Laboratory Safety

This course is designed to help make employers aware of the OSHA standards and best practices available to prevent injury and illness as well as protect workers from the diverse hazards encountered in primarily non-production laboratories, including exposure to chemical, biological, and radiological hazards.
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OSHAcademy Course 757 Study Guide

Laboratory Safety

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Contact OSHAcademy to arrange for use as a training document.

This study guide is designed to be reviewed off-line as a tool for preparation to successfully complete OSHAcademy Course 757.

Read each module, answer the quiz questions, and submit the quiz questions online through the course webpage. You can print the post-quiz response screen which will contain the correct answers to the questions.

The final exam will consist of questions developed from the course content and module quizzes.

We hope you enjoy the course and if you have any questions, feel free to email or call:

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Course Introduction

More than 500,000 workers are employed in laboratories in the U.S. The laboratory environment can be a hazardous place to work. Laboratory workers are exposed to numerous potential hazards, including chemical, biological, physical and radioactive hazards, as well as musculoskeletal stresses.

Laboratory safety is governed by numerous local, state and federal regulations. Over the years, OSHA has promulgated rules and published guidance to make laboratories increasingly safe for personnel. This document is intended for supervisors, principal investigators and managers who have the primary responsibility for maintaining laboratories under their supervision as safe, healthy places to work and for ensuring that applicable health, safety and environmental regulations are followed. Worker guidance in the form of Fact Sheets and QuickCards™ is also provided for certain hazards that may be encountered in laboratories. There are several primary OSHA standards that apply to laboratories and these are discussed below. There are also other OSHA standards that apply to various aspects of laboratory activities and these are referenced in this course.

The Occupational Exposure to Hazardous Chemicals in Laboratories standard (29 CFR 1910.1450) was created specifically for non-production laboratories. For those hazards that are not covered by a specific OSHA standard, OSHA often provides guidance on protecting workers from these hazards.

This course is designed to help make employers aware of the OSHA standards as well as OSHA guidance that is available to protect workers from the diverse hazards encountered in laboratories.
Module 1: The Standards

The OSH Act of 1970

Section 5(a)(1) of the Occupational Safety and Health Act of 1970 (OSH Act), the General Duty Clause, requires that employers:

“shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or likely to cause death or serious physical harm to his employees.”

This means employers are responsible to protect employees from all workplace hazards they recognize, not just specific hazards or hazardous operations.

For example, best practices that are issued by non-regulatory organizations such as the National Institute for Occupational Safety and Health (NIOSH), the Centers for Disease Control and Prevention (CDC), the National Research Council (NRC), and the National Institutes of Health (NIH), can be enforceable under section 5(a)(1) of the OSH Act of 1970.

Applicable OSHA Standards

The primary OSHA standards that apply to all non-production laboratories are listed below. Although this is not a complete list, it includes standards that cover the major hazards that workers are most likely to encounter in their daily tasks.

Employers must be fully aware of these standards and must implement all aspects of the standards that apply to specific laboratory work conditions in their facilities.
**29 CFR 1910.1450**

This standard is commonly referred to as the Laboratory Standard. The Laboratory Standard applies to all individuals engaged in laboratory use of hazardous chemicals. “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 non-production basis.

**Laboratory Defined**

It’s important to know that not all laboratories are covered by the Laboratory Standard. For example, most quality control laboratories are not covered under the standard. These laboratories are usually adjuncts of production operations, which typically perform repetitive procedures for the purpose of assuring reliability of a product or a process.

On the other hand, laboratories that conduct research and development and related analytical work are subject to the requirements of the Laboratory Standard, regardless of whether or not they are used only to support manufacturing.

**Laboratory Use of Hazardous Chemicals**

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

- Chemical manipulations are carried out on a “laboratory scale” (i.e., work with substances in which the containers used for reactions, transfers, and other handling of substances is designed to be easily handled by one person).

- Multiple chemical procedures or chemicals are used.

- The procedures involved are not part of a production process, nor do they in any way simulate a production process.

- Protective laboratory practices and equipment are available and in common use to minimize the potential for worker exposure to hazardous chemicals.
The Laboratory Standard consists of five major elements:

- hazard identification
- chemical hygiene plan
- information and training
- exposure monitoring
- medical consultation and examinations

**Hazard Identification**

Each laboratory must identify which hazardous chemicals will be encountered by its workers. Hazardous chemicals can be serious physical and/or health threats to workers in clinical, industrial, and academic laboratories. Hazardous laboratory chemicals include:

- cancer-causing agents (carcinogens);
- toxins that may affect the liver, kidney, or nervous system;
- irritants, corrosives, and sensitizers; and
- agents that act on the blood system or damage the lungs, skin, eyes, or mucous membranes.

OSHA rules limit all industry exposures to approximately 400 substances.

**Chemical Hygiene Plan**

The standard requires the employer to designate a Chemical Hygiene Officer and have a written Chemical Hygiene Plan (CHP), and actively verify that it remains effective. The CHP must include provisions for:
• worker training
• chemical exposure monitoring where appropriate
• medical consultation when exposure occurs
• criteria for the use of personal protective equipment (PPE) and engineering controls
• special precautions for particularly hazardous substances
• a requirement for a Chemical Hygiene Officer responsible for implementation of the CHP

The CHP must be tailored to reflect the specific chemical hazards present in the laboratory where it is to be used. Laboratory personnel must receive training regarding the Laboratory Standard, the CHP, and other laboratory safety practices, including exposure detection, physical and health hazards associated with chemicals, and protective measures. See a sample CHP and more information on CHP elements.

Information and Training

Laboratory workers must be provided with information and training relevant to the hazards of the chemicals present in their laboratory. The training must be provided at the time of initial assignment to a laboratory and prior to assignments involving new exposure situations.

The employer must inform workers about the following:

• The content of the OSHA Laboratory Standard and its appendices (the full text must be made available);

• The location and availability of the Chemical Hygiene Plan;

• Permissible exposure limits (PELs) for OSHA-regulated substances, or recommended exposure levels for other hazardous chemicals where there is no applicable standard;
• Signs and symptoms associated with exposure to hazardous chemicals in the laboratory; and

• The location and availability of reference materials on the hazards, safe handling, storage and disposal of hazardous chemicals in the laboratory, including, but not limited to, Safety Data Sheets (SDS).

Training must include the following:

• Methods and observations used to detect the presence or release of a hazardous chemical (These may include employer monitoring, continuous monitoring devices, and familiarity with the appearance and odor of the chemicals);

• The physical and health hazards of chemicals in the laboratory work area;

• The measures that workers can take to protect themselves from these hazards, including protective equipment, appropriate work practices, and emergency procedures;

• Applicable details of the employer’s written Chemical Hygiene Plan;

• Retraining, if necessary.

**Exposure Monitoring**

OSHA has established permissible exposure limits (PELs) for hundreds of chemical substances. A PEL is the chemical-specific concentration in inhaled air that is intended to represent what the average, healthy worker may be exposed to daily for a lifetime of work without significant adverse health effects.

The employer must ensure that workers’ exposures to OSHA-regulated substances do not exceed the PEL. However, most of the OSHA PELs were adopted soon after the Agency was first created in 1970 and were based upon scientific studies available at that time. Since science has continued to move forward, in some cases, there may be health data that suggests a hazard to workers below the levels permitted by the OSHA PELs.
Other agencies and organizations have developed and updated recommended occupational exposure limits (OELs) for chemicals regulated by OSHA, as well as other chemicals not currently regulated by OSHA. The American Conference of Governmental Industrial Hygienists (ACGIH), the American Industrial Hygiene Association (AIHA), the National Institute for Occupational Safety and Health (NIOSH), as well as some chemical manufacturers have established OELs to assess safe exposure limits for various chemicals.

Employers must conduct exposure monitoring, through air sampling, if there is reason to believe that workers may be exposed to chemicals above the action level or, in the absence of an action level, the PEL.

The employer should notify workers of the results of any monitoring within 15 working days of receiving the results. Some OSHA chemical standards have specific provisions regarding exposure monitoring and worker notification. Employers should consult relevant standards to see if these provisions apply to their workplace.

**Medical Consultation and Examinations**

Employers must do the following:

- Provide all exposed workers with an opportunity to receive medical attention by a licensed physician, including any follow-up examinations the examining physician determines to be necessary.

- Provide an opportunity for a medical consultation by a licensed physician whenever a laboratory worker may have experienced hazardous exposure from a spill, leak, explosion, or other occurrence. The licensed physician must determine whether a medical examination is needed.

- Provide an opportunity for a medical examination by a licensed physician whenever a worker develops signs or symptoms associated with a hazardous chemical to which he or she may have been exposed to in the laboratory.

- Establish medical surveillance for a worker as required by the particular standard when exposure monitoring reveals exposure levels routinely exceeding the OSHA action level or, in the absence of an action level, the PEL for an OSHA regulated substance.
• Provide the examining physician with the identity of the hazardous chemical(s) to which the individual may have been exposed, and the conditions under which the exposure may have occurred, including quantitative data, where available, and a description of the signs and symptoms of exposure the worker may be experiencing.

• Provide all medical examinations and consultations without cost to the worker, without loss of pay, and at a reasonable time and place.

• Ensure a copy of the examining physician’s written opinion is provided to the exposed worker.

**Recordkeeping**

Employers must also maintain an accurate record of exposure monitoring activities and exposure measurements as well as medical consultations and examinations, including medical tests and written opinions. Employers generally must maintain worker exposure records for 30 years and medical records for the duration of the worker’s employment plus 30 years, unless one of the exemptions listed in 29 CFR 1910.1020(d)(1)(i)(A)-(C) applies. Such records must be maintained, transferred, and made available to an individual’s physician or made available to the worker or his/her designated representative upon request.

**Roles and Responsibilities in Implementing the Laboratory Standard**

The following are the National Research Council’s recommendations concerning the responsibilities of various individuals for chemical hygiene in laboratories.

**Chief Executive Officer**

• Bears ultimate responsibility for chemical hygiene within the facility.

• Provides continuing support for institutional chemical hygiene.

**Chemical Hygiene Officer**

• Develops and implements appropriate chemical hygiene policies and practices.

• Monitors procurement, use, and disposal of chemicals used in the lab.
• Ensures that appropriate audits are maintained.

• Helps project directors develop precautions and adequate facilities.

• Knows the current legal requirements concerning regulated substances.

• Seeks ways to improve the chemical hygiene program.

**Laboratory Supervisors**

• Have overall responsibility for chemical hygiene in the laboratory.

• Ensure that laboratory workers know and follow the chemical hygiene rules.

• Ensure that protective equipment is available and in working order.

• Ensure that appropriate training has been provided.

• Provide regular, formal chemical hygiene and housekeeping inspections, including routine inspections of emergency equipment.

• Know the current legal requirements concerning regulated substances.

• Determine the required levels of PPE and equipment.

• Ensure that facilities and training for use of any material being ordered are adequate.

**Laboratory Workers**

• Plan and conduct each operation in accord with the facility’s chemical hygiene procedures, including use of PPE and engineering controls, as appropriate.

• Develop good personal chemical hygiene habits.

• Report all accidents and potential chemical exposures immediately.

**Students**
Witnessing lab procedures gone awry may make students think twice about some of their own safety shortcomings. Featuring Sue Bober, Schaumburg High School, IL. This video is part of the Flinn Scientific Teaching Chemistry video series. More than 126 professional development videos for chemistry teachers are available at http://elearning.flinnsci.com.

Module 1 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. According to the OSH Act of 1970, each employer must furnish to each of his employees employment and a place of employment which are free from _____.
   a. health issues
   b. recognized hazards
   c. confirmed safety hazards
   d. hazards affecting employees

2. Which of the following is true for laboratories covered by OSHA’s Laboratory Standard?
   a. Relatively small quantities of hazardous chemicals are used on a non-production basis.
   b. Large quantities of hazardous chemicals are present and create multiple exposures.
   c. Large quantities of hazardous chemicals for use in building maintenance are covered.
   d. Small quantities are used in quality control laboratories for testing products.
3. Which of the following is one of the required components in a laboratory Chemical Hygiene Plan?

   a. a chemical design or redesign procedure
   b. a five-point chemical reduction process
   c. a Chemical Hygiene Officer
   d. an exposure control committee

4. The _____ is the OSHA term describing the chemical-specific concentration of inhaled air a healthy worker may be exposed to daily for a lifetime of work without significant adverse health effects.

   a. Lifetime Exposure Limit (LEL)
   b. Long-Term Permissible Concentration (LTPC)
   c. Chronic Inhalation Level (CIL)
   d. Permissible Exposure Limit (PEL)

5. Who is responsible for providing regular, formal chemical hygiene and housekeeping inspections, including routine inspections of emergency equipment?

   a. Laboratory Supervisor
   b. Chemical Hygiene Officer
   c. Laboratory Worker
   d. All students
Module 2: Related OSHA Standards


This standard is also called the HazCom Standard. It requires evaluating the potential hazards of chemicals, and communicating information concerning those hazards and appropriate protective measures to employees. The standard includes provisions for:

- developing and maintaining a written hazard communication program for the workplace, including lists of hazardous chemicals present;
- labeling of containers of chemicals in the workplace, as well as containers of chemicals being shipped to other workplaces;
- preparation and distribution of Safety Data Sheets (SDSs) to workers and downstream employers; and
- development and implementation of worker training programs regarding hazards of chemicals and protective measures.

