENSING AND REGULATORY AFFAIRS

DIRECTOR'S OFFICE

OCCUPATIONAL HEALTH STANDARDS

Filed with the Secretary of State on January 9, 1992 (as amended July 28, 2003) **(as amended January 10, 2014)**

These rules become effective immediately upon filing with the Secretary of State unless adopted under section 33, 44, or 45a(6) of 1969 PA 306.

Rules adopted under these sections become effective 7 days after filing with the Secretary of State.

(By authority conferred on the director of the department of licensing and regulatory affairs by sections 14 and 24 of 1974 PA 154, MCL 408.1001 to 408.1094, and Executive Reorganization Order Nos. 1996-1, 1996-2, 2003-1, 2008-4, and 2011-4, MCL 330.3101, 445.2001, 445.2011, 445,2025, and 445.2030.)

R 325.70101, R 325.70103, R 325.70107, R 325.70109, R 325.70110, and R 325.70111 of the Michigan Administrative Code are amended, and R 325.70102a is added, and R 325.70113 and R 325.70114 are rescinded, as follows:

PART 431. HAZARDOUS WORK IN LABORATORIES

Table of Contents:

R 325.70101 Scope; effective date of subrule (2).

Rule 1. (1) These rules set forth the requirements for laboratory use of hazardous chemicals. Subjects to which these rules apply include all of the following:

(a) Exposure limits.
(b) Exposure monitoring.
(c) Written chemical hygiene plan.
(d) Employee information and training.
(e) Medical surveillance.
(f) Hazard identification.
(g) Use of respiratory protection.
(h) Recordkeeping.

(2) These rules, where they apply as specified in R 325.70102, supersede all Michigan occupational safety and health act (MIOSHA) occupational health standards that govern the use of specific chemical substances, except as provided in R 325.70104, R 325.70105, and R 325.70108.

Also, where they apply, these rules supersede the requirements of the occupational safety and health administration (OSHA) hazard communication standard, being 29 C.F.R. §1910.1200, which is incorporated by section 14a of 1974 PA 154, MCL 408.1014a. This subrule takes effect when an employer has developed and implemented a written chemical hygiene plan as prescribed by R 325.70106.

(3) All occupational health standards that do not deal with a specific chemical substance apply to laboratory operations as do any occupational safety standards administered by the Michigan department of Licensing and Regulatory Affairs. Such non-chemical substance standards that apply to laboratory operations include all of the following rules, which are referenced in R 325.70102a:

(a) Occupational Health Standard Part 380 “Occupational Noise Exposure.”

(b) Occupational Health Standard Part 381 “Ionizing Radiation.”

(c) Occupational Health Standard Part 382 "Nonionizing Radiation."

(d) Occupational Health Standard Part 520 "Ventilation Control."

(e) Occupational Health Standard Part 490 "Permit-Required Confined Spaces."

(f) Occupational Health Standard Part 451 "Respiratory Protection."

(g) Occupational Health Standard Part 474 "Sanitation."

(h) Occupational Health Standard Part 472 "Medical Services and First Aid."

(i) Occupational Health Standard Part 470 "Employee Medical Records and Trade Secrets."

R 325.70102 Application

Rule 2. (1) These rules apply to all employers who have an employee or employees involved in the laboratory use of hazardous chemicals as defined in R 325.70103.

(2) These rules do not apply to either of the following:

(a) Work involving chemicals that do not meet the conditions of the definition of laboratory use of hazardous chemicals. In such cases, the employer shall comply with all relevant specific substance standards even if such use occurs in a laboratory type setting.

(b) Work involving the laboratory use of hazardous chemicals that does not have the potential for employee exposure.

R 325.70102a Referenced standards and appendices.

Rule 2a. (1) The OSHA standard 29 C.F.R. §1910.1450 "Occupational exposure to hazardous chemicals in laboratories," is adopted by reference in these rules. A copy of this regulation is available from the U.S. Department of Labor, via the internet at website www.osha.gov, at no charge as of the time of adoption of these rules.

(2) The standard adopted in subrule (1) of this rule is also available for inspection at the Department of Licensing and Regulatory Affairs, MIOSHA Standards Section, 7150 Harris Drive, Lansing, Michigan, 48909-8143.

(3) Copies of the standard adopted in subrule (1) of this rule may be obtained from the publisher or may also be obtained from the Department of Licensing and Regulatory Affairs, MIOSHA Standards Section, 7150 Harris Drive, P.O. Box 30643, Lansing, Michigan, 48909-8143, at the cost charged in this rule, plus $20.00 for shipping and handling.

(4) The following Michigan occupational safety and health standards are referenced in these rules. Up to 5 copies of these standards may be obtained at no charge from the Michigan Department of licensing and regulatory affairs, MIOSHA standards section, 7150 Harris Drive, P.O. Box 30643, Lansing, MI, 48909-8143 or via the internet at website: www.michigan.gov/mioshastandards. For quantities greater than 5, the cost, at the time of adoption of these rules, is 4 cents per page.

(a) Occupational Health Standard Part 380 "Occupational Noise Exposure," R 325.60101 to R 325.60128.

(b) Occupational Health Standard Part 381 "Ionizing Radiation," R 325.60601a to R 325.60618.

(c) Occupational Health Standard Part 382 "Nonionizing Radiation," R 325.60701 to R 325.60704.

(d) Occupational Health Standard Part 430 "Hazard Communication," R 325.77001 to R 325.77003.

(e) Occupational Health Standard Part 451 "Respiratory Protection," R 325.60051 to R 325.60052.

(f) Occupational Health Standard Part 470 "Employee Medical Records and Trade Secrets," R 325.3451 to R 325.3476.

(g) Occupational Health Standard Part 472 "Medical Services and First Aid," R 325.47201.

(h) Occupational Health Standard Part 474 "Sanitation," R 325.47401 to R 325.47425.

(i) Occupational Health Standard Part 490 "Permit-Required Confined Spaces," R 325.63001 to R 325.63049.

(j) Occupational Health Standard Part 520 "Ventilation Control," R 325.52001 to R 325.52012.

(5) Appendices to these rules are informational only and are not intended to create any additional obligations or requirements not otherwise imposed by these rules or to detract from any established obligations or requirements.

R 325.70103 Definitions.

Rule 3. (1) "Action level" means a concentration which is designated in established MIOSHA health standards for a specific substance, calculated as an 8-hour, time-weighted average, and which initiates certain required activities, such as exposure monitoring and medical surveillance.

(2) "Chemical hygiene officer" means an employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure.

(3) "Chemical Hygiene Plan" means a written program which is developed and implemented by the employer, which sets forth procedures, equipment, personal protective equipment, and work practices that are capable of protecting employees from the health hazards presented by the hazardous chemicals used in a particular workplace, and which is in compliance with R 325.70106.

(4) "Director" means the director of the Michigan department of Licensing and Regulatory Affairs or his or her designee.

(5) “Emergency” means any occurrence, such as equipment failure, the rupture of containers, or the failure of control equipment, that results in an uncontrolled release of a hazardous chemical into the workplace.

(6) “Employee” means a person who is assigned to work in a laboratory workplace and who may be exposed to hazardous chemicals in the course of his or her assignments.