The standard also requires manufacturers and importers of hazardous chemicals to provide Safety Data Sheets to users of the chemicals describing potential hazards and other information. They must also attach hazard warning labels to containers of the chemicals. Employers must make SDSs available to workers. They must also train their workers in the hazards caused by the chemicals workers are exposed to and the appropriate protective measures that must be used when handling the chemicals.

For additional training on this topic, be sure to check out Course 705 Hazard Communication Program.

The BPP standard requires employers to protect workers from infection with human bloodborne pathogens in the workplace. The standard covers all workers with “reasonably anticipated” exposure to blood or other potentially infectious materials (OPIM).

It requires that information and training be provided:

- before the worker begins work that may involve occupational exposure to bloodborne pathogens
- annually
- before a worker is offered a hepatitis B vaccination

The Bloodborne Pathogens standard also requires advance information and training for all workers in research laboratories who handle human immunodeficiency virus (HIV) or hepatitis B virus (HBV).

The employer must develop a written exposure control plan (ECP) to provide a safe and healthy work environment and is allowed some flexibility in accomplishing this goal. Among other things, the ECP requires employers to:

- Make an exposure determination.
- Establish procedures for evaluating incidents.
- Determine a schedule for implementing the standard’s requirements, including engineering and work practice controls.
- Provide and pay for appropriate PPE for workers with occupational exposures.

Although the OSHA standard only applies to bloodborne pathogens, the protective measures in the standard (e.g., ECP, engineering and work practice controls, administrative controls, PPE, housekeeping, training, post-exposure medical follow-up) are the same measures for effectively controlling exposure to other biological agents.
For additional training on bloodborne pathogens safety, take Course 655 Bloodborne Pathogens in the Workplace and Course 755 Bloodborne Pathogens Program Management.


This standard requires employers to provide and pay for PPE and ensure that it is used wherever hazards are encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact. The types of hazards covered include:

- hazards of processes or environment
- chemical hazards
- radiological hazards
- mechanical irritants

In order to determine whether and what PPE is needed, the employer must assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of PPE. Based on that assessment, the employer must select appropriate PPE that will protect the affected worker from the hazards and select PPE that properly fits each affected employee.

Employers must provide training for workers required to use PPE that addresses when and what PPE is necessary, how to wear and care for PPE properly, and the limitations of PPE. Of course, the training should also include why the use of the specific PPE is important.

**The Eye and Face Protection Standard (29 CFR 1910.133)**

This standard requires employers to ensure that each affected worker uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.
The Respiratory Protection Standard (29 CFR 1910.134)

This standard requires that a respirator be provided to each worker when such equipment is necessary to protect the health of such individual. The employer must provide respirators that are appropriate and suitable for the purpose intended. The employer is responsible for establishing and maintaining a respiratory protection program that includes the following:

- selection of respirators for use in the workplace;
- medical evaluations of workers required to use respirators;
- fit testing for tight-fitting respirators;
- proper use of respirators during routine and emergency situations;
- procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing and discarding of respirators;
- procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators;
- training of workers in respiratory hazards that they may be exposed to during routine and emergency situations;
- training of workers in the proper donning and doffing of respirators, and any limitations on their use and maintenance; and
- regular evaluation of the effectiveness of the program.

The Hand Protection Standard (29 CFR 1910.138)

This standard requires employers to select and ensure that workers use appropriate hand protection when their hands are exposed to hazards such as:

- those from skin absorption of harmful substances
- severe cuts or lacerations
- severe abrasions
- punctures
- chemical burns
- thermal burns
- harmful temperature extremes

Employers must base the selection of appropriate hand protection on an evaluation of the performance characteristics of the hand protection relative to the task(s) to be performed, conditions present, duration of use, and the hazards and potential hazards identified.


Often called the “Lockout/Tagout” standard, this regulation establishes basic requirements for locking and/or tagging out equipment while installation, maintenance, testing, repair, or construction operations are in progress. The primary purpose of the standard is to protect workers from the unexpected energization or startup of machines or equipment, or release of stored energy. The procedures apply to the shutdown of all potential energy sources associated with machines or equipment, including pressures, flows of fluids and gases, electrical power, and radiation.

- When laboratory workers are using large analyzers and other equipment, their potential exposure to electrical hazards associated with this equipment must be assessed by employers and appropriate precautions taken.

- Worker exposure to wet floors, spills or clutter can lead to slips, trips, falls and other possible injuries. Employers must assure that these hazards are minimized.

- While large laboratory fires are rare, there is the potential for small bench-top fires, especially in laboratories using flammable solvents.

**Foot Protection**

Foot protection is designed to prevent injury and illness from exposure to corrosive chemicals, heavy objects, and electrical shock. Foot protection should also provide adequate traction on wet floors. The most vulnerable portion of the body is feet if a corrosive chemical or heavy
object falls on the floor. Therefore, foot protection should completely cover and protect the foot.

Foot protection should be selected to protect against the specific hazards in the laboratory. Caution should be used when wearing fabric shoes because they readily absorb chemical substances. Be sure to remove footwear immediately if chemicals spill on fabric shoes.

The following are recommended types of footwear:

- Safety shoes protect against crushing injuries caused by impact from any object during work.
- Treated shoes, rubber boots or shoe covers protect against corrosive chemicals.
- Insulated shoes protect against electric shock.
- Rubber boots with slip resistant outer soles provide traction when floors are wet.
Module 2 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. Which of the following requires evaluating the potential hazards of chemicals, and communicating information concerning those hazards and appropriate protective measures to employees?
   - a. Bloodborne Pathogens Standard
   - b. Process Safety Standard
   - c. Hazard Communication Standard
   - d. Hazardous Wasted and Recovery Standard

2. Which standard covers all workers with “reasonably anticipated” exposure to blood or other potentially infectious materials (OPIM)?
   - a. Bloodborne Pathogens Standard
   - b. Process Safety Standard
   - c. Hazard Communication Standard
   - d. Hazardous Wasted and Recovery Standard

3. Which of the following is NOT one of the components of the Respiratory Protection Standard?
   - a. Safety data sheets
   - b. Fit testing
   - c. Training
   - d. Medical evaluations
4. The primary purpose of the Lockout/Tagout Standard is to protect workers from _____.
   a. inadvertent equipment damage to electrical shutdown
   b. unexpected energization or startup of machines or equipment
   c. unauthorized persons who attempt to enter the laboratory
   d. unnecessary use of electrical equipment to reduce carbon credits

5. Foot protection is necessary in the laboratory to prevent injuries from exposure to all the following EXCEPT _____.
   a. corrosive chemicals
   b. heavy objects
   c. electrical shock
   d. poor posture
Module 3: Controlling Laboratory Hazards

The Hierarchy of Controls

There are many different types of hazards in the lab. Hazards are generally categorized into two types: 1) hazardous conditions and 2) unsafe work practices/behaviors.

- Hazardous conditions include unsafe materials, equipment, environment and employees.
- Unsafe work practices and behaviors include allowing untrained workers to perform hazardous tasks, taking unsafe shortcuts, horseplay, or long work schedules.

To combat these hazardous conditions and unsafe work practices, control strategies, called the "Hierarchy of Controls," have been developed.

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 workers to reduce their exposure. The types of measures that may be used to protect laboratory workers, prioritized from the most effective to least effective, are:

1. Elimination
2. Substitution
3. Engineering controls
4. Administrative controls
5. Personal protective equipment

The idea behind this hierarchy is that the control methods at the top of the list are potentially more effective and protective than those at the bottom.
• The first three methods eliminate or reduce the hazard itself.

• The last two methods attempt to control exposure to the hazard.

Following the hierarchy normally leads to the implementation of inherently safer systems, ones where the risk of illness or injury have been substantially reduced. Let's take a closer look at the hierarchy of control strategies.

**Elimination and Substitution**

Elimination and substitution, while most effective at reducing hazards, also tend to be the most difficult to implement in an existing process. If the process is still at the design or development stage, elimination and substitution of hazards may be inexpensive and simple to implement. For an existing process, major changes in equipment and procedures may be required to eliminate or substitute for a hazard.

These strategies are considered first because they have the potential of completely eliminating the hazard, thus greatly reducing the probability of an accident. Redesigning or replacing equipment or machinery may be expensive, but remember the average direct and indirect cost of a lost work time injury is over $39,000 and more than a million dollars to close a fatality claim.

Some examples of these two strategies include:

• Removing the source of excessive temperatures, noise, or pressure

• Substituting a toxic chemical with a less toxic or non-toxic chemical

**Engineering Controls**

These controls focus on eliminating or reducing the actual source of the hazard, unlike other control strategies that generally focus on employee exposure to the hazard. The basic concept behind engineering controls is that, to the extent feasible, the work environment and the job itself should be designed to eliminate hazards or reduce exposure to hazards. While this approach is called engineering controls, it does not necessarily mean that an engineer is required to design the control.
Why Engineering Controls?

Although hazardous conditions directly account for only about 3% of all workplace injuries, top priority should be given to eliminating them. If elimination or substitution is not possible, OSHA law requires employers to attempt to remove hazards through the use of feasible engineering controls because they also have the potential to totally eliminate hazards in the lab.

Engineering controls do not necessarily have to be expensive or complicated. They can be quite simple in some cases. Engineering controls are based on the following broad strategies:

1. If feasible, **design or redesign** the tools, equipment, machinery, materials and/or facility.
2. **Enclose** the hazard to prevent exposure in normal operations; and
3. If complete enclosure is not feasible, establish **barriers** or local **ventilation** to reduce exposure to the hazard in normal operations.

Enclosure of Hazards

When you cannot remove a hazard and cannot replace it with a less hazardous alternative, the next best control in the laboratory is enclosure. Enclosing a hazard usually means that there is no hazard exposure to workers during normal operations. There still will be potential exposure to workers during maintenance operations or if the enclosure system breaks down. For those situations, additional controls such as safe work practices or personal protective equipment (PPE) may be necessary to control exposure.

Some examples of enclosure designs are:

- Complete enclosure of moving parts of machinery;
- Complete containment of toxic liquids or gases from the beginning to end of a process;
- Glove box operations to enclose work with dangerous microorganisms, radioisotopes, or toxic substances; and
- Complete containment of noise, heat, or pressure producing processes with materials especially designed for those purposes.
Barriers or Local Ventilation

When the potential hazard cannot be removed, replaced, or enclosed, the next best approach is a barrier to exposure or, in the case of air contaminants, local exhaust ventilation to remove the contaminant from the workplace. This engineered control involves potential exposure to the worker even in normal operations. Consequently, it should be used only in conjunction with other types of controls, such as safe work practices designed specifically for the site condition and/or PPE. Examples include:

- Ventilation hoods in laboratory work
- Machine guarding (including electronic barriers)
- Isolation of a process in an area away from workers
- Baffles used as noise-absorbing barriers
- Nuclear radiation or heat shields

If elimination, substitution or engineering controls eliminate the hazard, it may also remove the need to control employee behaviors through the use of administrative controls. Remember:

*No hazard... no exposure... no accident.*

Administrative Controls

Administrative controls are aimed at reducing employee exposure to hazards that engineering controls fail to eliminate. Administrative controls work by designing safe work practices into job procedures and adjusting work schedules. Ultimately, effective administrative controls will successfully eliminate the human behaviors that result in most workplace accidents. Examples include:

- Developing a Chemical Hygiene Plan, and
- Developing Standard Operating Procedures for chemical handling.

Administrative controls are only as effective as the safety management system that supports them. It’s always better to eliminate the hazard so that you don’t have to rely on management
controls that tend to work only as long as employees behave. Here’s an important principle that reflects this idea.

*Any system that relies on human behavior is inherently unreliable.*

To make sure management controls are effective in the long term, they must be designed from a base of solid hazard analysis and sustained by a supportive safety culture. They then must be accompanied by adequate resources, training, supervision, and appropriate consequences. Remember, administrative controls should be used in conjunction with, and not as a substitute for, more effective or reliable engineering controls. Now, let's look at examples of some administrative controls.