(7) “Hazardous chemical” means any chemical which is classified as health hazard or simple asphyxiant in accordance with the Occupational Health Standard Part 430 “Hazard Communication,” as referenced in R 325.70102a.

(8) “Health hazard” means a chemical that is classified as posing 1 of the following hazardous effects:

(a) Acute toxicity, any route of exposure.

(b) Skin corrosion or irritation.

(c) Serious eye damage or eye irritation.

(d) Respiratory or skin sensitization.

(e) Germ cell mutagenicity.

(f) Carcinogenity.

(g) Reproductive toxicity.

(h) Specific target organ toxicity, single or repeated exposure.

(i) Aspiration hazard.

(j) The criteria for determining whether a chemical is classified as a health hazard are detailed in Appendix A of Occupational Health Standard Part 430 “Hazard Communication,” as referenced in R 325.70102a, rule §1910.1200(c) which includes the definitions of "simple asphyxiant".

(9) “Laboratory” means a facility where the laboratory use of hazardous chemicals occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a nonproduction basis.

(10) “Laboratory scale” means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by 1 person. "Laboratory scale" does not mean those workplaces whose function is to produce commercial quantities of materials.

(11) “Laboratory-type hood” means a work chamber which is used in a laboratory, which is enclosed on 5 sides and has a moveable sash or fixed partial closure on the remaining side, which is constructed and maintained to draw air from the laboratory and prevent or minimize the escape of air contaminants into the laboratory, and which allows chemical manipulations to be conducted in the enclosure without inserting any portion of the employee's body other than hands and arms. The term includes walk-in hoods with adjustable sashes if the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and so that employees do not work inside the enclosure during the release of airborne hazardous chemicals.

(12) “Laboratory use of hazardous chemicals” means the handling or use of such chemicals in which all of the following conditions are met:

(a) Chemical manipulations are carried out on a laboratory scale.

(b) Multiple chemical procedures or chemicals are used.

(c) The procedures that are involved are not part of production process, nor in any way simulate a production process.

(d) Protective laboratory practices and equipment are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

(13) “Medical consultation” means a consultation that takes place between an employee and a licensed physician to determine what medical examinations or procedures, if any, are appropriate.

(14) “Mutagen” means chemicals that cause permanent changes in the amount or structure of the genetic material in a cell. Chemicals classified as mutagens in accordance with Occupational Health Standard Part 430 “Hazard Communication,” as referenced in R 325.70102a, shall be considered mutagens for purposes of these rules.

(15) “Physical hazard” means a chemical that is classified as posing 1 of the following hazardous effects:

(a) Explosive.

(b) Flammable, gases, aerosols, liquids, or solids.

(c) Oxidizer as a liquid, solid, or gas.

(d) Self-reactive.

(e) Pyrophoric as a gas, liquid or solid.

(f) Self-heating.

(g) Organic peroxide.

(h) Corrosive to metal.

(i) Gas under pressure.

(j) In contact with water emits flammable gas.

(k) Combustible dust.

(l) The criteria for determining whether a chemical is classified as a physical hazard are in Appendix B of Occupational Health Standard Part 430 “Hazard Communication,” as referenced in R 325.70102a, rule §1910.1200(c) which includes the definitions of "combustible dust" and "pyrophoric gas."

(16) “Protective laboratory practices and equipment” means those laboratory procedures, practices, and equipment that are accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, in minimizing the potential for employee exposure to hazardous chemicals.

(17) “Reproductive toxins” means chemicals that affect the reproductive capabilities, including adverse effects on sexual function and fertility in adult males and females, as well as adverse effects on the development of the offspring.

Chemicals classified as reproductive toxins in accordance with the Occupational Health Standard Part 430 “Hazard Communication,” as referenced in R 325.70102a, shall be considered reproductive toxins for purposes of these rules.

(18) “Select carcinogen” means any substance that meets 1 or more of the criteria set forth in the definition of select carcinogen in OSHA standard 29 C.F.R. §1910.1450, paragraph (b), as referenced in R 325.70102a. The cited definition is printed as Appendix C to these rules.

R 325.70104 Permissible exposure limits

Rule 4. For laboratory uses of MIOSHA-regulated substances, an employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in MIOSHA occupational health standards.

R 325.70105 Exposure monitoring

Rule 5. (1) An employer shall measure an employee's exposure to any substance that is regulated by a standard that requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level or, in the absence of an action level, the permissible exposure limits (PEL).

(2) If the initial monitoring prescribed by subrule (1) of this rule discloses employee exposure over the action level or, in the absence of an action level, the PEL, an employer shall comply with the exposure monitoring provisions of the relevant standard.

(3) Monitoring may be terminated in accordance with the relevant standard.

(4) An employer shall, within 15 working days after the receipt of any monitoring results, notify an employee of these results, in writing, either individually or by posting the results in an appropriate location that is accessible to employees.

R 325.70106 Chemical hygiene plan

Rule 6. (1) Where hazardous chemicals as defined by these rules are used in the workplace, an employer shall develop and carry out the provisions of a written chemical hygiene plan that provides for both of the following:

(a) Protecting employees from health hazards that are associated with hazardous chemicals in that laboratory.

(b) Keeping exposures below the limits specified in R 325.70104.

(2) The chemical hygiene plan shall be readily available to employees, employee representatives, and, upon request, to the director.

(3) The chemical hygiene plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection:

(a) Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals.

(b) Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals, including engineering controls, the use of personal protective equipment, and hygiene practices. Particular attention shall be given to the selection of control measures for chemicals that are known to be particularly hazardous.

(c) A requirement that laboratory-type hoods and other protective equipment are functioning properly and the specific measures that shall be taken to ensure the proper and adequate performance of such equipment.

(d) Provisions for employee information and training as prescribed in R 325.70107.

(e) The circumstances under which a particular laboratory operation, procedure, or activity shall require prior approval from the employer or the employer's designee before implementation.

(f) Provisions for medical consultation and medical examinations in accordance with R 325.70108.

(g) Designation of personnel who are responsible for implementing the chemical hygiene plan, including the assignment of a chemical hygiene officer and, if appropriate, establishment of a chemical hygiene committee.

(h) Provisions for additional employee protection for work with particularly hazardous substances, such as select carcinogens, reproductive toxins, and substances that have a high degree of acute or chronic toxicity. Specific consideration shall be given to the following provisions, which shall be included where appropriate:

(i) The establishment of a designated area or areas that indicate the physical limits of exposure to particularly hazardous substances.

(ii) The use of containment devices, such as laboratory-type hoods or glove boxes.

(iii) Procedures for the safe removal of contaminated waste.

(iv) Decontamination procedures.

(4) An employer shall review and evaluate the effectiveness of the chemical hygiene plan at least annually and update it as necessary.

(5) Appendix A to these rules is nonmandatory, but provides guidance to assist employers in the development of a chemical hygiene plan.

R 325.70107 Employee information and training.

Rule 7. (1) An employer shall provide employees with information and training to ensure that they are apprised of and understand the hazards of chemicals present in their work areas.