**Safe Work Practices**

Safe work practices may be quite specific or general in their applicability. They may be a very important part of a single job procedure or applicable to many jobs in the workplace. Safe work practices include:

- removing tripping, blocking, and slipping hazards
- removing accumulated toxic dust on surfaces
- wetting down surfaces to keep toxic dust out of the air
- using safe lifting techniques
- maintaining equipment and tools in good repair
- using personal protective equipment (PPE)

Other safe work practices apply to specific jobs in the workplace and involve specific procedures for accomplishing a job. To develop safe procedures, you conduct a job hazard analysis (JHA). If, during the JHA, you determine that a procedure presents hazards to the worker, you would decide that a training program is needed. We recommend using the JHA as a tool for training your workers in the new procedures. A training program may be essential if your employees are working with highly toxic substances or in dangerous situations.
Personal Protective Equipment (PPE)

Using personal protective equipment is a very important safe work practice. It’s important to remember, like other administrative controls, the use of PPE does not control the hazard itself, but rather it merely controls exposure to the hazard by setting up a barrier between the employee and the hazard. Use of PPE may also be appropriate for controlling hazards while engineering controls are being installed or work practices developed.

PPE Drawbacks

The limitations and drawbacks of safe work practices also apply to PPE. Employees need training in why the PPE is necessary and how to use and maintain it. It also is important to understand that PPE is designed for specific functions and are not suitable in all situations. For example, no one type of glove or apron will protect against all solvents. To pick the appropriate glove or apron, you should refer to recommendations on the safety data sheets of the chemicals you are using.

Your employees need positive reinforcement and fair, consistent enforcement of the rules governing PPE use. Some employees may resist wearing PPE according to the rules, because some PPE is uncomfortable and puts additional stress on employees, making it unpleasant or difficult for them to work safely. This is a significant drawback, particularly where heat stress is already a factor in the work environment. An ill-fitting or improperly selected respirator is particularly hazardous, since respirators are used only where other feasible controls have failed to eliminate a hazard.

Interim Measures

When a hazard is recognized, the preferred correction or control cannot always be accomplished immediately. However, in virtually all situations, interim measures can be taken to eliminate or reduce worker risk. These can range from taping down wires that pose a tripping hazard to actually shutting down an operation temporarily.

The importance of taking these interim protective actions cannot be overemphasized. There is no way to predict when a hazard will cause serious harm, and no justification to continue exposing workers unnecessarily to risk. By the way, OSHA believes there is always some kind of interim measure that can be used to temporarily reduce or remove a hazard.
Maintenance Strategies to Control Hazards

What two general types of maintenance processes are needed?

- Preventive maintenance to make sure equipment and machinery operates safely and smoothly
- Corrective maintenance to make sure equipment and machinery gets back into safe operation quickly

Hazard Tracking Procedures

An essential part of any day-to-day safety and health effort is the correction of hazards that occur in spite of your overall prevention and control program. Documenting these corrections is equally important, particularly for larger sites.

Documentation is important because:

- It keeps management and safety staff aware of the status of long-term correction items.
- It provides a record of what occurred, should the hazard reappear at a later date.
- It provides timely and accurate information that can be supplied to an employee who reported the hazard.

Final Thoughts

The hierarchy of controls is the standard system of strategies to effectively eliminate workplace hazards. Remember, the first question to ask when considering ways to eliminate a hazard is, "can we apply engineering controls?" You may need to use a combination of strategies to effectively eliminate the hazard. Whatever it takes, do it. You are not just saving a life... you are saving a father, a mother, a son, or a daughter... you are saving a family. It's worth the effort.
Module 3 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. **To combat these hazardous conditions and unsafe work practices in the laboratory, control strategies, called the _____ have been developed?**
   - a. Engineering controls
   - b. Hierarchy of Controls
   - c. Administrative controls
   - d. Substitution

2. **Elimination, as a hazard control strategy is considered the top priority because it has the potential to do which of the following?**
   - a. Elimination addresses conditions as well as behavior
   - b. Elimination can completely eliminate the hazard
   - c. Elimination may completely eliminate exposure
   - d. Elimination cost more but is less expensive in the long run

3. **Which of the following hazard control strategies is aimed at reducing employee exposure to hazards that other controls fail to eliminate?**
   - a. Engineering controls
   - b. Hierarchy of Controls
   - c. Administrative controls
   - d. Substitution

4. **There is usually no hazard exposure to workers during normal operations by _____.**
   - a. enclosing a hazard
   - b. proper ventilation
   - c. using warning cones
   - d. proper lockout/tagout
5. To pick the appropriate glove or apron, you should refer to recommendations on the _____ of the chemicals you are using.

   a. PPE label
   b. chemical label
   c. manufacturer’s brochure
   d. safety data sheets
Module 4: Chemical Hazards in the Laboratory

Introduction

Each laboratory must identify which hazardous chemicals will be encountered by its workers. All containers for chemicals must be clearly labeled. The employer must ensure that workers do not use, store, or allow any other person to use or store, any hazardous substance in the laboratory if the container does not meet the labeling requirements outlined in the Hazard Communication Standard. Labels on chemical containers must not be removed or defaced.

Hazard Communication and Safety Data Sheets

Safety Data Sheets (SDSs) for chemicals received by the laboratory must be supplied by the manufacturer, distributor, or importer and must be maintained and readily accessible to laboratory workers. SDSs are written or printed materials concerning a hazardous chemical. Employers must have a SDS in the workplace for each hazardous chemical in use.

The United States is participating in the Global Harmonization System of Classifying and Labeling Chemicals (GHS) process and has adopted the GHS in its HazCom 2012 standard (29 CFR 1910.1200).

The GHS is a system that defines and classifies the hazards of chemical products, and communicates health and safety information on labels and Safety Data Sheets.

Chemical Hygiene Plan (CHP)

As we mentioned earlier, each laboratory should develop a Chemical Hygiene Plan, or CHP. The purpose of the CHP is to provide guidelines for prudent practices and procedures for the use of chemicals in the laboratory. The Laboratory standard requires that the CHP set forth procedures, equipment, PPE and work practices capable of protecting workers from the health hazards presented by chemicals used in the laboratory. See a sample CHP and more information on CHP elements.
**Specific Chemical Hazards**

**Air Contaminants in the Laboratory**

OSHA’s Air Contaminants standard (29 CFR 1910.1000) provides rules for protecting workers from airborne exposure to more than 400 chemicals. Several of these chemicals are commonly used in laboratories and include: toluene, xylene, and acrylamide.

**Toluene** and **xylene** are solvents used to fix tissue specimens and rinse stains. They are primarily found in histology, hematology, microbiology and cytology laboratories.

The amount of toluene that a worker breathes over a work day is determined by the concentration in the air, and the length of time the worker is in that atmosphere. Recommendations for exposure limits have been made by the National Institute for Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists. The Hazard Communication Standard requires that the Threshold Limit Value (TLV) be disclosed on a safety data sheet.

For more information on Toluene and Xylene, see [OSHA’s Safety and Health Topics page on Toluene](https://www.osha.gov/safetyandhealth-topics/at-exposure-by-skin-contact.html) and the [Agency for Toxic Substances & Disease Registry](https://www.atsdr.cdc.gov/toxprofile/tpid2241.html).

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<thead>
<tr>
<th>Exposure routes</th>
<th>Symptoms</th>
<th>Target Organs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhalation; Ingestion;</td>
<td>Irritation of eyes, nose;</td>
<td>Eyes; Skin;</td>
</tr>
<tr>
<td>Skin and/or eye contact;</td>
<td>Weakness, exhaustion, confusion, euphoria,</td>
<td>Respiratory system;</td>
</tr>
<tr>
<td>Skin absorption.</td>
<td>headache;</td>
<td>Central nervous system;</td>
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<td></td>
<td>Dilated pupils, tearing;</td>
<td>Liver; Kidneys.</td>
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<td></td>
<td>Anxiety;</td>
<td></td>
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<td>Muscle fatigue;</td>
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<td></td>
<td>Insomnia;</td>
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<td></td>
<td>Tingling, pricking, or numbness of skin;</td>
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<td>Dermatitis;</td>
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<td></td>
<td>Liver, kidney damage.</td>
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The Environmental Protection Agency reports that commercial or mixed xylene usually contains about 40-65% m-xylene and up to 20% each of o-xylene and p-xylene and ethylbenzene.
Xylenes are released into the atmosphere as fugitive emissions from industrial sources, from auto exhaust, and through volatilization from their use as solvents.

Acute (short-term) inhalation exposure to mixed xylenes in humans results in irritation of the eyes, nose, and throat, gastrointestinal effects, eye irritation, and neurological effects. Chronic (long-term) inhalation exposure of humans to mixed xylenes results primarily in central nervous system (CNS) effects, such as headache, dizziness, fatigue, tremors, and incoordination; respiratory, cardiovascular, and kidney effects have also been reported.

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</tr>
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<tbody>
<tr>
<td>Inhalation; Ingestion; Skin</td>
<td>Irritation of eyes, skin, nose, throat; Dizziness, excitement, drowsiness, incoherence. staggering gait; Corneal vacuolization (cell debris); Anorexia, nausea, vomiting, abdominal pain; Dermatitis.</td>
<td>Eyes; Skin; Respiratory system; Central nervous system; Gastrointestinal; Blood; Liver; Kidneys.</td>
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</table>

**Acrylamide** is usually found in research laboratories and is used to make polyacrylamide gels for separations of macromolecules (e.g., DNA, proteins).

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</tr>
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<tbody>
<tr>
<td>Inhalation; Ingestion; Skin</td>
<td>Irritation of eyes, skin; Ataxia (staggering gait), numb limbs, tingling, pricking, or numbness of skin; Muscle weakness; Absence of deep tendon reflex; Hand sweating; Tearing, Drowsiness; Reproductive effects; Potential occupational carcinogen.</td>
<td>Eyes; Skin; Central nervous system; Peripheral nervous system; Reproductive system (in animals: tumors of the lungs, testes, thyroid and adrenal glands).</td>
</tr>
</tbody>
</table>
The International Agency for Research on Cancer (IARC) has classified acrylamide as a possible human carcinogen (Group 2B); the American Conference of Governmental Industrial Hygienists (ACGIH) lists acrylamide as a suspected human carcinogen.

To prevent worker exposure, employers must implement a written program for chemicals that workers are exposed to and that meet the requirements of the Hazard Communication standard. This program must contain provisions for worker training, warning labels and access to Safety Data Sheets (SDSs).

For more information on Acrylamide, see the [Agency for Toxic Substances & Disease Registry](https://www.atsdr.cdc.gov).

**Formaldehyde**

Formaldehyde is used as a fixative and is commonly found in most laboratories. The employer must ensure that no worker is exposed to an airborne concentration of formaldehyde which exceeds 0.75 parts formaldehyde per million parts of air (0.75 ppm) as an 8-hour time weighted average (TWA), see [29CFR1910.1048(c)[1]].

<table>
<thead>
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</tr>
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<tbody>
<tr>
<td>Inhalation; Ingestion; Skin and/or eye contact.</td>
<td>Irritation of eyes, skin, nose, throat, respiratory system; Tearing; Coughing; Wheezing; Dermatitis; Potential occupational nasal carcinogen.</td>
<td>Eyes; Skin; Respiratory system.</td>
</tr>
</tbody>
</table>

The Hazard Communication Standard requires employers to maintain a SDS, which manufacturers or distributors of formaldehyde are required to provide. The SDS must be kept in an area that is accessible to workers that may be exposed to formaldehyde.

Employers must provide the following to workers to prevent exposure:

- Appropriate PPE must be provided.
Acceptable eye wash facilities within the immediate work area for emergency use, if there is any possibility that a worker’s eyes may be splashed with solutions containing 0.1 percent or greater formaldehyde.

For more information on Formaldehyde, See OSHA’s Safety and Health Topics page on Formaldehyde and the Agency for Toxic Substances & Disease Registry.

**Latex**

One of the most common chemicals that laboratory workers are exposed to is latex, a plant protein. The most common cause of latex allergy is direct contact with latex, a natural plant derivative used in making certain disposable gloves and other products. Some healthcare workers have been determined to be latex sensitive, with reactions ranging from localized dermatitis (skin irritation) to immediate, possibly life-threatening reactions. Under OSHA’s Personal Protective Equipment Standard (29 CFR 1910.132), the employer must ensure appropriate personal protective equipment (PPE) is accessible at the worksite or issued to workers.

Latex-free gloves, glove liners, powder-free gloves, or other similar alternatives are obtainable and must be readily accessible to those workers who are allergic to latex gloves or other latex-containing PPE.

Latex allergy should be suspected in workers who develop certain symptoms after latex exposure, including:

- nasal, eye, or sinus irritation
- hives or rash
- difficulty breathing
- coughing
- wheezing
- nausea
- vomiting
- diarrhea

An exposed worker who exhibits these symptoms should be evaluated by a physician or other licensed healthcare professional because further exposure could cause a serious allergic reaction.