(2) Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and before assignments that involve new exposure situations. Refresher information and training shall be provided by the employer to ensure that an employee is aware of the risks of exposure to hazardous chemicals.

(3) Employees shall be informed of all of the following:

(a) The contents of these rules and appendices, which shall be made available to employees.

(b) The location and availability of the employer's chemical hygiene plan.

(c) The permissible exposure limits for MIOSHA-regulated substances or the recommended exposure limits for other hazardous chemicals if there are no applicable MIOSHA rules.

(d) Signs and symptoms associated with exposures to hazardous chemicals that are used in the laboratory.

(e) The location and availability of known reference material on the hazards, safe handling, storage, and disposal of hazardous chemicals found in the laboratory including, but not limited to, safety data sheets (SDS) received from a chemical supplier.

(4) Employee training shall include all of the following:

(a) Methods and observations that may be used to detect the presence or release of a hazardous chemical, such as monitoring conducted by the employer, continuous monitoring devices, and the visual appearance or odor of hazardous chemicals when being released.

(b) The physical and health hazards of chemicals in the work environment.

(c) The measures employees can take to protect themselves from health hazards, including specific procedures that the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.

(5) The employee shall be trained about the applicable details of the employer's written chemical hygiene plan.

R 325.70108 Medical surveillance.

Rule 8. (1) An employer shall provide all employees who work with hazardous chemicals an opportunity to receive the following medical attention, including any follow-up examinations which the examining physician determines to be necessary:

(a) When an employee develops signs or symptoms that are associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.

(b) If exposure monitoring reveals an exposure level that is routinely above the action level or, in the absence of an action level, the PEL for a MIOSHA-regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.

(c) When an event takes place in the work areas, such as a spill, leak, explosion, or other occurrence that results in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

(2) All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician who is familiar with the general health effects of hazardous chemicals and sources of specific information on such effects and shall be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

(3) An employer shall provide all of the following information to the physician:

(a) The identity of the hazardous chemical or chemicals to which the employee may have been exposed.

(b) A description of the conditions under which the exposure occurred, including quantitative exposure data, if available.

(c) A description of the signs and symptoms of exposure that the employee is experiencing, if any.

(4) For examination or consultation that is required under this rule, an employer shall obtain a written opinion from the examining physician. The opinion shall include all of the following:

(a) Any recommendation for further medical follow-up.

(b) The results of the medical examination and any associated tests.

(c) Any medical condition revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical that is found in the workplace.

(d) A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

(5) The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

R 325.70109 Hazard identification.

Rule 9. (1) With respect to labels and safety data sheets (SDS) for hazardous chemicals, both of the following provisions apply:

(a) Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.

(b) Employers shall maintain any safety data sheets that are received with incoming shipments of hazardous chemicals and ensure that safety data sheets are readily accessible to laboratory employees.

(2) All of the following provisions shall apply to chemical substances that are developed in the laboratory:

(a) If the composition of the chemical substance that is produced exclusively for the laboratory's use is known, an employer shall determine if it is a hazardous chemical. If the employer determines that the chemical is hazardous, the employer shall provide appropriate training as required by R 325.70107.

(b) If the chemical produced is a by-product of unknown composition, an employer shall assume that the substance is hazardous and shall implement the provisions of R 325.70106.

(c) If the chemical substance is produced for another user outside of a laboratory, an employer shall comply with the Occupational Health Standard Part 430 “Hazard Communication,” as referenced in R 325.70102a, including the requirements for preparation of safety data sheets and labeling.

R 325.70110 Use of respiratory protection.

Rule 10. If, after appropriate application of feasible engineering and work practice controls, the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory protection equipment. Respirators shall be selected and used in accordance with the requirements of Occupational Health Standard Part 451 “Respiratory Protection,” as referenced in R 325.70102a.

R 325.70111 Recordkeeping.

Rule 11. (1) An employer shall establish and maintain, for each employee, an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations, including tests or written opinions required by these rules.

(2) An employer shall assure that such records are kept, transferred, and made available in accordance with the provisions of Occupational Health Standard Part 470 “Employee Medical Records and Trade Secrets,” as referenced in R 325.70102a, and are protected from unauthorized disclosure.

R 325.70112. Rescinded.

R 325.70113. Rescinded.

R 325.70114. Rescinded.

APPENDIX A AND APPENDIX B

Table of Contents:

1910.1450 APPENDIX A
NATIONAL RESEARCH COUNCIL RECOMMENDATIONS CONCERNING CHEMICAL HYGIENE IN LABORATORIES (NON-MANDATORY)

To assist employers in developing an appropriate laboratory Chemical Hygiene Plan (CHP), the following non-mandatory recommendations were based on the National Research Council's (NRC) 2011 edition of "Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards." This reference, henceforth referred to as "Prudent Practices," is available from the National Academies Press, 500 Fifth Street NW., Washington DC 20001 (www.nap.edu). "Prudent Practices" is cited because of its wide distribution and acceptance and because of its preparation by recognized authorities in the laboratory community through the sponsorship of the NRC. However, these recommendations do not modify any requirements of the OSHA Laboratory standard. This appendix presents pertinent recommendations from "Prudent Practices," organized into a form convenient for quick reference during operation of a laboratory and during development and application of a CHP. For a detailed explanation and justification for each recommendation, consult "Prudent Practices."

"Prudent Practices" deals with both general laboratory safety and many types of chemical hazards, while the Laboratory standard is concerned primarily with chemical health hazards as a result of chemical exposures. The recommendations from "Prudent Practices" have been paraphrased, combined, or otherwise reorganized in order to adapt them for this purpose. However, their sense has not been changed.

Section F contains information from the U.S. Chemical Safety Board's (CSB) Fiscal Year 2011 Annual Performance and Accountability report and Section F contains recommendations extracted from the CSB's 2011 case study, "Texas Tech University Laboratory Explosion," available from: http://www.csb.gov/.

Culture of Safety

With the promulgation of the Occupational Safety and Health Administration (OSHA) Laboratory standard (29 CFR 1910.1450), a culture of safety consciousness, accountability, organization, and education has developed in industrial, governmental, and academic laboratories. Safety and training programs have been implemented to promote the safe handling of chemicals from ordering to disposal, and to train laboratory personnel in safe practices. Laboratory personnel must realize that the welfare and safety of each individual depends on clearly defined attitudes of teamwork and personal responsibility. Learning to participate in this culture of habitual risk assessment, experiment planning, and consideration of worst-case possibilities—for oneself and one's fellow workers—is as much part of a scientific education as learning the theoretical background of experiments or the step-by-step protocols for doing them in a professional manner. A crucial component of chemical education for all personnel is to nurture basic attitudes and habits of prudent behavior so that safety is a valued and inseparable part of all laboratory activities throughout their career.

Over the years, special techniques have been developed for handling chemicals safely. Local, state, and federal regulations hold institutions that sponsor chemical laboratories accountable for providing safe working environments. Beyond regulation, employers and scientists also hold themselves personally responsible for their own safety, the safety of their colleagues and the safety of the general public. A sound safety organization that is respected by all requires the participation and support of laboratory administrators, workers, and students. A successful health and safety program requires a daily commitment from everyone in the organization. To be most effective, safety and health must be balanced with, and incorporated into, laboratory processes. A strong safety and health culture is the result of positive workplace attitudes—from the chief executive officer to the newest hire; involvement and buy-in of all members of the workforce; mutual, meaningful, and measurable safety and health improvement goals; and policies and procedures that serve as reference tools, rather than obscure rules.

In order to perform their work in a prudent manner, laboratory personnel must consider the health, physical, and environmental hazards of the chemicals they plan to use in an experiment. However, the ability to accurately identify and assess laboratory hazards must be taught and encouraged through training and ongoing organizational support. This training must be at the core of every good health and safety program. For management to lead, personnel to assess worksite hazards, and hazards to be eliminated or controlled, everyone involved must be trained.

A. General Principles

1. Minimize All Chemical Exposures and Risks

Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted. In addition to these general guidelines, specific guidelines for chemicals that are used frequently or are particularly hazardous should be adopted.

Laboratory personnel should conduct their work under conditions that minimize the risks from both known and unknown hazardous substances. Before beginning any laboratory work, the hazards and risks associated with an experiment or activity should be determined and the necessary safety precautions implemented. Every laboratory should develop facility-specific policies and procedures for the highest-risk materials and procedures used in their laboratory. To identify these, consideration should be given to past accidents, process conditions, chemicals used in large volumes, and particularly hazardous chemicals.

Perform Risk Assessments for Hazardous Chemicals and Procedures Prior to Laboratory Work:

(a) Identify chemicals to be used, amounts required, and circumstances of use in the experiment. Consider any special employee or laboratory conditions that could create or increase a hazard. Consult sources of safety and health information and experienced scientists to ensure that those conducting the risk assessment have sufficient expertise.

(b) Evaluate the hazards posed by the chemicals and the experimental conditions. The evaluation should cover toxic, physical, reactive, flammable, explosive, radiation, and biological hazards, as well as any other potential hazards posed by the chemicals.

(c) For a variety of physical and chemical reasons, reaction scale-ups pose special risks, which merit additional prior review and precautions.

(d) Select appropriate controls to minimize risk, including use of engineering controls, administrative controls, and personal protective equipment (PPE) to protect workers from hazards. The controls must ensure that OSHA's Permissible Exposure Limits (PELs) are not exceeded. Prepare for contingencies and be aware of the institutional procedures in the event of emergencies and accidents.

One sample approach to risk assessment is to answer these five questions:

(a) What are the hazards?
(b) What is the worst thing that could happen?
(c) What can be done to prevent this from happening?
(d) What can be done to protect from these hazards?
(e) What should be done if something goes wrong?

2. Avoid Underestimation of Risk

Even for substances of no known significant hazard, exposure should be minimized; when working with substances that present special hazards, special precautions should be taken. Reference should be made to the safety data sheet (SDS) that is provided for each chemical. Unless otherwise known, one should assume that any mixture will be more toxic than its most toxic component and that all substances of unknown toxicity are toxic.

Determine the physical and health hazards associated with chemicals before working with them. This determination may involve consulting literature references, laboratory chemical safety summaries (LCSSs), SDSs, or other reference materials. Consider how the chemicals will be processed and determine whether the changing states or forms will change the nature of the hazard. Review your plan, operating limits, chemical evaluations and detailed risk assessment with other chemists, especially those with experience with similar materials and protocols.

Before working with chemicals, know your facility's policies and procedures for how to handle an accidental spill or fire. Emergency telephone numbers should be posted in a prominent area. Know the location of all safety equipment and the nearest fire alarm and telephone.

3. Adhere to the Hierarchy of Controls

The hierarchy of controls prioritizes intervention strategies based on the premise that the best way to control a hazard is to systematically remove it from the workplace, rather than relying on employees to reduce their exposure. The types of measures that may be used to protect employees (listed from most effective to least effective) are: engineering controls, administrative controls, work practices, and PPE. Engineering controls, such as chemical hoods, physically separate the employee from the hazard. Administrative controls, such as employee scheduling, are established by management to help minimize the employees' exposure time to hazardous chemicals. Work practice controls are tasks that are performed in a designated way to minimize or eliminate hazards. Personal protective equipment and apparel are additional protection provided under special circumstances and when exposure is unavoidable.

Face and eye protection is necessary to prevent ingestion and skin absorption of hazardous chemicals. At a minimum, safety glasses, with side shields, should be used for all laboratory work. Chemical splash goggles are more appropriate than regular safety glasses to protect against hazards such as projectiles, as well as when working with glassware under reduced or elevated pressures (e.g., sealed tube reactions), when handling potentially explosive compounds (particularly during distillations), and when using glassware in high-temperature operations. Do not allow laboratory chemicals to come in contact with skin. Select gloves carefully to ensure that they are impervious to the chemicals being used and are of correct thickness to allow reasonable dexterity while also ensuring adequate barrier protection.

Lab coats and gloves should be worn when working with hazardous materials in a laboratory. Wear closed-toe shoes and long pants or other clothing that covers the legs when in a laboratory where hazardous chemicals are used. Additional protective clothing should be used when there is significant potential for skin-contact exposure to chemicals. The protective characteristics of this clothing must be matched to the hazard. Never wear gloves or laboratory coats outside the laboratory or into areas where food is stored and consumed.

4. Provide Laboratory Ventilation

The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by the use of hoods and other ventilation devices. To determine the best choice for laboratory ventilation using engineering controls for personal protection, employers are referred to Table 9.3 of the 2011 edition of ''Prudent Practices.'' Laboratory chemical hoods are the most important components used to protect laboratory personnel from exposure to hazardous chemicals.

(a) Toxic or corrosive chemicals that require vented storage should be stored in vented cabinets instead of in a chemical hood.

(b) Chemical waste should not be disposed of by evaporation in a chemical hood.

(c) Keep chemical hood areas clean and free of debris at all times.

(d) Solid objects and materials, such as paper, should be prevented from entering the exhaust ducts as they can reduce the air flow.

(e) Chemical hoods should be maintained, monitored and routinely tested for proper performance.

A laboratory ventilation system should include the following characteristics and practices:

(a) Heating and cooling should be adequate for the comfort of workers and operation of equipment. Before modification of any building HVAC, the impact on laboratory or hood ventilation should be considered, as well as how laboratory ventilation changes may affect the building HVAC.

(b) A negative pressure differential should exist between the amount of air exhausted from the laboratory and the amount supplied to the laboratory to prevent uncontrolled chemical vapors from leaving the laboratory.

(c) Local exhaust ventilation devices should be appropriate to the materials and operations in the laboratory.

(d) The air in chemical laboratories should be continuously replaced so that concentrations of odoriferous or toxic substances do not increase during the workday.

(e) Laboratory air should not be recirculated but exhausted directly outdoors.

(f) Air pressure should be negative with respect to the rest of the building. Local capture equipment and systems should be designed only by an experienced engineer or industrial hygienist.

(g) Ventilation systems should be inspected and maintained on a regular basis. There should be no areas where air remains static or areas that have unusually high airflow velocities.