Once a worker becomes allergic to latex, special precautions are needed to prevent exposures. Certain medications may reduce the allergic symptoms, but complete latex avoidance is the most effective approach.

Appropriate work practices should be used to reduce the chance of reactions to latex. If a worker must wear latex gloves, oil-based hand creams or lotions (which can cause glove deterioration) should not be used unless they have been shown to reduce latex-related problems and maintain glove barrier protection. After removing latex gloves, workers should wash their hands with a mild soap and dry them thoroughly.

For more information on latex, see OSHA’s Safety and Health Topics page and the CDC/NIOSH Safety and Health Topics page.
Module 4 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. The employer must ensure that workers do not use or store any hazardous substance in the laboratory if the container does not meet the labeling requirements outlined in the _____.
   a. Hazard Communication Standard
   b. OSH Act of 1970
   c. Hazardous Waste Standard
   d. Laboratory Best Practices Rule

2. Which of the following defines and classifies the hazards of chemical products, and communicates health and safety information on labels and Safety Data Sheets.
   a. World Safety Council Recommendations (WSCR)
   b. European Union Hazard Communication Standard (EUHC)
   c. Global Harmonization System of Classifying and Labeling Chemicals (GHS)
   d. Common Hazard Communication Labeling and Information System (CHCS)

3. OSHA’s Air Contaminants Standard provides rules for protecting workers from airborne exposure to _____.
   a. dust and molds
   b. removal and disposal of chemicals
   c. hazardous ventilation
   d. more than 400 chemicals
4. Exposure to all of the following can result in symptoms, including irritation of the eyes and skin, EXCEPT _____.
   
   a. toluene  
   b. xylene  
   c. formaldehyde  
   d. acrylamide

5. What must the employer do if a laboratory worker exhibits symptoms of an allergic reaction to latex?
   
   a. Reassign the worker to a job that does not require exposure to latex  
   b. Ensure the worker uses powder between skin and latex to reduce symptoms  
   c. Require the worker use latex-free gloves to test reaction  
   d. Make sure the worker is evaluated by a licensed healthcare professional

Module 5: Biological Hazards

Biological Agents (Other than Bloodborne Pathogens) and Biological Toxins

Many laboratory workers encounter daily exposure to biological hazards. These hazards are present in various sources throughout the laboratory such as blood and body fluids, culture specimens, body tissue and cadavers, and laboratory animals, as well as other workers.

Harmful biological agents are generally divided into either infectious agents or non-infectious agents. Infectious agents are:

- pathogenic bacteria  
- viruses  
- fungi

Non-infectious agents are called "toxins" and are produced from:

- infectious agents  
- other living organisms and plants
Biological agents (e.g., viruses, bacteria, fungi, and prions) and toxins have the potential to pose a severe threat to public health and safety, to animal or plant health, or to animal or plant products.

The agents and toxins that affect animal and plant health are also referred to as:

- high-consequence livestock pathogens and toxins
- non-overlap agents and toxins
- listed plant pathogens

Select agents and toxins are defined by lists that appear in sections 73.3 of Title 42 of the Code of Federal Regulations, sections 121.3 and 121.4 of Title 9 of the Code of Federal Regulations, section 331.3 of Title 7 of the Code of Federal Regulations, and Part 121, Title 9, Code of Federal Regulations.

Employers may use the list below as a starting point for technical and regulatory information about some of the most virulent and prevalent biological agents and toxins. The OSHA Safety and Health Topics Page entitled Biological Agents can be accessed at: www.osha.gov/SLTC/biologicalagents/index.html.

**Anthrax**

Anthrax is an acute infectious disease caused by a spore-forming bacterium called Bacillus Anthracis. It is generally acquired following contact with anthrax-infected animals or anthrax-contaminated animal products. Anthrax is receiving heightened attention because of its use as a biological warfare agent.

In October 2001, four workers died from inhalation of anthrax and an additional 13 developed cutaneous or inhalational disease as a result of intentional terrorist activity. In most cases seen thus far, the disease was linked to unexpected workplace exposures to anthrax spores contained in letters mailed through the United States Postal Service. Fortunately, the number of workplaces contaminated with the spores has also been quite limited. Nevertheless, employers and workers are concerned about possible exposure to Bacillus Anthracis in the workplace.
Risk Reduction Matrix

To help employers determine appropriate work practices and precautions, OSHA has divided workplaces and work operations into three risk zones, according to the likelihood of contamination with anthrax spores and employee exposure to them. These zones are called the green zone, the yellow zone, and the red zone.

- **Green Zone**: workplaces where contamination with anthrax spores is unlikely.
- **Yellow Zone**: workplaces where contamination with anthrax spores is possible.
- **Red Zone**: workplaces where public health or law enforcement authorities have stated that contamination with anthrax spores has been confirmed or is strongly suspected.

We show these zones within the shape of a pyramid to represent how the risk appears to be distributed. Based on information currently available, contamination with anthrax spores and exposure to the bacterium are unlikely in the vast majority of American workplaces, represented by the green zone.

Making Informed Decisions

This matrix is intended to help employers understand how to assess the risk of exposure to anthrax spores in their workplaces and to make the necessary decisions to successfully protect their workers from this exposure. The level of risk in any particular workplace is based upon factors such as:

- current patterns of workplaces contaminated with anthrax spores;
- the likelihood of the workplace being a target for Bacillus Anthracis contamination;
- the proximity of a workplace or workstation to areas known to be contaminated with anthrax spores;
- the likelihood of the workplace receiving mail or other items from a contaminated facility;
• any information provided by law enforcement or public health officials about the workplace's risk of receiving contaminated items;

• the amount of mail the workplace receives;

• the type of workplace (for example, a post office, bulk mail center, or public or private mail room where cross-contamination might be possible);

• the potential that workplace operations and tasks could result in exposure if contaminated mail is received;

• the use of high speed mail handling equipment, or other processes that might aerosolize anthrax spores during processing; or

• any other information or analysis that would indicate the workplace might be contaminated with anthrax spores.

Visit OSHA’s Anthrax eTool for more information.

**Avian Flu**

Avian influenza, commonly known as "avian flu" or "bird flu," is caused by influenza type A viruses that normally only occur in birds. Wild birds, particularly waterfowl, are natural hosts of avian flu viruses and often show no symptoms; however, some of the viruses can cause high mortality in poultry, including the H5N1 virus. Some strains of avian flu viruses carried by these wild birds can infect domestic fowl and, in turn, can infect humans, causing fever, cough, sore throat, eye infections and muscle pain.

Avian flu can also lead to pneumonia, acute respiratory distress, and other severe and life-threatening complications. The most common route of transmission to humans is by contact with contaminated poultry.

**Transmission to Humans**
Exposure of the conjunctival membranes of the eyes and/or the oral or nasal mucosa to secretions (oral, nasal or fecal) from AI-infected birds is the predominant route of transmission of these viruses to humans.

Avoid direct contact with bird secretions and inhalation of dust contaminated with these secretions.

There are several subtypes of avian influenza A viruses. The subtype that has become of major concern is avian influenza A (pN1) virus which has caused the deaths of millions of birds and also poses a health risk to humans.

Symptoms in humans range from fever, cough, sore throat and muscle aches to diarrhea, eye infections, pneumonia and severe respiratory diseases. The symptoms of avian influenza may depend on which virus caused the infection but are often similar to those associated with human seasonal influenza.

**Basic Infection Control Measures for Laboratory Employees**

HPAI H5N1 is classified as a select agent and must be worked with under Biosafety Level (BSL) 3 with enhancements. These conditions include BSL 3 procedures, plus the following:

- controlled access, double-door entry with change room and shower;
- use of showers by personnel before exiting;
- decontamination of all wastes; and
- use of at least an N-95 respirator.

**Key Considerations**

- Virus culture studies on respiratory specimens from patients suspected of having HPAI H5N1 infections should NOT be attempted except under stringent BSL 3 conditions with enhancements.
- If a clinical laboratory does not have appropriate facilities (BSL 3 laboratories with enhancements), virus isolations should not be ordered for patients suspected of having HPAI H5N1 infection.
• Molecular assays (e.g., RT-PCR) or commercial antigen detection testing can be conducted on clinical specimens from suspect HPAI H5N1 cases using standard BSL 2 work practices.

Personnel should not eat, drink, or smoke or use bathroom facilities while engaged in activities where contact with contaminated animals or surfaces are possible. PPE should be properly removed and discarded or disinfected. Hands should then be washed thoroughly before eating, drinking, smoking or bathroom use.

For more information, see OSHA Publication 3323-10N 2006, Protecting Employees from Avian Flu (Avian Influenza) Viruses.

**Botulism**

Cases of botulism are usually associated with consumption of preserved foods. However, botulinum toxins are currently among the most common compounds explored by terrorists for use as biological weapons. Botulinum neurotoxins, the causative agents of botulism, are HHS/CDC select agents.

In the United States an average of 110 cases of botulism are reported each year. Botulism is a muscle-paralyzing disease caused by a toxin made by a bacterium called Clostridium Botulinum. Botulinum toxins are some of the most poisonous substances known. Miniscule quantities are capable of producing disease in humans.

**Foodborne Disease**

Foodborne illnesses are caused by viruses, bacteria, parasites, toxins, metals, and prions (microscopic protein particles). Symptoms range from mild gastroenteritis to life-threatening neurologic, hepatic and renal syndromes.

They are contracted from eating contaminated food or beverages. Illnesses include foodborne intoxications and infections, which are often incorrectly referred to as food poisoning. There are more than 250 different foodborne diseases including: Botulism, Brucellosis, Campylobacter enteritis, Escherichia coli, Hepatitis A, Listeriosis, Salmonellosis, Shigellosis, Toxoplasmosis, Viral gastroenteritis, Taeniasis and Trichinosis.
The quality of food, and controls used to prevent foodborne diseases, are primarily regulated by the US Food and Drug Administration (FDA), the Centers for Disease Control and Prevention (CDC), and local public health authorities. These diseases may be occupationally related if they affect the food processors (e.g., poultry processing workers), food preparers and servers (e.g., cooks, waiters), or workers who are provided food at the worksite. Foodborne disease is addressed in specific standards for the general and construction industries.

For more information on foodborne disease see OSHA’s Foodborne Disease topics page.

**Hantavirus**

Hantaviruses are transmitted to humans from the dried droppings, urine, or saliva of mice and rats. The disease begins as a flu-like illness characterized by fever, chills, and muscle aches, but it can rapidly progress to a life-threatening condition marked by respiratory failure as the lungs fill with fluid.

Animal laboratory workers and persons working in infested buildings are at increased risk to this disease, particularly during dusty clean-up activities. Infection with hantavirus can progress to Hantavirus Pulmonary Syndrome (HPS), which can be fatal.

There are several other ways rodents may spread hantavirus to people:

- If a rodent with the virus bites someone, the virus may be spread to that person, but this type of transmission is rare.

- Researchers believe that people may be able to get the virus if they touch something that has been contaminated with rodent urine, droppings, or saliva, and then touch their nose or mouth.

- Researchers also suspect people can become sick if they eat food contaminated by urine, droppings, or saliva from an infected rodent.

For more information on Hanta Virus see the CDC home page on Hantavirus.
Legionnaires’ Disease

Legionnaires' disease is a common name for one of the several illnesses caused by Legionnaires' disease bacteria (LDB). Legionnaires' disease is an infection of the lungs and is a form of pneumonia. More than 43 species of Legionella have been identified and more than 20 linked with human diseases. Legionellosis is the term for the diseases produced by LDB. In addition to Legionnaires' disease, the same bacteria also causes a flu-like disease called Pontiac fever.

Legionnaires' disease sources may include almost any warm water system or device, including man-made or natural, that disseminates water, particularly as aerosols, sprays or mists, and provides favorable conditions for LDB growth and amplification.

Disease transmission is most likely to occur via:

- **Inhalation** of aerosols, fine sprays, mists or other microscopic droplets of water contaminated with LDB, providing direct access into the lungs.

- **Aspiration** such as may occur when choking or spontaneously during the drinking, ingesting, or swallowing process. This allows oral fluids and particles to by-pass natural gag reflexes and enter into the respiratory tract and lungs instead of the esophagus and stomach.

- There is no evidence that the diseases are transmitted from one person to another.

Legionnaires' disease treatment requires the use of antibiotics. Early treatment reduces the severity of symptoms and improves chances of recovery. The drugs of choice belong to a class of antibiotics called macrolides. They include azithromycin, erythromycin, and clarithromycin.