Before work begins, laboratory workers should be provided with proper training that includes how to use the ventilation equipment, how to ensure that it is functioning properly, the consequences of improper use, what to do in the event of a system failure or power outage, special considerations, and the importance of signage and postings.

5. Institute a Chemical Hygiene Program

A comprehensive chemical hygiene program is required. It should be designed to minimize exposures, injuries, illnesses and incidents. There should be a regular, continuing effort that includes program oversight, safe facilities, chemical hygiene planning, training, emergency preparedness and chemical security. The chemical hygiene program must be reviewed annually and updated as necessary whenever new processes, chemicals, or equipment is implemented. Its recommendations should be followed in all laboratories.

6. Observe the PELs and TLVs

OSHA's Permissible Exposure Limits (PELs) must not be exceeded. The American Conference of Governmental Industrial Hygienists' Threshold Limit Values (TLVs) should also not be exceeded.

B. Responsibilities

Persons responsible for chemical hygiene include, but are not limited to, the following:

1. Chemical Hygiene Officer

(a) Establishes, maintains, and revises the chemical hygiene plan (CHP).
(b) Creates and revises safety rules and regulations.
(c) Monitors procurement, use, storage, and disposal of chemicals.
(d) Conducts regular inspections of the laboratories, preparations rooms, and chemical storage rooms, and submits detailed laboratory inspection reports to administration.
(e) Maintains inspection, personnel training, and inventory records.
(f) Assists laboratory supervisors in developing and maintaining adequate facilities.
(g) Seeks ways to improve the chemical hygiene program.

2. Department Chairperson or Director

(a) Assumes responsibility for personnel engaged in the laboratory use of hazardous chemicals.
(b) Provides the chemical hygiene officer (CHO) with the support necessary to implement and maintain the CHP.
(c) After receipt of laboratory inspection report from the CHO, meets with laboratory supervisors to discuss cited violations and to ensure timely actions to protect trained laboratory personnel and facilities and to ensure that the department remains in compliance with all applicable federal, state, university, local and departmental codes and regulations.
(d) Provides budgetary arrangements to ensure the health and safety of the departmental personnel, visitors, and students.

3. Departmental Safety Committee reviews accident reports and makes appropriate recommendations to the department chairperson regarding proposed changes in the laboratory procedures.

4. Laboratory Supervisor or Principal Investigator has overall responsibility for chemical hygiene in the laboratory, including responsibility to:

(a) Ensure that laboratory personnel comply with the departmental CHP and do not operate equipment or handle hazardous chemicals without proper training and authorization.
(b) Always wear personal protective equipment (PPE) that is compatible to the degree of hazard of the chemical.
(c) Follow all pertinent safety rules when working in the laboratory to set an example.
(d) Review laboratory procedures for potential safety problems before assigning to other laboratory personnel.
(e) Ensure that visitors follow the laboratory rules and assumes responsibility for laboratory visitors.
(f) Ensure that PPE is available and properly used by each laboratory employee and visitor.
(g) Maintain and implement safe laboratory practices.
(h) Provide regular, formal chemical hygiene and housekeeping inspections, including routine inspections of emergency equipment;
(i) Monitor the facilities and the chemical fume hoods to ensure that they are maintained and function properly. Contact the appropriate person, as designated by the department chairperson, to report problems with the facilities or the chemical fume hoods.

5. Laboratory Personnel
   (a) Read, understand, and follow all safety rules and regulations that apply to the work area;
   (b) Plan and conduct each operation in accordance with the institutional chemical hygiene procedures;
   (c) Promote good housekeeping practices in the laboratory or work area.
   (d) Notify the supervisor of any hazardous conditions or unsafe work practices in the work area.
   (e) Use PPE as appropriate for each procedure that involves hazardous chemicals.

C. The Laboratory Facility

General Laboratory Design Considerations Wet chemical spaces and those with a higher degree of hazard should be separated from other spaces by a wall or protective barrier wherever possible. If the areas cannot be separated, then workers in lower hazard spaces may require additional protection from the hazards in connected spaces.

1. Laboratory Layout and Furnishing
   (a) Work surfaces should be chemically resistant, smooth, and easy to clean.
   (b) Hand washing sinks for hazardous materials may require elbow, foot, or electronic controls for safe operation.
   (c) Wet laboratory areas should have chemically resistant, impermeable, slip resistant flooring.
   (d) Walls should be finished with a material that is easy to clean and maintain.
   (e) Doors should have view panels to prevent accidents and should open in the direction of egress.
   (f) Operable windows should not be present in laboratories, particularly if there are chemical hoods or other local ventilation systems present.

2. Safety Equipment and Utilities
   (a) An adequate number and placement of safety showers, eyewash units, and fire extinguishers should be provided for the laboratory.
   (b) Use of water sprinkler systems is resisted by some laboratories because of the presence of electrical equipment or water reactive materials, but it is still generally safer to have sprinkler systems installed. A fire large enough to trigger the sprinkler system would have the potential to cause far more destruction than the local water damage.

D. Chemical Hygiene Plan (CHP)

The OSHA Laboratory standard defines a CHP as ‘‘a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace.’’ (29 CFR 1910.1450(b)). The Laboratory Standard requires a CHP: ‘‘Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan.’’ (29 CFR 1910.1450(e)(1)). The CHP is the foundation of the laboratory safety program and must be reviewed and updated, as needed, and at least on an annual basis to reflect changes in policies and personnel. A CHP should be facility specific and can assist in promoting a culture of safety to protect workers from exposure to hazardous materials.

1. The Laboratory’s CHP must be readily available to workers and capable of protecting workers from health hazards and minimizing exposure. Include the following topics in the CHP:
   (a) Individual chemical hygiene responsibilities;
   (b) Standard operating procedures;
   (c) Personal protective equipment, engineering controls and apparel;
   (d) Laboratory equipment;
   (e) Safety equipment;
   (f) Chemical management;
   (g) Housekeeping;
   (h) Emergency procedures for accidents and spills;
   (i) Chemical waste;
   (j) Training;
   (k) Safety rules and regulations;
   (l) Laboratory design and ventilation;
   (m) Exposure monitoring;
   (n) Compressed gas safety;
   (o) Medical consultation and examination.

It should be noted that the nature of laboratory work may necessitate addressing biological safety, radiation safety and security issues.

2. Chemical Procurement, Distribution, and Storage

Prudent chemical management includes the following processes:

Chemical Procurement:

(a) Information on proper handling, storage, and disposal should be known to those who will be involved before a substance is received.

(b) Only containers with adequate identifying labels should be accepted.

(c) Ideally, a central location should be used for receiving all chemical shipments.

(d) Shipments with breakage or leakage should be refused or opened in a chemical hood.

(e) Only the minimum amount of the chemical needed to perform the planned work should be ordered.

(f) Purchases of high risk chemicals should be reviewed and approved by the CHO.

(g) Proper protective equipment and handling and storage procedures should be in place before receiving a shipment.

Chemical Storage:

(a) Chemicals should be separated and stored according to hazard category and compatibility.

(b) SDS and label information should be followed for storage requirements.

(c) Maintain existing labels on incoming containers of chemicals and other materials.

(d) Labels on containers used for storing hazardous chemicals must include the chemical identification and appropriate hazard warnings.

(e) The contents of all other chemical containers and transfer vessels, including, but not limited to, beakers, flasks, reaction vessels, and process equipment, should be properly identified.

(f) Chemical shipments should be dated upon receipt and stock rotated.

(g) Peroxide formers should be dated upon receipt, again dated upon opening, and stored away from heat and light with tightfitting, nonmetal lids.

(h) Open shelves used for chemical storage should be secured to the wall and contain 3/4-inch lips. Secondary containment devices should be used as necessary.

(i) Consult the SDS and keep incompatibles separate during transport, storage, use, and disposal.

(j) Oxidizers, reducing agents, and fuels should be stored separately to prevent contact in the event of an accident.

(k) Chemicals should not be stored in the chemical hood, on the floor, in areas of egress, on the bench top, or in areas near heat or in direct sunlight.

(l) Laboratory-grade, flammable-rated refrigerators and freezers should be used to store sealed chemical containers of flammable liquids that require cool storage. Do not store food or beverages in the laboratory refrigerator.

(m) Highly hazardous chemicals should be stored in a well-ventilated and secure area designated for that purpose.

(n) Flammable chemicals should be stored in a spark-free environment and in approved flammable-liquid containers and storage cabinets. Grounding and bonding should be used to prevent static charge buildups when dispensing solvents.

(o) Chemical storage and handling rooms should be controlled-access areas. They should have proper ventilation, appropriate signage, diked floors, and fire suppression systems.

Chemical Handling:

(a) As described above, a risk assessment should be conducted prior to beginning work with any hazardous chemical for the first time.

(b) All SDS and label information should be read before using a chemical for the first time.

(c) Trained laboratory workers should ensure that proper engineering controls (ventilation) and PPE are in place.

Chemical Inventory:

(a) Prudent management of chemicals in any laboratory is greatly facilitated by keeping an accurate inventory of the chemicals stored.

(b) Unneeded items should be discarded or returned to the storeroom.

Transporting Chemicals:

(a) Secondary containment devices should be used when transporting chemicals.

(b) When transporting chemicals outside of the laboratory or between stockrooms and laboratories, the transport container should be break-resistant.

(c) High-traffic areas should be avoided.

Transferring Chemicals:

(a) Use adequate ventilation (such as a fume hood) when transferring even a small amount of a particularly hazardous substance (PHS).

(b) While drum storage is not appropriate for laboratories, chemical stockrooms may purchase drum quantities of solvents used in high volumes. Ground and bond the drum and receiving vessel when transferring flammable liquids from a drum to prevent static charge buildup.

(c) If chemicals from commercial sources are repackaged into transfer vessels, the new containers should be labeled with all essential information on the original container.

Shipping Chemicals:

Outgoing chemical shipments must meet all applicable Department of Transportation (DOT) regulations and should be authorized and handled by the institutional shipper.

3. Waste Management

A waste management plan should be in place before work begins on any laboratory activity. The plan should utilize the following hierarchy of practices:

(a) Reduce waste sources. The best approach to minimize waste generation is by reducing the scale of operations, reducing its formation during operations, and, if possible, substituting less hazardous chemicals for a particular operation.

(b) Reuse surplus materials. Only the amount of material necessary for an experiment should be purchased, and, if possible, materials should be reused.

(c) Recycle waste. If waste cannot be prevented or minimized, the organization should consider recycling chemicals that can be safely recovered or used as fuel.

(d) Dispose of waste properly. Sink disposal may not be appropriate. Proper waste disposal methods include incineration, treatment, and land disposal. The organization's environmental health and safety (EHS) office should be consulted in determining which methods are appropriate for different types of waste.

Collection and Storage of Waste:

(a) Chemical waste should be accumulated at or near the point of generation, under the control of laboratory workers.

(b) Each waste type should be stored in a compatible container pending transfer or disposal. Waste containers should be clearly labeled and kept sealed when not in use.

(c) Incompatible waste types should be kept separate to ensure that heat generation, gas evolution, or another reaction does not occur.

(d) Waste containers should be segregated by how they will be managed. Waste containers should be stored in a designated location that does not interfere with normal laboratory operations. Ventilated storage and secondary containment may be appropriate for certain waste types.

(e) Waste containers should be clearly labeled and kept sealed when not in use. Labels should include the accumulation start date and hazard warnings as appropriate.

(f) Non-explosive electrical systems, grounding and bonding between floors and containers, and non-sparking conductive floors and containers should be used in the central waste accumulation area to minimize fire and explosion hazards. Fire suppression systems, specialized ventilation systems, and dikes should be installed in the central waste accumulation area. Waste management workers should be trained in proper waste handling procedures as well as contingency planning and emergency response. Trained laboratory workers most familiar with the waste should be actively involved in waste management decisions to ensure that the waste is managed safely and efficiently. Engineering controls should be implemented as necessary, and personal protective equipment should be worn by workers involved in waste management.

4. Inspection Program

Maintenance and regular inspection of laboratory equipment are essential parts of the aboratory safety program. Management should participate in the design of a laboratory inspection program to ensure that the facility is safe and healthy, workers are adequately trained, and proper procedures are being followed.

Types of inspections: The program should include an appropriate combination of routine inspections, self-audits, program audits, peer inspections, EHS inspections, and inspections by external entities.

Elements of an inspection:

(a) Inspectors should bring a checklist to ensure that all issues are covered and a camera to document issues that require correction.

(b) Conversations with workers should occur during the inspection, as they can provide valuable information and allow inspectors an opportunity to show workers how to fix problems.

(c) Issues resolved during the inspection should be noted.
(d) An inspection report containing all findings and recommendations should be prepared for management and other appropriate workers.
(e) Management should follow-up on the inspection to ensure that all corrections are implemented.

5. Medical Consultation and Examination

The employer must provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations that the examining physician determines to be necessary, whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory. If an employee encounters a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee must be provided an opportunity for a medical consultation by a licensed physician. All medical examinations and consultations must be performed by or under the direct supervision of a licensed physician and must be provided without cost to the employee, without loss of pay and at a reasonable time and place. The identity of the hazardous chemical, a description of the incident, and any signs and symptoms that the employee may experience must be relayed to the physician.

6. Records

All accident, fatality, illness, injury, and medical records and exposure monitoring records must be retained by the institution in accordance with the requirements of state and federal regulations (see 29 CFR part 1904 and § 1910.1450(j)). Any exposure monitoring results must be provided to affected laboratory staff within 15 working days after receipt of the results (29 CFR 1910.1450(d)(4)).

7. Signs

Prominent signs of the following types should be posted:

(a) Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers;

(b) Location signs for safety showers, eyewash stations, other safety and first aid equipment, and exits; and

(c) Warnings at areas or equipment where special or unusual hazards exist.