For more information on Legionnaires’ disease, see [OSHA’s Legionnaires’ Disease](#).
Molds and Fungi

Molds are fungi that are found everywhere—both indoors and outdoors all year round. The terms fungi and mold are often used interchangeably, but mold is actually a type of fungi. Concern about indoor exposure to mold has increased along with public awareness that exposure to mold can cause a variety of adverse health effects.

There are many thousands of species of mold and most if not all of the mold found indoors comes from outdoor sources. It seems likely to grow and become a problem only when there is water damage, high humidity, or dampness.

Molds produce and release millions of spores small enough to be air-, water-, or insect-borne. They can also produce toxic agents known as mycotoxins. Spores and mycotoxins can have negative effects on human health.

For those laboratory employees who are affected by mold exposures there can be a wide variation in how they react. Employees at greatest risk of health effects are individuals with allergies, asthma, sinusitis, or other respiratory conditions and weakened immune systems.

For more information on molds, read OSHA’s publication 3304-04N 2006, Preventing Mold-Related Problems in the Indoor Workplace.

Plague

Plague is a disease well-known to humankind. Throughout history, in a series of epidemics, plague has claimed the lives of millions throughout the world. Infective fleabites are the most common mode of transmission, but direct human contact with infected tissues or body fluids of animals and humans also may serve as sources of infection. Human plague in the United States occurs as mostly scattered cases in rural areas effecting 10 to 20 persons each year. Globally, the World Health Organization (WHO) reports 1,000 to 3,000 cases every year.

Yersinia pestis, a documented laboratory hazard, is the causative agent of plague. It is a gram-negative, microaerophilic coccobacillus frequently characterized by a “safety pin” appearance on stained preparations from specimens. Specific biosafety procedures, including PPE,
engineering controls, and additional work practices have been established for handling plague bacteria in laboratories.

Laboratory and field personnel should be counseled on methods to avoid fleabites and accidental autoinoculation when handling potentially infected live or dead animals. Special care should be taken to avoid generating aerosols or airborne droplets while handling infectious materials or when performing necropsies on naturally or experimentally infected animals. Gloves should be worn when handling potentially infectious materials including field or laboratory infected animals.

**Ricin Toxin**

Ricin is one of the most toxic and easily produced plant toxins. Ricin is produced in maturing seeds of the castor bean, *Ricinus communis*, which has been recognized for centuries as a highly poisonous plant for humans and livestock. Ricin belongs to a family of ribosome inactivating proteins from plants, including abrin, modeccin, and viscum, that share a similar overall structure and mechanism of action.

Gastric ingestion of ricin causes nausea, vomiting, diarrhea, abdominal cramps and dehydration. Initial symptoms may appear more rapidly following gastric ingestion (1-5 h), but generally require exposure to much higher levels of toxin compared with the inhalation route.

Ricin is a relatively non-specific cytotoxin and irritant that should be handled in the laboratory as a non-volatile toxic chemical. A BSC (Class II, Type B1 or B2) or a chemical fume hood equipped with an exhaust HEPA filter and charcoal filter are indicated for activities with a high potential for aerosol, such as powder samples, and the use of large quantities of toxin. Laboratory coat, gloves, and full-face respirator should be worn if there is a potential for creating a toxin aerosol.

**Severe Acute Respiratory Syndrome (SARS)**

SARS is a severe viral illness that was first reported in Asia in February 2003. The illness is characterized by a variety of symptoms including fever, cough, and shortness of breath. In a
minority of patients (6-9%), SARS may even progress to death. SARS has been reported in North America among persons returning from travel to Asia, among health care workers, and among others in contact with individuals with SARS. Because new outbreaks may occur, laboratory employees should be aware of the recommended measures to prevent occupational SARS infection.

SARS is spread primarily by close contact with a SARS patient or contact with respiratory secretions/body fluids from a SARS patient. Transmission from contaminated objects has been reported. The incubation period is typically between two and seven days.

SARS presentation is typical of a respiratory viral illness. Patients usually present with a high fever (>100.4 F), cough, chills and headache. Most will progress to develop pneumonia and some will even require mechanical ventilation.

Work Procedures to prevent the spread of disease include frequent hand cleansing and avoiding direct contact with body fluids of SARS patients. Personal protective equipment (PPE) is appropriate in healthcare facilities and certain occupational settings, such as airline clean-up, when SARS infection is a known risk. Staff should not sort soiled linens suspected of SARS contamination at the point of use. Laundering soiled linens in warm water and detergent has been advised. Compressed air should not be used for cleaning areas where SARS patients or their body fluids

Engineering Controls include use of airborne isolation rooms or negative air pressure environments for aerosol generating procedures (e.g. sputum induction in SARS patients) and handling laboratory specimens in biological safety cabinets.

Smallpox

Smallpox is a highly contagious disease unique to humans. It is estimated that no more than 20 percent of the population has any immunity from previous vaccination. Smallpox outbreaks have occurred from time to time for thousands of years, but in 1980 the disease was declared eradicated following worldwide vaccination programs. Except for stockpiles in high-security
laboratories, the virus has been eliminated. However, if obtained and deliberately released as a bioweapon, smallpox could cause a public health catastrophe.

Generally, direct and fairly prolonged face-to-face contact is required to spread smallpox from one person to another. Smallpox also can be spread through direct contact with infected bodily fluids or contaminated objects such as bedding or clothing. Rarely, smallpox has been spread by virus carried in the air in enclosed settings such as buildings, buses, and trains. Humans are the only natural hosts of variola. Smallpox is not known to be transmitted by insects or animals.

A person with smallpox is sometimes contagious with onset of fever (prodrome phase), but the person becomes most contagious with the onset of rash. At this stage the infected person is usually very sick and not able to move around in the community. The infected person is contagious until the last smallpox scab falls off.

Vaccination within 3 days of exposure will completely prevent or significantly modify smallpox in the vast majority of people. Vaccination 4 to 7 days after exposure likely offers some protection from disease or may modify the severity of disease.
Tularemia

Tularemia is a disease of animals and humans caused by the bacterium *Francisella tularensis*. Rabbits, hares, and rodents are especially susceptible and often die in large numbers during outbreaks. Humans can become infected through several routes, including:

- Tick and deer fly bites
- Skin contact with infected animals
- Ingestion of contaminated water
- Laboratory exposure
- Inhalation of contaminated dusts or aerosols

Symptoms vary depending upon the route of infection. Although tularemia can be life-threatening, most infections can be treated successfully with antibiotics.

Steps to prevent tularemia include:

- Use of insect repellent
- Wearing gloves when handling sick or dead animals
- Avoiding mowing over dead animals

*Francisella tularensis* is highly infectious when grown in culture, and laboratory-acquired infections have been documented. The isolation of *F. tularensis* from clinical specimens, especially if unanticipated, can generate concern among laboratory workers about possible exposure.
Ebola and Viral Hemorrhagic Fevers (VHFs)

Ebola virus disease (EVD) is a severe disease that causes hemorrhagic fever in humans and animals. Diseases that cause hemorrhagic fevers, such as Ebola, are often fatal as they affect the body's vascular system (how blood moves through the body). This can lead to significant internal bleeding and organ failure.

Hemorrhagic fever viruses are among the agents identified by the Centers for Disease Control and Prevention (CDC) as the most likely to be used as biological weapons. Many VHFs can cause severe, life-threatening disease with high fatality rates.

Some viruses that cause hemorrhagic fever can spread from one person to another, once an initial person has become infected. Ebola, Marburg, Lassa and Crimean-Congo hemorrhagic fever viruses are examples. This type of secondary transmission of the virus can occur directly, through close contact with infected people or their body fluids. It can also occur indirectly, through contact with objects contaminated with infected body fluids. For example, contaminated syringes and needles have played an important role in spreading infection in outbreaks of Ebola hemorrhagic fever and Lassa fever.

Safety Data Sheets (SDSs) on Infectious Agents

Although SDSs for chemical products have been available to workers for many years in the U.S. and other countries, Canada is the only country that has developed SDSs for infectious agents. These SDSs were produced by the Canadian Public Health Agency for personnel working in the life sciences as quick safety reference material relating to infectious microorganisms.

These SDSs on Infectious Agents are organized to contain health hazard information such as infectious dose, viability (including decontamination), medical information, laboratory hazard, recommended precautions, handling information and spill procedures.

For more information on these SDSs see the Canadian Public Health Agency’s Pathogen Safety Data Sheets and Risk Assessment web page.
Module 5 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. Harmful biological agents are generally divided into either infectious agents or non-infectious agents. Which of the following is NOT an infectious agent?
   a. Toxins
   b. Pathogenic bacteria
   c. Viruses
   d. Funguses

2. Which of the following is receiving heightened attention because of its use as a biological warfare agent?
   a. Tularemia
   b. Polio virus
   c. Anthrax
   d. Toluene

3. Employees at greatest risk of health effects are individuals with _____, or other respiratory conditions and weakened immune systems.
   a. allergies, asthma, sinusitis
   b. viruses
   c. infectious bacteria
   d. plant-based toxins

4. To prevent plague, laboratory and field personnel should be counseled on methods to _____ when handling potentially infected live or dead animals.
   a. wash after each exposure to viruses that might cause illness
   b. avoid fleabites and accidental autoinoculation
   c. report any exposure to insects within the laboratory
   d. install defensive techniques such as “zappers”
5. Which of the following contain health hazard information such as infectious dose, viability, and recommended precautions?

a. OSHA standards covering exposure to infectious agents
b. NIOSH Dose and Toxicological standards
c. ANSI laboratory standards
d. Safety Data Sheets (SDSs) on Infectious Agents
Module 6: Bloodborne Pathogens

The OSHA Bloodborne Pathogens (BBP) Standard

OSHA’s Bloodborne Pathogens standard (29 CFR 1910.1030) is designed to protect laboratory employees and others from the health hazards of exposure to bloodborne pathogens. Employers are subject to the BBP standard if they have workers whose jobs put them at reasonable risk of coming into contact with blood or other potentially infectious materials (OPIM).

These employers must develop a written Exposure Control Plan, provide training to exposed workers, and comply with other requirements of the standard, including use of Standard Precautions when dealing with blood and OPIM. In 2001, in response to the Needlestick Safety and Prevention Act, OSHA revised the Bloodborne Pathogens standard. The revised standard clarifies the need for employers to select safer needle devices and to involve workers in identifying and choosing these devices. The updated standard also requires employers to maintain a log of injuries from contaminated sharps.

OSHA estimates that 5.6 million workers in the healthcare industry and related occupations are at risk of occupational exposure to bloodborne pathogens, including HIV, HBV, HCV, and others.

All occupational exposure to blood or OPIM places workers at risk for infection with bloodborne pathogens. OSHA defines blood to mean human blood, human blood components, and products made from human blood.

Other potentially infectious materials (OPIM) include:

1. the following human body fluids:
   
   - semen
   - vaginal secretions
   - cerebrospinal fluid
   - synovial fluid
   - pleural fluid
- pericardial fluid
- peritoneal fluid
- amniotic fluid
- saliva in dental procedures
- any body fluid that is visibly contaminated with blood
- all body fluids in situations where it is difficult or impossible to differentiate between body fluids

2. any unfixed tissue or organ (other than intact skin) from a human (living or dead); and

3. HIV- or HBV-containing cell or tissue cultures, organ cultures, and HIV-or HBV-containing culture medium or other solutions; and blood, organs, or other tissues from experimental animals infected with HIV or HBV.

The Centers for Disease Control and Prevention (CDC) notes that although more than 200 different diseases can be transmitted from exposure to blood, the most serious infections are:

- hepatitis B virus (HBV)
- hepatitis C virus (HCV)
- human immunodeficiency virus (HIV)

Fortunately, the risk of acquiring any of these infections is low. HBV is the most infectious virus of the three viruses listed above. For an unvaccinated healthcare worker, the risk of developing an infection from a single needlestick or a cut exposed to HBV-infected blood ranges from 6-30%. The risk for infection from HCV- and HIV-infected blood under the same circumstances is 1.8 and 0.3 percent, respectively.

Many factors influence the risk of becoming infected after a needlestick or cut exposure to HBV-, HCV- or HIV-contaminated blood. These factors include:

- the health status of the individual
- the volume of the blood exchanged
- the concentration of the virus in the blood
- the extent of the cut or the depth of penetration of the needlestick

**Unsafe Activities in the Laboratory**

Employees working in laboratories should not:

- perform mouth pipetting/suctioning of blood or OPIM;
- Eat, drink, smoke, apply cosmetics or lip balm, or handle contact lenses in work areas where there is a reasonable likelihood of exposure to blood or OPIM; and
- Store food or drink in refrigerators, freezers, shelves, cabinets or on countertops or benchtops where blood or OPIM are present.