8. Spills and Accidents

Before beginning an experiment, know your facility's policies and procedures for how to handle an accidental release of a hazardous substance, a spill or a fire. Emergency response planning and training are especially important when working with highly toxic compounds. Emergency telephone numbers should be posted in a prominent area. Know the location of all safety equipment and the nearest fire alarm and telephone. Know who to notify in the event of an emergency. Be prepared to provide basic emergency treatment. Keep your co-workers informed of your activities so they can respond appropriately. Safety equipment, including spill control kits, safety shields, fire safety equipment, PPE, safety showers and eyewash units, and emergency equipment should be available in well-marked highly visible locations in all chemical laboratories. The laboratory supervisor or CHO is responsible for ensuring that all personnel are aware of the locations of fire extinguishers and are trained in their use. After an extinguisher has been used, designated personnel must promptly recharge or replace it (29 CFR 1910.157(c)(4)). The laboratory supervisor or CHO is also responsible for ensuring proper training and providing supplementary equipment as needed.

Special care must be used when handling solutions of chemicals in syringes with needles. Do not recap needles, especially when they have been in contact with chemicals. Remove the needle and discard it immediately after use in the appropriate sharps containers. Blunt-tip needles are available from a number of commercial sources and should be used unless a sharp needle is required to puncture rubber septa or for subcutaneous injection.

For unattended operations, laboratory lights should be left on, and signs should be posted to identify the nature of the experiment and the hazardous substances in use. Arrangements should be made, if possible, for other workers to periodically inspect the operation. Information should be clearly posted indicating who to contact in the event of an emergency. Depending on the nature of the hazard, special rules, precautions, and alert systems may be necessary.

9. Training and Information

Personnel training at all levels within the organization, is essential. Responsibility and accountability throughout the organization are key elements in a strong safety and health program. The employer is required to provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area (29 CFR 1910.1450(f)). This information must be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations.

The frequency of refresher information and training should be determined by the employer. At a minimum, laboratory personnel should be trained on their facility's specific CHP, methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released), the physical and health hazards of chemicals in the work area and means to protect themselves from these hazards. Trained laboratory personnel must know shut-off procedures in case of an emergency. All SDSs must be made available to the employees.

E. General Procedures for Working With Chemicals

The risk of laboratory injuries can be reduced through adequate training, improved engineering, good housekeeping, safe work practice and personal behavior.

1. General Rules for Laboratory Work With Chemicals

(a) Assigned work schedules should be followed unless a deviation is authorized by the laboratory supervisor.
(b) Unauthorized experiments should not be performed.
(c) Plan safety procedures before beginning any operation.
(d) Follow standard operating procedures at all times.
(e) Always read the SDS and label before using a chemical.(f) Wear appropriate PPE at all times.
(g) To protect your skin from splashes, spills and drips, always wear long pants and closed-toe shoes.
(h) Use appropriate ventilation when working with hazardous chemicals.
(i) Pipetting should never be done by mouth.
(j) Hands should be washed with soap and water immediately after working with any laboratory chemicals, even if gloves have been worn.
(k) Eating, drinking, smoking, gum chewing, applying cosmetics, and taking medicine in laboratories where hazardous chemicals are used or stored should be strictly prohibited.
(l) Food, beverages, cups, and other drinking and eating utensils should not be stored in areas where hazardous chemicals are handled or stored.
(m) Laboratory refrigerators, ice chests, cold rooms, and ovens should not be used for food storage or preparation.
(n) Contact the laboratory supervisor, Principal Investigator, CHO or EHS office with all safety questions or concerns.
(o) Know the location and proper use of safety equipment.
(p) Maintain situational awareness.
(q) Make others aware of special hazards associated with your work.
(r) Notify supervisors of chemical sensitivities or allergies.
(s) Report all injuries, accidents, incidents, and near misses.
(t) Unauthorized persons should not be allowed in the laboratory.
(u) Report unsafe conditions to the laboratory supervisor or CHO.
(v) Properly dispose of chemical wastes.

Working Alone in the Laboratory

Working alone in a laboratory is dangerous and should be strictly avoided. There have been many tragic accidents that illustrate this danger. Accidents are unexpected by definition, which is why coworkers should always be present. Workers should coordinate schedules to avoid working alone.

Housekeeping

Housekeeping can help reduce or eliminate a number of laboratory hazards. Proper housekeeping includes appropriate labeling and storage of chemicals, safe and regular cleaning of the facility, and proper arrangement of laboratory equipment.

2. Nanoparticles and Nanomaterials

Nanoparticles and nanomaterials have different reactivities and interactions with biological systems than bulk materials, and understanding and exploiting these differences is an active area of research. However, these differences also mean that the risks and hazards associated with exposure to engineered nanomaterials are not well known. Because this is an area of ongoing research, consult trusted sources for the most up to date information available. Note that the higher reactivity of many nanoscale materials suggests that they should be treated as potential sources of ignition, accelerants, and fuel that could result in fire or explosion. Easily dispersed dry nanomaterials may pose the greatest health hazard because of the risk of inhalation. Operations involving these nanomaterials deserve more attention and more stringent controls than those where the nanomaterials are embedded in solid or suspended in liquid matrixes.

Consideration should be given to all possible routes of exposure to nanomaterials including inhalation, ingestion, injection, and dermal contact (including eye and mucous membranes). Avoid handling nanomaterials in the open air in a freeparticle state. Whenever possible, handle and store dispersible nanomaterials, whether suspended in liquids or in a dry particle form, in closed (tightly-sealed) containers. Unless cutting or grinding occurs, nanomaterials that are not in a free form (encapsulated in a solid or a nanocomposite) typically will not require engineering controls. If a synthesis is being performed to create nanomaterials, it is not enough to only consider the final material in the risk assessment, but consider the hazardous properties of the precursor materials as well.

To minimize laboratory personnel exposure, conduct any work that could generate engineered nanoparticles in an enclosure that operates at a negative pressure differential compared to the laboratory personnel breathing zone. Limited data exist regarding the efficacy of PPE and ventilation systems against exposure to nanoparticles. However, until further information is available, it is prudent to follow standard chemical hygiene practices. Conduct a hazard evaluation to determine PPE appropriate for the level of hazard according to the requirements set forth in OSHA's Personal Protective Equipment standard (29 CFR 1910.132).

3. Highly Toxic and Explosive/Reactive Chemicals/Materials

The use of highly toxic and explosive/ reactive chemicals and materials has been an area of growing concern. The frequency of academic laboratory incidents in the U.S. is an area of significant concern for the Chemical Safety Board (CSB). The CSB issued a case study on an explosion at Texas Tech University in Lubbock, Texas, which severely injured a graduate student handling a high-energy metal compound. Since 2001, the CSB has gathered preliminary information on 120 different university laboratory incidents that resulted in 87 evacuations, 96 injuries, and three deaths.

It is recommended that each facility keep a detailed inventory of highly toxic chemicals and explosive/reactive materials. There should be a record of the date of receipt, amount, location, and responsible individual for all acquisitions, syntheses, and disposal of these chemicals. A physical inventory should be performed annually to verify active inventory records. There should be a procedure in place to report security breaches, inventory discrepancies, losses, diversions, or suspected thefts.

Procedures for disposal of highly toxic materials should be established before any experiments begin, possibly even before the chemicals are ordered. The procedures should address methods for decontamination of any laboratory equipment that comes into contact with highly toxic chemicals. All waste should be accumulated in clearly labeled impervious containers that are stored in unbreakable secondary containment.