**Protective Measures**

Employers must provide employees with the following protective measures:

- Appropriate PPE for workers if blood or OPIM exposure is anticipated.
- Gloves must be worn when hand contact with blood, mucous membranes, OPIM, or non-intact skin is anticipated, or when handling contaminated items or surfaces.
- Surgical caps or hoods and/or shoe covers or boots must be worn in instances when gross contamination can reasonably be anticipated such as during autopsies or orthopedic surgery.
- Effective engineering and work practice controls to help remove or isolate exposures to blood and bloodborne pathogens.
• Hepatitis B vaccination (if not declined by a worker) under the supervision of a physician or other licensed healthcare professional to all workers who have occupational exposure to blood or OPIM.

**Labels**

When any blood, OPIM or infected animals are present in the work area, a hazard warning sign incorporating the universal biohazard symbol must be posted on all access doors.

**Engineering Controls and Work Practices for All HIV/HBV Laboratories**

Employers must ensure that:

• All activities involving OPIM are conducted in Biological Safety Cabinets (BSCs) or other physical-containment devices; work with OPIM must not be conducted on the open bench. For more information on BSCs, see OSHA’s publication, Laboratory Safety – Biosafety Cabinets (BSCs).

• Certified BSCs or other appropriate combinations of personal protection or physical containment devices, such as special protective clothing, respirators, centrifuge safety cups, sealed centrifuge rotors, and containment caging for animals, be used for all activities with OPIM that pose a threat of exposure to droplets, splashes, spills, or aerosols.

• Each laboratory contains a facility for hand washing and an eyewash facility which is readily available within the work area.

• Each work area contains a sink for washing hands and a readily available eyewash facility.

• The sink must be foot, elbow, or automatically operated and must be located near the exit door of the work area.

**Additional Requirements for HIV and HBV Research Laboratories**

Additional requirements for laboratories conducting HIV and HBV research include:
• Waste materials:
  o All regulated waste must either be incinerated or decontaminated by a method such as autoclaving known to effectively destroy bloodborne pathogens.
  o Contaminated materials that are to be decontaminated at a site away from the work area must be placed in a durable, leak-proof, labeled or color-coded container that is closed before being removed from the work area.

• Access:
  o Laboratory doors must be kept closed when work involving HIV or HBV is in progress.
  o Access to the production facilities’ work area must be limited to authorized persons.
  o Written policies and procedures must be established whereby only persons who have been advised of the potential biohazard, who meet any specific entry requirements, and who comply with all entry and exit procedures must be allowed to enter work areas.
  o Access doors to the production facilities’ work area or containment module must be self-closing.
  o Work areas must be separated from areas that are open to unrestricted traffic flow within the building. Passage through two sets of doors must be the basic requirement for entry into the work area from access corridors or other contiguous areas. Physical separation of the high-containment work area from access corridors or other areas or activities may also be provided by a double-doored clothes-change room (showers may be included), airlock, or other access facility that requires passing through two sets of doors before entering the work area.
  o The surfaces of doors, walls, floors and ceilings in the work area must be water-resistant so that they can be easily cleaned. Penetrations in these surfaces must be sealed or capable of being sealed to facilitate decontamination.

The above requirements do not apply to clinical or diagnostic laboratories engaged solely in the analysis of blood, tissue, or organs.
Module 6 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. OSHA defines blood to mean _____ blood, _____ blood components, and products made from _____ blood?
   a. human
   b. all
   c. infected
   d. primate

2. Which of the following is NOT one of the three most serious infections resulting from exposure to bloodborne pathogens?
   a. Hepatitis B virus (HBV)
   b. Hepatitis C virus (HCV)
   c. Hepatitis A Virus (HAV)
   d. Human immunodeficiency virus (HIV)

3. Laboratory workers should NEVER perform _____.
   a. mouth pipetting/suctioning of blood or OPIM
   b. handling infectious viruses with latex gloves
   c. first aid on other workers who are bleeding
   d. mixing human blood with heparin

4. Employers must provide a vaccination for _____ (if not declined by a worker) to employees who have occupational exposure to human blood or OPIM.
   a. Hepatitis A
   b. Hepatitis B
   c. Hepatitis C
   d. Hepatitis B and C
5. When any blood, OPIM or infected animals are present in the work area, where must a hazard warning sign incorporating the universal biohazard symbol be posted?

   a. On all laboratory cabinets
   b. On all laboratory windows
   c. On all OPIM containers
   d. On all access doors
Module 7: Research Animal Laboratory Safety

Research on animals should only be performed by laboratory employees with the proper training. By using safe work practices and appropriate PPE, workers can minimize the likelihood that they will be bitten, scratched, and/or exposed to animal body fluids and tissues.

Possible Injuries/Illnesses

The most common work-related health complaints reported by individuals working with small animals are the following:

- sprains
- strains
- bites
- allergies

Allergies

Of the complaints listed above, allergies (i.e., exaggerated reactions by the body’s immune system) to proteins in small animals’ urine, saliva, and dander are the greatest potential health risk. An allergic response may evolve into life-long asthma. Because mice and rats are the animals most frequently used in research studies, there are more reports of allergies to rodents than other laboratory animals.

Most workers who develop allergies to laboratory animals will do so within the first twelve months of working with them. Sometimes reactions only occur in workers after they have been handling animals for several years. Initially, the symptoms are present within minutes of the
worker’s exposure to the animals. Approximately half of allergic workers will have their initial symptoms subside and then recur three or four hours following the exposure.

Employers should adopt the following best practices to reduce allergic responses of workers:

- Eliminate or minimize exposure to the proteins found in animal urine, saliva and dander.
- Limit the chances that workers will inhale or have skin contact with animal proteins by using well-designed air handling and waste management systems.
- Have workers use appropriate PPE (e.g., gloves, gowns, hair covers, respirators) to further minimize their risk of exposure.

**Zoonotic Diseases**

There are a host of possible infectious agents that can be transferred from animals to humans. These are referred to as zoonotic diseases. The common routes of exposure to infectious agents are:

- **Inhalation**: Inhalation hazards may arise during work practices that can generate aerosols. These include the following: centrifugation, mixing (e.g., blending, vortexing, and sonication), pouring/decanting and spilling/splashing of culture fluids.

- **Inoculation**: Inoculation hazards include needlesticks and lacerations from sharp objects.

- **Ingestion**: Ingestion hazards include the following: splashes to the mouth, placing contaminated articles/fingers in mouth, consumption of food in the laboratory, and mouth pipetting.

- **Contamination**: Contamination of skin and mucous membranes can occur via splashes or contact with contaminated fomites (e.g., towels, bedclothes, cups, money).

Some of the zoonotic diseases that can be acquired from animals are discussed in the next few sections.
Wild and Domesticated Animals

Wild rodents and other wild animals may inflict an injury such as a bite or scratch. Workers need to receive training on the correct way to capture and handle any wild animals. While they may carry or shed organisms that may be potentially infectious to humans, the primary health risk to individuals working with captured animals is the development of an allergy.

The development of disease in the human host often requires a preexisting state that compromises the immune system. Workers who have an immune compromising medical condition or who are taking medications that impair the immune system (steroids, immunosuppressive drugs, or chemotherapy) are at higher risk for contracting a rodent disease.

- Wild rodents may act as carriers for viruses such as Hantavirus and lymphocytic choriomeningitis virus (LCMV) depending on where they were captured.

- Each rodent species may harbor their own range of bacterial diseases, such as tularemia and plague. These animals may also have biting insect vectors which can act as a potential carrier of disease (mouse to human transmission).

- Examples of zoonotic diseases that can be transmitted from wild and domesticated animals to humans are listed in the table below.
Non-human Primates

It should not be surprising that, given our many similarities, humans and non-human primates are susceptible to similar infectious agents. Because of our differences, the consequences of infection with the same agent often vary considerably. Infection may cause few if any symptoms in one group and may be lethal to the other. Exposures to body fluids from non-human primates should be treated immediately.
Training and Best Practices

Employers should ensure that workers are trained to adhere to the following good practices to prevent exposure to zoonotic diseases when working with research animals:

- Avoid use of sharps whenever possible.
- Take extreme care when using a needle and syringe to inject research animals or when using sharps during necropsy procedures.
- Never remove, recap, bend, break, or clip used needles from disposable syringes. Use safety engineered needles when practical.
- Take extra precautions when handling hoofed animals. Due to the physical hazards of weight and strength of the animal, large hoofed mammals pose additional concerns for workers. Hoofed mammals may resist handling and may require multiple workers to administer medication or perform other functions.
- Keep hands away from mouth, nose and eyes.
- Wear appropriate PPE (i.e., gloves, gowns, face protection) in all areas within the animal facility.
- A safety specialist may recommend additional precautions, based upon a risk assessment of the work performed.
- Wear tear-resistant gloves to prevent exposure by animal bites. Micro-tears in the gloves may compromise the protection they offer.
- Remove gloves and wash hands after handling animals or tissues derived from them and before leaving areas where animals are kept.
- Use mechanical pipetting devices (no mouth pipetting).
- Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take or apply medicine in areas where research animals are kept.
- Perform procedures carefully to reduce the possibility of creating splashes or aerosols.
• Contain operations that generate hazardous aerosols in BSCs or other ventilated enclosures, such as animal bedding dump stations.

• Wear eye protection.

• Wear head/hair covering to protect against sprays or splashes of potentially infectious fluids.

• Keep doors closed to rooms where research animals are kept.

• Clean all spills immediately.

• Report all incidents and equipment malfunctions to the supervisor.

• Promptly decontaminate work surfaces when procedures are completed and after surfaces are soiled by spills of animal material or waste.

• Properly dispose of animal waste and bedding.

• Workers should report all work-related injuries and illnesses to their supervisor immediately.

• Following a bite by an animal or other injury in which the wound may be contaminated, first aid should be initiated at the work site.
  o Contaminated skin and wounds should be washed thoroughly with soap and water for 15 minutes.
  o Contaminated eyes and mucous membranes should be irrigated for 15 minutes using normal saline or water.

• Consult an occupational health physician concerning wound care standard operating procedures (SOPs) for particular animal bites/scratches.

For more information see OSHA’s publication, Laboratory Safety-Working with Small Animals.
Module 7 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. Which of the following complaints by laboratory workers working with small animals presents the greatest potential health risk?
   
   a. Allergies
   b. Bites
   c. Strains
   d. Sprains

2. Centrifugation, mixing (e.g., blending, vortexing, and sonication), pouring/decanting and spilling/splashing of culture fluids may result in exposure to _____.
   
   a. injection hazards
   b. inoculation hazards
   c. inhalation hazards
   d. ingestion hazards

3. Workers who have an immune compromising medical condition or who are taking medications that impair the immune system _____.
   
   a. are at higher risk for contracting a rodent disease
   b. should handle animals only with latex gloves
   c. should receive all required vaccines regardless of exposure
   d. are at no higher risk in handling animals in the laboratory

4. Which of the following is a best practice to prevent exposure by animal bites?
   
   a. Wear non-latex gloves
   b. Wear tear-resistant gloves
   c. Use animal restraints
   d. Anesthetize the animal prior to handling
5. Following a bite by an animal or other injury in which the wound may be contaminated, wash contaminated skin/wounds and irrigate eyes/mucous membranes for at least ______.

   a. 5 minutes
   b. 10 minutes
   c. 15 minutes
   d. 20 minutes
Module 8: Physical Hazards and Others

Besides exposure to chemicals and biological agents, laboratory workers can also be exposed to a number of physical hazards. Some of the common physical hazards that they may encounter include the following:

**Ergonomic Hazards**

Laboratory workers are at risk for repetitive motion injuries during routine laboratory procedures such as pipetting, working at microscopes, operating microtomes, using cell counters and keyboarding at computer workstations.

Repetitive motion injuries develop over time and occur when muscles and joints are stressed, tendons are inflamed, nerves are pinched and the flow of blood is restricted.

Standing and working in awkward positions in front of laboratory hoods/biological safety cabinets can also present ergonomic problems.

By becoming familiar with how to control laboratory ergonomics-related risk factors, employers can reduce chances for occupational injuries while improving worker comfort, productivity, and job satisfaction.

In addition to the general ergonomic guidance, laboratory employers are reminded of some simple adjustments that can be made at the workplace. While there is currently no specific OSHA standard relating to ergonomics in the laboratory, it is recommended that employers provide information and training on the importance of ergonomics best practices.

For more information on ergonomics, be sure to enroll in OSHAcademy Courses 711, *Introduction to Ergonomics* and/or 722, *Ergonomics Program Management*.
**Ionizing Radiation**

OSHA’s Ionizing Radiation Standard sets forth the limitations on exposure to radiation from atomic particles. Ionizing radiation sources are found in a wide range of occupational settings, including laboratories.

There are three main kinds of ionizing radiation:

1. **Alpha particles**, which include two protons and two neutrons
2. **Beta particles**, which are essentially electrons
3. **Gamma rays and x-rays**, which are pure energy (photons).

These radiation sources can pose a considerable health risk to affected workers if not properly controlled.

Any laboratory possessing or using radioactive isotopes must be licensed by the Nuclear Regulatory Commission (NRC) and/or by a state agency that has been approved by the NRC, 10 CFR 31.11 and 10 CFR 35.12.

The fundamental objectives of radiation protection measures are:
• to limit entry of radionuclides into the human body (via ingestion, inhalation, absorption, or through open wounds) to quantities as low as reasonably achievable (ALARA) and always within the established limits; and

• to limit exposure to external radiation to levels that are within established dose limits and as far below these limits as is reasonably achievable.

All areas in which radioactive materials are used or stored in the laboratory must conspicuously display the symbol for radiation hazards and access should be restricted to authorized personnel.

The OSHA Ionizing Radiation Standard requires precautionary measures and personnel monitoring for workers who are likely to be exposed to radiation hazards. Personnel monitoring devices (film badges, thermoluminescent dosimeters (TLD), pocket dosimeters, etc.) must be supplied and used if required to measure an individual’s radiation exposure from gamma, neutron, energetic beta, and X-ray sources. The standard monitoring device is a clip-on badge or ring badge bearing the individual assignee’s name, date of the monitoring period and a unique identification number.

The OSHA Safety and Health Topics webpage provides links to technical and regulatory information on the control of occupational hazards from ionizing radiation.

**Non-ionizing Radiation**

Non-ionizing radiation is described as a series of energy waves composed of oscillating electrical and magnetic fields traveling at the speed of light.

Non-ionizing radiation includes the spectrum of ultraviolet (UV), visible light, infrared (IR), microwave (MW), radio frequency (RF), and extremely low frequency (ELF). Lasers commonly operate in the UV, visible, and IR frequencies. Non-ionizing radiation is found in a wide range of occupational settings and can pose a considerable health risk to potentially exposed workers if not properly controlled.
Extremely Low Frequency Radiation (ELF). Extremely Low Frequency (ELF) radiation at 60 HZ (a frequency of 60 cycles per second) is produced by power lines, electrical wiring, and electrical equipment. Common sources of intense exposure include ELF induction furnaces and high-voltage power lines.

Radiofrequency and Microwave Radiation. Microwave radiation (MW) is absorbed near the skin, while radiofrequency (RF) radiation may be absorbed throughout the body. At high enough intensities both will damage tissue through heating. Sources of RF and MW radiation include radio emitters and cell phones.

Infrared Radiation (IR). The skin and eyes absorb infrared radiation (IR) as heat. Workers normally notice excessive exposure through heat sensation and pain. Sources of IR radiation include heat lamps and IR lasers.

Visible Light Radiation. The different visible frequencies of the electromagnetic (EM) spectrum are "seen" by our eyes as different colors. Good lighting is conducive to increased production, and may help prevent incidents related to poor lighting conditions. Excessive visible radiation can damage the eyes and skin.

Ultraviolet Radiation (UV). Ultraviolet radiation (UV) has a high photon energy range and is particularly hazardous because there are usually no immediate symptoms of excessive exposure. Sources of UV radiation in the laboratory include black lights and UV lasers.

LASER. LASER is an acronym which stands for Light Amplification by Stimulated Emission of Radiation. Lasers typically emit optical (UV, visible light, IR) radiations and are primarily an eye and skin hazard. The use of lasers in laboratories is expanding rapidly, especially in research laboratories. Labs using lasers should develop a written laser safety program and appoint a Laser Safety Officer (LSO) who is responsible for managing risk and has authority to make sure lab workers comply with policies and standards.

For more information on laser hazards in the laboratory, see OSHA’s Technical Manual, Section III: Chapter 6, Laser Hazards.

The OSHA Safety and Health Topics webpage provides links to technical and regulatory information on the control of occupational hazards from non-ionizing radiation.
Noise

Employers must implement a Hearing Conservation Program where laboratory workers are exposed to a time weighted average noise level of 85 dBA or higher over an 8 hour work shift.

Hearing Conservation Programs require employers to measure noise levels, provide free annual hearing exams and free hearing protection, provide training, and conduct evaluations of the adequacy of the hearing protectors in use unless changes to tools, equipment and schedules are made so that they are less noisy and worker exposure to noise is less than the 85 dBA.

To learn more about time-weighted averages and other hearing protection topics, review OSHA Academy Course 751, Hearing Conservation Program Management.

The monitoring program must include the following components:

- All continuous, intermittent, and impulsive sound levels from 80-130 dBA must be included in noise measurements;

- Instruments used to measure worker noise exposure must be calibrated to ensure measurement accuracy; and

- Monitoring must be repeated whenever a change in production, process, equipment, or controls increases noise exposures.

Laboratory workers are exposed to noise from a variety of sources. Operation of large analyzers (e.g., chemistry analyzer), fume hoods, biological safety cabinets, incubators, centrifuges (especially ultracentrifuges), cell washers, sonicators, and stirrer motors, all contribute to the noise level in laboratories.

Further sources of noise in laboratories include fans and compressors for cryostats, refrigerators, refrigerated centrifuges, and freezers. As an example, a high-speed refrigerated centrifuge alone can generate noise levels as high as 65 dBA. If noise
levels exceed 80 dBA, people must speak very loudly to be heard, while at noise levels of 85 to 90 dBA, people have to shout. For more examples, be sure to visit the NIOSH Noise Meter web page.

In order to determine if the noise levels in the laboratory are above the threshold level that damages hearing, the employer must conduct a noise exposure assessment using an approved sound level monitoring device, such as a dosimeter, and measure an 8-hour TWA exposure. If the noise levels are found to exceed the threshold level, the employer must provide hearing protection at no cost to the workers and train them in the proper use of the protectors.

The potential dangers of miscommunicating instructions or laboratory results are obvious, and efforts should be made to improve the design of clinical laboratories and to evaluate new instrumentation with regard to the impact of these factors on worker noise exposure. The employer should evaluate the possibility of relocating equipment to another area or using engineering controls to reduce the noise level below an 8-hour TWA of 85 dBA in order to comply with OSHA’s Occupational Noise Exposure Standard.

**Health Effects**

Exposure to continuous noise may lead to the following stress-related symptoms:

- depression
- irritability
- decreased concentration in the workplace
- reduced efficiency and decreased productivity
- noise-induced hearing loss
- tinnitus (i.e., ringing in the ears)
- increased errors in laboratory work

There are several steps that employers can take to minimize the noise in the laboratory, including:

- Moving noise-producing equipment (e.g., freezers, refrigerators, incubators and centrifuges) from the laboratory to an equipment room;
• Locating compressors for controlled-temperature rooms remotely; and
• Providing acoustical treatment on ceilings and walls.
Module 8 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. Which of the following injuries may result from routine laboratory procedures such as pipetting, working at microscopes, operating microtomes, and keyboarding at computer workstations?
   - a. Eye strain
   - b. Cuts or scratches
   - c. Repetitive motion injuries
   - d. Slips, trips, and falls

2. All areas in which radioactive materials are used or stored in the laboratory must conspicuously display the symbol for radiation hazards and _____.
   - a. restrict entry to non-essential workers
   - b. ensure all workers are properly inoculated
   - c. access should be restricted to authorized personnel
   - d. all personnel located behind lead shielding

3. Labs using lasers should develop a written laser safety program and ______.
   - a. appoint a Laser Safety Officer (LSO)
   - b. submit it to OSHA for approval
   - c. receive program approval from unions
   - d. ensure only Class I lasers are used in a laboratory

4. Employers must implement a Hearing Conservation Program where laboratory workers are exposed to a time weighted average noise level of _____.
   - a. 45 dBA or higher over an 4 hour period
   - b. 70 dBA or higher over an 6 hour work shift
   - c. 75 dBA or higher over an 8 hour period
   - d. 85 dBA or higher over an 8 hour work shift
5. Operation of large analyzers, cell washers, sonicators, and stirrer motors, all contribute to the _____ in laboratories.

   a. noise level
   b. ergonomics hazards
   c. cuts and scratches
   d. eye hazards
Module 9: Safety Hazards

Employers must assess tasks to identify potential worksite hazards and provide and ensure that workers use appropriate personal protective equipment (PPE) as stated in the PPE standard, 29 CFR 1910.132.

Employers must require workers to use appropriate hand protection when hands are exposed to hazards such as sharp instruments and potential thermal burns. Examples of PPE which may be selected include using oven mitts when handling hot items and steel mesh or cut-resistant gloves when handling or sorting sharp instruments as stated in the Hand Protection Standard, 29 CFR 1910.138.

Autoclaves and Sterilizers

An autoclave is used in laboratories to sterilize equipment and supplies. They pose several hazards to laboratory workers, including:

- Burns from pressurized heat and steam. When opening the door, be sure to keep face, body and hands away from escaping heat and steam.

- Explosions if the door seals fail during operation. Pressure and heat in the autoclave’s chamber can escape causing serious injury.

- Ergonomic lifting injuries when moving equipment. Get help when moving heavy equipment.

- When handling or sorting hot sterilized items or sharp instruments, cuts can occur. Be sure to be careful when removing them from autoclaves or sterilizers.
Centrifuges

Due to the high speed at which they operate, centrifuges have great potential for injuring users if not operated properly. Unbalanced centrifuge rotors can result in injury, even death. Sample container breakage can generate aerosols that may be harmful if inhaled.

The majority of all centrifuge accidents are the result of user error. To avoid injury, workers should follow the manufacturer’s operating instructions for each make and model of centrifuge they use.

Follow these steps for the safe operation of centrifuges:

- Ensure centrifuge bowls and tubes are dry.
- Ensure the spindle is clean.
- Use matched sets of tubes, buckets and other equipment.
- Always use safety centrifuge cups to contain potential spills and prevent aerosols.
- Inspect tubes or containers for cracks or flaws before using them.
- Avoid overfilling tubes or other containers (e.g., in fixed angle rotors, centrifugal force may drive the solution up the side of the tube or container wall).
- Ensure the rotor is properly seated on the drive shaft.
- Make sure tubes or containers are properly balanced in the rotor.
- Only check O-rings on the rotor if you are properly trained.
- Apply vacuum grease in accord with the manufacturer’s guidelines.
- Do not exceed the rotor’s maximum run speed.
- Close the centrifuge lid during operation.
- Make sure the centrifuge is operating normally before leaving the area.
• Make sure the rotor has come to a complete stop before opening the lid.

Employers should instruct workers when centrifuging infectious materials that they should wait 10 minutes after the centrifuge rotor has stopped before opening the lid. Workers should also be trained to use appropriate decontamination and cleanup procedures for the materials being centrifuged if a spill occurs and to report all accidents to their supervisor immediately.

Compressed Gases

Within laboratories, compressed gases are usually supplied either through fixed piped gas systems or individual cylinders of gases. Compressed gases contained in cylinders vary in chemical properties, ranging from inert and harmless to toxic and explosive. The high pressure of the gases constitutes a serious hazard in the event that gas cylinders sustain physical damage and/or are exposed to high temperatures.

Compressed gases can be toxic, flammable, oxidizing, corrosive, or inert. Leakage of any of these gases can be hazardous in the following ways:

- Leaking inert gases (e.g., nitrogen) can quickly displace air in a large area creating an oxygen-deficient atmosphere;
- Toxic gases can create poison atmospheres; and
- Flammable (oxygen) or reactive gases can result in fire and exploding cylinders.

In addition, there are hazards from the pressure of the gas and the physical weight of the cylinder, including:

- A gas cylinder falling over can break containers and crush feet.
- The gas cylinder can itself become a missile if the cylinder valve is broken off.

Laboratories must include compressed gases in their inventory of chemicals in their Chemical Hygiene Plan.

Store, handle, and use compressed gases in accord with OSHA’s Compressed Gases Standard (29 CFR 1910.101) and Pamphlet P-1 from the Compressed Gas Association. Be sure to adhere to the following:
- All cylinders whether empty or full must be stored upright.
- Secure cylinders of compressed gases. Cylinders should never be dropped or allowed to strike each other with force.
- Transport compressed gas cylinders with protective caps in place and do not roll or drag the cylinders.

**Cryogens and Dry Ice**

Cryogens, substances used to produce very low temperatures [below -153°C (-243°F)], such as liquid nitrogen (LN2) which has a boiling point of -196°C (-321°F), are commonly used in laboratories. Although not a cryogen, solid carbon dioxide or dry ice which converts directly to carbon dioxide gas at -78°C (-109°F) is also often used in laboratories. Shipments packed with dry ice, samples preserved with liquid nitrogen, and, in some cases, techniques that use cryogenic liquids, such as cryogenic grinding of samples, present potential hazards in the laboratory.