Highly reactive and explosive materials that may be used in the laboratory require appropriate procedures and training. An explosion can occur when a material undergoes a rapid reaction that results in a violent release of energy. Such reactions can happen spontaneously and can produce pressures, gases, and fumes that are hazardous. Some reagents pose a risk on contact with the atmosphere. It is prudent laboratory practice to use a safer alternative whenever possible.

If at all possible, substitutes for highly acute, chronic, explosive, or reactive chemicals should be considered prior to beginning work and used whenever possible.

4. Compressed Gas

Compressed gases expose laboratory personnel to both chemical and physical hazards. It is essential that these are monitored for leaks and have the proper labeling. By monitoring compressed gas inventories and disposing of or returning gases for which there is no immediate need, the laboratory can substantially reduce these risks. Leaking gas cylinders can cause serious hazards that may require an immediate evacuation of the area and activation of the emergency response system. Only appropriately trained hazmat responders may respond to stop a leaking gas cylinder under this situation.

F. Safety Recommendations—Physical Hazards

Physical hazards in the laboratory include combustible liquids, compressed gases, reactives, explosives and flammable chemicals, as well as high pressure/energy procedures, sharp objects and moving equipment. Injuries can result from bodily contact with rotating or moving objects, including mechanical equipment, parts, and devices. Personnel should not wear loose fitting clothing, jewelry, or unrestrained long hair around machinery with moving parts.

The Chemical Safety Board has identified the following key lessons for laboratories that address both physical and other hazards:

(1) Ensure that research-specific hazards are evaluated and then controlled by developing specific written protocols and training.

(2) Expand existing laboratory safety plans to ensure that all safety hazards, including physical hazards of chemicals, are addressed.

(3) Ensure that the organization's EHS office reports directly to an identified individual/office with organizational authority to implement safety improvements.

(4) Develop a verification program that ensures that the safety provisions of the CHP are communicated, followed, and enforced at all levels within the organization.
(5) Document and communicate all laboratory near-misses and previous incidents to track safety, provide opportunities for education and improvement to drive safety changes at the university.
(6) Manage the hazards unique to laboratory chemical research in the academic environment. Utilize available practice guidance that identifies and describes methodologies to assess and control hazards.
(7) Written safety protocols and training are necessary to manage laboratory risk.

G. Emergency Planning

In addition to laboratory safety issues, laboratory personnel should be familiar with established facility policies and procedures regarding emergency situations. Topics may include, but are not limited to:

(1) Evacuation procedures—when it is appropriate and alternate routes;
(2) Emergency shutdown procedures—equipment shutdown and materials that should be stored safely;
(3) Communications during an emergency—what to expect, how to report, where to call or look for information;
(4) How and when to use a fire extinguisher;
(5) Security issues—preventing tailgating and unauthorized access;
(6) Protocol for absences due to travel restrictions or illness;
(7) Safe practices for power outage;
(8) Shelter in place—when it is appropriate;
(9) Handling suspicious mail or phone calls;
(10) Laboratory-specific protocols relating to emergency planning and response;
(11) Handling violent behavior in the workplace; and
(12) First-aid and CPR training, including automated external defibrillator training if available.

It is prudent that laboratory personnel are also trained in how to respond to short-term, long-term and large-scale emergencies. Laboratory security can play a role in reducing the likelihood of some emergencies and assisting in preparation and response for others. Every institution, department, and individual laboratory should consider having an emergency preparedness plan. The level of detail of the plan will vary depending on the function of the group and institutional planning efforts already in place.

Emergency planning is a dynamic process. As personnel, operations, and events change, plans will need to be updated and modified. To determine the type and level of emergency planning needed, laboratory personnel need to perform a vulnerability assessment. Periodic drills to assist in training and evaluation of the emergency plan are recommended as part of the training program.

H. Emergency Procedures

(1) Fire alarm policy. Most organizations use fire alarms whenever a building needs to be evacuated—for any reason. When a fire alarm sounds in the facility, evacuate immediately after extinguishing all equipment flames. Check on and assist others who may require help evacuating.
(2) Emergency safety equipment. The following safety elements should be met:
a. A written emergency action plan has been provided to workers;
b. Fire extinguishers, eyewash units, and safety showers are available and tested on a regular basis; and
c. Fire blankets, first-aid equipment, fire alarms, and telephones are available and accessible.
(3) Chemical spills. Workers should contact the CHO or EHS office for instructions before cleaning up a chemical spill. All SDS and label instructions should be followed, and appropriate PPE should be worn during spill cleanup.
(4) Accident procedures. In the event of an accident, immediately notify appropriate personnel and local emergency responders. Provide an SDS of any chemical involved to the attending physician. Complete an accident report and submit it to the appropriate office or individual within 24 hours.
(5) Employee safety training program. New workers should attend safety training before they begin any activities. Additional training should be provided when they advance in their duties or are required to perform a task for the first time. Training documents should be recorded and maintained. Training should include hands-on instruction of how to use safety equipment appropriately.
(6) Conduct drills. Practice building evacuations, including the use of alternate routes. Practice shelter-in-place, including plans for extended stays. Walk the fastest route from your work area to the nearest fire alarm, emergency eye wash and emergency shower. Learn how each is activated. In the excitement of an actual emergency, people rely on what they learned from drills, practice and training.
(7) Contingency plans. All laboratories should have long-term contingency plans in place (e.g., for pandemics). Scheduling, workload, utilities and alternate work sites may need to be considered.

I. Laboratory Security

Laboratory security has evolved in the past decade, reducing the likelihood of some emergencies and assisting in preparation and response for others. Most security measures are based on the laboratory's vulnerability. Risks to laboratory security include, but are not limited to:

(1) Theft or diversion of chemicals, biologicals, and radioactive or proprietary materials, mission-critical or high-value equipment;
(2) Threats from activist groups;
(3) Intentional release of, or exposure to, hazardous materials;
(4) Sabotage or vandalism of chemicals or high-value equipment;
(5) Loss or release of sensitive information; and
(6) Rogue work or unauthorized laboratory experimentation. Security systems in the laboratory are used to detect and respond to a security breach, or a potential security breach, as well as to delay criminal activity by imposing multiple layered barriers of increasing stringency. A good laboratory security system will increase overall safety for laboratory personnel and the public, improve emergency preparedness by assisting with preplanning, and lower the organization's liability by incorporating more rigorous planning, staffing, training, and command systems and implementing emergency communications protocols, drills, background checks, card access systems, video surveillance, and other measures. The security plan should clearly delineate response to security issues, including the coordination of institution and laboratory personnel with both internal and external responders.

[76 FR 33609, June 8, 2011; 77 FR 17888, March 26, 2012; 78 FR 4325, Jan. 22, 2013]

1910.1450 APPENDIX B
REFERENCES (NON-MANDATORY)

The following references are provided to assist the employer in the development of a Chemical Hygiene Plan. The materials listed below are offered as non-mandatory guidance. References listed here do not imply specific endorsement of a book, opinion, technique, policy or a specific solution for a safety or health problem. Other references not listed here may better meet the needs of a specific laboratory.

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(b) Hazardous Substances Information:

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