**Overview of Cryogenic Safety Hazards**

The safety hazards associated with the use of cryogenic liquids are categorized as follows:

1. **Cold contact burns.** Liquid or low-temperature gas from any cryogenic substance will produce effects on the skin similar to a burn.

2. **Asphyxiation.** Degrees of asphyxia will occur when the oxygen content of the working environment is less than 20.9% by volume. This decrease in oxygen content can be caused by a failure/leak of a cryogenic vessel or transfer line and subsequent vaporization of the cryogen. Effects from oxygen deficiency become noticeable at levels below approximately 18% and sudden death may occur at approximately 6% oxygen content by volume.

3. **Explosion – Pressure.** Heat flux into the cryogen from the environment will vaporize the liquid and potentially cause pressure buildup in cryogenic containment vessels and
transfer lines. Adequate pressure relief should be provided to all parts of a system to permit this routine outgassing and prevent explosion.

4. **Explosion – Chemical.** Cryogenic fluids with a boiling point below that of liquid oxygen are able to condense oxygen from the atmosphere. Repeated replenishment of the system can thereby cause oxygen to accumulate as an unwanted contaminant. Similar oxygen enrichment may occur where condensed air accumulates on the exterior of cryogenic piping. Violent reactions (e.g., rapid combustion or explosion) may occur if the materials that make contact with the oxygen are combustible.

Whenever working with cryogenic fluids, be sure to use the following personal protective equipment:

- **Face shield or safety goggles.** Eye protection is required at all times when working with cryogenic fluids. When pouring a cryogen, working with a wide-mouth Dewar flask or around the exhaust of cold boil-off gas, use of a full face shield is recommended.

- **Safety gloves.** Hand protection is required to guard against the hazard of touching cold surfaces. It is recommended that Cryogen Safety Gloves be used by the worker.

- **Long-sleeved shirts, lab coats, and aprons.** Chemical-resistant sleeves should be used to provide additional protection. To protect against the risk of a splash hazard, consider using a chemical-resistant apron, such as those made from rubber, neoprene or PVC (depending on compatibility). Lab coat materials may be made of materials for limited reuse, or disposable one time use. If chemicals penetrate the coat or sleeve material, take it off and be sure to wash any affected area of your skin for 15 minutes.

For more information on laboratory PPE, click on the following link:

- **Lawrence Berkeley National Laboratory** (Berkeley Lab) PPE requirements, Chapter 19.

**Electrical**

In the laboratory, there is the potential for workers to be exposed to electrical hazards including electric shock, electrocutions, fires and explosions.

Damaged electrical cords can lead to possible shocks or electrocutions. A flexible electrical cord may be damaged by door or window edges, by staples and fastenings, by equipment rolling over it, or simply by aging.
The potential for possible electrocution or electric shock or contact with electrical hazards can result from a number of factors, including the following:

- Faulty electrical equipment/instrumentation or wiring;
- Damaged receptacles and connectors; and
- Unsafe work practices.

Employers are responsible for complying with OSHA’s electrical safety standard, 1910 Subpart S - Electrical. This standard is comprehensive and addresses electrical safety requirements for the practical safeguarding of workers in their workplaces, including:

- Electrical equipment must be free from recognized hazards.
- Listed or labeled equipment must be used or installed in accord with any instructions included in the listing or labeling.
- Sufficient access and working space must be provided and maintained around all electrical equipment operating at less than or equal to 600 volts to permit ready and safe operation and maintenance of such equipment;
- Ensure that all electrical service near sources of water is properly grounded.
- Repair all damaged receptacles and portable electrical equipment before placing them back into service.
- Ensure that workers do not plug or unplug equipment when their hands are wet.
- Follow requirements for Hazardous Classified Locations, 29 CFR 1910.307. This section covers the requirements for electric equipment and wiring in locations that are classified based on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers that may be present therein and the likelihood that a flammable or combustible concentration or quantity is present.
- Only “Qualified Persons,” as defined by OSHA in 29 CFR 1910.399, are to work on electrical circuits/systems.
Workers must be trained to know the locations of circuit breaker panels that serve their lab area.

**Lockout/Tagout**

Laboratory workers performing service or maintenance on equipment may be exposed to injuries from the unexpected energization, startup of the equipment, or release or stored energy in the equipment.

OSHA’s Control of Hazardous Energy Standard, 29 CFR 1910.147, commonly referred to as the “Lockout/Tagout” Standard, requires employers to adopt and implement safe practices and procedures to:

- shut down equipment,
- isolate it from its energy source(s), and
- prevent the release of potentially hazardous energy while maintenance and servicing activities are being performed.

The standard covers servicing and maintenance of machines and equipment in which the “unexpected” energization or startup of the machines or equipment, or release of stored energy could cause injury to workers.

The term “unexpected” also covers situations in which the servicing and/or maintenance is performed during ongoing normal production operations if:

- a worker is required to remove or bypass machine guards or other safety devices, or
- a worker is required to place any part of his or her body into a point of operation or into an area on a machine or piece of equipment where work is performed, or into the danger zone associated with the machine’s operation.

Unexpected and unrestricted release of hazardous energy can occur if:

- all energy sources are not identified;
- provisions are not made for safe work practices with energy present; or
deactivated energy sources are reactivated, mistakenly, intentionally, or accidentally, without the maintenance worker’s knowledge.

Employers should develop, implement and enforce effective procedures for controlling hazards to ensure worker safety during maintenance.

**Fire**

Fire is the most common serious hazard in a typical laboratory. Small bench-top fires in laboratory spaces are not uncommon. Large laboratory fires are rare.

While proper procedures and training can minimize the chances of an accidental fire, laboratory workers should still be prepared to deal with a fire emergency. In dealing with a laboratory fire, all containers of infectious materials should be placed into autoclaves, incubators, refrigerators, or freezers for containment.

However, the risk of severe injury or death is significant because fuel load and hazard levels in labs are typically very high. Laboratories, especially those using solvents in any quantity, have the potential for flash fires, explosion, rapid spread of fire, and high toxicity of products of combustion (heat, smoke, and flame).

**Fire Safety Training**

Employers should train workers to remember the “PASS” rule for fire extinguishers.

PASS summarizes the operation of a fire extinguisher.

- **P** – Pull the pin.
- **A** – Aim extinguisher nozzle at the base of the fire.
- **S** – Squeeze the trigger while holding the extinguisher upright.
- **S** – Sweep the extinguisher from side to side; cover the fire with the spray.

The two most common types of extinguishers in the chemistry laboratory are pressurized dry chemical (Type BC or ABC) and carbon dioxide. In addition, you may also have a specialized Class D dry powder extinguisher for use on flammable metal fires.

**Water-filled extinguishers are not acceptable for laboratory use.**
Employers should train workers on appropriate procedures in the event of a clothing fire.

- If the floor is not on fire, STOP, DROP and ROLL to extinguish the flames or use a fire blanket or a safety shower if not contraindicated (i.e., there are no chemicals or electricity involved).

- If a coworker’s clothing catches fire and he/she runs down the hallway in panic, tackle him/her and smother the flames as quickly as possible, using appropriate means that are available (e.g., fire blanket, fire extinguisher).

Employers should also train laboratory workers on the Laboratory Emergency Action Plan (see OSHA Academy Course 717: Emergency Action Plans) and to do the following to prevent fires:

- Use only the minimum quantities of chemicals needed for laboratory processes and observe restrictions on equipment (i.e., keeping solvents only in an explosion-proof refrigerator).

- Keep work areas uncluttered, and clean frequently. Put unneeded materials back in storage promptly. Keep aisles, doors, and access to emergency equipment unobstructed at all times.

- Keep barriers in place (shields, hood doors, lab doors).

- Wear proper clothing and personal protective equipment.

- Avoid working alone.

- Store solvents properly in approved flammable liquid storage cabinets.

- Limit open flames use to under fume hoods and only when constantly attended.

- Keep combustibles away from open flames.

- Do not heat solvents using hot plates.

Make sure workers are trained in the following emergency procedures:

- Know what to do. You tend to do under stress what you have practiced or pre-planned. Therefore, planning, practice and drills are essential.
• Know where things are, including the nearest fire extinguisher, fire alarm box, exit(s), telephone, emergency shower/eyewash, and first-aid kit, etc.

• Be aware that emergencies are rarely “clean” and will often involve more than one type of problem. For example, an explosion may generate medical, fire, and contamination emergencies simultaneously.

• Train workers and exercise the emergency plan.

For more information on laboratory fire safety see OSHAcademy Course 718, Fire Prevention Plans.

**Slips, Trips and Falls**

Worker exposure to wet floors or spills and clutter can lead to slips/trips/falls and other possible injuries. In order to keep workers safe, employers should refer to:

• OSHA standard 29 CFR 1910 Subpart D – Walking-Working Surfaces,

• Subpart E – Means of Egress, and

• Subpart J - General environmental controls

General best practices to prevent slips, trips, and falls include:

• Keep floors clean and dry. In addition to being a slip hazard, continually wet surfaces promote the growth of mold, fungi, and bacteria that can cause infections.

• Provide warning (caution) signs for wet floor areas.

• Where wet processes are used, maintain drainage and provide false floors, platforms, mats, or other dry standing places where practicable, or provide appropriate waterproof foot-gear.

• The Walking/Working Surfaces Standard requires that all employers keep all places of employment clean and orderly and in a sanitary condition.
• Keep aisles and passageways clear and in good repair, with no obstruction across or in aisles that could create a hazard.

• Provide floor plugs for equipment, so that power cords need not run across pathways.

• Keep exits free from obstruction. Access to exits must remain clear of obstructions at all times.

• Ensure spills are reported and cleaned up immediately.

• Eliminate cluttered or obstructed work areas.

• Use prudent housekeeping procedures such as using caution signs, cleaning only one side of a passageway at a time, and provide good lighting for all halls and stairwells to help reduce accidents, especially during the night hours.

• Instruct workers to use the handrail on stairs, to avoid undue speed, and to maintain an unobstructed view of the stairs ahead of them even if that means requesting help to manage a bulky load.

• Eliminate uneven floor surfaces.

• Promote safe work practices, even in cramped working spaces.

• Avoid awkward positions, and use equipment that makes lifting easier.
Module 9 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. When opening a/an _____ door, be sure to keep face, body and hands away from escaping heat and steam.
   a. refrigerator
   b. microwave oven
   c. autoclave
   d. centrifuge

2. Which of the following physical hazards can cause laboratory worker injury or even death?
   a. Unbalanced centrifuge rotors
   b. Misaligned microscope
   c. Mechanical pipetting
   d. Horseplay

3. Which of the following can quickly displace air in a large area creating an oxygen-deficient atmosphere in the laboratory?
   a. Compressed gases
   b. Leaking inert gases (e.g., nitrogen)
   c. Toxic fumes
   d. Flammable (oxygen) or reactive gases

4. Whenever working with cryogenic fluids, be sure to use all of the following personal protective equipment, EXCEPT _____.
   a. face shield
   b. coat or apron
   c. ear plugs
   d. safety gloves
5. _____ is the most common serious hazard in a typical laboratory.

   a. Fire
   b. Falling
   c. Being cut
   d. Getting infected
References


National Institute of Occupational Safety and Health, Registry of Toxic Effects of Chemical Substances, (published annually) U.S. Department of Health and Human Services, Occupational Health Guidelines for Chemical Hazards, NIOSH/OSHA.


University of Illinois at Urbana-Champaign. UIUC Model Chemical Hygiene Plan, 1999.


Endnotes


Biosafety in Microbiological and Biomedical Laboratories (BMBL), CDC, http://www.cdc.gov/biosafety/publications/bmbl5/index.htm

Glossary

**ACGIH STEL**: American Conference of Governmental and Industrial Hygienists' short-term exposure limit; 15-min time-weighted-average exposure that should not be exceeded at any time during a workday even if the 8-h time-weighted-average is within the threshold limit value.

**ACGIH TLV**: ACGIH's threshold limit value expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effects.

**LC50 (Lethal Concentration50)**: A calculated concentration of a chemical in air to which exposure for a specific length of time is expected to cause death in 50% of a defined experimental animal population.

**LOAEL**: Lowest observed adverse effect level.

**NIOSH IDLH**: National Institute of Occupational Safety and Health's immediately dangerous to life or health concentration; NIOSH recommended exposure limit to ensure that a worker can escape from an exposure condition that is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from the environment.

**NIOSH REL**: NIOSH's recommended exposure limit; NIOSH-recommended exposure limit for an 8- or 10-h time-weighted-average exposure and/or ceiling.

**NIOSH STEL**: NIOSH's recommended short-term exposure limit; a 15-minute TWA exposure which should not be exceeded at any time during a workday.

**OSHA PEL**: Occupational Safety and Health Administration's permissible exposure limit expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effect averaged over a normal 8-h workday or a 40-h workweek.